



# Diaphragmatic plication

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## Background

Diaphragmatic eventration results in an abnormal elevation of one or both sides of the diaphragm. This condition with an incidence of less than 0.05% is rare and affects more often males and the left side of the diaphragm. Aetiologies are a congenital muscular defect of the diaphragm, or a congenital disorder of the central or peripheral nervous system (1,2). Diaphragmatic paralysis is more common, and either of acquired (traumatic, infectious, tumoral), iatrogenic (phrenic nerve trauma during surgery, radio-/chemo-therapy), or idiopathic origin (3).

Both pathologies may vary from no symptoms to recurrent respiratory infections in small children, and progressive dyspnea on exertion or asthma in adolescents and adults (4). Only the presence of those symptoms warrants surgical treatment (5,6). An elevated hemidiaphragm in an asymptomatic patient does not require surgical repair (7). The goal of surgical repair is to flatten the diaphragmatic dome and allowing re-expansion of the lung, reducing paradoxical diaphragmatic movements, and leading to more efficient ventilation.

Traditionally, symptomatic diaphragmatic elevation was treated by open surgery, via an abdominal or thoracic access (8). However, with the more widespread use of video-assisted thoracoscopic surgery (VATS) also minimally invasive techniques have been developed to treat this condition.

In their review article “Diaphragmatic plication for eventration or paralysis”, Patrini and co-authors provide a comprehensive overview of etiology, pathophysiology, diagnosis, indications and contraindications of diaphragmatic plication (DP) (9). As main technical problem of DP the risk of injury to abdominal organs while performing

full thickness stitches of the diaphragm was pointed out. Standard surgical techniques such as the central imbrication technique and the radial plication technique, both requiring thoracotomies, are presented. The authors concluded that the choice of surgical access (minimal invasive versus open surgery) depends on the surgeon’s experience.

Nowadays, as VATS has become a standard approach even for more demanding thoracic surgical procedures (i.e., pulmonary anatomical resections), also various techniques for minimally invasive DP have been described, although most of them still involve a mini-thoracotomy for diaphragmatic suturing (10,11). Intrathoracic suturing and especially suturing and approximating two tissue edges under tension are the main challenging aspects of a minimally invasive approach.

## Evolution of minimally invasive surgery (MIS) and advantages of completely endoscopic DP techniques

Benefits of conventional MIS are well known (12): Minimal scarring, lower risk of infections and complications, less postoperative pain, less need for intensive medical care, shorter hospital stay, and prompt return to daily activities.

Dyspnea as main symptom in diaphragmatic elevation may be more efficiently reduced when the plication is performed without a dolorous thoracotomy, especially since the risk of involvement of chronic neuralgia has been related to open thoracotomy (13).

Despite those obvious advantages, completely endoscopic DP has still not become the gold standard. To overcome the two main concerns of this surgical procedure, i.e., the risk of injury to abdominal organs when performing full-

thickness diaphragmatic sutures and suturing a tissue under tension, various approaches to the diaphragm have been described (11-17): by open surgery, by MIS comprising a mini-thoracotomy, completely by thoracoscopy or transabdominal. But only a completely endoscopic approach without thoracotomy warrants the abovementioned advantages of MIS.

Some surgeons prefer a laparoscopic approach since the risk of any injury to the bowel and other intraabdominal organs may be less likely thanks to full visualization of abdominal organs. Furthermore, an abdominal approach obviates the need for single lung ventilation and additional abdominal pathologies may be identified (12).

On the other hand, laparoscopic approaches carry a certain risk of injuring the lung when suturing the diaphragm and furthermore right-sided diaphragmatic eventration is more accessible by thoracoscopy since the liver located on the right side represents a major obstacle. In addition, the risk of injuring the bowel while suturing the diaphragm through a thoracoscopic approach is less likely on the right than on the left side (12).

Also, robotic-assisted surgery has been described in the literature, using the da Vinci Surgical System (Intuitive Surgical Inc., Sunnyvale, CA, USA) (18). Especially since suturing seems to be almost as easy as in open surgery with this technique. Nevertheless, it has to be noted that robotic assistance comes with a significant increase in costs, which is why the robotic approach will most likely not become the gold standard in the near future for this otherwise relatively simple procedure.

As recently described by our group there is a safe and relatively simple technique of completely endoscopic thoracoscopic DP during which the abundant part of the diaphragm is cut with an endostapler and removed and the staple line is reinforced with a running suture (15). An anti-Trendelenburg position of the patient, the additional use of intrathoracic CO<sub>2</sub>-insufflation, and the technique of rolling up the diaphragm on a grasper until the desired tightness is reached, are some of the intraoperative tricks which may further help in minimizing the risk of injury to intraabdominal organs. Furthermore, by stapling and removing the excess of diaphragm tissue, suturing the diaphragm becomes much easier. The aforementioned additional running suture was adopted to reinforce the staple line in order to prevent staple line breakage (16). In the end, the completely endoscopic technique responds to another important concern of DP: suture tension and stability against the intra-abdominal pressure.

## Conclusions

Surgery for diaphragmatic elevation is warranted only in symptomatic patients. To date, no gold standard surgical technique exists for DP. Different surgical techniques and pathways exist to repair this pathology but in order to guarantee a fast recovery with minimal postoperative pain for the patient, completely endoscopic techniques should be preferred.

Although evidence is lacking, completely thoracoscopic techniques without thoracotomy, as for example the technique suggested by our group (15), are in line with the constant effort to reduce surgical trauma and improve patient outcome.

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