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TRANSTHORACIC REPAIR OF DIAPHRAGMATIC HERNIA IN INFANTS*

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Congenital diaphragmatic hernia producing symptoms in the newborn period should be dealt with as a surgical emergency. In spite of the fact that untreated diaphragmatic hernias are not uniformly fatal, the mortality is so high during the neo-natal period in untreated patients as to place this lesion, in our opinion, in the category of congenital anomalies incompatible with life, but amenable to surgical correction.

Many infants with a diaphagmatic hernia are in great distress, and the decision to operate upon them is not a difficult one. However, some newborn infants have a period of temporary improvement with the administration of oxygen or after aspiration of mucus from the nasopharynx, and the temptation to postpone operation may become great. One never knows when the delicate balance in cardiorespiratory reserve may be upset by further crowding of abdominal viscera into the thorax, with consequent shift of the mediastinum. There would therefore seem to be no excuse for postponement of surgery in infants with diaphragmatic hernias, either to await growth of the child, or improvement of the symptoms and signs caused by the lesion itself.

The subject of congenital diaphragmatic hernia has been well covered in the surgical literature.[1-4] These lesions seem to be reported more frequently than formerly and this probably reflects earlier diagnosis and more prompt treatment.

A satisfactory classification of congenital diaphragmatic hernias is given by most authors and includes the usual sites of the foramen of Bochdalek, the esophageal hiatus, the foramen of Morgagni and posterior defects or congenital absence of the diaphragm.

DIAGNOSIS

When the diagnosis of diaphragmatic hernia can be made in the delivery room, the infant is usually in severe distress. Cyanosis is a prominent finding and diaphragmatic hernia should be considered in any newborn infant whose cyanosis persists after the usual measures directed at clearing the airway and establishing respirations have been carried out.

Most congenital diaphragmatic hernias that give symptoms at birth are on the left side. Physical examination of the infant usually reveals a relatively large thorax, the left side of which lags behind the right in respiratory effort. The abdomen is small and frequently scaphoid. The heart is displaced to the right and often to an extreme degree. Breath sounds are absent over the left chest and are heard only over the upper portion of the right lung field, where they are usually of harsh character. Later, as gas fills the bowel, the mediastinal shift increases and symptoms become more se-

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vere. In right-sided lesions, the thoracic signs are reversed and usually less severe because the liver serves as a barrier below the diaphragmatic defect.

The diagnosis can be, and usually is made on physical findings alone, but roentgenograms of the chest are almost universally taken to confirm the clinical impression. The use of a contrast medium in the bowel in most instances is unnecessary and is contraindicated except in unusual circumstances. Should the necessity arise for using a radiopaque substance in the upper gastro-intestinal tract, an iodized oil preparation is preferable to barium because of the likelihood of vomiting and the danger of aspiration.

In ascertaining the nature of a small mass of abdominal viscera in the chest, which may be colon only, the injection of a radiopaque medium into the colon might be desirable. Here, again, a radiopaque material other than barium is preferable because of the desirability of using fluid which can be evacuated readily. Fortunately, those patients in whom the diagnosis is not clear on the basis of physical signs alone, are usually not severely embarrassed from the cardiorespiratory standpoint, so that studies can be undertaken without undue risk.

COMPARISON OF ABDOMINAL AND TRANSTHORACIC APPROACHES

Most authors have advocated the repair of diaphragmatic hernia in infants by the abdominal approach[1-5] even when the thoracic approach is considered to be superior for adults.[5] Our experience leads us to recommend the thoracic approach for infants as well.

The difficulties of an abdominal approach in the repair of diaphragmatic defects are several, and even though means may be found of circumventing them, there are some trying moments for the surgeon during the procedure.

Perhaps the major problem lies in the fact that anesthesia seldom improves the cardiorespiratory status of these patients, and hence it is the desire of the surgeon to remove the abdominal viscera from the thorax as rapidly as possible. In this endeavor he is frequently hindered by the difficulty of extracting gas-filled loops of bowel through the defect in the diaphragm from the abdominal side.

Secondly, the repair of the defect itself must be carried out with difficult exposure caused by the overhanging costal cage.

Finally, there exist the difficulties associated with enclosing the viscera in a peritoneal cavity not large enough to contain them. These difficulties are reflected in the technics of closure which have been described, such as delayed closure of fascia and the use of through-and-through sutures instead of the conventional closure in layers.[4]

Because of the problems presented in repairing congenital diaphragmatic hernia in the neo-natal period by the abdominal approach, we have used a transthoracic approach to the diaphragm in 15 infants with diaphragmatic hernia or eventration of the diaphragm.

The first advantage of the trans-thoracic approach is encountered when in a cyanotic, distressed infant, with a materially diminished cardiovascular reserve, it is possible to empty the pleural cavity of abdominal viscera and relieve the respiratory distress by making a rapid intercostal incision. As soon as the chest is opened, the viscera deliver themselves, the mediastinum is free to return toward the midline, the compressed lung is permitted to expand, and the patient becomes a relatively normal cardiovascular risk under anesthesia. The remainder of the procedure can then be undertaken without the previous urgency, and with appreciably diminished risk.

In the second place, we have not found it difficult to replace the abdominal viscera through the diaphragmatic opening, except in one instance, when it was necessary to

enlarge the defect to free the incarcerated bowel. It has proved less difficult to accomplish this than to close the peritoneum in patients with a small peritoneal cavity and a large mass of abdominal viscera.

A third advantage that becomes obvious is the ease with which the closure of the diaphragmatic defect is possible under direct vision. We have used an imbrication of the anterior lip of the defect over the posterior in most patients.

OPERATIVE FINDINGS

Three of the infants in this series had eventration of the diaphragm which was suspected preoperatively, but not diagnosed without question (Table I). Of the remaining 12 hernias, six were through the foramen of Bochdalek, two through the esophageal hiatus, one through the foramen of Morgagni, two through a defect which seemed to combine the foramina of Bochdalek and Morgagni, and there was one congenital absence of the left hemidiaphragm.

TABLE I.

Pt.	Sex	Age	Symptoms	Age at Onset of Symptoms	Operative Findings	Side	Associated Anomalies	Complications
L.J.	M	7 wks	Cyanosis; hematemesis Dyspnea	Birth	Eventration	L		
C.S.	F	3 dys	Cyanosis	8 hrs.	Esophageal hiatus Defect		Malrotation of colon Duodenal bands	Intestinal obstruction
E.H.	M	17 m	Cyanosis; convulsions	15 m.	Foramen of Morgagni with sac			Atelectasis
P.D.	F	13 m	Deformity of costal cage		Eventration	R		
R.L.	M	4 dys	Cyanosis; difficulty with feeding	2 dys	Foramen of Bochdalek with sac	L		
B.B.	F	6 hrs	Cyanosis; dyspnea	Birth	Absence of diaphragm	L	Agenesis of left lung: Premature ossification of skull	Died; subarachnoid hemorrhage
E.C.	M	11 m	Recurrent U.R.I. Dyspnea; melena	Birth	Foramen of Bochdalek	L		
D.H.	F	2 dys	Cyanosis; dyspnea	Birth	Anterior defect	L		
H.W.	M	9 m	Cyanosis; cough; vomiting; hematemesis	Birth	Esophageal hiatus			
R.D.	F	7 m	Dyspnea	Birth	Foramen of Bochdalek	R	Pleural sac encased right lower lobe	
J.S.	M	20 dys	Cyanosis; dyspnea	19 dys	Foramen of Bochdalek	L		
B.M.	M	1 d	Cyanosis; periods of apnea	Birth	Anterior defect	L		Died; congenital heart lesion
L.S.	M	6 m	Vomiting	2 mos.	Foramen of Bochdalek with sac	R	Partial situs inversus, duodenal obstruction by portal vein and common bile duct	Cardiac arrest, died
N.G.	M	5 m	Fever; dx pneumonia	2 mos.	Eventration	L		
S.W.	M	4 m	Vomiting	3 mos.	Foramen of Bochdalek	R		

There would seem to be two additional physiologic advantages to the trans-thoracic approach. The thoracotomy closure is secure and safe by standard layer approximation. In addition, there seems to be less ileus when there is no opportunity for the bowel to come in contact with a raw surface as in those instances when the fascia is left open and the skin and subcutaneous tissue alone are closed.

Additional anomalies found in the thorax were agenesis of the lung in B.B., who died a few hours postoperatively, and a pleural sac about the right lower lobe in R. D. Malrotation of the colon in C. J. was corrected a month after thoracotomy when vomiting led to a diagnosis. L. S., who died three days after cardiac arrest and resuscitation

on the operating table, had situs inversus of stomach and duodenum with both the portal vein and the common bile duct crossing the duodenum anteriorly.

Splenectomy was carried out in two patients. One infant with an eventration required a right nephropexy in the retro-pleural space when the repaired diaphragm depressed the kidney sufficiently to kink the ureter. Crushing of the phrenic nerve was not found necessary.

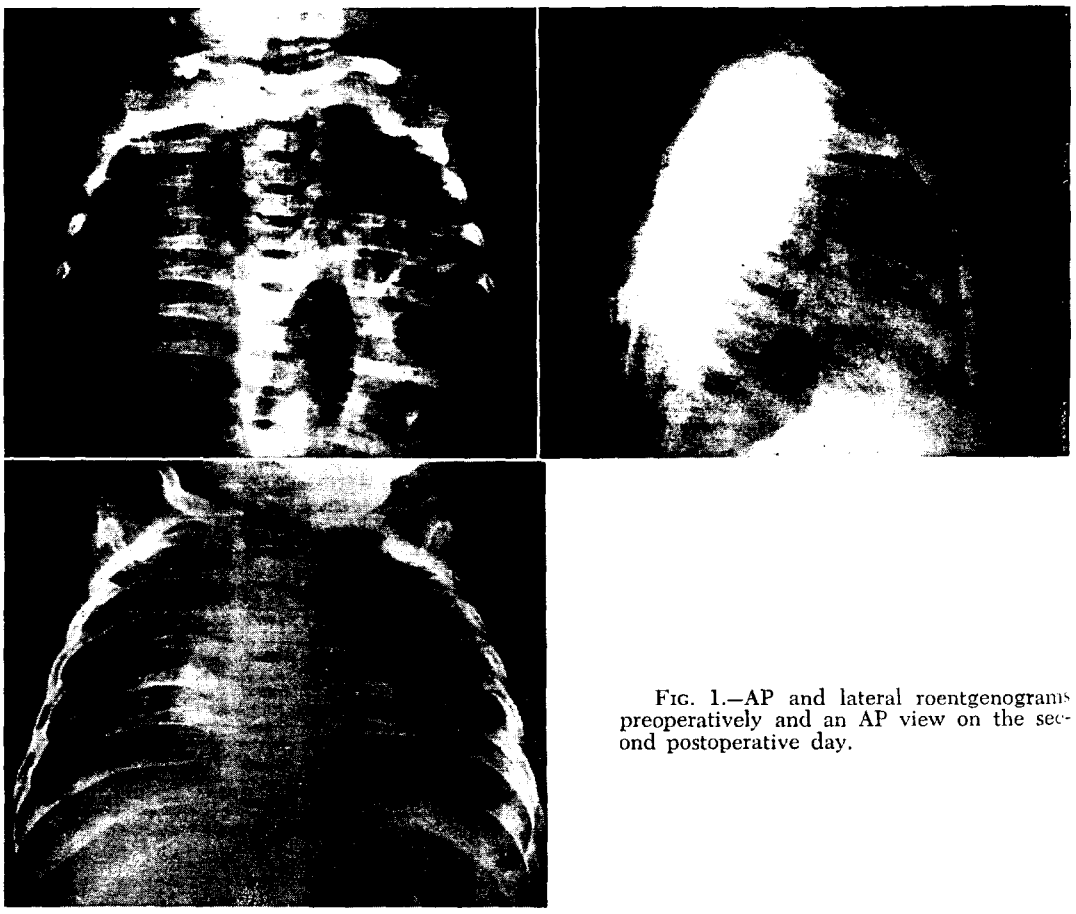

FIG. 1.—AP and lateral roentgenograms preoperatively and an AP view on the second postoperative day.

ANESTHESIA

Positive pressure endotracheal anesthesia is most desirable if not essential. The anesthetist has better control of the respiratory situation under these circumstances than with any other variety of administration. This is especially obvious when the patient is turned on the side opposite that of the hernia prior to making the intercostal incision. The added encroachment on the available space for functioning lung by the shift of the thoracic contents with a change in position could produce serious sequellae without a method of controlling respiration under this circumstance.

POSTOPERATIVE COURSE

All thoracotomy wounds were closed primarily without drainage. No patient had a pneumothorax postoperatively of suffi-

cient size to warrant aspiration. The return of the heart and mediastinum toward the midline was evident by physical examination immediately in the postoperative period, and roentgen examinations taken about eight hours postoperatively showed about 80 per cent of the total return to normal to be accomplished in that interval. Several patients showed roentgenologic evidence of fluid in the costophrenic sulcus, but none required thoracentesis. A definite haziness was discernible over the dome of the diaphragm postoperatively, but was uniformly clear in two weeks (Fig. 1).

Postoperatively all patients were maintained on gastric suction drainage and intravenous fluids until peristalsis was heard. Transfusions of blood or plasma were given for the first four to five days.

Feedings were begun by gavage tube rather than by nursing bottle in most infants to prevent dilatation of the stomach with air, usually on the second or third postoperative day. Feedings were given by bottle to all by the end of the first postoperative week.

Special attention was given to keeping the air-ways clear of secretions by aspirating the nasopharynx when indicated.

Films of the chest were taken daily for three days, if indicated, and then at intervals of about four days until discharge. One-half of the incisional sutures were removed on the fourth or fifth day, and the remainder on the sixth or seventh day.

RESULTS

Three of the 15 patients in this series succumbed postoperatively. In each of them, death was attributable to other causes than the diaphragmatic hernia or its treatment. One four-pound infant (B. B.) had agenesis of the left lung, premature ossification of the skull, and subarachnoid hemorrhages, as well as complete absence of the left diaphragm. Another infant had been cyanotic for so long as to raise reasonable doubt concerning her cerebral function. Autopsy revealed, in addition to an anterior diaphragmatic hernia, a congenital cardiac anomaly with large interventricular and interatrial septal defects. L. C. died with decerebrate rigidity after cardiac arrest and had the additional anomalies noted above.

Of the remaining 12 patients, serious postoperative problems were encountered in only one (C. S.) where a subsequent operation was necessary for correction of malrotation of the colon causing duodenal obstruction. One infant (E. H.) had a partial atelectasis of the right lung relieved by aspirating a mucous plug from his trachea by catheter. The postoperative course of the remaining ten patients was consistently benign. No wound complications occurred. Discharge from the hospital was usually accomplished in less than ten days following operation.

None of the successfully treated patients have had recurrences of symptoms or return of the hernia. The period of followup varies from two months to two years.

SUMMARY

Fifteen congenital diaphragmatic defects occurring in infancy have been repaired by a trans-thoracic approach. Three infants who died postoperatively had associated congenital anomalies, two of them incompatible with life. The advantages of the trans-thoracic over the abdominal approach in the repair of diaphragmatic defects in infants are discussed.

BIBLIOGRAPHY

1 Donovan, E. J.: Congenital Diaphragmatic Hernia. Ann. Surg., **122**: 569, 1945.

2 Harrington, S. W.: Congenital Diaphragmatic Hernias in Children. Ann. Surg., **115**: 705, 1942.

3 Hartzell, J. B.: Congenital Diaphragmatic Hernias in Children: Resume of 68 Cases Treated by Operation. Am. J. Surg., **48**: 582, 1940.

4 Ladd, W. E., and R. E. Gross: Congenital Diaphragmatic Hernia. New England J. Med., **223**: 917, 1940.

5 Thorek, P.: Congenital Hernia, Anatomic and Surgical Importance of the Left Triangular Ligament of the Liver. Arch. Surg., **56**: 238, 1948.