

## Surgery for diaphragmatic eventration: Technical aspects by thoracotomy and VATS

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The "diaphragmatic eventration" is a condition of relaxation of the diaphragm by maintaining its normal attachments to the dorsolumbar spine, the lower ribs, and the sternum. Diaphragmatic eventration is rare (incidence <0.05%), and more common in males. It can be unilateral or bilateral, but usually left hemidiaphragm is affected. It may be congenital, (due to a defect of diaphragmatic development) or acquired. Macroscopically, the (affected portion of the) diaphragm is attenuated, abundant, membranous, and without muscular appearance. Microscopically there is paucity or absence of muscular fibers and diffuse fibroelastic changes. It can be partial or complete affecting the whole hemidiaphragm. The 'true' eventration is always a congenital condition. If the condition is severe, it causes severe cardio-respiratory symptoms secondary to hypoplasia of the lung on the affected site.

The "acquired paralysis" ' or "acquired elevation" is a condition of relaxation of the diaphragm

that occurs in adults. In the case of 'true' eventration there is a congenital problem in the musculature of the diaphragm, but in 'acquired paralysis' there is a loss of contractility of the muscle that leads to progressive muscular atrophy by causing distension of the dome. Trauma, infection (polio, herpes zoster, diphtheria, or influenza), neoplastic diseases, or autoimmune pathologies directly involving the diaphragm or the phrenic nerve may be the cause of this clinical condition. The 'idiopathic' form affects adults, and may be the result of a subclinical viral infection with unilateral involvement. The major difference between 'true' eventration and the acquired form is that the latter may resolve spontaneously. The congenital form does not improve with time and even may be worse.

Clinically, eventration of diaphragm refers to an abnormal elevation of one leaf of an intact diaphragm as a result of paralysis, aplasia, or atrophy of varying degrees of muscle fibers. In some cases, it may be difficult or impossible to distinguish from diaphragmatic paralysis.

On physical examination; Breath sound at the affected side is reduced. A chest x-ray shows elevation of the hemidiaphragm. A chest CT demonstrates distended colon or stomach under the affected diaphragm. A "sniff test" (fluoroscopic assessment of diaphragmatic function) may show paradoxical movement of the elevated hemidiaphragm.

Ultrasonography can help in establishing the diagnosis of partial eventration and in distinguishing it from diaphragmatic nerve palsy.

During inspiration, the normal caudal movement of the diaphragm is impaired. This causes decreased lung volumes which results in dyspnea. The affected diaphragm might have minimal movement, no movement or paradoxical movement. It has been shown that, in patients with unilateral diaphragmatic paralysis, there is a significant decrease in the tidal volume,

trans-diaphragmatic pressure, the ratio of gastric to esophageal pressure and dynamic lung compliance.

Surgical correction is indicated when the respiratory symptoms are present without resolution of the condition over a short period of observation (3 to 6 months). The dyspnea which prevents the patient from simple daily activities is the most common indication for surgery. Other possible causes of dyspnea should be excluded before proceeding to surgery like heart failure or COPD.

Most of the studies comparing respiratory function tests before and after correction of the diaphragm demonstrates significant improvement.

### **Surgical treatment**

When there is extreme diaphragmatic elevation an open approach through the chest may be preferred or even unavoidable. A preoperative bowel preparation, a nasogastric tube placement and a lateral thoracotomy position are mandatory. A muscle-sparing thoracotomy may be performed in the 5th intercostal space. Single lung ventilation may not be needed in open approaches.

The most commonly used treatment for diaphragmatic eventration is diaphragmatic plication. This is generally performed via thoracotomy. Several techniques are employed on to the paralyzed diaphragm with the aim of pleating it. By ligating the sutures, the lax diaphragm becomes taut and moves to a lower position. By this maneuvers, the chest cavity is enlarged, the lung expands and functions better than before.

***Several techniques may be used during thoracotomy:*** Mainly used techniques with thoracotomy are, A- Placement of U-stiches with the support of a pledged on both ends and B- Opening the diaphragm at the dome and placement of abdominal organs into abdominal cavity and resecting the redundant part of diaphragm and reconstructions of the both ends of the diaphragm with

single sutures.

### ***VATS diaphragmatic plication***

Gharagozloo introduced the VATS plication of the diaphragm in 1995 with a similar technique to the open surgery, except for the use of the camera. In 1996, Mouroux reported a more technically feasible thoracoscopic plication. However, the technique did not gain wide acceptance and surgeons still preferred open approaches. In the Mouroux's technique, the diaphragm was pushed down to obtain sufficient space and make a pleat. The slack of diaphragm was located into the abdominal cavity, instead of thoracic cavity and superimposed running sutures were used.

The reasons for not having wide acceptance were as follows:

- 1- As the diaphragm is pushed down, the gap between the diaphragm and abdominal organs is decreased and contact surface is increased which increased the risk of abdominal organ injury,
- 2- Many surgeons still prefer interrupted sutures for the diaphragm in order to prevent the risk of recurrence due to suture breakdown.
- 3- An expert assistant is necessary to perform the procedure to maintain the adequate tension of the suture while using continuous running suture technique.

Other modifications of the thoracoscopic technique were reported. Main modifications were changing the position of the patient (head up position to descend the abdominal organs by the help of gravity), locations of incisions (having the incisions in different parts of the hemithoracic cavity), CO<sub>2</sub> insufflation and techniques of suturing to plicate the diaphragm (Reefing the mainsail, invaginating the diaphragmatic dome and pleating technique).

Nuances of the various techniques can be tailored to the particular characteristics of the child and the adult. A nasogastric tube was inserted for complete gastric drainage. The patient was positioned in a lateral position. When stomach drainage was deemed complete, the surgical table was tilted head up to facilitate descent of the abdominal viscera. For lung handling minimal head

down tilt may be used in some part of the operation, without the need for single lung ventilation. Although CO<sub>2</sub> insufflation may provide to get the diaphragm down to start the procedure, intestinal clamps may also be used to push the diaphragm down to the abdominal cavity. Extracorporeal suturing and bedding the sutures safely comprise the main points of the nuances.

### **What are the advantages of a thoracoscopic plication of diaphragmatic eventration?**

Improvement in PFTs and shortness of breath, returning to physical activity and complications in patients who underwent thoracoscopic and open plication for unilateral diaphragm paralysis were compared by Freeman et al. Thirty patients who had video assisted thoracoscopic surgery (VATS) diaphragmatic plication were compared with thoracotomy plication (11 patients) or non-surgical intervention (7 patients). The median length of follow-up was 57 months range: 49–80 months). PFTs were improved in all surgical patients; and the dyspnea score was improved in 90% of the surgical patients. In the group of patients who did not undergo surgical repair recurrent hospitalization was frequent as was loss of employment. One patient in the VATS group had a superficial wound infection (3%) and 1 patient in the thoracotomy group had a deep vein thrombosis (DVT) (9%). Length of hospital stay was 1.7 days less in the VATS group. As a result VATS provided better results in terms of:

- Less pain from the incisions after surgery
- Shorter hospital stay
- Shorter recovery time
- Faster return to work or normal activity
- Better cosmetic healing

## Reading references

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