

THE COSTOMEDIASTINAL BORDER OF THE LEFT PLEURA IN THE PRECORDIAL AREA

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TWO FIGURES

INTRODUCTION

It has long been apparent that a considerable discrepancy exists between the traditional textbook treatment of the margin of the left pleura in the precordial area and the usual findings in dissection of the region. This investigation was made to determine the magnitude of this discrepancy and to establish if possible the normal topographic relations of this margin with the sternum and costal cartilages.

The problem exhibits many facets, among which may be mentioned the level at which the left pleura emerges from the sternal margin, its mean distance from the sternal margin at each subsequent costal or intercostal level, its corresponding extreme positions and their variations, and the character of the curve (concave or convex to the median plane) of the left pleural margin.

Review of the literature

Bourgery, writing in 1835, stated that Heister's observation that the inferior portion of the border of the left pleura leaves the sternum and lies behind the costal cartilages was the basis for the practice of penetration of the pericardium by an aspirating needle along the left lower border of the sternum. Bourgery noted from his personal observations, however, that the pleura frequently remains close to the

sternal margin and recommended caution in following Heister's suggestion.

Luschka's data (1863) largely established the traditional teaching concerning the relations of the left pleural margin. He stated that although variability exists, in most cases he found, in the adult, distances from the sternal border to the left pleural margin of 1.5 cm at the level of the fifth costal cartilage, of 2 cm at the level of the sixth cartilage, and 3.5 cm at the seventh. He did comment, however, that the left pleura is frequently so little divergent that the intermediate space is reduced to a minimum.

During the following years a number of studies appeared which largely refuted or modified the conclusions of Luschka. Luschka, himself, noted the findings of Nuhn (1860) who concluded that there is normally insufficient space to reach the pericardium without perforating the pleura. Sick (1885) analyzed the condition in 23 adult cadavers and found the left pleura at the fifth cartilage under or just at the border of the sternum in 18 cases, in a comparable position at the level of the sixth cartilage in 10 cases, and just leaving the sternum at the seventh cartilage in 8 cases. In his 12 cases of children the pleural margin showed a still closer adherence to the sternal border. Tanja (1891) criticized Luschka's description as being based on impressions rather than statistical analysis. Tanja found no asymmetry of the pleural borders in lower mammals or monkeys and more divergence, but no essential asymmetry in higher apes. His 42 human cases comprised 28 foetal, newborn and infant bodies, and 14 between the ages of 8 and 76 years. Tanja emphasized the considerable variability in the anterior margins of both pleural sacs and the variation in level at which the left margin leaves the sternum (third rib to ensiform cartilage). His tracings of pleural margins tend to invalidate the concept of a cardiac notch in the pleura, i.e., a deviation similar to but less extensive than that of the left lung. Ruge ('10) found that an outbowing of the pleural margin due to the heart appeared to be rare among monkeys, the right and left lines coming

down straight and parallel behind the sternum in the usual case. The apes show a wider separation of the 2 margins but both behave similarly, there being no cardiac notch. In man he reported that the left pleural margin begins to deviate opposite the sternal end of cartilages 6, 5, 4 or even 3. He stated that it has a gentle curve with a left sided convexity. Among his tracings of the pleural borders in 12 human cases, only 1 shows a marked cardiac notch and only 2 others show any left-sided convexity of the left margin.

Similarly Brooks (1889) found the left pleural margin entirely under cover of the sternum in 4 of 7 cases and quite close to the sternal border in 1 other cadaver. He concluded that the area of pericardium uncovered by pleura was normally very small.

Noback ('32) made a brief note pertinent to this question in relation to his observations of 100 adult cadavers. He observed that the left pleural margin does not usually deviate at the level of the fourth costal cartilage, but that, on the contrary, in 90 cases the right and left pleural reflections were in close contact behind the sternum and extended thus inferiorly to the sixth or seventh costosternal junction. He concluded that the customarily described area of pericardium devoid of pleural covering in this region is not present.

Merkel (1899 and '02) stated of the left pleural border that the usual curved course of the line is altered in the region of the pericardium by the fact that the right directed convexity is changed to a concavity and that the sixth rib is not reached at its sternal insertion, but somewhat farther out along its cartilage. His figure has been copied extensively and shows the left pleura diverging abruptly from the right at the level of the fourth rib insertion, crossing the fourth interspace slightly lateral to the sternal margin, being further separated from it in the fifth interspace and following the lower border of the sixth cartilage laterally. The figure of Poirier (1898) shows a more gradual curve of divergence of the left pleural border, the convexity of which reverses itself only slightly. It shows the pleural margin at the sternal border in the

fourth interspace but well away from it in the fifth and sixth intervals. He described a slight internal concavity which his figure only just indicates. This figure more nearly approaches my own findings (fig. 2) than any other in the literature, although showing greater divergence to the left than the mean position of the present study.

Rauber-Kopsch ('07) described the left pleural margin as exhibiting an easy left-sided outbowing which does not quite reach the cardiac notch of the left lung. His figure, which is also copied in 1 current anatomical text, shows a rather extreme divergence from the sternal border at the level of the fourth interspace with wide intervals between the pleural margin and the sternum in the fifth and sixth interspaces.

Further discussion of figures and descriptions in texts and reference books would be fruitless. Suffice it to say that Merkel's figure is basic to illustrations in Gegenbaur (1890) and Corning ('07) and is similar to that of Testut (1894 and later editions). That of Rouvière ('24) is modified from Merkel and shows no clear interval in the fourth interspace but is otherwise the same. Merkel's figure also appears with occasional modifications in the currently standard anatomical textbooks (Gray, Morris, Cunningham). Such figures show a reversed curve in the left pleural margin, its lower portion having a left-sided convexity as it withdraws from the sternal margin through the levels of the fifth and sixth costal cartilages. Descriptive matter in these texts reflects, however, the realization of recent revising editors that the Luschka tradition is in error, in that they place the left pleural margin near (at or beyond) the sternal border at the levels of the fifth and sixth ribs and interspaces. Piersol has taken cognizance of the more serious investigations of the pleural margins. He describes the left margin as passing from behind the sternum at about the junction with the sixth cartilage and denies the traditional teaching that the left pleura takes a curve similar to that of the left lung (cardiac notch). His figure, however, shows a left-sided convexity in the lower substernal part of the margin.

Radiological studies have been useful in determining the inferior pleural margins and the pleural relations in the superior mediastinal area, but have contributed little on the contour of the pleural borders in the precordial area.

AUTHOR'S MATERIALS AND METHODS

One hundred and two consecutive adult cadavers were used in this investigation. Following removal of the skin, fascia and pectoral musculature in routine class dissection, headless pins were inserted through the sternal extremities of the fourth, fifth and six intercostal spaces. These passed immediately against the sternal margin and by means of a probe were pushed vertically downward through the intercostal membrane and muscles into the tissues of the mediastinum. The sternoclavicular joint having been disarticulated, the upper 6 ribs were cut at their angles and removed together with the manubrium and body of the sternum. This exposed the pleural sacs, the pericardium and the great vessels, and the pins protruding from these structures marked accurately the sternal extremities of the fourth, fifth and sixth intercostal spaces. The margin of the left pleura was then defined by gently freeing it from the mediastinal areolar tissue. Measurements (accurate to 0.5 mm) were then made of the distance (either to right or left) between the pleural margin and the pins marking the left sternal border. A free-hand sketch was made of the relationship of the pleural margin to the pins and in a considerable number of instances map pins with large heads were substituted after the measurements were taken and a permanent record was made photographically (fig. 1). A long straight-edge was also employed to mark the midline of the body and measurements of the pleural margin were made to it in the fourth, fifth and sixth interspaces.

Effect of disease

Of the 102 specimens examined 7 were discarded because of extreme displacements due to disease, leaving 95 cases for

consideration. Pulmonary lesions are frequent in cadavers and in general produced no significant shift of pleural borders. Large hearts, likewise, produced as a group no noticeable deviation of the pleural margins. Such conditions appeared to produce no greater deviation of the pleural borders than was exhibited in the variations among the "normal" group. Thus, there are included in the data all except the most extreme cases of gross lesions. The effect of this is to widen the range but should have little effect on the mean position of the pleural margins.

ANALYSIS OF DATA

A. Level of deviation of left pleural margin

The 2 pleural margins usually lie closely approximated behind the upper part of the body of the sternum slightly to the left of the midline. In this study the left margin began to deviate from the right anywhere from the third rib to the fifth interspace. At times this divergence is so gradual as to be equivocal and consequently the data here reported covers 80 cases. The mean level of deviation is that of the fourth rib. 70% of the 80 cases showed divergence of the left margin at some level between the third and fourth interspaces.

B. Level of emergence of pleura from left sternal margin

This point varied in the 86 cases giving reliable data from the third interspace to the seventh costal cartilage, the mean level being the upper third of the fifth intercostal space. Emergence of the pleura at levels from the fourth interspace to the lower border of the sixth costal cartilage, inclusive, accounted for 73% of all cases.

C. Relations of pleural margin at the fourth intercostal space

Ninety-five cases gave information on this relationship. Measurements were made both to the left sternal margin and to the midline of the body.

Mean position—0.6 cm to the right of the left sternal margin, i.e., substernal in position or 1.16 cm from the midline.

Total range—1.5 cm to left of (lateral to) the sternal margin to 3 cm to its right or 3 cm to the left of the midline to 0.7 cm to its right. In 76 cases the border was substernal and in 19 cases to the left of the sternal margin.

Range of 70% of cases grouped around the mean. 1 cm on either side of the mean includes 70% of the cases (slightly over 1 standard deviation).

D. Relations of pleural margin at the fifth intercostal space in 95 cases

Mean position—0.2 cm to the left of (lateral to) the left sternal margin or 1.9 cm to the left of the midline.

Total range—2.5 cm left of the sternal margin to 2.5 cm to its right or from 0.1 to 4.4 cm to the left of the midline.

In 27 cases the border lay substernally, in 5 cases at the sternal margin, and in 63 cases to the left of it.

Range of 70% of cases grouped around the mean—0.8 cm on either side of the mean related to the sternal margin or 1 cm on either side of the mean related to the midline are the limits of this group.

E. Relations of pleural margin at the sixth intercostal space in 94 cases

Mean position—1.1 cm to the left of sternal margin or 2.5 cm to left of midline.

Total range—1.5 cm to right of sternal margin to 3.5 cm to its left or 0.5 to 5.7 cm to the left of the midline. In 10 cases the pleural border lay substernally, in 3 at the sternal margin, and in 81 was to its left.

Range of 70% of cases grouped around the mean. 1 cm on either side of the mean includes this group.

Horizontal measurements taken to the left of the sternal margin at the sixth interspace rapidly reach points under the sixth costal cartilage; thus the mean position of the pleura

as determined in this study locates the pleural margin under the sixth cartilage. The mean pleural margin crosses the sixth interspace at a distance of 1.5 cm from the sternal border as measured along the sloping under border of the sixth costal cartilage, measurement being made on a life-size figure (fig. 2). A distance of 2.5 cm from the sternal margin similarly measured marks the limit in that direction of the central 70% of cases.

F. Curvature of the left pleural margin in 94 cases

An analysis of photographs and tracings of the left pleural margin with respect to its curvature may be summarized as follows:

Marked convexity to right	7 cases
Slight convexity to right	22 cases
Essentially straight-line contour	30 cases
Slight convexity to left	24 cases
Marked convexity to left	11 cases

More than 80% of the cases fall into the central classifications of essentially uncurved or slightly convex to right or to left.

G. Validity of the data

Internal evidence of the data gives some indication of its validity. When the mean positions of the pleural margin are located on a life-size sketch of the anterior chest wall incorporating the outline of an average sternum, the measurement of the mean from the left sternal margin and from the midline check within 0.5 mm of each other at all 3 interspace positions. Further, all points lie on a smoothly defined curve, which intersects the sternal margin at the level determined by the data (fig. 2).

DISCUSSION AND SUMMARY

It is unfortunate that no method has been devised as yet to visualize the lower costomediastinal border of the left pleura in the living. Radiographic studies have elucidated

its upper portion (Stephani and Kirsch, '33, and others) and the inferior pleural border (Lachman, '42) but the radiologic density of the heart is at present a barrier to use of this method in the precordial area. However, cadaver study has been and is of considerable value.

The early studies of this pleural segment (Luschka, 1863) emphasized an extreme position perhaps due to the examination of highly pathological material and were perhaps influenced by the lack of proper fixing and hardening agents.

The comparative investigations of Tanja (1891) and Ruge ('10) are of interest in showing no differences between the right and left margins of the pleura in lower mammals or monkeys and no essential asymmetry in their relations among the apes. The studies of these authors and of Sick (1885) with respect to the relations in man were perhaps based on too few observations but indicated clearly that Luschka's findings did not represent a true mean. Tanja stressed the variability of the pleural position in the costomediastinal region, a point of view which this study fully corroborates. Its variability emphasizes the necessity of examining a large number of specimens.

To recapitulate the main results of this study, the left costomediastinal pleural border has the following mean relationships. It diverges from its fellow of the right side at the level of the fourth cartilage, lies substernally 0.6 cm medial to the left sternal margin at the level of the fourth intercostal space, emerges from the cover of the sternum in the upper third of the fifth intercostal space and moves only 0.2 cm lateral to the sternum in the midregion of this interspace. Measured from the sternal end of the sixth interspace it lies 1.1 cm lateral to the sternal margin, which measurement is a location under the sixth costal cartilage due to the considerable slope of this cartilage. The curve defined by these points passes the lower border of the sixth costal cartilage 1.5 cm from the sternal end of that interspace measured along the sloping lower border of the cartilage.

Examination of the central grouping of the data reveals that plus or minus 1 cm from the mean at all levels measured includes 70% or more of the cases. This proportion of cases is cited as being comparable to 1 standard deviation in statistical treatment. The mathematical computations of a true standard deviation were not undertaken.

The character of the curvature of the left pleural border as traced and photographed is instructive with respect to traditional illustrations. There was a marked convexity to the left in only 11 cases and to the right in only 7 cases. In 76 of the 94 cases the border was relatively straight or showed a slight curvature (see fig. 1). A slight convexity to the left was scarcely more frequent (24 cases) than to the right (22 cases).

The variability of the pleural margin is considerable. The total range of location of the various points for all cases is 5 cm at the fifth and sixth interspaces and slightly less at the fourth. It is possible that somewhat less variability occurs among essentially normal living individuals.

Comparison of figure 2 with illustrations in current texts and reference works emphasizes their differences. The pleural margin in the precordial area in the latter will be found to adhere closely to the more laterally placed of the line of crosses of figure 2. Since this line marks 1 limit of the central group of 70% of my cases, then approximately 85% of pleural margins lie more medialward than the average line of heretofore acceptable illustrations.

This study has emphasized the variations occurring in a cadaver group in the lower costomediastinal border of the left pleura and has established the mean relationships and central tendency of this margin in a large number of cases. It is hoped that it will provide a broad and at the same time a more precise view of thoracopleural topography in the precordial area.

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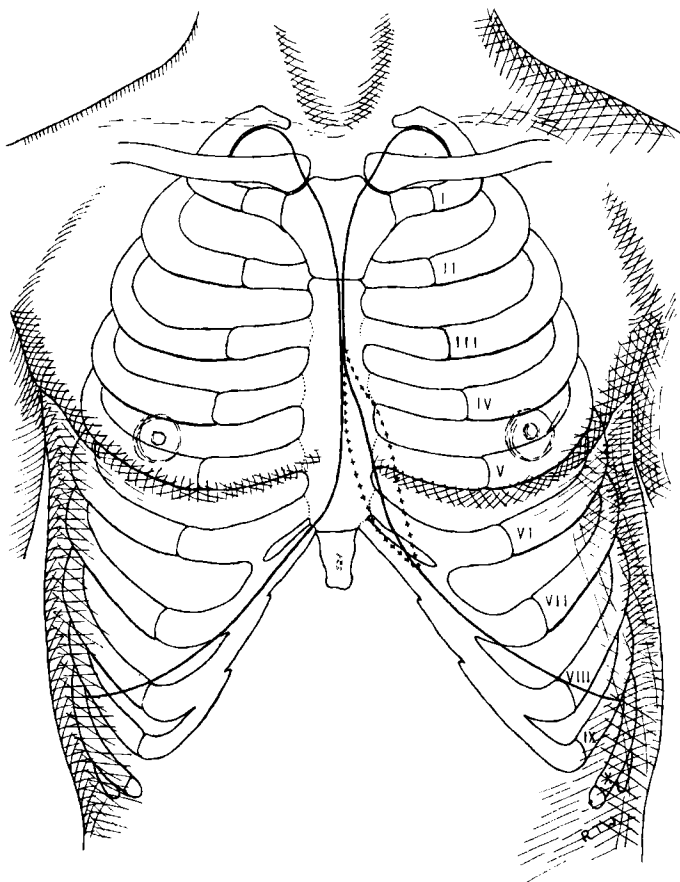
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PLATE 1

EXPLANATION OF FIGURE

1 Examples of photographic records of the left pleural reflection. A and B show conditions close to the mean, C a more medially placed and D a more laterally placed pleural margin. The plus mark the sternal extremities of the fourth, fifth and sixth interspaces. Arrows directed to the right call attention to the pins, those directed to the left emphasize the position of the left pleural margin.





2 The relations of the pleural reflections to the anterior chest wall. The solid line on the left represents the mean. The interrupted lines (crosses) in the precordial area represent variants between which lie 70% of the cases studied.