Fiberoptic Transillumination: A New Tool for the Pediatric Surgeon

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• Transillumination (TI) is a safe and reliable technique for evaluating masses or the presence of free air in the thorax or abdomen. TI can also be of help in the accurate placement of catheters or needles in the chest, abdomen, bladder, or vessels. Its use in several hundred cases has been documented by this report.

INDEX WORD: Transillumination.

TRANSILLUMINATION (TI) is an infrequently used clinical tool; however, the recent availability of high powered cold transillumination equipment has resulted in a renewed interest in its application. At the Mott Children's Hospital transillumination has been used in over 250 infants for both diagnostic and therapeutic purposes; the present report describes our experience with this technique over the last 2 yr.

HISTORY

Richard Bright is credited with the first description of TI in his report in 1831 of James Cardinal, an apparent hydrocephalic.[1] Curling's textbook on the testis in 1843 includes a description of the technique of scrotal transillumination for evaluation of a hydrocele.[2] Cutler reported on the use of transillumination of the breast in 1929;[3] however, it was not until the 1950s and 1960s that TI was rediscovered for the evaluation of the head.[4-10] At this time its application for abdominal evaluation of the infant and child was also initiated.[10,11] Recent preliminary reports from our institution have demonstrated the usefulness of high intensity TI as a diagnostic aid in evaluating pneumothorax, pneumomediastinum, and pneumopericardium in neonates and as means of identifying cutaneous veins in newborns and in obese infants.[12,13]

MATERIALS AND METHODS

The instrument used for TI of the neonate and infant is the Minilight Illuminator.* The unit consists of a light source on a portable stand with a coaxially-sheathed 5 ft fiberoptic probe which provides 5000 foot candles of incoherent light (Fig. 1). The instrument is easily managed by one person and is approved for placement in supplemental oxygen environments, enabling examination without disruption of life support systems and monitoring equipment. The flexible fiberoptic probe is modified by placing a soft opaque rubber collar at the tip to provide

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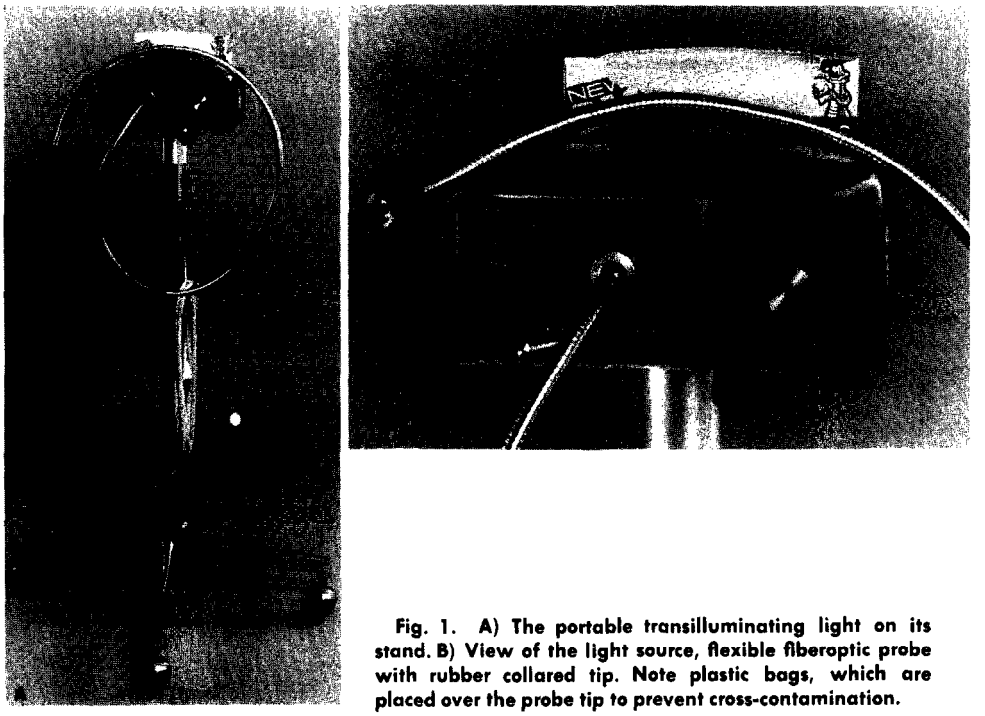


Fig. 1. A) The portable transilluminating light on its stand. B) View of the light source, flexible fiberoptic probe with rubber collared tip. Note plastic bags, which are placed over the probe tip to prevent cross-contamination.

an occlusive contact with the skin. The probe tip is covered with a piece of polyethylene sheeting to prevent cross contamination. Sandwich bags work nicely for this purpose.

To perform the examination, the room lights are dimmed; absolute darkness and dark adaptation are not required. The probe is placed perpendicular on the skin and sufficient pressure applied to prevent light leak. Examination is then undertaken in a systematic fashion. Changes in the size and shape of the corona of light are noted as well as the appearance of light separated from the corona.

The skin must be protected from the thermal effects of the transillumin .ing light source. It was originally thought that the cold fiberoptic light would eliminate the heat problem; however, significant heat build-up can occur.[14] Therefore, we move the probe tip every 15 sec when used at maximum intensity.

In January 1975, a prospective study utilizing the high intensity fiberoptic transilluminator to follow neonates with respiratory distress was begun. Concomitantly, the use of transillumination as a routine diagnostic and therapeutic aid in other areas was also started. Table 1 lists the conditions where TI was of value.

CLINICAL EXPERIENCE

Thorax

Transillumination has proven extremely useful as a diagnostic tool in evaluating pneumothorax (PT) and pneumomediastinum (PM) in neonates. As little as 10 cc of free air can be detected. To examine the neonate the illuminating probe is placed first above and then below the nipple and the corona is compared with that on the contralateral side (Fig. 2). Suspicious areas are investigated with multiple placements of the probe. PT appears as an irregular glow of the chest wall apart from the normal corona (Fig. 3). A smaller than normal corona may be present on the contralateral side due to lung compression. A small PM appears as a linear midline translucent area when the probe is placed

Table 1. Fiberoptic Transillumination

Diagnostic Use
Thorax
pneumothorax
pneumomediastinum
pneumopericardium
diaphragmatic hernia
Abdomen
pneumoperitoneum
ascites
hydronephrosis
sacrococcygeal teratoma
cysts of various origins
Head
hydrocephalus
hydranencephaly
subdural effusion
leptomeningeal cyst
epidermoid cyst
Neck
subcutaneous emphysema
cystic hygroma
neuroblastoma
rhabdomyosarcoma
Therapeutic Use
intravenous line insertion
suprapubic taps
duodenal catheter placement

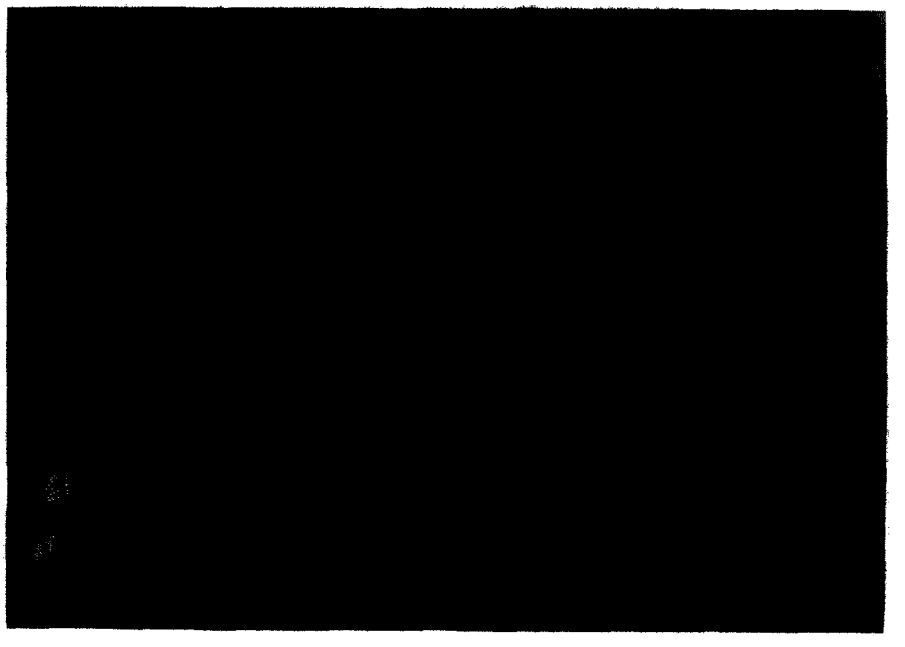


Fig. 2. Neonate with fiberoptic probe placed on left chest showing a normal regular transillumination corona.

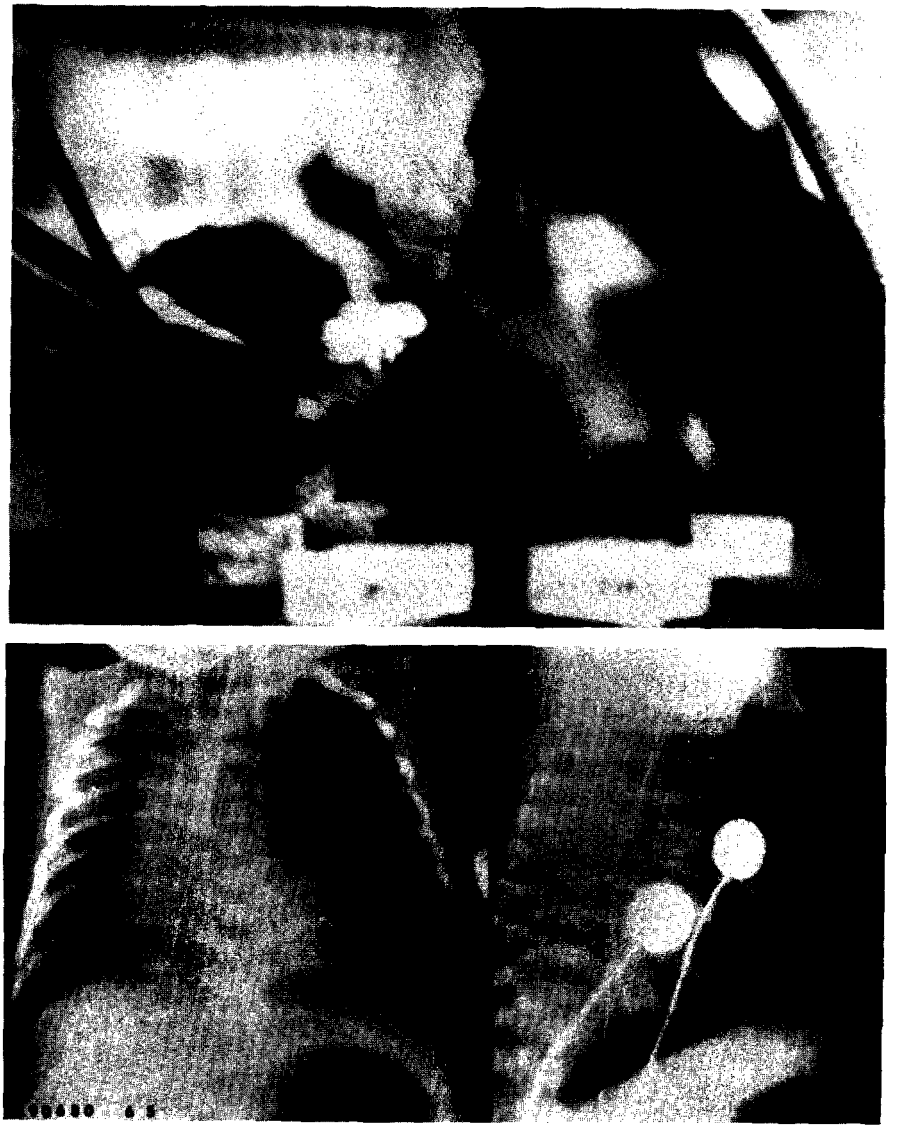


Fig. 3. A) Irregular area of abnormal transillumination (arrows) over large left pneumothorax. B) AP and cross table lateral radiographs of neonate in 3A.

parasternally. A large PM may look identical to a PT (Fig. 4). Either a PT or PM may have a subpulmonic extension on TI that is detected by placing the light over the lower anterior rib cage. Pneumopericardium is seen as a relatively smooth edged corona occupying the lower left chest (Fig. 5).

A prospective study was undertaken to determine the accuracy of TI in the diagnosis of PT and PM when there was radiographic proof of free air. One hundred consecutive cases of radiographically proven PT or PM in the neonatal intensive care unit underwent transillumination just prior to x-ray examination. The presence and location of abnormal transillumination within the chest was

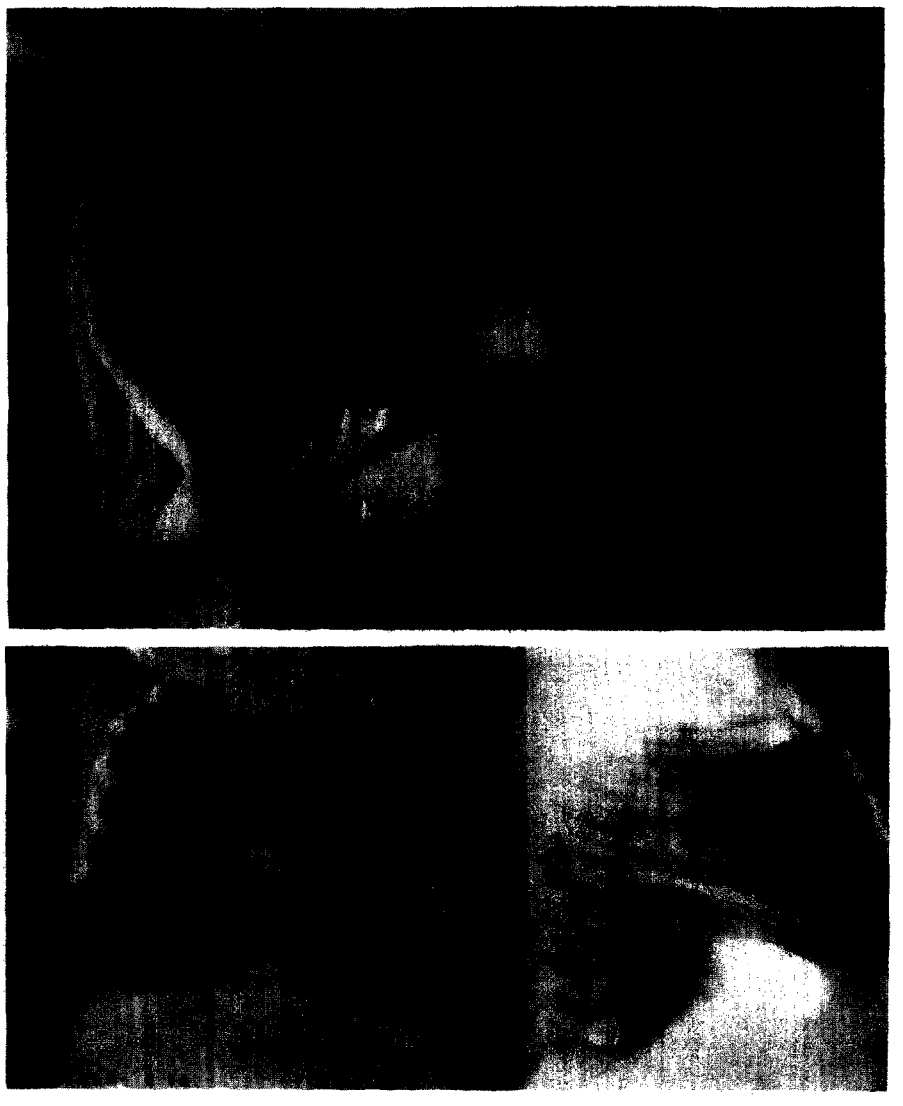


Fig. 4. A) *Transillumination of large pneumomediastinum in term infant.* B) *Radiographs of this infant showing midline pneumomediastinum with anteriorly projecting right thymic lobe ("sail sign"). Thymic lobe blocks TI to right of sternum.*

noted and an attempt made at quantitation. Anteroposterior and cross-table lateral chest films were then immediately obtained and the presence of free air was graded minimal, moderate, or severe. The results of the comparison of the TI findings of the first 100 consecutive cases in which the concurrently obtained radiographs demonstrated free air are shown in Table 2. Fifty-seven pneumothoracies were proven radiographically; and of these, one moderate and one large PT were missed by TI. Gross chest wall edema was present in one of these two cases while the other infant had increased subcutaneous fat characteristic of an infant of a diabetic mother. In 43 cases of radiographically confirmed PM,

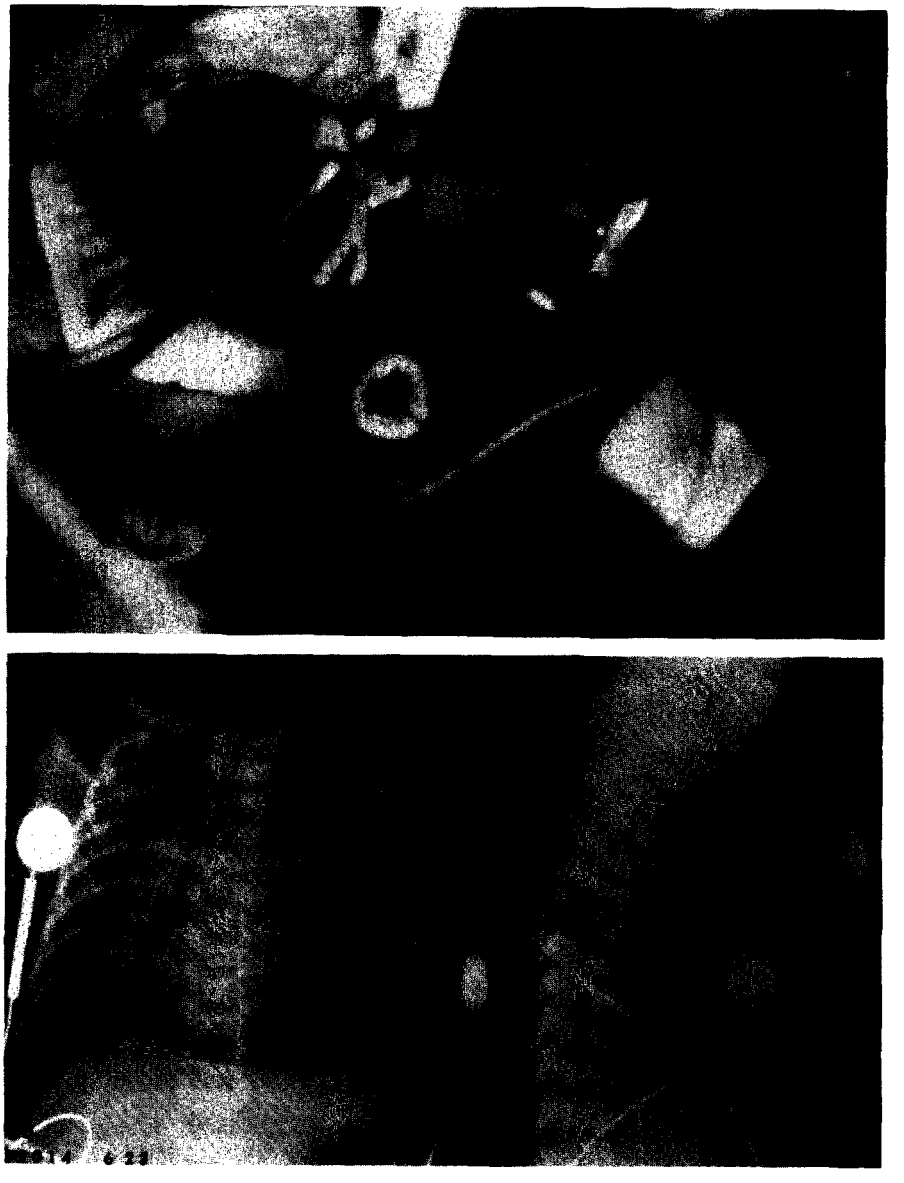


Fig. 5. A) Abnormal anterior left chest transillumination in hypotensive dyspneic premature infant. B) and C) Radiographs of infant 5A demonstrating large pneumomediastinum and pneumopericardium.

three minimal collections were missed by TI. Therefore, the accuracy of TI in the diagnosis of radiographically proven PT and PM was 96% and 93% respectively. The false positive rate of TI for either PT or PM has been evaluated by the authors previously and is approximately 4%.[12]

TI is now used routinely in our neonatal ICU. Neonates at risk are serially studied by TI performed by housestaff or trained nursing personnel. If the diagnosis of minimal PT or PM is made, immediate radiologic confirmation is

Table 2. 100 Radiographically Proven Cases of Pneumothorax or Pneumomediastinum Undergoing Simultaneous Transillumination

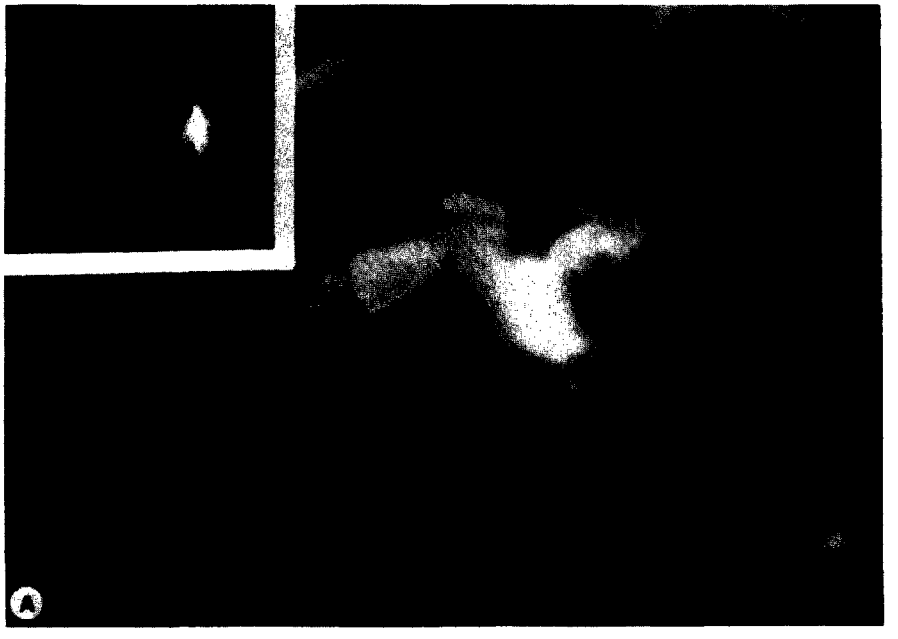
Size	Total Cases	TI Positive	TI Negative
		Pneumothorax	
Minimal	7	7	0
Moderate	24	23	1
Severe	26	25	1
Subtotal	57	55	2
		Pneumomediastinum	
Minimal	18	15	3
Moderate	15	15	0
Severe	10	10	0
Subtotal	43	40	3
Total	100	95	5

obtained. If life-threatening PT or PM occurs, treatment is instituted on the basis of TI alone.

Three cases of pneumopericardium have been suspected during TI, although the diagnosis could not be made by TI alone. Three infants with congenital diaphragmatic hernia have also been studied; the affected hemithorax did not transilluminate abnormally. The principal benefit of TI in diaphragmatic hernia is the ability to closely monitor the contralateral hemithorax in the postoperative period.

Abdomen

Transillumination of the abdomen can be a helpful part of the physical examination of infants.[15,16] Several cases have been reported demonstrating its usefulness in the presence of ascitic fluid and in the differentiation of cystic from solid masses.[10,11] The high intensity illuminator was of value in 23 of our patients with intraabdominal abnormalities. Five cases of pneumoperitoneum were identified (Fig. 6). Four of these were in neonates with necrotizing enterocolitis being followed serially with TI, and one was in an infant with a perforated duodenal ulcer. The TI findings are striking; the peritoneal cavity glows brightly and the abdominal wall vessels and falciform ligament can be easily seen. The liver and spleen may also be visible but are not as prominent as the falciform ligament or abdominal wall vessels since they tend to be displaced posteriorly by the free air in the supine neonate. All cases of pneumoperitoneum detected by TI were confirmed by radiologic examination. Five cases of ascites were encountered and had transillumination findings similar to those of pneumoperitoneum; however, the illumination was not as bright. Liver, gall bladder, and spleen are better seen in the presence of ascites since they tend to float anteriorly. The falciform ligament on the other hand is poorly visualized in the ascitic abdomen. The TI pattern of ascites in the lateral decubitus position shifts inferiorly in contrast to the pattern noted with free air or bowel gas which shifts superiorly. In the normal infant, especially the premature, dilated loops of bowel or dilated stomach will transilluminate; however, abdominal wall structures or organs will not be seen.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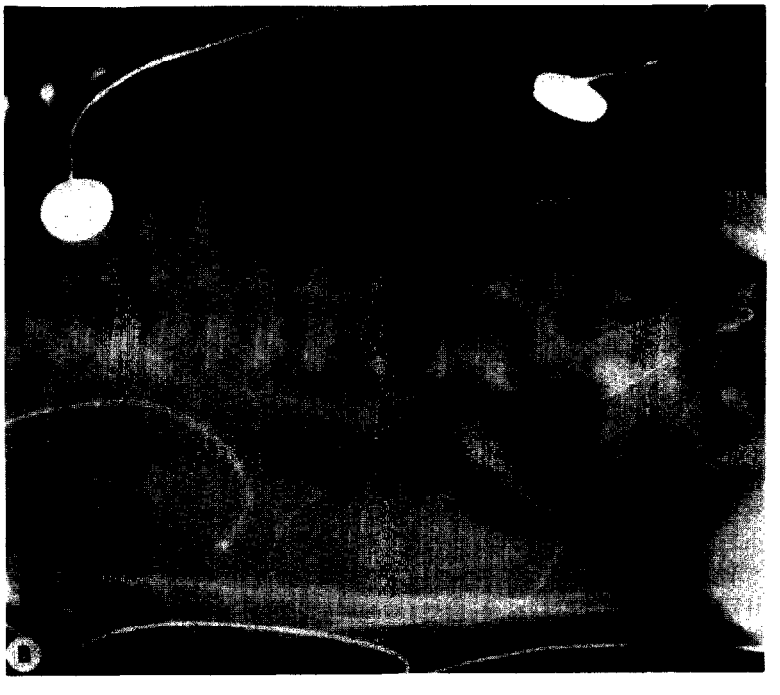
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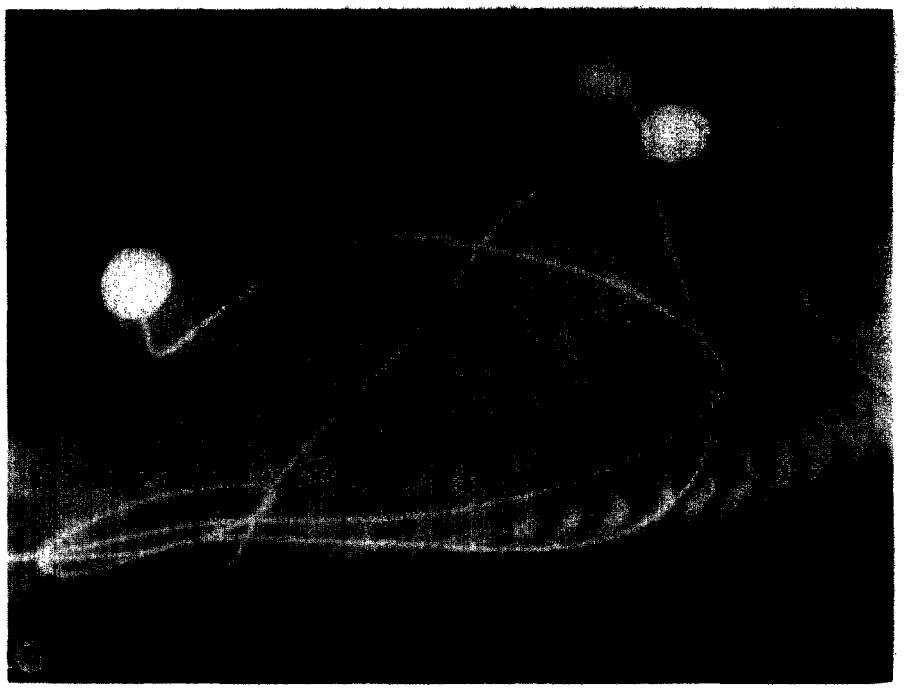


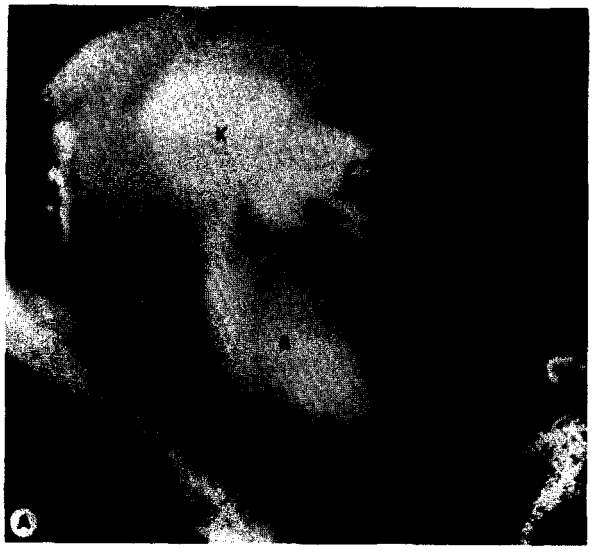
Fig. 6. A) Transillumination of pneumoperitoneum in neonate with sudden abdominal distension. Head in lower left hand corner, probe applied to umbilicus. The entire abdomen glows with poor visualization of the falciform ligament (arrow). Insert, falciform ligament (arrowheads) seen in left oblique position with probe placed in left lower quadrant. B) Lateral decubitus radiograph of this infant, falciform ligament (arrowheads). C) Cross table lateral radiograph of 6A.

TI is also helpful in demonstrating urinary tract obstruction. Seven cases of hydronephrosis, hydroureter, or multicystic kidney had positive TI (Fig. 7). Decompression was instituted early and the adequacy of suprapubic or transurethral drainage was followed by TI. To perform TI of the kidney, the infant is placed on its side. The probe is placed anteriorly over the kidney area and is manipulated in the same manner as that used for deep palpation of the renal fossa. The kidney is then observed during the respiratory cycle. The hydronephrotic kidney makes a marked excursion with inspiration. The hydronephrotic or cystic kidney also has a more multiloculated transilluminating pattern when compared with that of bowel gas.

Head and Neck

We have utilized TI of the head and neck in the care of 24 infants. In 10 cases the glow of hydrocephalus was observed (Fig. 8). Three cases had the diagnostic findings of hydranencephaly, which are marked TI of the cranial vault along with TI of the pupils on occipital placement of the probe. One subdural effusion was illuminated. A leptomeningeal cyst was identified as well as two superficial epidermoid cysts of the scalp.

In examination of the neck, five cases of subcutaneous emphysema were seen in neonates being followed for respiratory distress. Increased TI was present over the involved area in each patient. Diagnostic evaluation of three masses in



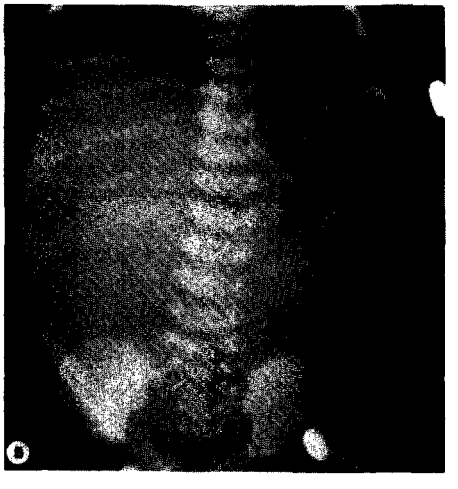


Fig. 7. A) TI of kidney and bladder noted in hydronephrotic infant (K = kidney, B = bladder). B) Mass effect on plain films and excretory urogram of this infant (C).

the neck was aided by TI: a cystic hygroma transilluminated easily in contrast to the negative illumination of a neuroblastoma and a rhabdomyosarcoma.

Therapeutic Use

Aside from its diagnostic potential TI has proven useful in the performance of a number of procedures. The size and location of the bladder for percutaneous suprapubic taps can be reliably shown by TI. The illuminating probe has been used to gauge the distension of the stomach with air, which has been used to aid in the passage of an oroduodenal feeding tube.[17]

The infant hand or foot is small and therefore ideally suited for TI. Superficial veins become readily apparent, making percutaneous access much easier and, thereby, obviating the need for a cutdown (Fig. 9). Venipuncture has been

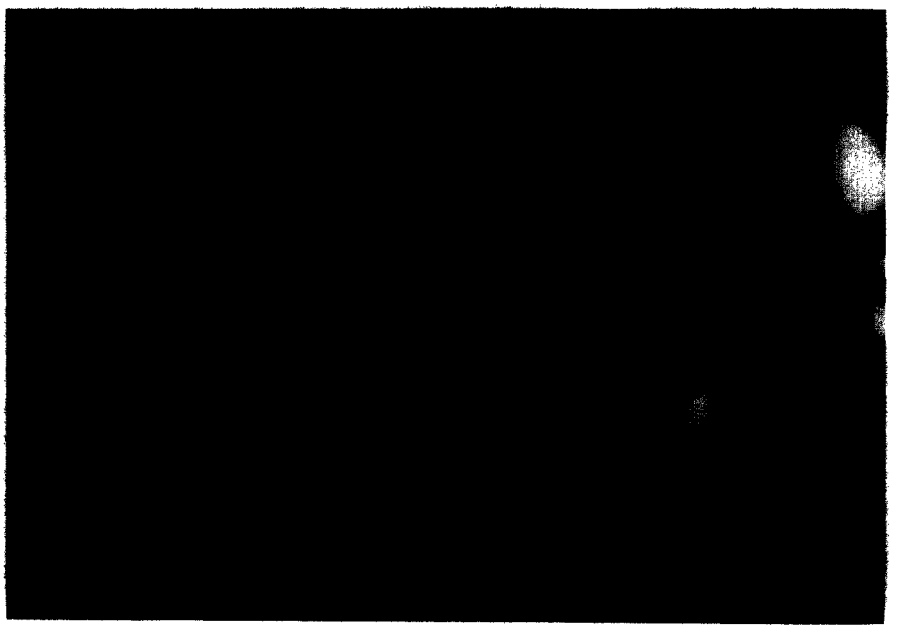


Fig. 8. Transillumination of hydrocephalus. Infants nose denoted (arrow). Superficial veins and previous venipuncture sites on scalp can be seen.

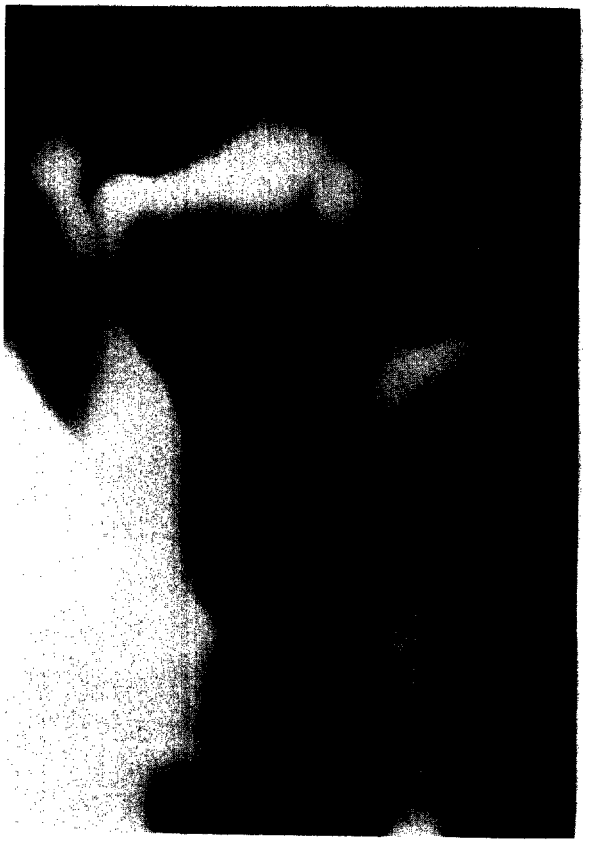


Fig. 9. Transillumination of veins on dorsum of infant hand.

successful in over 100 infants using this technique. TI is also useful in intravenous placement difficulties encountered in older children where obesity or previous extensive use of superficial veins is encountered.

DISCUSSION

The size and shape of the transillumination corona varies when the light source encounters structures that alter light absorption or reflectance. Superficial structures that influence the procedure include hair, skin thickness and color, subcutaneous fat, bandages, overlying bone or vessels and the presence of edema. Essentially, any part of the body of a small infant is of suitable size to allow some TI. The technique is quite safe and has permitted a reduction in the number of serial chest x-rays needed in infants at risk of PT or PM. To date, over 250 infants have been evaluated with transillumination. False negative results can occur in infants with increased subcutaneous fat or edema. The thickened tissue, particularly in the case of edema, causes diffraction of the light. This interferes with TI by enlarging the corona and causing the edges to become less distinct. These effects can easily mask a PT or PM. False positives have occurred in infants where a slightly enlarged irregular corona was interpreted as demonstrating free air. Fortunately, these false positives occur in nonurgent situations where the subtle changes can be checked radiographically.

The ability to follow infants at risk for pneumoperitoneum and to follow fluid shifts as in urinary decompression or ascites has also been of benefit. Certain therapeutic measures can be facilitated with TI. Infants without obvious veins are often cannulated with the aid of TI. Accurate suprapubic taps and oral feeding tube placements are now performed with little difficulty with the aid of transillumination.

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