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IMPACT TOLERANCE - ABDOMINAL INJURY

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1.0 SUMMARY

In order to provide data on human tolerance to blunt abdominal impact a literature study and laboratory tests were carried out to determine the major causes of abdominal injury, injury mechanisms, a quantitative relationship between input and occurrence of trauma and to develop the criteria to recommend performance requirements for materials which often produce blunt abdominal injury. An extensive analysis of case reports indicated that the most frequent causes of blunt abdominal injury were the steering wheel, seat belt and various protruding objects in a vehicle; the organs most often injured were the liver, pancreas, spleen and intestine. However the results indicate that the vervet monkey (Cercopithecus pygerythrus) can survive (injury level of 3) blunt impacts to the upper abdomen with the various impactors used at velocities up to 22 mph, while in the midabdomen it can survive impacts of this type of approximately 26 mph and in the lower abdomen of 34 mph.

2.0 INTRODUCTION

This study was conducted to define and analyze abdominal injuries to restrained and unrestrained vehicle occupants and pedestrians during crashes. Injury types were associated with the trauma producing agent and ranked according to the probability of occurrence. This aspect of the study was based on a careful review of over 43,000 references to abdominal impact cited in the literature. Twelve hundred documented cases of blunt abdominal injury were tabulated and ranked according to cause and frequency of occurrence. Three of the most probable causes of abdominal injury were selected to be the steering wheel rim, seat belt and any protruding round object. Controlled laboratory tests simulating these causes were performed using 53 animals to aid in the prediction of the probability of occurrence of abdominal injuries and to establish a quantitative relationship between a measurable input and the occurrence of trauma. These criteria were used to make initial recommendations for the performance requirements for structures, devices and surfaces against which there is a high probability of abdominal injury.

3.0 DEFINITION AND ANALYSIS OF ABDOMINAL INJURIES; INJURY TYPES AND PROBABILITY OF OCCURRENCE - LITERATURE REVIEW

An analysis of the literature revealed pertinent new information on the types of injury which develop from various impact situations. Because of the very large number of cases, such information has a higher degree of reliability than any previous study of this type.

The data from over 1200 cases of abdominal injury are presented graphically in Tables I through X. Each table is devoted to a particular type of injury cause - e.g. lap belt, steering wheel, pedestrian, motorcycle, etc. The injury patterns as to the site of injury can be detected readily by a glance at each table. These patterns and their inter-relationships will be discussed below. An injury scale was adopted for purposes of expressing this literature review based on graduations from one to ten with the upper end of the scale representing the most severe injury.

3.1 INJURY SCALE

- | | |
|---------------|---------------|
| 1. Bruise | 4. Laceration |
| Abrasion | Perforation |
| Contusion | Rent |
| 2. Ecchymosis | Rupture |
| Hematoma | Tear |
| Edema | Fragmentation |
| Adhesions | 5. Avulsion |
| 3. Cyst | Transection |
| Pseudocyst | Severance |
| Fistula | Amputation |
| Mass | 6. Herniation |

- | | |
|---|---|
| <p>7. Hemorrhage
Occlusion
Thrombosis</p> | <p>9. Maceration
Crush
Obliteration</p> |
| <p>8. Gangrene
Necrosis
Infarction</p> | <p>10. Massive Hemorrhage
and Shock = Fatal</p> |

3.2 INJURY PATTERN AND MECHANISM

The analysis of lap belt injuries is presented semi-graphically in Table I, Part A which depicts the trends of these injuries associated with each type of impact. It is apparent from Table I, Part A that lap belt injuries primarily involve the small intestine. The degree of trauma varies considerably but it can be assumed that minor injuries in this area, 1 to 3 on the scale, would not generally be detected. Within the area of the small intestine most injuries were located in the ileum or its mesentery. Most injuries were in the 4 to 5 range indicative of lacerations, rupture and transection. There was markedly less trauma to the duodenum which is higher and consequently less apt to be trapped under the seat belt as is the case for the liver and spleen. There was however also less injury in the large intestine which is usually directly under the belt. Most of the trauma in this area was found in the sigmoid colon which is situated more in the center of the abdomen and perhaps consequently absorbed more of the blow than the laterally situated ascending and descending colon in which injury was rare. A few injuries were also found in the caecum, where a rather abrupt narrowing occurs at the entrance to the small intestine. The transverse colon was free from trauma perhaps because of its superior position. The mesentery of the sigmoid colon was frequently injured apparently because of its attachments. The primary reason for injury to the caecum where the small and large intestines join is likely to be due to a sudden build up of pressure as the contents of the colon are forced away from the site of impact. The sudden narrowing at this point, and a slightly weakened muscular wall at their junction would seem to be a natural site for injury to occur. The spleen and liver were also fairly common sites of injury from lap belts. Such trauma must be due to wearing the belt too high or else from a combination of lap belt-steering wheel impact. The danger from such trauma lies primarily in the loss of blood from hemorrhage which may be excessive before adequate surgical procedures can be implemented.

Injury patterns from the 2-point shoulder belt are presented in Table I, Part B. The injuries are almost entirely in the more solid abdominal organs or in the abdominal wall. Most injuries occurred in the liver and spleen, followed by the kidneys.

Trauma from the 3-point belt (Table I, Part C) was similar to that produced by the lap belt alone in that it involved the small intestine. However the pattern was different; most of these injuries from the 3-point belt were in the duodenum while most injuries from lap belt were located lower in the ileum. It would appear that the 3-point belt produces trauma across the line of contact. In addition, it is possible that the lap belt is usually worn higher when worn with a shoulder harness. This might also tend to increase injury to the duodenum. Table I, Part D presents injuries from belts of unspecified types. Most trauma in this group is to the small intestine.

Steering wheel-induced injuries constitute the next class to be considered and results from 149 cases are presented in Table II. It is immediately apparent from inspection of this table that most trauma from the steering wheel is to the duodenum, pancreas, and liver. Such organs are located in the upper part of the abdomen and are susceptible to blunt trauma. The duodenum seems especially susceptible to injury, depending on the direction of the forces as well as by the shape of the object. If the victim tends to submerge after the lower rim of the steering wheel is deeply embedded into the abdomen, the upper abdominal organs including the duodenum, pancreas, and liver may be subjected to vertical tearing forces in addition to the crushing forces produced by lateral movement into the steering wheel rim. Such motions would explain injury to the duodenum and pancreas, both of which are relatively fixed and consequently subject to the effects of shearing forces.

Injuries to pedestrians are collated in Table III. A marked shift in injury patterns is immediately apparent. Most pedestrian abdominal trauma is to the more solid organs - spleen, liver, diaphragm, kidneys and pancreas with little to the small intestine and almost none to the large intestine. Injuries to the diaphragm and spleen are the most prominent. A higher percentage of the pedestrian cases were fatalities due to abdominal injury than was the case for the seat belt or steering wheel impacts. Such a higher mortality rate may in part influence the

evaluation of the injuries, i.e., autopsies are generally more thorough than surgical examination. In addition some injuries become obvious only after some delay while sequelae and/or scar tissue develops. Most lethal injuries do not allow for such a delay before examination.

The more detailed reports of injury kinematics are collated in Table IV. Table IV, Part A gives the injury pattern resulting from dashboard impacts. Most of the trauma in this group of 11 cases was to the liver, which might be expected because of the location of the dashboard relative to the abdominal contents. Other injuries to the head and thorax are probably more common but have not been considered in this report on abdominal impact. Table IV, Part B presents data on armrest-induced injury. The spleen is the target organ for most injuries from this impact, but the liver and kidney also are injured fairly often. Table IV, Part C presents four cases of trauma to rear seat occupants who sustained injuries to the diaphragm, liver, spleen, and pancreas. In Table IV, Part D, 43 cases of injury from miscellaneous causes are collated with detailed kinematic descriptions of the car crash but no information on the object causing the injury. Injuries in these cases are primarily in the liver, diaphragm, spleen and kidneys.

Bicycle injury cases are given in Table V; bicycle-auto accidents are collated in Table V, Part A. The injury pattern is fairly evenly distributed over the range of solid abdominal organs and the small intestine. The greatest amount of trauma was to the spleen, liver and pancreas. Bicycle handlebar injuries (42 cases) are shown in Table V, Part B. Trauma was predominately to the pancreas and duodenum with some to the jejunum. Apparently this slower impact produces tears especially in the pancreas. Injury to the duodenum, while common, is less severe than that to the pancreas. Miscellaneous bicycle injuries given in Table V, Part C are mostly to the spleen.

Reports of motorcycle accident cases are shown in Table VI. The injury pattern is predominately in the area of the more solid organs - liver, spleen, and pancreas - and in the duodenum.

Trauma from ejection from a moving vehicle (Table VII) is also predominately to the more solid organs - the spleen and liver are particularly vulnerable. There was also some trauma to the duodenum and other organs. This trauma pattern contrasts sharply as might be expected with steering wheel-

induced injuries which are primarily to the duodenum and pancreas and also with belt-induced trauma to the small intestine. The ejection injury pattern involving the liver and spleen is closer to that resulting from motorcycles (Table VI) which perhaps are also primarily ejections. The dashboard (Table IV) and pedestrian (Table III) injury patterns are similar to that caused by ejections but include injury to the diaphragm. The injury pattern from bicycle accidents (Table V), however, differs considerably with most of the injury occurring in the pancreatic-duodenal region. Thus there is a large range of injuries with markedly different trends.

Blunt abdominal crushing trauma as occurs from low velocity accidents such for example as a pedestrian caught between the tailgate of a truck and a loading dock, is presented in Table VIII. Such injuries are diversified involving about equally the more solid organs and the small intestine. Injuries were more prevalent to the liver, duodenum, diaphragm, pancreas, stomach and jejunum. There was no major trend evident except the absence of trauma to the large intestine.

Tables IX and X show trauma from unspecified impact objects in vehicular accidents and other miscellaneous injuries. Results from Table X, miscellaneous vehicular blunt abdominal trauma, show that most such injuries were to the more solid abdominal organs and especially the spleen and liver. Table IX, showing injury patterns from unspecified causes, indicates that the injuries are primarily to the spleen, diaphragm and liver. A complete tabulation of the data from the cases described in this section is presented in Table XI.

A. LAP BELT CONTINUED

Case No.	EXTRA PERITONEAL		MORE SOLID ORGANS						SMALL INTESTINE						LARGE INTESTINE								MISC.		FATAL														
	Abdominal Wall	Abdominal Muscles Omentum	Diaphragm	Liver	Stomach	Spleen	Kidneys	Bladder- ureter	Gallbladder	Pancreas	Duodenum	Duodenal Mesentery	Jejunum	Jejunal Mesentery	Ileum	Ileal Mesentery	Unspecified S.I. Injury	Unspecified S.I. Mesentery Injury	Appendix	Ascending Colon	Ascending Colon Mesentery	Descending Colon	Descending Colon Mesentery	Transverse Colon		Transverse Colon Mesentery	Signoid Colon	Signoid Colon Mesentery	Caecum	Caecal Mesentery	Unspecified L.I. Injury	Unspecified L.I. Mesentery Injury	Arteries	Retroperitoneal	Unspecified Abdominal				
85.	1									4/	4/																												
86.																																							
87.	2																																						
88.	2					4/					4/	4	4	4	4	4	4																						
89.	2					4/																																	
90.																																							
91.	2																																						
92.																																							
93.	2						4																																
94.	2									4/																													
95.	1																																						
96.	1+																																						
97.																																							
98.																																							
99.	1																																						
100.	2									4/	4/									4/																			
101.																																							
102.																																							
103.																																							
104.																																							
105.	1																																						

7
(10)

x

7

7/

4(77)

{44}
{77}

5(4)

8(4)

A. LAP BELT CONTINUED

Case No.	EXTRA PERITONEAL	MORE SOLID ORGANS	SMALL INTESTINE	LARGE INTESTINE	MISC.	FATAL
106.	Abdominal Wall Abdominal Muscles Omentum	Diaphragm Liver Stomach Spleen Kidneys Bladder-ureter Gallbladder Pancreas	Duodenum Duodenal Mesentery Jejunum Jejunal Mesentery Ileum Ileal Mesentery Unspecified S.I. Injury Unspecified S.I. Mesentery Injury	Appendix Ascending Colon Ascending Colon Mesentery Descending Colon Descending Colon Mesentery Transverse Colon Transverse Colon Mesentery Sigmoid Colon Sigmoid Colon Mesentery Caecum Caecal Mesentery Unspecified L.I. Injury Unspecified L.I. Mesentery Injury	Arteries Retroperitoneal Unspecified Abdominal	
107.						
108.	8					
109.	1 2					
110.	1		4*			
111.	4(1)		1			

Case No.	EXTRA PERITONEAL	MORE SOLID ORGANS	SMALL INTESTINE	LARGE INTESTINE	MISC.	FATAL
43.	Abdominal Wall Abdominal Muscles Omentum	Diaphragm Liver Stomach Spleen Kidneys Bladder-ureter Gallbladder Pancreas	Duodenum Duodenal Mesentery Jejunum Jejunal Mesentery Ileum Ileal Mesentery Unspecified S.I. Injury Unspecified S.I. Mesentery Injury	Appendix Ascending Colon Ascending Colon Mesentery Descending Colon Descending Colon Mesentery Transverse Colon Transverse Colon Mesentery Sigmoid Colon Sigmoid Colon Mesentery Caecum Caecal Mesentery Unspecified L.I. Injury Unspecified L.I. Mesentery Injury	Arteries Retroperitoneal Unspecified Abdominal	
44.	1	4	5	2		
45.	2		4/			
46.		4/		4/		
47.		4/4	2		2	
48.			4			
49.			4/		2	
50.			4/			
51.			4/			
52.			11			
53.		4/				
54.			(5/10)			
55.		4/				
56.		(S)				
57.			2			
58.		4/ 4/4	5	2	2	
59.		7/	5	4/4		
60.			5(1)		5	
61.		4/	5(1)			
62.			4/			
63.	4/		4/			

Case No.	EXTRA PERITONEAL	MORE SOLID ORGANS	SMALL INTESTINE	LARGE INTESTINE	MISC.	FATAL
85.	Abdominal Wall Abdominal Muscles Omentum	Diaphragm Liver Stomach Spleen Kidneys Bladder-ureter Gallbladder Pancreas	Duodenum Duodenal Mesentery Jejunum Jejunal Mesentery Ileum Ileal Mesentery Unspecified S.I. Injury Unspecified S.I. Mesentery Injury	Appendix Ascending Colon Ascending Colon Mesentery Descending Colon Descending Colon Mesentery Transverse Colon Transverse Colon Mesentery Sigmoid Colon Sigmoid Colon Mesentery Caecum Caecal Mesentery Unspecified L.I. Injury Unspecified L.I. Mesentery Injury	Arteries Retroperitoneal Unspecified Abdominal	
86.						
87.						
88.						
89.						
90.						
91.						
92.						
93.						
94.						
95.						
96.						
97.						
98.						
99.						
100.						
101.						
102.						
103.						
104.						
105.						

(4+)
(7)

(4+)
(3)

(42)

7

46

X
X
X

Case No.	EXTRA PERITONEAL Abdominal Wall Abdominal Muscles Omentum	MORE SOLID ORGANS Diaphragm Liver Stomach Spleen Kidneys Bladder-ureter Gallbladder Pancreas	SMALL INTESTINE Duodenum Duodenal Mesentery Jejunum Jejunal Mesentery Ileum Ileal Mesentery Unspecified S.I. Injury Unspecified S.I. Mesentery Injury	LARGE INTESTINE Appendix Ascending Colon Ascending Colon Mesentery Descending Colon Descending Colon Mesentery Transverse Colon Transverse Colon Mesentery Sigmoid Colon Sigmoid Colon Mesentery Caecum Caecal Mesentery Unspecified L.I. Injury Unspecified L.I. Mesentery Injury	MISC. Arteries Retroperitoneal Unspecified Abdominal	FATAL
106.		4/				
107.						
108.		5			2	
109.		5				
110.						
111.						
112.						
113.						
114.		4+				
115.		4/				
116.						
117.		4+				
118.		5				
119.		6(4)				
120.						
121.	2					
122.		4+				
123.						
124.		4/				
125.		4+				
126.	1+	4+				

Case No.		
148.	Abdominal Wall Abdominal Muscles Omentum	EXTRA PERITONEAL
149.	Diaphragm Liver Stomach Spleen Kidneys Bladder-ureter Gallbladder Pancreas	MORE SOLID ORGANS
2	Duodenum Duodenal Mesentery Jejunum Jejunal Mesentery Ileum Ileal Mesentery Unspecified S.I. Injury	SMALL INTESTINE
2	Unspecified S.I. Mesentery Injury Appendix Ascending Colon Ascending Colon Mesentery Descending Colon Descending Colon Mesentery Transverse Colon Transverse Colon Mesentery Sigmoid Colon Sigmoid Colon Mesentery Caecum Caecal Mesentery Unspecified L.I. Injury Unspecified L.I. Mesentery Injury	LARGE INTESTINE
	Arteries Retroperitoneal Unspecified Abdominal	MISC.
		FATAL

Case No.	EXTRA PERITONEAL	MORE SOLID ORGANS	SMALL INTESTINE	LARGE INTESTINE	MISC.	FATAL
43.	Abdominal Hall Abdominal Muscles	Diaphragm Liver Stomach Spleen Kidneys Bladder- ureter Gallbladder Pancreas	Duodenum Duodenal Mesentery Jejunum Jejunum Duodenal Mesentery Ileum Ileum Ileal Mesentery Unspecified Mesentery S.I. Injury Unspecified S.I. Mesentery Injury	Ascending Colon Ascending Colon Mesentery Descending Colon Descending Colon Mesentery Transverse Colon Transverse Colon Mesentery Stigmoid Colon Stigmoid Colon Caecum Caecal Mesentery Unspecified L.I. Injury Unspecified L.I. Mesentery Injury	Arteries Retroperitoneal Unspecified Abdominal	
44.						x
45.						x
46.						x
47.						
48.						
49.						
50.						
51.						
52.						
53.						x
54.						x
55.						
56.						
57.						
58.						x
59.						x
60.						
61.						
62.						
63.						x

Case No.	EXTRA PERITONEAL	MORE SOLID ORGANS	SMALL INTESTINE	LARGE INTESTINE	MISC.	FATAL
127.	Abdominal Wall Abdominal Muscles Omentum	Diaphragm Liver Stomach Spleen Kidneys Bladder-ureter Gallbladder Pancreas	Duodenum Duodenal Mesentery Jejunum Jejunum Mesentery Ileum Ileal Mesentery Unspecified Mesentery Unspecified S.I. Injury Unspecified S.I. Mesentery Injury	Ascending Colon Ascending Colon Mesentery Descending Colon Descending Colon Mesentery Transverse Colon Transverse Colon Mesentery Sigmoid Colon Sigmoid Colon Mesentery Caecum Caecal Mesentery Unspecified L.I. Injury Unspecified L.I. Mesentery Injury	Arteries Retropertitoneal Unspecified Abdominal	X X X X X X X X X X X X X
128.	4	4		2 4		X
129.	4/	4/				X
130.	4	4				X
131.	4/ 4	4/ 4			2/	X
132.	4/	4/	4/			X
133.	4/	4/	4/			X
134.	4+	4+				X
135.			4/			X
136.			4/			X
137.		4			4(2)	X
138.		4				X
139.	4	4	4/			X
140.		4				X
141.		4(3)				X
142.	4(6) 4+	4				X
143.	4	X				X
144.	4	X				X
145.	4	X				X
146.	4	X				X
147.	4	4		4/	4(7)	X

Case No.	EXTRA PERITONEAL	MORE SOLID ORGANS	SMALL INTESTINE	LARGE INTESTINE	MISC.	FATAL
12.			Duodenum 4+			
13.		Pancreas 5				
14.		Stomach 2 2 Spleen 2(7) 5				
15.		Kidneys 4 Stomach 4	Duodenum 4	Ascending Colon 2		
16.		Liver 4	Duodenum 4	Ascending Colon 4		X
17.		Bladder-ureter 3 Kidneys 4	Duodenum 4	Descending Colon 4		
18.		Gallbladder 4	Duodenum 4	Descending Colon 4		
19.				Descending Colon 7		
20.				Transverse Colon 7		
21.				Transverse Colon 2		
22.		Liver 4		Transverse Colon 2		
23.		Stomach 4 Spleen 4		Caecal Mesentery 2		
24.		Liver X		Caecal Mesentery 2		
25.		Diphryga 1		Caecal Mesentery 2		
26.		Liver 4+		Caecal Mesentery 2		
27.		Liver 4(7)		Caecal Mesentery 2		
28.		Liver 4(6)		Caecal Mesentery 2		
29.		Liver 4(6)		Caecal Mesentery 2		X
30.				Caecal Mesentery 2		
31.				Caecal Mesentery 2		
32.				Caecal Mesentery 2		

Case No.	EXTRA PERITONEAL	MORE SOLID ORGANS										SMALL INTESTINE										LARGE INTESTINE										MISC.		FATAL		
	Abdominal Wall Abdominal Muscles Omentum	Diaphragm	Liver	Stomach	Spleen	Kidneys	Bladder-ureter	Gallbladder	Pancreas	Duodenum	Duodenal Mesentery	Jejunum	Jejunal Mesentery	Ileum	Ileal Mesentery	Unspecified S.I. Injury	Unspecified S.I. Mesentery injury	Appendix	Ascending Colon	Ascending Colon Mesentery	Descending Colon	Descending Colon Mesentery	Transverse Colon	Transverse Colon Mesentery	Signoid Colon	Signoid Colon Mesentery	Caecum	Caecal Mesentery	Unspecified L.I. Injury	Unspecified L.I. Mesentery Injury	Arteries	Retroperitoneal	Unspecified Abdominal			
33.		4*																														4(7)			X	
34.	1																																			X
35.			4*																														10			X
36.			4/																																	X
37.	1																																			X
38.	1*																																			X
39.			1/					1								1/																				X
40.			4/																																	X
41.			4/																																	X
42.			4/ 4/																																	X
43.			4(6)																																	X

5
(10)

TABLE V.

A. STRUCK BY AUTO

EXTRA PERITONEAL
Abdominal
Muscles
Diaphragm
Liver
Stomach
Spleen
Kidneys
Bladder-
ureter
Gallbladder
Pancreas
Duodenum
Duodenal
Mesentery
Jejunum
Jejunal
Mesentery
Ileum
Ileal
Mesentery
Unspecified
S.I. Injury
Unspecified
S.I. Injury
Appendix
Ascending Colon
Ascending Colon
Mesentery
Ascending Colon
Descending Colon
Descending Colon
Mesentery
Transverse Colon
Transverse Colon
Mesentery
Signoid Colon
Signoid Colon
Caecum
Caecal Mesentery
Unspecified L.I.
Injury
Unspecified
L.I. Injury
Unspecified
Retroperitoneal
Arteries
Unspecified
Abdominal

Case No.	EXTRA PERITONEAL	MORE SOLID ORGANS	SMALL INTESTINE	LARGE INTESTINE	MISC.	FATAL
1.		Liver 4				
2.		Spleen 4				
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						
11.						
12.						
13.						
14.						
8. FALL - HANDLEBARS						
1.						
2.						
3.						
4.						
5.						
6.						

Case No.	EXTRA PERITONEAL	MORE SOLID ORGANS	SMALL INTESTINE	LARGE INTESTINE	MISC.	FATAL
7.						
8.			2(7)			
9.			2			
10.						
11.						
12.						
13.						
14.						
15.						
16.						
17.						
18.						
19.						
20.						
21.						
22.						
23.						
24.						
25.						
26.						
27.						

Case No.	Abdominal Wall	Abdominal Muscles	Omentum	LARGE SOLID ORGANS	SMALL INTESTINE	LARGE INTESTINE	MISC.	FATAL
6.				Diaphragm Liver Stomach Spleen Kidneys Bladder- ureter Gallbladder Pancreas	Duodenum Duodenal Mesentery Jejunum Jejunal Mesentery Ileum Ileal Mesentery Unspecified Mesentery S.I. Injury Unspecified S.I. Injury Unspecified Mesentery Injury	Ascending Colon Ascending Colon Mesentery Descending Colon Descending Colon Mesentery Transverse Colon Transverse Colon Mesentery Transverse Colon Sigmoid Colon Sigmoid Colon Mesentery Caecum Caecal Mesentery Unspecified L.I. Injury Unspecified L.I. Mesentery Injury	Arteries Retroperitoneal Unspecified Abdominal	
7.		4 (7)						
8.		4						
9.		4						
10.				1	2		2	
11.					2			
12.				4				
13.		5						
14.								
15.		4f						

Case No.	EXTRA PERITONEAL	MORE SOLID ORGANS	SMALL INTESTINE	LARGE INTESTINE	MISC.	FATAL
19.	Abdominal Wall Abdominal Muscles Omentum	Diaphragm Liver Stomach Spleen Kidneys Bladder-ureter Gallbladder Pancreas	Duodenum Duodenal Mesentery Jejunum Jejunal Mesentery Ileum Ileal Mesentery Unspecified S.I. Injury Unspecified S.I. Mesentery Injury	Appendix Ascending Colon Ascending Colon Mesentery Descending Colon Descending Colon Mesentery Transverse Colon Transverse Colon Mesentery Sigmoid Colon Sigmoid Colon Mesentery Caecum Caecal Mesentery Unspecified L.I. Injury Unspecified L.I. Mesentery Injury	Arteries Retroperitoneal Unspecified Abdominal	
20.		4 (10)				
21.		4(2)			4(7)	
22.			2			X

Case No.	EXTRA PERITONEAL	MORE SOLID ORGANS							SMALL INTESTINE										LARGE INTESTINE											MISC.			FATAL				
		Diaphragm	Liver	Stomach	Spleen	Kidneys	Bladder-ureter	Gallbladder	Pancreas	Duodenum	Duodenal Mesentery	Jejunum	Jejunal Mesentery	Ileum	Ileal Mesentery	Unspecified S.I. Injury	Unspecified S.I. Mesentery Injury	Appendix	Ascending Colon	Ascending Colon Mesentery	Descending Colon	Descending Colon Mesentery	Transverse Colon	Transverse Colon Mesentery	Signoid Colon	Signoid Colon Mesentery	Caecum	Caecal Mesentery	Unspecified L.I. Injury	Unspecified L.I. Mesentery Injury	Arteries	Retropertitoneal		Unspecified Abdominal			
43.	Abdominal Wall Abdominal Muscles Omentum		4(7)		1																									4			X				
44.			4																																		
45.																														4(7)							
46.			X		X																																
47.																																					
48.				X																																	
49.					4																																X
50.						1																															X
51.					4																									2							

Case No.	EXTRA PERITONEAL	MORE SOLID ORGANS	SMALL INTESTINE	LARGE INTESTINE	MISC.	FATAL
22.	Abdominal Wall Abdominal Muscles Omentum	Diaphragm		Ascending Colon Ascending Colon Mesentery Descending Colon Descending Colon Mesentery Transverse Colon Transverse Colon Mesentery Caecum Caecal Mesentery Unspecified L.I. Injury Unspecified L.I. Mesentery Injury	Arteries Retroperitoneal Unspecified Abdominal	X
23.		Liver 4+ Stomach 4+ Spleen 4+ Kidneys Bladder- Ureter			2	
24.			4(1)			
25.		4(6)				
26.		5(7)			7(4) 2	
27.		4				
28.		4(6)				
29.		4 4	5	4(7)		
30.		3				
31.						
32.						
33.		4(10)			5 4 (10)	X
34.		4+				X
35.			4(2)	8	2	

Case No.	EXTRA PERITONEAL	MORE SOLID ORGANS	SMALL INTESTINE	LARGE INTESTINE	MISC.	FATAL
5.		Diaphragm Liver Stomach Spleen Kidneys Bladder- ureter Gallbladder Pancreas	Duodenum Duodenal Mesentery Jejunum Jejunum Mesentery Ileum Ileum Mesentery S.I. Injury S.I. Injury Unspecified S.I. Mesentery Injury Appendix	Ascending Colon Ascending Colon Mesentery Descending Colon Mesentery Descending Colon Mesentery Transverse Colon Mesentery Transverse Colon Mesentery Caecum Caecal Mesentery Injury Unspecified L.I. Injury Unspecified L.I. Mesentery Injury	Arteries Retroperitoneal Unspecified Abdominal	
6.			5			
7.		4			7	
8.		2				
9.		4 4 1	4 4 4 1			
10.		4				
11.		1	5			
12.						
13.			4 4		7 2	
14.			4(6)			
D. UNSPECIFIED IMPACT						
1.						X
2.						X
3.						X
4.						X
5.						X
6.						X
7.		4 4	4 4 4 4 4	4 4 4 4 4 4 4	4 4	X
8.		4 4 4	4 4 4	4		X
9.		4 4 4	4 4 4 4 4			X
10.		4 4	4 4	4 4		X

Case No.	EXTRA PERITONEAL	MORE SOLID ORGANS	SMALL INTESTINE	LARGE INTESTINE	MISC.	FATAL
	Abdominal Muscles Abdominal Wall Diaphragm Liver Stomach Spleen Kidneys Bladder-ureter Gallbladder Pancreas	Jejunum Jejunum Duodenum Duodenum Jejunum Jejunum Duodenum Jejunum Ileum Ileum Intestines unspecified Small Intestine Injury Intestines unspecified Large Intestine Injury Intestines unspecified Large Intestine Injury Intestines unspecified Large Intestine Injury	Ascending Colon Ascending Colon Descending Colon Descending Colon Transverse Colon Transverse Colon Sigmoid Colon Sigmoid Colon Rectum Rectum Sigmoid Colon Transverse Colon Transverse Colon	Arteries Retroperitoneal Abdominal		
53.	4					
54.		3+				
55.	4					
56.	4	4	5			x
57.	4	4				
58.		4(7)				
59.		4(7)				
60.	4		4			
61.			4			
62.			4			
63.			4			
64.			4			x
65.	4(6)					
66.	4	4				
67.	4	4(2)				
68.		4				
69.				4		
70.			4			
71.	5(6)					
72.	4					
73.			4			

Case No.	EXTRA PERITONEAL	MORE SOLID ORGANS	SMALL INTESTINE	LARGE INTESTINE	MISC.	FATAL
95.	Abdominal Wall Abdominal Muscles Omentum	Diaphragm Liver Stomach Spleen Kidneys Bladder- ureter Gallbladder Pancreas	Duodenum Duodenal Mesentery Jejunum Jejunum Mesentery Ileum Ileum Mesentery Unspecified S.I. Injury Unspecified Mesentery Injury	Ascending Colon Ascending Colon Mesentery Descending Colon Descending Colon Mesentery Transverse Colon Transverse Colon Mesentery Sigmoid Colon Sigmoid Colon Mesentery Caecum Caecal Mesentery Unspecified L.I. Injury Unspecified L.I. Mesentery Injury	Arteries Retroperitoneal Unspecified Abdominal	
96.		4				
97.		4(6)				
98.		4(6)				
99.		4(6)				
100.		4(6)				
101.		4(6)				
102.		4				x
103.		4(6)				
104.		4				
105.		4				x
106.					2	
107.		4(2)				
108.		4(7)				
109.		4(2)				
110.		4(6)				
111.		4(6)				
112.		4(6) 4				
113.		4(6)				
114.		4(6)				x
115.		4(7)				

Case No.	EXTRA PERITONEAL	MORE SOLID ORGANS	SMALL INTESTINE	LARGE INTESTINE	MISC.	FATAL
116.	Abdominal Wall Abdominal Muscles Omentum	Diaphragm Liver Stomach Spleen Kidneys Bladder- ureter Gallbladder Pancreas	Bladder Jejunum Jejunum Jejunum Duodenal Mesentery Duodenal Mesentery Ileal Mesentery Unspecified Mesentery S.I. Injury Unspecified S.I. Mesentery Injury	Ascending Colon Ascending Colon Mesentery Descending Colon Descending Colon Mesentery Transverse Colon Transverse Colon Mesentery Transverse Colon Sigmoid Colon Sigmoid Colon Mesentery Caecum Caecal Mesentery Unspecified L.I. Injury Unspecified L.I. Injury Mesentery Injury	Arteries Retroperitoneal Unspecified Abdominal	
117.		4(2)				
118.						
119.						
120.		4(7)				
121.		3				
122.		4				X
123.		4(7)				
124.		4(6)				
125.		5(6)				
126.		4				
127.		X X X				
128.		X				
129.						X X
130.		4				
131.		4				
132.		4				
133.		4				
134.		4(6)				
135.		4(6)				
136.		4+				

Case No.	EXTRA PERITONEAL	MORE SOLID ORGANS	SMALL INTESTINE	LARGE INTESTINE	MISC.	FATAL
158.	Abdominal Wall Abdominal Muscles Omentum	Diaphragm Liver Stomach Spleen Kidneys Bladder- ureter Gallbladder Pancreas	Duodenum Duodenal Mesentery Jejunum Jejunat Mesentery Ileum Ileal Mesentery Unspecified S.I. Injury Unspecified Mesentery Injury	Ascending Colon Ascending Colon Mesentery Descending Colon Descending Colon Mesentery Transverse Colon Transverse Colon Mesentery Sigmoid Colon Sigmoid Colon Mesentery Caecum Caecal Mesentery Unspecified L.I. Injury Unspecified L.I. Mesentery Injury	Arteries Retroperitoneal Unspecified Abdominal	
159.						
160.		Liver Stomach Spleen Kidneys 4				
161.		4(6)				
162.		4(6)				
163.		4				X
164.		4				
165.		4(6)				
166.		4				X
167.		4				
168.		4				
169.						
170.		4				
171.		4				
172.		4				
173.		4				
174.		4				
175.		4				X
176.		4				X
177.		4				
178.		5				

Case No.	EXTRA PERITONEAL		MORE SOLID ORGANS								SMALL INTESTINE							LARGE INTESTINE											MISC.		FATAL										
	Abdominal Wall	Abdominal Muscles	Diaphragm	Liver	Stomach	Spleen	Kidneys	Bladder-ureter	Gallbladder	Pancreas	Duodenum	Duodenal Mesentery	Jejunum	Jejunum Mesentery	Ileum	Ileal Mesentery	Unspecified S.I. injury	Unspecified S.I. Mesentery Injury	Appendix	Ascending Colon	Ascending Colon Mesentery	Descending Colon	Descending Colon Mesentery	Transverse Colon	Transverse Colon Mesentery	Sigmoid Colon	Sigmoid Colon Mesentery	Caecum	Caecal Mesentery	Unspecified L.I. Injury		Unspecified L.I. Mesentery Injury	Arteries	Retroperitoneal	Unspecified Abdominal						
179.			4(7)																																						
180.			4																																						X
181.																																								X	
182.																																								X	
183.																																								X	
184.																																								X	
185.																																								X	
186.																																							X		
187.																																							X		
188.																																							X		
189.																																							X		
190.																																							X		
191.																																							X		
192.																																							X		
193.																																							X		
194.																																							X		
195.																																							X		
196.																																							X		
197.																																							X		
198.																																							X		
199.																																							X		

7

Case No.	EXTRA PERITONEAL	MORE SOLID ORGANS	SMALL INTESTINE	LARGE INTESTINE	MISC.	FATAL
285.	Diaphragm	Liver		Ascending Colon Ascending Colon Ascending Colon Transverse Colon Transverse Colon Transverse Colon Sigmoid Colon Sigmoid Colon Caecum Caecal Mesentery Unspecified L.I. Injury Unspecified L.I. Injury	Arteries	
286.					7(2)	
287.		Bladder-Urter			2	X
288.		4(2)				X
289.			4+ 4+			
290.					5	
291.						
292.	Diaphragm					
293.						
294.						
295.						X
296.					2	
297.						
298.						
299.						
300.						
301.						
302.						
303.					7	X
304.						
305.						

	SEAT BELT				DETAILED OCCUPANT KINEMATICS							BICYCLE ACCIDENT					UNSPECIFIED IMPACT					NO. OF INJURIES	
	Lap Belt	Diagonal 2 Pt.	Diagonal Lap Belt	Unspecified Seat Belt	Steering Wheel	Pedestrian	Dashboard Impact	Armrest - Door Impact	Rear Seat	Front Seat	Misc.	Bicycle - Auto	Fall onto Handbars	Misc.	Motorcycle Accidents	Ejections	Blunt Compression Trauma	Area of Injury	Seat Position	Semi-Deflated	Unspecified		Misc. B.A.T.
ASCENDING COLON	1	0	1	0	4	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	4	0	13
ASCENDING COLON MESENTERY	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	6
DESCENDING COLON	0	0	0	0	0	3	0	0	0	1	0	0	0	0	0	2	1	0	0	0	0	0	7
DESCENDING COLON MESENTERY	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
TRANSVERSE COLON	0	0	0	0	2	4	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	8
TRANSVERSE COLON MESENTERY	2	0	1	0	11	2	0	0	0	0	0	1	0	1	1	0	0	0	1	1	1	0	22
SIGMOID COLON	11	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	0	15
SIGMOID COLON MESENTERY	10	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	1	0	0	1	0	0	15
CAECUM	4	0	1	0	1	3	0	0	0	0	0	0	0	0	1	0	1	0	0	2	0	0	13
CAECAL MESENTERY	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
UNSPECIFIED L.I. INJURY	3	0	0	0	3	6	0	1	0	1	1	0	0	0	0	0	0	0	0	0	5	0	20
UNSPECIFIED L.I. MESENTERY INJURY	1	0	0	0	2	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	5
ARTERIES	11	4	2	0	16	19	0	0	0	6	0	1	0	2	13	7	5	0	1	27	0	0	114
RETROPERITONEAL UNSPECIFIED ABDOMINAL	4	0	1	1	11	25	0	1	0	3	1	0	3	4	5	7	0	1	1	21	4	0	93
	5	1	0	0	4	12	1	0	0	1	2	0	1	0	2	0	2	3	0	11	0	0	45
NO. INJURIES	277	24	28	16	290	454	16	32	10	92	26	65	26	86	108	78	33	45	29	664	25	0	
NO. CASES	111	12	13	7	149	228	11	13	4	43	14	45	15	45	51	35	16	20	14	345	14	0	

3.3 SUMMARY AND CONCLUSIONS OF THE LITERATURE REVIEW

A summary of the data from 1,200 cases of abdominal injury is shown in Table XII. Each "X" represents a 10% frequency of injury to an individual organ from a particular cause. Most injuries with all causes included were to the liver, spleen, duodenum, pancreas and diaphragm in descending order of frequency. Considering specific causes, injury to the liver was common in every group, and the spleen was injured from everything except the steering wheel and bicycle handlebar. The lap belt produced injury to the lower small intestine - the jejunum, ileum and ileal mesentery - presumably because of the lower location of the impact. The higher part of the small intestine - the duodenum - was injured by the 3-point belt, the steering wheel, and the bicycle handlebar, and in motorcycle, ejection and compression accidents. Trauma to the pancreas resulted from steering wheel, pedestrian, bicycle-auto and bicycle-handlebar, motorcycle, and compression impacts. Injury to the kidney occurred in pedestrian, dashboard, armrest, and ejection induced trauma. The diaphragm was injured in the pedestrian, armrest, motorcycle, compression and unspecified groups. An injury pattern to the liver, spleen and duodenum was caused by the 3-point seat belt and motorcycle ejection accidents.

Definite trends are present in the injury patterns from 1,200 cases of abdominal trauma. Although the reason for such trends is not always clear, the most common reason seems to be simply a matter of anatomical location of specific abdominal organs in relation to the site of the impact. Most mid-abdominal impacts strike in the region of the liver which is very large and is most often injured. Lower lap belt injuries occur to the lower anatomical structures, the ileum and jejunum. The large intestine is rarely injured perhaps, partly because of the protection offered by the pelvic girdle. The spleen, pancreas, and duodenum are frequently injured and they too are located at prominent mid-abdominal sites. The major results of this extensive literature search are presented in Figure 1 showing the liver, spleen, duodenum and pancreas to be major sites of injury. Lap belt injuries are anatomically lower in the ileum and jejunum. The liver, spleen and duodenum are frequently injured together; this is true for impacts from the 3-point lap belt, motorcycle and ejection injuries.

This analysis of the literature deals exclusively with injury to specific abdominal organs because that is what was reported and available for our review. Yet it is very likely that the greatest number of deaths from accidents involving abdominal injury were more directly due to hemorrhage and respiratory problems. Hemorrhage is usually from an injured abdominal organ but the cause of death is not the injury itself, but circulatory shock from the loss of blood. The second major cause of death is that of respiratory complications causing asphyxia. Such complications result from abdominal injury alone or in conjunction with other injury. Such problems can be due to airway blockage or neurogenic lung stiffness making breathing difficult. Both such factors - hemorrhage and respiratory complications - occur immediately at the scene of an accident, often have fatal consequences, and deserve additional extensive investigation.

TABLE XII - SUMMARY INJURY PATTERNS

Based on 1,200 Cases*

Group	Liver	Spleen	Duodenum	Pancreas	Diaphragm	Kidney	Jejunum	Ileum	Ileal Mesentery
Lap Belt-I-A							X	X	X
2-Pt. Belt-I-B	XX	XX							
3-Pt. Belt-I-C	X	X	XXX				X		X
Steering Wheel-II	X		XXX	XX					
Pedestrian-III	X	X		X	X	X			
Dashboard-IV-A	XXX XXX	X				X			
Armrest-IV-B	X	XX			X	X			
Bicycle-Auto V-A	XX	XX		XX				X	
Bicycle-Handlebar-V-B	X		XX	XXX			XX		
Motorcycle-VI	XX	XX	X	X	X				
Ejection-VII	X	XX	X			X	X		
Compression-VIII	X		X	X	X		X		
Unspecified IX	X	XX		X	XX	X			
Misc.-X	XX	XX	X	X	X				

*Each "X" represents injury in 10% of the cases surveyed; organs not shown were found to be below this frequency level.

4.0 MECHANISMS OF INJURY - LITERATURE REVIEW

The two major causes of death from abdominal injury are: (1) hemorrhage from any highly vascular organ - liver, spleen, pancreas or the omentum, and (2) respiratory complications acting to reduce the air supply. Both of these effects of trauma are immediate threats to survival. While little can be done by ambulance emergency crews to treat internal hemorrhage, pulmonary problems can be reduced by the administration of positive pressure ventilation and by clearing the airway to lessen the likelihood of a respiratory death. Such effects - hemorrhage and respiratory complications - are usually additive to the effects of other injuries which result from a car crash. The other general categories of injury which are life-threatening if not diagnosed and treated include laceration or bursting of the gastro-intestinal tract; severe pancreatic trauma; and laceration of the gallbladder or any other structure where injury to the organ itself impairs function or allows the contents of such an organ to spill into the abdominal cavity, permitting a secondary infection to develop. While the latter category of injuries may result in delayed complications, surgical treatment is often effective. Surprisingly, however, the literature has little to say about the first two categories; the emphasis is extensively on injuries to specific organs. The reasons are clear - most clinical reports are based on autopsies or surgical repair procedures. Both tend to emphasize the lesions to specific abdominal organs which are evident in this kind of postmortem or surgical examination. Thus this literature review necessarily will deal mostly with injury to specific organs but will include a special section devoted to hemorrhage and respiratory problems.

4.1 INJURY TO THE PANCREAS

Sudden high velocity blunt impact to the abdomen results in rapid movement of the mobile abdominal viscera from the high pressure center of impact to the relatively low pressure peripheral areas. The majority of pancreatic injuries are apparently due to blunt trauma usually from the steering wheel (Thal and Wilson, 1964), with some others from bicycle accidents. A common mechanism was suggested for such traumatic injury. The head and body of the pancreas and the second portion of the duodenum are firmly fixed to the posterior parietal wall; while the liver, protected by

the lower rib cage, is abruptly displaced upward and the hepatic flexure of the colon downward. With the liver and the colon traveling in opposite directions away from the pancreas and duodenum, there is a tendency toward rupture of the common bile duct and gastro-duodenal artery, and horizontal tearing across the transverse mesocolon with injury to the middle colic vessels. The impact over the body of the pancreas and the tension to the superior mesenteric vein results in separation of the tissue plane between the body of the pancreas and the superior mesenteric vein.

The symptoms and signs are related to the crushing trauma inflicted on the head of the pancreas and to the shearing effect on blood vessels and the biliary tract as the liver and colon are pushed cephalad and caudad respectively. Surgery is required for adequate repair. While some of the literature suggests that pancreatic injuries are not very common, extensive damage frequently has been reported to result from steering wheel impact (Thal and Wilson, 1964). Our own experimental work cited in this report suggests that such injuries may result from any high abdominal impact such as might be produced by a seat belt or steering wheel. Additional evidence is presented in the specific literature review section.

4.2 GENERAL MECHANISM OF INJURY TO THE SMALL BOWEL

Injury to the small bowel may be caused by:

- (1) Crushing of the small bowel between the anterior abdominal wall as it is forced inwards and the vertebral column, ribs or pelvic bone.
- (2) Tearing from an obliquely applied force with the result that the bowel is torn loose from its attachments to the posterior abdominal wall or mesentery.
- (3) Compression causing bursting of the bowel as a result of a sudden force applied to a gas or fluid-filled loop of the bowel.
- (4) Deceleration suddenly may result in shearing and tearing as the bowel moves relative to the body.
- (5) Blunt force may rupture a major vessel in the mesentery or cause a hematoma within the mesentery which infarcts the overlying bowel. (Cantor, 1970).

The term "whiplash abdominal injury" has been used recently (Berardi, 1969)

to refer to injuries to the small intestine resulting from shearing forces which develop during sudden deceleration. The small intestine is relatively viable being attached to the mesentery. The vessels and particularly the arteries in the mesentery, however, impart to it a certain "stiffness" which resists sudden deformation. According to Berardi, because of the torturous route of the intestine, a whip-like motion can be given to the mesentery which may rupture certain of the vessels. Presumably the force of the impact or deceleration would influence the degree of vascular rupture and extent of subsequent hemorrhage or gastro-intestinal complications. The main characteristic of such a "whiplash abdominal injury" is given as no direct contact with the abdominal wall. Such an explanation seems possible to me but unlikely in the laboratory where the impactor strikes and deeply penetrates the abdominal wall. We found no mesenteric injury except directly under or adjacent to the point of impact. However, this would not entirely rule out some whiplash effect.

4.3 DUODENUM

Duodenal rupture in blunt abdominal trauma is a severe injury unless adequately diagnosed and surgically treated. Only approximately 5% of patients operated upon for blunt abdominal trauma have a duodenal injury (Roman, et al., 1971). Although this makes such an injury seem unusual when all types of car crash injuries are considered, our own literature review shows that steering wheel impact frequently does cause injury to the duodenum. The duodenum lies in the depth of the peritoneal cavity protected by the liver, lower rib cage and vertebral column. This anatomic advantage does not, however, offer complete protection.

The mechanism of duodenal injury may be threefold (Roman, et al., 1971). First, the anterior abdominal wall is pushed posteriorly to the spine. The second or third portions of the duodenum may be thrust to the right in continuity with the head of the pancreas while the first or fourth portions move to the left with the stomach or proximal duodenum. Second, intraluminal pressure may become suddenly increased as the pylorus and ligament of Trietz become occluded forming a closed loop with resultant blowout. Such a mechanism was considered unlikely by Roman et al. (1971) in light of experimental tests using dogs where blowouts induced by injection of saline solution or

air were quite different from those found clinically. Such tests produced pin-point perforations at the proximal or distal level of the duodenum in contrast to clinical injuries which were transverse lacerations of 50% or more of the duodenum. Third, the impact may create a tearing or shearing force at the site of a junction between fixed and mobile parts of the duodenum. The third possibility seems most likely in lieu of the transverse tears observed clinically. It should perhaps be noted here that in our own laboratory experiments no duodenal injury aside from minor contusions of the wall was found. The possibility exists, of course, that such a contused area could over a period of days develop into a small perforation.

Another type of injury observed clinically some time after blunt abdominal injury is that of an intramural hematoma. A hematoma in the wall of the duodenum may slowly expand and partially or totally occlude the lumen producing effective obstruction (Freak, et al., 1966). Such damage may not be apparent shortly after injury, even at autopsy, because such a hematoma may develop slowly.

4.4 COLON

Injuries to the colon rarely result from non-penetrating trauma (Kennedy, 1960). In our laboratory work, occasionally there was evidence of minor contusion to the wall of the large intestine. Tears may develop which can eventually result in perforation.

4.5 URETER AND BLADDER

Injury of the ureter and bladder from blunt abdominal trauma is rare. Rupture of the bladder is frequently associated with pelvic fractures which do not fall directly into the area of abdominal impact.

4.6 ABDOMINAL WALL INJURIES

The abdominal wall is usually the direct site of impact in such traumatic injuries. The rectus muscles and blood vessels in the wall may be injured as a result of being struck by the impacting object, especially if clothing is light and the object unpadded. Seat belts can also produce abrasions to the abdominal cavity as can the steering wheel if the victim moves vertically

during the deceleration. While the primary symptom is pain, pulmonary complications can occur as a result of sympathetic nerve stimulation which is of consequence when combined with other injuries. Our laboratory tests showed little evidence of such injury to the wall of the abdomen.

4.7 LIVER

The mortality in non-penetrating wounds to the liver is high if the effects of hemorrhage alone are included in such estimates. A 40-60% mortality rate has been estimated by Hellstrom (1966). However, over half of these cases were dead on admission suggesting that hemorrhage or blood loss into the abdominal cavity with subsequent shock was an even greater cause of death.

In addition to hemorrhage into the abdominal cavity, a number of other results of blunt trauma to the liver were cited by Hellstrom (1966) and serve to point out that the mechanisms of liver injury do not only involve the liver itself. The central nervous system may be involved in blunt abdominal impact in the region of the liver. Compression of the lower thorax or upper part of the abdomen may result in traumatic asphyxia (Moritz, 1954), a condition characterized by petechiae, mainly on the face, combined with intraocular hemorrhages. According to Moritz, this is due to rapid displacement of blood from the right atrium and valveless superior vena cava. Intracranial hemorrhage was also a frequent result of blunt trauma to the liver. The occurrence of cerebral microaneurysms may be an additional consequence of such rapid shifts of blood towards the head. Such disturbances in cerebral circulation often occurred with traumatic asphyxia which suggests centrally induced pulmonary complications of nervous origin. While Hellstrom (1966) suggests a vagal mechanism, recent work by (Beckman et al. 1971) demonstrates a sympathetic influence to be a more likely causal mechanism.

Cardiac lesions in the absence of direct trauma may occur either as a result of sudden displacement of the heart or by a sudden increase of intra-cardiac pressure. Rupture of the right heart may occur as a result of cranial ventricle displacement of the heart and a sudden increase in pressure resulting from blunt impact to the liver. Bright and Beck (1933) showed in dog experiments that acute cardiac dilatation occurred on sudden compression of the lower half of the body. The major finding was that of epicardial hemorrhage.

Circulatory failure also may result from myocardial ischemia induced during the shock phase, most likely by a neurogenic mechanism (Beckman et al., 1971). Another cause of reduced myocardial function may be post-traumatic blood cell aggregation. Although such effects are often delayed at least for a few hours after the injury, it may be assumed that myocardial function is reduced after trauma to the liver. Our own experimental work demonstrated marked ECG changes after such injury which are indications of at least temporary cardiac impairment.

Aortic rupture occurs clinically in 35% of the cases of liver rupture (Hellstrom, 1966). Such aortic rupture was not found, however, in our own laboratory work, perhaps because the forces involved were excessively high. Two factors predominate in the literature to explain the mechanisms of aortic rupture:

1. Stretching of the aorta, in a cranial direction, as a result of a direct decelerative forces (Hass, 1944); (McKnight et al, 1964).
2. A sudden increase in the aortic blood pressure (Oppenheim, 1918; Gable and Townsen, 1963).
3. A combination of these (Thorin, 1958; Moritz, 1954; Lundevall, 1964). The third possibly seems most likely, with stretching of the aortic wall making a pressure blowout more likely to occur.

While pathogenesis of pulmonary changes will be considered as a separate topic, its relation to blunt injury to the liver will be considered here. Pulmonary hemorrhage which easily can be detected at autopsy may result from a direct blow to the lower thorax or upper abdominal region or from an increase in pulmonary vascular pressures resulting in extravasation of blood (Hass, 1944; Beckman and Bean, 1970). It perhaps may be assumed that the sudden rise in pressure which was shown by Bright (1934) to occur in the right heart in association with abdominal injury may propagate into the lungs and give rise to capillary ruptures. The recent work of Beckman et al. (1971) suggests an additional neurogenic mechanism for such lung changes. The sympathetic nervous system, which is most likely stimulated during abdominal impact (also found occur during mechanical head injury, Beckman and Bean, 1969), was shown to directly alter the surface lining of the alveoli of the lung which in turn results in the development of a "wet lung" with decreased compliance.

Liver lesions resulting from blunt trauma may be divided into the following groups (Sandblom, 1948).

1. Ruptures through the capsule and the parenchyma
2. Subcapsular lesions
 - (a) Subcapsular hematoma
 - (b) Subcapsular rupture
 - (c) Central rupture

Central ruptures are considered to be as common clinically as capsular ruptures (Sandblom, 1948). Because of their location in the interior of the liver they do not give rise to hemorrhage and bile leakage into the peritoneal cavity and as a result, many such internal injuries apparently go undiagnosed. While some ruptures heal others cause abscesses with future complications.

Fatality following blunt trauma to the liver is most likely due to one or a combination of the following:

1. Direct damage to the liver
2. Hemorrhage
3. Pulmonary complications
4. Disturbance in the physical properties of blood
5. Shock (induced neurogenically or due to blood loss)
6. Disturbance of cardiac rhythm

It is concluded that the mechanisms of injury from blunt trauma to the liver involve many factors but that the prominent ones are: (1) rupture of the liver, (2) hemorrhage, and (3) pulmonary complications. The latter two especially deserve additional emphasis and investigation.

4.8 GALL BLADDER

Rupture of the gall bladder from blunt trauma is rare (Kennedy, 1960), and therefore will not be given special consideration as to possible injury mechanisms.

4.9 KIDNEY

The kidneys are protected from injury by the lower ribs, the spine, the lumbar muscles and the abdominal viscera. The incidence of serious injury to

the kidney from blunt trauma is not high (Kennedy, 1960) but still many cases have been cited in the literature. The effects of trauma are usually direct by hydraulic compression, although occasionally they are indirect. In most cases of renal injury, the impact is over the kidney anteriorly, posteriorly or laterally. The most common injury from blunt trauma is to the surface or perinephric fat involving hemorrhage and the possible development of calcification or a cyst. Injury to the kidney itself may in the form of contusion show (very common in our own laboratory experiments), laceration, or a combination of the two. Lacerations are mostly on the surface, but occasionally are very deep. Most lesions heal spontaneously without serious after-effects (Kennedy, 1960).

4.10 SPLEEN

Rupture of the spleen from blunt abdominal impact reportedly is fairly common and can be very serious when it does occur because of rapid excessive blood loss. While in our own experimental work lacerations to the tip of the spleen were often found on postmortem examination, such effects may be partly artefactual having been caused by the edge of the impactor or sled. Rupture or laceration is due primarily to direct trauma to the spleen. Our literature review indicates that injury to the spleen is a common consequence of pedestrian accidents, ejection, and motorcycle injuries and from impacts involving a car occupant striking a dashboard or armrest. The lap belt also is an occasional cause of injury to the spleen.

5.0 EXPERIMENTAL STUDIES OF ABDOMINAL TRAUMA

5.1 INTRODUCTION

The literature review indicates that the most frequent causes of blunt abdominal injury were the steering wheel and the lap belt; the organs most often injured were the liver, pancreas, spleen, and intestines. Based on this information a series of animal abdominal impacts were designed to study the relationship between shape and type of impactor, velocity of impact, body region impacted and injury level.

The (Cercopithecus pygerythrus) vervet monkey was chosen as the primary test animal for this study. The monkey has been found to be a very good research animal for abdominal studies because of its great similarities to man. The second animal used in this study was the (Sus scrofa) mini-pig. His torso weight can be made comparable to man's, thus allowing more realistic impact forces for scaling to man.

Fifty-three animals were exposed to controlled abdominal impacts for quantitative determination of input versus occurrence of trauma. Three of the most probable causes of abdominal trauma were selected as the steering wheel which was represented by a metal plate for controlled test purposes, the seat belt which was scaled to the general size of the animals tested, and various objects such as the armrest, gear shift, etc. represented by a round rigid impactor. Vervet monkeys were exposed to each of these impactors and 15 pigs to the round impactor.

5.2 TEST METHODS

5.2.1 Vervet Monkey Front Abdominal Impacts. The test animals were housed in the Biomedical Laboratory's vivarium of the Highway Safety Research Institute for a minimum of two days. During this time the animals were examined and their physical condition recorded. This pre-impact physical was then compared to the post-impact physical and used in evaluating the extent of injury.

The animal to be tested was anesthetized with 30 mg/kg of ketalar [d1 2-(0-chlorephenyl)-2-(methylamino) cyclohexanone Hydrochloride]. This drug

is a rapid-acting general anesthetic producing an anesthetic state characterized by profound analgesia, normal pharyngeal-laryngeal reflexes and normal or slightly enhanced skeletal muscle tone. With this drug the post-impact state of consciousness can be determined. The good muscle tone provided by this drug made the test conditions more realistic and representative of the responses of the alert animal.

After the animal is fully anesthetized, he is shaved and targeted for high speed photographic analysis. The animal was then taken to the impact room where EKG, respiratory rate and reflex state were recorded. A complete set of anthropometric measurements were then made of each test animal. The test animal was seated on a bench type seat and supported by surgical thread through the ears. This method of support makes the animal essentially a free body. It was found to provide reproducible results and eliminated the complicated boundary conditions of a seat or sling.

All impacts were carried out by a pneumatically operated testing machine especially constructed for impact studies (Figure 1). The machine consists of an air reservoir, and a ground and honed cylinder with two carefully fitted pistons. One, the transfer piston, is propelled by compressed air through the cylinder and transfers its momentum to the impact piston. A striker plate, attached to the impact piston, travels a distance of about four inches, when an inversion tube absorbs the energy of the impact piston and halts its movement. The stroke of the impactor was controlled by its initial positioning and its velocity was controlled by the reservoir pressure. The impactor was instrumented with an accelerometer and an inertia compensated force transducer. High speed motion pictures at 5000 fps were taken for photographic analysis (Figure 2).

5.2.1.1 Sled Test with Lap Belt and Air Bag. Four sled tests were conducted using the HSRI small high velocity sled facility. This facility is capable of powering a 25 pound sled to a velocity of 60 mph. High speed motion pictures (up to 10,000 frames per second) are synchronized with the sled's motion to obtain the test animal's body kinematics. Sled acceleration and belt loads were recorded on an oscilloscope (Figure 3).

The test animal was belted to the sled by a one inch nylon seat belt pulled tight over the Eminentia Ilipectinea (Figure 4). The belt was varied from this position up to the iliac crest, in a series of four sled runs.

With the use of lap belts the animal is slammed onto the floor or some stopping surface in front of him under the sled deceleration. As a result of this secondary collision injuries not associated with the belts have been reported by researchers. To avoid this problem a small preinflated air bag was positioned in front of the test animal. This air bag was equipped with an adjustable pressure relief valve so a precise ride down of the sled could be obtained (Figure 5).

5.2.1.2 Abdominal Impacts. The body impacts were carried out with two types of impactors. The first was a rigid impactor weighing 22 pounds consisting of three different contacting surfaces. Each contacting surface was 8 inches long (this was to insure total body contact) and 1/2, 1 and 2 inches in width respectively (Figure 6).

The second type impactor consisted of a belt stretched between two supports (Figure 7). Three different size belts were used: 1/2, 1 and 2 inches for comparison with the rigid impactor tests.

Contacting force and pulse duration was recorded on an oscilloscope. Impactor velocity was determined from the high speed movie analysis. The animals were positioned to limit the depth of penetration to approximately 50% body width, and a one-foot thick soft foam pad was arranged to prevent injury after impact.

There were three impact locations on the midline of the body. The first was midway between the base of xiphoid process and the transpyloric plane approximately 20% down from the base of the xiphoid process to the iliac crests. The second impact location was midway between the transpyloric plane and the transtuberular plane approximately 53% down from the base of the xiphoid process to the iliac crests. The third impact location was in the transtuberular plane approximately 81% down from the base of the xiphoid process to the iliac crests. These percentages mark the center contact point for each impact test.

The animal was impacted at one of the predetermined impact points and the injury evaluated. If the injury was not serious, then the next animal was impacted at the same location but at a higher velocity. This procedure was continued for each impact location and each impactor (Figure 8 and 9).

5.2.2 Mini-Pig Front Abdominal Impact. The mini-pig front abdominal impacts were carried out using a single impactor. This impactor weighed 30 pounds and has a 3 inch diameter circular impacting surface. The pigs were supported by a rope around the back and under the front legs, again making the animal essentially a free body. The impactors depth of penetration was preset at approximately 3 inches.

Three impact locations were located on the right and left midclavicular lines. Each of these impact locations were 15%, 30% and 45% respectively down from the base of the xiphoid process to the iliac crests. The same instrumentation used in the monkey test set-up was used in the mini-pig test.

5.2.3 Biomedical Data Collection. Gross autopsy was conducted in the Autopsy Laboratory, especially equipped for dissection. Autopsies were conducted as a blind study, according to accepted research procedure, with the investigator conducting the gross autopsy having no knowledge of physical data on the intensity, location of impact, or circumstances of each test. Careful anatomical dissection of the head, face and neck tissues, where head impacts occurred allowed discrete identification of many sites of vascular failure. When gross trauma was found it was photographically recorded using a specially modified Pentax camera with close-up lens, either in situ or as an isolated entity to provide a permanent record of the injury. Tissues were saved from all major organs for further histopathologic examination. A typical copy of the autopsy report form used for each subject is included in Appendix A. Weights of major organs were obtained, including the heart, brain, lungs, liver, spleen, pancreas, adrenals, and kidneys. Each autopsy report includes gross and microscopic pathology, anthropometry, pre- and post-impact radiographs, color photographic documentation of dissections, injuries and the animal test preparation. Isoenzyme determinations in the case of larger primates were also made. Included are all background information relative to the history, case, and any medication of the particular subject.

It should be noted that no animal carcass was destroyed post-autopsy without making an effort to more fully utilize the remains within the Medical School community. In this connection, some 12 departments received carcass materials which were of direct benefit to other medical research studies in progress. Some examples included the testis which were used by

the Department of Gynecology and Obstetrics for hormone studies, thighs by the Department of Surgery for fascia graft experiments, and other 'discarded' materials were received by the Human Growth Center, Department of Anatomy, Department of Ophthalmology, Department of Otorhinolaryngology, Department of Pathology, Kresge Hearing Research Institute, Department of Anthropology, University of Michigan Museum, and hands and feet were used for a study of dermatoglyphics by the School of Public Health investigators. Thus, the animal subjects were optimally utilized in respect to all animal utilization codes of ethics.

Tissue specimens were prepared in the HSRI Histology Laboratory for microscopic examination. Fixed in a solution of formalin, the specimens were dehydrated with alcohol, cleaned, infiltrated and finally imbedded in paraffin. The paraffin blocks were placed in the microtome and tissues were sectioned at a thickness of 5 microns, using an AO Spencer 820 microtome and mounted on a glass slide. Various stains were used, but in the case of brain tissue some slides for each subject were prepared with Gallocyamin stain for Nissl substance, since early dissolution of Nissl substance has been found to occur subsequent to nerve cell injury.

Microscopic examination and study of the tissue preparations was accomplished with an AO Spencer Series 10 microscope using 4X, 10X and 45X objectives with trinocular body, which permits the use of a Pentax H/A camera for microphotography. Histopathology was evaluated by specialists from the University School of Medicine. These included Dr. Thomas Johnson, Dr. Paul Gikas, Dr. Thomas Sodeman from the Department of Pathology, and Dr. Gary Boorman from the Unit for Laboratory Animal Care. As a further check on interpretation, selected brain tissues were submitted for evaluation by two additional pathologists experienced in infra-human brain pathology, Dr. Weatherbee, Chief of the U.S. Veteran's Hospital Pathology Department at Ann Arbor, and Dr. G.T. Price, pathology consultant. A difference in brain histopathology observations as well as interpretation is not unusual among pathologists, and the submission of critical tissue specimens to more than one pathologist without the knowledge of the other was intended as a check to decrease the chances of missing any pertinent pathology, as well as alert us to any specific cases where there might be a difference of opinion as to pathological interpretation. A similar procedure was also followed in

the final interpretation of injury severity related to both gross and microscopic findings, with separate ratings made by two researchers experienced in infra-human primate injury investigations. Interpretations and scoring was consistently within 1/2 scaling point, giving considerable confidence to our final scaling design. The following is the 5-point injury scale used to rate the injury of all test animals.

1. No injury - minor injury.
2. Recoverable injuries (these may be severe, but non-dangerous to life).
3. Marginal as to whether injury is irreversible (i.e., results in permanent disability of function or structure).
4. Serious injury, non-reversible, probably not survivable.
5. Fatal trauma.

5.3 RESULTS

5.3.1 Results of Vervet Monkey Abdominal Impacts. The results of the vervet monkey abdominal impact tests are given in Table XIII. The force/area column in this table was determined by dividing the peak impact force by the area of the impactor in contact with the animal. The contacting area for the rigid impactor was found by multiplying the impactor's width by the diameter of the test animal at the point of impact, while the contacting area for the flexible impactor was based on the half circumference of the test animal at the contact location.

The injuries seen in these impact tests were quite similar to those seen clinically in automobile accidents.

The injuries associated with the rigid impactor were quite similar to steering wheel rim injuries. The liver, spleen, and pancreas were generally involved in this type of impact (Figure 11).

The injuries observed in the flexible impactor experiments were very similar to lap belt injuries described in the literature. These injuries were generally to the liver, stomach, jejunum, and ileum. All of these observed injuries involved tears or ruptures of the organs involved (Figure 12). Three impact areas were established. These were the upper abdomen which was centered 20% of the distance from the base of the xiphoid process to the iliac crests, the midabdomen which was centered midway between the

xiphoid process and the iliac crests and the lower abdomen which was centered 81% of the distance between the xiphoid process and the iliac crests.

There was little difference between the results obtained with the flexible impacts and the rigid impactor. This was probably due to the very low stiffness of the abdominal region. The impactor stiffness would have to be of the same order of magnitude before any significant influences would occur.

The average pressures varied over a wide range for both location and velocity. It must be recognized that this was a pilot study of experimental abdominal impact and many more species of animals must be studied before sufficient data is available to develop scaling relationships that would allow extrapolation to man. However the results indicate that the vervet monkey (Cercopithecus pygerythrus) can survive (injury level of 3) blunt impacts to the upper abdomen with the various impactors used at velocities up to 22 mph, while in the midabdomen it can survive impacts of this type of approximately 26 mph and in the lower abdomen of 34 mph.

5.3.2. Sled Tests Vervet Monkey. Four sled tests were performed with the animal seated in a scaled chair and lap belted. Sled pulses ranged from 20 to 40 g's with durations from 100 to 120 milliseconds. The sled pulse used had a very carefully arranged square profile. No serious injuries were observed. Belt load cell indicated peak forces of from 340 to 490 pounds resulting in average lap belt bearing pressures of from 68 to 115 psi.

Although plans have been made to extend the capacity of this sled, at the time of this writing the maximum pulse capability was 40 g's for 120 milliseconds. Injury levels of 1 and 2 were observed indicating that this primate can withstand at least this level of loading provided the head is well protected.

5.3.3 Results of Mini-Pig Abdominal Impacts. The results of the mini-pig impact experiments are presented in Table XIV. The force/area column was determined as described above.

The injuries seen in this study were very localized. Clinically these injuries resembled injuries received from blunt objects in the car, for example, the gear shift lever (Figure 13). The mini-pig proved to be an

excellent animal for the study of localized blunt trauma to the abdomen. The mini-pig's abdomen is anatomically and anthropometrically quite similar to mans so that little if any scaling considerations are required. The liver was the organ most frequently involved (Table XIV). The liver could be ruptured with blows from the 1 1/2 radius impactor applied in any of the abdominal regions. The velocity of the impactor and the depth of penetration were the two most critical input parameters. The method of suspension of the animal significantly effected the depth of penetration. More work must be performed before a correlation of impactor area, impactor velocity, abdominal location and depth of penetration can be accomplished. Preliminary correlation analysis indicate that approximately 30 more animals would provide a statistically acceptable data base for these correlations.

TABLE XIII.
TEST DATA

	RUN NO.	BODY WEIGHT (kg)	IMPACT LOCATION*	VELOCITY (MPH)	PEAK CONTACT FORCE (LBS.)	FORCE/AREA (LB/SQ. IN.)	IMPACT DURATION (msec)	SCALING INDEX NO**
A. Flexible 6" X 1/2" (Vervet)	71-22 ab	3.1	Upper Abdomen	20.2	376	223.2	5.0	3
	71-19 ab	2.7	Upper Abdomen	(25.0)	LOD†	LOD†	LOD	2
	71-20 ab	2.9	Upper Abdomen	25.8	408	262	6.6	2
	71-23 ab	2.3	Mid Abdomen	17.6	204	225.6	4.8	3
	71-21 ab	3.4	Mid Abdomen	26.2	380	268	4.4	3
	71-24 ab	2.9	Lower Abdomen	23.4	266	236	6.0	1
	71-34 ab	3.2	Lower Abdomen	34.2	430	340	5.6	3
B. Flexible 6" X 1" (Vervet)	71-27 ab	3.8	Upper Abdomen	20.7	260	71.8	10.4	2
	71-26 ab	3.2	Upper Abdomen	22.9	304	88.8	8.4	2
	71-28 ab	1.9	Mid Abdomen	24.0	254	101.2	10.0	2
	71-25 ab	2.3	Lower Abdomen	22.8	364	172	8.6	1
C. Flexible 6" X 2" (Vervet)	71-29 ab	3.7	Upper Abdomen	17.9	186	27.4	7.4	1
	71-31 ab	3.4	Upper Abdomen	25.6	354	50.4	9.2	4
	71-30 ab	3.5	Mid Abdomen	20.0	166	26.4	9.4	1
	71-33 ab	1.9	Mid Abdomen	24.2	220	45.6	5.6	4
	71-32 ab	3.4	Lower Abdomen	26.8	354	67.6	9.4	1
D. Rigid 8" X 1/2" (Vervet)	71-06 ab	3.1	Upper Abdomen	27.5	450	260.0	9.4	3
	71-07 ab	3.8	Mid Abdomen	25.4	320	206.0	10.6	2
	71-05 ab	3.6	Lower Abdomen	32.5	282	200.0	6.4	1
	71-36 ab	3.3	Lower Abdomen	34.8	525	400.0	7.6	3
E. Rigid 8" X 1" (Vervet)	71-18 ab	3.4	Upper Abdomen	20.5	170	53.4	11.6	3
	71-15 ab	2.7	Upper Abdomen	21.8	133	42.5	7.2	2
	71-13 ab	4.3	Upper Abdomen	22.0	300	81.0	11.4	3
	71-14 ab	4.3	Mid Abdomen	18.8	116	40.6	7.6	1
	71-12 ab	3.6	Mid Abdomen	28.2	431	133.0	11.2	4
	71-11 ab	3.8	Lower Abdomen	27.0	506	176.0	11.2	1
F. Rigid 8" X 2" (Vervet)	71-17 ab	2.4	Upper Abdomen	21.2	190	29.8	13.0	3
	71-10 ab	5.2	Upper Abdomen	25.0	225	29.0	7.2	4
	71-16 ab	3.6	Mid Abdomen	19.6	280	44.8	12.6	1
	71-09 ab	4.6	Mid Abdomen	28.3	413	61.5	10.0	3
	71-08 ab	3.3	Lower Abdomen	27.4	489	93.5	9.4	1
	71-35 ab	3.6	Lower Abdomen	35.1	450	88.0	8.0	3
	G. Rigid 1-1/2" Radius (Mini-Pig)	71-46 ab	65	Upper Rt. Abdomen	23.8	650	92.0	11.0
71-38 ab		53	Upper Rt. Abdomen	29.2	600	85.0	LOD†	2
71-51 ab		47	Mid Rt. Abdomen	20.5	600	85.0	16.0	3
71-48 ab		48	Mid Rt. Abdomen	23.4	LOD	LOD†	LOD†	1
71-47 ab		58	Mid Rt. Abdomen	27.6	700	99.2	17.5	5
71-42 ab		50	Mid Rt. Abdomen	30.0	550	77.8	9.5	2
71-53 ab		44	Lower Rt. Abdomen	31.0	850	120.0	14.5	3
71-41 ab		49	Lower Rt. Abdomen	32.0	700	99.3	11.0	3
71-45 ab		48	Upper Lf. Abdomen	24.3	600	85.0	11.5	2
71-39 ab		51	Upper Lf. Abdomen	37.8	650	92.0	10.5	2
71-40 ab		47	Mid Lf. Abdomen	23.7	600	85.0	11.0	5
71-50 ab		45	Mid Lf. Abdomen	30.8	850	120.0	10.0	4
71-49 ab		50	Lower Lf. Abdomen	28.6	LOD†	LOD†	LOD†	2
71-44 ab		43	Lower Lf. Abdomen	31.2	425	60.2	10.0	1
71-52 ab		51	Lower Lf. Abdomen	32.4	950	134.0	12.5	3
H. Seat Belt Sled (Vervet)	71-01 s	4.3	Lap	37.0	480	113.2	100.0	1
	71-03 s	4.6	Lap	44.5	490	115.6	104.0	1
	71-02 s	4.3	Lap	49.3	472	111.8	106.0	1
	71-04 s	4.5	Lap	48.5	340	68.	120.0	2
I. Rigid 1-1/2" Radius +1-1/2" Pad (Vervet)	71-43 ab	3.5	Upper Abdomen	28.6	250	35.3	8.0	3
	71-37 ab	2.6	Mid Abdomen	24.4	150	21.2	10.0	2

*Impact location: vervet - 20% (high); 53% (mid); 81% (low), down the midline from the base of xiphoid process to the iliac crests. Mini-Pig - 2-1/2" right or left of the midline; 3, 6 or 9 inches below the base of the xiphoid process.

**Injury scale 1 to 5: 1 = no injury to minor; 2 = recoverable; 3 = marginal recovery; 4 = severe; 5 = lethal.

†Loss of Data

TABLE XIV
INJURY PATTERNS FROM TESTS

	RUN NO.	FORCE/AREA (LBS/SQ. IN.)	SCALING INDEX*	MEMORRHAGE (cc)	RESPIRATION INDEX**	SPECIFIC ORGANS WITH INDEX*
1. Flexible 6" X 1/2" (Vervet)	71-22 ab	223.2	3	50	2	Liver - 3
	71-19 ab	LOD †	2	0	N.A.**	Liver - 2, lung - 2, duod.
	71-20 ab	262.	2	100	N.A.**	Liver - 2
	71-23 ab	225.6	3	20	3	Spleen - 2
	71-21 ab	268.	3	30	2	Spleen - 3
	71-24 ab	236.	1	0	2	1
2. Flexible 6" X 1" (Vervet)	71-27 ab	71.8	2	0	1	Pancreas - 1, stomach - 2
	71-26 ab	88.8	2	30	N.A.**	Liver - 2, pancreas - 2, lungs - 2
	71-28 ab	101.2	2	0	N.A.**	Lungs - 3, spleen - 1, stomach - 1
	71-25 ab	172.	1	0	2	1
3. Flexible 6" X 2" (Vervet)	71-29 ab	27.4	1	0	1	R. kidney - 1
	71-31 ab	50.4	4	20	1	Liver - 4, pancreas - 1
	71-30 ab	26.4	1	0	1	L. kidney - 1
	71-33 ab	45.6	4	50	N.A.**	Liver - 4, Omentum - 2
	71-32 ab	67.6	1	0	1	Spleen - 1, L. kidney - 1
4. Rigid 8" X 1/2" (Vervet)	71-06 ab	260.0	3	30	2	Pancreas - 4, liver - 1, stomach - 4
	71-07 ab	206.0	2	1	3	Intestine - 1, colon - 1
	71-05 ab	200.0	1	5	1	Intestine - 2
	71-36 ab	400.0	3	20	3	D. Colon - 3
5. Rigid 8" X 1" (Vervet)	71-18 ab	53.4	3	30	1	Liver - 3
	71-15 ab	42.5	2	20	2	Liver - 1
	71-13 ab	81.0	3	30	1	Pancreas - 4, liver - 2
	71-14 ab	40.6	1	0	2	Pancreas - 1
	71-12 ab	133.0	4	100	2	Pancreas - 3, liver - 1, spleen - 4
	71-11 ab	176.0	1	10	1	Intestine - 1
6. Rigid 8" X 2" (Vervet)	71-17 ab	29.8	3	30	2	Liver - 3, colon - 1, intestine - 1
	71-10 ab	29.0	4	100	3	Liver - 4
	71-16 ab	44.8	1	0	1	Liver - 1
	71-09 ab	61.5	3	30	3	Pancreas - 4, spleen - 3
	71-08 ab	93.5	1	1	1	Intestine - 1, colon - 1
	71-35 ab	88.0	4	10	N.A.**	D. Colon - 4, lungs - 3
7. Rigid 1-1/2" Radius (Mini-Pig)	71-46 ab	92.0	1	0	N.A.**	1
	71-38 ab	85.0	2	10	N.A.**	Liver - 1, lung - 4
	71-51 ab	85.0	3	500 - 1000	N.A.**	Liver - 3
	71-48 ab	100 †	1	0	N.A.**	1
	71-47 ab	99.2	5	500	N.A.**	Liver - 5
	71-42 ab	77.8	2	200	N.A.**	Liver - 2
	71-53 ab	120.0	3	1000 - 1500	N.A.**	Liver - 3
	71-41 ab	99.3	3	500	N.A.**	Liver - 2, ribs - 2
	71-45 ab	85.0	2	200 - 300	N.A.**	Liver - 4, lung - 3
	71-39 ab	92.0	2	0	N.A.**	Lung - 4
	71-40 ab	85.0	5	1000 - 2000	N.A.**	Liver - 5
	71-50 ab	120.0	4	1000 - 2000	N.A.**	Liver - 3, spleen - 4, lung - 1
	71-49 ab	100 †	2	100 - 200	N.A.**	Omentum - 2
	71-44 ab	60.2	1	10	N.A.**	Lung - 1
	71-52 ab	134.0	3	1000 - 1500	N.A.**	Liver - 3
8. Seat Belt - Sled (Vervet)	71-01 s	113.2	1	1	N.A.**	Intestine - 1
	71-03 s	115.6	1	1	1	1
	71-02 s	111.8	1	1	1x	1
	71-04 s	68.	2	2	3	Intestine - 2
9. Rigid 1-1/2" + 1-1/2" Pad (Vervet)	71-43 ab	35.3	3	50 - 75	1	Liver - 4, omentum - 1, pancreas - 1
	71-37 ab	21.2	2	20	1	Liver - 1, spleen - 3, pancreas - 1

*Injury Scale 1 to 5: 1 = no injury to minor; 2 = recoverable; 3 = marginal recovery; 4 = severe; 5 = lethal.

**Not available

†Loss of Data

TABLE XV.
POST MORTEM EXAMINATION DATA

	RUN NO.	IMPACT LOCATION	FORCE/AREA (LB/SQ. IN.)	SCALING INDEX NO.	AUTOPSY RESULTS
A. Flexible 6" X 1/2" (Vervet)	71-22 ab	Upper Abdomen	223.2	3	Fifty cc blood in the abdominal region; moderate laceration of several lobes of the liver; no change in lung compliance.
	71-19 ab	Upper Abdomen	100 +	2	No blood in the abdominal cavity; minor laceration to the posterior surface of the liver; minor contusion of the duodenum; moderate gross pulmonary hemorrhage.
	71-20 ab	Upper Abdomen	262.	2	One hundred cc blood in the abdominal cavity; moderate laceration of the inferior edges of the liver; lung weight 21.5 gms.
	71-23 ab	Mid Abdomen	225.6	3	Twenty cc blood in the abdominal cavity; laceration of the spleen; moderate gross lung congestion and hemorrhage; lung weight 20 gms; lung compliance decrease 88% (severe).
	71-21 ab	Mid Abdomen	268.	3	Thirty cc blood in the abdominal region; crushed and transected spleen; 58% lung compliance decrease; lung weight 12.5 g.
	71-24 ab	Lower Abdomen	236.	1	No evidence of any injury except for minor evidence of the lung congestion - 2 central hemorrhagic areas; lung weight 20 gms; compliance decrease 60%.
	71-34 ab	Lower Abdomen	340.	3	Blow out perforation of the ileum, 1 cm diameter; contusion of the ileum.
B. Flexible 6" X 1" (Vervet)	71-27 ab	Upper Abdomen	71.8	2	Very little evidence of injury; minor contusion to anterior wall of the body of the stomach; very minor evidence of hemorrhage from the neck of the pancreas; no change in lung compliance.
	71-26 ab	Upper Abdomen	88.8	2	Thirty cc blood in the abdominal cavity; lacerations of the right and left lobes of the liver both on the anterior and posterior surfaces; minor evidence of hemorrhages from the head of the pancreas; gross lung congestion; lung weight 30.5 gms.
	71-28 ab	Mid Abdomen	101.2	2	No blood in the abdominal cavity; minor laceration of the tip of the spleen; minor contusion to the ventral wall of the body of the stomach. Severe gross pulmonary hemorrhagic congestion; lung weight 31.5 gms indicative of severe congestion.
	71-25 ab	Low Abdomen	172.	1	No evidence of any injury except for a minor abrasion on the surface of the abdomen and a 72% lung compliance decrease.
C. Flexible 5" X 2" (Vervet)	71-29 ab	Upper Abdomen	27.4	1	No blood in the abdominal region; very minor contusion to the medial surface of the right kidney.
	71-31 ab	Upper Abdomen	50.4	4	Twenty cc blood in the abdominal region; multiple severe lacerations of the liver especially of the anterior surface; moderate evidence of hemorrhage from the head of the pancreas; no lung changes.
	71-30 ab	Mid Abdomen	26.4	1	The only evidence of injury was that of minor contusion of the left kidney.
	71-33 ab	Mid Abdomen	45.8	4	Fifty cc blood in the abdominal cavity; very severe lacerations of the left lobe of the liver on both anterior and posterior surfaces; severe bruise on the anterior abdominal wall; severe hemorrhage from the omentum; gross pulmonary congestion.
	71-32 ab	Low Abdomen	67.6	1	Very little evidence of any injury. Minor tear at the tip of the spleen; minor contusion to the left kidney; minor hemorrhage of the omentum; no lung changes.
D. Rigid 8" X 1/2" (Vervet)	71-06 ab	Upper Abdomen	260.0	3	Thirty cc of blood in the abdominal region; 1 cm round blow out perforation in the cardia of the stomach; severe contusion and laceration of the pancreas; minor laceration of the liver and spleen compliance decrease of 36% just after the test.
	71-07 ab	Mid Abdomen	206.0	2	One cc blood in the abdominal region, minor contusion to small intestine and its mesentery; contusion to ascending colon (dorsal side); lung compliance decrease of 39%; very minor evidence of gross lung congestion.
	71-05 ab	Lower abdomen	200.0	1	Five cc blood in the abdominal region; minor contusion to much of the small and large intestine, small laceration in the wall of the duodenum.

	<u>RUN NO.</u>	<u>IMPACT LOCATION</u>	<u>FORCE/AREA (LB/SQ. IN.)</u>	<u>SCALING INDEX NO.</u>	<u>AUTOPSY RESULTS</u>
	71-36 ab	Lower Abdomen	400.0	3	Twenty cc blood in the abdominal cavity; two small perforations in the descending colon; minor hemorrhage from the mesenteric vessels; 40% decrease in lung compliance; minor pulmonary edema.
E. Rigid 8" X 1" (Vervet)	71-18 ab	Upper Abdomen	53.4	3	Thirty cc blood in the abdominal cavity; extensive laceration of the liver; no change in lung compliance; lung weight 17 gms.
	71-15 ab	Upper Abdomen	42.5	2	Twenty cc blood in the abdominal region; minor laceration of the liver; very minor pancreatic hemorrhage; lung compliance decrease of 28%; lung weight normal - 16 gms.
	71-13 ab	Upper Abdomen	81.0	3	Thirty cc blood in the abdominal cavity; severe laceration or rupture of the pancreas; numerous minor lacerations in the liver; minor mesenteric hemorrhage; lung compliance decrease, 12%; lung weight 27 g indicative of some congestion.
	71-14 ab	Mid Abdomen	40.6	1	Very little evidence of any injury. Minor pancreatic hemorrhage; lung compliance decrease of 36%; lung weight 15.5 gms.
	71-12 ab	Mid Abdomen	133.0	4	Fifty to 100 cc blood in the abdominal cavity; near transection of spleen; deep laceration to the head and tail of the pancreas; minor laceration of liver, 20% decrease in lung compliance; lung weight 28.5 gms indicative of congestion.
	71-11 ab	Lower Abdomen	176.0	1	Ten cc blood in the abdominal cavity; minor hemorrhage to the mesentery of the small intestine and descending colon and minor contusion to the jejunum. No other evidence of injury.
F. Rigid 8" X 2" (Vervet)	71-17 ab	Upper Abdomen	29.8	3	Thirty cc blood in the abdominal cavity; extensive laceration of the liver; minor contusion to the duodenum; lung compliance decrease of 34%.
	71-10 ab	Upper Abdomen	29.0	4	One hundred cc blood in the abdominal region; severely crushed right lobe of the liver; minor contusion to the left kidney; lung compliance decreased by 58%; petechial hemorrhage of the lungs; lung weight 30.3 g indicative of considerable congestion.
	71-16 ab	Mid Abdomen	44.8	1	No evidence of injury except for a lung compliance decrease of 15%.
	71-09 ab	Mid Abdomen	61.5	3	Thirty cc blood in abdominal region; massive bleeding from the spleen and pancreas; severe laceration of the spleen; partial transection of the pancreas; 45% decrease in lung compliance lung weight 24.59 indicative of congestion.
	71-08 ab	Lower Abdomen	93.5	1	One cc blood in abdominal region; very minor contusion to the intestine and colon, no lung compliance change.
	71-35 ab	Lower Abdomen	88.0	3	Ten cc blood in the abdominal cavity; large tear in the descending colon; numerous mesenteric hematomas; lungs very edematous and hemorrhagic.
G. Rigid 1-1/2" Radius (Mini-Pig)	71-46 ab	Upper Rt. Abdomen	92.0	1	No evidence of any injury.
	71-38 ab	Upper Rt. Abdomen	85.0	2	Approximately 10 cc blood in the abdominal cavity; a small round contused or puncture wound to the lower right ventral lobes of the liver, very severe marked pulmonary embolism, edema, hemorrhagic consolidation and patchy atelectasis; lung weight 387 gms.
	71-51 ab	Mid Rt. Abdomen	85.0	3	Five hundred to one thousand cc blood in the abdominal cavity; severe lacerations to the liver; posterior surface, left lobe, and quadrate lobe and especially between the left and quadrate lobes.
	71-48 ab	Mid Rt. Abdomen	LOO†	1	No evidence of any injury.
	71-47 ab	Mid Rt. Abdomen	99.2	5	Five hundred cc blood in the abdominal cavity; very severe laceration between the right and left lobes of the liver, the lobes were almost torn apart; no other evidence of injury except partial consolidation of a small central lobe of the lungs, lung weight 378 gms.
	71-42 ab	Mid Rt. Abdomen	77.8	2	Two hundred cc blood in the abdominal cavity; minor lacerations to the liver, anterior right lobe and posterior right lobe adjacent to the gallbladder, no other evidence of injury.
	71-53 ab	Lower Rt. Abdomen	120.0	3	One thousand to 1500 cc blood in the abdominal region, very severe laceration to the liver, posterior surface of right lobe and quadrate lobe.

TABLE XV Continued

	RUN # NO.	IMPACT LOCATION	FORCE/AREA (LB/SQ. IN.)	SCALING INDEX NO.	AUTOPSY RESULTS
(continued)	71-41 ab	Lower Rt. Abdomen	99.3	3	Five hundred cc blood in the abdominal cavity, minor lacerations to the liver on the posterior quadrate lobe; 3 broken ribs, no other evidence of injury. Organ weights: lungs - 634 g, spleen - 142 g, r. kidney - 135 g, pancreas - 62 g, heart - 242 g, liver - 1240 g.
	71-45 ab	Upper Lf. Abdomen	85.0	2	Two hundred to 300 cc blood in the abdominal region; moderate laceration on the liver on the posterior side between the left and quadrate lobes; minor evidence of edema and consolidation of the lungs. (Note: death by pneumothorax may have masked any possible lung changes). Organ weights: heart - 325 g, r. lung - 385 g, l. lung - 235 g, r. kidney - 145 g, l. kidney - 135 g, pancreas - 35 g, and liver - 1815 g.
	71-39 ab	Upper Lf. Abdomen	92.0	2	No blood in the abdominal cavity; only evidence of injury was that to the lungs which included severe gross hemorrhage, severe embolization, edema, lung weight, 513 gms indicative of edema.
	71-40 ab	Mid Lf. Abdomen	85.0	5	Severe hemorrhage in the abdominal region, 1000 - 2000 cc of blood; very severe lacerations of the liver especially on the posterior medial left lobe and quadrate lobe in the pyloric area; lungs normal.
	71-50 ab	Mid Lf. Abdomen	120.0	4	One to two thousand cc blood in the abdominal cavity; severely lacerated spleen; severe lacerations to the liver, posterior surface of the left and quadrate lobe; minor pulmonary edema.
	71-49 ab	Lower Lf. Abdomen	LOD†	2	One to two hundred cc blood in the abdominal cavity; hemorrhage from the greater omentum.
	71-44 ab	Lower Lf. Abdomen	60.2	1	Ten cc blood in the abdominal region; very minor evidence of hemorrhage in the lungs; (Note: death by pneumothorax may have masked any possible lung changes).
	71-52 ab	Lower Lf. Abdomen	134.0	3	One thousand to 1500 cc blood in the abdominal region; very severe laceration to the liver, anterior surface of right lobe.
H. Seat Belt - Sled (Vervet)	71-01 s	Lap	113.2	1	Very minor injury; no blood in the abdominal region; slight discoloration along lower left lobe and inferior lobes of liver; slight contusion to upper descending colon.
	71-03 s	Lap	115.6	1	Very minor external bruises were the only evidence of any injury.
	71-02 s	Lap	111.8	1	No evidence of any pathology except for minor bruises to the external abdominal wall apparently due to the seat belt.
	71-04 s	Lap	68	2	Two cc blood in the abdominal region, contusion to the ascending colon; slight hemorrhage from the mesenteric vessels; partial laceration of the duodenum with contents still contained; lung compliance decrease of 44% immediately after the test; minor petechial hemorrhage just below where the seat belt was positioned during the test.
I. Pigid 1-1/2" Radius + 1-1/2" Pad (Vervet)	71-43 ab	Upper Abdomen	35.3	3	Fifty to 75 cc blood in the abdominal cavity; severe lacerations of the liver, posterior surface of right and left lobes; hemorrhage from the greater omentum; minor contusion to the duodenum; minor hemorrhage from the pancreas; lungs grossly normal.
	71-37 ab	Mid Abdomen	21.2	2	Twenty cc blood in the abdominal cavity; major tear in the spleen, left kidney contusion and subcapsular hemorrhage; hemorrhage from the tail of the pancreas; contusion on the posterior wall of the stomach-cardia; no evidence of gross lung damage.

Loss of Data

TABLE XVI.
ADDITIONAL TEST DATA

	RUN NO.	SEX	EKG (HEART RATE)			RESPIRATORY RATE		IMPACTOR PENETRATION	
			BEFORE	AFTER	% CHANGE	BEFORE	AFTER	INCHES	%
A. Flexible 6" X 1/2" (Vervet)	71-22 ab	Female	150	150	0	20	20	(0.7)	(21.7)
	71-19 ab	Male	120	150	+25	24	36	LOD †	LOD †
	71-20 ab	Female	190	150	-21	25	N.A.**	1.3	41.3
	71-23 ab	Male	150	150	0	N.A.**	34	0.9	32.9
	71-21 ab	Female	180	150	-20	20	N.A.**	0.9	32.0
	71-24 ab	Male	90	120	+25	28	28	1.4	61.8
	71-34 ab	Male	150	90	-33	22	18	1.4	55.0
B. Flexible 6" X 1" (Vervet)	71-27 ab	Male	150	180	+20	18	26	0.8	23.3
	71-26 ab	Female	150	180	+20	32	28	0.9	26.0
	71-28 ab	Female	180	150	-17	16	16	0.8	33.4
	71-25 ab	Male	150	120	-20	32	24	1.5	69.0
C. Flexible 6" X 2" (Vervet)	71-29 ab	Male	180	150	-17	20	32	1.3	38.5
	71-31 ab	Male	180	180	0	20	32	2.0	56.7
	71-30 ab	Male	120	150	+25	16	20	0.8	24.2
	71-33 ab	Female	180	210	+17	N.A.**	24	0.9	36.8
	71-32 ab	Male	150	120	-20	22	28	2.1	79.3
D. Rigid 8" X 1/2" (Vervet)	71-06 ab	Female	90	120	+33	24	20	3.1	70.5
	71-07 ab	Male	90	60	-33	N.A.**	28	2.4	59.3
	71-05 ab	Female	120	90	-25	20	24	2.1	55.5
	71-36 ab	Male	90	90	0	21	20	3.1	70.0
E. Rigid 8" X 1" (Vervet)	71-18 ab	Male	120	150	-25	34	48	2.7	65.0
	71-15 ab	Female	150	150	0	26	20	2.0	48.0
	71-13 ab	Male	90	60	-33	20	18	2.3	54.3
	71-14 ab	Female	150	180	+20	22	N.A.**	2.3	56.1
	71-12 ab	Female	180	180	0	20	30	2.6	59.5
	71-11 ab	Female	180	150	-17	20	N.A.**	2.3	60.0
F. Rigid 8" X 2" (Vervet)	71-17 ab	Female	130	90	-31	22	20	2.1	60.0
	71-10 ab	Male	120	120	0	24	22	2.4	51.6
	71-16 ab	Male	120	120	0	22	28	2.3	55.1
	71-09 ab	Male	120	60	-50	22	19	2.7	59.7
	71-08 ab	Female	150	150	0	28	40	1.8	56.0
	71-35 ab	Male	120	120	0	24	24	2.6	63.5
G. Rigid 1-1/2" Radius (Mini-Pig)	71-46 ab	Male	150	150	0	N.A.**	N.A.**	3.5	27.8
	71-38 ab	Male	90	N.A.**	N.A.**	N.A.**	N.A.**	2.9	22.9
	71-51 ab	Male	120	180	+50	N.A.**	N.A.**	4.2	37.8
	71-48 ab	Male	90	N.A.**	N.A.**	N.A.**	N.A.**	2.9	20.9
	71-47 ab	Male	120	210	+75	N.A.**	N.A.**	5.3	44.1
	71-42 ab	Male	150	120	-20	N.A.**	N.A.**	4.1	36.0
	71-53 ab	Male	150	150	0	N.A.**	N.A.**	5.0	41.5
	71-41 ab	Male	90	90	0	N.A.**	N.A.**	4.4	37.5
	71-45 ab	Male	150	60	-60	N.A.**	N.A.**	4.0	31.0
	71-39 ab	Male	90	120	+33	N.A.**	N.A.**	3.9	33.9
	71-40 ab	Male	90	210	+133	N.A.**	N.A.**	4.2	39.2
	71-50 ab	Male	90	150	+66	N.A.**	N.A.**	5.0	38.6
	71-49 ab	Male	120	120	0	N.A.**	N.A.**	3.0	24.8
	71-44 ab	Male	90	90	0	N.A.**	N.A.**	4.3	39.8
	71-52 ab	Male	150	150	0	N.A.**	N.A.**	5.0	40.1
H. Seat Belt - Sled (Vervet)	71-01 s	Male	120	90	-25	20	28	N.A.**	N.A.**
	71-03 s	Male	150	120	-20	34	48	N.A.**	N.A.**
	71-02 s	Male	90	120	+33	36	N.A.**	N.A.**	N.A.**
	71-04 s	Male	120	120	0	40	N.A.**	N.A.**	N.A.**
I. Rigid 1-1/2" Radius +1-1/2" Pad (Vervet)	71-43 ab	Female	150	150	0	20	N.A.**	3.0	60.4
	71-37 ab	Female	180	120	-33	31	N.A.**	1.2	31.0

†Loss of Data
**Not available

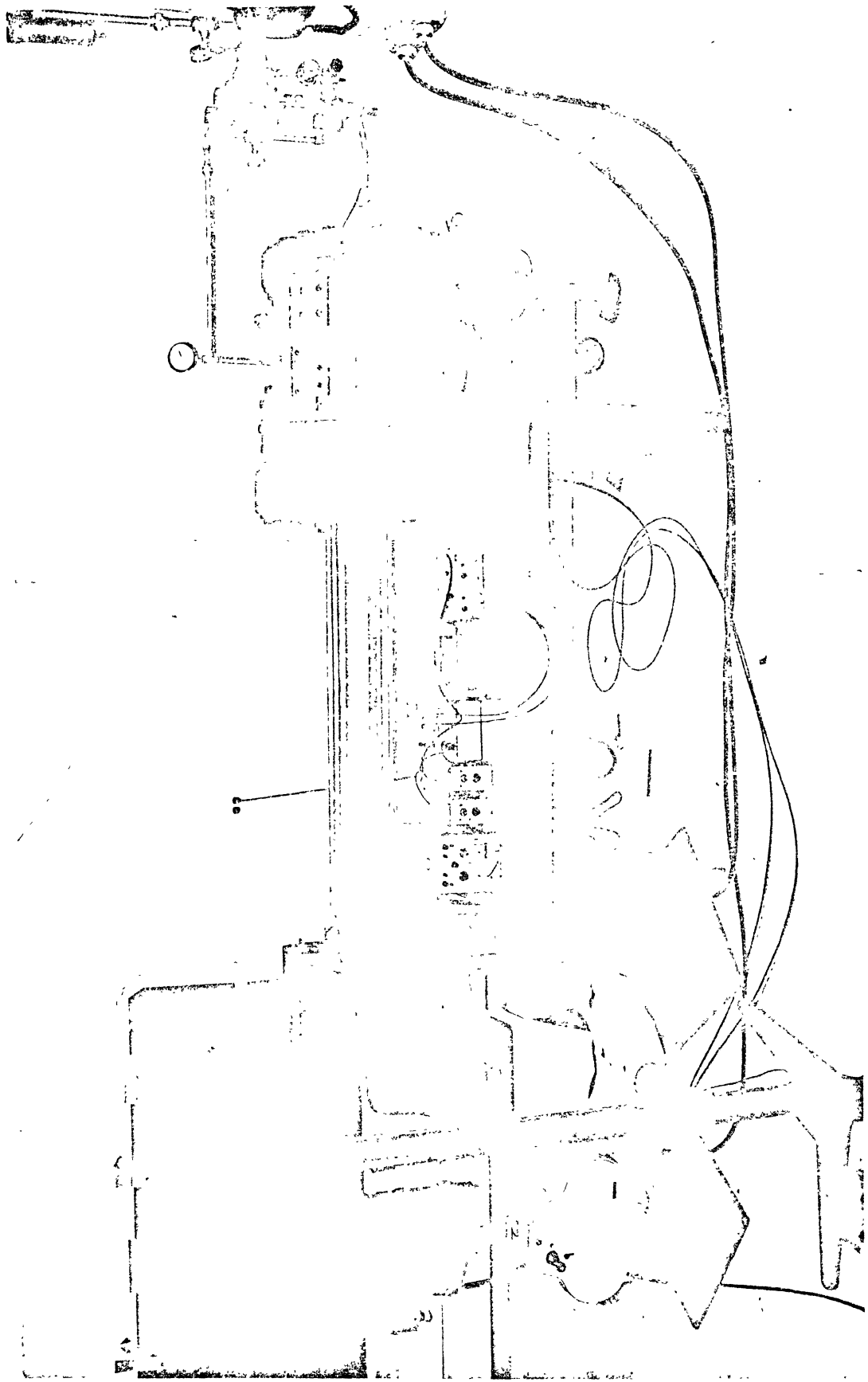
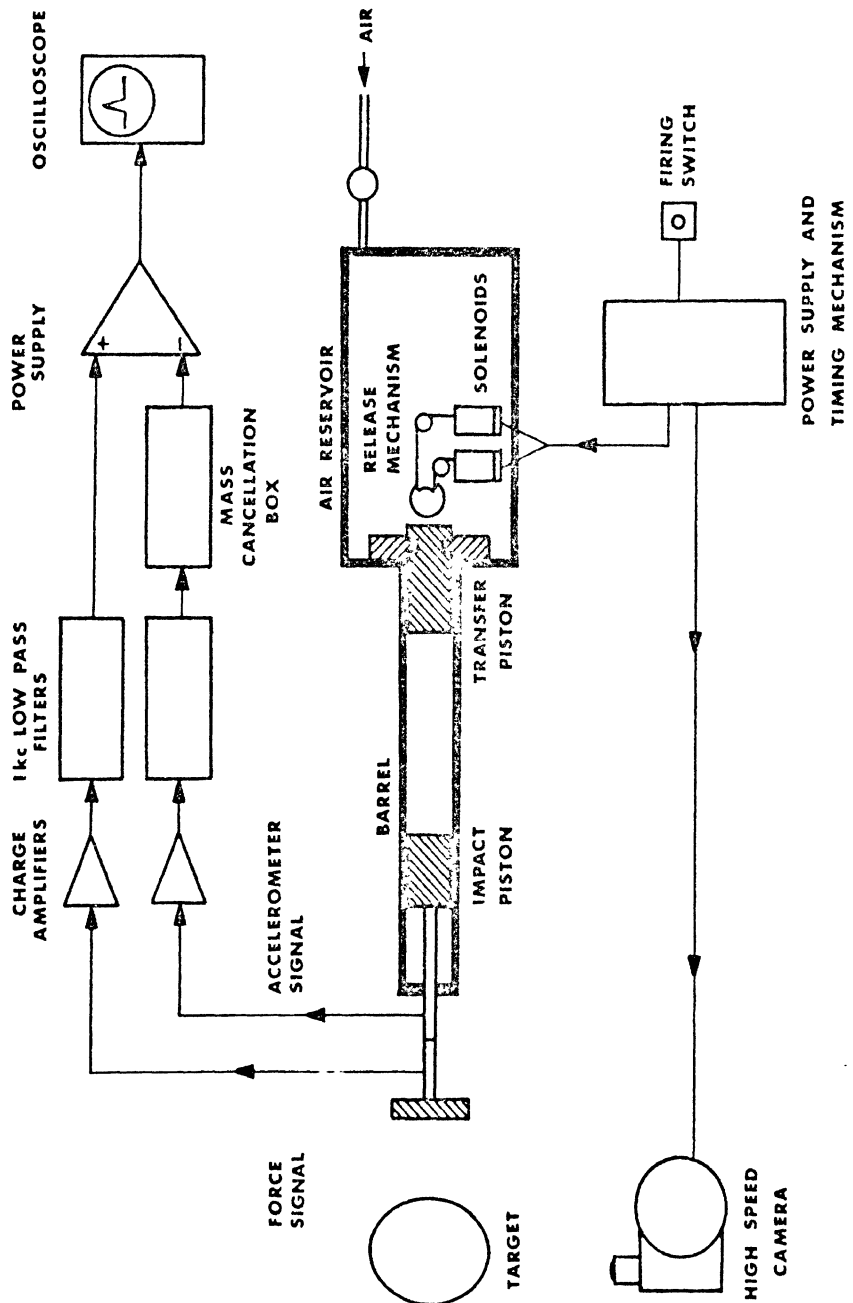
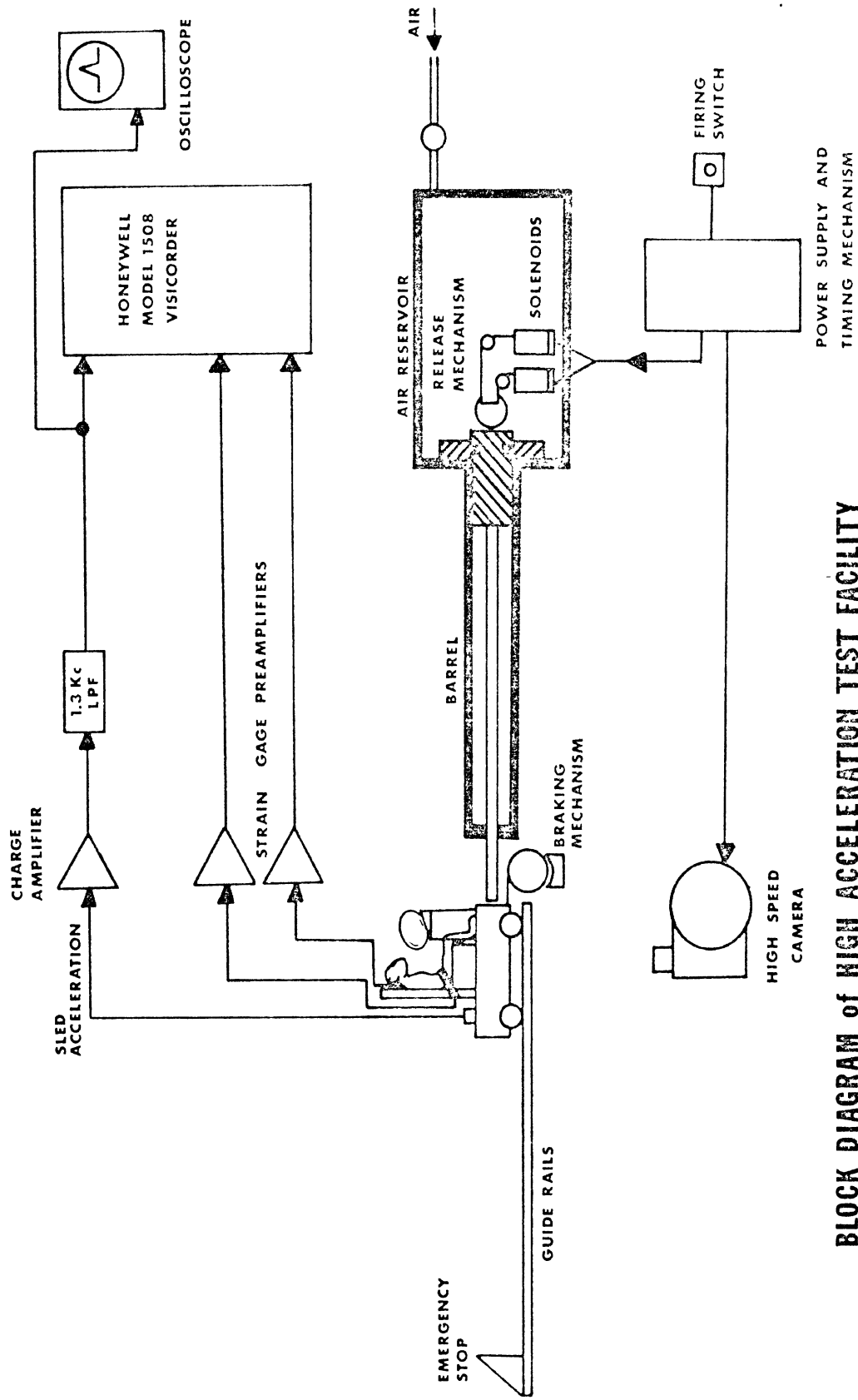


FIGURE 1. OVER-ALL VIEW OF IMPACTING FACILITY



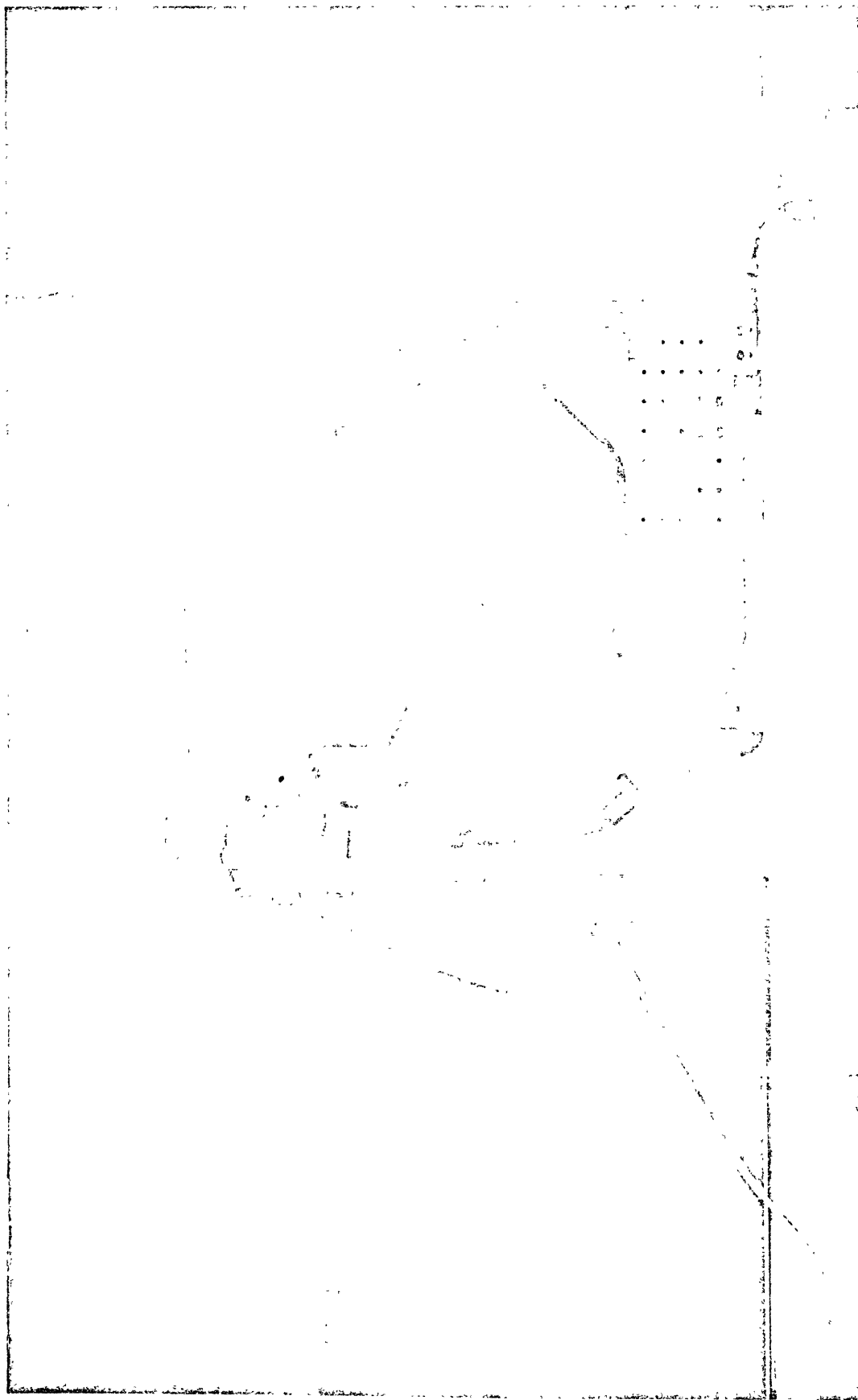
BLOCK DIAGRAM of HEAD IMPACT FACILITY

FIGURE 2.



BLOCK DIAGRAM OF HIGH ACCELERATION TEST FACILITY

FIGURE 3



**FIGURE 4. TYPICAL SET-UP FOR LAP BELT
SEAT TEST WITH RIC 720**

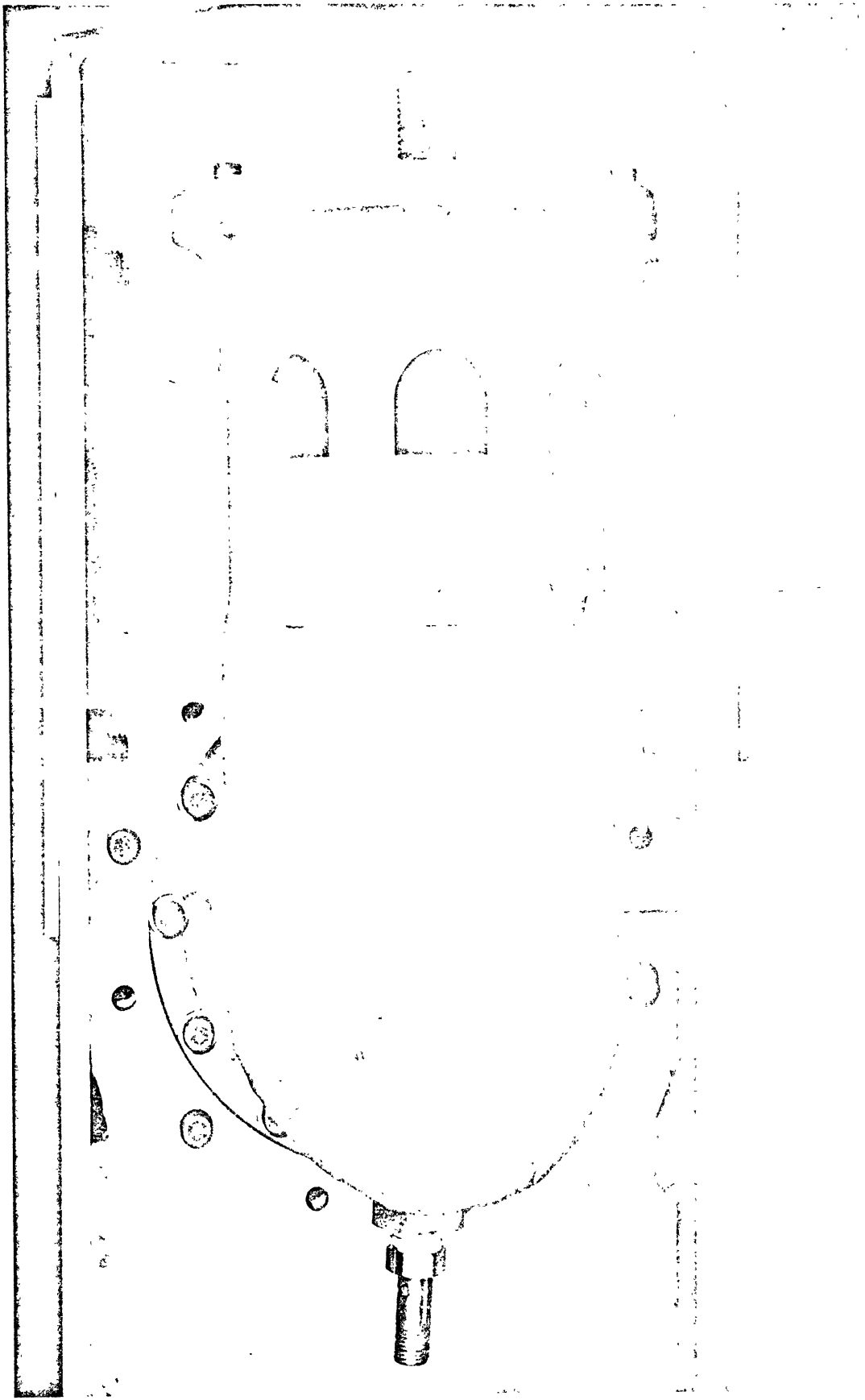


FIGURE 5. AIR BAG PRESSURE RELIEF VALVE

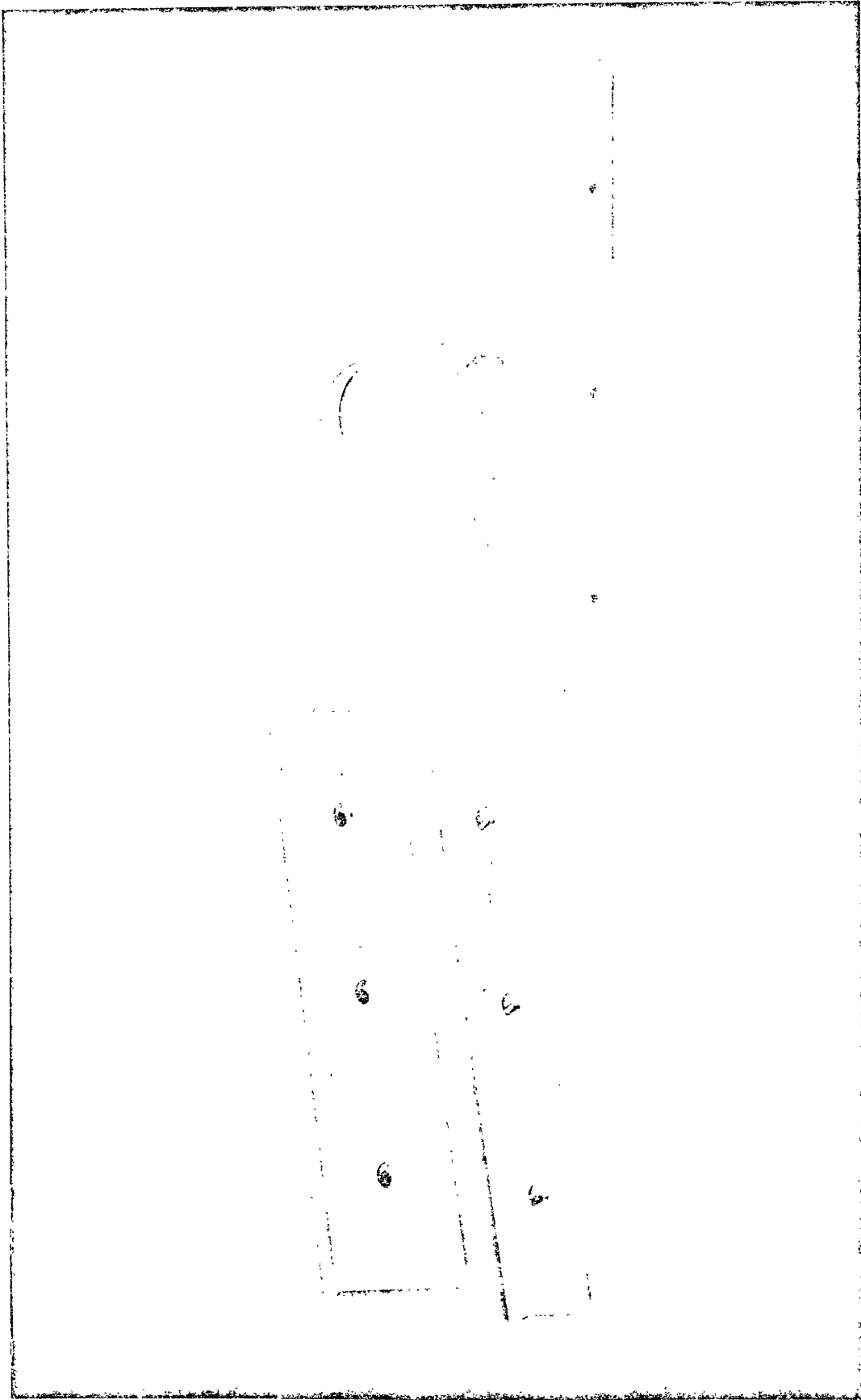


FIGURE 6. RIGID IMPACTOR

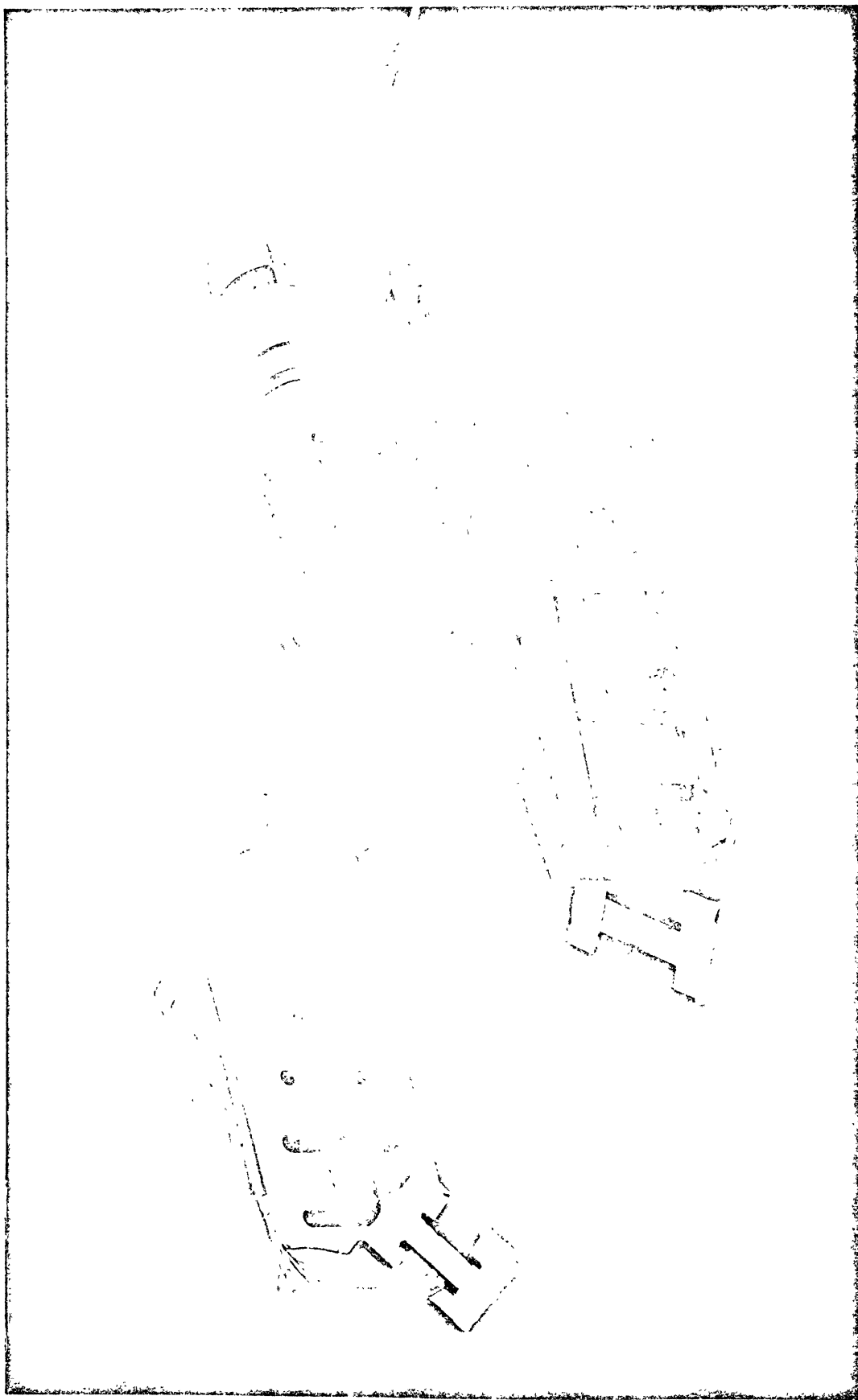


FIGURE 7. FLEXIBLE IMPACTOR

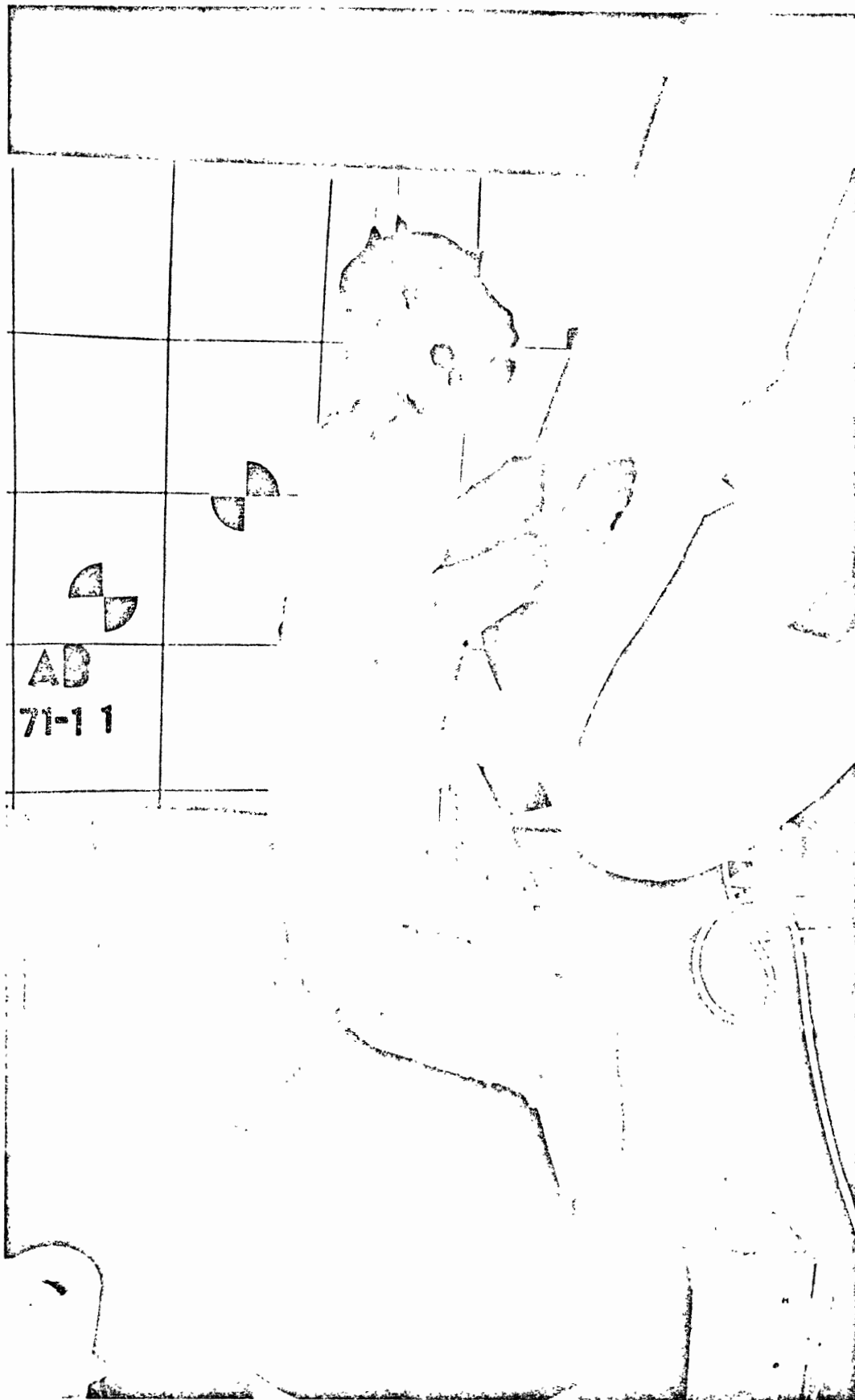


FIGURE 8. TYPICAL SET-UP FOR TEST WITH RIGID IMPACTOR

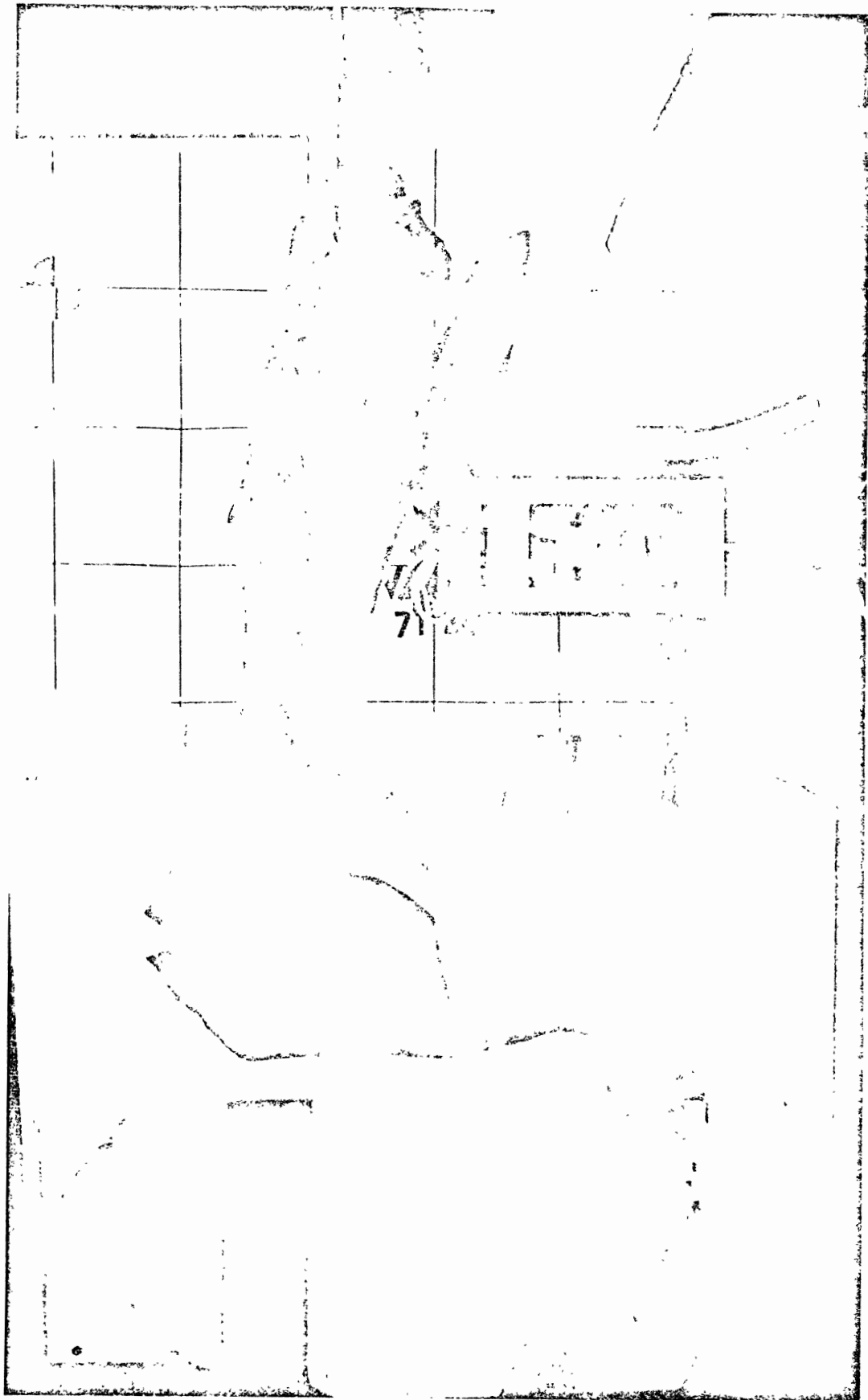


FIGURE 9. TYPICAL SET-UP FOR TEST WITH FLEXIBLE IMPACTOR

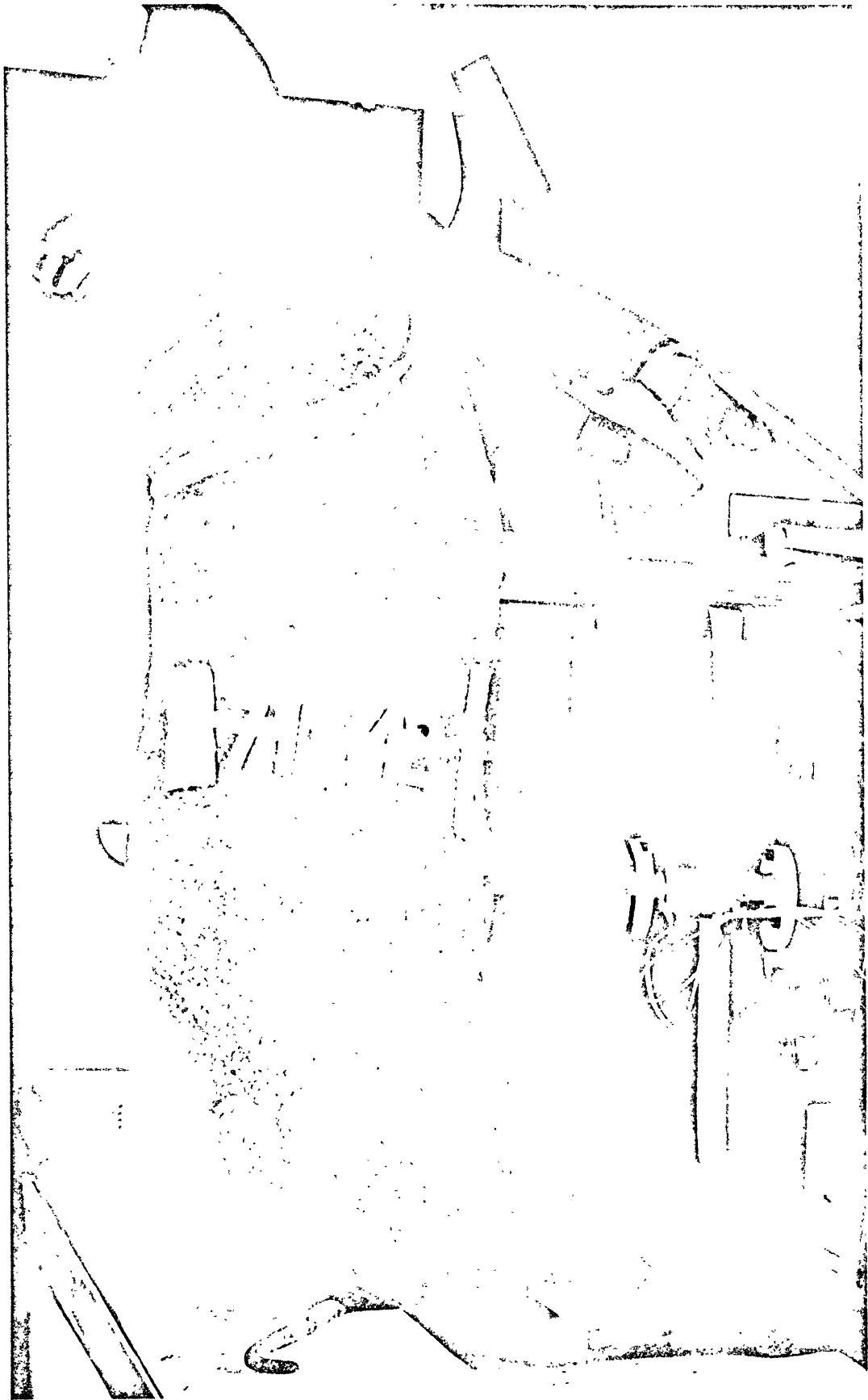
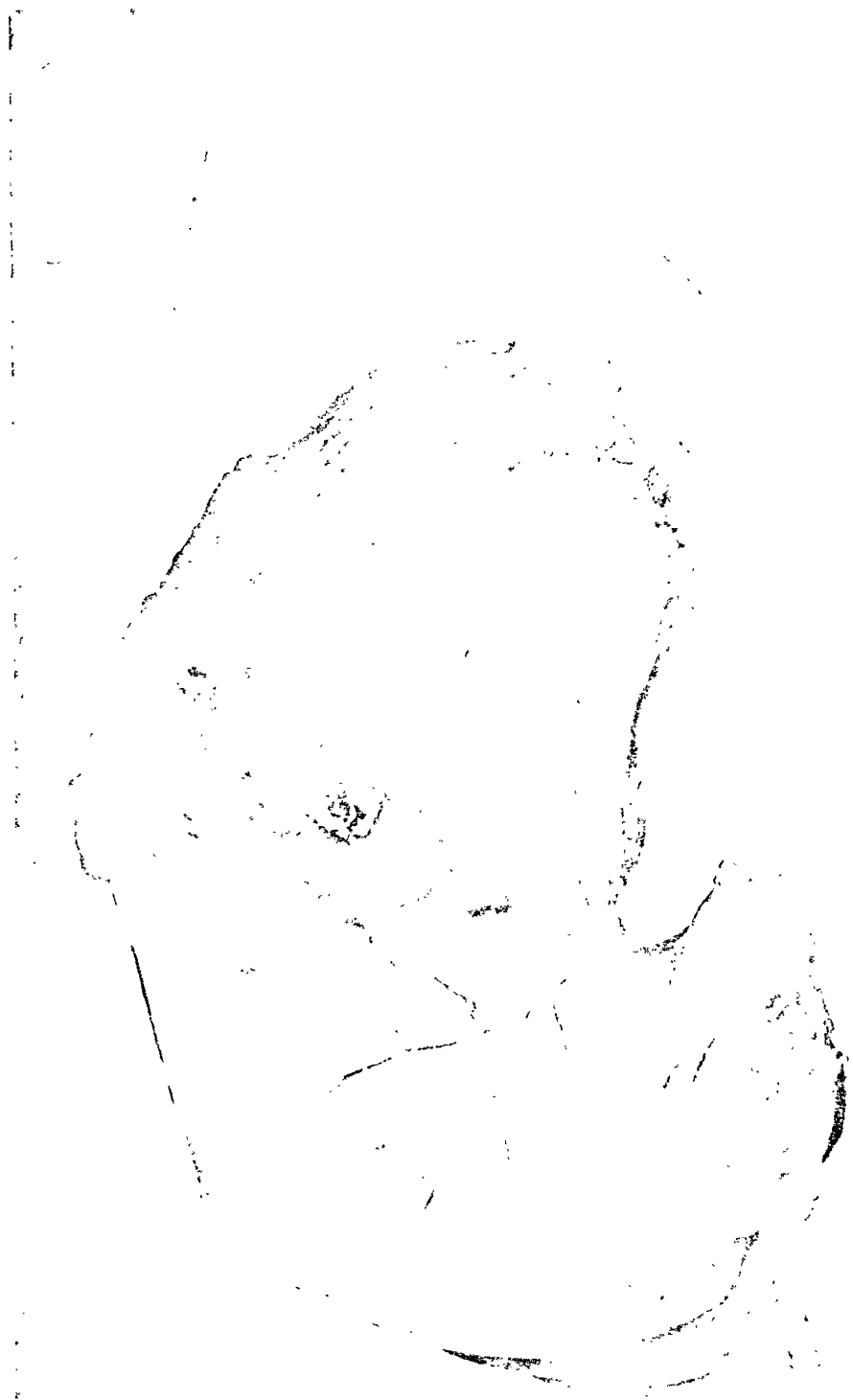


FIGURE 10. TYPICAL MINI-PIG IMPACT SET-UP



VE-71-12-ab

**FIGURE 11. TYPICAL SPLEEN INJURY
FROM RIGID IMPACTOR**



ve 71 27 ab

FIGURE 12. STOMACH INJURY FROM FLEXIBLE IMPACTOR

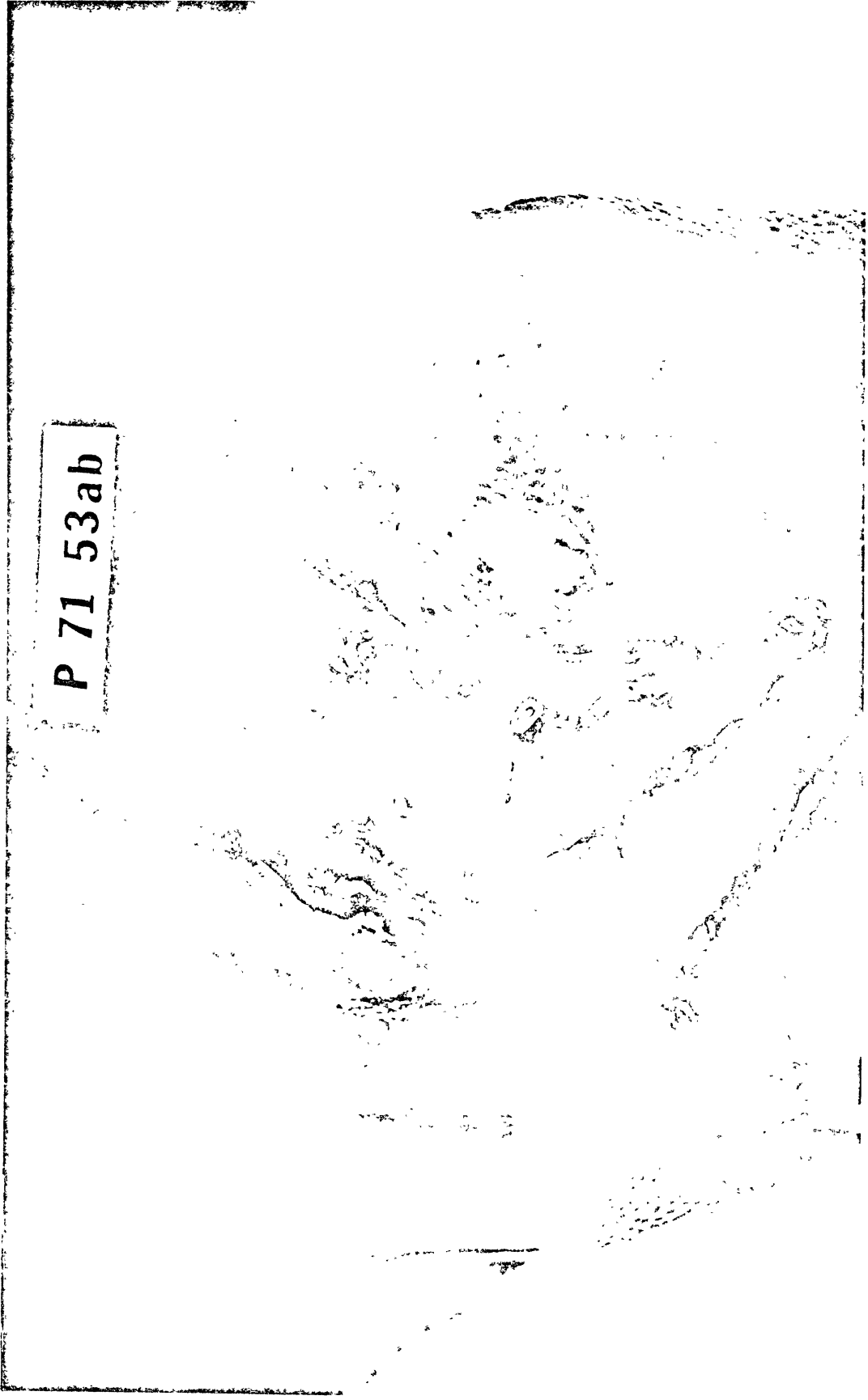


FIGURE 13. TYPICAL LIVER INJURY FROM ROUND RIGID IMPACTOR

6.0 A MATHEMATICAL MODEL FOR ABDOMINAL IMPACT by Ali Engin

6.1 INTRODUCTION

The subject matter of this investigation is the dynamic analyses of fluid-filled shells of revolution, void of all bending rigidity and subjected to general axisymmetric loads of considerable magnitude. Although linear shell theory can only be used within a limited range of loading, for most practical applications it provides us with numerical values which are in good agreement with the experimental results. The situation, however, is quite different if one desires to model the abdominal region of the human body. In order for the model to represent the abdomen with some closeness to reality it should allow not only large displacements and rotations but also large elastic strains. Hence, a nonlinear formulation of fluid-filled shells of revolution, which allows large displacements as well as large strains, is very desirable and it will be the subject of this paper.

As far as this author knows, a treatment of large displacements and large strains theory of fluid-filled shells of revolution does not exist in the literature of theoretical mechanics. Most of the previous work has been on the static analyses of sheets and shells. Bromberg and Stoker (1945) first introduced a paper dealing with the problem of nonlinear theory of curved elastic sheets. Very extensive treatment of the nonlinear field theory of the continuum mechanics was presented by Truesdell and Noll (1965) in the third volume of the *Encyclopedia of Physics (Handbuch der Physik)*. Books by Eringen (1962) and Green and Adkins (1968) provide good reference material. Some of the more recent papers on the large deformation of sheets and shells are by Sanders and Liepins (1963), Naghdi and Nordgren (1963), Sanders (1963) and Yang (1967).

In this paper the fundamentals of large displacements and large strains theory of fluid-filled shells of revolution will be discussed in some detail.

At the beginning, to familiarize the reader with the shell theory, we present a very brief preliminary part and introduce the equations of motion of an arbitrary shell. From these general equations, the equations of motion for membrane shells of revolution are obtained. Later on, with the aid of geometrical relations, the equations of motion for membrane shells of revolution are obtained for large displacements and large strains. The shell material is assumed to be elastic, isotropic, and incompressible and its stress-strain behavior is expressed by means of a strain energy function, W , which can represent highly nonlinear behavior of the biological tissues. The properties of fluid are taken to be isotropic, incompressible and viscous. The equations of motion are cast into nine nonlinear partial differential equations in nine unknowns for axisymmetric forced oscillations of the fluid-shell system. The theory presented here can be used for both global and local modeling of the abdominal injury. With global modeling we are referring to the behavior of the abdominal region as a whole unit with its solid and hollow viscus and are representing it with fluid-filled membrane. This model will be useful in describing intra-abdominal pressures as well as stresses generated in the abdominal wall due to a lap-type seat belt in the event of a vehicle deceleration of high magnitude. With local modeling we are referring to the behavior of a specific organ such as intestines. For example, during an external loading to the abdomen, a fluid- or food-filled segment of intestine can be kinked at two places or kinked at one place and have a closure by trauma at a second place, a situation which makes the intestine quite vulnerable to a bursting type of injury if some local transverse force acts on the segment. In this case also the magnitudes of intraluminal pressure and membrane stresses play an important role.

6.2 FORMULATION OF THE PROBLEM

The equations of motion of a thin shell can be derived by means of Hamilton's principle as it was done by some authors in the past. Before we present these equations let us indicate some of the quantities appearing in these equations. Let α_1 and α_2 be the curvilinear coordinates for the shell surface* and R_1 and R_2 be the corresponding radii of curvature. On this surface the differential length of an arc, ds , is given by:

$$ds = [A_1^2(d\alpha_1)^2 + 2A_3^2d\alpha_1d\alpha_2 + A_2^2(d\alpha_2)^2]^{1/2} \quad (1)$$

where A_1^2 , A_2^2 and A_3^2 are called the first order fundamental quantities since Eq. (1) is known to be the first fundamental form of the surface.

For thin elastic shells, since the strains and the stresses have been shown to be linearly distributed across the thickness of the shell, it is convenient to introduce the following stress resultants, N_1 , N_2 , N_{12} , Q_1 and Q_2 along with the moment resultants M_1 , M_2 , M_{12} which are all defined per unit arc length of the reference surface; usually the reference surface is taken to be the midsurface of the shell (for definition of these stress and moment resultants see e.g. Flügge (1962)).

All the forces acting on the surface of the shell can be combined in a vector form as:

$$\bar{q}(\alpha_1, \alpha_2, t) = q_1(\alpha_1, \alpha_2, t)\hat{t}_1 + q_2(\alpha_1, \alpha_2, t)\hat{t}_2 - q_n(\alpha_1, \alpha_2, t)\hat{n} \quad (2)$$

where q_1 , q_2 and q_n are the scalar components of the total surface force along α_1 , α_2 and the shell normal; \hat{t}_1 , \hat{t}_2 and \hat{n} are the unit vectors along the corresponding coordinates and t is time.

*Every surface in the rectangular coordinate system (x, y, z) can be written as a function of the two parameters α_1 and α_2 as follows:

$$x = f_1(\alpha_1, \alpha_2), \quad y = f_2(\alpha_1, \alpha_2), \quad z = f_3(\alpha_1, \alpha_2)$$

where f_1 , f_2 and f_3 are single-valued and continuous functions.

After the above preliminaries we can now introduce the following equations of motion for an arbitrary thin shell:

$$\frac{\partial(N_1 A_2)}{\partial \alpha_1} + \frac{\partial(N_{21} A_1)}{\partial \alpha_2} + N_{12} \frac{\partial A_1}{\partial \alpha_2} - N_2 \frac{\partial A_2}{\partial \alpha_1} + A_1 A_2 \left(\frac{Q_1}{R_1} + q_1 \right) = A_1 A_2 \rho_s h \frac{\partial^2 u_1}{\partial t^2} \quad (3)$$

$$\frac{\partial(N_{12} A_2)}{\partial \alpha_1} + \frac{\partial(N_2 A_1)}{\partial \alpha_2} + N_{21} \frac{\partial A_2}{\partial \alpha_1} - N_1 \frac{\partial A_1}{\partial \alpha_2} + A_1 A_2 \left(\frac{Q_2}{R_2} + q_2 \right) = A_1 A_2 \rho_s h \frac{\partial^2 u_2}{\partial t^2} \quad (4)$$

$$\frac{\partial(Q_1 A_2)}{\partial \alpha_1} + \frac{\partial(Q_2 A_1)}{\partial \alpha_2} - \left(\frac{N_1}{R_1} + \frac{N_2}{R_2} \right) A_1 A_2 - q_n A_1 A_2 = A_1 A_2 \rho_s h \frac{\partial^2 u_3}{\partial t^2} \quad (5)$$

$$\frac{\partial(M_1 A_2)}{\partial \alpha_1} + \frac{\partial(M_{21} A_1)}{\partial \alpha_2} + M_{12} \frac{\partial A_1}{\partial \alpha_2} - M_2 \frac{\partial A_2}{\partial \alpha_1} - Q_1 A_1 A_2 = 0 \quad (6)$$

$$\frac{\partial(M_{12} A_2)}{\partial \alpha_1} + \frac{\partial(M_2 A_1)}{\partial \alpha_2} + M_{21} \frac{\partial A_2}{\partial \alpha_1} - M_1 \frac{\partial A_1}{\partial \alpha_2} - Q_2 A_1 A_2 = 0 \quad (7)$$

$$N_{21} - N_{12} + \frac{M_{21}}{R_2} - \frac{M_{12}}{R_1} = 0, \quad (8)$$

where ρ_s is shell mass density, h is the shell thickness and u_1 , u_2 , u_3 are midsurface displacement components along α_1 , α_2 and n . The last equation is identically satisfied for thin shells since $N_{12} = N_{21}$ and $M_{12} = M_{21}$ for these shells. Note that the symmetry of the stress tensor (i.e. $\tau_{ij} = \tau_{ji}$) does not necessarily imply the above equalities.

Since our main concern here is the theoretical modeling of abdominal injury we are interested in membrane equations of fluid-filled shells of revolution. For the membrane theory $M_1 = M_2 = M_{12} = M_{21} = 0$, and Eqs. (6)-(8) will also yield $Q_1 = Q_2 = 0$ and $N_{12} = N_{21}$. The first fundamental form of the midsurface of shells of revolution is given as

$$(ds)^2 = r_\phi^2 (d\phi)^2 + (r_\theta \sin\phi)^2 (d\theta)^2 \quad (9)$$

Hence, $A_1 = R_1 = r_\phi$, $A_2 = r_\theta \sin\phi$, $R_2 = r_\theta$, $\alpha_1 = \phi$, $\alpha_2 = \theta$ and for a surface of revolution, the Gauss condition takes the form $R_1 \cos\phi = \frac{d}{d\phi}(R_2 \sin\phi)$. For a shell of revolution r_ϕ and r_θ are also independent of θ . The equations of motion for membrane shells of revolution can easily be obtained from Eqs. (3)-(5) using the parameters that we have identified above. Thus, Eqs. (3)-(5) reduce to

$$\frac{1}{r_\phi} \frac{\partial N_\phi}{\partial \phi} + \frac{\cot\phi}{r_\theta} (N_\phi - N_\theta) + \frac{1}{r_\theta \sin\phi} \frac{\partial N_{\phi\theta}}{\partial \theta} + q_\phi = \rho_s h \frac{\partial^2 u_1}{\partial t^2} \quad (10)$$

$$\frac{1}{r_\theta \sin\phi} \frac{\partial N_\theta}{\partial \theta} + \frac{2\cot\phi}{r_\theta} N_{\phi\theta} + \frac{1}{r_\phi} \frac{\partial N_{\phi\theta}}{\partial \phi} + q_\theta = \rho_s h \frac{\partial^2 u_2}{\partial t^2} \quad (11)$$

$$\frac{N_\phi}{r_\phi} + \frac{N_\theta}{r_\theta} - q_n = \rho_s h \frac{\partial^2 u_3}{\partial t^2} \quad (12)$$

Eqs. (10)-(12) are linear partial differential equations and they are good for describing small oscillations of membrane. For large deformations, the equations of motion have to be written for the deformed shell element. The following development is similar to that of Reissner (1949) up to Eq. (19) after which we shall proceed in a different direction. We shall also restrict ourselves to symmetrically loaded shells of revolution. Instead of using θ and ϕ as coordinates, let us use θ and ξ for the parametric representation of the shell midsurface.

Geometrical Relations - I

Let $r = r(\xi)$ and $z = z(\xi)$ be the parametric representation of the midsurface at a given time, t , where ξ is a parameter on the surface and r and z are the radial and axial coordinates of a point on the surface. It can be shown that the first fundamental form of such a surface is

$$(ds)^2 = \alpha^2 (d\xi)^2 + r^2 (d\theta)^2 \quad (13)$$

where $\alpha^2 = \left(\frac{dr}{d\xi}\right)^2 + \left(\frac{dz}{d\xi}\right)^2$, $r_\phi = \frac{\alpha}{\frac{d\phi}{d\xi}} (=r_\xi)$, $r_\theta = \frac{r}{\sin\phi}$ and ϕ is the angle formed by the normal of the shell midsurface and the vertical axis (axis of revolution).

The location of an arbitrary point in the shell space can be described by the following position vector:

$$\vec{R} = r(\xi)\hat{e}_r + z(\xi)\hat{k} + \zeta\hat{n} \quad (14)$$

where \hat{e}_r , \hat{k} and \hat{n} are unit vectors shown in Fig.14 and ζ denotes the distance of the point from the midsurface. The coordinates ξ, θ, ζ define a system of orthogonal curvilinear coordinates in the shell space. For this coordinate system it is easy to show that the magnitude of a differential line element is obtained from

$$(dl)^2 = \alpha^2(1 + \zeta/r_\phi)^2(d\xi)^2 + r^2(1 + \zeta/r_\theta)^2(d\theta)^2 + (d\zeta)^2 \quad (15)$$

where r_ϕ and r_θ are the principal radii of curvature of the midsurface of the shell and their values are given after Eq. (13). Let Eq. (15) represent the differential line element after deformation; the same element before deformation is given by

$$(dl_0)^2 = \alpha_0^2(1 + \zeta/r_{\phi_0})^2(d\xi)^2 + r_0^2(1 + \zeta/r_{\theta_0})^2(d\theta)^2 + (d\zeta)^2 \quad (16)$$

Hence, the zero subscripted variables refer to the original (undeformed) configuration of the shell.

Analysis of Strain and Equations of Motion for the Shell

The original and the later configurations of the shell are related by

$$r(\xi, t) = r_0(\xi) + u(\xi, t), \quad z(\xi, t) = z_0(\xi) + w(\xi, t), \quad \phi(\xi, t) = \phi_0(\xi) - \beta(\xi, t) \quad (17)$$

where $u(\xi, t)$ and $w(\xi, t)$ are respectively the radial and axial displacements and β is the rotation of a tangent to a meridian at a given material point. With the usual assumptions of the thin shell theory, i.e. deformations due to transverse shear stress and transverse normal stress are neglected compared with the deformations due to the remaining stresses, from the comparison of Eqs. (15) and (16) one can obtain the following strains:

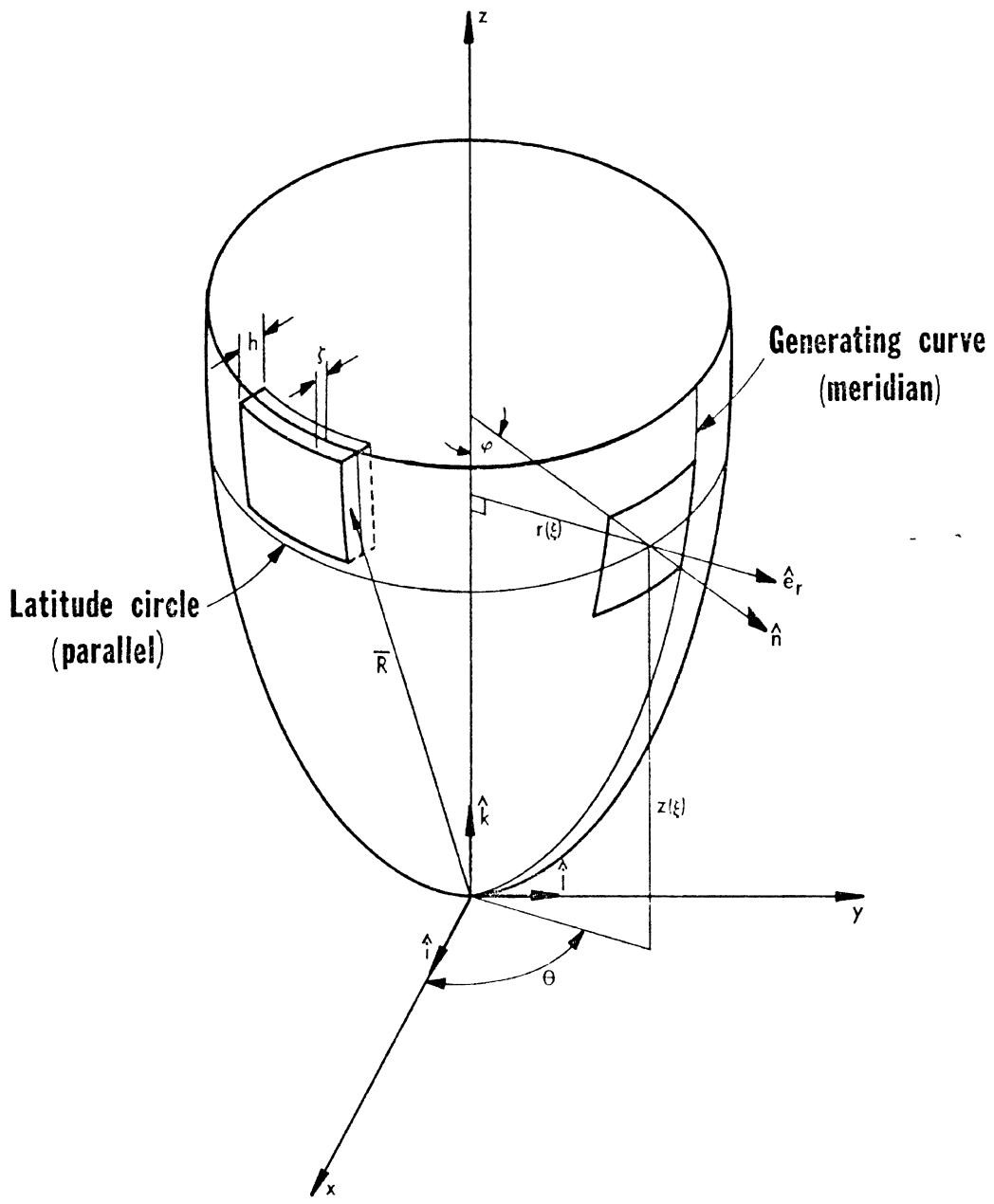


Figure 14 Geometry of a shell of revolution showing various coordinates.

$$\begin{aligned}\epsilon_{\phi} &= \frac{\alpha - \alpha_0 + \zeta \left(\frac{\partial \phi}{\partial \xi} - \frac{d\phi_0}{d\xi} \right)}{\alpha_0 \left(1 + \frac{\zeta}{\alpha_0} \frac{d\phi_0}{d\xi} \right)} \\ \epsilon_{\theta} &= \frac{r - r_0 + \zeta (\sin \phi - \sin \phi_0)}{r_0 \left(1 + \frac{\zeta}{r} \sin \phi_0 \right)}\end{aligned}\quad (18)$$

Due to thinness of the shell the terms with ζ in the denominator of the strain expressions can be neglected. The resulting quantities can now be written as

$$\epsilon_{\phi} = \frac{\alpha - \alpha_0}{\alpha_0} + \zeta \frac{\frac{\partial \phi}{\partial \xi} - \frac{d\phi_0}{d\xi}}{\alpha_0} = \frac{\alpha}{\alpha_0} - 1 + \frac{\zeta}{\alpha_0} \frac{\partial \beta}{\partial \xi}$$

or

$$\begin{aligned}\epsilon_{\phi} &= \left(\frac{\cos \phi_0}{\cos \phi} \right) \left(\frac{1 + \frac{\partial u}{\partial \xi}}{\frac{dr_0}{d\xi}} \right) - 1 + \frac{\zeta}{\alpha_0} \frac{\partial \beta}{\partial \xi} \\ \epsilon_{\theta} &= \frac{r - r_0}{r_0} + \zeta \frac{\sin \phi - \sin \phi_0}{r_0} = \frac{u}{r_0} + \zeta \frac{\sin \phi - \sin \phi_0}{r_0}\end{aligned}\quad (19)$$

We can also define the membrane strains in the following way directly from Fig. 2:

$$\begin{aligned}\epsilon_{\theta} &= \frac{r - r_0}{r_0} = \frac{u}{r_0} \\ \epsilon_{\phi} &= \frac{\alpha - \alpha_0}{\alpha_0} = \frac{\alpha}{\alpha_0} - 1 = \frac{r_{\phi} d\phi}{r_{\phi_0} d\phi_0} - 1\end{aligned}\quad (20)$$

$$\text{From Eq. (20)} \quad r = r_0 (1 + \epsilon_{\theta}) \quad (21a)$$

$$r_{\phi} d\phi = r_{\phi_0} d\phi_0 (1 + \epsilon_{\phi}) \quad (21b)$$

We shall use Eq. (21b) in relating the derivatives with respect to ϕ and ϕ_0 :

$$\frac{1}{r_{\phi}} \frac{\partial [\]}{\partial \phi} = \frac{1}{r_{\phi_0} (1 + \epsilon_{\phi})} \frac{\partial [\]}{\partial \phi_0} \quad (22)$$

Furthermore we have the following relations for the stress resultants, N_{ϕ_0} , N_{θ_0} , of the undeformed shell and the stress resultants, N_{ϕ} , N_{θ} , of the deformed shell:

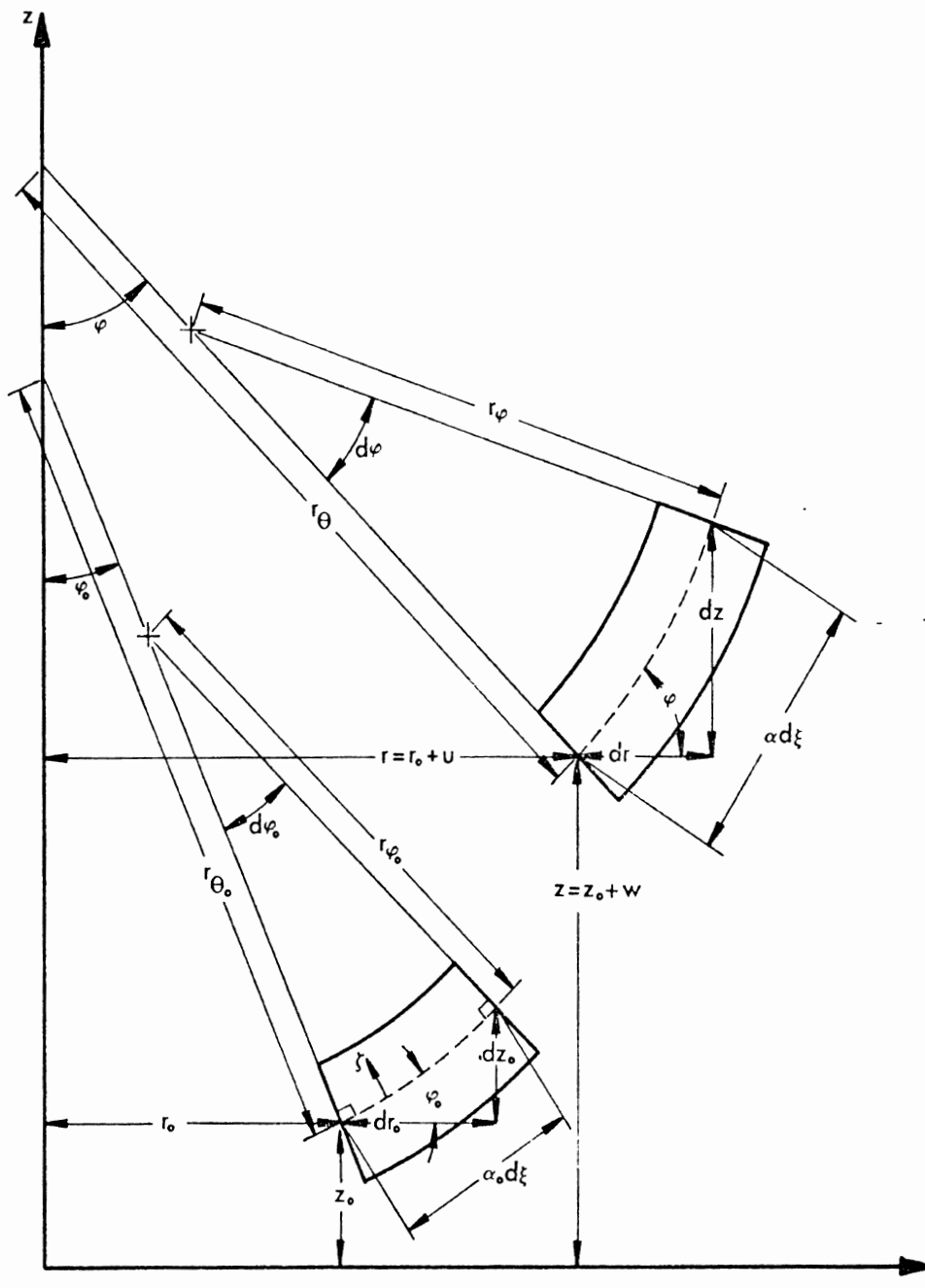


Figure 15 Side view of an element of shell in undeformed and in deformed state.

$$N_{\phi}(r_o + u)d\theta = N_{\phi_o} r_o d\theta \quad (23a)$$

$$N_{\theta} r_{\phi} d\phi = N_{\theta_o} r_{\phi_o} d\phi_o = \frac{N_{\theta_o} r_{\phi} d\phi}{(1 + \epsilon_{\phi})} \quad (23b)$$

In Eq. (23a) inertia effects are neglected since they are second order compared to the stress resultants. For axisymmetric loading the equations of motion (10)-(12) take the following form:

$$\frac{1}{r_{\phi}} \frac{\partial N_{\phi}}{\partial \phi} + \frac{\cot \phi}{r_{\theta}} (N_{\phi} - N_{\theta}) + q_{\phi} = \rho_s h \frac{\partial^2 u_1}{\partial t^2} \quad (24a)$$

$$\frac{N_{\phi}}{r_{\phi}} + \frac{N_{\theta}}{r_{\theta}} - q_n = \rho_s h \frac{\partial^2 u_3}{\partial t^2} \quad (24b)$$

Since the shape of the deformed shell at a given time is not known in advance, it is necessary to express all the quantities occurring in Eqs. (24a) and (24b) in terms of those measured on the undeformed shell. For this we make use of Eqs. (21a)-(23b). Before we do this let us write a different form of Eqs. (24a) and (24b) by writing the dynamic equilibrium of forces parallel to the axis of the shell and in the direction of the radius, r_o :

$$\frac{\partial}{\partial \phi} (N_{\phi} r_{\phi} \sin \phi) + (q_n \cos \phi + q_{\phi} \sin \phi) r r_{\phi} = r r_{\phi} \rho_s h \frac{\partial^2 w}{\partial t^2} \quad (25a)$$

$$\frac{\partial}{\partial \phi} (N_{\phi} r_{\phi} \cos \phi) - N_{\theta} r_{\phi} + (q_{\phi} \cos \phi - q_n \sin \phi) r r_{\phi} = r r_{\phi} \rho_s h \frac{\partial^2 u}{\partial t^2} \quad (25b)$$

where $r = r_o + u = r_{\theta} \sin \phi$. We can now express Eqs. (25a) and (25b) in terms of undeformed variables:

From Eq. (25a)

$$\frac{\partial (N_{\phi_o} r_o \sin \phi)}{\partial \phi_o} + (q_n \cos \phi + q_{\phi} \sin \phi) (1 + \epsilon_{\theta}) (1 + \epsilon_{\phi}) r_o r_{\phi_o} = (1 + \epsilon_{\theta}) (1 + \epsilon_{\phi}) r_o r_{\phi_o} \rho_s h \frac{\partial^2 w}{\partial t^2} \quad (26a)$$

Similarly from Eq. (25b)

$$\begin{aligned} & \frac{\partial(N_{\phi_0} r_o \cos\phi)}{\partial\phi_0} - N_{\theta_0} r_{\phi_0} + (q_{\phi} \cos\phi - q_{\eta} \sin\phi)(1 + \epsilon_{\theta})(1 + \epsilon_{\phi})r_o r_{\phi_0} \\ & = (1 + \epsilon_{\theta})(1 + \epsilon_{\phi})r_o r_{\phi_0} \rho_s h \frac{\partial^2 u}{\partial t^2} \end{aligned} \quad (26b)$$

Geometrical Relations - II

With the help of Fig.15 we can write the following geometrical relations:

$$dr_o = r_{\phi_0} d\phi_o \cos\phi_o \quad (27a)$$

$$dz_o = r_{\phi_0} d\phi_o \sin\phi_o \quad (27b)$$

$$dr = r_{\phi} d\phi \cos\phi = r_{\phi_0} d\phi_o (1 + \epsilon_{\phi}) \cos\phi \quad (27c)$$

$$dz = r_{\phi} d\phi \sin\phi = r_{\phi_0} d\phi_o (1 + \epsilon_{\phi}) \sin\phi \quad (27d)$$

$$\text{From Eq. (27d) } \frac{dz}{d\phi_o} = r_{\phi_0} (1 + \epsilon_{\phi}) \sin\phi \quad (28a)$$

Next let us differentiate Eq. (21a) with respect to ϕ_o and use Eqs. (27a) and (27c) in the differentiated expression to obtain the following relation

$$(1 + \epsilon_{\phi}) \cos\phi = (1 + \epsilon_{\theta}) \cos\phi_o + \frac{r_o}{r_{\phi_0}} \frac{d\epsilon_{\theta}}{d\phi_o} \quad (28b)$$

Stress-Strain Relations for the Shell

Due to the highly nonlinear behavior of the biological tissues the linear Hook's Law is not applicable for the analysis. We will use the concept of strain energy function, W , in describing the material behavior of the shell. Furthermore the material is assumed to be elastic, isotropic and incompressible. The strain energy function, W , is a function of the three strain invariants I_1 , I_2 , I_3 which are defined by:

$$\begin{aligned} I_1 &= \lambda_1^2 + \lambda_2^2 + \lambda_3^2 \\ I_2 &= \lambda_1^2 \lambda_2^2 + \lambda_2^2 \lambda_3^2 + \lambda_3^2 \lambda_1^2 \\ I_3 &= \lambda_1^2 \lambda_2^2 \lambda_3^2 \end{aligned} \quad (29)$$

where $\lambda_1, \lambda_2, \lambda_3$ are the stretch-ratios along the three principal directions [e.g. see Green and Adkins (1960)].

For an incompressible material strain invariants become

$$\begin{aligned} I_1 &= \lambda_1^2 + \lambda_2^2 + \lambda_3^2 = \lambda_1^2 + \lambda_2^2 + \lambda_1^{-2}\lambda_2^{-2} \\ I_2 &= \lambda_1^{-2} + \lambda_2^{-2} + \lambda_3^{-2} = \lambda_1^{-2} + \lambda_2^{-2} + \lambda_1^2\lambda_2^2 \\ I_3 &= \lambda_1^2\lambda_2^2\lambda_3^2 = 1 \end{aligned} \quad (30)$$

The biaxial state of stress is given by

$$\begin{aligned} t_1 &= 2\left(\lambda_1^2 - \frac{1}{\lambda_1^2\lambda_2^2}\right)\left(\frac{\partial W}{\partial I_1} + \lambda_2^2\frac{\partial W}{\partial I_2}\right) \\ t_2 &= 2\left(\lambda_2^2 - \frac{1}{\lambda_1^2\lambda_2^2}\right)\left(\frac{\partial W}{\partial I_1} + \lambda_1^2\frac{\partial W}{\partial I_2}\right) \end{aligned} \quad (31)$$

where t_1 and t_2 are the physical components of stress referred to the deformed state. In our particular formulation of the shell problem $\lambda_1 \equiv \lambda_\theta = 1 + \epsilon_\theta$ and $\lambda_2 \equiv \lambda_\phi = 1 + \epsilon_\phi$. Since we are using variables measured in the undeformed state, the stress resultant stretch-ratio relation for the shell can now be written as

$$\begin{aligned} N_{\theta_o} \lambda_\theta &= 2h\left(\lambda_\theta^2 - \frac{1}{\lambda_\theta^2\lambda_\phi^2}\right)\left(\frac{\partial W}{\partial I_1} + \lambda_\phi^2\frac{\partial W}{\partial I_2}\right) \\ N_{\phi_o} \lambda_\phi &= 2h\left(\lambda_\phi^2 - \frac{1}{\lambda_\theta^2\lambda_\phi^2}\right)\left(\frac{\partial W}{\partial I_1} + \lambda_\theta^2\frac{\partial W}{\partial I_2}\right) \end{aligned} \quad (32)$$

For W any suitable form can be chosen; for example, Aubert (1955) has chosen an exponential form for the load-extension relation of the sartorius muscle. Here, we can also accept an exponential form of W for the abdominal wall:

$$W(I_1, I_2) = c_1 [e^{c_2 I_1 (I_1^2 - 3I_2)} - 1] \quad (33a)$$

where c_1 and c_2 are two parametric constants. Another useful form of W for incompressible material is:

$$W = W(I_1 - 3, I_2 - 3) \quad (33b)$$

Treloar (1958) has given a power series expansion of Eq. (33b) in the following double series form:

$$W = \sum_{i=0, j=0}^{\infty} c_{ij} (I_1 - 3)^i (I_2 - 3)^j \quad (33c)$$

Recently, Hoppmann and Wan (1970) represented the strain energy function in a Taylor's series as follows:

$$W = \sum_{n=1}^{\infty} \{A_{1n} (I_1 - 3) + A_{2n} (I_2 - 3)\}^n \quad (33d)$$

where the terms A_{1n} and A_{2n} represent the usual partial derivatives in a Taylor's expansion, evaluated at I_1 equal 3 and I_2 equal 3. Incidentally, both representations given by Eqs. (33c) and (33d) are equivalent.

Equation of Motion for Fluid

For an incompressible viscous fluid the Navier-Stokes equations and the equation of continuity in the case of axisymmetric motion in cylindrical coordinates [e.g. see Landau-Lifshitz (1959)] are:

$$\frac{\partial v_r}{\partial t} + v_r \frac{\partial v_r}{\partial r} + v_z \frac{\partial v_r}{\partial z} = - \frac{1}{\rho_f} \frac{\partial p}{\partial r} + \nu \left(\frac{\partial^2 v_r}{\partial r^2} + \frac{\partial^2 v_r}{\partial z^2} + \frac{1}{r} \frac{\partial v_r}{\partial r} - \frac{v_r}{r^2} \right) \quad (34a)$$

$$\frac{\partial v_z}{\partial t} + v_r \frac{\partial v_z}{\partial r} + v_z \frac{\partial v_z}{\partial z} = - \frac{1}{\rho_f} \frac{\partial p}{\partial z} + \nu \left(\frac{\partial^2 v_z}{\partial r^2} + \frac{\partial^2 v_z}{\partial z^2} + \frac{1}{r} \frac{\partial v_z}{\partial r} \right) \quad (34b)$$

$$\frac{\partial v_r}{\partial r} + \frac{\partial v_z}{\partial z} + \frac{v_r}{r} = 0 \quad (34c)$$

where v_r and v_z are the fluid velocities in the r and z directions, ρ_f is the fluid density, $\nu = \frac{\mu}{\rho_f}$ is the kinematic viscosity and p is dynamic fluid pressure.

Boundary Conditions Between Fluid and Shell

Whether the fluid is viscous or not, the kinematical condition that the normal velocity of the fluid in contact with the shell must be equal to the normal velocity of the shell, should be satisfied. If the fluid is viscous (i.e. $\nu \neq 0$)

than the continuity of tangential velocities is also required. Thus there is no relative motion between the shell and the fluid when they are in contact with each other. This condition can be stated in vectorial form on the boundary as follows:

$$\vec{V}_s - \vec{V}_f = 0 \quad (35)$$

The two scalar components of Eq. (35) along r and z directions are:

$$\frac{\partial u}{\partial t^2} - v_r = 0 \quad (36a)$$

$$\frac{\partial w}{\partial t^2} - v_z = 0 \quad (36b)$$

Before we continue further, note that since the displacement of shell in r direction is given by $u = r - r_o = r_o \epsilon_\theta = r_o (\lambda_\theta - 1)$, $\frac{\partial^2 u}{\partial t^2} = r_o \frac{\partial^2 \lambda_\theta}{\partial t^2}$. Similarly, $\frac{\partial^2 w}{\partial t^2} = \frac{\partial^2 z}{\partial t^2}$, hence the boundary conditions between the fluid and shell become

$$\frac{\partial^2 \lambda_\theta}{\partial t^2} = v_r / r_o \quad (37a)$$

$$\frac{\partial^2 z}{\partial t^2} = v_z \quad (37b)$$

In light of the above change of variables, the equations of motion, Eqs. (26a) and (26b), of the shell become:

$$\frac{\partial(N_{\phi_o} r_o \sin\phi)}{\partial\phi_o} + (q_n \cos\phi + q_\phi \sin\phi) \lambda_\theta \lambda_\phi r_o r_{\phi_o} = \lambda_\theta \lambda_\phi r_o r_{\phi_o} \rho_s h \frac{\partial^2 w}{\partial t^2} \quad (38a)$$

$$\frac{\partial(N_{\phi_o} r_o \cos\phi)}{\partial\phi_o} - N_{\theta_o} r_{\phi_o} + (q_\phi \cos\phi - q_n \sin\phi) \lambda_\theta \lambda_\phi r_o^2 r_{\phi_o} = \lambda_\theta \lambda_\phi r_o r_{\phi_o} \rho_s h \frac{\partial^2 \lambda_\theta}{\partial t^2} \quad (38b)$$

where for a given shell r_o and r_{ϕ_o} are known functions and q_n and q_ϕ are t and ϕ dependent scalar components of the external force on the shell. Eqs. (28a) and (28b) become

$$\frac{\partial w}{\partial\phi_o} = r_{\phi_o} \lambda_\phi \sin\phi - \frac{dz_o}{d\phi_o} \quad (39a)$$

$$\lambda_\phi \cos\phi = \lambda_\theta \cos\phi_o + \frac{r_o}{r_{\phi_o}} \frac{\partial \lambda_\theta}{\partial\phi_o} \quad (39b)$$

Eqs. (32), (34), (38) and (39) are nine partial differential equations for the nine unknowns, N_{ϕ_0} , N_{θ_0} , λ_ϕ , λ_θ , ϕ , w , v_r , v_z and p ; hence, in principle the formulation of the problem has been completed.

If desired, the above formulation can be extended to include another fluid-filled shell of revolution having a common symmetry axis with the outside shell. Of course, this addition will complicate the problem extremely since nine more partial differential equations very similar to those given by Eqs. (32), (34), (38) and (39) will be added to the original set, bringing the total number of unknowns to eighteen.

The application of the present formulation of the fluid-filled shells of revolution to a specific geometry and the solution of the resulting equations will constitute future investigations in the area of abdominal injury modeling.

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6.4 NOMENCLATURE

A_1^2, A_2^2, A_3^2	The first order fundamental quantities
I_1, I_2, I_3	Strain invariants
M_1, M_2, M_{12}	Moment resultants
N_1, N_2, N_{12}	Stress resultants
N_{ϕ_0}, N_{θ_0}	Stress resultants referred to the undeformed shell
N_ϕ, N_θ	Stress resultants referred to the deformed shell
Q_1, Q_2	Stress resultants in the transverse direction
R_1, R_2	Radii of curvature
W	Strain energy function for the shell material
h	Shell thickness
$\hat{i}, \hat{j}, \hat{k}$	Unit vectors for the (x, y, z) coordinate system
p	Dynamic fluid pressure
q_1, q_2, q_n	Scalar components of the total surface force along α_1, α_2 and the shell normal, respectively
r_o, r	$r_{\theta_0} \sin \phi_o, r_\theta \sin \phi$ respectively
r_{θ_0}, r_{ϕ_0}	Radii of curvature for the undeformed shell
r_θ, r_ϕ	Radii of curvature for the deformed shell
t	Time
t_1, t_2	The physical components of stress referred to the deformed state
$\hat{t}_1, \hat{t}_2, \hat{n}$	Unit vectors along α_1, α_2 and the shell normal, respectively
u_1, u_2, u_3	Displacement components of the shell midsurface along α_1, α_2 and the shell normal, respectively

- u, w Displacement components of the shell midsurface along the axial (z) and the radial (r) directions, respectively
- v_r, v_z The fluid velocities in the radial (r) and axial (z) directions, respectively
- (x, y, z) Cartesian coordinate system
- α_1, α_2 Curvilinear coordinates for the shell surface
- α_o, α $\left[\left(\frac{dr}{d\xi} \right)^2 + \left(\frac{dz}{d\xi} \right)^2 \right]^{1/2}$, $\left[\left(\frac{\partial r}{\partial \xi} \right)^2 + \left(\frac{\partial z}{\partial \xi} \right)^2 \right]^{1/2}$, respectively
- β The rotation of a tangent to a meridian at a given material point
- $\epsilon_\phi, \epsilon_\theta$ The membrane strains in ϕ and θ directions, respectively
- θ, ϕ Circumferential angle and the angle formed by the normal of the shell surface and the axis of revolution, respectively
- $\lambda_1, \lambda_2, \lambda_3$ The stretch-ratios in the three principal directions
- $\lambda_\theta, \lambda_\phi$ The stretch-ratios in the directions of θ and ϕ , respectively
- μ Dynamic viscosity for the fluid
- ν μ/ρ_f , kinematic viscosity for the fluid
- ρ_f, ρ_s Densities of fluid and shell, respectively
- (ξ, θ, ζ) Orthogonal curvilinear coordinates for the shell element

7.0 RECOMMENDATIONS AND CONCLUSION

This study of abdominal injury indicates that most of the internal organs can easily be injured by blows to the abdomen. The lethal force levels are low. In the mini-pig a force of 8 x body weight applied over a 7 square inch area in the abdominal region generally ruptured the liver. It is recognized therefore that the abdomen is extremely vulnerable to blunt trauma and great care should be taken in the design of automotive vehicle interior to insure that the abdomen is not impacted by the steering wheel or other protruding levers and knobs. Careful instruction regarding the proper use of seat belts to avoid loading the abdomen should be issued.

The experimental studies described in this report are preliminary and limited in scope. However they clearly show that abdominal injuries can be produced in experimental animals that are amazingly similar to those experienced by humans in automotive vehicle accidents. More work must be performed before suitable correlation and scaling relationships can be developed to adequately describe human abdominal impact tolerance on a quantitative basis.

The mathematical analysis described in this report will provide a basis for further modeling efforts and demonstrate the feasibility of this approach.

In terms of effective emergency treatment in response to abdominal trauma an understanding of the mechanism of injury is of the greatest importance, for only through a knowledge of the forces applied in each individual case is the proper management of that patient possible. A few minutes at the very onset devoted to learning the details of the accident are almost indispensable. Careful attention to the location of contusions and lacerations about the abdomen may be the key to acquiring an understanding of the direction and intensity of the forces applied and thru that an immediate diagnosis of the organs involved and the level of injury.

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APPENDICES

APPENDIX A
BIBLIOGRAPHY

Appendix A
BIBLIOGRAPHY

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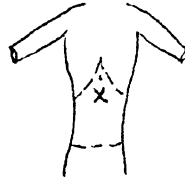
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APPENDIX B
REPRESENTATIVE DATA SHEETS

IMPACT TOLERANCE
 Contract FH-11-7608

SUMMARY SHEET

1. Run Number	71-13 ab	
2. Animal, species and sex	Vervet Adult Male	
3. Area and Type of Impact	Upper frontal thorax-abdomen	
4. Velocity Impact	22.0	mph
5. Animal Total Body Weight	9.35	lbs.
6. Area of Impactor	8.0	in. ²
7. Type of Impactor	8" X 1" rigid impactor	
8. Location of Impact		



20% (sternum - hips)

9. Impact Duration	11.4	msec
10. Peak Contact Force	300.	lbs.
11. Force/Area	81.0	lbs/in ²
12. Impulse	Does not apply	lb-sec.
13. Depth of Penetration	2.29 inches	54.3 %
14. Camera Framing Speed	5050.	Frames/sec.
15. Blow-Up Factor	4.65	in/Van. in.
16. Quality of Movie	Good	
17. Animal Arrival:	Feb. 15, 1971	Impact: Feb. 23, 1971
Termination:	Feb. 23, 1971	
18. Evidence of Injury Post-impact:	No obvious signs of injury.	

22.	Loss of Consciousness	<u>No loss</u>	<u>min.</u>		
23.	Heart-Beat Rate Pre-impact	<u>90</u>	<u>beats/min.</u>		
	Post-impact	<u>60</u>	<u>beats/min.</u>		
24.	Respiratory Rate Pre-impact	<u>20</u>	<u>breaths/min.</u>		
	Post-impact	<u>18</u>	<u>breaths/min.</u>		
25.	Reflex State (pupillary, eyelid, ear pinch, etc.)				
	Pre-impact	<u>All present - slow</u>			
	Post-impact	<u>No corneal - all else</u>			
26.	Behavior Pre-impact	<u>Appears normal</u>			
	Post-impact	<u>Appears slowed down</u>			
27.	Anesthetic Used <u>Ketamine (I.M.)</u>	Amount <u>23.5</u>	<u>mg/kg</u>		
	Approx. Time Last Injection Given	<u>N.A.*</u>			
	Approx. Time Impact	<u>N.A.*</u>			
	Condition of Animal	<u>Moderately drugged</u>			
28.	X-rays Pre-impact	<u>None</u>			
	Post-impact	<u>None</u>			
29.	Blood Samples:	<u>N.A.*</u>			
	<u>Pre</u>	<u>Post</u>	<u>1 Day</u>		
			<u>2 Days</u>		
			<u>Other</u>		
	SGOT	<u> </u>	<u> </u>	<u> </u>	<u>Int. Units</u>
	SGPT	<u> </u>	<u> </u>	<u> </u>	<u>Int. Units</u>
	LDH	<u> </u>	<u> </u>	<u> </u>	<u>Int. Units</u>
	AIKP'tase	<u> </u>	<u> </u>	<u> </u>	<u>Int. Units</u>
	CPK	<u> </u>	<u> </u>	<u> </u>	<u>Int. Units</u>
30.	Skull Cleaned and Stored	<u>No</u>			
31.	EKG Pre-impact	<u>Yes</u>			
	Post-impact	<u>Yes</u>			

*Not available

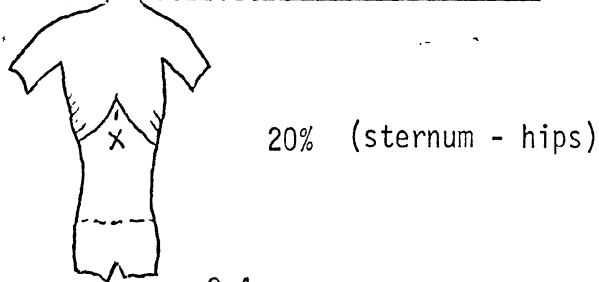
32. Autopsy Comments: 30 cc blood in the abdominal cavity;
severe laceration or rupture of the pancreas; numerous minor
lacerations in the liver; minor mesenteric hemorrhage; lung
compliance decrease, 12%; lung weight 27 g indicative of some
congestion.

Histopathology: None

33. Scaling Index Number: 3

IMPACT TOLERANCE
Contract FH-11-7608

SUMMARY SHEET

1. Run Number	<u>71-26 ab</u>		
2. Animal, species and sex	<u>Vervet Adult Female</u>		
3. Area and Type of Impact	<u>Upper frontal thoracic-abdom.</u>		
4. Velocity Impact	<u>22.9</u>		<u>mph</u>
5. Animal Total Body Weight	<u>7.04</u>		<u>lbs.</u>
6. Area of Impactor	<u>6.0</u>		<u>in²</u>
7. Type of Impactor	<u>1" X 6" flexible impactor</u>		
8. Location of Impact			
9. Impact Duration	<u>8.4</u>		<u>msec</u>
10. Peak Contact Force	<u>304</u>		<u>lbs.</u>
11. Force/Area	<u>88.8</u>		<u>lbs/in²</u>
12. Impulse	<u>Does not apply</u>		
13. Depth of Penetration	<u>0.89</u>	<u>inches</u>	<u>26.0*</u> %
14. Camera Framing Speed	<u>4240.</u>		<u>Frames/sec</u>
15. Blow-Up Factor	<u>2.78</u>		<u>in/Var.in.</u>
16. Quality of Movie	<u>Good</u>		
17. Animal Arrival:	<u>February 18, 1971</u>	Impact:	<u>March 24, 1971</u>
Termination:	<u>March 24, 1971</u>		
18. Evidence of Injury Post-Impact:	<u>No obvious signs of injury</u>		

*calculated values

22.	Loss of Consciousness	<u>No loss</u>	<u>min.</u>
23.	Heart-Beat Rate Pre-impact	<u>150</u>	<u>beats/min.</u>
	Post-impact	<u>180</u>	<u>beats/min.</u>
24.	Respiratory Rate Pre-impact	<u>32</u>	<u>breaths/min.</u>
	Post-impact	<u>28</u>	<u>breaths/min.</u>
25.	Reflex state (pupillary, eyelid, ear pinch, etc.)		
	Pre-impact	<u>All appears normal</u>	
	Post-impact	<u>All present and normal</u>	
26.	Behavior Pre-impact	<u>Appears normal</u>	
	Post-impact	<u>No apparent change</u>	
27.	Anesthetic Used <u>Ketamine (I.M.)</u>	Amount <u>31.3</u>	<u>mg/kg</u>
	Approx. Time Last Injection Given	<u>N.A.*</u>	
	Approx. Time Impact	<u>N.A.*</u>	
	Condition of Animal	<u>Moderately drugged</u>	
28.	X-rays Pre-impact	<u>None</u>	
	Post-impact	<u>None</u>	
29.	Blood Samples:	<u>N.A.*</u>	
	<u>Pre</u>	<u>Post</u>	<u>1 Day</u>
	<u>2 Days</u>	<u>Other</u>	
	SGOT	<u>Int. Units</u>	
	SGPT	<u>Int. Units</u>	
	LDH	<u>Int. Units</u>	
	AIKP'tase	<u>Int. Units</u>	
	CPK	<u>Int. Units</u>	
30.	Skull Cleaned and Stored	<u>No</u>	
31.	EKG Pre-impact	<u>Yes</u>	
	Post-impact	<u>Yes</u>	

*Not available

32. Autopsy Comments: 30 cc free blood in abdomen.

Lacerations left and right lobes of the liver, anterior and
posterior. Pancreas - some hemorrhage near head.

No duodenal-colon tears.

Lungs - moderate gross congestion wt. 30.5 g.

Autopsied same day as impact.

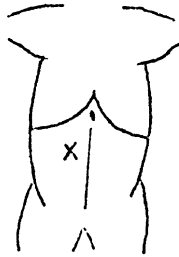
Histopathology: None

33. Scaling Index Number: 2

IMPACT TOLERANCE
Contract FH-11-7608

SUMMARY SHEET

- 1. Run Number 71-47 ab
- 2. Animal, species and sex Mini-Pig Adult Male
- 3. Area and Type of Impact Mid frontal abd. 6" right side
- 4. Velocity Impact 27.6 mph
- 5. Animal Total Body Weight 128 lbs
- 6. Area of Impactor 7.06 in²
- 7. Type of Impactor 1-1/2" radius circular rigid impactor
- 8. Location of Impact 6" from xiphium right side



6" from xiphium right side

- 9. Impact Duration 17.5 msec
- 10. Peak Contact Force 700 lbs.
- 11. Force/Area 99.2 lbs/in.²
- 12. Impulse Does not apply lbs-sec.
- 13. Depth of Penetration 5.3 inches 44.1 %
- 14. Camera Framing Speed 5000 Frames/sec.
- 15. Blow-Up Factor 3.01 in/Var. in.
- 16. Quality of Movie Good
- 17. Animal Arrival May 13, 1971 Impact May 13, 1971
Termination May 13, 1971
- 18. Evidence of Injury Post-impact No obvious signs of injury.

22. Loss of Consciousness No loss min.
23. Heart-Beat Rate Pre-impact 120 beats/min.
Post-impact 210 beats/min.
24. Respiratory Rate Pre-impact Not recorded breaths/min.
Post-impact Not recorded breaths/min.
25. Reflex State (pupillary, eyelid, ear pinch, etc.)
Pre-impact None
Post-impact None
26. Behavior Pre-impact Appears normal
Post-impact Can not be determined
27. Anesthetic Used Sernylan (I.M.) Na Pento (I.M.) Amount >30 mg/kg
Approx. Time Last Injection Given N.A.*
Approx. Time Impact N.A.*
Condition of Animal Mod - deeply drugged
28. X-rays Pre-impact None
Post-impact None
29. Blood Samples N.A.*
- | | <u>Pre</u> | <u>Post</u> | <u>1 Day</u> | <u>2 Days</u> | <u>Other</u> | |
|-----------|--------------|--------------|--------------|---------------|--------------|------------|
| SGOT | <u>_____</u> | <u>_____</u> | <u>_____</u> | <u>_____</u> | <u>_____</u> | Int. Units |
| SGPT | <u>_____</u> | <u>_____</u> | <u>_____</u> | <u>_____</u> | <u>_____</u> | Int. Units |
| LDH | <u>_____</u> | <u>_____</u> | <u>_____</u> | <u>_____</u> | <u>_____</u> | Int. Units |
| AIKP'tase | <u>_____</u> | <u>_____</u> | <u>_____</u> | <u>_____</u> | <u>_____</u> | Int. Units |
| CPK | <u>_____</u> | <u>_____</u> | <u>_____</u> | <u>_____</u> | <u>_____</u> | Int. Units |
30. Skull Cleaned and Stored No
31. Ekg Pre-impact Yes
Post-impact Yes

*Not available

32. Autopsy Comments: Five hundred cc blood in the abdominal cavity;
very severe lacerations between the right and left lobes of the
liver, the lobes were almost torn apart; no other evidence of
injury except partial consolidation of a small central lobe of
the lungs, lung weight 378 gms.

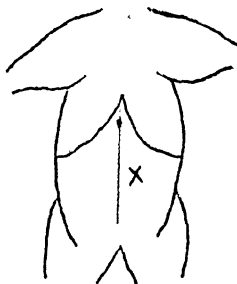
Histopathology: None

33. Scaling Index Number: 5

IMPACT TOLERANCE
Contract FH-11-7608

SUMMARY SHEET

1. Run Number 71-50 ab
 2. Animal, species and sex Mini-Pig Adult Male
 3. Area and Type of Impact Mid frontal abd. 6" left side
 4. Velocity Impact 30.8 mph
 5. Animal Total Body Weight 99. lbs.
 6. Area of Impactor 7.06 in²
 7. Type of Impactor 1-1/2" radius circular rigid impactor
 8. Location of Impact _____



6" from xiphium left side

9. Impact Duration 10 msec
 10. Peak Contact Force 850 lbs.
 11. Force/Area 120 lbs/in²
 12. Impulse Does not apply lb-sec
 13. Depth of Penetration 4.98 inches 38.6 %
 14. Camera Framing Speed 5000 Frames/sec.
 15. Blow-Up Factor 3,05 in/Van.in.
 16. Qulaity of Movie Good
 17. Animal Arrival: May 18, 1971 Impact: May 18, 1971
 Termination: May 18, 1971
 18. Evidence of Injury Post-impact No obvious signs of injury.

22.	Loss of Consciousness	<u>No loss</u>	<u>min.</u>
23.	Heart-Beat Rate Pre-impact	<u>90</u>	<u>beats/min.</u>
	Post-impact	<u>150</u>	<u>beats/min.</u>
24.	Respiratory Rate Pre-impact	<u>Not recorded</u>	<u>breaths/min.</u>
	Post-impact	<u>Not recorded</u>	<u>breaths/min.</u>
25.	Reflex State (Pupillary, eyelid, ear pinch, etc.)		
	Pre-impact	<u>None</u>	
	Post-impact	<u>None</u>	
26.	Behavior Pre-impact	<u>Appears Normal</u>	
	Post-impact	<u>Cannot determine</u>	
27.	Anesthetic Used	<u>Sernylan (I.M.) Pento (I.M.)</u>	<u>Amount >30 mg/kg</u>
	Approx. Time Last Injection Given	<u>N.A.*</u>	
	Approx. Time Impact	<u>N.A.*</u>	
	Condition of Animal	<u>Moderate - deeply drugged</u>	
28.	X-rays Pre-impact	<u>None</u>	
	Post-impact	<u>None</u>	
29.	Blood Samples:	<u>N.A.*</u>	
	<u>Pre</u>	<u>Post</u>	<u>1 Day</u> <u>2 Days</u> <u>Other</u>
	SGOT	<u> </u>	<u> </u> <u> </u> <u> </u> Int. Units
	SGPT	<u> </u>	<u> </u> <u> </u> <u> </u> Int. Units
	LDH	<u> </u>	<u> </u> <u> </u> <u> </u> Int. Units
	AIKP'tase	<u> </u>	<u> </u> <u> </u> <u> </u> Int. Units
	CPK	<u> </u>	<u> </u> <u> </u> <u> </u> Int. Units
30.	Skull cleaned and stored	<u>No</u>	
31.	EKG Pre-impact	<u>Yes</u>	
	Post-impact	<u>Yes</u>	

*Not available

32. Autopsy Comments: One to two thousand cc blood in the abdominal
cavity; severely lacerated spleen; severe lacerations to the
liver, posterior surface of the left and quadrate lobe; minor
pulmonary edema.

Histopathology: None

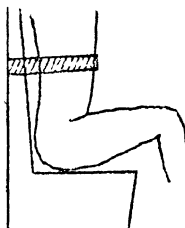
33. Scaling Index Number: 4

IMPACT TOLERANCE
Contract FH-11-7608

SUMMARY SHEET

1. Run Number	<u>71-04 sled</u>
2. Animal, species and sex	<u>Vervet Adult Male</u>
3. Area and Type of Impact	<u>Seat belted - Airbag small sled</u>
4. Sled Velocity	<u>48.5</u> mph
5. Animal Total Body Weight	<u>9.9</u> lbs.
6. Area of Impactor	<u>None</u> in ²
7. Type of Impactor	<u>Seat belt - high and snug</u>
8. Location of Impact	<u>No actual impact</u>

Belt Loading



9. Impact Duration	<u>120</u> msec
10. Peak Belt force	<u>340</u> lbs.
11. Force/Area	<u>68</u> lbs/in ²
12. Sled Acceleration	<u>Peak 36 Ave. 20</u> G's
13. Depth of Penetration	<u>Does not apply</u> inches %
14. Camera Framing Speed	<u>5000</u> Frames/sec.
15. Blow-Up Factor	<u>8.7</u> in/Van.in.
16. Quality of Movie	<u>Good</u>
17. Animal Arrival <u>Feb. 3, 1971</u>	Impact: <u>Feb. 15, 1971</u>
Termination <u>Feb. 15, 1971</u>	
18. Evidence of Injury Post-impact	<u>Tail broken. No other obvious injury.</u>

22.	Loss of Consciousness	<u>Unconscious - stunned</u> <u>1</u> min.					
23.	Heart-Beat Rate Pre-impact	<u>120</u>	<u>beats/min.</u>				
	Post-impact	<u>120</u>	<u>beats/min.</u>				
24.	Respiratory Rate Pre-impact	<u>40</u>	<u>breaths/min.</u>				
	Post-impact	<u>Not recorded</u>	<u>breaths/min.</u>				
25.	Reflex State (pupillary, eyelid, ear pinch, etc.)						
	Pre-impact	<u>All normal</u>					
	Post-impact	<u>after 1 min. all normal</u>					
26.	Behavior Pre-impact	<u>Appears normal</u>					
	Post-impact	<u>Can not be determined</u>					
27.	Anesthetic Used <u>Ketamine (I.M.)</u>	Amount <u>22.2</u>	<u>mg/kg</u>				
	Approx. Time Last Injection Given	<u>N.A.*</u>					
	Approx. Time Impact	<u>N.A.*</u>					
	Condition of Animal	<u>Moderately drugged</u>					
28.	X-rays Pre-impact	<u>None</u>					
	Post-impact	<u>None</u>					
29.	Blood Samples:	<u>N.A.*</u>					
		<u>Pre</u>	<u>Post</u>	<u>1 Day</u>	<u>2 Days</u>	<u>Other</u>	
	SGOT	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u>Int. Units</u>
	SGPT	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u>Int. Units</u>
	LDH	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u>Int. Units</u>
	AIKP'tase	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u>Int. Units</u>
	CPK	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u>Int. Units</u>
30.	Skull cleaned and stored	<u>No</u>					
31.	EKG Pre-impact	<u>Yes</u>					
	Post-impact	<u>Yes</u>					

*Not available

32. Autopsy Comments: Two cc blood in the abdominal region;
contusion to the ascending colon; slight hemorrhage from
the mesenteric vessels; partial laceration of the duodenum
with contents still contained; lung compliance decrease of
44% immediately after the test; minor petechial hemorrhage
just below where the seat belt was positioned during the
test.

Histopathology: None

33. Scoring Index Number: 2

APPENDIX C

CASES OF ABDOMINAL INJURY FROM REVIEW OF THE LITERATURE

A. Lap Belt

CAUSE OF INJURY	AGE	SEX	WT.	PERTINENT DATA	ABDOMINAL INJURIES REPORTED	REFERENCE
1. Seat Belt - collided at 40-50 mph into truck going 10-15 mph	34	M	210		Large adhesion of the terminal ileum to right brim of pelvis	Kulowski & Rost 1956 (379)
2. Seat Belt - aircraft accident - crashed into ground- severe blunt abdominal trauma	55	M			Five separate perforations of the jejunum - peritonitis - severe muscle damage - large infarct replacing 1/2 of rt. liver lobe - pt. died	Bonilla & Bowers 1960 (64)
3. Seat Belt - head on collision - both cars impacting at 35 mph - driver	32	M	120		Ruptured pancreas and duodenum	Garrett & Braunstein 1962 (250)
4. Seat Belt - roll at 55 mph - front right passenger	60	M	180		Contusion of bladder and kidney - severe abdominal wall hematoma and severe contusions of both inguinal regions	Garrett & Braunstein 1962 (250)
5. Seat Belt -					Lower abdominal pain and tenderness - microscopic hematuria	Garrett & Braunstein 1962 (250)
6. Seat Belt - front rt. passenger - automobile accident - belt high on abdomen	25	F		Multiple facial fractures	Perforation of jejunum - peritonitis	Aiken, D.W. 1963 (7)
7. Seat Belt - struck another auto broad-side at 35 mph - front right passenger	62	F	146		Severely ruptured spleen	Cocke & Meyer 1963 (115)
8. Seat Belt - (lap) - car struck telephone pole in left front at 65 mph		M	152		Blow out perforation of the small bowel in the upper jejunal region - mid-abdominal wall contusion	Tolins, S.H. 1964 (684)
9. Seat Belt - (lap) - 60-70 mph into apartment - thrown forward and to the right - front rt. passenger	26	F			Ventral hernia - ecchymosis of abdominal wall	Hurwitt & Silver 1965 (322)
10. Seat Belt - lap belt - airplane crash Middle rt. seat - Army Caribou	31	M			A two ft. segment of terminal ileum was avulsed from its mesentery and bleeding - hematoma of l. transverse mesocolon - capsular tear of spleen - abdominal bruises	Fish & Wright 1965 (221)
11. Seat Belt - lap belt - airplane crash rt. rear seat - Army Caribou	25	M			Proximal ileum was partially transected and the adjacent bowel contused - abdominal wall contusions	Fish & Wright 1965 (221)
12. Seat Belt - lap belt - airplane crash rt. rear seat - Army Caribou	31	M			Lacerated proximal ileum - large mesenteric tear - seat belt contusions	Fish & Wright 1965 (221)
13. Seat Belt - lap belt - airplane crash - rt. rear seat - Army Caribou	26	M			Large segment of small intestine and a segment of sigmoid colon were avulsed from their mesentery - peritoneal hemorrhage - fatal	Fish & Wright 1965 (221)

14.	Seat Belt - lap belt - loosely fastened - rear passenger	48	F		Laceration of jejunum - multiple lacerations of small bowel mesenteric attachments - traumatic amputation of lower half of lower cmentum	Gerritsen, Frobese and Pezzi, 1966 (255)
15.	Seat Belt - lap belt - loosely fastened rear passenger	56	F		Large lacerations of the mesenteric attachment of the small bowel - lacerations of the ileum and cecum - tear of serosa of sigmoid colon - contusions of abdomen - 3000 cc blood in abdominal cavity	Gerritsen, Frobese. and Pezzi, 1966 (255)
16.	Seat Belt - lap belt - front rt. passenger - automobile accident at intersection	55	F	Cardiac arrest	Transverse abdominal seat belt bruise - avulsed small bowel mesentery - superior mesenteric artery bleeding - hemorrhage - pt. died	Herbsman, H. 1966 (302)
17.	Seat Belt - 45 mph into rearend of stopped car - driver	42	M		2 cm perforation on the antimesenteric border of the mid-ileum	Williams, Lies & Hale, 1966 (728)
18.	Seat Belt - travelling at 20 mph - struck in rt. front by another auto at 50 mph - front rt. passenger	33	F	Fracture of L ₂	Contusion of anterior abdominal wall - rectus muscle transected - hematoma of anterior rectus sheath - mid portion of omentum amputated from its attachemnt to the transverse colon - hematoma in mesentery of sm. bowel - rt. colon contused with 3 cm tear in serosa	Williams, Lies & Hale, 1966 (728)
19.	Seat Belt - slid sideways into fire-plug - F. R. passenger	16	F		Transverse tear at the junction of the 2nd and 3rd portions of the duodenum involving 2/3 of circumference	Williams, Lies & Hale 1966 (728)
20.	Seat Belt - head on into tree at 50 mph (+) - rear left passenger	20	M		6 cm. tear in the mesentery of the mid-ileum - similar tear in the mesosigmoid - sigmoid contused with subserosal hemorrhage	Williams, Lies and Hale 1966 (728)
21.	Seat Belt - Lap Belt - rear seat passenger - belt loosely attached - thrown forward at impact		M	Compression fracture of two lumbar vertebrae	Evislon of mesentery and small bowel of the ileum - pt. died	Wood, M. 1966 (743)
22.	Seat Belt - Lap Belt - Skid at 35 mph into pole - thrown laterally against door - driver	25	M		Linear tear of the mesosigmoid extending to its root - avulsion of the mesentery of a four inch segment of redundant sigmoid	Blumenberg, R.M. 1967 (54)
23.	Seat Belt - Lap Belt - front passenger - high speed head-on collision with parked vegetable truck	23	F	Compression fracture of L ₃	Seat belt bruise - perforation of the anti-mesenteric border of the jejunum	Haddad & Zickel 1967 (280)
24.	Seat Belt - Lap Belt - her car struck in rear - belt loosely fastened - front right passenger	26	F		Large hernia containing colon and small intestine in the rt. side of abdomen - ecchymosis and contusion of abdominal wall	Lemire, et al. 1967 (387)

25.	Seat Belt - Lap Belt - head-on collision - seat belt broke	24	M	4 cm perforation in the proximal end of the jejunum	Lemire, et al. 1967 (337)
26.	Seat Belt - Lap Belt - head-on at 50 mph - front seat passenger	27	M	Contused segment of distal ileum with 5 in. rent in mesentery - arterial bleeding - retroperitoneal hematoma - 1500 cc blood	Sube, Ziperman, McIver 1967 (667)
27.	Seat Belt - Lap Belt - head-on at 50 mph - rear seat passenger	38	F	Two complete transections of the jejunum - transverse mesocolon torn from its posterior attachments	Sube, Ziperman, McIver, 1967 (667)
28.	Seat Belt - rear end collision - rear seat passenger	61	F	Tear in the mesentery of the small bowel with about 12 in. of gangrenous bowel found - peritonitis - intermedullary hemorrhage into left adrenal gland - fatal	Backwinkel, K.D. 1968 (30)
29.	Seat Belt - ran into rear of trailer truck - high speed - front seat passenger	19	M	Small perforation of the ileum - large rent in mesentery of the small bowel - incomplete tear of the ileocolic artery - 15 cm. long segment of sigmoid colon completely stripped of its external coat	Backwinkel, K.D. 1968 (30)
30.	Seat Belt - Lap Belt - back seat passenger in sedan - high speed collision with tree	21	M	Abdominal bruises	Carroll & Gruber 1968 (99)
31.	Seat Belt - Lap Belt - back seat passenger in sedan - high speed collision with tree	20	M	Abdominal bruises - hematoma	Carroll & Gruber 1968 (99)
32.	Seat Belt - Lap Belt - two car collision	59	M	Cerebral concussion	DiFiore & Gin 1968 (146)
33.	Seat Belt - Lap Belt - two car collision	62	F	Multiple lacerations	DiFiore & Gin 1968 (146)
34.	Seat Belt - Lap Belt - automobile accident	45	F	Two perforations of jejunum - perforated sigmoid colon	DiFiore & Gin 1968 (146)
35.	Seat Belt - Lap Belt - automobile accident	20	F	Ruptured liver	DiFiore & Gin 1968 (146)
36.	Seat Belt - Lap Belt - automobile accident	16	M	Multiple rib fractures	DiFiore & Gin 1968 (146)
37.	Seat Belt - Lap Belt - automobile accident	42	M	Massive brain damage	DiFiore & Gin 1968 (146)

38.	Seat Belt - Lap Belt - automobile accident	34	M	Ruptured spleen - mid-abdominal (wall) laceration	DiFiore & Gin 1968 (146)
39.	Seat Belt - Lap Belt - automobile accident	24	M	Ruptured liver	DiFiore & Gin 1968 (146)
40.	Seat Belt - Lap Belt - automobile accident	65	F	Hernia	DiFiore & Gin 1968 (146)
41.	Seat Belt - Lap Belt - automobile accident	30	F	Abdominal (wall) fat necrosis	DiFiore & Gin 1968 (146)
42.	Seat Belt - Lap Belt - automobile accident	44	F	Abdominal (wall) contusion	DiFiore & Gin 1968 (146)
43.	Seat Belt - head on collision	45	M	Large mesenteric laceration beneath 15" segment of infarcted ileum - abdominal contusions	Doersch & Dozier 1968 (150)
44.	Seat Belt - head on collision	21	M	Two perforations of the cecum with abscesses - mesenteric tears - hemoperitoneum	Doersch & Dozier 1968 (150)
45.	Seat Belt - head on collision	23	F	Vertebra fracture (4th)	Doersch & Dozier 1968 (150)
46.	Seat Belt - Driver - struck tree at 50 mph - flexed over steering wheel and struck instrument panel in front of and to the left of the steering wheel	23	M	Vertebra fracture (5th)	Doersch & Dozier 1968 (150)
47.	Seat Belt - Lap Belt - head on collision	21	M	Skull fracture and cerebral injury	Huelke & Chewning 1968 (317)
48.	Seat Belt - Lap Belt - thrown forward striking head against instrument panel - belt loosely applied	9	F	Two blowout perforations in the midjejunum and proximal ileum - terminal ileum gangrenous with 1/2 absent - contusions over abdomen	Porter & Green 1968 (543)
49.	Seat Belt - Lap Belt - automobile accident	42	M	Complete obstruction of distal ileum - perforation of small bowel	Schneider, R.C., et al., 1968 (593)
				Large tears in mesentery of the small intestine - perforation of the jejunum - contusions.	Shamblin, J.R. 1968 (604)

1968 (6071)

50. Seat Belt - utility pole - front passenger

1968 (742)

51. Seat Belt - Lap Belt - struck an overpass abutment at high speed

1968 (742)

52. Seat Belt - Lap Belt - seated next to driver - head-on collision - her head struck dashboard

1968 (742)

53. Seat Belt - Lap Belt - front seat passenger - collision with another vehicle at high speed

1968 (742)

54. Seat Belt - Lap Belt - front seat passenger - struck concrete barrier at 50 mph - car seat broke loose from floor

1968 (742)

55. Seat Belt - Lap Belt - seated next to driver - automobile accident

1969 (90)

56. Seat Belt - Lap Belt - loosely worn - driver - pick up truck turned over seven times down a 70 ft. cliff

1969 (318)

57. Seat Belt - rear left passenger - front end collision

pylorus - large retroperitoneal hematoma around pancreas - fatal

Perforation of the duodenum just proximal to the superior mesenteric vessels

Perforation on the antimesenteric border of the jejunum - small bowel partly bruised

Segment of the proximal ileum avulsed from its mesenteric root - hemorrhage of the ileal arterial branches - mesentery and serosa torn away from distal jejunum - multiple lacerations of the sigmoid colon mesentery

Two large tears in mesentery of the ileum - complete avulsion of the greater omentum

Contusions of lower abdominal wall - jejunal perforation on the anti-mesenteric border - large laceration of the jejunal mesentery

Third degree seat belt burn - tear in mesenteric arteries to the small bowel - laceration of the inferior vena cava - hepatic flexure and sigmoid colon were both devitalized and crushed - small bowel lacerated - dissection of the abdominal aorta

Tear of anterior abdominal muscles - lacerated ascending colon - abdominal arterial bleeding - fatal

M

F

M

M

F

M

F

Head impacted on dashboard

Wedge fracture of L1

58.	Seat Belt - R. R. passenger - front end collision	13	F		Tearing of anterior abdominal muscles - several tears of the intestinal walls - seat belt bruises	Huelke & Chewing 1969 (313)
59.	Seat Belt - Driver - Headon into x-way sign - spin-hit other sign support behind rt. door.	16	M	Seat belt not tight	Abdominal wall abrasions	Huelke & Chewing 1969 (318)
60.	Seat Belt - R. Left passenger - Headon into x-way sign - spin - hit other sign support behind rt. door	16	F	Vertebra fracture	Abrasions of abdominal wall	Huelke & Chewing 1969 (318)
61.	Seat Belt - front passenger - headon into x-way sign - spin - hit other sign support behind rt. door	17	M	Seat belt snug	Abdominal wall abrasions	Huelke & Chewing 1969 (318)
62.	Seat Belt - R. R. passenger - head on into x-way sign - spin - hit other sign support behind rt. door	18	M	Invasion into his side of car	Ruptured spleen - laceration of peritoneum and jejunal mesentery	Huelke & Chewing 1969 (318)
63.	Seat Belt - R. M. passenger - head on into x-way sign - spin - hit other sign support behind rt. door	17	F		Laceration of spleen - multiple lacerations of liver - abrasions of abdominal wall	Huelke & Chewing 1969 (318)
64.	Seat Belt - lap belt - Driver - automobile accident - car completely demolished	32	M	Compression fracture of L3	Perforation of ileum - small mesenteric rent - seromuscular tears of the small bowel and sigmoid	Macleod & Nicholson 1969 (409)
65.	Seat Belt - Lap Belt - front seat passenger - automobile accident - belt fit tight - 70 mph impact - car demolished	18	M		Abdominal wall contusions - perforation on the antimesenteric surface of the mid-jejunum	Macleod & Nicholson 1969 (409)
66.	Seat Belt - Lap Belt - Driver - automobile accident - 70 mph impact - car demolished	22	M		Abdominal wall contusions - rent in mesentery of proximal and distal ileum - distal ileum completely transected - hematoma in root of mesentery	Macleod & Nicholson 1969 (409)
67.	Seat Belt - Lap Belt - front seat passenger - struck head on by another vehicle - 45 mph	40.	F	110 Fractures of transverse process L1-L4 - fractures of spinous process L4 and L5	Tear of jejunum - occlusion of infrarenal aorta - multiple abscesses - small amount of retroperitoneal hematoma	Rybak & Thomford 1969 (574)
68.	Seat Belt - Lap Belt - snugly fastened - F. R. passenger - 30-40 mph head on into another car travelling 30-40 mph	52	F	Anterior fracture dislocation of L2 on L3	Ecchymotic band across anterior abdominal wall	Steckler, R.M., et al. 1969 (648)

69.	Seat Belt - Lap Belt - loosely fastened - automobile accident - front right seat	31	F	Perforation on the mesenteric border of the jejunum - echymotic area below umbilicus	Traylor, F.A., et al. 1969 (690)
70.	Seat Belt - Lap Belt - loosely fastened - front right passenger - head on collision - head hit dashboard	34	F	Ileum torn from its mesentery (10 cm)	Traylor, F.A., et al. 1969 (690)
71.	Seat Belt - rear seat passenger - head on collision - loosely fastened over upper abdomen	12	F	Abdominal wall abrasion - three perforations of the small bowel - four lacerations of the root of the mesentery - omentum partially avulsed from transverse colon	Traylor, F.A., et al. 1969 (690)
72.	Seat Belt - Lap Belt - firmly fastened over iliac spine - head on collision - rear seat passenger in station wagon	58	M	Echymotic area across lower abdomen - tears in rear of mesentery - perforation in distal jejunum - sigmoid colon completely denuded of its seromuscular coat - multiple small tears of the serosa of the sigmoid colon and its mesentery	Traylor, F.A., et al. 1969 (690)
73.	Seat Belt - Lap Belt - head on collision - rear seat passenger in station wagon	57	F	Abdominal abrasion - perforation of the antimesenteric border of the proximal jejunum - two very small serosal tears of the sigmoid colon	Traylor, F.A., et al. 1969 (690)
74.	Seat Belt - Lap Belt - front passenger - front right of auto ran into concrete abutment	70	F	Comminuted fracture of rt. iliac wing	Boger, M.M. 1970 (59)
75.	Seat Belt - head on into tree at 55 mph - driver - thrown forward and to the rt. towards glovebox	38	M	Serious abdominal abrasion and perforation through the peritoneal cavity	DOT, HS 600 088 Case No. MCR-69-8, 1970 (181)
76.	Seat Belt - laterally impacted concrete pillar at 30-45 mph - driver - thrown back and to left forcing head into roof, then thrown into steering wheel	25	M	Multiple major injuries	DOT, HS 600 024 PB. 190 507, 1970 (162)
77.	Seat Belt - auto sliding laterally at 45 mph impacted on rt. broadside at 50-60 mph - driver - thrown to rt. impacted center arm rest	51	M	Lacerations of the liver, spleen and rt. kidney - fatal	DOT, HS 600 058 PB. 190 742, 1970 (170)
78.	Seat Belt - auto sliding laterally 45 mph impacted rt. broadside at 50-60 mph - F. R. passenger - struck by intruding door	41	F	Extensive lacerations of the stomach, liver, left kidney and spleen - fatal	DOT, HS 600 058 PB. 190 742 (170)

Case No.	Age	Sex	Accident Description	Injury Description	Pathology	Reference
79.	45	F	Seat Belt - Lap Belt - front right passenger - head on collision	Concussion	Perforation of jejunum	Fisher, L.D. (224)(4)
80.	48	M	Seat Belt - Lap Belt - head on collision		Avulsion of sigmoid mesentery - seromuscular tear of sigmoid	Fisher, L.D. (224)(4)
81.	24	M	Seat Belt - Lap Belt - R. L. passenger - auto descending pass at 60-75 mph went into ditch on rt. side of road - sudden stop	Severe comminuted fracture of L3 with avulsion of laminae and spine	Severe abdominal wall contusion and ecchymosis - complete transection of the rt. rectus abdominis muscle - mesentery of ileum avulsed - ileum transected in four places - appendix avulsed from mesentery - seromuscular layer torn from proximal third of sigmoid colon with avulsion of adjacent mesentery	Gill, W.T. (258)(2)
82.	24	M	Seat Belt - Lap Belt - R. R. passenger - auto descending pass at 60-75 mph went into ditch on rt. side of road - sudden stop	Fractured left transverse process of L4	Severe hematoma of rectus muscles - proximal ileum avulsed from its mesentery and was necrotic - segment of sigmoid colon avulsed from mesosigmoid - sigmoid mesentery severely contused and contained hematoma	Gill, W.T. (258)(2)
83.	14	M	Seat Belt - Lap Belt - front seat passenger - travelling at 35 mph struck head on by another vehicle at 65 mph	Fracture of L3	Retropertitoneal hemorrhage - ecchymosis	Greenbaum, E., et al. (258)(2)
84.	19	M	Seat Belt - Lap Belt - driver - head on into a boulder at 25 mph		Contusion of lower abdominal wall - perforation of jejunum 2 in. from Lig. of treitz	Heune, D.R. (304)
85.	18	M	Seat Belt - Lap Belt - passenger - head on into a boulder at 25 mph		Lower abdominal bruise - perforation of jejunum 2 in. from lig. of treitz	Heune, D.R. (304)(1)
86.	22	M	Seat Belt - Lap Belt - driver - head on collision - 50 mph	Fracture of two rt. ribs	Transverse tear in mesentery of ileum	Hoyt, R.K. (315)
87.	20	M	Seat Belt - Lap Belt - automobile accident		Laceration of small bowel mesentery - hemoperitoneum - ecchymotic band across abdomen	Mandelbaum & Enderle (416)(6)
88.	48	M	Seat Belt - Lap Belt - automobile accident		Four perforations of jejunum and ileum and mesentery - ruptured spleen - ecchymotic band across abdomen	Mandelbaum & Enderle (416)
89.	39	F	Seat Belt - Lap Belt - automobile accident		Ecchymotic band across abdomen - two perforations of small intestine and mesentery	Mandelbaum & Enderle (416)
90.	72	F	Seat Belt - Lap Belt - automobile accident	Irreversible Shock	Four perforations of small bowel and mesentery - thrombosed right common iliac artery - ruptured spleen - pt. died	Mandelbaum & Enderle (416)

91.	Seat Belt - Lap Belt - Automobile accident	50	F	Tachycardia (120)	Perforation small bowel mesentery - mesentery with necrosis 13 cms. ileum - ecchymotic band across abdomen	Mandelbaum & Enderle 1970 (416)
92.	Seat Belt - Lap Belt - automobile accident	32	M		Perforation small bowel mesentery - hemoperitoneum 700 cc.	Mandelbaum & Enderle 1970 (416)
93.	Seat Belt - Lap Belt - automobile accident	64	F		Two perforations of small intestine and mesentery - laceration of rt. diaphragm - ecchymotic band across abdomen	Mandelbaum & Enderle 1970 (416)
94.	Seat Belt - Lap Belt - automobile accident	50	F	Contusion of rt. Lung	Perforation of jejunum - ecchymotic band across iliac crest	Mandelbaum & Enderle 1970 (416)
95.	Seat Belt - Lap Belt - F.R. passenger - head on into pickup truck at 50 mph	15	F	Fractured L3	Lower abdominal wall contusion	Marsh & Bailey 1970 (419)
96.	Seat Belt - Lap Belt - rear seat passenger - automobile accident - pt. asleep	22	M	Belt loosely fastened - fracture of L3	Massive bruises of entire lower abdomen	Marsh & Bailey 1970 (419)
97.	Seat Belt - Lap Belt - airplane accident - crash at 90 mph	33	M		Tear (5 in.) in mesentery of ileum - 3000 cc blood	Morton, J.H. 1970 (468)
98.	Seat Belt - Lap Belt - driver - upper body thrown against steering wheel	21	M		Perforated meckels diverticulum (caecum)	Park & Lucas 1970 (538)
99.	Seat Belt - Lap Belt - while passing a truck at 50 mph - struck head on by another auto	35	F	Fracture of L2	Transverse abdominal wall contusion - circumferential serosal tear at mid-jejunal level - punctate laceration of the antimesenteric border of proximal ileum - serosal tear of hepatic flexure of colon	Ritchie, W.P. et al. 1970 (1234)
100.	Seat Belt - Lap Belt - while passing a truck at 50 mph - struck head on by another auto	11	F	Vertebrae fracture (L3-L4)	Extensive ecchymosis over the lower quadrants - circumferential transection of proximal ileum - serosal tear along antimesenteric border of ileum - rent in mesentery of ascending colon	Ritchie, W.P. et al. 1970 (1234)
101.	Seat Belt - Lap Belt - while passing a truck at 50 mph - struck head on by another auto	35	M		Terminal ileum transected in two places - subjacent mesentery also interrupted	Ritchie, W.P. et al. 1970 (1234)
102.	Seat Belt - Lap Belt - automobile accident	45	M		Tear in mesentery of distal ileum - perforation of infarcted segment of terminal ileum	Seitter & Sharp 1970 (599)

Case No.	Accident Description	Age	Sex	Tachycardia	Injuries	Reference
103.	Seat Belt - Lap Belt - driver - automobile accident	44	M		Radial tear of mesentery at level of ileocecal junction with two actively bleeding arteries - gangrene (ileal and cecal)	Seitter & Sharp 1970 (599)
104.	Seat Belt - Lap Belt - front right seat passenger - automobile accident	13	M		Seat belt abrasion - perforation of mid-ileum - avulsion of cecal and ascending colon mesentery	Seitter & Sharp 1970 (599)
105.	Seat Belt - Lap Belt - automobile accident	16	F	Pt. drinking beer	Gross hematuria - ruptured bladder	Seitter & Sharp 1970 (599)
106.	Seat Belt - Lap Belt - front rt. seat - car struck in rear at red light	60	M		Ruptured membranous urethra	Wiles, C.E. 1970 (724)
107.	Seat Belt - Lap Belt - passenger - automobile accident	21	M		Perforation distal to ligament of treitz	Wiles, C.E. 1970 (724)
108.	Seat Belt - Lap Belt - passenger - automobile accident - obese female	32	F		Marked abrasion turned into full thickness skin necrosis	Wiles, C.E. 1970 (724)
109.	Seat Belt - Lap Belt - driver - car struck on rt. side by auto travelling 50 mph	75	F		Lower abdominal wall bruise - intramuscular hematoma	Williams, J.S. 1970 (729)
110.	Seat Belt - Lap Belt - front right passenger - head on collision		F		Contusion of lower abdomen - tear of ileal mesentery (15 cm)	Zeplovitz, F.A. 1970 (758)
111.	Seat Belt - Lap Belt - front right seat passenger - 1963 Pontiac, left road struck fixed object - 35 mph	29	M	Pt. sleeping - head injuries	Laceration of the mesentery of both the large and small bowel - abrasions and small laceration of rt. lower quadrant	Harkins, J.A. 1971 (294)

	F	Fractured pelvis		Ruptured urethra - tremendous umbilical hernia containing transverse colon - pt. died	Brunius & Lindgren 1961 (76)
1. Seat Belt - 2 pt. - passenger - car drove into ditch - struck on passengers side by bus	F				
2. Seat Belt - 2 pt. - front right passenger in Opel Rekord - travelling at 20 mph - struck truck (25 mph) road on	F			Hepatic veins torn from vena cava - pt. died	Engberg, A. 1961 (200)
3. Seat Belt - 2 pt. - driver - hit from side - possible head belt secured under rt. arm - rt. hand steering V.W.	M	Left rib fractures and cardiac arrest		Ruptured left kidney - left renal artery torn from aorta - pt. died	Von Bahr & Eriksson 1961 (695)
4. Seat Belt - 2 pt. - front rt. passenger in Ford Taurus - ran broadside into other car	F			Ruptured liver and spleen	Von Bahr & Eriksson 1961 (695)
5. Seat belt - 2 pt. - front rt. passenger in V.W. - head on collision	F			Ruptured rt. kidney	Von Bahr & Eriksson 1961 (695)
6. Seat Belt - 2 pt. - driver of Mercedes Benz - collided head on with V.W.	M	Rt. Rib fracture		Deep laceration of rt. liver lobe	Von Bahr & Eriksson 1961 (695)
7. Seat Belt - 2 pt. - passenger - bus drove into rear side of parked car	F			Large umbilical hernia containing transverse colon and part of stomach - pt. died.	Lindgren & Warg 1962 (395)
8. Seat Belt - 2 pt. - turned over 2-3 times at 55 mph - front rt. passenger - belt worn under both arms	F			Laceration of liver - large rupture of rt. diaphragm - contusion of rt. kidney - fatal	Backstrom, C.G. 1963 (29)
9. Seat Belt - 2 pt. - head on both cars at 40 mph - front rt. passenger	F	Massive pneumonia		Small rupture at the hilus of the spleen - pt. died	Backstrom, C.G. 1963 (29)
10. Seat Belt - 2 pt. - head on into parked truck at 40 mph - front rt. passenger	F			Rupture of spleen	Backstrom, C.G. 1963 (29)
11. Seat Belt - 2 pt. - auto hit a tree at 20 mph - front rt. passenger	F			Intraabdominal hemorrhage - small tearing of the capsules from the splenic hilum and gastro-lieno ligament	Hansen & Rasmussen 1963 (289)
12. Seat Belt - 2 pt. - front seat passenger - small motor vehicle involved in collision with larger vehicle	F			Superlateral surface of rt. liver lobe sheared off	Thomas & Wright 1968 (677)

1.	Seat Belt - 3 pt. - collided into broadside of another car - 5-10 mph	42	F		Severely lacerated spleen - massive hemorrhage	Fisher, P., 1965 (225)		
2.	Seat Belt - 3 pt. - driver - small car collided obliquely with truck travelling 45 mph	40	M		Severe rupture of rt. liver lobe extending from hilus to dome - hemorrhage	Slatis, P., 1967 (621)		
3.	Seat Belt - 3 pt. - driver - medium sized car ran into rear of another auto (40 mph)	50	M	Loosely adjusted belt	Three mesenteric tears along mesenteric border of distal ileum and two in distal jejunum	Slatis, P., 1967 (621)		
4.	Seat Belt - 3 pt. - driver - small car collided obliquely with another auto - 45 mph - thrown forward violently to the right	28	M	Belt improperly worn under arm	Mesenteric tear of distal jejunum - necrosis of jejunum	Slatis, P., 1967 (621)		
5.	Seat Belt - 3 pt. - x-way accident - sports car in frontal collision at 85 mph	46	M		Laceration of mesentery of the upper ileum - laceration of superior mesenteric artery with hemorrhage - laceration of the mesentery of the lower ileum	Baumgartl & Steiner 1968 (49)		
6.	Seat Belt - 3 pt. - driver - travelling at 45 mph - struck in side by another auto - forced into other lane where struck head on by another auto travelling at 45 mph	36	M		Tear in jejunum - considerable bruising of jejunal wall	Hamilton, J.B., 1968 (286)		
7.	Seat Belt - 3 pt. - front seat passenger - travelling at 45 mph - struck in side by another auto - forced into other lane where struck head on by another auto travelling at 45 mph	34	F	Left rib fracture (3,4) - fracture dislocation at C6-C7	Seat belt burises - retroperitoneal pseudocyst from injury to 3rd part of duodenum - bruising of bowel wall	Hamilton, J.B., 1968 (286)		
8.	Seat Belt - 3 pt. - front seat passenger - travelling at 45 mph struck head on by another auto travelling at 45 mph	25	F		Tear in anterior wall of 3rd part of duodenum with retroperitoneal abscess - distension of the ascending colon - tear in splenic capsule	Hamilton, J.B., 1968 (286)		
9.	Seat Belt - 3 pt. - loosely worn - front seat passenger - collided with the vehicle in front		F		Tear on the anterior aspect of the first part of the duodenum	Buxton, B., 1969 (82)		
10.	Seat Belt - 3 pt. - passenger - glanced off a tree at 65 mph	19	M		Two perforations of the caecum - one perforation of the third portion of the duodenum	Leger, L., et al., 1969 (385)		

	M	Multiple fractures and lacerations	Retroperitoneal hematoma on left	Siegel, Van Wagoner & Nahum, 1969 (613)
11. Seat Belt - 3 pt. - driver - 1967 Simca ran off road at 65 mph + and struck bridge abutment with left front side - then spun counter clockwise into middle of highway	M			
12. Seat Belt - shoulder harness - driver - high speed collision - motor and steering wheel pushed against abdomen at impact	M		Massive pancreatico - duodenal injury	Roman, E., et al., 1971 (564)
13. Seat Belt - 3 pt. - driver - head on collision	M		Laceration of caudate lobe of liver - hematoma of rt. half of transverse mesocolon - complete transection of the common bile duct	Spitz & Van Blerk 1971 (544)
D. Unspecified Safety Belt				
1. Seat Belt - struck a sliding auto broadside - right front passenger	M		Rectus muscle transected bilaterally with hematoma - jejunum completely transected with tear in mesentery - small serosal tears in jejunum and ileum	Porter & Green, 1968 (543)
2. Seat Belt - head on collision	F	Died of pneumonia	Blowout perforation of small bowel - ruptured spleen - avulsion of jejunal mesentery - pt. died	Porter & Green, 1968 (543)
3. Seat Belt - loosely fastened around upper abdomen - driver - two car accident	M		Ecchymotic area over lower abdomen - perforation on the antimesenteric border of the small bowel	Traylor, F.A., et al., 1969 (690)
4. Seat Belt - automobile head on collision into an overturned truck	F	Pt. 5 mo. pregnant	Uterus extensively lacerated - left retroperitoneal hematoma	Traylor, F.A., et al., 1969 (690)
5. Seat Belt - car spun off the road - driver	M		Abdominal abrasion and ecchymosis - two tears in the terminal ileum - bowel completely separated from its mesentery in several places	Traylor, F.A., et al., 1969 (690)
6. Seat Belt - impacted head on at 20-30 mph into another auto travelling 15-25 mph	F	Loosely fastened belt	Abdominal contusions	DOT 600 005 PB 190 330 1970 (158)
7. Seat Belt - head on into utility pole - 50-60 mph - front rt. passenger	F		Bruises on abdomen	DOT HS 600 061 PB 190 745 1970 (172)

CAUSE OF INJURY	AGE	SEX	WT.	PERTINENT DATA	ABDOMINAL INJURIES REPORTED	REFERENCE
1. Midget car accident - car jumped track hit light post (10-15 mph) - abdomen struck steering post	18	M			Perforation of descending duodenum	Hunt & Bowden (321), 1944
2. Tractor accident - tractor ran off edge of steep ramp and turned over against concrete wall - knob on steering wheel struck abdomen	47	M			Perforation on antimesenteric border of ileum	Hunt & Bowden (321), 1944
3. Automobile accident - driver - head on collision - rt. upper abdomen thrust against steering wheel	30	M			Transverse tear at junction of 2nd and 3rd portions of duodenum - oblique tear in duodenum	Siller, V.E., 1949 (614)
4. Automobile accident - driver - auto struck telephone pole - jammed against steering wheel	35	F			Large perforation of duodenum - perforation at base of mesentery - omental hematoma - pt. died 3 weeks P.O. - abscess behind ascending colon	Jacobson & Carter, 1951 (328)
5. Automobile accident - thrown against steering wheel	27	M			Extensive hematoma of transverse colon - retroperitoneal rupture of duodenum	Cohn, I., et al., 1952 (119)
6. Automobile accident - steering wheel struck upper abdomen	39	M			Necrotic pancreas	Joseph, M., 1952 (342)
7. Automobile accident - steering wheel struck pit of stomach - 4 yrs. previously	51	F	4 yrs. of constant pain		Degenerated thrombotic fatty tumor found over the head of the pancreas	Joseph, M., 1952 (342)
8. Automobile accident - steering wheel struck him in lower chest and abdomen	32	M			Laceration of the head of the pancreas with hematoma and active bleeding - contusion of the hepatic flexure of the colon with hematoma	Joseph, M., 1952 (342)
9. Automobile accident - driver - thrown against steering wheel	47	M	Rt. rib fractures (9,10)		Complete transection of the pancreas - completely lacerated pancreatic duct - laceration of transverse mesocolon with fat necrosis - pt. died	Rini, J.M., 1952 (558)
10. Automobile accident - steering wheel struck abdomen			Ribs fractured bilaterally		Pancreas contused as it crossed over vertebrae	Berne & Walters (50), 1953
11. Automobile accident - steering wheel struck abdomen					Pancreatitis with fat necrosis	Berne & Walters (50), 1953

12. Automobile accident - steering wheel struck abdomen	36	M	Tail of pancreas lacerated and bleeding - ruptured spleen - laceration of colon	Berne & Walters 1953 (50)
13. Automobile accident - epigastrium struck by steering wheel	42	F	Pancreas completely divided at its neck - multiple hematomas of stomach wall and transverse mesocolon	Becker, W.F. 1954 (43)
14. Automobile accident - steering wheel injury to epigastrium	16	F	Edematous and necrotic pancreas	Becker, W.F. 1954 (43)
15. Automobile accident - struck in epigastrium by steering wheel	23	M	Large firm hemorrhagic mass in the head of the pancreas with fat necrosis involving the pancreas, retroperitoneal tissues, omentum and transverse mesocolon - pancreatic pseudocyst	Becker, W.F. 1954 (43)
16. Truck accident - driver - hit a tree stump - thrown forward striking upper abdomen against steering wheel	31	M	Posterior retroperitoneal transverse laceration of the duodenum (1/2 circum.)	Keith & Burch 1954 (350)
17. Automobile accident - thrown forward striking upper abdomen against the steering wheel	24	M	Retroperitoneal perforation of duodenum - abscess	Keith & Burch 1954 (350)
18. Automobile accident - steering wheel caused severe blow to abdomen - driver	29	M	Lacerations of right lobe of liver - laceration and contusion of gallbladder	Smith, S.W. & Hastings 1954 (629)
19. Automobile accident - thrown against steering wheel	28	M	Transverse tear (1/2 circum.) of 3rd portion of duodenum - hematoma of ascending mesocolon - serosal tear in ascending colon	Stransky, J.J. 1954 (661)
20. Automobile accident - driver - struck steering wheel in collision	27	M	Laceration of spleen	Wyman, A.C. 1954 (751)
21. Automobile accident - driver - collision - struck left chest (abdomen) against steering wheel - thrown out of car	31	M	Spleen ruptured into three separate pieces	Wyman, A.C. 1954 (751)
22. Automobile accident - driver - crashed into a post - steering wheel injury	25	M	Duodenum 3/4 severed in its 3rd portion	Kelley & Todd 1956 (352)
23. Automobile accident - struck in abdomen by steering wheel - (head struck windshield)			Transcapsular rupture of the pancreas (with King, J.C., 1956 maceration and fat necrosis) - injury to serosal surface of the 2nd portion of the duodenum with rupture of vein	(366)

Case No.	Sex	Age	Accident Description	Findings	Author(s) & Year
34.	M	220	Automobile accident - car overturned - driver - struck accessory knob of steering wheel	Rupture of gallbladder	Knepper, P. A. et al., 1956 (374)
35.	F	19	Automobile accident - struck rt. side (abdomen) on steering wheel	Hematoma of the duodenum	Melemed & Pantone 1956 (441)
36.	M	28	Automobile accident - hit a bus going 50 mph - thrown against steering wheel	Contusion abdominal wall - complete severance of the common bile duct	Mohardt, J. H. 1956 (460)
37.	M		Automobile accident - severe blow from steering wheel	Blowout of badly contused and edematous duodenum - hematoma in mesentery at base of mesocolon - pt. died	Johnson, M. L. 1957 (334)
38.	M	29	Automobile accident - thrown against the steering wheel	Transverse tear in 3rd portion of duodenum - hematoma of ascending colon - multiple serosal tears of the ascending colon	Stransky, J. J. 1957 (662)
39.	F	47	Automobile accident - head on collision - driver thrown into steering wheel	Tear along lateral border of 2nd portion of duodenum - laceration of 3rd portion of duodenum - pt. died	Field, R. J., et al., 1959 (220)
40.	M	27	Automobile accident - struck in the abdomen by the steering wheel	Large duodenal submucosal defect (hematoma)	Mabry, E. H., 1959 (405)
41.	M	33	Automobile accident - struck in abdomen by steering wheel	Large intramural hematoma of the duodenum	Rowe, E. B., et al., 1959 (572)
42.	M	36	Automobile accident - car struck tree - driver - steering wheel injury	Complete severance of the common bile duct	Tollins, S. H., 1959 (683)
43.	M	45	Automobile accident - head on into rear of another car - driver - body thrown forward striking the upper part of the abdomen against the steering wheel	Complete severance of the common bile duct - hepatoduodenal ligament edematous	Mast & Oz 1960 (425)
44.	M	21	Automobile accident - struck in abdomen by steering column	Large retroperitoneal hematoma - defect at junctions of 2nd and 3rd parts of duodenum with additional perforation - pt. died Liver contained multiple infarcts	Thorlakson, R. H. 1960 (681)
45.	F	38	Automobile accident - steering wheel injury to abdomen	Perforation of jejunum with small rent on the antimesenteric border - subcutaneous hematoma on left midabdominal wall	Chambers & Card 1961 (105)

36. Automobile accident - steering wheel trauma to mid-abdomen	19	M		Intramural hematoma of 2nd and 3rd portions of duodenum	Davis & Thomas (135) (1961)
37. Automobile accident - struck abdomen on steering wheel	47	F		Pancreatic pseudocyst	Eastman, P.F., et al., (192) (1961)
38. Automobile accident - struck abdomen on steering wheel	26	F		Pancreatic pseudocyst	Eastman, P.F., et al., (192) (1961)
39. Automobile accident - struck in abdomen by steering wheel	37	F		Lesser Omentum completely lacerated - liver lacerated - pancreas lacerated completely through	Pellegrini, J.N., and Stein, I.S., 1961 (521)
40. Automobile accident - driver - steering wheel struck upper abdomen	23	M		Stenosis of the common bile duct and duodenum	Scavone & Pulaski (587) (1961)
41. Automobile accident - struck in chest (abdomen) by steering wheel	54	M	Fractured left rib (4th)	Avulsion of two branches off the superior mesenteric vein	Shuck & Trump (612) (1961)
42. Automobile accident - struck telephone pole - steering wheel trauma - driver	44	M		Transverse laceration of the second portion of the duodenum - traumatic pancreatitis at head of pancreas	Stephens, G.L. (651) (1961)
43. Automobile accident - driver - crush into side of stopped train - steering wheel struck upper abdomen	18	M	265	Small laceration of rt. liver lobe - complete severance of the common bile duct - ecchymosis of the transverse mesocolon - abdominal wall contusion	Stewart, J.H. (653) (1961)
44. Automobile accident - collision with another car - thrown against the steering wheel	47	M		Ecchymotic area in upper left quadrant - rupture of the common bile duct - hematoma in mesentery of small intestine	Stewart & Silen (654) (1961)
45. Automobile accident - crushing injury to upper abdomen and lower thorax by steering wheel	42	M		Acute perforation of the cecum	Adamson & Williams (4) (1962)
46. Automobile accident - thrown into steering wheel	38	M		2 cm. rent through fundus of gallbladder	Barnes & Diamond (36) (1963)
47. Automobile accident - steering wheel struck upper abdomen	22	M		Multiple lacerations of liver - very large retroperitoneal hematoma involving pancreas	Cleveland, H.C., et al., (112) (1963)
48. Automobile accident - struck in upper abdomen by steering wheel	45	F		Perforation in second portion of duodenum	Cleveland & Waddell (113) (1963)
49. Automobile accident - steering wheel injury to abdomen	45	F		Laceration of duodenum - contused pancreas large retroperitoneal hematoma - pt. died	Cleveland & Waddell (113) (1963)

50. Automobile accident - driver - was struck from behind by another auto - thrown against steering wheel	24	F	Rupture of 3rd portion of duodenum	Cleveland & Maddell 1963 (113) (13)
51. Automobile accident - driver - steering wheel to abdomen	30	M	Rupture of 3rd part of duodenum	Cleveland & Maddell 1963 (113) (13)
52. Automobile accident - steering wheel to abdomen	42	M	Laceration on 3rd part of duodenum - pancreas contused	Cleveland & Maddell 1963 (113) (13)
53. Automobile accident - driver - struck in lower abdomen by steering wheel	54	M	Ruptured urinary bladder	Farr & Falik 1963 (214) (1)
54. Automobile accident - driver - head on collision - thrown forcibly against steering wheel	21	M	Complete transection of duodenum with additional perforation - pt. died	Gould & Thorpyworth 1963 (265) (13)
55. Automobile accident - car ran off road and hit culvert - driver - struck rt. side of abdomen against steering wheel	48	M	Laceration and collapse of gallbladder	Hogue & Munneil 1963 (313) (1)
56. Automobile accident - driver of truck - crushed into steering wheel	44	M	Avulsion of the diaphragm - stomach transverse colon and small intestine herniated	Alivisatos, C.N., et al, 1964 (9) (1)
57. Automobile accident - driver - hit head against windshield - steering wheel driven into abdomen	34	F	Considerable hematoma of the duodenum	Bertelsen & Suhr 1964 (51) (1)
58. Automobile accident - driver - struck a concrete bridge railing - steering wheel struck abdomen	47	M	Large rent in anterior wall of the body of the stomach - postero-inferior surface of liver ruptured - pt. died	Greig, M.T. 1964 (270)
59. Automobile accident - head on collision - impact between the steering wheel and the right upper quadrant of abdomen	39	M	False aneurysm of hepatic artery - colon bile duct completely torn across - retroperitoneal hematoma - hematoma transverse mesocolon and small intestine - pt. died 7 mo. after surgery	Thal & Wilson 1964 (674)
60. Automobile accident - collision with truck - rt. upper quadrant abdomen impacted against steering wheel	52	M	Massive bleeding spleen - avulsed middle and rt. colic arteries - almost complete transection of the 3rd portion of duodenum - pancreas contused and transected at head - tear in the small intestinal mesentery - large rent in the transverse and right mesocolon - pt. died after 10 days	Thal & Wilson 1964 (674)

61. Automobile accident - upper abdomen impacted against steering wheel	M	32	Deep tear in liver - extensive contusion of the head of the pancreas and duodenum with complete avulsion of the common bile duct	Thal & Wilson 1964 (674) (14)
62. Automobile accident - steering wheel injury to abdomen	F	25	Longitudinal tear in first portion of the duodenum	Cegielski, M. 1965 (102) (102)
63. Automobile accident - steering wheel injury to abdomen	M	31	Almost complete rupture of the third portion of duodenum - tear in omentum serosa of colon and posterior parietal peritoneum	Cegielski, M. 1965 (102) (102)
64. Automobile accident - steering wheel injury to abdomen	M	48	Almost complete rupture of 3rd portion of duodenum	Cegielski, M. 1965 (102) (102)
65. Automobile accident - steering wheel injury to abdomen	M	42	Almost complete rupture of 4th portion of duodenum - laceration of the superior mesenteric vein - laceration of the root of the mesentery	Cegielski, M. 1965 (102) (102)
66. Automobile accident - head on collision - upper abdomen struck forcibly against rim of steering wheel	M	19	Common bile duct avulsed from the head of the pancreas	Dorton, H.E. 1965 (156) (56)
67. Automobile accident - steering wheel to abdomen	M	23	Omentum necrotic - laceration of duodenum - Papilla of Vater avulsed from duodenum	Fish, J.C. & Johnson 1965 (222) (222)
68. Automobile accident - passenger - steering wheel injury to abdomen	M	49	Ruptured spleen - laceration of transverse mesocolon - complete transection of superior mesenteric vessels - severe contusion of pancreas	Freeark, R.J., et al. 1965 (236) (236)
69. Automobile accident - collision with another auto - driver - steering wheel injury to abdomen	F	18	Complete avulsion of the second portion of the duodenum from the head of the pancreas	Freeark, R.J., et al. 1965 (236) (236)
70. Automobile accident - steering wheel injury to lower chest and abdomen	M	35	Stellate laceration of liver - hematoma at base of small bowel mesentery - pancreatic laceration	Freeark, R.J., et al. 1965 (236) (236)
71. Automobile accident - upper abdomen struck by steering wheel column	M	28	Retropertitoneal perforation of 3rd portion of duodenum	Hill, M.C. 1965 (306) (306)
72. Automobile accident - mild steering wheel injury to anterior chest (abdomen)	M	49	Rupture of the posterior wall of the common bile duct - pt. died	Kalderon & Sobel 1965 (346) (346)

73. Automobile accident - struck in epigastrum by the steering wheel	23	M		Large transverse laceration of the duodenum - interstitial type of pancreatitis	Nick, W.V., et al., 1965 (486)
74. Automobile accident - driver - struck abdomen against steering wheel	18	M		Induration of the head of the pancreas - distended gallbladder - distended common bile duct	Arminio, J.A., 1966 (21)
75. Automobile accident - steering wheel injury				Amputation of rt. liver lobe to cava - pt. died	Baker, R.J., et al., 1966 (33)
76. Automobile accident - steering wheel injury			Flail chest - head injury	Laceration of falciform of liver - spleen ruptured - pt. died	Baker, R.J., et al., 1966 (33)
77. Automobile accident - steering wheel injury	30	M		Retroperitoneal perforation of the 2nd portion of duodenum	Donovan, A.J. & Hagen 1966 (153)
78. Automobile accident - steering wheel impact	29	M		Perforation of 2nd portion of duodenum - pt. died	Donovan, A.J. & Hagen 1966 (153)
79. Automobile accident - driver - rear end collision - struck abdomen on steering wheel	22	M		Hematoma in posterior wall of transverse duodenum at point of crossing the vertebral column - transverse tear in pancreas where it crosses the vertebral column - large retroperitoneal hematoma which extended into the root of the small bowel mesentery and transverse mesocolon	Freeark, R.J., et al., 1966 - Arch Surg. (233) (238)
80. Automobile accident - driver - ran into tree - hit in abdomen by steering wheel as she was thrown forward	27	F		Tear in serosa of anterior wall of stomach superficial tear in the posterior muscularis - large plegmonous mass	Marx, F.W., 1966 (423)
81. Automobile accident - driver - drove into parked car at high speed - thrown forward and struck abdomen against steering wheel	32	F		Retroperitoneal hematoma - epigastric mass	Marx, F.W., 1966 (423)
82. Automobile accident - driver - head on collision with another vehicle - abdomen struck steering wheel	49	M		Very large deep laceration of the root of the mesentery at the superior mesenteric axis - laceration of the mesentery of the lower jejunum - bleeding blood vessels - hematoma - epigastric mass	Marx, F.W., 1966 (423)
83. Automobile accident - struck in upper part of abdomen by the steering wheel		F		Large portion of stomach herniated through hiatus - pt. died	Nelson, J.F., 1966 (480)
84. Automobile accident - steering wheel injury	32	M	Shock	Laceration of spleen - first part of duodenum almost completely ruptured - profuse bleeding from gastro-duodenal artery - laceration of anterior liver - head of pancreas pulped	St. Pierre, P.E. 1966 (576)

85. Automobile accident - injured in upper part of epigastrium by steering wheel	18	F	Pancreatic pseudocyst - aneurysm of the gastroduodenal artery - hemorrhage	Frey, C.F., et al., 1967 (244)
86. Automobile accident - driver - truck struck rear of bus - thrown against steering wheel	29	M	Intramural duodenal hematoma	Gordon & Hauser 1967 (263)
87. Automobile accident - struck abdomen against steering wheel	21	M	Duodenal fistula	Isfort, A., (325) 1967
88. Automobile accident - head on collision - driver - Blunt trauma to abdomen by steering wheel	53	M	Fistula between the transverse colon and the proximal jejunum	Isfort, A., (325) 1967
89. Automobile accident - driver - car struck a stopped car - thrown against steering wheel	15	M	Perforation of small intestine	Klinger & Gibson 1967 (372)
90. Automobile accident - thrown against lower rim of steering wheel	32	F	Hematoma of liver	Shapiro, H.N., et al., 1967 (606)
91. Automobile accident - steering wheel injury to abdomen	28		Transection of common duct at ampulla	Warren & Wagner 1967 (705)
92. Automobile accident - struck in abdomen by steering wheel	24	F	Perforation of stomach - severe laceration of pancreas with pseudocyst	Warren & Wagner, 1967 (705)
93. Automobile accident - driver - hit bridge abutment - thrown against steering wheel - struck epigastrium and rt. upper quadrant	27	M	Complete transection of the common bile duct	Dobbie & Stormo 1968 (149)
94. Automobile accident - head on collision - thrown into steering column	19	M	Laceration of liver	Huelke & Chewning 1968 (317)
95. Automobile accident - struck a tree at 45 mph - thrown into steering wheel column	45	M	Laceration of liver - pt. died	Huelke & Chewning 1968 (317)
96. Automobile accident - head on 50 mph - thrown into steering wheel column	46	M	Lacerations of liver and mesentery with intraabdominal hemorrhage - fatal	Huelke & Chewning 1968 (317)
97. Tractor accident - steering wheel injury to upper abdomen	17	M	Hematoma of the 2nd and 3rd parts of duodenum - perforation of the 2nd part of the duodenum	Keplinger, et al., 1968 (357)

98. Automobile accident - steering wheel injury to abdomen	22	M	Complete transection of the pancreas over the spine	Meyers, H.I., 1968 (449)
99. Automobile accident - steering wheel injury to abdomen	24	M	Intramural hematoma of duodenum - retroperitoneal hematoma surrounding head of pancreas	Meyers, H.I., 1968 (449)
100. Automobile accident - steering wheel injury to rt. side of abdomen	24	M	Transection (3/4) of duodenum at junction of 2nd and 3rd parts	Meyers, H.I., 1968 (449)
101. Automobile accident - while parking, went over curb down embankment and struck tree head on - driver - struck abdomen against steering wheel	45	M	Complete transection of duodenum adjacent to pylorus - contusion of head of pancreas - retroperitoneal hematoma	Oglesby, J.E., et al., 1968 (500)
102. Automobile accident - struck rear of parked car at 25 mph - driver - thrown forward against steering wheel	27	F	Eccymosis of 3rd portion of duodenum and mesocolon - small hematomas of uterus - subintimal hematoma the aorta and iliac arteries	Tomatis, L.A. et al 1968 (585)
103. Automobile accident - steering wheel injury to abdomen	29	M	Rupture of the pancreas	Weitzman & Rothschild 1968 (717)
104. Automobile accident - steering wheel injury to abdomen	23	F	Transection of the body of the pancreas	Weitzman & Rothschild 1968 (717)
105. Automobile accident - severe blow to upper abdomen from steering wheel	58	F	Blood filled cavity in left liver lobe - hemobilia	Wilkinson, G.M. et al 1958 (725)
106. Automobile accident - driver - while driving struck auto at 28 to 70 mph - struck against steering wheel, crest and epigastrium against steering wheel	26	M	Small rent in posterior surface of left hepatic duct - tear in liver	Estrada & Sutherland 1969 (209)
107. Automobile accident - driver - thrown to ward and struck upper abdomen against steering wheel	29	M	Head of pancreas macerated and filled with blood clot - transverse tear thru 2/3 circum. of duodenum - head of pancreas separated from second portion of duodenum - gall bladder torn free from liver - retroperitoneal hematoma near duodenal loop	Foley, W.J. et al 1969 (230)
108. Automobile accident - driver - struck in upper abdomen by steering wheel	40	M	Head of pancreas torn from portal vein and extensively destroyed - stomach transected transversely at pylorus	Foley, W. J. et al 1969 (230)
109. Automobile accident - driver - smashed into rear of truck on x-way - thrown forward with steering wheel hitting upper abdomen	28	M	Pancreas torn free from portal vein - head of pancreas completely macerated and filled with hematoma - complete transection of the stomach just proximal to the pylorus	Foley, W. J. et al 1969 (230)

110.	24	M	Automobile accident - steering wheel injury to abdomen	Complete transection of the neck of the pancreas	Jordan, G. L. et al 1969 (341)
111.	29	M	Automobile accident - struck in abdomen by steering wheel	Complete transection through the head of the pancreas - severe trauma to splenic artery	Jordan, G.L. et al 1969 (341)
112.	29	M	Automobile accident - steering wheel injury to abdomen	Transected pancreas	Jordan, G.L. et al 1969 (341)
113.	44	F	Automobile accident - thrown against steering wheel - struck rt. upper quadrant	Complete transection of common bile duct - minimal contusion of pancreas - small hematoma in the porta hepatis	Moffat & Lucas 1969 (459)
114.	26	M	Automobile accident - steering wheel injury to abdomen	Massive fragmentation of the rt. and left liver lobes	Nemhauser, G.M. et al 1969 (481)
115.	39	M	Automobile accident - driver - seat belt broke - struck utility pole head on at 35 mph - struck abdomen against steering wheel	Laceration of the liver - torn mesenteric vein	Patrick & Van Kirk 1969 (1233)
116.		F	Automobile accident - steering wheel driven into upper abdomen	Rupture of pancreas - retroperitoneal abscess - pt. died	Sawyer, R. B. et al 1969 (586)
117.			Automobile accident - head on collision between 1967 Merc. Cougar (30-40 mph) and 1964 Buick (60 mph) - Buick driver struck steering wheel column with thorax (abdomen) lower instrument panel, face of instrument panel and windshield	Extensive laceration of rt. liver lobe - fatal	Siegel, Van Wagoner & Nahum 1969 (613)
118.	27	M	Automobile accident - struck forcibly in epigastrium by steering wheel - head on crash	Almost complete transection of rt. liver lobe	Smith, I.B. 1969 (625)
119.	23	M	Automobile accident - steering wheel injury to left chest (abdomen)	Tear in left diaphragm - herniation of spleen and omentum	Sterns, L. P. et al 1969 (652)
120.	33	F	Automobile accident - car struck a utility pole - driver - thrown against steering wheel - struck in mid-abdomen	Small laceration of transverse colon mesentery - acute abdominal aortic occlusion	Wellborn & Sawyers 1969 (719)
121.	54	F	Automobile accident - head on collision - driver - rear engine automobile traveling at moderate speed - steering wheel injury	Large ecchymosis of rt. abdominal wall - gangrene of the entire large bowel and terminal ileum - abdominal arterial laceration and dissection	David & Blumenberg 1970 (133)
				Septic shock	
				Multiple bilateral rib fractures - lung laceration - coronary occlusion	
				Rt. rib fracture (9th)	
				Multiple bilateral rib fractures	

122. Automobile accident - crashed into tanker truck - struck steering wheel - driver	25	M	140	Multiple crushing injuries	Superficial rupture on rt. lobe of liver - multiple splenic ruptures - fatal	D.O.T. HS 600 083 Case No. 68-13, 1970 (178)
123. Automobile accident - head on into telephone pole at 20 mph - driver - impacted into steering wheel	18	M	135		Retroperitoneal perforation of the duodenum - fatal	D.O.T. HS 600 036 P.B. 190534, 1970 (165)
124. Automobile accident - impacted dirt embankment head on at 50 mph - driver - thrown against steering wheel	51	F	118	Laceration of aorta & transection of spinal cord	Laceration of liver - fatal	D.O.T. HS 600 054 P.B. 190 738, 1970 (169)
125. Automobile accident - head on into rear of wrecker truck at 45 mph - driver - steering wheel spokes caused abdominal injuries	23	M		Multiple major injuries	Multiple lacerations of the liver - hemoperitoneum 500 cc - fatal	D.O.T. HS 600 004 P.B. 190329, 1970 (151)(157)
126. Seat belt - laterally impacted concrete pillar at 30-45 mph - driver - thrown back and to the left forcing head into roof, then thrown into steering wheel	25	M	220	Multiple major injuries	Multiple tears of the liver and mesenteric structures - multiple abrasions & contusions of abdomen - fatal	D.O.T. HS 600 024 P.B. 190 507, 1970 (162)
127. Automobile accident - head on into power pole at 10-15 mph - driver - thrown forward and struck steering wheel column	27	F	105		Traumatic pancreatitis - contusion of liver - possible ruptured bowel	D.O.T. HS 600 041 P.B. 190 725, 1970 (166)
128. Automobile accident - severe steering wheel injury to abdomen	23	F	110		Hemorrhagic pancreatitis	Dudrick, S.J. et al 1970 (199)(2)
129. Automobile accident - steering wheel trauma to the abdomen	40	M			Complete transection of duodenum - fracture transecting neck of pancreas - horizontal fracture through head of pancreas - two lacerations of superior mesenteric vein - small stellate laceration on under surface of rt. liver lobe	Gibbs, B. F. et al 1970 (257)(57)
130. Automobile accident - steering wheel injury to abdomen	21	M			Bruising over epigastrium - pancreas completely transected - pancreas edematous and hematoma	comp-Ho, W. C. 1970 (311)
131. Automobile accident - fell over steering wheel - struck parked car - 15 mph	50	M			Almost complete transection thru the body of the pancreas - laceration of pancreas - large intramural hematoma to 2nd portion of duodenum - large rent in portal vein - pt. died	Menick & Kim 1970 (443) (153)

132. Automobile accident - driver - hit cement retaining wall on x-way - thrown forward against steering wheel	46	M		Perforation on antimesenteric surface of the ileum - laceration and contusion at root of proximal bowel mesentery	Percy, E. C. 1970 (527)
133. Automobile accident - thrown forcibly against the steering wheel	25	M		Common bile duct completely transected at duodenum - gastroduodenal artery transected - two small non-bleeding non-capsular tears in the liver	Rydell, W. B. 1970 ((575))
134. Automobile accident - struck rear of another auto on x-way - steering wheel trauma to abdomen	72	F		Ruptured bladder - traumatic rupture of diaphragm	Walt & Grifka 1970 (701)
135. Automobile accident - steering wheel injury to epigastrium	34	M		Blowout laceration of the gall bladder	Walt & Grifka 1970 (701)
<u>ADDENDUM</u>					
136. Tractor accident - pinned against steering wheel with abdomen	35	M	Fracture L ₂	Pancreas edematous and hemorrhagic - small tear of liver	Phillips & Seybold 1948 (536)
137. Automobile accident - steering wheel injury to abdomen	25	M		Retroperitoneal perforation of 3rd portion of the duodenum	Williamson, N.L. 1961 (735)
138. Automobile accident - passenger - thrown into steering wheel	23	M		Perforation on the antimesenteric border of the jejunum	Romney, D. 1962 (565)
139. Automobile accident - driver - ran into tree (frontal impact) - forced against steering wheel	33	M	Multiple rib fractures	minor rupture of rt. dome of liver - gallbladder completely torn from its bed - pt. died	Halkier, E. 1963 (281)
140. Automobile accident - driver - frontal collision with bus - forced against steering wheel	44	M	Rib fractures - cardiac arrest	Gallbladder completely torn from its bed - small tear of left liver lobe - severed cystic artery - hemorrhage - rupture of transverse mesocolon - large hematoma. rt. kidney - pt. died	Halkier, E. 1963 (281)
141. Automobile accident - steering wheel injury to rt. abdomen	56	F		Gangrene of small bowel - abscess	Keller & Mengoli 1964 (351)
142. Automobile accident - steering wheel injury to abdomen	27	M		Rupture of 3rd portion of duodenum - retroperitoneal emphysema	McCort, J.J. 1964 (434)
143. Automobile accident - struck in midabdomen by steering wheel	65	M		Perforated jejunum - lacerated mesentery	McCort, J.J. 1964 (434)

144. Automobile accident - steering wheel injury to mid-abdomen	50	F	Rent in 3rd portion of duodenum	Flandreau, R.H. 1966 (227)
145. Automobile accident - steering wheel trauma to abdomen	49	M	Transection of the neck of the pancreas - ruptured spleen	Freeark, R.J. et al 1966 (237) 7)
146. Automobile accident - steering wheel trauma to abdomen	18	F	Pancreatoduodenal speparation	Freeark, R.J. et al 1966 (237)
147. Automobile accident - steering wheel trauma to abdomen	35	M	Partial tear of the head of the pancreas - laceration of liver	Freeark, R.J. et al 1966 (237)
148. Automobile accident - steering wheel trauma to the abdomen	22	M	Intramural hematoma of the 3rd and 4th portions of the duodenum	Freeark, R.J. et al 1966 (238)
149. Automobile accident - thrown against the steering wheel	26	M	Intramural hematoma of 3rd portion of duodenum	Essenhigh, D.M. et al 1968 (205) 57)

CAUSE OF INJURY	AGE	SEX	WT.	PERTINENT DATA	ABDOMINAL INJURIES REPORTED	REFERENCE
1. Pedestrian - automobile ran over her lower chest and abdomen	3	F			Large deep laceration of spleen - hemorrhage in liver and peritoneal cavity - fatal	Blocker, T. G. 1939 (53) (3)
2. Pedestrian - struck by auto	38	M			1/4 in. perforation of duodenum - laceration of abdominal wall - pt. died	Ficarra, B. J. 1944 (218)
3. Pedestrian - struck by auto	75	M		Shock	Three small perforations in ileum - generalized peritonitis - pt. died	Ficarra, B. J. 1944 (218)
4. Pedestrian - struck by auto	45	M			1-3/4 in. rent in jejunum (3/4 circumference) - mesenteric hematoma - generalized peritonitis - pt. died	Ficarra, B. J. 1944 (218)
5. Pedestrian - struck by auto	66	M		Shock	1/2" laceration of small intestine (2 ft. from ileocecal valve) - generalized peritonitis - pt. died	Ficarra, B. J. 1944 (218)
6. Pedestrian - struck by auto	50	M		Shock - skull fracture - brain laceration	1/2 in. laceration in ileum - generalized peritonitis - pt. died	Ficarra, B. J. 1944 (218)
7. Pedestrian - struck by trolley car	6	M			1 in. laceration of jejunum	Ficarra, B. J. 1944 (218)
8. Pedestrian - struck by auto	45	M			Three perforations on the antimesenteric border of the ileum	Ficarra, B. J. 1944 (218)
9. Pedestrian - struck by automobile	6	F		Shock	Laceration of rt. lobe of liver (almost split in half) - pt. died	Wright, L.T. et al 1947 (748) (8)
10. Pedestrian - struck by automobile	12	F		Shock	Laceration of rt. liver lobe - hemorrhage pt. died 24 hrs. P.O.	Wright, L.T. et al 1947 (748) (8)
11. Pedestrian - while alighting from a street car slipped and fell under rear wheel of truck - wheel passed over abdomen	9	M		Pelvis extensively comminuted	Ruptured urinary bladder - two long retro-peritoneal hematomata extending from upper pole of kidney to the brim of the pelvis - six small rents in the descending and sigmoid colon - laceration of left diaphragm	Bechm, W. 1948 (57)
12. Pedestrian - struck by automobile	6	F			Rent in omentum - tear in tail of pancreas	Hart, J.F. & Lisa 1948 (235)
13. Pedestrian - knocked down by truck	6	F		Pelvic fracture	Large tear in dome of rt. diaphragm - colon and most of liver herniated	Evans & Simpson 1950 (210)

14.	Pedestrian - run over by car - crush injury to abdomen	16	M	Fractured pelvis	Tear in left diaphragm - stomach herniated - retroperitoneal hematoma - pt. died	Evans & Simpson 1950 (210)
15.	Pedestrian - struck by car - rear wheel passed over chest and abdomen	6	M		Traumatic hemorrhagic pancreatitis	Wright, L. T. et al 1950 (749)
16.	Pedestrian - struck by automobile - car passed over her abdomen and chest	8	F	Multiple rib fractures	Contusions of abdomen - rent in diaphragm with herniation of colon, small intestine, left liver lobe, stomach and spleen into thorax	Carter, B. N. et al 1951 (100)
17.	Wheels of truck passed over abdomen	8	M		Ecchymosis over area of left iliac spine - large rent in diaphragm with herniation of stomach, spleen, omentum, transverse colon and small intestine - subserosal hemorrhage in small intestine and its mesentery	Carter, B. N. et al 1951 (100)
18.	Pedestrian - struck by automobile	35	M		Large perforation of duodenum - diffuse peritonitis - contusion of transverse colon, liver, rt. kidney - 3,100 cc fluid - pt. died 11 days P.O.	Jacobson & Carter 1951 (328)
19.	Pedestrian - struck by automobile	67	M	Pt. comatose - pneumonia	Contusion of rt. lower abdominal wall - rupture of underlying terminal ileum - pt. died	Jacobson & Carter 1951 (328)
20.	Run over by cart - wheels passed over thoracico-abdominal region	14	M	Severe shock	Complete severance of spleen - abundant peritoneal hemorrhage	Larghero & Giuria 1951 (382)
21.	Pedestrian - run over by a car	12	M	Severe shock	Rupture of the spleen - rupture of the kidney - moderate retroperitoneal hematoma - hematoma of the transverse mesocolon	Larghero & Giuria 1951 (382)
22.	Pedestrian - auto passed over pt. and pinned him against wall	42	M		Large rent in stomach wall - gastrocolic omentum torn free from stomach - pt. died	Estes, W. L. et al 1952 (208)
23.	Pedestrian - struck by automobile	28	M		Mesenteric thrombosis with gangrene of the ileum - pt. died	McCune, W. S. et al 1952 (435)
24.	Pedestrian - struck by automobile while crossing street	61	M		Gangrenous and ruptured mesentery of jejunum - inguinal hernia - pt. died	McCune, W. S. et al 1952 (435)
25.	Pedestrian - struck by bus				Lower half of left kidney avulsed	Orkin, L. A. 1952 (504)

ADDITIONAL INJURIES REPORTED

PERMANENT DATA

AGE

SEX

DAYS

MILE

REFERENCE

ADDITIONAL INJURIES REPORTED	PERMANENT DATA	AGE	SEX	DAYS	MILE	REFERENCE
Perforation of gall bladder		3	M			Benson, C. D. & Prust 1953 (46)
Rupture of the common bile duct		6	M			Benson, C. D. & Prust 1953 (46)
Pancreas edematous with greenish fluid under capsule - laceration of liver						Berne & Walters 1953 (50)
Contusion of pancreas - contusion of jejunum and mesentery	Multiple fractures					Berne & Walters 1953 (50)
Pancreas edematous with fat necrosis - hematoma of left kidney - tear in 2nd portion of duodenum						Berne & Walters 1953 (50)
Rupture of the porta hepatitis near the junction of the right and left hepatic ducts		2	M			Walker, J. H. M. 1953 (700)
Ruptured diaphragm - herniated stomach - contusion of kidney	Multiple rib fractures	35	M			Adams & Musselman 1954 (3)
Perforated caecum		24	M			Clarke, R. 1954 (109)
Rupture of jejunum - laceration of spleen - peritonitis - pt. died		4	M			Clarke, R. 1954 (109)
Large tear of diaphragm - considerable abdominal bleeding - pt. died	Fractured pelvis - fractured left ribs (7-12) cardiac arrest	12	M			Clarke, R. 1954 (109)
Tear of diaphragm extended into the abdominal wall - rupture of abdominal vessels - profused bleeding - uncontrollable hemorrhage - pt. died	Fractured pelvis	11	M			Clarke, R. 1954 (109)
Ruptured rt. kidney with complete tear of renal vessels - shattered spleen - torn psoas muscle - pt. died	Fracture of right lower ribs - avulsion of transverse process	20	M			Clarke, R. 1954 (109)
Laceration of liver - rupture of small intestine - rupture of diaphragm - gross damage to descending and pelvic colon - hemorrhage - pt. died	Fractured ribs and pelvis	39	M			Clarke, R. 1954 (109)
Ruptured liver and rt. kidney - pt. died	Severe shock	6				R. Clarke, 1954 (109)

40.	Pedestrian - knocked down by car	7	Fractured rt. ribs (3-9) - severe head injury	Ruptured liver - pt. died	Clarke, R. 1954 (109)
41.	Pedestrian - run over by car	16	Fractured rt. ribs - laceration of lungs	Laceration of liver - pt. died	Clarke, R. 1954 (109)
42.	Pedestrian - knocked down by car	65	Fractured left ribs - fractured pelvis	Ruptured kidney - pt. died	Clarke, R. 1954 (109)
43.	Pedestrian - knocked down by car	75	Fractured ribs	Pulped kidney - pt. died	Clarke, R. 1954 (109)
44.	Pedestrian - run over by bus	5	Pulmonary edema	Superficial tear of kidney and spleen - pt. died	Clarke, R. 1954 (109)
45.	Pedestrian - struck by car	9	M	Multiple lacerations of rt. liver lobe - ileus	Glas, W. W. et al 1955 (259)
46.	Pedestrian - struck by automobile	50	Flail chest	Ruptured spleen - pt. died	Helsper, J. T. 1955 (301)
47.	Pedestrian - struck by automobile	25		Ruptured spleen	Helsper, J. T. 1955 (301)
48.	Pedestrian - struck by automobile	6		Ruptured spleen - retroperitoneal hemorrhage	Helsper, J. T. 1955 (301)
49.	Pedestrian - struck by automobile	4		Ruptured spleen	Helsper, J. T. 1955 (301)
50.	Pedestrian - struck by automobile	10		Ruptured spleen	Helsper, J. T. 1955 (301)
51.	Pedestrian - struck by automobile	29		Ruptured spleen - retroperitoneal hemorrhage	Helsper, J. T. 1955 (301)
52.	Pedestrian - struck by automobile	16		Ruptured spleen	Helsper, J. T. 1955 (301)
53.	Pedestrian - struck by automobile	35	Multiple injuries	Ruptured liver - pt. died	Helsper, J. T. 1955 (301)
54.	Pedestrian - struck by automobile	72	Multiple injuries	Contused kidney - pt. died	Helsper, J. T. 1955 (301)
55.	Pedestrian - struck by automobile	44		Contused kidney	Helsper, J. T. 1955 (301)
56.	Pedestrian - struck by automobile	24		Contused kidney	Helsper, J. T. 1955 (301)
57.	Pedestrian - struck by automobile	19		Contused bladder	Helsper, J. T. 1955 (301)
58.	Pedestrian - struck by automobile	57	Multiple injuries	Ruptured bladder - pt. died	Helsper, J. T. 1955 (301)
59.	Pedestrian - struck by automobile	79	Multiple injuries	Ruptured bladder - pt. died	Helsper, J. T. 1955 (301)
60.	Pedestrian - struck by automobile	62		Contused kidney	Helsper, J. T. 1955 (301)
61.	Pedestrian - struck by automobile	4		Contused kidney	Helsper, J. T. 1955 (301)

62.	Pedestrian - struck by automobile	35			Ruptured bladder - contused kidney	Helsper, J. T. 1955 (301);
63.	Pedestrian - struck by automobile	5		Multiple injuries	Lacerated liver - pt. died	Helsper, J. T. 1955 (301);
64.	Pedestrian - struck by automobile	8			Lacerated liver	Helsper, J. T. 1955 (301);
65.	Pedestrian - struck by automobile	42			Lacerated liver	Helsper, J. T. 1955 (301);
66.	Pedestrian - struck by automobile	23			Lacerated liver	Helsper, J. T. 1955 (301);
67.	Pedestrian - struck by automobile	57			Perforated ileum - pt. died	Helsper, J. T. 1955 (301);
68.	Pedestrian - struck by car on left side	6	M		Deep laceration of spleen	Mansfield, R. D. 1955 (418);
69.	Pedestrian - struck by car on left side	10	M		Multiple lacerations of spleen	Mansfield, R. D. 1955 (418);
70.	Pedestrian - struck by auto	72	F		Two small lacerations of the ileum	Schlosser & Harkins 1955 (591);
71.	Pedestrian - struck by car	45	F		Rupture of retroperitoneal duodenum	Schlosser & Harkins 1955 (591);
72.	Pedestrian - struck by truck	12	M		Laceration and contusion of liver - hematoma of the head of the pancreas - pt. died	King, J. C. 1956 ((366))
73.	Car rolled over his body	3	M	Lung rupture	Complete separation of left liver lobe - rupture of spleen - hemorrhage - pt. died	King, J. C. 1956 ((366))
74.	Pedestrian - struck by car	67	F	Pelvic fracture - extensive brain damage	Laceration of spleen - subcapsular hemorrhage of left kidney - pt. died	King, J. C. 1956 ((366))
75.	Pedestrian - struck by a car	44	M	Multiple rib fractures (5,7,9)	Rupture of spleen - formation of cyst	Pontius, G. V. et al 1956 (542);
76.	Pedestrian - run over by ice truck - two rear wheels passing over abdomen	6	M		Ruptured left diaphragm	Desforges, G. et al 1957 ((141));
77.	Pedestrian - struck by car	29	M		Diaphragm lacerated - portion of omentum and splenic flexure of colon herniated through - omentum hemorrhagic	Desforges, G. et al 1957 ((141));
78.	Pedestrian - standing behind one automobile and was struck by another at high speed	20	M		Extensive laceration of diaphragm - herniation of liver into rt. chest	Desforges, G. et al 1957 ((141));
79.	Pedestrian - run over by automobile 26 years before	39	M		Ruptured diaphragm - stomach and colon in left hemi thorax	Desforges, G. et al 1957 ((141));

					REFERENCE	
80.	Pedestrian - hit in abdomen by car	5	F		Laceration of spleen	Halter & Gross 1957 ((285))
81.	Pedestrian - struck by rolling automobile	4	F		Laceration of liver and spleen	Halter & Gross 1957 ((285))
82.	Pedestrian - struck by fender of moving automobile	9	M		Laceration of spleen	Halter & Gross 1957 ((285))
83.	Pedestrian - struck by automobile from left	7		Left rib fractures (5,6,7)	Transverse laceration of spleen	Halter & Gross 1957 ((285))
84.	Pedestrian - struck by car	5	M		Multiple lacerations of spleen which was almost torn from its pedicle - large retroperitoneal hematoma over pancreas and rt. renal fossa - 4500 cc free blood.	Halter & Gross 1957 ((285))
85.	Pedestrian - struck by truck	3	M		Transverse laceration of spleen	Halter & Gross 1957 ((285))
86.	Pedestrian - struck by automobile	8	F		Fractured and gangrenous kidney	Halter & Gross 1957 ((285))
87.	Pedestrian - struck by automobile	3-1/2	M		Avulsion of rt. colon with complete mobilization - three lacerations of colon	Halter & Gross 1957 ((285))
88.	Pedestrian - hit by truck	2	M		Three lacerations of liver - contused kidney	Halter & Gross 1957 ((285))
89.	Struck by car while sliding	10	M		Rupture of pancreas - large retroperitoneal cyst	Hannon & Sprafka 1957 ((288))
90.	Pedestrian - struck by automobile	60	F	Severe head injury - multiple injuries	Ruptured diaphragm with herniation of stomach into chest - perforation of stomach	Perry, T. et al 1957 ((534))
91.	Pedestrian - stabbed by ornament on front of car	17	M		Lacerated spleen, stomach, pancreas - died 3 hours P.O.	Root & Christensen 1957 ((567))
92.	Pedestrian - struck by truck	2	M	Fractured pelvis	Abrasion left side - laceration of diaphragm - herniation of stomach, spleen and colon	Becker, W. T. 1958 ((44))
93.	Pedestrian - run over by car	20			Stellate laceration of diaphragm - transection of ileum	Carlson, R. F. et al 1958 ((98))
94.	Pedestrian - struck by automobile	68	F	Rib fractures (9-11)	Torn diaphragm - fundus of stomach herniated - pt. died	Sutherland, H. D. 1958 ((668))
95.	Run across midriff by slow-moving truck	7	M		Tear in rt. diaphragm (20 cm.) - liver, omentum, transverse colon and small bowel herniated	Sutherland, H. D. 1958 ((668))

96.	Pedestrian - run over by truck	11	M	Multiple rib fractures - fractured pelvis	Ruptured diaphragm - stomach, spleen, colon and small bowel herniated - pt. died	Grage, T. B. et al 1959 (2677)
97.	Pedestrian - run over by truck	6	M	Cerebral concussion	Rupture of left and rt. diaphragm - herniation of stomach	Grage, T. B. et al 1959 (2677)
98.	Pedestrian - struck by auto	63	F	Fractured ribs - fractured pelvis - cerebral concussion	Ruptured left diaphragm - stomach, colon, spleen herniated	Grage, T. B. et al 1959 (2677)
99.	Pedestrian - struck by auto	15	M	Unconscious - shock-pelvic fracture	Ruptured left diaphragm - ruptured spleen - ruptured kidney - laceration of pancreas - herniated spleen and stomach - pt. died	Grage, T. B. et al 1959 (2677)
100.	Pedestrian - chest and abdomen run over by wheel of truck	23	M		Contusion of kidneys - hemorrhage	Kastl, W. H. 1959 (3477)
101.	Pedestrian - struck by car - landed on top of car then fell to street	43	F	Multiple fractures	Rupture of fundus of gall bladder - necrotic left liver lobe	Manlove, C. H. et al 1959 (4177)
102.	Run over by tractor	11			Splenic hematoma	Requarth, W. 1959 (552)
103.	Pedestrian - struck by automobile in upper left abdomen	2-1/2	M		Torn abdominal muscles - herniation of omentum and transverse colon	Wilson, T. H. 1959 (740)
104.	Pedestrian - struck and knocked down by a bus	53	M		Two lacerations of the spleen - 2000 cc blood	Kennedy, R. H. 1960 (356)
105.	Pedestrian - hit and knocked down by taxicab - abdomen and left flank	62	M		Two perforations in the mid jejunum - inguinal hernia	Kennedy, R. H. 1960 (356)
106.	Pedestrian - struck by auto	63	M		Ruptured spleen - hemoperitoneum - fatal	Shaftan, G. W. 1960 (602)
107.	Pedestrian - struck by auto	69	M		Liver laceration - hemoperitoneum - pt. died	Shaftan, G. W. 1960 (602)
108.	Pedestrian - struck by auto	65	M	Multiple comminuted fractures	Rupture of bladder & urethra - pt. died	Shaftan, G. W. 1960 (602)
109.	Pedestrian - struck by auto	42	F		Massive retroperitoneal hematoma - ileus	Shaftan, G. W. 1960 (602)
110.	Pedestrian - struck by auto	10	M		Ileus pattern	Shaftan, G. W. 1960 (602)
111.	Struck by moving bicycle	11	M		Intramural hematoma of jejunum	Davis & Thomas 1961 (135)

Case No.	Accident Description	Age	Sex	Injury	Pathology	Reference
112.	Pedestrian - knocked down by automobile	45	M		Pancreatic pseudo cyst	Eastman, P. F. et al 1961 (192)
113.	Pedestrian - run over by a car	11	P		Small tear on the undersurface of the rt. liver lobe with 1-1/2 liters of blood stained bile - biliary peritonitis - small stellate tear on the anterior surface of the liver - pt. died	Hellstrom, G. 1961 (299)
114.	Pedestrian - struck by auto			Severe head injury	Laceration of hilum of spleen - hemo-peritonium - pt. died	Maugnon, J. S. et al 1961 (429)
115.	Pedestrian - run over by slow-moving car	3	M		Small rent in rt. hepatic duct near the point where it emerges from the liver	Nikishin, I. F. 1961 (469)
116.	Run into parked automobile while running	5	M		Perforation of jejunum	Perelman, H. 1961 (526)
117.	Pedestrian - abdomen run over by auto wheel	2	M	Shock - cardiac arrest	Echymoses of rt. lower quadrant - dome of liver avulsed from diaphragm - large rent in rt. hepatic lobe which was avulsed from the rt. hepatic vein and the vena cava - massive hemorrhage - pt. died	Shuck & Trump 1961 (612)
118.	Pedestrian - collided with car - struck over abdomen and left thigh	4	F		Hernia of abdominal wall - muscle lacerated beneath fascia - large defect at peritoneum	Hung, C. R. et al 1962 (320)
119.	Pedestrian - knocked over by car	49	M	Concussion	Entire rt. side of colon from caecum to the middle of the transverse colon was gangrenous - thrombosis of the rt. colonic arterial arcades	Mathieson, A. J. 1962 (427)
120.	Pedestrian - struck by automobile	75	M	rt. rib fractures (8-9)	Laceration of liver dome - hematoma between liver and diaphragm - laceration of rt. kidney - pt. died	McCort, J. 1962 (433)
121.	Pedestrian - struck by taxicab while standing near curb - knocked down striking left flank and back	62	M	Fractures of L-1-2-3-4	Two small perforations in proximal ileum - inguinal hernia	Payson & Mage 1962 (518)
122.	Pedestrian - struck by automobile - thrown forcefully to the ground	80	M		Laceration of the mesenteric border of the ileum - inguinal hernia - pt. died	Payson & Mage 1962 (513)
123.	Pedestrian - struck by truck - thrown 18 ft.	12	F		Ruptured spleen	Williams, A. M. 1962 (726)
124.	Pedestrian - struck in mid-abdomen by rt. fender of automobile	9	M		Longitudinal laceration of jejunum	Williams, A. M. 1962 (726)

125. Pedestrian - struck by automobile - hood ornament caused gaping chest wound	45	M	Large liver laceration - ruptured diaphragm	Worman, L. W. et al 1962 (746)
126. Pedestrian - struck by automobile	10	M	Extensive trauma and hemorrhage of spleen - severely lacerated and hemorrhagic left kidney	Davis, C., et al 1963 (134)
127. Pedestrian - crushed between two cars	12	M	Laceration of liver - hematoma around transverse colon and pancreas - pancreatic pseudocyst	Doubilet & Mulholland 1963 (386)
128. Pedestrian - hit by auto	36	M	Lacerated diaphragm and abdomen - stomach and colon perforation - pt. died	Lucido & Wall 1963 (404)
129. Pedestrian - hit by auto	62	M	Ruptured left diaphragm	Lucido & Wall 1963 (404)
130. Pedestrian - hit by auto	32	M	Ruptured diaphragm - ruptured spleen (probable) - pt. died	Lucido & Wall 1963 (404)
131. Pedestrian - hit by truck	7	M	Ruptured diaphragm - ruptured spleen and liver - retroperitoneal hemorrhage - pt. died	Lucido & Wall 1963 (404)
132. Pedestrian - hit by bus	64	M	Ruptured diaphragm - perforation of jejunum - avulsion of small bowel mesentery - pt. died	Lucido & Wall 1963 (404)
133. Pedestrian - struck by car	73	M	Ruptured left diaphragm - large rupture of spleen - pt. died	Lucido & Wall 1963 (404)
134. Pedestrian - struck by auto	40	M	Large tear rt. liver lobe	Poulos, E. 1963 (544)
135. Pedestrian - run over by car	57	M	1/2 in. rupture of the afferent jejunal loop - pt. died	Wilson, D. H. 1963 (738)
136. Pedestrian - run over by car - 10. 1963	2	F	Rupture of the common bile duct	Walshausen, et al 1963 (655)
137. Pedestrian - struck by automobile	63	M	Laceration of common iliac vein with hematoma	Buxton, R. H. 1964 (83)
138. Pedestrian - struck by auto backing out - tire ran over stomach	4	F	Abrasion and bruising on rt. side - large laceration in pyloric region (anterior wall) of stomach - pt. died	Greig, M. T. 1964 (270)
139. Pedestrian - struck by slowly moving car	2	F	Fracture of duodenum lobe of liver - large laceration of left and rt. hepatic ducts join. - 500 cc. blood	Harrison & Cresney 1964 (290)

140. Pedestrian - struck by truck	7-1/2	M	3 cm. perforation in the gall bladder - 3 liters fluid in abdomen	Hartman & Greaney (296) 1964
141. Pedestrian - struck by truck	2	M	Laceration of spleen with cystic hematoma	Lorimer, W. S. 1964 (402)
142. Pedestrian - run over by front wheel of heavy watering tank	5	M	Abdominal abrasion - multiple lacerations of rt. liver lobe - rupture of diaphragm - herniation of perforated stomach - patient died (2-1/2 yrs. P.O. from this injury)	Myers, N. A. 1964 (474)
143. Pedestrian - knocked down by car	6	F	Injury to spleen - tear of stomach	Anand & Davey 1965 (17)
144. Pedestrian - knocked down by truck	16	M	Injury to spleen - pt. died	Anand & Davey 1965 (17)
145. Pedestrian - knocked down by cyclist	59	F	Splenic injury	Anand & Davey 1965 (17)
146. Pedestrian - knocked down by car	10	M	Splenic injury - small laceration of liver	Anand & Davey 1965 (17)
147. Pedestrian - struck by automobile	51	M	Lacerations of liver, gall bladder, pancreas, and transverse mesocolon - hemoperitoneum 1000 cc. - necrosis of the hepatic flexure of the colon - superior mesenteric vein (middle colic branch) lacerated	Freeerk, R. J. et al 1955 (236)
148. Pedestrian - struck on rt. side of abdomen by passing car	7	M	Laceration of left and rt. lobes of liver and gall bladder - massive hemorrhage	Hanna, W. A. et al 1965 (267)
149. Pedestrian - hit by auto while waiting at a tram stop	22	M	Rupture of rt. diaphragm - herniation of liver - small tear in root of esophagus	Hardy, K. J. 1965 (251)
150. Pedestrian - knocked over by car	62	M	Tear of left diaphragm - stomach, splenic flexure of colon herniated	Hardy, K. J. 1965 (291)
151. Pedestrian - struck down by motor vehicle	50	M	Retropertitoneal hematoma of rt. flank - lumbar hernia	Wade, P. et al 1965 (557)
152. Pedestrian - struck by automobile	50	M	Rupture of liver and colon - pt. died	Wilson, C. B. et al (737) 1965
153. Pedestrian - struck by vehicle			Laceration of dome and rt. lower lobe - pt. died	Baker, R. J. et al 1966 (33)
154. Pedestrian - struck by vehicle			Rt. liver lobe split to vena cava - pt. died	Baker, R. J. et al 1966 (33)

Cardiac arrest

Multiple lumbar vertebrae & rib fractures

Depressed skull fracture

Case No.	Accident Description	Sex	Age	Cerebral damage	Other Injuries	Author(s) & Year
155.	Pedestrian - struck by vehicle				Laceration of rt. liver lobe - pt. died	Baker, R. J. et al (1966) (33)
156.	Pedestrian - struck by car	M	6		Intramural hematoma of duodenum - retroperitoneal hemorrhage	Devroede, G. J. et al (1966) (142)
157.	Pedestrian - run over by car	M	74	Multiple injuries	500 ml. blood from ruptures with small capsular lacerations of rt. lobe liver - pt. died	Hellstrom, G. 1966 (300)
158.	Pedestrian - run over by car	F	79		100 ml. blood from two ruptures on anterior side of rt. lobe of liver - pt. died	Hellstrom, G. 1966 (300)
159.	Pedestrian - run over by car	M	4		100 ml. blood from large rupture in rt. lobe of liver - pt. died	Hellstrom, G. 1966 (300)
160.	Pedestrian - knocked over in the street by a bus	F	73	Aortic rupture	Large rupture of rt. lobe of liver - pt. died	Hellstrom, G. 1966 (300)
161.	Pedestrian - ran into almost stationary bus	M	2		Trauma - liver lobe - rt. atrial rupture - rt. kidney partly detached from abdominal wall - pt. died	Hellstrom, G. 1966 (300)
162.	Pedestrian - run over by car	M	32		Large superficial ruptures in rt. liver lobe - D.O.A.	Hellstrom, G. 1966 (300)
163.	Pedestrian - struck by automobile			Multiple fractures - pelvic fracture	Left breast avulsed from uteropelvic junction	Holland, M. E. et al (1966) (314)
164.	Pedestrian - struck by truck	M	21		Fracture of the pancreas - rupture of 3rd portion of duodenum - contusion of anterior surface of rt. liver lobe - subcapsular hematoma of duodenum - large hematoma of root of small bowel mesentery - large laceration in region of pancreas	Nelson, J. F. 1966 (400)
165.	Pedestrian - struck by automobile	M	67		Retroperitoneal hematoma - adrenal cortical cyst - hemorrhage - duodenal wall (3rd & 4th parts) contused & hemorrhagic	Robins & Sullivan 1966 (562)
166.	Pedestrian - unspecified blunt abdominal trauma		61	Brain concussion	Liver injury - Pt. died	Rodkey, G. V. 1966 (565)
167.	Pedestrian - unspecified blunt abdominal trauma		33	Brain and pelvic injury	Small bowel and bladder injury - pt. died	Rodkey, G. V. 1966 (563)

168. Pedestrian -	70	Brain injury	Spleen and liver injury - hemorrhage - pt. died	Rodkey, G. V. 1966 ((563))
169. Pedestrian - unspecified blunt abdominal trauma	47	Brain and pelvic injury	Colon and bladder injury - pt. died	Rodkey, G. V. 1966 ((563))
170. Pedestrian - unspecified blunt abdominal trauma	65	Brain and pelvic injury	Retroperitoneal hematoma (huge) - pt. died	Rodkey, G. V. 1966 ((563))
171. Pedestrian - unspecified blunt abdominal trauma	64	Pelvic injury	Pancreas and bladder injury - retroperitoneal hematoma - pt. died	Rodkey, G. V. 1966 ((563))
172. Pedestrian - knocked down by car	30		Abrasion to the rt. of umbilicus - oblique tear from the 2nd to the 3rd parts of the duodenum - large retroperitoneal hematoma - pt. died	Thevathasan, C. G. 1966 ((675))
173. Pedestrian - struck by car	12		Tear at junction of 2nd and 3rd parts of duodenum - large retroperitoneal hematoma	Thevathasan, C. G. 1966 ((675))
174. Pedestrian - struck by auto	11		Ruptured diaphragm - lacerated rt. liver lobe	Sutton, J. P. et al 1967 ((669))
175. Gravel truck ran over abdomen	20		Ruptured diaphragm - stomach herniated into chest - lacerated liver - torn distal ileum	Sutton, J. P. et al 1967 ((669))
176. Pedestrian - struck by slowly moving auto in anterior abdomen	9		Intramural hematoma of the duodenum - retroperitoneal hematoma overlaying inf. vena cava and 3rd portion of duodenum	Webb and Taylor 1967 ((713))
177. Pedestrian - struck by auto-mobile	41		Head of pancreas severely contused and bleeding - 1st & 2nd portions of duodenum destroyed - distal part of common duct avulsed	Brawley, R. K. et al 1968 ((70))
178. Pedestrian - run over by car	6		Rupture of the posterior aspect of the common bile duct	Plewes & McKee 1968 ((538))
179. Pedestrian - struck by car and thrown several feet	6		Hematuria - avulsion of kidney	Samuels & Smith 1968 (580)
180. Pedestrian - struck by car while crossing street	8		Laceration of rt. kidney with extravasation	Samuels & Smith 1968 ((580))
181. Pedestrian - struck by automobile	9		Transection of tail of pancreas	Weitzman & Rothschild 1969 ((717))

NO.	AGE	SEX	DETAILS DATA	ADDITIONAL INJURIES REPORTED	REFERENCE
182.	8	M	Pedestrian - struck by automobile	Transsection of the body of the pancreas	Weitzman & Rothschild 1968 (Z17)
183.	59	M	Pedestrian - struck by automobile	Pelvic fracture	Allen, R. E. et al 1969 (12)
184.	9	M	Pedestrian - car jumped sidewalk and hit him in abdomen		Espinosa & Marks 1969 (204)
185.	7	M	Pedestrian - struck by automobile	Multiple injuries	Guerrier, K. et al 1969 (275)
186.	52	M	Pedestrian - hit by automobile at 25 mph	Multiple skull and vertebral fracture	Huejke, D. F. & Davis 1969 (319)
187.	47	M	Pedestrian - hit by automobile at 30 mph	Rupture of thoracic aorta	Huejke, D. F. & Davis 1969 (319)
188.	72	M	Pedestrian - hit by automobile at 30 mph	Skull fracture and intracranial hemorrhage	Huejke, D. F. & Davis 1969 (319)
189.	29	M	Pedestrian - hit by automobile at 60 (+) mph	Skull fracture - brain hemorrhage	Huejke and Davis 1969 (319)
190.	16	F	Pedestrian - hit by automobile at 55 mph	Crushing head injuries	Huejke and Davis 1969 (319)
191.	11	M	Ran into tailfin of 1961 Cadillac striking upper abdomen		Jordan, G. L. et al 1969 (371)
192.	64	M	Pedestrian - struck by automobile	Fractured pelvis	Motsay, G. J. et al 1969 (470)
193.	31	F	Pedestrian - struck by automobile	Fractured pelvis	Motsay, G. J. et al 1969 (470)

CAUSE OF INJURY	AGE	SEX	WT.	PERTINENT DATA	ABDOMINAL INJURIES REPORTED	REFERENCE
194. Pedestrian - struck by automobile	66	F		Fractured pelvis	Laceration of left common iliac vein - completely avulsed left external iliac vein - massive hemorrhage - pt. died	Rotroy, G. J. et al 1969 (470)
195. Pedestrian - struck by automobile	15	M			Massive stellate laceration of rt. liver lobe	Pearlman & Grayer 1959 ((519))
196. Pedestrian - struck by a car	8	M			Large stellate fracture of left liver lobe - avulsion of rt. gastric artery - serosal tear of the transverse colon	Payne, W. D. et al 1969 (517)
197. Standing against wall - struck by bicycle	5	M			Perforation of midportion of jejunum	Dickinson, S.J. et al 1970 (144)
198. Pedestrian - struck on left side by car	3	M			Perforation of jejunum	Dickinson, S. J. et al 1970 (144)
199. Pedestrian - ran into road - knocked down by car	10	M			Segment of jejunum intussuscepted and edematous	Isbister, W. H. 1970 (324)
200. Pedestrian - struck by a bus	29	F		Multiple pelvic fractures	Large retroperitoneal hematoma - serosal tears of bowel	Nunes, G. et al 1970 (494)
201. Pedestrian - struck by car	8	F			Ruptured spleen - left retroperitoneal hematoma involving the left kidney	Nunes, G. et al 1970 (494)
<u>ADDENDUM</u>						
202. Pedestrian - struck by truck	6	M			Transverse tear (3/4 circum.) of upper jejunum	Lawson, R.S. 1940 (384)
203. Pedestrian - struck by truck	47	M		Fractured left ribs (10-12) - fractured pelvis	Retroperitoneal hematoma	Sallick, M.A. 1941 (577)
204. Pedestrian - hit by truck on left side of abdomen	2	M			Ruptured spleen - laceration of tail of pancreas - pt. died	Kelly, E.C. 1943 (353)
205. Pedestrian - ran into tailboard of parked truck with great force	15	M			Rupture of 2nd portion of duodenum	Sarnoff & Oremland 1943 (584)
206. Pedestrian - while walking across street - struck on left side by automobile	32	M		Left rib fracture (10-12)	Transverse rupture of spleen	Waugh & Prior 1943 (712)
207. Pedestrian - hit by automobile - wheel passed over body	9	M			Perforation of stomach - contusion of the large and small bowel - hematomata of the mesentery and omentum	Bunch, J.R. 1944 ((78))

CAUSE OF INJURY	AGE	SEX	WT.	PERTINENT DATA	ABDOMINAL INJURIES REPORTED	REFERENCE
203. Pedestrian - struck by automobile	65	M			Subserosal hematoma of mesenteric border of upper end of ileum - large retro-peritoneal hematoma	Bunch, J.R. 1944 (78)
209. Pedestrian - struck by automobile	19	M			Terminal ileum avulsed - rent in mesentery - pt. died	Hicken & Carlquist 1944 (305)
210. Pedestrian - struck by auto - thrown twenty feet	7	F		Severe shock	Spleen torn into two halves - hemorrhage - contusion of left kidney	Mazel, M.S. 1945 (430)
211. Pedestrian - struck by automobile	16	M		Skull fracture	Ruptured spleen - pt. died	Cohn, I. 1949 (118)
212. Run over by rear wheel of heavy oil field truck	16	M		Three left rib fractures	Diaphragmatic rupture (left) - entire stomach, spleen and transverse colon herniated	Ward, B.W. 1951 (703)
213. Pedestrian - run over by car - struck in abdomen by bumper	26	M		Massive hemorrhage	Rupture of left diaphragm - herniation of stomach - pt. died	Ramstrom & Alsen 1954 (547)
214. Pedestrian - knocked down by a van	3	M		Fractured left pubis	Ureter avulsed at pelvi-ureteral junction	Seright, W. 1959 (600)
215. Pedestrian - run down by bus starting up	5	M			Complete avulsion of ureter	Zufall, R. 1961 (759)
216. Pedestrian - run over by auto	2	M			Pararenal pseudohydronephrosis	Dowse & Kihn 1963 (168)
217. Pedestrian - run over by wheel of van	2	M		Fractured pelvis	Ruptured diaphragm - pt. died	Ker, H., 1963 (358)
218. Pedestrian - struck by automobile	72	M		Multiple left rib fractures	Ruptured left diaphragm - herniation of colon - ruptured spleen	McCort, J.J. 1964 (434)
219. Pedestrian - struck by automobile	11	M			Complete avulsion of upper ureter	Fruchtman & Newman 1965 (246)
220. Pedestrian - struck by automobile	11	M			Complete avulsion of upper ureter	Fruchtman & Newman 1965 (246)
221. Pedestrian - struck by automobile	58	F		Fracture of L3 - skull fracture	Complete <u>bilateral</u> severance of ureter	Smith, R.J. 1962 (527)
222. Pedestrian - struck by automobile	51	M			Partial tear of the neck of pancreas - gallbladder, colon, and liver injuries	Freeark, R.J. et al 1966 (237)
223. Pedestrian - struck by automobile	12				Rupture of left diaphragm - stomach herniated into chest	Noon, G.P. et al 1966 (431)

CAUSE OF INJURY	AGE	SEX	WT.	PERTINENT DATA	ABDOMINAL INJURIES REPORTED	REFERENCE
224. Pedestrian - knocked down by car while walking - struck in abdomen by front fender and headlight	16	F			Subcutaneous rupture of the abdominal wall - prolapse of the transverse colon and omentum - hematoma	Fredlund & Dahn 1967 (235)
225. Pedestrian - struck by automobile	6	F		Rt. rib fracture (7th)	Severance of the renal pedicle - small parenchymal laceration of upper pole of kidney	Watkins, J.P. et al 1967 (709)
226. Pedestrian - knocked over by auto	16	M			Hematoma of 3rd and 4th parts of duodenum - hematoma of pancreas	Essenhigh, D.M. et al 1968 (205)
227. Pedestrian - struck by automobile	10	M			Two perforations on the antimesenteric border of the small intestine	Weiss & Dreiling 1968 (715)
228. Pedestrian - struck by automobile	7	M		Left pubic ramis fractures	Tear of left diaphragm - seromuscular tear of cecum	Radhakrishna, C. et al 1969 (546)

IV. DETAILED DESCRIPTION OF OCCUPANT KINEMATICS

CAUSE OF INJURY	AGE	SEX	WT.	PERTINENT DATA	ABDOMINAL INJURIES REPORTED	REFERENCE
A. Dashboard Impact						
1. Automobile accident - head on into oncoming at high speed - front passenger - thrown thru windshield	30	M			Tear involving 2/3 circumference of gall bladder - laceration of liver - generalized peritonitis	Newell, C. E. 1948 (482)
2. Automobile accident - front seat passenger in Jeep - crashed under rear end of parked truck - Jeep's windshield impacted into lower rib area (ribcage)	16	M			Extensive (5 in.) laceration of rt. liver lobe - hemorrhage	Sanders, G.B. et al 1949 (582)
3. Automobile accident - thrown against dashboard	2	F			Rupture of extrahepatic bile ducts	Mason, L. B. et al 1954 (424)
4. Automobile accident - passenger - collision with truck - struck left side against dashboard	22	M			Laceration of spleen - massive hemorrhage	Wyman, A. C. 1954 (751)
5. Automobile accident - front passenger thrown against dashboard	2	M			Abdominal hemorrhage - hemoperitoneum (at laparotomy source of hemorrhage could not be found)	Mathieson, A. J. 1962 (427)
6. Automobile accident - thrown against dashboard	4	F			Rupture of left liver lobe - hemobilia	Whelan & Gillespie 1965 (710)
7. Automobile accident - high speed accident - thrown against the dashboard - blunt trauma to thorax and abdomen	18	M			Large rt. intrahepatic hematoma - ruptured with hemorrhage - pt. died	Richardson, R. E. et al 1967 (555)
8. Automobile accident - driver - ran off road and struck power pole - 35-30 mph impacted steering wheel, lower instrument panel and windshield				Fractured rt. ribs (7-9)	Contusion of kidney	Siegel, VanWagoner & Nahum 1969 (613)
9. Automobile accident - collided head-on into rear of bus - front passenger - abdomen & head thrown into glove compartment	24	M	185		Liver completely transected at mid-portion	D.O.T. HS 600 050 PB 190734 1970 (168)
10. Automobile accident - Broadside (rt.) into telephone pole at 45-55 mph - F.R. passenger (seated on lap) thrown into windshield	2	F			Minimal laceration of abdomen	D.O.T. HS 600 066 PB 190750 1970 (175)

11.	Automobile accident - Broadside (rt.) into parked car at 30-40 mph - driver - struck windshield and received injuries from instrument panel	36	M		Abrasion of rt. anterior flank of the abdomen	D.O.T. 600 071 PB 190755	1970 (176)	
B. Armrest - Door Impact								
1.	Automobile accident - passenger - collision with another vehicle - thrown against door of car	88	F		Echymotic hemorrhagic and gangrenic intestine - mesentery of the small bowel hemorrhagic with thrombosis - pt. died	McCune, W. S. et al 1952	(435)	
2.	Automobile accident - driver - struck left side against door	17	M		Deep laceration of spleen	Wyman, A. C. 1954	((751))	
3.	Automobile accident - front seat passenger (next to driver) - struck broadside by another vehicle - auto impacted on passenger's side	28	F	Multiple left rib fractures - pelvic fracture	Ruptured bladder - fragmentation of spleen	Rea, D. 1963	(54(549))	
4.	Automobile accident - struck in rt. flank by armrest	35	M		Gross hematuria of the rt. flank - enlarged, damaged rt. kidney	Tomskey, et al 1965	(686)	
5.	Automobile accident - struck in left flank by armrest	40	F		Gross hematuria - left colon displaced medially - complete rupture of left kidney - retroperitoneal hemorrhage	Tomskey, et al 1965	(686)	
6.	Automobile accident - driver - 1967 Chev. struck broadside (left front door) by 1966 Mustang at 30-40 mph - 26-28 in. penetration - driver impacted against door and narrow arm rest			Left rib fractures - pulmonary and myocardial contusions - cerebral concussion	Laceration at dome of urinary bladder	Siegel, Van Wagoner & Nahum 1969	(673)	
7.	Automobile accident - hurled against door next to which he was sitting	4	M		Laceration of the gall bladder	Schechter, D. C. 1969	((589))	
8.	Automobile accident - struck broadside by car, then struck again by truck - thrown against left interior - then thrown to right - Driver	41	M	180	Blunt force to abdomen	Ruptured liver, spleen, gall bladder - massive hemo. peritoneum - multiple contusions of mesenteric structures and bowels = fatal	D.O.T. HS 600 106 Case No. 6914 1970	((182))
9.	Seat Belt - auto sliding laterally at 45 mph impacted on rt. broadside 50-60 mph - driver - thrown to right impacted center arm rest	51	M	180	Multiple injuries - brain	Lacerations of the liver, spleen and rt. kidney - fatal	D.O.T. HS 600 058 PB 190 742	1970 ((170))

10.	Seat Belt - auto sliding laterally at 45 mph, impacted on rt. Broadside at 50-60 mph - F.R. passenger - struck by intruding door	41	F	115	Multiple injuries - heart	Extensive lacerations of the stomach, liver, left kidney and spleen - fatal	D.O.T. HS 600 058 PB 190 742	1970 (170)	
11.	Automobile accident - travelling at 60 mph was impacted on left side at 50-65 mph - driver - thrown to left into door and armrest	30	M	162	Multiple injuries - cranial	Large laceration of left diaphragm with herniation of spleen into thoracic cavity - anterior pole of spleen amputated - contusion on serosal surface of stomach - fatal	D.O.T. HS 600 063 PB 190 747	1970 (174)	
12.	Automobile accident - broadside into telephone pole at 45-55 mph - F.R. passenger - struck by armrest	21	F	100		Herniation of liver into rt. hemothorax with multiple lacerations of the liver - fatal	D.O.T. HS 600 066 PB 190 750	1970 (175)	
13.	Automobile accident - left front into bridge abutment at 30-40 mph - driver - abdomen struck intruding left door	50	M	175	Aorta ruptured - multiple injuries	Tears on lateral surface of spleen - fatal	D.O.T. HS 600 072 PB 190 756	1970 (177)	
C. Rear Seat									
1.	Automobile accident - rear passenger thrown forward against drivers seat	39	F		7-1/2 mo. pregnant	Rent in left diaphragm (4 in.) - stomach, colon and most of liver herniated	Evans & Simpson 1950 (210)		
2.	Automobile accident - car rolled at 75 mph - back seat passenger		M			Laceration of diaphragm - herniation of entire stomach into left chest	Bogedain & Carpathios 1959 (58)		
3.	Automobile accident - while traveling 45-55 mph, was struck in front by another auto at 30-40 mph - R.R. passenger - impacted back of front seat	17	M			Moderate contusion of abdomen	D.O.T. HS 600 085 Case No. 66	1970 (179)	
4.	Automobile accident - rear seat passenger - fast moving vehicle struck abutment	16	M			Duodenum completely transected at pylorus - laceration of liver - pancreas contused and hemorrhagic - multiple lacerations of the spleen	Menick & Kim 1970 (443)		
D. Miscellaneous Impact									
1.	Automobile accident - train wreck	49	M		pt. died of bronchopneumonia	Splenic rupture	Zabinski 1943 (756)		
2.	Automobile accident - passenger - car rolled over - thrown around inside of car	58	M			Jagged laceration in one loop of small bowel	Collins, A. N. 1944 (120)		

3.	Automobile accident - driver - struck concrete bridge abutment	20	M		Transverse tear on posterior surface of 2nd portion of duodenum	Newell, R. B. et al 1951 ((483))
4.	Automobile accident - struck by train	25	M	Multiple fractures	Lacerated bleeding spleen - ruptured diaphragm with partial herniation of stomach	Adams & Musselman 1954 ((3))
5.	Automobile accident - ran into abandoned automobile - F. R. passenger	22	M		Multiple liver lacerations - hemorrhage	Stone, F. A. et al 1965 ((657))
6.	Automobile accident - car struck by another auto - front passenger	39	F	150	Contusion and hemorrhage of abdominal wall - rt. rectus muscle torn across the peritoneal cavity - 12 in. laceration along the mesentery of terminal ileum - hemorrhagic appendix	Gatewood & Russum 1956 ((251))
7.	Automobile accident - went out of control at high speed - passenger	30	M	Cardiac arrest	Ruptured left diaphragm with major portion of stomach in chest - pt. died	Desforages, G. et al 1957 ((141))
8.	Automobile accident - car hit by train	73	M	Rib fractures - comatose - shock	Ruptured left diaphragm - ruptured spleen herniated stomach, spleen, omentum - pt. died	Grage, T. B. et al 1959 ((267))
9.	Automobile accident - car overturned	21	M		Contusion of rt. kidney - retro-peritoneal hemorrhage	Kastl, W. H. 1959 ((347))
10.	Automobile accident - two car collision - each car traveling at (5 mph)	70	M		Extensive retroperitoneal hematoma involving the left kidney	Kastl, W. H. 1959 ((347))
11.	Automobile accident - car struck telephone pole at 90 mph	18	M	Cerebral contusions - subdural hematoma - pulmonary hematoma	Abdominal abrasions - pt. died	Shaftan, G. W. 1960 ((602))
12.	Automobile accident - passenger in truck - thrown forward one struck in mid-abdomen by gearshift	42	F		Large transverse tear on the anti-mesenteric border of the jejunum	Thorlakson, R. H. 1960 ((681))
13.	Automobile accident - passenger - sports car skidded and turned over	21	F		Complete vertical split of the pancreas	Bracey, D. W. 1961 ((58))
14.	Automobile accident - struck by gearshift lever	40	F		Cystic hematoma between spleen and stomach	O'Brien & Fyshe 1961 ((433))
15.	Automobile accident - F.R. passenger - thrown and pinned between driver and steering wheel	30	F		Subcapsular hematoma spleen - bleeding from small splenic vein - left kidney fractured into two pieces - hematoma transverse colon	Stephens, G. L. 1961 ((557))

16.	Automobile accident - speeding car into tree- driver	26	M		Hemoperitoneum - ruptured spleen - lacerated diaphragm - pt. died	Van Wagoner 1961 (696)
17.	Automobile accident - driver - head on collision with another auto	31	M		Pancreatic fistula - extensive retro-peritoneal blood - small tear in lesser omentum - small tears in the serosa of anterior stomach wall and the duodeno-jejunal flexure	Greig & Rea 1962 (269)
18.	Automobile accident - driver - head on into telephone pole	32	M		Rupture of third portion of duodenum	Gould & Thorworth 1963 (255)
19.	Truck accident - struck bridge abutment - driver	34	M		Laceration on the posterolateral wall of gall bladder - generalized bile peritonitis	Hogue & Munnell 1963 (313)
20.	Automobile accident - roll - pt. hit roof of car and came down on back seat	44	M		Mesentery hemorrhagic - annular constructive lesion on descending colon	Altner, P. C. 1964 (113)
21.	Automobile accident - car struck from behind by truck	59	M	Rib fracture	Extensive adhesions encroaching the small intestine and omentum - pericolic hematoma	Altner, P. C. 1964 (113)
22.	Automobile accident - car overturned - front seat passenger	18	F		1300 ml. blood from 2 ruptures of rt. liver lobe - killed at impact	Hellstrom, G. 1966 (300)
23.	Automobile accident - car overturned - driver	18	M		Ruptures of liver and spleen	Hellstrom, G. 1966 (300)
24.	Automobile accident - thrown onto the floor of the auto	1	M		Widespread hepatoblastoma	Miller, R. C. et al 1966 (454)
25.	Automobile accident - driver - skid on water puddle - ran head on into another auto	29	M	Rt. rib fractures (7-9) - cerebral concussion	Contusions of rt. kidney and liver	Yap, E. T. 1966 (752)
26.	Automobile accident - driver - hit a truck - lost control of car	19	M		Spleen ruptured in four places	Yap, E. T. 1966 (752)
27.	Automobile accident - car hit a tree - severe crushing injury to upper abdomen	33	F		Laceration of dome of rt. liver lobe - hemobilia	Gundersen & Green 1967 (276)
28.	Automobile accident - head on into another vehicle - driver	50	F	Fractures of left posterior ribs	Laceration in dome of left diaphragm - herniation of spleen - ruptured spleen	Asbury, G.F. 1968 (24)
29.	Automobile accident - driver - car struck a bridge	74	M	Fractured ribs	Rupture of right diaphragm - herniation of liver, colon, small bowel and gall bladder into thorax - pt. died	Epstein & Lempke 1968 (203)

30.	Automobile accident - driver - struck a parked car	41	M	Hematoma of 2nd part of duodenum with obstruction	Keplinger et al 1968 (357)
31.	Automobile accident - driver - struck an abutment	46	M	Oblique laceration that transected jejunum at lig. of Treitz	Keplinger et al 1968 (357)
32.	Automobile accident - struck a parked car at 35 mph	31	M	Jagged ribs lacerated diaphragm - flail chest	Albo, D. et al 1969 (8)
33.	Automobile accident - (Jeep accident on mountain trail)	21	M	Large stellate laceration of rt. liver lobe - laceration of diaphragm - tear in vena cava - hemorrhage	Albo, D. et al 1969 (8)
34.	Automobile accident - hit broadside by truck at 50 mph - driver	21	M	Contusions on rt. and center of abdomen	D.O.T. HS 600 107 Case No. 6915 1970 (183)
35.	Automobile accident - hit broadside by truck at 50 mph - passenger	35	M	Multiple large tears in rt. lobe of liver - fatal	D.O.T. HS 600 107 Case No. 6915 1970 (183)
36.	Automobile accident - hit broadside by truck at 50 mph - passenger	28	M	Ruptured liver, spleen, bladder, kidneys - contusions and bruises of the bowel - hemoperitoneum - fatal	D.O.T. HS 600 107 Case No. 6915 1970 (183)
37.	Automobile accident - hit tree and rolled at 55 mph - driver	21	M	Abrasions of the abdomen	D.O.T. HS 600 036 Case No. MCR-69-4 1970 (180)
38.	Automobile accident - laterally sliding auto at 10-20 mph, impacted broadside by truck at 50-60 mph - R.L. passenger	34	F	Multiple abrasions of abdominal wall - <u>fatal</u>	D.O.T. HS 600 062 PB 190746 1970 (173)
39.	Automobile accident - travelling at 10-20 mph was impacted in rt. front at 60 mph - driver	41	M	Contusion of intestinal track and liver - bruising of kidneys	D.O.T. HS 600 018 PB 190 343 1970 (160)
40.	Automobile accident - slid into utility pole laterally at 25-40 mph - driver - extensive deformation and intrusion	21	F	Lacerations of the liver - fatal	D.O.T. HS 600 022 PB 190505 1970 (161)
41.	Automobile accident - pick-up truck impacted a concrete post and a wooden bridge - driver - impalement	24	M	Tears of left lobe liver, spleen - perforation of the fundus - complete severing of inf. vena cava - fatal	D.O.T. HS 600 033 PB 190516 1970 (163)
42.	Automobile accident - auto sliding laterally at 70 mph, impacted on left broadside at 25 mph - driver	18	M	Rupture of liver, spleen and diaphragm - fatal	D.O.T. HS 600 059 PB 190743 1970 (171)
43.	Truck accident - head-on collision - driver of truck	50	M	The entire stomach, spleen, tail of the pancreas and splenic flexure of the colon were herniated into the left thoracic cavity	Walt & Grifka 1970 (701)

V. BICYCLE ACCIDENTS

CAUSE OF INJURY	AGE	SEX	WT.	PERTINENT DATA	ABDOMINAL INJURIES REPORTED	REFERENCE
A. Struck by Automobile						
1. Bicycle accident - run down by auto	14	M			Rupture of spleen and liver with large hemorrhage	Blocker, T. G. 1939 ((53))
2. Bicycle accident - knocked down by automobile	7	M			Spleen completely detached from pedicle - large subcapsular hematoma of the liver - many subperitoneal hemorrhages on intestines	Blocker, T. G. 1939 ((53))
3. Bicycle accident - struck by automobile					Rupture of mesenteric border of the jejunum - rent in mesentery and gastrocolic ligament	Veal & Barnes 1941 (694))
4. Bicycle accident - struck by auto while riding	10	M			Retroperitoneal rupture of the duodenum	Johnson, M. L. 1944 (333))
5. Bicycle accident - collided with automobile				Fractured ribs	Tail of pancreas lacerated and bleeding - ruptured spleen	Berne & Walters 1953 ((50))
6. Bicycle accident - struck by truck	9	M			Ruptured spleen - pancreatic pseudocyst	Levitzky, E., et al 1956 ((389))
7. Bicycle accident - brushed by car - knocked to ground	39	M			Tail of pancreas transected at junction with body	Doubilet & Mulholland 1959 (165))
8. Bicycle accident - struck by auto				Fractured rt. rib (9th)	Ruptured liver	Requarth, W. 1959 ((552))
9. Bicycle accident - struck by cement truck	22	M		Multiple injuries	Ileum and its mesentery torn completely through - huge retroperitoneal hematoma - pt. died	Thoriakson, R. H. 1960 ((81))
10. Bicycle accident - cyclist run over by car	70	M			Spleen ruptured - two large ruptures of the posterior aspect of the bowel - large subphrenic hematoma	Hellstrom, G. 1961 ((239))
11. Bicycle accident - struck by car - thrown over and fell on rt. side	18	M			Stellate laceration of rt. liver lobe	Amesur, N. R. et al 1953 ((16))
12. Bicycle accident - struck by bus	58	M			Perforation along antimesenteric border of ileum - pt. died	Amesur, N. R. et al 1963 ((16))

13.	Bicycle accident - knocked to ground by auto	39	M	Tail of pancreas transected at junction with body	Doubilet & Mulholland 1963 (186)
14.	Bicycle accident - knocked off bicycle by truck	34	M	Large rent in anterior wall of stomach near the greater curvature	Greig, M. T. 1964 (270)
B. Fall onto Handlebars					
1.	Bicycle accident - fall over handlebars			Rupture of the mesenteric border of the jejunum	Veal & Barnes 1941 (694)
2.	Bicycle accident - fall over handlebars			Ruptured jejunum	Veal & Barnes 1941 (694)
3.	Bicycle accident - struck in epigastrium by handlebars of bicycle	14	M	1/4 in. perforation of duodenum - tear in superior pancreaticoduodenal artery - pt. died	Ficarra, B.J. 1944 (218)
4.	Bicycle accident - hit an auto - handlebars driven into abdomen	15	M	Rent in jejunum (1/2 circum)	Ficarra, B.J. 1944 (218)
5.	Bicycle accident - struck in abdomen by handlebars	14	F	1/2 in. laceration in jejunum	Ficarra, B.J. 1944 (218)
6.	Bicycle accident - received hard blow from handlebar over rt. lower chest (abdomen)	7	M	Hemorrhage into biliary tract - blood clot in gall bladder	Sandbloom, P. 1948 (591)
7.	Bicycle accident - struck abdomen on handle bar of bicycle	4	M	Intramural hematoma (hemorrhage) of the jejunum	Zabin, A. 1952 (754)
8.	Bicycle accident - fell over handlebars of bicycle - mainly on left side	9	M	Very large subserous hematoma of the duodenum (2nd, 3rd, 4th parts) and jejunum - obstruction	Stirk, D. I. 1953 (655)
9.	Bicycle accident - blow in left hypochondrium from handlebars	6	M	Subserosal hematoma of the jejunum	Cooling, C. I. 1953 (125)
10.	Tricycle accident - fell against steering post	6	M	Spleen ruptured near hilus	Halter & Gross 1957 (285)
11.	Bicycle accident - end of handlebar struck rt. upper quadrant	9	M	Complete transection of the pancreas - head of pancreas necrotic	Hannon & Sprafka 1957 (255)
12.	Bicycle accident - fell striking handlebars under left ribs into abdomen	10	F	Complete transverse severance at neck of pancreas - pancreas edematous	Letton & Wilson 1959 (332)

13.	Bicycle accident - struck in upper rt. quadrant of abdomen by handlebars	10	F	Retroperitoneal hematoma of the duodenum	Mabry, E. H. 1959 (405)
14.	Bicycle accident - struck in pit of stomach by handlebar when bicycle collided with auto	8	F	Retroperitoneal hematoma around transverse mesocolon and pancreas - pancreatic pseudocyst	Oeconomopoulos & Lee 1960 (499)
15.	Bicycle accident - sudden stop - abdomen thrust into handlebar area - struck left lower quadrant	8	M	Transverse rupture of jejunum	Chambers & Card 1961 (105)
16.	Bicycle accident - fall from bicycle - handlebars struck abdomen in left upper quadrant	7	M	Fat necrosis of pancreas, omentum, transverse colon	Parker & Christiansen 1961 (510)
17.	Bicycle accident - struck in the epigastrium by handlebar	12	M	Hematoma of lateral duodenal wall	Williams, A. M. 1962 (726)
18.	Bicycle accident - struck in abdomen by handlebar	7	M	Complete severance of the pancreas - mesentery of large bowel lacerated - large rent in peritoneum	Johnston & Sher 1963 (337)
19.	Bicycle accident - fell - striking head against ground - fairly light blow to abdomen from handlebar	12	M	Brain concussion	Bertelsen & Suhr 1964 (51)
20.	Bicycle accident - Rode bicycle into sand pile - handlebar struck upper left quadrant	8	M	Perforation of fourth portion of duodenum	Cocke & Meyer 1964 (116)
21.	Bicycle accident - struck in abdomen by bicycle handle	14	F	Ruptured pancreas	Currie, R. A. et al 1964 (132)
22.	Bicycle accident - struck epigastric area against handlebar	6	F	Pancreatic pseudocyst adherent to posterior stomach wall	Miller, R. E. 1964 (455)
23.	Bicycle accident - front wheel hit stone - rider thrown upwards into air landing on handlebar striking left lower abdominal wall	9	M	Lower anterior abdominal wall muscles split - hernia	Roberts, G. R. 1964 (560)
24.	Bicycle accident - thrown against handlebars	7	M	Laceration of pancreas (against vertebrae)	Adams, J. T. et al 1966 (212)
25.	Bicycle accident - ran into pole - struck abdomen on handlebar	7	M	Traumatic injury to pancreas	Arminio, J. A. 1966 (2)

26.	Fell from tree onto handlebars of tricycle	3	M	Intramural duodenal and jejunal hematoma	Devroede, G. J. et al 1966 (143)
27.	Bicycle accident - brakes failed - bicycle struck side of garage - handlebar struck left upper quadrant	8	M	Almost complete avulsion of small bowel	Nelson, J. F. 1966 (480)
28.	Bicycle accident - fell - struck in epigastrium by handlebar	7	F	Laceration on surface of rt. liver lobe - subcapsular hematoma of the dome of the liver	Nelson, J. F. 1966 (480)
29.	Bicycle accident - fall with blunt handlebar trauma to abdomen	8	M	Large laceration of liver - laceration of common hepatic (bile) duct	Noone, R. B. et al 1967 (462)
30.	Bicycle accident - struck in abdomen by handlebar	6	F	Intramural duodenal hematoma	Babbitt, D. P. et al 1968 (28)
31.	Bicycle accident - fell off bicycle - struck in abdomen by handlebar	8	M	Central rupture of the rt. liver lobe - pseudocyst of liver	Enge, I. et al 1968 (201)
32.	Bicycle accident - fell - struck upper part of abdomen on handlebars	10	M	Duodenal contusion with intramural hematoma	Essenhig, D. M. et al 1968 (205)
33.	Bicycle accident - fell - struck in abdomen by handlebars	8	M	Bluish discoloration of midline of epigastrium - laceration of pancreas - transection of the duct of Wirsung	Martin, L. W. et al 1968 (422)
34.	Bicycle accident - upper abdomen struck handlebars during fall	7	F	Transection of the neck of the pancreas - dividing the duct of Wirsung	Martin, L. W. et al 1968 (422)
35.	Bicycle accident - handlebar struck abdomen	7	F	Pancreatitis with pseudocyst - ruptured spleen	Otherson, H.B. et al 1968 (506)
36.	Bicycle accident - handlebar struck abdomen	9	M	Pancreatitis with pseudocyst	Otherson, H. B. et al 1968 (506)
37.	Bicycle accident - handlebar struck abdomen	11	F	Pancreatitis with pseudocyst	Otherson, H. B. et al 1968 (506)
38.	Bicycle accident - handlebar of bicycle into epigastric region	10	M	Intrahepatic hematoma - intrahepatic cyst - upper abdominal pain	Tank, E. S. et al 1968 (672)
39.	Bicycle accident - crashed "full speed" - fell onto upturned handlebar - sharp blow to epigastrium	7	M	Pancreas swollen, edematous with clot	Fraser, G. C. 1969 (234)

40.	Bicycle accident - fell - struck in abdomen by handlebars	9	F	Linear tear in jejunum (1/3 circum)	Oates, R. K. 1969 (496)
41.	Bicycle accident - fell - struck epigastrium on handlebar	9	F	Intramural duodenal hematoma	Resnicoff & Morton 1969 (554)
42.	Bicycle accident - fell on handlebar of bicycle - upper left quadrant	6	M	Intramural hematoma of the 3rd portion of the duodenum - subcapsular hematoma of pancreas with sapronification of the retroperitoneal tissue	Resnicoff & Morton 1969 (554)
C. Miscellaneous					
1.	Bicycle accident - fell over a hydrant - struck left side of abdomen	13	M	Ruptured spleen - ruptured pancreas - hemorrhage	Mazel, M. S. 1945 (430)
2.	Bicycle accident - struck a stone wall	13	M	Rupture of jejunum	Booth, B. M. 1948 (55)
3.	Bicycle accident - thrown from bicycle	8	F	Large rent in upper pole of rt. kidney	Bell, R. 1949 (10)(45)
4.	Bicycle accident - fell striking head and left chest (abdomen)	14	M	Pt. hemophiliac Massive rupture of spleen - massive hemorrhage - pt. died	Wyman, A. C. 1954 (75)
5.	Bicycle accident - fall	6		Ruptured spleen - retroperitoneal hemorrhage	Helsper, J. T. 1955 (301)
6.	Bicycle accident - unspecified blunt abdominal trauma	13		Ruptured spleen - hemorrhage	Tagart, R. B. 1955 (670)
7.	Bicycle accident - fall	10	F	Ruptured spleen	Tagart, R. B. 1955 (670)
8.	Bicycle accident - fall from bicycle	7-1/2	M	Elongated laceration of spleen	Halter & Gross 1957 (285)
9.	Bicycle accident - unspecified blunt abdominal trauma	10	M	1-1/2 in. capsular tear rent in left kidney - retroperitoneal hematoma	Wilson, D. H. 1963 (738)
10.	Bicycle accident - fell striking his abdomen	12	M	Retroperitoneal hematoma in area of pancreas and duodenum - subserosal hematoma of duodenum - contusion of pancreas	Judd, D. R. et al 1964 (344)
11.	Tricycle accident - falls from tricycle	2	M	Subserosal hematoma extending from the 2nd and 3rd portions of the duodenum into the jejunum	Judd, D. R. et al 1964 (344)
12.	Bicycle accident - unspecified blunt abdominal trauma	18	M	Laceration of left median segment of liver - liver almost completely divided in half - ruptured gall bladder	Aronson, K. F. et al 1968 (23)

13. Bicycle accident - fall	20	M	Ruptured spleen	Doporto, J. M. 1969 (155)
14. Bicycle accident - fall	13	F	Perforated jejunum	Doporto, J. M. 1969 (155)
15. Bicycle accident - fall	6	M	Large stellate fracture of the rt. liver lobe	Payne, W. D. et al 1969 (5177)

VI. MOTORCYCLE ACCIDENTS

CAUSE OF INJURY	AGE	SEX	WT.	PERTINENT DATA	ABDOMINAL INJURIES REPORTED	REFERENCE
A. Detailed Report						
1. Motorcycle accident - thrown off after colliding with auto	22	M		Multiple fractures	Transverse rupture of the jejunum - pt. died	Lawson, R. S. 1940 (384)
2. Motorcycle accident - drove motorcycle into car	22	M		Fractures of cervical vertebrae (4-5)	Rupture of 3rd portion of duodenum - pt. died	Kelly, E. C. 1943 (353)
3. Motorcycle accident - ran into car - struck in abdomen by handlebar	18	M			Rupture of left rectus muscle - rupture of both anterior and posterior walls of the stomach - pt. died	Kelly, E. C. 1943 (353)
4. Motorcycle accident - struck in abdomen by handlebar					Pancreas edematous with hematoma - fat necrosis	Berne & Walters 1953 (50)
5. Motorcycle accident - handlebar struck abdomen					Pancreatic collection (cyst)	Berne & Walters 1953 (50)
6. Motorcycle accident - knocked down by truck	16	M			Three inch split in rt. liver lobe - spleen shattered - oblique tear in 2nd part of duodenum	Clarke, R. 1954 (109)
7. Motorcycle accident - struck a telephone pole	53	M		Multiple rib fractures	Large deep laceration of left lobe of liver with lacerations of rt. liver lobe - pt. died	Glas, W. W. et al 1955 (259)
8. Motorcycle accident - struck by truck - handlebar thrust into left lower abdomen	14	M			Omentum and sigmoid colon herniated thru muscle - hematoma of sigmoid mesocolon	Landry, R. M. 1956 (381)
9. Mo Ped accident - drove off the road and struck rt. side of abdomen against fence	17	M			Retroperitoneal and pancreatic hematoma - rupture of duodenum	Eklund, A. E. 1958 (199)
10. Motorcycle accident - collided with auto	66	M			Rupture of liver - pt. died	Hellstrom, G. 1961 (299)
11. Motorscooter accident - ran into rear of large truck - steering wheel of cart (scooter) or bumper of truck into upper abdomen	26	M			Laceration of liver (just to left of falciform ligament) - transverse tear of duodenum (3/4 circum.) - head of pancreas traumatized	Neely & Hardy, 1961 (478)

12.	Motorcycle accident - collided with rear end of truck	21	M	Swollen and very bruised pancreas - hematoma in stomach wall - fat necrosis in the omentum	Greig & Rea 1962 (269)
13.	Motorcycle accident - knocked off motorscooter	20	M	Ruptured spleen with hematoma - peritoneal blood (3-4 pints)	Wilson, D. H. 1963 (738)
14.	Motorcycle accident - motorcycle fell on him - handlebar into lower abdomen (groin)	48	M	Tear in conjoint tendon - hematoma	Clain, A. 1964 (107)
15.	Motorcycle accident - collided with car	18	M	1000 ml. blood from liver and spleen rupture - pt. died	Hellstrom, G. 1966 (300)
16.	Motorcycle accident - riding Moped - riding towards truck and was struck once struck	63	M	7 cm. rupture through the superior side of the rt. liver lobe - contusions - pt. died	Hellstrom, G. 1966 (300)
17.	Motorcycle accident - skid - struck in the abdomen	23	M	Junction of 1st and 2nd parts of duodenum badly ruptured with severe shredding - laceration of liver - large retroperitoneal hematoma	Thevathasan, C. G. 1966 (675)
18.	Motorcycle accident - fall (onto carburetor in left pocket	17	M	Ruptured spleen - ptosis of the rt. kidney	Khanna, H. L. et al 1967 (361)
19.	Motorcycle accident - heavy blow to the upper abdomen	16	M	Massive bursting injury of the 2nd part of the duodenum - complete avulsion of the head of the pancreas from the duodenum - distal common bile duct and the ampulla of Vater were avulsed from the duodenum	Salyer & McClelland 1967 (579)
20.	Motorcycle accident - thrown from the motorcycle	17	M	Capsular tears at hilus of spleen - with large subcapsular hematoma	Berk & Wholey 1968 (45)
21.	Motorcycle accident - collided with bullcock cart - blunt injury to epigastrium	30	M	Bruise over rt. hypochondrium - perforation of duodenum between 2nd and 3rd parts - small hematoma of transverse mesocolon	Doodhar, M. C. et al 1966 (133)
22.	Motorcycle accident - hit by truck	37	M	Rent in the rt. hepatic duct - hemo-peritoneum - patient died 70 days P.O.	Maier, M. P. et al 1968 (415)
23.	Motorcycle accident - collided with automobile	28	M	Rupture of capsule and parenchyma of left kidney - massive retroperitoneal hematoma	McKenzie, D. J. 1970 (439)

VI. MOTORCYCLE ACCIDENTS - Cont'd

B. Unspecified Blunt Abdominal Trauma

1.	Motorcycle accident	22	M	Fractured pelvis	Extraperitoneal rent of the bladder	Orkin, L. A. 1952 ((504))
2.	Motorcycle accident	34			Ruptured spleen - pt. died	Clarke, R. 1954 ((109))
3.	Motorcycle accident - unspecified blunt abdominal trauma	17			Ruptured spleen - hemorrhage	Tagart, R. B. 1955 ((670))
4.	Motorcycle accident - unspecified blunt abdominal trauma	19			Ruptured spleen - hemorrhage	Tagart, R. B. 1955 ((670))
5.	Motorcycle accident - unspecified blunt abdominal trauma	22			Ruptured spleen - hemorrhage	Tagart, R. B. 1955 ((670))
6.	Motorcycle accident				Perforation of jejunum	Geohagan & Brush 1956 ((253))
7.	Motorcycle accident	30	M	Multiple head injuries	Rupture of spleen - ruptured left kidney - pt. died	Averbook & Pearson 1959 ((27))
8.	Motorcycle accident	29	M	Puncture wound of left upper abdomen	Laceration of spleen - small perforation of stomach (both due perhaps to penetrating wound) - avulsion of entire small bowel mesentery - pt. died	Averbook & Pearson 1959 ((27))
9.	Motorcycle accident	42	M		Ruptured left diaphragm - small bowel, stomach and colon herniated - pt. died	Grage, T. B. et al 1959 ((267))
10.	Motorcycle accident	29	M	Multiple pelvic fractures	Ruptured left diaphragm - small bowel and colon herniated	Grage, T. B. et al 1959 ((267))
11.	Motorcycle accident - unspecified blunt abdominal trauma		M	Fractured pelvis	Rent in left diaphragm - bowel herniated	MacLean, L. D. 1961 ((408))
12.	Motorcycle accident - unspecified blunt abdominal trauma	36	M	Fractured pelvis	Bladder injury (unspecified)	Mathieson, A. J. 1962 ((427))
13.	Motorcycle accident - unspecified blunt abdominal trauma	23	M	Testis injured	Rt. liver lobe injury (unspecified) - pt. died	Mathieson, A. J. 1962 ((427))
14.	Motorcycle accident - unspecified blunt abdominal trauma	19	M	Testis injured	Stomach rupture	Mathieson, A. J. 1962 ((427))
15.	Motorcycle accident - unspecified blunt abdominal trauma	23	M	Fracture L ₅	Rupture rt. liver lobe - hematuria - left kidney injury	Mathieson, A. J. 1962 ((427))

16.	Motorcycle accident - unspecified blunt abdominal trauma	26	M		Perforation along antimesenteric border of terminal ileum	Amesur, N. R. et al 1963 ((16))
17.	Motorscooter accident - unspecified blunt abdominal trauma	14	M	Perforated lung	Ruptured left diaphragm - perforated stomach - ruptured spleen	Lucido & Wall 1963 ((404))
18.	Motorcycle accident - unspecified blunt abdominal trauma	19	M		Spleen torn in several places - retro-peritoneal hematoma from diaphragm to pelvis - rent in posterior parietal peritoneum - large hematoma in mesentery	Wilson, D. H. 1963 ((738))
19.	Motorcycle accident	17	M	Slight cerebral concussion	Intramural hematoma of the duodenum	Trippestad, A. 1966 ((691))
20.	Motorcycle accident	22	M	Multiple injuries	Eviscerated fractured liver - massive hemorrhage - pt. died	Williams, L. F. & Byrne 1966 ((773))
21.	Motorcycle accident - unspecified blunt abdominal trauma	16	M		Intimal tears with distal thrombosis of both renal arteries	Grablowsky, O.M. et al 1970 ((266))
22.	Motorcycle accident - blunt abdominal trauma	26	M		Delayed rupture of the spleen with perisplenic hematoma	Walt & Grifka 1970 ((701))

VII. EJECTION

CAUSE OF INJURY	AGE	SEX	WT.	PERTINENT DATA	ABDOMINAL INJURIES REPORTED	REFERENCE
1. Fell out of a truck	21	M		Laceration of lung	Rupture of jejunum pt. died	Kelly, E. C. 1943 (353)
2. Automobile accident - thrown from auto	64	M		Fractured ribs and bronchopneumonia	Two small perforations in the ileum - generalized peritonitis - pt. died	Ficarra, B.J. 1944 (218)
3. Truck accident - driver thrown from cab - struck abdomen against telephone pole		M			Perforation of jejunum - multiple stellate lacerations of the tail of the pancreas - pt. died	Hicken & Carlquist 1944 (305)
4. Automobile accident - driver - truck overturned - thrown out	32	M		Fractured pelvis	Perforation of the jejunum	Poer, D. H. 1946 (540)
5. Automobile accident - thrown from truck - body wrapped around wooden post	18	M			Rt. liver lobe almost completely severed - hemorrhage	Devine & Burwell 1949 (142)
6. Automobile accident - body pinned against curb	52	M		Fractured rib	Rupture of jejunum - rupture of small artery - hemorrhage - pt. died	Jacobson & Carter 1951 (328)
7. Automobile accident - thrown from his car and run over by another auto	18	M		Left rib fractures (7-9)	Linear contusion marks across upper abdomen - extensive fat necrosis of pancreas - lacerated spleen - perforated gall bladder; pt. died	Rini, J. M. 1952 (558)
8. Automobile accident - thrown from car	28	M			Partial gangrene of terminal ileum, cecum and first portion of ascending colon - early peritonitis	Johnston, L. B. 1954 (336)
9. Sleigh accident - thrown from sleigh striking left side	14	M			Multiple lacerations of the spleen - massive hemorrhage	Wyman, A. C. 1954 (751)
10. Automobile accident - driver - collision - struck left chest (abdomen) against steering wheel - thrown out of car	27	M			Spleen ruptured into three separate pieces	Wyman, A. C. 1954 (751)
11. Ejected from rear of pick-up truck	11	F		Heart and brain damage	Focal hemorrhages of the spleen - pt. died	Kulowski, J. 1955 (378)
12. Ejected on collision impact and run over	3	F		Multiple injuries	Ruptured spleen - pt. died	Kulowski, J. 1955 (378)

13.	Automobile accident - thrown out of jeep when it ran into some boxes at side of road	21	M		Severe contusion of abdomen - contusion of rt. kidney	Lloyd, F. A. 1955 (399)
14.	Thrown from truck while inebriated	33	M		Pancreatitis	Kinnaird, D. W. 1956 (367)(367)
15.	Fall (after jumping) from moving truck	11	F		Complete transection (laceration) of the spleen	MacAuley, C. 1956 (406)
16.	Automobile accident - rear passenger - thrown to the pavement from the car after a collision	6	F		Long transverse rent in the 3rd & 4th portion of the duodenum (2/3 circum.) - transverse mesocolon hematoma with extravasation of the blood into the mesentery	Murphy & Minckler 1956 (473)
17.	Thrown from platform of a streetcar - struck left chest and abdomen	15	M		Laceration of spleen	Pontius, G. V. et al 1956 (542)
18.	Automobile accident - thrown from car	64	F		Ruptured diaphragm with intrathoracic stomach	Desforages, G. et al 1957 (141)
19.	Fall from back of truck - struck epigastric area	21	M		Extraperitoneal ecchymosis - submucosal hemorrhage of duodenum	Patton, T. B. 1957 (515)
20.	Automobile accident - ejected from car - struck abdomen against telephone pole	20	M	Rib separations - rib fracture	Two ruptures of jejunum - tear in mesentery of jejunum - large hematoma of lesser omentum and stomach	Williams, E. R. 1957 (727)
21.	Automobile accident - thrown from automobile	32	F	Pulmonary edema	Lacerated spleen - massive hemorrhage - pt. died	Downs, J. W. 1958 (187)
22.	Automobile accident - ran into stump - thrown out of the automobile - driver	81	M		Complete severance of the 3rd part of duodenum - pt. died	Field, R. J. et al 1959 (220)
23.	Automobile accident - thrown with considerable violence out of the vehicle	20	M		Large subphrenic abscess (extra hepatic biliary tract)	Thompson, J. 1960 (679)
24.	Automobile accident - thrown out of vehicle	20	M	Fractured L ₁ -L ₄	Infarction of left kidney	Lichtenheld, F. R. et al 1961 (393)
25.	Automobile accident - thrown from convertible when it rolled over	21	M	Shock - cardiac arrest	Severely lacerated spleen and liver - avulsed vena cava - massive hemorrhage - pt. died	Shuck & Trump 1961 (612)
26.	Truck accident - pinned under cab of three ton truck	17	M	Shock - cardiac arrest	Lacerations of liver - avulsion of the hepatic veins off the vena cava - massive hemorrhage - avascular left liver lobe - pt. died	Shuck & Trump 1961 (612)(612)

27.	Automobile accident - thrown from car	47	M	Multiple rib fractures	Avulsion and thrombosis of left colic vessels - avulsion of descending colon with necrosis - large retroperitoneal hematoma	Shuck & Trump 1961 () (612)
28.	Automobile accident - thrown from car that was hit by train	43	M	Fractured pelvis - shock	Hematoma of rt. lower quadrant - ruptured spleen - laceration of splenic vein at hilus - massive retroperitoneal hemorrhage	Shuck & Trump 1961 () (612)
29.	Automobile accident - thrown out of car			Fractured pelvis	Right ureter avulsed from renal pelvis - laceration of spleen, liver, rt. kidney	Stone & Jones 1962 () (558)
30.	Fall from truck - rear wheel passed over abdomen	12	M		Lacerated spleen and rt. liver lobe - laceration of duodenum	Cleveland & Maddell 1963 () (1113)
31.	Automobile accident - thrown from car	39	F	Fractured left ribs (6-8) fractured pelvis	Ruptured left diaphragm - bladder trauma - hematuria	Lucido & Wall 1963 () (404)
32.	Fall from moving motorcar	12	M		Ruptured liver	Stephans & Hollings 1963 () (650)
33.	Jumped from moving automobile	18	F		Small hematoma surrounding an omental vein	Buxton, R. W. 1964 () (83)
34.	Fall from automobile	6	F		Ruptured liver	Currie, R. A. et al 1964 () (132)
35.	Thrown from a moving car after releasing brake	3-1/2	M		Left lobe of liver completely severed - 500 cc blood in peritoneal cavity	Hartman & Greaney 1964 () (236)
36.	Automobile accident - thrown from auto - unspecified blunt abdominal trauma	25	M		Complete transection of rectus muscle and sheath - large hematoma small bowel mesentery - rents in superior mesenteric veins and artery - hemorrhage - perforation of jejunum	Killen, D. A. 1964 () (352)
37.	Automobile accident - trauma to chest from steering wheel - thrown from the car	17	M		Intramural hematoma with obstructed duodenum	Watne, A.L. et al 1964 () (710)
38.	Fell from truck onto left side	31	M		Large subcapsular hematoma of spleen	Anand & Davey 1965 () (17) (17)
39.	Thrown from a truck	42	M		Laceration of splenic pedicle with intra-abdominal hemorrhage - pt. died	Wilson, C. B. et al 1965 () (737)

40.	Automobile accident - driver - convertible - collided with utility pole at high speed - rolled over and pinned him under car	16	M	Left rib fractures (9-10) - fractures of the left transverse process of L1-L3	Rt. liver (hepatic) lobe severely lacerated with some fragments separated completely - profuse hemorrhage - small laceration of spleen	Judd & Moore 1966 () (345)
41.	Fall from truck - rear wheels passed over abdomen	6	M		Rupture of rt. diaphragm - entire rt. leaf of diaphragm torn from its peripheral attachments - laceration of rt. adrenal gland - herniation of liver	Asbury, G. F. 1968 () (24)
42.	Automobile accident - truck collided with auto - thrown off the truck	20	M	Fracture of L1-L5	Complete avulsion of the renal pedicle - large retroperitoneal hematoma	Lokkegaard & Fredens 1968 () (401)
43.	Automobile accident - front seat passenger - ejected from automobile - rt. side of car hit light post	24	F	Multiple rib fractures - contusions of the heart - coma	Severance of renal arteries and veins - multiple lacerations and subcapsular hemorrhage of liver - contusion of spleen - retroperitoneal hematoma - pt. died	Pizzi, W. F. 1968 () (537)
44.	Automobile accident - thrown from cab of pickup truck that was struck by another vehicle	11	F		Fracture of rt. liver lobe - tear in inf. vena cava - hemorrhage	Smith, R. J. 1968 () (627)
45.	Automobile accident - thrown from auto	17	M		Transsection of the body of the pancreas	Weitzman & Rothschild 1968 () (717)
46.	Automobile accident - ejected from auto at accident	25	F	Severe head injury - pelvic fracture	Rt. liver lobe and splenic injury	Colver, H. D. 1970 () (122)
47.	Automobile accident - struck from behind at 30 mph - rolled - struck the roof above the left windshield - ejected - driver	39	M	225	Extraperitoneal rupture of the bladder	D.O.T. HS 600 109 Case No. 7C03 1970 () (184)
48.	Automobile accident - struck in rt. front side by another auto at 60 mph driver - ejected out passenger door	54	M	140	Multiple injuries	D.O.T. HS 600 006 PB 190331 1970 () (159)
49.	Automobile accident - skid - roll at 100 mph - driver - ejected	19	M	175	Laceration of rt. lobe of liver - lacerations of spleen - fatal	D.O.T. HS 600 034 PB 190517 1970 () (164)
50.	Automobile accident - roll at 55-65 mph FR passenger - ejected	18	F	107	Contusion of left kidney	D.O.T. HS 600 048 PB 190732 1970 () (167)
51.	Fell out of an automobile	20	F		Ruptured spleen - large retroperitoneal hematoma extending downwards to the left kidney	Walt & Grifka 1970 () (701)

VIII. BLUNT ABDOMINAL COMPRESSION TRAUMA

CAUSE OF INJURY	AGE	SEX	WT.	PERTINENT DATA	ABDOMINAL INJURIES REPORTED	REFERENCE
1. Caught between two backing trucks	35	M			Large retroperitoneal hematoma - pt. died	Sallick, M. A. 1941 (577)
2. Crushed between two trucks	25	M			Rupture of 3rd portion of duodenum - pt. died	Kelly, E. C. 1943 (353)
3. Caught between truck and car which crashed into it	19	M		Severe shock	Tear of jejunum - pt. died	Collins, A. N. 1944 (120)
4. Crushed between overturned loading truck and heavy concrete gutter rail	26	M			Extensive retroperitoneal lacerations involving 2/3 of the liver lobe - several additional large lacerations of liver - contusion over upper pole of rt. kidney - extensive retroperitoneal hematoma	Sanders, G. B. et al 1949 (532)
5. Crushed between truck and box car	12	M			Laceration of duodenum (at junction of 2nd and 3rd)	Siler, V. E. 1949 (614)
6. Crushed between car and truck	50	M			Ruptured spleen - jejunum torn almost completely across in two places - descending colon completely ruptured	Clarke, R. 1954 (109)
7. Crushed between car and truck	69			Fractured pelvis	Tear of mesentery of small intestine - gangrene of bowel - pt. died	Clarke, R. 1954 (109)
8. Trapped between two trucks	56			Fracture of lower left ribs	Ruptured liver - hepatic degeneration - pt. died	Clarke, R. 1954 (109)
9. Caught between truck and loading platform	22	M			Large laceration in peritoneum - laceration of superior mesenteric artery	Ulvestad, L. E. 1954 (692)
10. Crushed between corner of grocery truck tailgate and loading platform	44	F			Contusion of midepigastrium - complete transection of the body of the pancreas - complete rupture of the transverse portion of the duodenum - complete avulsion of the gastrophrenic omentum - 2 in. tear of abdominal aorta	Kirkland, M. L. 1955 (370)
11. Struck across upper abdomen by backing up truck - sustained a severe compressing force to abdomen	39	M			Rent in duodenum - head of pancreas almost completely severed - retroperitoneal hematoma	Strode & Gilbert 1955 (663)

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|-----|--|----|---|--|-------------------------------|
| 12. | Crushed between back of truck and wall (rt. lower chest - abdomen) | 25 | M | Several non-bleeding splits with a deep laceration of the liver - hole in left hepatic duct | Baty, J.A. 1956 (39) |
| 13. | Pinned to wall by truck | | | Small perforation of jejunum | Geoghegan & Brush 1956 (253) |
| 14. | Crushed between tractor and wall | | | Perforation of jejunum - mesentery stripped for 1.5 ft. | Geoghegan & Brush 1956 (253) |
| 15. | Crushed between truck and loading platform | 58 | M | Mesenteric rupture of pancreas, mesocolon, duodenum and base of mesentery - Pseudocyst | Kimball, D.M. 1956 (367) |
| 16. | Crushed between truck tailboard and platform | | M | Laceration of gastrocolic mesentery - mesenteric laceration of jejunum - retroperitoneal hematoma | Migliaccio & Bowen 1957 (450) |
| 17. | Caught between two trucks - rt. colon | 65 | M | Rupture of mesentery of distal ileum | Migliaccio & Bowen 1957 (450) |
| 18. | Caught between moving freight car and building | 29 | M | Small tear in mesentery of sigmoid | Migliaccio & Bowen 1957 (450) |
| 19. | Crushed against truck by another truck | 37 | M | Tear in mesentery of terminal ileum - sigmoid gangrenous - tear in mesentery of sigmoid - pt. died | Migliaccio & Bowen 1957 (450) |
| 20. | Caught between truck and loading platform | 35 | M | Complete avulsion of the stomach - tear in first portion of duodenum | Patton, T.B. 1957 (515) |
| 21. | Crushed between car and building | 52 | M | Diaphragm avulsed from chest wall (midline to posterior axillary line) | Perry, T. et al 1957 (504) |
| 22. | Caught between moving car and garage door | 50 | M | Hematoma abdominal wall | Root & Christensen 1957 (567) |
| 23. | Crushed between bus and pillar | 29 | M | Large laceration of liver - deep laceration of spleen - retroperitoneal hematoma - pt. died | Averbook & Pearson 1959 (27) |
| 24. | Crushed between two trucks | 18 | M | Severely contused and perforated terminal ileum | Thorlakson, R.H. 1960 (681) |
| 25. | Crushed between two coal trucks | 57 | M | Rent in diaphragm - herniation of liver and spleen | Probert & Havard 1961 (545) |
| 26. | Coal cart derailed and compressed him over the rt. abdomen | 28 | M | Stomach completely severed at prepyloric region - massive bleeding from rt. gastric artery, rt. gastropiploic artery and stomach walls - retroperitoneal hematoma. | Hung, C.R. et al 1962 (320) |

27.	Crushed between two automobiles	52	F	Ruptured left diaphragm	Currie, R.A. et al 1964 (132)
28.	Crushed by milk truck	2	M	Tear in left diaphragm - herniation of stomach, transverse colon, greater omentum and small bowel	Myers, N.A. 1964 (474)
29.	Crushed between truck and loading platform	44	M	Almost complete rupture of 4th portion of duodenum - torn splenic pedicle - laceration of the root of the mesentery with hemorrhage - seromuscular laceration of anterior gastric wall	Cegielski, M. 1965 (102)
30.	Severe crushing injury to upper abdomen and lower chest	32	M	Devitalizing trauma to periphery of rt. liver lobe - bile cyst	Little, J.M. 1965 (397)
31.	Crushed by clam dumper	65	M	Generalized pancreatic trauma - not sufficient to require surgery	Sturim, H.S. 1965 (664)
32.	Crushed between truck and power pole	30	M	Transection of pancreas - splenic vein severed	Barnett, W.O. et al 1966 (37)
33.	Crushed between two buffers	60	M	Large hemorrhage from liver rupture - laceration of inferior vena cava - pt. died	Hellstrom, G. 1966 (300)
34.	Crushed in upper abdominal region	50	M	1500 ml. blood from four ruptures on left lobe of liver - laceration of omentum - B.O.A.	Hellstrom, G. 1966 (300)
35.	Fell across tailboard of truck - closed injury to duodenum	54	M	Laceration of duodenum at junction of 2nd and 3rd parts - large retroperitoneal hematoma around duodenum - fat necrosis around ascending colon	Thevathasan, C.G. 1966 (675)

IX. AUTOMOBILE ACCIDENT WITH UNSPECIFIED BLUNT ABDOMINAL TRAUMA

A. Area of Injury Specified

CAUSE OF INJURY	AGE	SEX	WT.	PERTINENT DATA	ABDOMINAL INJURIES REPORTED	REFERENCE
1. Automobile accident - injury to rt. side of abdomen two years previously	54	M			Capsule of kidney displaced from kidney	Bell, R. 1949 (45)
2. Automobile accident - mild blow to rt. side of abdomen	25	M			Transverse rent in the kidney at the juncture of the middle and lower third	Bell, R. 1949 (45)
3. Automobile accident - crushing force to left side of abdomen	28	F			Ruptured diaphragm - lacerated spleen and kidney - hemorrhage - pt. died	Adams & Musselman 1954 (3)
4. Automobile accident - crush injury to abdomen	25	M			Avulsion of the portal vein from inside the portal fissure - massive hemorrhage - pt. died	the Clarke, R. 1954 (109)
5. Automobile accident - severe abdominal trauma	26	M			Traumatic cyst of the spleen - 20,000 cc. fluid removed	Jeans, V.E. 1957 (329)
6. Automobile accident - blow to left flank area	70	M			Ruptured spleen - supcapsular hematoma spleen - intraparenchymal hemorrhage	Fahlund & Smedley 1966 (212)
7. Automobile accident - blunt trauma to middle of the abdomen	35	M			Rupture of left diaphragm - herniation of stomach into thorax	Ebert, P.A. et al., 1967 (193)
8. Automobile accident - blunt trauma to upper part of abdomen	15	M			Extensive lacerations of the liver - massive hematemesis - recurrent hemobilia	Herman & Hoerr 1967 (303)
9. Automobile accident - blunt trauma to thoraco-abdominal area	34	M		Cerebral concussion	Large rt. intrahepatic hematoma	Richardson, R.E. et al., 1967 (555)
10. Automobile accident - blow to rt. side of abdomen	29	M			Extensive subserosal hematoma of the cecum	Nance & Crowder 1968 (476)
11. Automobile accident - severe blunt abdominal trauma	47	M			Severe deep liver lacerations - hemorrhage	Ackroyd, F.W. et al., 1969 (1)
12. Automobile accident - severe abdominal trauma	49	F	110		Ecchymosis over lower quadrants - duodenum fractured at junction of 2nd and 3rd portions	Dudrick, S.J. et al., 1970 (190)
13. Automobile accident - blunt trauma to upper left quadrant	27	M		Left rib fractures (10-12)	Intimal fracture of rt. renal artery with subintimal hematoma - laceration of spleen - pt. died	Ross, R. et al., 1970 (569)

14.	Automobile accident - blunt trauma to abdomen and left flank	38	F	Ruptured spleen - tears in small bowel mesentery and mesosigmoid - total occlusion of left renal artery	Ross, R. et al., 1970 (569)
15.	Automobile accident - blunt trauma to rt. upper abdomen and rt. anterior thorax	18	M	Large hematoma of rt. and left liver lobes	Thomas, C.S. et al., 1970 (676)
16.	Automobile accident - injury to the epigastric area	48	M	Ruptured spleen - laceration of 2nd portion of duodenum involving 3/4 of its circumference - minor hematoma in rt. upper quadrant	Walt & Grifka 1970 ((701)
B. Seat Position Specified					
1.	Automobile accident - front seat passenger	23	M	Axistons across lower abdomen - perforation of liver - laceration of flexor digitorum profundus from laceration of mesentery	Bradley & Cook 1954 (63)
2.	Automobile accident - passenger in auto involved in severe collision	5	F	Multiple lacerations of spleen - complete laceration of left kidney - massive hemorrhage	Wyman, A.C. 1954 (751)
3.	Automobile accident - car collided with large trailer truck - driver	28	M	Multiple fractures	Schneider, C.F. 1956 (592)
4.	Automobile accident - struck by another auto - passenger	40	M	Omentum, stomach, transverse colon and spleen herniated thru diaphragm - spleen ruptured at hilum with two lacerations - pt. died	Desforges, G. et al., 1957 (141)
5.	Automobile accident - struck by another car - passenger	51	F	5 in. rent in diaphragm - major portion of stomach herniated into chest	Desforges, G. et al., 1957 (141)
6.	Automobile accident - struck by another car - passenger	36	M	Ruptured diaphragm - stomach omentum and large bowel found in chest - pt. died	Desforges, G. et al., 1957 (141)
7.	Automobile accident - struck a tree - driver	59	M	Ruptured diaphragm with infra thoracic stomach	Desforges, G. 1957 (141)
8.	Automobile accident - car struck tree - driver	28	M	Ruptured Diaphragm	Desforges, G. 1957 (141)
9.	Automobile accident - driver - unspecified blunt abdominal trauma	20	M	Pulmonary laceration -Dyspnea and abdominal pain - pt. died contusions of heart	Shaftan, G.W. 1960 (602)
10.	Automobile accident - passenger			Multiple rib fractures - shock	Drepanas & McDonald 1961 (189)
				Cerebral contusion	Maughon, J.S. et al., 1961 (429)
				Avulsion of spleen - lacerations of liver - hemoperitoneum - pt. died	

11.	Automobile accident - passenger		M		Hemoperitoneum due to torn mesentery of the small bowel - pt. died	Van Wagoner 1961 / (696)
12.	Automobile accident - passenger	15	F	Concussion	Rt. Kidney grossly ruptured with profuse bleeding - gross hematuria	Mathieson, A.J. 1962(427)
13.	Automobile accident - seat next to driver,	21	M		Large retroperitoneal hematoma over pancreas and mesentery of transverse colon - rent in 3rd part of duodenum - contused pancreas - ileum contused	Cleveland & Waddell 1963 (113)
14.	Automobile accident - driver	46	M	Fractured left ribs (4-10) - contusion heart - fractured pelvis	Ruptured left diaphragm - ruptured spleen herniated into chest	Lucido & Wall 1963 (404)
15.	Automobile accident - front passenger	26	F	Pt. had aortic rupture	200 ml. blood from crushed rt. lobe of liver - pt. died	Hellstrom, G. 1966 (300)
16.	Automobile accident - driver	22	M	Aortic rupture	Liver and splenic rupture - died at impact	Hellstrom, G. 1965 (300)
17.	Automobile accident - motor accident - unspecified blunt abdominal trauma - driver	34	M		Perforation on the antimesenteric border of the jejunum	Weiss & Dreiling 1968(715)
18.	Automobile accident - driver - unspecified blunt abdominal trauma	41	M		Perforation on antimesenteric border of jejunum	Weiss & Dreiling 1968 (715)
19.	Automobile accident - back seat passenger	20	F	Pt. pregnant	Subcapsular hematoma of spleen - small rent in jejunal mesentery - large retroperitoneal hematoma	Freedman, M.G. et al. 1969 (242)
20.	Automobile accident - driver	35	M	Fractured ribs (7,8)	Cornel and unruptured behind duodenum - laceration of liver	Moyle & Karl 1969 - (471)

C. Semi-Detailed Cases

1.	Automobile accident - car struck freight car	47	M	Cerebral concussion	Longitudinal rupture of the jejunum - hematoma in the mesentery	Bunch, J.R. 1944 (76)
2.	Automobile accident - driver - forced off the road	24	M		Hemorrhagic cyst of the spleen	Salzer, Sawyer, Forsee 1951 (578)
3.	Automobile accident - five persons killed in her car	18	F	Fracture of left rib (6)	Abrasions and contusions of abdomen - ruptured diaphragm - herniation of stomach, spleen, colon - spleen lacerated	Becker, W.T. 1958 (44)

Case No.	Accident Description	Age	Sex	Injury Description	Author(s) & Year
4.	Automobile accident - head on collision between two cars	22	M	Tear of left diaphragm	Sutherland, H.D. 1958 (688)
5.	Automobile accident - head on collision (19 yrs previously)	60	F	Laceration of left diaphragm - herniation of colon, omentum, left liver lobe and stomach	Sutherland, H.D. 1958 (688)
6.	Automobile accident - car struck a rock cliff	43	M	Complete transection and shredding of and portion of diaphragm - multiple intrathoracic areas of the omentum, ascending and transverse mesocolon	Boggs & Lawton 1959 (60)
7.	Automobile accident - head on into rear of another auto	39	M	Laceration of the liver	Perelman & Sherwood 1960 (528)
8.	Automobile accident - midget car racing	44	M	Paracostals - lacerated slightly smaller and medial	Griggs & Ada 1962 (269)
9.	Automobile accident - freeway accident	22	M	Laceration of left liver lobe - several ruptures of the capsule of the spleen - contusion of rt. kidney - pneumonia	Wright & Orloff 1964 (756)
10.	Automobile accident - driver - skidded on road	18	M	Longitudinal laceration of rt. liver lobe	Yee, E.T. 1966 (732)
11.	Automobile accident - head on collision	42	M	Complete transection of the body of the pancreas - contusions on rt. liver lobe	Riechhoff & Denahoo 1967 (556)
12.	Automobile accident - car struck a pole	34	M	Trans perforations of the jejunum	Messers, H.I. 1968 (413)
13.	Automobile accident - auto went out of control - struck in abdomen by unknown structure	45	M	Laceration of jejunum - thrombosis of abdominal aorta - small retroperitoneal hematoma	Borja & Lansing 1970 (55)
14.	Automobile accident - roller down 200 ft. embankment in auto	21	M	Stomach, spleen, splenic flexure and 1/2 of small bowel herniated through left diaphragm - rt. liver lobe herniated through right diaphragm	Clay & Munro 1971 (119)

9. unspecified impact								
1. Automobile accident - unspecified blunt abdominal trauma	20	M						Rupture of jejunum - laceration of mesentery - pt. died
								Cooke, H.H. 1932 (124)
2. Automobile accident - unspecified blunt abdominal trauma	24	M						Rupture of ascending colon - pt. died - laceration of mesentery
								Cooke, H.H. 1932 (124)
3. Automobile accident - unspecified blunt abdominal trauma	7	M						Rupture of jejunum - pt. died
								Cooke, H.H. 1932 (124)
4. Automobile accident - unspecified blunt abdominal trauma	51	F						Rupture of abdomen - pt. died
								Cooke, H.H. 1932 (124)
5. Automobile accident - unspecified blunt abdominal trauma	39	M					Fractured ribs	Transverse rupture of jejunum - laceration of mesentery - pt. died
								Cooke, H.H. 1932 (124)
6. Automobile accident - unspecified blunt abdominal trauma	55	M						Rupture of jejunum - laceration of mesentery - pt. died
								Cooke, H.H. 1932 (124)
7. Automobile accident - unspecified blunt abdominal trauma	45	M						Transverse rupture of jejunum - tears in liver, kidneys - lacerations of mesentery - pt. died
								Cooke, H.H. 1932 (124)
8. Automobile accident - unspecified blunt abdominal trauma	12	F						Transv. rupt. of jejunum - tears of spleen, liver - abdom. wall abras. rupt. stom. fatal
								Cooke, H.H. 1932 (124)
9. Automobile accident - unspecified blunt abdominal trauma	23	M					Skull fracture	Rupture of ileum - tears of spleen, liver, kidneys - rupture of stomach - pt. died
								Cooke, H.H. 1932 (124)
10. Automobile accident - unspecified blunt abdominal trauma	13	M						Transverse rupture of duodenum - tears of spleen, liver, pancreas - pt. died
								Cooke, H.H. 1932 (124)
11. Automobile accident - unspecified blunt abdominal trauma	5	M					Skull fracture	Rupture of jejunum - pt. died
								Cooke, H.H. 1932 (124)
12. Automobile accident - unspecified blunt abdominal trauma	65	M						Rupture of ileum - tear in spleen - rupture of stomach wall - pt. died
								Cooke, H.H. 1932 (124)
13. Automobile accident - unspecified blunt abdominal trauma	27	M						Left kidney and liver ruptured, spleen torn - jejunum completely severed - hemoperitoneum - hemorrhage - fatal
								Blocker, T.G. 1939 (53)
14. Automobile accident - unspecified blunt abdominal trauma	28	M					Bronchopneumonia	Laceration of spleen - fatal
								Blocker, T.G. 1939 (53)
15. Automobile accident - unspecified blunt abdominal trauma	48	M						2.5 cm. laceration of the splenic capsule with hematoma - blood in peritoneal cavity
								Zabinski & Harkins 1943 (755)

16.	Automobile accident - unspecified blunt abdominal trauma	23	M	Rent in jejunum - pt. died	Metheny, D. 1944 (446)
17.	Automobile accident - unspecified blunt abdominal trauma	20	M	Small rupture of jejunum	Metheny, D. 1944 (446)
18.	Automobile accident - unspecified blunt abdominal trauma	37	M	Rupture of gallbladder	Norgore, M. 1946 (493)
19.	Automobile accident - unspecified blunt abdominal trauma	22	M	Large rent in diaphragm - herniation of stomach and omentum	Carter, B.N. et al., 1951 (100)
20.	Automobile accident - unspecified blunt abdominal trauma	20	M	Rent in diaphragm - herniation of splenic flexure, omentum and jejunum	Carter, B.N. et al., 1951 (100)
21.	Automobile accident - unspecified blunt abdominal trauma	38	M	Ruptured spleen (extrusion in its lower half) - hematuria	Larghero & Giuria 1951 (332)
22.	Automobile accident - unspecified blunt abdominal trauma	37	M	Secondary rupture of the spleen	Larghero & Giuria 1951 (332)
23.	Automobile accident - unspecified blunt abdominal trauma	26	F	Perforation of stomach - severe laceration of pancreas - pseudocyst	Warren, K.W. 1951 (704)
24.	Automobile accident - unspecified blunt abdominal trauma	50	F	Injury to left kidney - hemorrhage	Orkin, L.A. 1952 (100)
25.	Automobile accident - unspecified blunt abdominal trauma		M	Upper pole of left kidney split in half, right upper half necrotic	Orkin, L.A. 1952 (100)
26.	Automobile accident - unspecified blunt abdominal trauma	10	M	Perforation of stomach - laceration of small bowel	Orkin, L.A. 1952 (100)
27.	Automobile accident - unspecified blunt abdominal trauma	46	F	Ruptured diaphragm - herniation of spleen, stomach, and small bowel - ruptured spleen - contusion left kidney - pt. died	Caubie, W.G. 1950 (101)
28.	Automobile accident - unspecified blunt abdominal trauma	8	F	Pancreatitis - transient icterus - paralytic ileus	Adams & Musselman 1954 (9)
29.	Automobile accident - unspecified blunt abdominal trauma	32	M	Rupture of sigmoid colon	Becker, W.F. 1954 (43)
30.	Automobile accident - unspecified blunt abdominal trauma	38	F	Ruptured spleen with massive hemorrhage - transection of pancreas	Bradley & Cook 1954 (69)
31.	Automobile accident - unspecified blunt abdominal trauma				Clarke, R. 1954 (109)

32.	Automobile accident - unspecified blunt abdominal trauma			Severe chest injury	Ruptured liver - pt. died	Clarke, R. 1954 (109)
33.	Automobile accident - unspecified blunt abdominal trauma	52		Fracture of skull - left rib	Small rupture of spleen - retro-peritoneal hematoma - pt. died	Clarke, R. 1954 (109)
34.	Automobile accident - unspecified blunt abdominal trauma	55		Multiple left rib fractures	Ruptured kidney - pt. died	Clarke, R. 1954 (109)
35.	Automobile accident - unspecified blunt abdominal trauma	71		Fractured ribs - cardiac failure	Tear of middle ileum - bruised mesentery - peritonitis - pt. died	Clarke, R. 1954 (109)
36.	Automobile accident - unspecified blunt abdominal trauma	64	M		Huge oblique laceration of rt. liver lobe - 2000 cc. blood	Estes, W.L. 1954 (207)
37.	Automobile accident - unspecified blunt abdominal trauma	13	M	Multiple fractures	Small lacerations, trapped under fragments of fractured rib causing pt. death fracture of rib - peritonitis - subcapsular hemorrhages in each kidney - retroperitoneal hemorrhage - pt. died	Johnston, L.B. 1954 (305)
38.	Automobile accident - unspecified blunt abdominal trauma	60	M	Low back pain	Multiple rib fractures - multiple fractures of ribs - peritonitis - retroperitoneal hemorrhage - pt. died	McKay, P.H. et al., 1954 (230)
39.	Automobile accident - unspecified blunt abdominal trauma	15	M		Fracture of 11th rib - liver lobe - 2000 cc. retroperitoneal blood - necrotic liver tissue	Bricker & Hay 1955 (74)
40.	Automobile accident - unspecified blunt abdominal trauma	20	F		Multiple rib fractures - 2nd, 3rd, 4th, 5th, 6th ribs - pt. died 2 weeks	Brooker & Gray 1955 (77)
41.	Automobile accident - unspecified blunt abdominal trauma	33	M		Multiple rib fractures - multiple fractures of ribs - peritonitis - retroperitoneal hemorrhage - pt. died	Brooker & Gray 1955 (77)
42.	Automobile accident - unspecified blunt abdominal trauma	43	M	Head injuries - multiple left rib fractures (5-9)	Laceration of 11th rib - stomach, omentum & spleen hemorrhaged small lacerations hemorrhaged	Brooker & Gray 1955 (77)
43.	Automobile accident - unspecified blunt abdominal trauma	23	M	Left rib fractures (6-9)	Laceration of 11th rib - stomach and transverse colon hemorrhaged	Brooker & Gray 1955 (77)
44.	Automobile accident - unspecified blunt abdominal trauma	56	F	Left rib fracture (5th)	Spleen severely fractured - omentum adherent to spleen	Fultz & Altmeier 1955 (240)
45.	Automobile accident - unspecified blunt abdominal trauma	62	M		Delayed rupture of spleen - ruptured subcapsular hematoma	Fultz & Altmeier 1955 (245)
46.	Automobile accident - unspecified blunt abdominal trauma	30	M		Delayed rupture of spleen - large amount of blood in capsule - multiple small hemorrhages	Fultz & Altmeier 1955 (248)

47.	Automobile accident - unspecified blunt abdominal trauma during automobile race	25	M	Left rib fracture (6-8)	Delayed rupture of spleen - multiple lacerations (splenic) with subcapsular hematoma	Fultz & Altemeier 1955 (248)
48.	Automobile accident - unspecified blunt abdominal trauma	21	M		Delayed ruptured spleen with four surface tears - subcapsular hematoma	Fultz & Altemeier 1955 (248)
49.	Automobile accident - unspecified blunt abdominal trauma	43	F	Left rib fractures (9-11) - rt. rib fractures (8,9)	Delayed rupture of spleen - laceration of upper pole	Fultz & Altemeier 1955 (248)
50.	Automobile accident - unspecified blunt abdominal trauma	19	M		Avulsion of rt. liver lobe	Glas, M.W. et al., 1955 (259)
51.	Automobile accident - unspecified blunt abdominal trauma	54		Multiple injuries	Ruptured bladder - ruptured diaphragm - pt. died	Helsper, J.T. 1955 (301)
52.	Automobile accident - unspecified blunt abdominal trauma	39			Ruptured bladder	Helsper, J.T. 1955 (301)
53.	Automobile accident - unspecified blunt abdominal trauma	21		Cerebral concussion	Lacerated liver	Helsper, J.T. 1955 (301)
54.	Automobile accident - unspecified blunt abdominal trauma	28	M		Spleen broken into five fragments	Mansfield, R.D. 1955 (418)
55.	Automobile accident - unspecified blunt abdominal trauma	55	M	Intracranial hemorrhage	Rupture of gallbladder - lacerations of liver	Schaer, S.M. et al., 1955 (588)
56.	Automobile accident - unspecified blunt abdominal trauma	24	M	Shock	Ruptured spleen, liver - partial transection of jejunum - laceration of diaphragm - laceration of left renal vein - pt. died	Schlusser & Harkins 1955 (591)
57.	Automobile accident - unspecified blunt abdominal trauma	44	M		Ruptured spleen - ruptured left kidney - hemorrhage	Tagart, R.B. 1955 (670)
58.	Automobile accident - unspecified blunt abdominal trauma	18		Broken ribs (4-11)	Ruptured spleen - hemorrhage	Tagart, R.B. 1955 (670)
59.	Automobile accident - unspecified blunt abdominal trauma	10			Ruptured spleen - hemorrhage	Tagart, R.B. 1955 (670)
60.	Automobile accident - unspecified blunt abdominal trauma	34	M		Small transverse lacerations of the porta hepatis - two small serosal tears in duodenum	Foman & Hinshaw 1956 (231)
61.	Automobile accident - unspecified blunt abdominal trauma				Two small perforations of jejunum	Geoghegan & Brush 1955 (233)

62.	Automobile accident - unspecified blunt abdominal trauma					Perforated ileum	Geoghegan & Brush 1956 (253)
63.	Automobile accident - unspecified blunt abdominal trauma					Perforation of jejunum	Geoghegan & Brush 1956 (253)
64.	Automobile accident - unspecified blunt abdominal trauma					Perforation of jejunum	Geoghegan & Brush 1956 (253)
65.	Automobile accident - unspecified blunt abdominal trauma	34	M	Multiple fractures		Rupture of left diaphragm - herniation - rupture of transverse colon and urinary bladder - pt. died	King, J.C. 1956 (366)
66.	Automobile accident - unspecified blunt abdominal trauma	6	F			Laceration of spleen (upper pole)	King, J.C. 1956 (366)
67.	Automobile accident - unspecified blunt abdominal trauma	10	M			Laceration of upper pole of rt. kidney with hematoma - laceration of rt. liver lobe	King, J.C. 1956 (366)
68.	Automobile accident - unspecified blunt abdominal trauma	44	M	Left rib fracture (5-8)		Lacerated mesentery of sigmoid colon - profuse bleeding from artery - small laceration of spleen	King, J.C. 1956 (366)
69.	Automobile accident - unspecified blunt abdominal trauma	63	M			Pancreas edematous with hematoma	Kinnaird, D.W. 1956 (367)
70.	Automobile accident - unspecified blunt abdominal trauma	27	M			Laceration of jejunum	Spensley, R.D. et al. 1956 (643)
71.	Automobile accident - 4 years previously	23	F			Large laceration left diaphragm - herniation of liver, colon, small bowel, stomach, spleen and omentum	Deforges, G. et al., 1957 (141)
72.	Automobile accident - 6 years previously	36	M			Ruptured diaphragm	Deforges, G. et al., 1957 (141)
73.	Automobile accident - unspecified blunt abdominal trauma	10	M			Rent in ileum - contused bowel	Halter & Gross 1957 (285)
74.	Automobile accident - unspecified blunt abdominal trauma	3	M			Complete transection of the pancreas - ruptured spleen	Hannon & Sprafka 1957 (288)
75.	Automobile accident - unspecified blunt abdominal trauma	58	M	Fractured ribs		Ruptured diaphragm with herniation	Perry, T. et al., 1957 (532)
76.	Automobile accident - unspecified blunt abdominal trauma	27				Tear of diaphragm - laceration of stomach	Carlson, R.I. et al., 1958 (99)
77.	Automobile accident - unspecified blunt abdominal trauma	43				Tear of diaphragm	Carlson, R.I. et al., 1958 (98)

78.	Automobile accident - unspecified blunt abdominal trauma	24			Tear of diaphragm	Carlson, R.I. et al., 1958 () (98)
79.	Automobile accident - unspecified blunt abdominal trauma	48	F	Multiple fractures - vertebral	Lacerations on under surface of liver and through the spleen - hemorrhage	Downs, J.W. 1958 () (187)
80.	Automobile accident - unspecified blunt abdominal trauma	42	F	Multiple rib fractures - cerebral concussion	Spleen avulsed from its pedicle - large lacerations over dome of liver - hemorrhage	Downs, J.W. 1958 () (187)
81.	Automobile accident - unspecified blunt abdominal trauma	68	M	Fracture of four ribs	Small intestine (gangrenous) herniated through tear in omentum	Mock, C.J. & Mock 1958 () (458)
82.	Automobile accident - unspecified blunt abdominal trauma	20	F	Rib fractures (7-11)	Laceration of left diaphragm - herniation of stomach	Sutherland, H.D. 1958 () (668)
83.	Automobile accident - unspecified blunt abdominal trauma - multiple death accident	22	M		Tear in left diaphragm - herniation of stomach and left liver lobe	Sutherland, H.D. 1958 () (668)
84.	Automobile accident - unspecified blunt abdominal trauma	32	M		Laceration of left diaphragm	Sutherland, H.D. 1958 () (668)
85.	Automobile accident - unspecified blunt abdominal trauma	33	M	Left lung collapse	Tear in left diaphragm - ruptured gangrenous stomach herniated	Sutherland, H.D. 1958 () (668)
86.	Automobile accident - unspecified blunt abdominal trauma	56	F		Tear in left diaphragm - stomach, spleen herniated - ruptured spleen	Sutherland, H.D. 1958 () (668)
87.	Automobile accident - unspecified blunt abdominal trauma - (10 years previously)	45	F		Lacerations of rt. diaphragm - herniation of liver	Sutherland, H.D. 1958 () (668)
88.	Automobile accident - unspecified blunt abdominal trauma	60	M	Fracture of 5th and displacement of 6th cervical vertebrae	Ruptured spleen - pt. died	Averbook & Pearson 1959 () (27)
89.	Automobile accident - unspecified blunt abdominal trauma	17	F		Laceration of spleen - abdominal hemorrhage - pt. died	Averbook & Pearson 1959 () (27)
90.	Automobile accident - unspecified blunt abdominal trauma	24	F	Left rib fractures (7,8) - cardiac arrest	Multiple lacerations of spleen - large volume of blood - massive retroperitoneal hematoma - pt. died	Averbook & Pearson 1959 () (27)
91.	Automobile accident - unspecified blunt abdominal trauma	34	F	Left rib fractures (5-9) - fracture of L1	Lacerated spleen - pt. died	Averbook & Pearson 1959 () (27)
92.	Automobile accident - unspecified blunt abdominal trauma	56	F	Shock and multiple rib fractures	Laceration of diaphragm with herniation	Bogedain & Carpathios 1959 () (58)

93.	Automobile accident - unspecified blunt abdominal trauma	23	M		Laceration of left diaphragm - ruptured spleen - several small lacerations of the liver - large subserosal hemorrhage of gallbladder - herniation of stomach, colon and spleen	Grage, T.B. et al., 1959 (267) (267)
94.	Automobile accident - unspecified blunt abdominal trauma	37	M	Fractured pubis	Rupture of rt. diaphragm	Grage, T.B. et al., 1959 (267) (267)
95.	Automobile accident - unspecified blunt abdominal trauma	26	F	Severe cerebral concussion - fractured pelvis	Ruptured left diaphragm - stomach herniated	Grage, T.B. et al., 1959 (267) (267)
96.	Automobile accident - unspecified blunt abdominal trauma	41	F	Fractured ribs	Ruptured left diaphragm - ruptured spleen	Grage, T.B. et al., 1959 (267) (267)
97.	Automobile accident - unspecified blunt abdominal trauma	32	M	Fractured pelvis	Ruptured left diaphragm - herniated stomach	Grage, T.B. et al., 1959 (267) (267)
98.	Automobile accident - unspecified blunt abdominal trauma	35	F	Fractured pelvis	Ruptured left diaphragm - herniated stomach, small bowel and colon	Grage, T.B. et al., 1959 (267) (267)
99.	Automobile accident - unspecified blunt abdominal trauma	23	M	Fractured pelvis - fractured ribs	Ruptured left diaphragm - herniated stomach, colon, liver	Grage, T.B. et al., 1959 (267) (267)
100.	Automobile accident - unspecified blunt abdominal trauma	49	M	Fractured ribs - fractured pelvis	Ruptured rt. diaphragm - stomach and omentum herniated	Grage, T.B. et al., 1959 (267) (267)
101.	Automobile accident - unspecified blunt abdominal trauma	66	M	Pelvic fracture	Ruptured left diaphragm - herniation of stomach - pt. died	Grage, T.B. et al., 1959 (267) (267)
102.	Automobile accident - unspecified blunt abdominal trauma	17	M	Cerebral concussion	Ruptured left diaphragm - lacerated spleen - stomach and colon herniated	Grage, T.B. et al., 1959 (267) (267)
103.	Automobile accident - unspecified blunt abdominal trauma	22	M	Cerebral concussion	Ruptured left diaphragm - herniated stomach, small bowel and colon	Grage, T.B. et al., 1959 (267) (267)
104.	Automobile accident - unspecified blunt abdominal trauma	36	M	Multiple rib fractures - comatose-shock	Ruptured left diaphragm - ruptured spleen - pt. died	Grage, T.B. et al., 1959 (267) (267)
105.	Automobile accident - unspecified blunt abdominal trauma	57	M		Laceration of lower pole of left kidney - retroperitoneal hematoma	Kastl, W.H. 1959 (347) (347)
106.	Automobile accident - unspecified blunt abdominal trauma	20	F		Complete transverse severance at neck of pancreas	Letton & Wilson 1959 (388) (388)
107.	Automobile accident - unspecified blunt abdominal trauma	31	M	Fractured ribs	Ruptured spleen - splenic hematoma	Requarth, W. 1959 (552) (552)

108. Automobile accident - unspecified blunt abdominal trauma	22	M	Fracture of left rib (9)	Laceration of spleen - hemorrhage	Cacioppo & Stander 1960 (87)
109. Automobile accident - unspecified blunt abdominal trauma	39	M	Fracture of several ribs on left side	Ruptured spleen - intra-splenic hematoma	Cacioppo & Stander 1960 (87)
110. Automobile accident - unspecified blunt abdominal trauma	17	M	Multiple left rib fractures	Tear of left diaphragm - spleen and colon herniated - lacerated spleen	Knight & McCook 1960 (375)
111. Truck accident - unspecified blunt abdominal trauma	20	M	Fractured pelvis	Rent in diaphragm - stomach, colon, spleen, left liver lobe herniated - lacerated spleen	Knight & McCook 1960 (375)
112. Automobile accident - unspecified blunt abdominal trauma	26	M	Head injury	Rt. diaphragm torn from anterior costal attachment - liver herniated - liver laceration	Knight & McCook 1960 (375)
113. Automobile accident - unspecified blunt abdominal trauma	40	M		Tear left diaphragm - spleen, stomach, colon herniated - lacerated spleen - pt. died	Knight & McCook 1960 (375)
114. Automobile accident - unspecified blunt abdominal trauma	30	M	Multiple left rib fractures	Defect left diaphragm - spleen, stomach, transverse colon, omentum herniated	Knight & McCook 1960 (375)
115. Automobile accident - unspecified blunt abdominal trauma	13			Ruptured and bleeding rt. kidney	Opit, L.J. et al., 1960 (503)
116. Automobile accident - unspecified blunt abdominal trauma	16	F		Ruptured left kidney - large hematoma	Opit, L.J. et al., 1960 (503)
117. Automobile accident - unspecified blunt abdominal trauma	29	F		Two small perforations of duodenum	Thorlakson, R.H. 1960 (681)
118. Automobile accident - unspecified blunt abdominal trauma	45	M		Retroperitoneal laceration of the duodenum	Drapanas & McDonald 1961 (189)
119. Automobile accident - unspecified blunt abdominal trauma	8	M		Hemobilia	Fallis & Stephens 1961 (213)
120. Automobile accident - unspecified blunt abdominal trauma	18	F		Hemoperitoneum (3000 cc.) - large, deep laceration of spleen	Lung, O.S. et al., 1961 (326)
121. Automobile accident - unspecified blunt abdominal trauma	22	M		Cystic hematoma of the spleen	Maughon, J.S. et al., 1961 (429)
122. Automobile accident - unspecified blunt abdominal trauma			Fractured pelvis - fractured left ribs	Lacerated hilum of spleen - lacerated left hemidiaphragm - pt. died	Maughon, J.S. et al., 1961 (429)
123. Automobile accident - unspecified blunt abdominal trauma	48	M		Delayed rupture of the spleen - blood in peritoneal cavity	O'Brien & Fyshe 1961 (498)

124.	Automobile accident - unspecified blunt abdominal trauma	53	M	Fractured rt. ribs - fractured pelvis	Defect in diaphragm - herniation of liver	Probert & Havard 1961 (545)
125.	Automobile accident - unspecified blunt abdominal trauma	25	M		Ileum Jejunum, omentum, transverse colon, the entire stomach, and left lobe of liver herniated into left thorax	Stephens, G.L. 1961 (651)
126.	Automobile accident - unspecified blunt abdominal trauma	36	F	Multiple fractures	Ruptured spleen	Hung, C.R. et al., 1962 (320)
127.	Automobile accident - unspecified blunt abdominal trauma	34	M	Concussion	Spleen, left liver lobe injured (unspecified)	Mathieson, A.J. 1962 (427)
128.	Automobile accident - unspecified blunt abdominal trauma	27	M	Fractured rib	Rt. liver lobe injury (unspecified)	Mathieson, A.J. 1962 (427)
129.	Automobile accident - unspecified blunt abdominal trauma	41	M	Shock	Small bowel and mesentery injury (unspecified) - pt. died	Mathieson, A.J. 1962 (427)
130.	Automobile accident - unspecified blunt abdominal trauma	63	M	Fractured pelvis	Tear of bladder - paralytic ileus - pt. died	Mathieson, A.J. 1962 (427)
131.	Automobile accident - unspecified blunt abdominal trauma	28	M	Rt. rib fractures (3-5)	Three lacerations of the liver	McCort, J. 1962 (433)
132.	Automobile accident - unspecified blunt abdominal trauma	17	M		Tear in dome of rt. liver lobe - severe rt. sided pain	McCort, J. 1962 (433)
133.	Automobile accident - unspecified blunt abdominal trauma			Rt. rib fractures (8-10)	Laceration on postero-inferior margin of the liver - contusion of rt. kidney - retroperitoneal bleeding	McCort, J. 1962 (433)
134.	Automobile accident - unspecified blunt abdominal trauma	40	M		Laceration of diaphragm with herniation of ileum - laceration of spleen	Nelson, J.B. et al., 1962 (479)
135.	Automobile accident - unspecified blunt abdominal trauma	18	F		Ruptured diaphragm with herniation	Nelson, J.B. et al., 1962 (479)
136.	Automobile accident - unspecified blunt abdominal trauma	30	M		Gallbladder completely detached - tear in cystic artery - deep laceration rt. lobe liver - contused duodenum	Penn, I. 1962 (525)
137.	Automobile accident - unspecified blunt abdominal trauma	24	M		Ruptured spleen - pt. died	Worman, L.W. et al., 1962 (746)
138.	Automobile accident - unspecified blunt abdominal trauma	17	M		Large retroperitoneal hematoma involving the left gutter, pancreas and splenic pedicle	Cleveland, H.C. et al. 1963 (112)
139.	Automobile accident - unspecified blunt abdominal trauma	37	M		Ruptured spleen - large retroperitoneal hematoma associated with pancreatic necrosis	Cleveland, H.C. et al. 1963 (112)

140. Automobile accident - unspecified blunt abdominal trauma	40	F	Complete transection of pancreas	Doubilet & Mulholland 1963 (186)
141. Automobile accident - unspecified blunt abdominal trauma	26	F	Rupture of spleen - transection of pancreas - rent in diaphragm	Doubilet & Mulholland 1963 (185)
142. Automobile accident - unspecified blunt abdominal trauma	20	F	Ruptured left diaphragm - ruptured spleen and urinary bladder	Lucido & Wall 1963 (404)
143. Automobile accident - unspecified blunt abdominal trauma	35	F	Ruptured diaphragm and spleen	Lucido & Wall 1963 (404)
144. Automobile accident - unspecified blunt abdominal trauma	49	M	Ruptured diaphragm - pt. died	Lucido & Wall 1963 (404)
145. Automobile accident - unspecified blunt abdominal trauma	18	M	Ruptured left diaphragm	Lucido & Wall 1963 (404)
146. Automobile accident - unspecified blunt abdominal trauma	38	M	Ruptured left diaphragm - pt. died	Lucido & Wall 1963 (404)
147. Automobile accident - unspecified blunt abdominal trauma	36	M	Ruptured left diaphragm	Lucido & Wall 1963 (404)
148. Automobile accident - unspecified blunt abdominal trauma	25	F	Ruptured left diaphragm - ruptured spleen - contusion of kidneys - massive retroperitoneal hemorrhage	Lucido & Wall 1963 (404)
149. Automobile accident - unspecified blunt abdominal trauma	46	F	Laceration of rt. diaphragm - rupture of urinary bladder - pt. died	Lucido & Wall 1963 (404)
150. Automobile accident - unspecified blunt abdominal trauma	52	M	Rupture of left diaphragm	Lucido & Wall 1963 (404)
151. Automobile accident - unspecified blunt abdominal trauma	32	F	Ruptured left diaphragm	Lucido & Wall 1963 (404)
152. Automobile accident - unspecified blunt abdominal trauma	73	F	Ruptured left diaphragm - ruptured spleen	Lucido & Wall 1963 (404)

153. Automobile accident - unspecified blunt abdominal trauma	44	M	Severe head injury lacerated pericardium - fract. pelvis	Ruptured left diaphragm - pt. died	Lucido & Wall 1963 (404)
154. Automobile accident - unspecified blunt abdominal trauma	56	F	Cerebral concussion laceration of pericardium	Ruptured left diaphragm	Lucido & Wall 1963 (404)
155. Automobile accident - unspecified blunt abdominal trauma	42	M	Severe head injury - fractured ribs (2-11)	Ruptured left diaphragm - ruptured spleen - contusion of kidneys - pt. died	Lucido & Wall 1963 (404)
156. Automobile accident - unspecified blunt abdominal trauma	26	M	Multiple fractured left ribs - severe head injury	Ruptured left diaphragm - ruptured spleen - pt. died	Lucido & Wall 1963 (404)
157. Automobile accident - unspecified blunt abdominal trauma	48	M	Fractured left ribs (2-4) 9,10 - mild concussion	Ruptured left diaphragm - laceration of spleen	Lucido & Wall 1963 (404)
158. Automobile accident - unspecified blunt abdominal trauma	21	M		Ruptured diaphragm - ruptured spleen	Lucido & Wall 1963 (404)
159. Automobile accident - unspecified blunt abdominal trauma	6	M	Fractured left ribs (2,3,9)	Ruptured left diaphragm - ruptured spleen	Lucido & Wall 1963 (404)
160. Automobile accident - unspecified blunt abdominal trauma	12	F	Fractured rt. ribs (11,12)	Ruptured left diaphragm - laceration of kidney and liver	Lucido & Wall 1963 (404)
161. Automobile accident - unspecified blunt abdominal trauma	25	M	Fractured rib	Ruptured diaphragm - incarceration of stomach and colon	Lucido & Wall 1963 (404)
162. Automobile accident - unspecified blunt abdominal trauma	22	M	Fractured ribs and pelvis	Ruptured diaphragm - stomach incarcerated	Lucido & Wall 1963 (404)
163. Automobile accident - unspecified blunt abdominal trauma	59	M	Fractured left ribs (7-9) - fractured pelvis - severe head and brain injury - laceration of pericardium	Rupture left diaphragm - pt. died	Lucido & Wall 1963 (404)
164. Automobile accident - unspecified blunt abdominal trauma	22	M	Severe head injury	Ruptured diaphragm - ruptured spleen	Lucido & Wall 1963 (404)
165. Automobile accident - unspecified blunt abdominal trauma	17	M	Fractured pelvis - mild brain concussion	Ruptured left diaphragm - stomach and colon herniated - stomach incarcerated	Lucido & Wall 1963 (404)
166. Automobile accident - unspecified blunt abdominal trauma	21	M	Severe head injury - fractured ribs - never conscious	Ruptured diaphragm - pt. died	Lucido & Wall 1963 (404)

167. Automobile accident - unspecified blunt abdominal trauma	28	M	Pericardium laceration	Ruptured left diaphragm - subcapsular splenic laceration	Lucido & Wall 1963 (404)
169. Automobile accident - unspecified blunt abdominal trauma	15	M		Ruptured left diaphragm - ruptured spleen	Lucido & Wall 1963 (404)
170. Automobile accident - unspecified blunt abdominal trauma	32	M	Skull fracture	Ruptured left diaphragm - lacerated spleen	Lucido & Wall 1963 (404)
171. Automobile accident - unspecified blunt abdominal trauma	49	F	Fractured left rib (6)	Ruptured left diaphragm	Lucido & Wall 1963 (404)
172. Automobile accident - unspecified blunt abdominal trauma	71	M	Fractured ribs, pelvis and lumbar vertebrae	Ruptured left diaphragm	Lucido & Wall 1963 (404)
173. Automobile accident - unspecified blunt abdominal trauma	30	M	Fractured left rib (2)	Ruptured left diaphragm	Lucido & Wall 1963 (404)
174. Automobile accident - unspecified blunt abdominal trauma	24	M	Skull injury	Ruptured left diaphragm	Lucido & Wall 1963 (404)
175. Automobile accident - unspecified blunt abdominal trauma	43	F	Moderate shock - never conscious	Ruptured left diaphragm - ruptured spleen - pt. died	Lucido & Wall 1963 (404)
176. Automobile accident - unspecified blunt abdominal trauma	59	M	Severe head injury - fractured skull base - severe shock and coma	Ruptured left diaphragm - ruptured spleen - pt. died	Lucido & Wall 1963 (404)
177. Automobile accident - unspecified blunt abdominal trauma	26	F		Soreness lower chest - extensive fracture type laceration of left liver lobe	Poulos, E. 1963 (544)
178. Automobile accident - unspecified blunt abdominal trauma	9	F		Almost complete fracture of left liver lobe	Poulos, E. 1963 (544)
179. Automobile accident - unspecified blunt abdominal trauma	19	F		Laceration of left lobe of liver - traumatic hemobilia	Spencer, F.C. et al., 1963 (640)
180. Automobile accident - unspecified blunt abdominal trauma	65	F		Ruptured liver - pt. died	Stephens & Hollings 1963 (650)
181. Automobile accident - unspecified blunt abdominal trauma	23	F		Common bile duct completely transected just proximal to the pancreas - 6000 cc. bile	Sturmer and Wilt 1963 (666)
182. Automobile accident - unspecified blunt abdominal trauma	50	M		Extensive laceration of the mesentery	Wilson, D.H. 1963 (738)

103.	Automobile accident - unspecified blunt abdominal trauma	22	M		Ruptured inferior vena cava - pt. died	Wilson, D.H. 1963 (738)
104.	Automobile accident - unspecified blunt abdominal trauma	82	F		Retroperitoneal hematoma	Wilson, D.H. 1963 (738)
105.	Automobile accident - unspecified blunt abdominal trauma	62	F		Hemorrhage into rt. adrenal gland - pt. died	Wilson, D.H. 1963 (738)
106.	Automobile accident - unspecified blunt abdominal trauma	23	M	Lung laceration	Captured liver - torn rt. renal artery - pt. died	Wilson, D.H. 1963 (738)
107.	Automobile accident - unspecified blunt abdominal trauma	28	M	Brain injury	Ruptured liver - pt. died	Wilson, D.H. 1963 (738)
108.	Automobile accident - unspecified blunt abdominal trauma	10	F		Ruptured liver - pt. died	Wilson, D.H. 1963 (738)
109.	Automobile accident - unspecified blunt abdominal trauma	23	M		Ruptured liver and spleen - pt. died	Wilson, D.H. 1963 (738)
110.	Automobile accident - unspecified blunt abdominal trauma		M		Ruptured liver, spleen and both kidneys - pt. died	Wilson, D.H. 1963 (738)
111.	Automobile accident - unspecified blunt abdominal trauma	3	M	Skull fracture	Ruptured liver - pt. died	Wilson, D.H. 1963 (738)
112.	Automobile accident - unspecified blunt abdominal trauma	27	M		Ruptured liver and avulsed rt. kidney - pt. died	Wilson, D.H. 1963 (738)
113.	Automobile accident - unspecified blunt abdominal trauma	18	M	Myocardial hemorrhage	Ruptured spleen - contused left kidney - retroperitoneal hematoma - pt. died	Wilson, D.H. 1963 (738)
114.	Automobile accident - unspecified blunt abdominal trauma	95	M		Retroperitoneal hematoma - pt. died	Wilson, D.H. 1963 (738)
115.	Automobile accident - unspecified blunt abdominal trauma	27	M		Retroperitoneal hematoma - pt. died	Wilson, D.H. 1963 (738)
116.	Automobile accident - unspecified blunt abdominal trauma	29	M		Laceration of the head of the pancreas with large hematoma and fat necrosis	Buxton, R.W. 1964 (83)
117.	Automobile accident - unspecified blunt abdominal trauma	63	M		Extensive hematoma in transverse mesocolon - middle colic artery severed	Buxton, R.W. 1964 (83)
118.	Automobile accident - unspecified blunt abdominal trauma	6	M		Left hepatic duct severed from common duct	Hartman & Greaney 1964 (296)
119.	Automobile accident - unspecified blunt abdominal trauma	34	M		Rent through small bowel mesentery - avulsion of superior mesenteric vein	Killen, D.A. 1964 (362)

200.	Automobile accident - unspecified blunt abdominal trauma	18	F	Head Injury	Rupture of spleen with cyst and hematoma	Lorimer, W.S. 1964 (402)
201.	Automobile accident - unspecified blunt abdominal trauma	36	M	Fractured pelvis	Laceration of spleen in severed places - hematoma	Lorimer, W.S. 1964 (402)
202.	Automobile accident - unspecified blunt abdominal trauma	32	M		Laceration of left liver lobe - injury to common bile duct - hemobilia from common hepatic artery	Shohl, T. 1964 (611)
203.	Automobile accident - unspecified blunt abdominal trauma	50	M	Lower left rib fractures	Subcapsular hematoma of spleen	Anand & Davey 1965 (17)
204.	Automobile accident - unspecified blunt abdominal trauma	21	M	Fractured left ribs	Injury to spleen - hematoma of kidney	Anand & Davey 1965 (17)
205.	Automobile accident - unspecified blunt abdominal trauma	30	M		Completely avulsed and fragmented spleen - hemorrhage - bruising of fundus of stomach	Anand & Davey 1965 (17)
206.	Automobile accident - unspecified blunt abdominal trauma	22	M		Large laceration on rt. liver lobe	Madding, G.F. and Kennedy 1965 (412)
207.	Automobile accident - unspecified blunt abdominal trauma	60	M		Pancreas lacerated - rt. kidney lacerated - hemorrhage - pt. died	Sturim, H.S. 1965 (664)
208.	Automobile accident - unspecified blunt abdominal trauma	53	M		Lacerated pancreas, spleen, left kidney, adrenal - pt. died	Sturim, H.S. 1965 (664)
209.	Automobile accident - unspecified blunt abdominal trauma	24	F		Lacerated pancreas, spleen, - intra-abdominal hemorrhage - pt. died	Sturim, H.S. 1965 (664)
210.	Automobile accident - unspecified blunt abdominal trauma	3 1/2	M	Cerebral concussion and coma	Pancreatic pseudocyst - pt. died 17 days post injury	Sturim, H.S. 1965 (664)
211.	Automobile accident - unspecified blunt abdominal trauma	20	M	Cerebral concussion and multiple fractrs.	Multiple lacerations of rt. liver lobe - hemobilia - pt. died	Whelan & Gillespie 1965 (720)
212.	Automobile accident - unspecified blunt abdominal trauma	17	M	Severe brain injury	Ruptured spleen with intra-abdominal hemorrhage - pt. died	Wilson, C.B. et al., 1965 (737)
213.	Automobile accident - unspecified blunt abdominal trauma				Avulsing fracture of rt. liver lobe - pt. died	Baker, R.J. et al., 1966 (33)
214.	Automobile accident - unspecified blunt abdominal trauma			Acute cerebral damage	Laceration of anterior surface of rt. liver lobe - pt. died	Baker, R.J. et al., 1966 (33)
215.	Automobile accident - unspecified blunt abdominal trauma	24	M		Ruptured spleen - death	Fahlund & Smedley 1966 (212)

Case No.	Accident Description	Age	Sex	Findings	Author(s) and Year
216.	Automobile accident - unspecified blunt abdominal trauma	25	F		German & Davis 1966 ((254))
217.	Automobile accident - unspecified blunt abdominal trauma	23	M		Hellstrom, G. 1966 ((300))
218.	Automobile accident - unspecified blunt abdominal trauma	59	M		Holland, M.E. et al. 1966 ((314))
219.	Automobile accident - unspecified blunt abdominal trauma	26	M		MacVaugh, H. et al., 1966 ((411))
220.	Automobile accident - unspecified blunt abdominal trauma	58	M	Fractured skull	McLeod & Brown 1956 ((440))
221.	Automobile accident - unspecified blunt abdominal trauma	20	F		Nelson, J.F. 1966 ((480))
222.	Automobile accident - unspecified blunt abdominal trauma	20	M		Nelson, J.F. 1966 ((400))
223.	Automobile accident - unspecified blunt abdominal trauma	32	F		Nelson, J.F. 1966 ((480))
224.	Automobile accident - unspecified blunt abdominal trauma	29	F	Compression fracture of spine - rib fractures	Nelson, J.F. 1966 ((480))
225.	Automobile accident - unspecified blunt abdominal trauma	20	M		Nelson, J.F. 1966 ((480))
226.	Automobile accident - unspecified blunt abdominal trauma	61	F		Nelson, J.F. 1966 ((480))
227.	Automobile accident - unspecified blunt abdominal trauma	20		Brain contusion	Rodkey, G.V. 1966 ((563))
228.	Automobile accident - unspecified blunt abdominal trauma	38		Flail chest	Rodkey, G.V. 1966 ((563))
229.	Automobile accident - unspecified blunt abdominal trauma	39		Brain damage	Rodkey, G.V. 1966 ((563))
230.	Automobile accident - unspecified blunt abdominal trauma	48		Lung and brain injury	Rodkey, G.V. 1966 ((563))
231.	Automobile accident - unspecified blunt abdominal trauma	26	M		Sizer, 1966 ((610))

Transverse rupture of spleen

Large rupture in rt. lobe of liver - 1500 ml. blood and hematoma around rt. adrenal gland - pt. died

Fracture of left kidney with renal infarct

Large laceration of rt. liver lobe - hemorrhilia

Ruptured spleen - massive hemoperitoneum - pt. died

Intramural duodenal hematoma causing obstruction

Splenic cyst (of probable subcapsular hematoma origin)

Severely lacerated rt. liver lobe

Crushed common bile duct

Laceration of left diaphragm - herniation

Tear in diaphragm - herniation of stomach

Liver and kidney injury - pt. died

Spleen and kidney injury - retroperitoneal hematoma - pt. died

Diaphragm, stomach and splenic injury - pt. died

Spleen and liver injury - pt. died

Spleen massively enlarged by subcapsular hematoma

232.	Automobile accident - unspecified blunt abdominal trauma	38	M		Ruptured subcapsular hematoma of the spleen	Sizer, 1966 (576) (618)
233.	Automobile accident - unspecified blunt abdominal trauma	15	M		Laceration of the splenic capsule with 2500 cc. of free peritoneal blood	Sizer, 1966 (576) (618)
234.	Automobile accident - unspecified blunt abdominal trauma	63	F		Ruptured spleen - laceration of splenic vein	St. Pierre, P.E. 1966 (576) (576)
235.	Automobile accident - unspecified blunt abdominal trauma	52	F	Flail chest - ten broken ribs (left)	Rupture of spleen, liver, pancreas, and small bowel	St. Pierre, P.E. 1966 (576) (576)
236.	Automobile accident - unspecified blunt abdominal trauma	40	M		Complete transection of pancreas	Sturim, 1966 (665) (665)
237.	Automobile accident - unspecified blunt abdominal trauma	31	M		Lacerated colon - mid-colic vein torn - transection of pancreas	Sturim, 1966 (665) (665)
238.	Automobile accident - unspecified blunt abdominal trauma	25	F		Complete transection of pancreas	Sturim, 1966 (665) (665)
239.	Automobile accident - unspecified blunt abdominal trauma	49	F		Complete transection of pancreas - torn spleen	Sturim, 1966 (665) (665)
240.	Automobile accident - unspecified blunt abdominal trauma	27	M		Complete transection of pancreas - liver and colon lacerated - greater omentum torn	Sturim, 1966 (665) (665)
241.	Automobile accident - unspecified blunt abdominal trauma	40	M		Complete transection of pancreas - mesentery torn	Sturim, 1966 (665) (665)
242.	Automobile accident - unspecified blunt abdominal trauma	17	M		Complete transection of pancreas - spleen torn	Sturim, 1966 (665) (665)
243.	Automobile accident - unspecified blunt abdominal trauma	45	M		Pt. liver lobe fracture - two holes in small bowel - pt. died	Williams, L.F. & Byrne 1966 (731) (731)
244.	Automobile accident - unspecified blunt abdominal trauma	22	F	Pt. pregnant - multiple pelvic fracture	Ruptured spleen - laceration of liver - profuse bleeding	Williams, L.F. & Byrne 1966 (731) (731)
245.	Automobile accident - unspecified blunt abdominal trauma	32	F	Left rib fractures (2,4)	Splenic hematoma with two fractures radiating from the hilum	Frey, C.F. et al., 1967 (244) (244)
246.	Automobile accident - unspecified blunt abdominal trauma	37	M	Left rib fractures (5,6,8)	Small tear in the capsule of the spleen - complete occlusion of the rt. renal artery included rt. kidney	Frey, C.F. et al., 1967 (244) (244)
247.	Automobile accident - unspecified blunt abdominal trauma	20	M		Small splenic laceration on border of rt. liver lobe - rupture of accessory hepatic vein from inferior vena cava - hemorrhage	Little, J.M. et al., 1967 (236) (236)

248.	Automobile accident - unspecified blunt abdominal trauma	10	M		Extensive rupture of rt. liver lobe	Little, J.M. et al., 1967, (398)
249.	Automobile accident - unspecified blunt abdominal trauma	18	M	Skull fracture	Small intestine and large intestine gangrenous - pancreas tail contused - small tears on undersurface of rt. liver lobe - bt. died	Renton, C.J. 1967 (551)
250.	Automobile accident - unspecified blunt abdominal trauma			Fractured ribs and pelvis	Ruptured diaphragm - herniation of stomach, colon and omentum	Schwandt & Gale 1967, (596)
251.	Automobile accident - unspecified blunt abdominal trauma			Fractured pelvis	Ruptured diaphragm - herniation of stomach, colon, omentum, small bowel and spleen	Schwandt & Gale 1967, (596)
252.	Automobile accident - unspecified blunt abdominal trauma			Fractured ribs	Ruptured diaphragm - herniation of stomach	Schwandt & Gale 1967, (596)
253.	Automobile accident - unspecified blunt abdominal trauma			Fractured ribs	Ruptured diaphragm - herniation of stomach, colon, spleen, omentum, small bowel, liver	Schwandt & Gale 1967, (596)
254.	Automobile accident - unspecified blunt abdominal trauma			Fractured ribs	Ruptured diaphragm - herniation of stomach, colon and small bowel	Schwandt & Gale 1967, (596)
255.	Automobile accident - unspecified blunt abdominal trauma	14	F		Laceration of the under surface of the liver - complete avulsion of the left hepatic duct	Sewell, J.H. 1967 (601)
256.	Automobile accident - unspecified blunt abdominal trauma	42	M		Ruptured diaphragm	Sutton, J.P. et al., 1967, (669)
257.	Automobile accident - unspecified blunt abdominal trauma	43	M		Ruptured diaphragm - small bowel, stomach, spleen, and liver herniated into chest	Sutton, J.P. et al., 1967, (669)
258.	Automobile accident - unspecified blunt abdominal trauma	59	M		Ruptured diaphragm - stomach, omentum, transverse colon, small bowel herniated into chest	Sutton, J.P. et al., 1967, (669)
259.	Automobile accident - unspecified blunt abdominal trauma	24	F		Ruptured diaphragm - ruptured spleen - herniation of stomach, small bowel and spleen into chest	Sutton, J.P. et al., 1967, (669)
260.	Automobile accident - unspecified blunt abdominal trauma	20	M		Ruptured diaphragm - herniation of kidney, small bowel and stomach into chest - ruptured spleen	Sutton, J.P. et al., 1967, (669)
261.	Automobile accident - unspecified blunt abdominal trauma	40	M		Ruptured diaphragm - stomach, colon, spleen herniated - pt. died	Sutton, J.P. et al., 1967, (669)

262.	Automobile accident - unspecified blunt abdominal trauma	38	M	Ruptured diaphragm - spleen, omentum, stomach, small bowel herniated - pt. died	Sutton, J.P. et al., 1967 (669)
263.	Automobile accident - unspecified blunt abdominal trauma	20	M	Ruptured diaphragm - stomach herniated into chest - rupture spleen	Sutton, J.P. et al., 1967 (669)
264.	Automobile accident - unspecified blunt abdominal trauma	18	M	Ruptured diaphragm - ruptured spleen - perforated stomach - stomach herniated into chest	Sutton, J.P. et al., 1967 (669)
265.	Automobile accident - unspecified blunt abdominal trauma	19	M	Deep cleft in liver passing through the gallbladder bed and making the rt. lobe ischemic	Aronsen, K.F. et al., 1968 (23)
266.	Automobile accident - unspecified blunt abdominal trauma	20	M	Rupture and large lacerations of rt. liver lobe	Aronsen, K.F. et al., 1968 (23)
267.	Automobile accident - unspecified blunt abdominal trauma	45	M	Rupture between rt. and left liver lobe - several deep ruptures in the rt. lobe - lesions of the left hepatic vein - pt. died	Aronsen, K.F. et al., 1968 (23)
268.	Automobile accident - unspecified blunt abdominal trauma	8	F	Laceration of rt. liver lobe - lesion of vena cava - pt. died Cerebral concussion and intracranial hemorrhage - cardiac arrest	Aronsen, K.F. et al., 1968 (23)
269.	Automobile accident - unspecified blunt abdominal trauma	53	M	Central liver rupture penetrating into the left and rt. liver lobes - several large ruptures in rt. liver lobe - lesion of the caval vein with rupture of several hepatic veins - pt. died	Aronsen, K.F. et al., 1968 (23)
270.	Automobile accident - unspecified blunt abdominal trauma	20	F	Stellate rupture of entire rt. liver lobe	Aronsen, K.F. et al., 1968 (23)
271.	Automobile accident - unspecified blunt abdominal trauma	28	M	Rt. liver lobe totally crushed - hepatic vein ruptured at its entrance into vena cava - pt. died Shock - cardiac arrest	Aronsen, K.F. et al., 1968 (23)
272.	Automobile accident - unspecified blunt abdominal trauma	26	M	Stellate laceration of spleen	Berk & Wholey 1968 (43)
273.	Automobile accident - unspecified blunt abdominal trauma	25	F	Ruptured spleen - complete laceration of renal pedicle Multiple rib fractures	Berk & Wholey 1968 (43)
274.	Automobile accident - unspecified blunt abdominal trauma	24	M	Left upper quadrant pain - rupture of the spleen	Berk & Wholey 1968 (43)

275. Automobile accident - unspecified blunt abdominal trauma	30	M	Complete transection of 2nd part of duodenum - pancreas partially transected with head of pancreas badly contused - pancreatic duct divided	Brawley, R.K. et al. 1968 (70)
276. Automobile accident - unspecified blunt abdominal trauma	32	M	Rt. rib fractures (4-8)	Epstein & Lempke 1968 ((203)
277. Automobile accident - unspecified blunt abdominal trauma	28	M	Rt. rib fractures (4-5) and brain damage	Epstein & Lempke 1968 (203)
278. Automobile accident - unspecified blunt abdominal trauma	35	M	Transsection of the pancreas through the head - large retroperitoneal hematoma	Meyers, H.I. 1968 (449)
279. Automobile accident - unspecified blunt abdominal trauma	28	M	Head of pancreas markedly enlarged - pancreatitis	Meyers, H.I. 1968 (449)
280. Automobile accident - unspecified blunt abdominal trauma	45	M	Rupture of jejunum	Meyers, H.I. 1968 (449)
281. Automobile accident - unspecified blunt abdominal trauma	19	M	Pancreatic pseudocyst	Parrish, R.A., et al 1969 (512)
282. Automobile accident - unspecified blunt abdominal trauma	22	M	Two deep lacerations of the rt. hepatic lobe - hepatic veins avulsed from vena cava - hemorrhage - pt. died	Schrock, T. et al., 1968 (595)
283. Automobile accident - unspecified blunt abdominal trauma	10	F	Cerebral contusion	Wilkinson, G.M. et al., 1968 (725)
284. Automobile accident - unspecified blunt abdominal trauma	18	F	Deep laceration of the dome of the rt. liver lobe - massive hemorrhage	Ackroyd, F.W. et al., 1969 (1)
285. Automobile accident - unspecified blunt abdominal trauma	19	M	Complete fracture of entire rt. liver lobe	Ackroyd, F.W. et al., 1969 (1)
286. Automobile accident - unspecified blunt abdominal trauma	50	M	Multiple rib fractures - fractured pelvis - 5th lumbar vertebrae fracture	Allen, R.E. et al., 1969 (12)
287. Automobile accident - unspecified blunt abdominal trauma	23	F	Severe laceration of lateral segment of left liver lobe - ruptured bladder - ruptured spleen - left kidney and left colon contused - large retroperitoneal hematoma	Balasegaram, M. 1969 (34)
288. Automobile accident - unspecified blunt abdominal trauma	20	M	Subcapsular hematoma with intra-lobar rupture of the rt. liver lobe - pt. died	Balasegaram, M. 1969 (34)

289.	Automobile accident - unspecified blunt abdominal trauma	38	M	Cardiac arrest	Fifteen small bowel perforations - gross laceration of the mesentery - pt. died	Doporto, J.M. 1969 (155)
290.	Automobile accident - unspecified blunt abdominal trauma	20	M		Transection of pancreas and splenic blood vessels	Doporto, J.M. 1969 (155)
291.	Automobile accident - unspecified blunt abdominal trauma	35	M		Three perforations of sigmoid colon	Doporto, J.M. 1969 (155)
292.	Automobile accident - unspecified blunt abdominal trauma	34	M		Ruptured diaphragm	Doporto, J.M. 1969 (155)
293.	Automobile accident - unspecified blunt abdominal trauma	43	F		Perforated ileum	Doporto, J.M. 1969 (155)
294.	Automobile accident - unspecified blunt abdominal trauma	23	F		Ruptured spleen	Doporto, J.M. 1969 (155)
295.	Automobile accident - unspecified blunt abdominal trauma	17	M		Ruptured spleen - laceration of liver - pt. died	Doporto, J.M. 1969 (155)
296.	Automobile accident - unspecified blunt abdominal trauma	50	M	Fractured pelvis	Ruptured spleen, left kidney, urethra - large retroperitoneal hematoma	Doporto, J.M. 1969 (155)
297.	Automobile accident - unspecified blunt abdominal trauma	12	F		Perforated jejunum	Doporto, J.M. 1969 (155)
298.	Automobile accident - unspecified blunt abdominal trauma	35	F		Ruptured spleen	Doporto, J.M. 1969 (155)
299.	Automobile accident - unspecified blunt abdominal trauma	45	M		Duodenum almost transected - laceration of liver	Doporto, J.M. 1969 (155)
300.	Automobile accident - unspecified blunt abdominal trauma	40	M		Ruptured spleen - laceration of liver	Doporto, J.M. 1969 (156)
301.	Automobile accident - unspecified blunt abdominal trauma	14	M		Rupture of inferior epigastric vessels	Doporto, J.M. 1969 (155)
302.	Automobile accident - unspecified blunt abdominal trauma	25	M	Multiple injuries - fractured ribs	Membrilia - adhesions between lesser curvature of the stomach and left liver lobe	Fish & Nippert 1969 (225)
303.	Automobile accident - unspecified blunt abdominal trauma	24	F	Pt. pregnant	Ruptured spleen - four deep lacerations of liver - hemorrhage - pt. died	Freeman, M.G. et al. 1969 (242)
304.	Automobile accident - unspecified blunt abdominal trauma	46	F		Complete transection through the neck of the pancreas - with fat necrosis and hemorrhage	Jordan, G.L. et al. 1969 (341)

305. Automobile accident - unspecified blunt abdominal trauma	21	M		Deep bleeding, stellate laceration of the liver	Nemhauser, G.M. et al. 1969 (481)
306. Automobile accident - unspecified blunt abdominal trauma	36	F		Extensive stellate laceration of rt. liver lobe	Nemhauser, G.M. et al. 1969 (481)
307. Automobile accident - unspecified blunt abdominal trauma	30	M		Large stellate fracture of rt. liver lobe - excessive bleeding	Payne, W.D. et al., 1969 (517)
308. Automobile accident - unspecified blunt abdominal trauma	20	M	Rib fractures	Extensive liver fracture in rt. lobe - laceration of rt. kidney	Payne, W.D. et al., 1969 (517)
309. Automobile accident - unspecified blunt abdominal trauma	35	F	Multiple rib fract. (2-7) - cerebral concussion	Rupture of diaphragm - herniation of spleen, stomach and transverse colon into chest	Andrus & Morton 1970 (19)
310. Automobile accident - unspecified blunt abdominal trauma	40	M	Rib fracture	Lacerations of the spleen - rupture of diaphragm	Andrus & Morton 1970 (19)
311. Automobile accident - unspecified blunt abdominal trauma	24	F		Large deep laceration over dome of rt. hepatic lobe	Colver, H.D. 1970 (122)
312. Automobile accident - unspecified blunt abdominal trauma	42	M	170	Contusion over rt. lower quadrant - large retroperitoneal hematoma	Dudrick, S.J. et al. 1970 (190)
313. Automobile accident - unspecified blunt abdominal trauma	24	M		Complete obstruction of ventral branch of left renal artery - retroperitoneal hematoma	Fu, W.R. 1970 (247)
314. Automobile accident - unspecified blunt abdominal trauma	24	M		Laceration of rt. kidney with extravasation	Fu, W.R. 1970 (247)
315. Automobile accident - unspecified blunt abdominal trauma	37	M		Intimal tear of left renal artery - subintimal hematoma	Grablowsky, O.M. et al. 1970 (266)
316. Automobile accident - unspecified blunt abdominal trauma	19	F		Subintimal hematoma - thrombosis of renal artery	Grablowsky, O.M. et al. 1970 (266)
317. Automobile accident - unspecified blunt abdominal trauma	26	M		Complete transection of 3rd part of duodenum - small rent in posterior peritoneum	Nixon, J.W. 1970 (450)
318. Automobile accident - unspecified blunt abdominal trauma	25	M		Laceration of the extrahepatic biliary ducts and the common hepatic duct and the hepatic artery - subcapsular hematoma - hemobilia	Thomas, C.S. et al. 1970 (676)
319. Automobile accident - unspecified blunt abdominal trauma	21	F	Fracture dislocation of C-5, 6	Complete avulsion of liver from the diaphragm - superficial laceration of left lobe - large intrahepatic hematoma in left lobe	Thomas, C.S. et al., 1970 (676)

320. Automobile accident - unspecified blunt abdominal trauma	36	M	Fracture - laceration of the left lateral lobe of the liver with necrosis of fractured segment - contusion of stomach, large bowel and kidney	Walt & Grifka 1970 (701)
321. Automobile accident - unspecified blunt abdominal trauma	34	F	Rupture spleen - ruptured contused duodenum near the ligament of treitz - large retroperitoneal hematoma	Walt & Grifka 1970 (701)
322. Automobile accident - unspecified blunt abdominal trauma	29	M	Loops of ileum were adherent to the caecum in the area of cecal perforation - perforation of the rt. colon below the hepatic flexure - the entire rt. colon body contused, very ecchymotic	Walt & Grifka 1970 (701)
<u>ADDENDUM</u>				
323. Automobile accident - unspecified blunt abdominal trauma			Rupture of the anti-mesenteric border of the ileum	Veal & Barnes 1941 (694)
324. Automobile accident - unspecified blunt abdominal trauma			Rupture of mesenteric border of jejunum - pt. died	Veal & Barnes 1941 (694)
325. Automobile accident - unspecified blunt abdominal trauma			Rupture of mesenteric border of duodenum and hepatic flexure of colon - hemorrhage - rent in mesocolon and gastrocolic ligament	Veal & Barnes 1941 (694)
326. Automobile accident - unspecified blunt abdominal trauma			Rent in ileum	Veal & Barnes 1941 (694)
327. Automobile accident - unspecified blunt abdominal trauma			Rent in jejunum - pt. died	Veal & Barnes 1941 (694)
328. Automobile accident - unspecified blunt abdominal trauma			Rent in ileum - hematoma - pt. died	Veal & Barnes 1941 (694)
329. Automobile accident - unspecified blunt abdominal trauma	27	F	Laceration of convex surface of the spleen	Ireneus, C. et al., 1945 (323)
330. Automobile accident - severe accident	31	F	Large pseudocyst of the pancreas	Moore & Shumaker 1951 (463)
331. Automobile accident - unspecified blunt abdominal trauma	16	F	Extensive stellate fracture of dome of rt. liver lobe	Sawyer, K.C. et al., 1951 (585)
332. Automobile accident - unspecified blunt abdominal trauma	31	F	Large hole on front of duodeno-jejunal flexure	MacAuley, C. 1956 (406)

333.	Automobile accident - unspecified blunt abdominal trauma	M			Rupture of subcapsular hematoma of spleen (upper pole crushed and fragmented)	MacAuley, C. 1956 (406)
334.	Automobile accident - unspecified blunt abdominal trauma	M	60	Multiple rt. rib fractures - skull fracture	Tear of rt. diaphragm - herniation of liver - pt. died	Peck, W.A. 1957 (521)
335.	Automobile accident - unspecified blunt abdominal trauma	M	60		Tear of rt. diaphragm - herniation of total liver	Peck, W.A. 1957 (520)
336.	Automobile accident - severe accident	M	60		Ruptured left diaphragm - gangrenous stomach herniated into chest - pt. died	MacLean, L.D. 1961 (408)
337.	Automobile accident - unspecified blunt abdominal trauma	M	24		Ruptured pancreas - pseudocyst	Brooks, V. 1964 (75)
338.	Automobile accident - unspecified blunt abdominal trauma	M	60		Ruptured rt. diaphragm - herniation of liver	McCort, J.J. 1964 (434)
339.	Automobile accident - unspecified blunt abdominal trauma	M	21		Rupture of the dome of the bladder	McCort, J.J. 1964 (434)
340.	Automobile accident - unspecified blunt abdominal trauma	F	21	Pelvic fracture	Retroperitoneal rupture of the bladder	McCort, J.J. 1964 (434)
341.	Automobile accident - unspecified blunt abdominal trauma		2		Rupture of left diaphragm - herniation of stomach, small bowel and colon into chest	Noon, G.P. et al., 1966 (491)
342.	Automobile accident - unspecified blunt abdominal trauma	M	46		Ruptured rt. diaphragm - herniation	Noon, G.P. et al., 1966 (491)
343.	Automobile accident - severe trauma to abdomen	M	68	Multiple fractures	Large hematoma of upper right quadrant - three lacerations of the small bowel	Weiss & Dreiling 1968 (715)
344.	Automobile accident - unspecified blunt abdominal trauma	M	26		Linear laceration on undersurface of rt. liver lobe - tear in mesentery close to ileocecal junction - transverse tear on dome of bladder - laceration in neck of gallbladder	Blumgart, L.H. 1969 (55)
345.	Automobile accident - unspecified blunt abdominal trauma	M	22		Subcapsular hematoma of the spleen which had ruptured into the subdiaphragmatic space	Peters, J.P. et al., 1970 (535)

X. MISCELLANEOUS VEHICULAR BLUNT ABDOMINAL TRAUMA

CAUSE OF INJURY	AGE	SEX	WT.	PERTINENT DATA	ABDOMINAL INJURIES REPORTED	REFERENCE
1. Scooter accident - fall - bruised rt. abdominal wall	9	M			Retroperitoneal hemorrhage - hematoma of duodenal wall causing obstruction	Magladry & Mathewson 1954 (414)
2. Scooter car accident - struck by automobile - fell to pavement on left side	45	M		Left rib fractures (9-12)	Deep laceration of spleen - lacerated peritoneum	Wyman, A.C. 1954 (751)
3. Struck by car while coasting on a wagon	9	M		Multiple fractures	Laceration of left bladder wall with bone spicule in bladder	Halter & Gross 1957 (285)
4. Fall from tractor striking epigastrium on angular projection of tractor	13	F			Confusion of head and neck of pancreas with subcapsular hematoma	Blandy, J.P. et al 1959 (52)
5. Tractor accident - large tractor wheel passed over abdomen	64	M			One inch tear in terminal ileum	Thorlakson, R.H. 1960 (681)
6. Tractor over turned crushing chest and upper abdomen				Fractured left ribs - brain concussion - myocardial failure	Lacerated upper pole of spleen - massive subcapsular hemorrhage - pt. died	Maughon, J.S. et al 1961 (429)
7. Tractor accident - tractor over turned - struck abdomen	44	M		Left rib fractures (6-8) - pelvic fractures	Bilateral diaphragmatic rupture - herniation of stomach, colon, liver - complete severance of bladder - retroperitoneal hematoma - pt. died	Edwards & Lipscomb 1962 (193)
8. Struck in rt. abdomen by automobile while sledding	13	M			Kidney completely avulsed from its pedicle - large retroperitoneal hematoma	Knappenberger, S.T. et al 1963 (273)
9. Tractor driver - work accident	34	M			Extensive rupture of spleen - peritoneal blood (2 pints)	Wilson, D.H. 1963 (738)
10. Scooter accident - fell against scooter - struck abdomen and ribs	9	M			Large intramural hematoma of duodenum (2nd part)	Hill, M.C. 1955 (306)
11. Fall from back of trailer	47	M			Liver laceration with massive hemoperitoneum and multiple retroperitoneal hematomata - pt. died	Lucas & Wirka 1965 (403)
12. Tractor rolled on him	33	M			Laceration of rt. liver lobe	Little, J.M. et al 1967 (398)

	AGE	SEX	WT.	PERTINENT DATA	ABDOMINAL INJURIES REPORTED	REFERENCE
13.	28	F			Abdominal ascites and pancreatic pseudocyst	Parrish, R.A. et al 1968 (512)
14.	8	M			Complete severance of left liver lobe	French, W.E. 1970 (243)