

## Laparoscopic repair of traumatic diaphragmatic hernias

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Received: 11 February 2000/Accepted: 15 April 2000/Online publication: 20 September 2000

### Abstract

**Background:** Traumatic diaphragmatic hernias are serious complications of blunt abdominal or thoracic trauma. In the early posttraumatic period, they are often missed, and they may be followed by a variety of subacute or chronic symptoms due to pulmonary or intestinal obstruction.

**Methods:** We present three cases of traumatic diaphragmatic hernias. Two of them were successfully treated by laparoscopy and direct suturing during the early posttraumatic period; the other was treated 10 years after the trauma.

**Results:** We found that laparoscopy is a safe, successful, and gentle procedure not only for diagnosis but for treatment as well. The postoperative course was uneventful in all cases. All patients remained asymptomatic during long-term follow-up (42–60 months). These results are promising. We expect the same good long-term results after laparoscopic repair as after open conventional surgery.

**Conclusion:** We recommend that surgeons with sufficient experience in laparoscopy use a minimally invasive approach to treat chronic as well as acute traumatic diaphragmatic hernias in hemodynamically stable patients.

**Key words:** Diaphragmatic hernia — Trauma — Diaphragmatic rupture — Laparoscopic surgery — Chilaiditi's syndrome — Hernia

It has been reported that the first successful operation for a diaphragmatic injury was performed in the 19th century. Following diagnosis, there is always an absolute indication for surgery. Direct suture via laparotomy or thoracotomy is recommended. With the advent of minimal-access surgery and increasing experience in laparoscopy, minimally invasive techniques are being applied more frequently. So far, there is no professional consensus on the appropriate patient selection and operative technique. Herein we report three patients in whom the laparoscopic repair of acute and

chronic traumatic diaphragmatic hernias was successful. These cases are discussed in light of the current literature.

### Patients and methods

#### Case 1

A 55-year-old woman was injured in a severe car accident on March 19, 1994. She had been seated in the front of the car next to the driver with her seat belt fastened. Her husband, who had been driving the car, died at the scene. She suffered a polytrauma. She was rushed to a community hospital nearby under stable hemodynamic and respiratory conditions.

A hemothorax due to serial fractures of ribs 2 to 11 on her left side made chest tube placement necessary. She suffered fractures of her sternum, the right collar bone, and the first and second lumbar vertebrae. A chest radiograph (Fig. 1) and CT scan upon admission revealed traumatic rupture of the diaphragm on the left side with atelectasis of the left lower lobe of the lung. The patient was transferred to our clinic 24 h after the injury and underwent immediate laparoscopy. Intraoperative exploration showed that the stomach, greater omentum, spleen, and a portion of the small intestine had been transposed into the thorax through a tear extending into the centrum tendineum underneath the pericardium (Fig. 2).

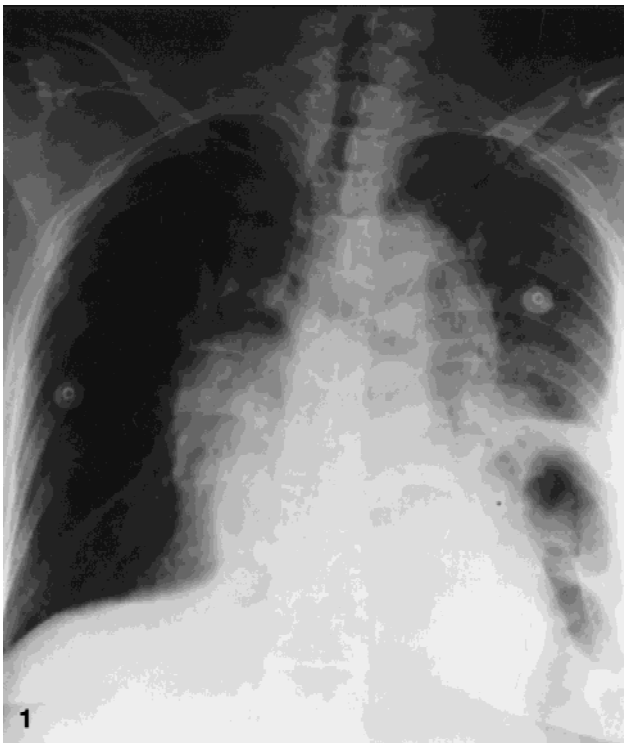
#### Case 2

An 18-year-old boy suffered a blunt trauma to the abdomen and chest during a car accident on December 12, 1994. The patient had multiple cut wounds and serial rib fractures with a pneumothorax on his left side. Chest radiograph showed an elevated left diaphragm with bloating of the stomach. The patient was admitted to our clinic for further observation.

During his stay, he developed increasing chest pain on his left side. A second chest radiograph revealed that the bloated stomach was completely displaced inside the thorax, causing dystelectasis of the left lower lobe. The patient underwent laparoscopic exploration immediately. The greater omentum and the stomach were found within the left thorax, protruding through a tear running along the left lower phrenic vein. Further traumatic lesions within the thorax were not encountered.

#### Case 3

Three months prior to admission, a 64-year-old female patient complained of increasing episodes of upper abdominal pain associated with dyspnea. Her symptoms increased, and 2 weeks before admission, they persisted without relief. Her history revealed that she had suffered blunt abdominal



**Fig. 1.** Case 1. Preoperative chest radiograph showing herniated stomach.

**Fig. 2.** Case 1. Intraoperative situs. Rupture of the left hemidiaphragm, herniated colon, and greater omentum.

trauma 10 years ago. Clinical examination with pulmonary auscultation detected the presence of bowel movements within the thorax.

The lower boundaries of the right lung were displaced upward by 8 cm. CT scans of the thorax and abdomen as well as MRT showed a hepar bipartita and the right colon lying next to the tracheal bifurcation. The right middle and lower lobe of the lung were almost completely atelectatic. The gallbladder was located within the thorax. The patient was referred to our center from a community hospital and treated by laparoscopic approach.

### *Operative technique*

Laparoscopic repair of a traumatic diaphragmatic hernia is performed in a 30° reverse Trendelenburg position. The surgeon stands between the patient's legs, one assistant to the left and one to the right of the patient. The procedure is performed under general anesthesia.

CO<sub>2</sub> gas is insufflated using a Veress needle inserted through a para-umbilical incision. A 10-mm trocar is placed, and a 30–45° angle laparoscope is introduced. The abdominal cavity is explored to avoid missing any other injuries.

Two to four additional trocars are placed under visual control. In our cases 1 and 3, two 10-mm and two 5-mm working trocars were placed in a half-circle in the right or left middle and upper abdomen so that the spleen and stomach could be retracted (case 1, Fig. 2) and parts of the liver (case 3). In the second case, one 5-mm and one 10-mm working trocar sufficed. The stomach and greater omentum were repositioned without difficulty. The pleural cavity was inspected in its entirety. Especially in the first case, it enabled us to exclude pericardial rupture, since the tear in the diaphragm extended into the base of the pericardium.

The atelectatic lower lobe of the right lung in our third case with chronic hernial rupture reexpanded completely, as affirmed by direct laparoscopic viewing. Following complete preparation of the torn rim of the diaphragm, the opposing edges were sutured using five to eleven nonabsorbable 0 sutures (Surgibraid; Auto Suture, Tönisvorst, Germany) tied extracorporeally. A direct or mattress suture technique permitted approximation without tension (Figs. 3 and 4). In the second patient, a hernia stapler was used to reinforce the suture line with single staples. In the third case, it was necessary to extend the tear laterally in order to reposition the entirely displaced right liver lobe. The second patient had a tear just next

to the lower phrenic vein; this vein was ligated to prevent hemorrhage. All patients had chest tube drainage for 24–48 h.

### **Results**

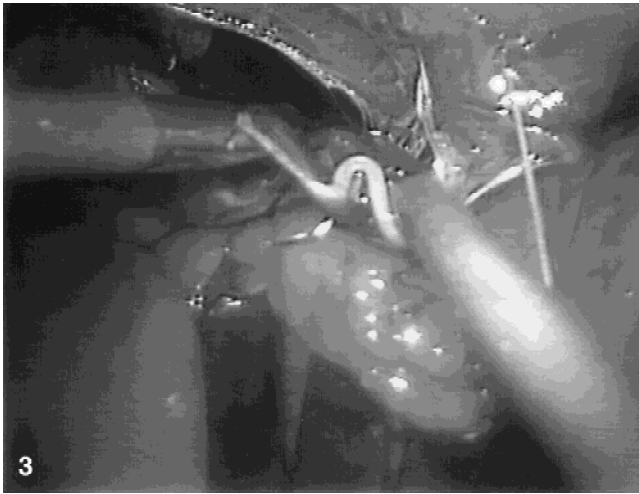
The minimally invasive approach proved successful in all three patients. The herniated organs were retracted and repositioned, and the defect was closed by direct suture. Mean operating time was 93 min (range, 60–125). Intraoperative blood loss was 60 ml (range; 0–200 ml). All patients were stable during the procedure, and pulmonary function was not compromised by the pneumoperitoneum. Intraoperative complications such as hemorrhage or injury to herniated organs were not encountered. The postoperative course was uneventful in all cases.

All patients were extubated immediately after surgery. Oral alimentation was started on the 1st postoperative day. Two patients were discharged on postoperative day 6. The first patient, who had suffered other severe injuries, was transferred to another center for rehabilitation 21 days after surgery. All three patients had a follow-up exam 6–12 weeks following discharge, and a reevaluation was completed just prior to this report. No recurrences were detected by radiologic imaging or ultrasonography. At last follow-up (first case, 60 months; second case, 52 months; third case, 42 months), all three patients were free of complaints and in good health.

### **Discussion**

#### *Etiology, pathophysiology, and chronology*

Table 1 In most instances, traumatic diaphragmatic hernias are caused by blunt abdominal trauma; less often, they are



**Fig. 3.** Intracorporeal suture placement (U-stitches).

**Fig. 4.** Completed suture line.

the result of blunt thoracic trauma. They occur on the left side in 90% of cases. Usually, a tear is found in the central tendon near the esophageal hiatus; it generally extends in a horizontal direction at the junction between the tendonous and muscular portion of the diaphragm. As seen in two of our patients, these tears can run very close to the hepatic veins or pericardium. In a third of all cases, a rupture of the diaphragm is overlooked during the acute posttraumatic period [14]. The tear can remain asymptomatic, or nonspecific minor symptoms may appear hours or days following trauma (initial phase). If the rupture remains unrecognized, a latency period ranging from hours (case 2) to many years (case 3) may occur until a significant prolapse of abdominal organs into the thorax develops, causing symptoms such as constipation, nausea, vomiting, colic or symptoms like dyspnea due to the displacement of thoracic organs [17, 20].

#### *Operative strategies*

The choice of operative approach—laparotomy or thoracotomy—depends upon the patient's clinical condition and the presence or absence of concomitant injuries. If intraab-

dominal injuries can be excluded, a minimally invasive laparoscopic or thoracoscopic approach may be preferred. We recommend an open conventional approach in perforating abdominal injuries, although this view has thus far been controversial [8, 11, 13, 15]. However, two prospective studies have described perforating intestinal injuries that were missed during laparoscopy [8, 13].

We believe that the anteriorly and centrally located acute or chronic traumatic diaphragmatic hernia without concomitant severe abdominal or thoracic injury is the best indication for a laparoscopic approach. Although there have been single reports of successful repairs using video-assisted thoracoscopy [1, 9, 10, 12, 20, 21], we have found that the laparoscopic approach has the significant advantage of being able to reposition herniated abdominal organs more easily. The abdominal approach permits excellent visualization of abdominal organs, especially the spleen and liver, thus preventing injuries. In a report by Kurata et al. [12], the authors expressed their preference for a thoracoscopic approach in a patient with a diaphragmatic tear and herniated stomach because they feared pulmonary complications due to the application of a pneumoperitoneum, which is necessary for laparoscopy. We cannot confirm their assumption. In the three cases presented in this report and also in our experience with other laparoscopic procedures performed on the diaphragm, such as in Morgagni hernias [7] or upside-down stomachs, we never encountered pulmonary complications as a result of a rise in intraabdominal pressure.

We do not believe that a thoracoscopic approach, as described by Kurata et al. [12], can facilitate the reposition of herniated abdominal organs in chronic traumatic diaphragmatic hernias, as we report in our third case. Furthermore, Jackson and Ferreira [9] showed that intrapleural adhesions may occur as early as 24 h after trauma, and that these adhesions may make a thoracoscopic approach more difficult. Also, single-lung ventilation is necessary for thoracoscopy, and lateral positioning during thoracoscopy poses a problem if the patient requires laparotomy for other reasons during the procedure [6]. Transdiaphragmatic exploration of thoracic organs through the laparoscopic approach was easily performed in all three of our patients; therefore, we believe that the risk of missing injuries to thoracic organs is very small. In contrast to the results reported by Power et al. [16], we did not experience a significant reduction in insufflatory pressure, and we never observed a tension pneumothorax during any of our procedures. Other investigators have confirmed our experience. Unlike Power et al., we do not think it is necessary to place a chest tube before a pneumoperitoneum is created. Instead, we agree with Horstmann et al. [6], who see an increased risk of perforating herniated organs during chest tube placement. If a chest tube is necessary, we recommend that it be introduced under direct visual control during laparoscopy.

Experience in the laparoscopic approach for closure of traumatic diaphragmatic hernias is limited. To date, there have been 1 reports using various techniques. Table 1 is however, the choice of method for the closure of the rupture is closed during laparoscopy is still a subject of debate. Some surgeons prefer to use the hernia stapler because of it is easy to handle and keeps operating time to a minimum

**Table 1.** Results of laparoscopic repair of traumatic diaphragmatic hernias after blunt and penetrating trauma

First author (yr)	<i>n</i>	Herniated organs	Time since trauma	Operative technique	Postop stay	Follow-up (mos)
Frantzides (1994)	1	omentum	<24 h	hernia stapler	3 d	10
Power (1994)	1	gastric fundus	>5 d	— <sup>a</sup>	18 wk	— <sup>a</sup>
Chen (1995)	1	none	— <sup>a</sup>	hernia stapler	— <sup>a</sup>	— <sup>a</sup>
Rasiah (1995)	1	stomach	4 wk	skin incision, prefascial tied sutures	2 d	18
Marks (1995)	1	none	<24 h	hernia stapler	3 d	— <sup>a</sup>
Horstmann (1996)	1	stomach fundus	4 d	singly placed sutures	9 d	— <sup>a</sup>
	1	stomach fundus	<24 h	— <sup>a</sup>	— <sup>a</sup>	— <sup>a</sup>
Ugazzi (1996)	1	stomach	<24 h	nonresorbable sutures	2 d	8
Gonzales-Rapado (1997)	1	stomach	<24 h	nonabsorbable running suture	20 d	— <sup>a</sup>
				singly placed sutures and additional Gore-Tex patch,		
Thalman (1997)	1	colon, omentum	7 yr	hernia stapler	— <sup>a</sup>	3
		gastric fundus, momentum, parts of the spleen and the colon				
Slim (1998)	1	stomach, colon	13 mo	polypropylene mesh, nonabsorbable sutures	7 d	3
		small bowel, spleen				
Domene (1998)	1	stomach, spleen, greater omentum, small bowel	3 yr	nonabsorbable sutures	5 d	— <sup>a</sup>
Case 1		stomach, greater omentum, small bowel	1 d	direct suturing with singly placed U-stitches	21 d	60
Case 2		stomach, greater omentum	1 d	singly placed sutures	6 d	52
Case 3		colon, parts of liver, gallbladder	10 yr	singly placed U-stitches	6 d	42

<sup>a</sup> No data or no accurate data available

[12]. Like some others [11], we prefer to use sutures, because they can be sewn through the entire wall of the diaphragm and thus offer greater stability. We usually use mattress sutures, which have the greatest strength; we also prefer to use them for conventional open surgery. To guarantee adequate tension, we perform extracorporeal knot tying.

Comparable long-term results can only be achieved by using the same stable suture techniques formerly employed in open conventional surgery. Ideally, direct closure of the tear can be facilitated by using mattress sutures consisting of nonabsorbable material. Rasiah and Crowe [17] described an alternative suture method that they used to repair a tear near the costal margin—an unusual location for a diaphragmatic hernia. The suture was passed through the abdominal wall, and the knot was tied on top of the outer fascia through a separate skin incision. However, in most cases, the ruptures are located centrally and this technique is not applicable.

We do not believe that stapling alone with a stapling device, as proposed by others [4, 11, 12], is sufficient for secure closure of a tear. Although the stapling technique is the simplest and quickest method, we agree with Koehler and Smith [11] that it cannot yet be recommended as the method of choice for diaphragmatic repair because long-term results are still lacking. The staples can loosen and fall off when put under tension, as happened in one of our cases following repair of a paraesophageal hernia. The use of an alloplastic mesh [20, 23] for closure was not necessary in our patients. However, in some cases with an older defect, it may be needed to achieve adequate closure of the defect,

as reported by Rau et al. [18]. In our opinion in most cases of acute traumatic rupture, direct suture should be possible.

The main advantage of the laparoscopic approach is that it prevents thoracotomy or upper abdominal laparotomy, thus reducing the overall trauma in polytraumatized patients, such as our first patient. In spite of her serial rib fractures, we were able to extubate this severely injured patient immediately after the surgery. Furthermore, laparoscopy permitted better orientation and surgical exposure. Inspection of the intrathoracic organs through the tear in the diaphragm was easy. Examination of the abdomen allowed us to exclude concomitant abdominal injuries. This type of abdominal approach with the laparoscope makes it unnecessary to perform two cavity procedures.

## Conclusions

As the 3- to 5-year long-term follow-up results of our patients demonstrate, the laparoscopic repair of traumatic diaphragmatic hernias is a safe and successful method comparable to open conventional techniques. Standard suturing techniques like those used in conventional surgery can be employed in the same manner laparoscopically. Herniated abdominal organs can be retracted more easily through an abdominal approach, and a thoracotomy can be avoided. Therefore, we believe that repair of traumatic diaphragmatic hernias should be performed in selected patients by a laparoscopic approach at centers with sufficient experience in minimally invasive surgery. Further multicenter studies are



needed to evaluate the application of this approach during the acute posttraumatic period.

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