



Lateral Approach to Laparoscopic Repair of Left Diaphragmatic Ruptures

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Abstract. Video-assisted repairs of traumatic diaphragmatic ruptures have been described where thoracoscopy or laparoscopy in the supine position were used. This study aims to validate a new lateral laparoscopic approach for left diaphragmatic repairs. Six consecutive patients were operated on for left diaphragmatic rupture using a lateral approach (Gagner's position). A series of 362 consecutive patients presenting with abdominal or thoracic trauma with or without diaphragmatic rupture over a 2-year period were reviewed retrospectively. Contraindications for immediate or delayed lateral laparoscopic approach were studied. The lateral approach provided complete visibility of the subdiaphragmatic space, easy reduction of herniated organs, easy thoracic inspection and cleaning, the use of low peritoneal pressure, full range of instrumental motion, and rapid diaphragmatic repair. No operative mortality or morbidity was noted. Altogether, 14% to 50% of the patients with diaphragmatic ruptures were candidates for immediate lateral laparoscopic repair. Associated spleen injury in 50% of the cases was the main contraindication. The lateral laparoscopic approach provides better exposure of the diaphragm on the left side and facilitates the diaphragmatic repair especially with a large herniation. Immediate repair is possible in selected cases (14–50%). There is no contraindication in case of delayed diagnosis.

There is a growing interest in the use of thoracoscopy for the diagnosis and treatment of diaphragmatic ruptures and penetrating injuries to the thorax [1–10]. Thoracoscopy enables one to fully explore the entire diaphragmatic surface regardless of side. Nevertheless, thoracoscopy does not give access to the abdominal cavity and necessitates selective lung intubation, which is not always well tolerated in case of recent trauma. Laparoscopy is a possible alternative. Its diagnostic role has been increasingly recognized in case of trauma, but its role in the surgical repair of abdominal organs is still anecdotal. Suturing a diaphragmatic rupture or a bowel laceration and autotransfusing a hemoperitoneum have been described [8, 11]. Since 1995 we have used video-assisted techniques to repair left diaphragmatic ruptures. Using the laparoscopic lateral approach for adrenalectomy, we noted the large exposure of the diaphragm provided by this technique. Six consecutive patients with a left rupture were then operated on successfully.

The first aim of this study was to describe the surgical tech-

nique. The second aim was to determine indications and contraindications in case of immediate or delayed surgery.

Population and Method

Patients Operated on by Lateral Laparoscopy

From June 1994 to February 1999, six patients aged 16 to 68 and presenting with a left diaphragmatic rupture were operated on using a video-assisted technique. Clinical, anesthetic, and surgical descriptions of the six patients are detailed in Tables 1, 2, and 3. They were operated on using a left lateral transperitoneal approach (Fig. 1). No patient was operated on within the first 6 hours after the accident so we could assess the feasibility of the technique in the safest conditions. Because this approach was new, highly restrictive contraindications for video-assisted techniques were used: unstable hemodynamic status; head trauma/spinal cord injury; moderate or abundant hemoperitoneum; retroperitoneal hematoma; lung or mediastinal lesion; splenic, liver, or renal injury (hematoma or rupture); perforated viscus (stomach, small bowel, colon); any fracture requiring immediate operation (femoral, pelvic ring, spine bone fracture); any thoracic or neurosurgery. A helicoidal thoracoabdominal computed tomography (CT) scan was used to rule out associated visceral lesions. No operative mortality or morbidity was related to the diaphragmatic repair (i.e., pulmonary morbidity, abdominal wall infection or hematoma, trocar incisional hernia).

Retrospective Analysis of Thoracic and Abdominal Trauma Patients

From January 1, 1995 to December 31, 1996 a total of 362 consecutive patients were referred to our institution for thoracic/abdominal trauma, with or without associated penetrating injury. The mean age was 38.6 ± 9.0 years. Most of the patients were male ($n = 259$, 71.5%). Altogether, 43% ($n = 155$) were thoracic trauma patients, 25% were abdominal trauma patients ($n = 90$), and 32% had both abdominal and thoracic trauma ($n = 117$). The 30-day mortality was 10.5% ($n = 38$). A diaphragmatic rupture

Table 1. Clinical data.

Patient	Gender	Weight (kg)	Age (years)	Past medical history	Method of diagnosis	Method of trauma	Associated lesions	Elapsed time after accident
A.B.	Male	65	68	Smoking, chronic bronchitis	CXR, CT	Car accident: driver	None	10 Days
A.M.	Female	50	16	None	CXR, NG tube, CT	Car accident: front passenger	Head trauma Pelvic bone fracture Left ankle fracture	3 Days
J.R.	Male	85	60	Epilepsy (seizure)	CT	Car accident: driver	Right ankle fracture	4 Days
M.D.	Male	80	55	Asthma, Paget's disease	CT	Car accident: driver	Left ribs fractured Left hemothorax Left pneumothorax	6 Hours
A.G.	Male	85	59	None	CXR, NG tube, CT	Car accident: driver	Left hemothorax Right forearm fracture	6 Hours
E.B.	Male	80	38	Smoking	CXR, CT	Car accident: driver	Left ribs fractured Left hemothorax Left pneumothorax Bilateral lung contusion Right forearm fracture	24 Hours

CXR: chest radiography; NG: nasogastric; CT: computed tomography.

Table 2. Anesthesiologic data.

Patient	Anesthetic agents	Insufflation pressure (mbar)	Mean blood pressure (mmHg)	EtCO ₂ (mmHg)	SpO ₂ (%)
A.B.	Thiopental Sufentanyl Vecuronium	22–28	110/70	30–35	≥ 98
A.M.	Isoflurane Propofol Sufentanyl Atracurium	20–30	110/70	31–45	≥ 98
J.R.	Isoflurane Thiopental Sufentanyl Rocuronium	18–21	100/70	30–37	≥ 98
M.D.	Isoflurane Thiopental Sufentanyl Rocuronium	15–35	100/60	22–35	≥ 98
A.G.	Isoflurane Thiopental Sufentanyl Rocuronium	Not recorded	120/80	34–42	≥ 98
E.B.	Desflurane Midazolam Fentanyl Rocuronium	22–39	120/80	37–45	≥ 98

EtCO₂: end-tidal CO₂ pressure in exsufflated gas; SpO₂: transcutaneous pulsatile oxygen saturation.

was found in 3.9% of the cases (14/362). Blunt trauma was always responsible for the ruptures in this study. Using the former contraindications, we selected a group of patients who would have been able to undergo a lateral video-assisted diaphragmatic repair safely as soon as possible after admission.

Statistical Analysis

The BMDP software was used to select groups and to perform the comparisons of categorical data with the suitable tests (χ^2 tests, with or without Yates correction; bilateral Fisher exact tests) (2D and 4F programs of Biological Models for Data Processing soft-

ware, Los Angeles, CA, USA). The level of significance was set at a 5% level.

Results

Population Operated on by Video-assisted Techniques

The same technique was used in all cases. The patients were positioned as described by Gagner for adrenalectomy and splenectomy (Fig. 1) [12, 13]. The four trocars were inserted 1 cm below the costal brim, and 10 mmHg pneumoperitoneum was maintained throughout the procedure. The herniated viscus were pulled back in the abdomen (Fig. 2); and the mediastinum and lung were checked.

Aspiration and lavage cleaned the pleural space. A 28F thoracic tube was placed under clear vision. The hiatal ring was reconstituted using an "X" stitch of 0 silk when required (4/6), and the remainder of the rupture was closed using running stitches (*Endostitch No. 0*; United States Surgical Corporation, Norwalk, CT, USA) (Fig. 3). At each stitch, a clip blocked the suture. The abdomen was exsufflated, and no drain was left in place in the abdomen.

Retrospective Study Results

Fourteen diaphragmatic ruptures occurred in 362 trauma patients (3.9%). They were situated on the left side in 10 cases (71.4%) and on the right side in 4 (28.6%).

Using previously defined exclusion criteria, 25.9% of the patients without diaphragmatic rupture (90/348) and 14.3% of the patients with diaphragmatic rupture (2/14) would have been suitable candidates for a lateral laparoscopic approach. Associated spleen injuries, hemothorax, and pneumothorax were found more frequently in the group with diaphragmatic rupture (Table 4).

Among the 14 diaphragmatic rupture cases, there were 3 (21.4%) unstable hemodynamic conditions, 7 (50%) spleen injuries with moderate or severe hemoperitoneum, 2 (14.3%) liver injuries, 1 (7.1%) lung injury necessitating a thoracotomy, 1 (7.1%) renal injury with retroperitoneal hematoma, and 6 (42.9%) head trauma/spinal cord injuries; two patients (14.3%)

Table 3. Surgical data and follow-up.

Patient	Operating time	Herniated organs	Site of the rupture	Type of suture	Follow-up
A.B.	1 hour 50 min	Stomach, splenic flexure	8 cm Radial from the esophageal ring to the phrenic center	Silk suture on the esophageal ring + Endostitch 0 running stitches	6 Months
A.M.	1 hour 30 min	Stomach, great omentum, colon	12 cm Radial from the esophageal ring to the phrenic center	Silk suture on the esophageal ring + Endostitch 0 running stitches	1 Year
J.R.	1 hour	Stomach	10 cm Radial from the esophageal ring to the phrenic center	Silk suture on the esophageal ring + Endostitch 0 running stitches	6 Months
M.D.	1 hour 30 min	Stomach, spleen	10 cm Posterior transversal	Silk suture on the esophageal ring + Endostitch 0 running stitches	3 Months
A.G.	3 hours	Stomach, splenic flexure	12 cm Radial from the back to the phrenic center	Silk suture + Endostitch 0 running stitches	10 Days
E.B.	1 hour 30 min	Stomach	8 cm Radial from the back toward the phrenic center	Endostitch 0 running stitches	2 Months

required an orthopedic operation immediately. No bowel perforation was founded from CT scan examination.

Discussion

In European countries, diaphragmatic ruptures are usually caused by blunt trauma during car accidents. Deceleration induces abdominal hyperpressure and may damage the diaphragmatic muscle [14, 15]. Penetrating injuries caused by stab wounds or gunshots seem less frequent than in North America [16]. These data are confirmed among the 14 patients with a diaphragmatic rupture admitted during a 2-year period at our institution. The length of the ruptures (around 10 cm) enabled the bowel or the spleen to pass into the thorax easily.

Laparotomy is the usual route for checking all the intraabdominal organs that may be injured. In the same way, laparoscopy is regularly used to evaluate abdominal trauma [11, 17–23]. Laparoscopy reduces the number of unnecessary laparotomies, but its use to repair a diaphragmatic rupture has seldom been mentioned in the literature [24, 25]. In contrast, short diaphragmatic ruptures have often been managed through thoracoscopy, especially when herniation into the thorax is moderate [2, 3, 5, 8–10]. Laparoscopic repairs in the supine position have already been carried out successfully [24, 25], although the diaphragmatic surface is not completely visible, especially its posterior margin. Thorough inspection of the spleen and the subdiaphragmatic space is not possible [7]. Gazzaniga et al. recommended tilting the table to the right during the procedure [18]. Park et al. perform splenectomy using the laparoscopic lateral approach [13]. This position enables the surgeon to explore the subdiaphragmatic space easily with a lower pressure because the last ribs act as a roof. Moreover intraabdominal organs are not pushed into the thorax. The pneumoperitoneum pressure does not exceed 10 mmHg at the beginning of the procedure and can be decreased as soon as the diaphragmatic surface is well exposed. The side effects of intraabdominal hyperpressure on intracranial pressure are minimized [26]. Moreover, the spleen, stomach, colon, and liver are drawn out from the operative field with minimal forceps traction. The immediate subcostal conversion on the trocar line is possible in case of emergency. The mediastinal and thoracic inspection is carried out at the same time through the diaphragmatic rupture.

Any fluid can be aspirated and any clot removed. The pericardium is inspected, looking for a rupture [27]. A thoracic tube is positioned under clear vision. Use of an *Endostitch No. 0* facilitates the repair with running stitches of nonabsorbable sutures. No pulmonary complication occurred, confirming the already known advantage of the laparoscopic approach over laparotomy. We did not repair any right diaphragmatic rupture. The right side is usually less concerned than the left one (29% in this series). We think that the same technique is feasible because the right lateral approach is regularly used for adrenalectomy. A case of laparoscopic repair of right diaphragmatic rupture has been described with the patient lying in the supine position [25].

As far as we know, few cases have been repaired via laparoscopy or thoracoscopy immediately after trauma [4, 10]. According to our retrospective results and using highly restrictive exclusion criteria, only 14% of patients with diaphragmatic rupture would have been good candidates for laparoscopic immediate repair. The larger incidence of spleen injuries associated with diaphragmatic ruptures (50%) highlights the specific hemorrhagic risk and confirms that the laparoscopic lateral approach must be used carefully in emergency situations. After a learning curve period, a less conservative attitude is possible. Some patients with intrasplenic, intrahepatic, and retroperitoneal hematomas or with minor lung or renal injuries are good candidates for the videoscopic lateral approach. Minor head trauma patients with normal CT scans are candidates as well. Two recent patients with associated spleen hematoma and pelvic ring fracture were operated on but are not presented because of the lack of follow-up. Another recent patient with an operation on the right side prompts us to develop this operation bilaterally.

Nevertheless, no more than 50% of patients are manageable laparoscopically because spleen injuries with active bleeding remain a contraindication. Conversely, this technique may be used in case of delayed diagnosis when the diaphragmatic rupture may be considered an isolated lesion.

Résumé

Fond du problème: La réparation vidéo-assistée des ruptures traumatiques du diaphragme est déjà bien décrite. L'intervention a lieu en décubitus dorsal soit par thoracoscopie soit par

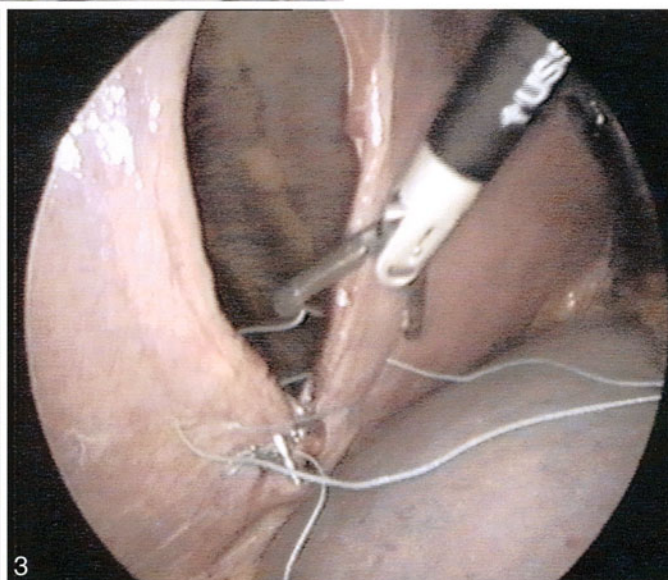
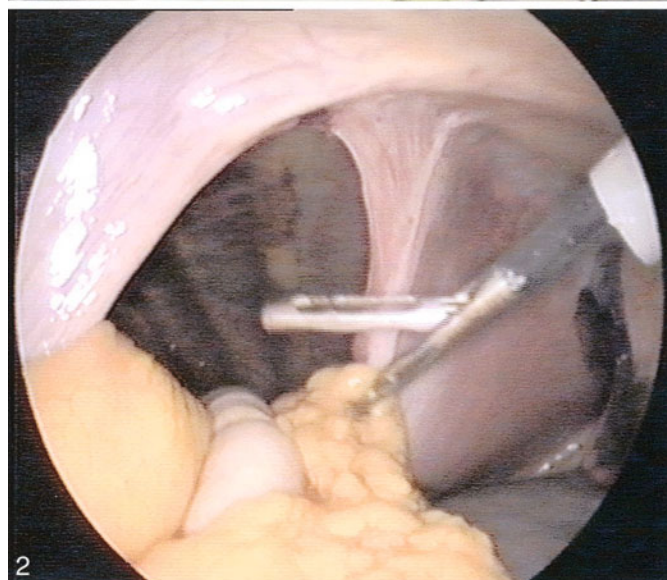


Fig. 1. Gagner's lateral position.

Fig. 2. Reduction of herniated organs. The procedure is facilitated by the low insufflation pressure (< 10 mmHg).

Fig. 3. Running stitches with use of the Endostitch device.

laparoscopie. L'objectif de cette étude a été de valider une nouvelle approche latérale laparoscopique pour la réparation des ruptures diaphragmatiques gauches. Population et méthodes: (1) Six patients consécutifs ont été opérés pour rupture diaphragmatique gauche par l'approche latérale (position de Gagner). (2) On a revu 362 dossiers consécutifs de patients ayant eu un traumatisme abdominal et/ou thoracique avec ou sans

rupture diaphragmatique pendant une période de deux ans. Les contre-indications à une réparation latérale laparoscopique immédiate ou retardées ont été étudiées. Résultats: (1) L'approche latérale permet: une visibilité complète de l'espace sous-diaphragmatique, une réduction aisée des organes herniés, la possibilité d'inspection et de toilette thoraciques faciles, l'utilisation d'une pression intra-abdominale basse, un champs

Table 4. Clinical and therapeutic data for thoracic and abdominal trauma patients.

Nature of associated lesion	Trauma without diaphragmatic rupture (n = 348)	Trauma with diaphragmatic rupture (n = 14)	p
Spleen injury	56 (16.1%)	7 (50%)	0.004
Hemothorax	101 (29.0%)	9 (64.3%)	0.01
Pneumothorax	106 (30.5%)	8 (57.1%)	0.04

No statistical difference was found for hemoperitoneum, lung injury, renal injury, cardiovascular collapse, liver injury, immediately required orthopedic surgery, immediately required neurosurgery, head trauma, spinal cord injury, mediastinal injury, retroperitoneal injury, bowel perforation, or pancreatic trauma.

d'action des instruments sans gêne et une réparation diaphragmatique rapide. On n'a noté aucune mortalité ou morbidité opératoire. (2) Quatorze à 50 pour-cent des patients ayant une rupture diaphragmatique ont été candidats à une réparation immédiate par cette approche. L'association de lésions spléniques dans 50% des cas a été la contre-indication majeure. Conclusions: L'approche latérale laparoscopique fournit une meilleure exposition du diaphragme du côté gauche et facilite la réparation surtout en cas d'orifice large. La réparation immédiate est possible dans un certain nombre de cas (14% à 50%). Il n'existe aucune contre-indication en cas de diagnostic retardé.

Resumen

Antecedentes: Se sabe, que las rupturas traumáticas del diafragma pueden ser tratadas mediante viedo-cirugia. Normalmente se utiliza la toroscopia o la laparoscopia en decúbito supino. Este estudio intenta revalidar un nuevo abordaje lateral para la reparación de las rupturas diafragmáticas izquierdas. Casuística y Métodos: (1) Seis pacientes con rupturas del hemidiafragma izquierdo fueron intervenidos mediante abordaje lateral (en posición de Gagner). (2) Se revisaron retrospectivamente 362 pacientes con traumatismo abdominal y/o torácico con o sin ruptura diafragmática tratados en un periodo de dos años. Se estudiaron las indicaciones y contraindicaciones del tratamiento precoz o diferido por vía laparoscópica. Resultados: (1) El abordaje lateral permite una completa visualización del espacio subdiafragmático, facilita la reducción de los órganos herniados, siendo la inspección torácica más fácil y más clara; la presión intrabdominal (neumoperitoneo) necesaria es menor y la movilidad de los instrumentos idónea, permitiendo una rápida reparación del defecto diafragmático. No se registró morbi-mortalidad alguna. (2) Entre el 15 y el 50% de pacientes con ruptura diafragmática fueron tratados precozmente mediante abordaje lateral laparoscópico. La contraindicación mayor, en el 50% de los casos, fue la ruptura concomitante del bazo. Conclusiones: El abordaje lateral laparoscópico permite una mejor exposición del hemidiafragma izquierdo y facilita la reparación diafragmática, sobre todo en casos de grandes hernias. La reparación precoz es posible en el 14 al 50% de casos seleccionados. La intervención no está contraindicada en pacientes diagnosticados tardíamente.

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