

The Diaphragm

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ABSTRACT

This study evaluates the embryological development of diaphragm, causes of elevation, clinical properties & diagnosis of elevation of diaphragm. It considers that the elevation of diaphragm is as result of affecting the diaphragm itself including eventration, traumatic diaphragm & paralysis of diaphragm.

ELEVATION OF DIAPHRAGM (E.D.): is defined as abnormal elevation of diaphragm that may be asymptomatic (E.D.), amenable to conservative treatment or symptomatic (E.D.). In children it is either congenital or acquired, which may require a surgical treatment. Diaphragmatic hernia could be caused by congenital disorder, blunt trauma, penetrating trauma.

Traumatic rupture is rare but potentially life threatening. Chest xrays were shown to be the most effective diagnostic method & fluoroscopy was recommended in all cases of hernia that occur within 24 hours. Barium studies of the gastrointestinal tract are limited only when chest ray still in doubt & with diluted contrast liquid, caution was advised with this method. CT scanning has become more valuable in the investigation of this case.

Eventration of diaphragm: is an abnormal elevation of dome of diaphragm. It is a condition in which all or part of diaphragm is largely composed of fibrous tissue with only a few interspersed muscle fibers. It can be congenital (non-paralytic) or acquired (paralytic). The congenital one divided into complete (total) and partial.

Keywords: Diaphragmatic hernia, rupture diaphragm, eventration of diaphragm

INTRODUCTION

Embryological Development of The Diaphragms

Embryologically, the diaphragm is derived from many structures which are: septum transversum, two pleuroperitoneal membranes-muscular component and the mesentery of diaphragm in which the crura of diaphragm developed. (16)

The development of diaphragm and separation of coelomic cavity into thoracic and abdominal cavities take place during 8-10 weeks of intrauterine life.

The failure of fusion of these elements results in herniation of abdominal contents into the thoracic cavity. (24)

Normal Level of The Diaphragm and Its Variation: The level of diaphragm varies from one person to another according to the body build, being higher in hypersthenic bodies. (12) The dome of diaphragm reaches the level of 6th rib anteriorly on inspiration and at, or below the 10th rib posteriorly. (22) The right dome is usually one interspace higher than the left one (12), the hemi-diaphragm may lie at the same level and in small percentage the left side is higher. (22) Felson studied 500 normal chests and he found that unilateral elevation noted in 11% (9% on left side, 2% on right side).

In half of the 9%, there were two domes at the same level whereas in the other half the left was higher. (12)

50% of cases with left-sided elevation shows gaseous distension of stomach-splenic flexure or both. (12)

By chance, elevation of diaphragm found on CXR done on other purposes & patients are usually asymptomatic (1)

Causes of Elevations

There are numbers of pathological processes that cause elevated diaphragm whether unilateral or bilateral which include:

1. Intrathoracic conditions. i.e. causes above the dome.
2. Causes in the diaphragm itself as event ration which shows marked elevation.
3. Upper abdominal conditions i.e. the causes below the dome and these are the most common of all.

In this review of articles, we consider causes at the diaphragmatic level which include event ration-paralysis and traumatic diaphragmatic hernia.

The distinction among these three conditions is extremely important, one from the standpoint of the patient survival. (12)

TRAUMATIC DIAPHRAGMATIC HERNIA

Diaphragmatic injury is defined as all traumatic defects whether or not- hernia ion of abdominal contents into the chest cavity had occurred. (10)

Mechanism and Etiology of Rupture:

Childress and Grimes postulated that diaphragmatic rupture is a consequence of the forces transmitted to the diaphragm through abdominal visera and these forces can be resulted from blunt trauma, in 80% of cases. Penetrating injury, surgical incision (9) and less often from thoracic trauma in 3% of cases. (3, 9, 15).

Kirsh. M, shows that the visceral injuries associated with traumatic hernia vary from 9-55%.

The low incidence of right-sided rupture is attributed to the protective effect of the dense liver and right kidney is far better than the less bulky stomach, left kidney which buffers the left diaphragm. (3,15), The stomach on the left side & liver on right side of hemi diaphragm are the most frequent involved organs due to diaphragmatic defect, followed by other abdominal organs including small intestine, omentum (3)

Incidence:

Left-sided hernias are far more common than those involving right side ones with approximate incidence of 95% to 5% respectively, (3,15).

In another study by a group of authors on 16 patients shows that, although the left side is involved in very large proportion of patients, right diaphragmatic disruption was present in 30% with only 3% of bilateral rupture. (21)

Hamilton SGL shows that the increase of reported cases of right-sided rupture is possibly due to improved survival rate of patients. with major liver injuries. (25)

Clinical Presentations

It is divided into three-time phases which is originally proposed by Cater et al. (9). The acute phase extends from time of injury to 14 days afterward. If the patient survives, the initial trauma and hernia do not manifest and the second phase (interval) enters and extends until the third stage which is the phase of obstruction or strangulation. (9, 11). Acute phase: here there is herniation of visera immediately so that the symptoms directly related to space-occupying effect of herniated visera within the pleural cavity (9, 15). The patient suffers from symptoms such as respiratory distress, bowel obstruction; these symptoms are caused normally by the dysfunction of diaphragm, excessive pulmonary hypertension & bowel or gastric hernia ion (4).

About one-third of the patients have no symptoms. While in other two-thirds there is marked respiratory distress due to massive herniation and compression of the lung. (23). In most of these patients the radiological findings are diagnostic. (23).

Conversely hernia ion in right side is unlikely unless the orifice is large where the diagnosis is usually done late (19).

Interval phase: the symptoms are either absent, or non-specific, (10)

Phase of obstruction: Garter found that 90% of strangulated hernias are traumatic in origin. The interval between injury and strangulation varies from one day to sixteen years. (10) Pain is the initial characteristic symptom localized to upper abdomen. (10).

Diagnosis:

Diaphragmatic hernia could be detected by CT scan, while chest x-ray (CXR), ultra sonography and barium tests could be contributed to the accurate diagnosis of hernia (5), prompt diagnosis of diaphragmatic hernia is of paramount importance in order to prevent fatal complication & CXR is useful tool (2).

Graivierl shows that a correct diagnosis is made in less than 50% of cases. (9). The chest film is the most reliable in suggesting the correct diagnosis, mainly in acute phase where the findings are characteristic and even sometimes diagnostic. (9, 12).

The most significant findings are:

- 1- An arch-like shadow suggesting elevated diaphragm.
- 2- Gas densities or bubbles above the level of the diaphragm.
- 3- Atelectasis adjacent to the arch like shadow.
- 4- Presence of air -fluid level within the left hemi thorax.
- 5- Displacement of the mediastinal structures to the other side. (9, 12).

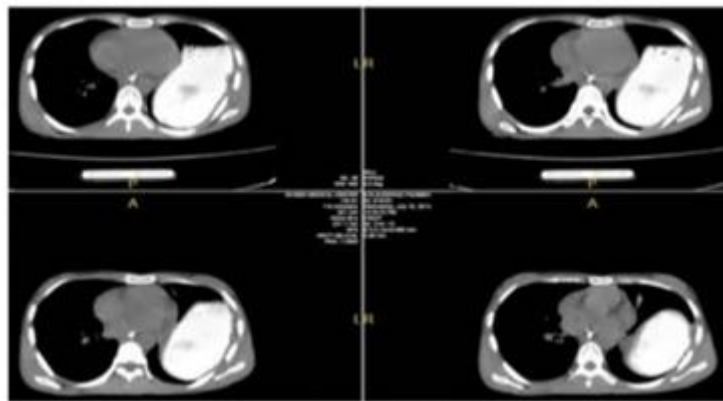


Figure 1: CT- scan of a patient with left diaphragmatic hernia



Figure 2: Chest X-ray in left diaphragmatic hernia

In spite of these findings, there are radiological difficulties in differentiating ruptured diaphragm from event ration, phrenic paralysis or non-traumatic hernia through the diaphragm. (11) Confusion of traumatic disruption with elevated diaphragm is common, especially if the colon is herniated where the gastric air bubble appears to be unusually far below the diaphragm. But the passage of naso-gastric tube may indicate rupture diaphragm if the tube is seen above the level of diaphragm on chest roentgenogram. (15)

At time, traumatic hernia may be mistaken for a tension pneumothorax radiographically. The insertion of nasogastric tube identifies the stomach in the chest and it relieves the symptoms. (15) If the plain films are inconclusive and the diagnosis still in doubt, contrast studies with gastrograffin or barium in the colon or stomach provide information that is essential in differential diagnosis. (11, 12, 15).

Carter et al described the possibilities in the filling of the stomach or colon on barium study with the characteristic «waist like» constriction as it passes through the defect with the afferent and efferent loop lie side by side as shown in (Figure 3 and 4).

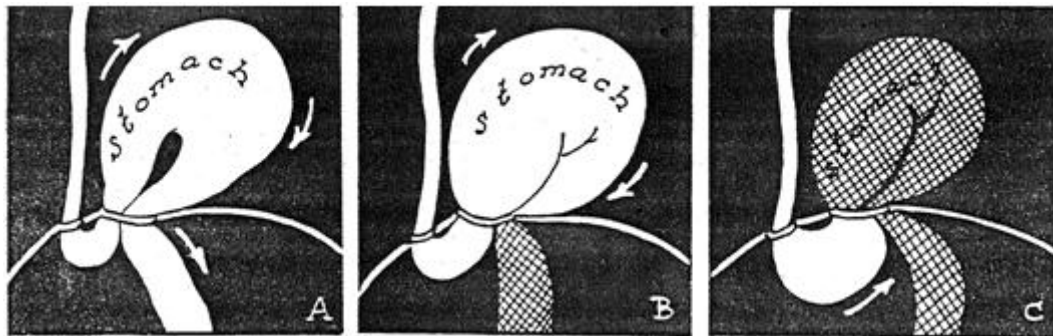


Figure -3- Diagram of Barium Meal Finding In Herniation of the Stomach Through A Diaphragmatic Tear.

A. NO Obstruction. B. Obstruction of efferent segment.
C. Obstruction of afferent segment.

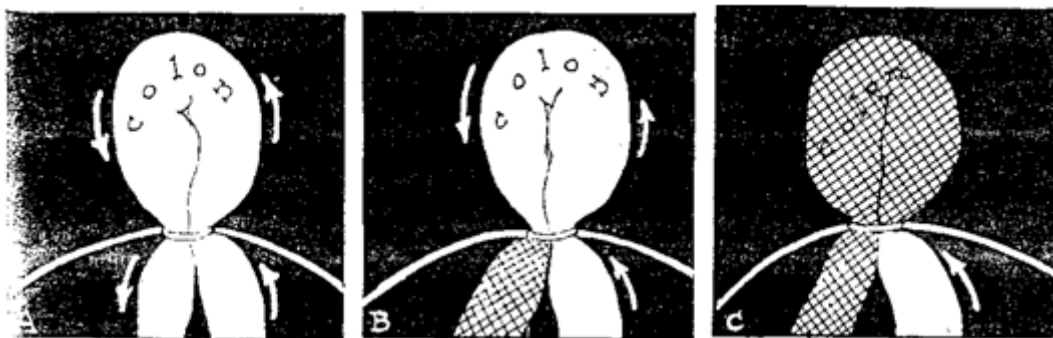


Figure 4: Diagram of Barium Meal Enema Finding In Herniation of the Colon Through A Diaphragmatic Tear.

A. NO Obstruction. B. Obstruction of proximal segment.
C. Obstruction of distal segment.

In contradistinction with those changes shown, in case of eventration, paralysis where the stomach or colon drapes itself beneath the elevated diaphragm and the afferent and efferent limbs do not lie alongside each other. (9, 12).

Also, barium study differentiates traumatic hernia associated with volvulus of the stomach from sub-phrenic abscess. (9)

If the strangulated viscus is fluid filled, it gives same radiological appearance of rupture spleen. (12)

Differentiation of traumatic hernia by barium study cannot be made from non-traumatic hernia. (11)

Heiberg et al reported that (CT) recognition of traumatic hernia which may be a useful tool in examining critically injured patients which examines multiple organs at risk. (9)

A rather characteristic findings on liver nuclear scan is emphasized the diagnosis of right- sided tears with liver herniation. (9)

Liver scan is valuable, both to show significant liver injury and to detect abnormal contour of the upper border which may be seen in plain chest film (24)

EVENTRATION

Eventration is defined as: an abnormal high leaf of intact diaphragm, it is a congenital condition with paucity or absence of muscle fiber in the diaphragm (6) or as a result of atrophy of varying degree of the muscle fibers. (23)

It is first to be recognized by (Petit) in 1774 during autopsy (23) and (Bechard) coined the term eventration in 1829. (23)

Eventration is classified into two groups according to its etiology as:
Congenital (non-paralytic).

acquired (paralytic).

Congenital type is divided on anatomical basis into:

Complete (total).

Partial.

Bilateral.

The acquired is usually complete. (22, 23).

Some authors prefer the term eventration only for congenital and the term diaphragmatic paralysis for the acquired type (19).

Causes:

The congenital type is as a result of incomplete or absent muscularization. while the acquired type is as a result of phrenic nerve involvement by many processes like inflammatory, traumatic during delivery and post-operative. (22) The major cause of traumatic eventration is breech presentation and difficult delivery with the use of forceps extraction. (13, 22, 23)

Most eventration in newborns are of developmental origin, acquired type even in infant can result from phrenic nerve injury. (19)

Incidences:

Beck and Motsan in (1952) found eventration in 4% of 2.500 CXR in newborns (22), while Christensen reported to be found in routine CXR once every 1.400 to once every 13.000 examinations (18); male to female ratio is 2:1. (23)

Thomas shows the majority are left-sided. (23)

Charles Garbaccio review of 6 patients shows that if it is congenital type, it is left sided whereas it is accepted that the cause is phrenic nerve disease then the both sides are affected equally but this is extremely uncommon. (13)

In a study by Donald of 36 patients, he found that if eventration is total, it is more in left side while in segmental it is more in right side. (18)

Symbas reviewed 10 patients and the incidence shows that: 70% right-sided, 20% left-sided and 10% bilateral. (21)

Campbell shows that in the congenital type, it is right-sided and in the acquired one, it is equally distributed. (20)

Clinical Pictures:

Eventration usually shows no difference in clinical presentation between congenital and acquired types. (23)

Clinically eventration is usually asymptomatic (23). Most common symptoms are dyspnea, orthopnea (1,6,8) It suddenly occurs soon after lying supine secondary to ascent of abdominal viscera (1,6,8)

It may be the cause of respiratory distress mainly in neonate (23) or it may present with gastro-intestinal symptoms including epigastric discomfort, belching, etc. (26), rarely life-threatening complications are also reported like stomach volvulus, ruptured eventrated diaphragm (27). which explain the rarity of symptoms in right-sided eventration. (18)

Diagnosis:

Eventration may be difficult to be diagnosed during early infancy because it may be confused with congenital heart disease as well as with Bochdalek hernia (20). So, attempt should be made to separate these entities (13).

Still, the diagnosis can be suspected by chest X - ray (anterio-posterior, Lateral) which shows marked elevated diaphragm with mediastinal shifting which is not separated from diaphragmatic hernia. (24)

Fluoroscopy is of little value in making the diagnosis.

Barium meal or enema may show high rising colon or stomach and a thin diaphragmatic outline overlying it. (24)

In order to exclude the presence of mediastinal mass involving phrenic nerve, bronchoscopy can be done. (24)

Rarely radio isotope of liver alone or with the lung is used for establishing the diagnosis in some patients. (20).

PARALYSIS OF THE DIAPHRAGM

Infrequently, paralysis has been mentioned as a cause of respiratory symptoms in children. (14)

Naunyn reported the first case in 1902. (14)

Etiologically, paralysis was found that it follows birth trauma in 38% of cases while in 60 %cases it follows thoracotomy (1), although Phillips shows both equally being the cause. (20)

Bishop reports a case of paralysis after chest tube placement in neonate. (20)

Incidences

Group of authors studied 12 patients and they found that in 56% of cases it was bilateral, 37% right-sided and 8% It was left-sided. (14)

Clinically the diagnosis is suspected whenever unexplained respiratory distress in newborn babies (22), although we have asymptomatic conditions mainly in older children. (20)

Diagnosis:

Roentgenographically, right diaphragmatic paralysis was suspected whenever the right diaphragm was at least two intercostal spaces higher than the left dome, while the left diaphragmatic paralysis was suspected whenever left dome is at **least** one intercostal space higher than the right one. (14, 9)

Although fluoroscopic examination shows that the affected side fails to move with respiratory movement, this does not confirm the diagnosis. (17)

Recently, group of authors use phrenic nerve stimulation during fluoroscopy or real-time ultrasound which provides more accurate diagnosis and useful information specially if they are both used together. (17)

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REFERENCES

- [1] Groth SS. Andrade RS Diaphragm plication for eventration or Paralysis: A Review of the literature. Ann Thoracic surg.2010, 89: 2146-50
- [2] Mansoor E. post traumatic diaphragmatic hernias importance of basic radiographic investigation case report. S Afr J Surg. 2013 : 51 :75 -6.
- [3] Glerada OS. imaging of the diaphragm. In G. Alexander Patterson, Joel D. Cooper, Jean Deslauriers, Antoon M.R. Lerut, James D.Luketich, Thomas W. Rice. Pearson's Thoracic& Esophageal surgery. Vol. 1, 3thed,G, Alexander Patterson, Tina Rebane.2008. P. 1380-95.
- [4] Ganie FA, Lone H, Lone GN, Wani ML, Ganie S.A. Delayed presentation of Traumatic Diaphragmatic Hernia: A diagnosis of suspicion with increased morbidity and mortality. Trauma monthly.2013;18:12.
- [5] Hajong R, Baruah A. post-Traumatic Diaphragmatic Hernia. Indian J Surg. 2012;74:334-5
- [6] Mouroux J, venissac N, Leo F, Altano M, Guillot Surgical treatment of diaphragmatic eventration using video –assisted thoracic surgery: a prospective study. Ann Thoracic Surgery 2005;79:308-12
- [7] Calvino P, Bastos C, Bernardo JE, Euenio L, Antunes MJ. Diaphragmatic eventration:(long-term follow up& results of open –chest plication. Eur J cardiothoracic surg. 2009, 36 :883-7.
- [8] Ribet M, Linder JL Plication of the diaphragm for unilateral eventration or paralysis Eur J Cardiothoracic surg.1992;6(7):357-60
- [9] Ball T, Moccroey. R. and Smith J.O.: Traumatic Diaphragmatic Hernia:Error in Diagnosis. American Journal of Roentgenology,138:633-637, April 1982
- [10] Drews. J A, Mercer. E. C. and Benfield. J. R.: Acute Diaphragmatic injuries. Annals of Thoracic Surgery, 16, No. 1: 67-78, July 1973. 4.Ribet M, Linder JL Plication of the diaphragm for unilateral eventration or paralysis Eur J Cardiothoracic surg 1992;6 (7):357-60
- [11] Efron. G. and Hyde. I: Non-penetrating Traumatic Rupture of The Diaphragm. Clinical Radiology, 18: 394-398, 1967. 5.deslauriers J.Eventration of the diaphragm Chest surg clin NORTH Am 1998;8::315-3
- [12] Felson. B.: Fundamentals of Chest Roentgenology. W.B. Saunders, 217-235, 1960.
- [13] Garbaccio. Ch., Gyepes. M. and Fonkalsurd. E. W.: Malfunction of the Intact Diaphragm in Infants and Children. Archives of surgery, 105: 57-61, July 1972.
- [14] Greene. W. and Hunt. C.: paralysis of the Diaphragm. American Journal of Diseases of children, 129: 1402-1405, Dec 1975.
- [15] Kirsh. M. M. and Sloan. H.: Blunt chest Trauma (General principles of management). Little Brown, 129-140: 1977.
- [16] Langman. J.: Medical Embryology. Williams and Wilkins, 305-309: 1975.
- [17] McCauley. R. G. K. and Labib. K. B.: Diaphragmatic paralysis Evaluated By phrenic Nerve Stimulation During Fluoroscopy or Real-time Ultra Sound. Radiology, 153: 33-369 Oct 1984.
- [18] McNamara. J. J., Paulson. D. L., Urschel. H. C. and Razzuk. M. A.: Eventration of The Diaphragm. Surgery, 64, No. 6: 1013-1021, Dec 1986.
- [19] Othersen. H. B. and Lorenzo. R. L.: Diaphragmatic paralysis and Eventration. Journal of pediatric Surgery, 12, No. 3: 309-315, June 1977.

- [20] Phillips. A. F., Rowe. J. C, and Raye. J. R.: Acute Diaphragmatic paralysis After Chest Tube Placement in a Neonate. American Journal of Roentgenology, 136: 824-825, April 1981.
- [21] Rodriguez.A. Rodrigues-Morales. G. and Shatney. C. H.:Acute Rupture of the Diaphragm in Blunt Trauma
- [22] Journal TRAUMA, 26:438-444, May 1986.
- [23] Sutton. D.: A Text Book of Radiology and Imaging. Churchill Livingstone, 330-331: 1987.
- [24] Symbas. P. N., Hatcher. R. and Waldo. W.: Diaphragmatic Eventration In Infancy And childhood. Annals of Thoracic Surgery, 16. No. 1: 113-119, July 1973.
- [25] Thomas. T. V.: congenital Eventration of The Diaphragm. The Annals of Thoracic Surgery, 10, No. 2: 180-192, Aug 1970.
- [26] Williams. R. S.: Traumatic Rupture of Diaphragm. The Medical Journal of Australia, 1, No.5: 208-212, March 1982.
- [27] Shield TW. Diaphragmatic function, diaphragmatic paralysis & eventration of diaphragm. In Shield Tw., Locicero JJ, Ponn RB, Rusch VW , editors, General Thoracic surgery Lippincott Williams & Wilkins 2005, p.740-5