Diaphragmatic Repair and/or Reconstruction During Upper Abdominal Urological Laparoscopy

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Purpose: We present our experience with and the technique of laparoscopic mesh reconstruction or suture repair of intentional resection or intraoperative injury of the diaphragm.

Materials and Methods: In a 10-year (1997 to 2006) review of 1,850 upper abdominal renal and/or adrenal laparoscopic procedures at our institution 13 patients (0.7%) sustained diaphragmatic entry, including iatrogenic injury in 7 (0.4%), deliberate laparoscopic excision of a portion of the diaphragm in 2 and diaphragmatic incision during transthoracic adrenalectomy in 4. Laparoscopic repair techniques involved primary suture repair in 11 cases and primary reconstruction with a synthetic graft in 2. A rubber catheter and water seal system were used to primarily evacuate the pneumothorax.

Results: Inadvertent diaphragmatic injury in 7 cases occurred during transperitoneal (6) and retroperitoneal (1) laparoscopy, including partial nephrectomy in 4, radical nephrectomy in 2 and adrenalectomy in 1. A diaphragmatic breach occurred due to hook electrocautery in 5 cases, trocar insertion in 1 and liver retraction in 1. Deliberate diaphragmatic excision and mesh reconstruction in 2 cases were performed after en bloc excision of the diaphragm during radical nephrectomy in 1 and during excision of a metastatic diaphragmatic nodule in 1. Four transthoracic transdiaphragmatic adrenalectomies were completed successfully without any intraoperative complications. All cases were completed laparoscopically without open conversion. A chest tube was placed prophylactically in the initial 2 patients undergoing transthoracic transdiaphragmatic adrenalectomy.

Conclusions: Laparoscopic and transthoracic repair/reconstruction of the diaphragm is safe and effective.

Keywords: adrenal glands, kidney, laparoscopy, diaphragm, intraoperative complications

Inadvertent pleural injury may occur during open flank surgery for renal or adrenal disease. These injuries are usually suture repaired primarily with simultaneous evacuation of pleural air. Operative breach of the diaphragm is uncommon during laparoscopic renal and adrenal surgery.[1–3] If such an injury is recognized intraoperatively, it should be repaired laparoscopically in a manner duplicating the principles of open surgery.

We describe our technique of laparoscopic repair for inadvertent diaphragm injury during upper abdominal urological laparoscopy as well as deliberate excision and mesh reconstruction of the diaphragm during treatment for advanced RCC. Our experience with TTA is also discussed.

MATERIALS AND METHODS

A retrospective review of 1,850 upper abdominal laparoscopic procedures performed under the supervision of 1 surgeon (ISG) during 10 years (1997 to 2006) revealed 7 iatrogenic injuries (0.4%) to the diaphragm that were identified intraoperatively and repaired laparoscopically. In addition, 2 patients underwent deliberate excision of a portion of the diaphragm and primary reconstruction with a synthetic graft. Finally, 4 patients with an adrenal mass underwent TTA since prior abdominal scarring precluded safe transabdominal laparoscopy. Three of these cases were reported earlier.[4]

Inadvertent Diaphragm Injury

In the 7 cases of inadvertent injury the pleural breach was identified due to noticeable billowing of the diaphragm, followed by direct laparoscopic visualization of the injury. Laparoscopic suture repair of the diaphragm replicated the technique followed during open surgery. Upon identification of the diaphragmatic injury the anesthesiologist was consulted to confirm patient hemodynamic and respiratory stability. The primary renal/adrenal procedure was then completed and the diaphragmatic rent was visually reidentified. A figure-of-8 or running stitch of 2-zero polyglactin on a CT-1 needle was used to close the defect (fig. 1, *A*). After the last throw of the suture a knot was created and kept loose.

A 14Fr rubber catheter with its external end occluded with a hemostat was introduced through a lateral 5 mm port into the diaphragmatic rent to enter the pleural space (fig. 1, *B*). The external end of this catheter was placed under a water seal positioned below the level of the pleural cavity and the external hemostat was removed (fig. 1, *C*). The 2 ends of the knot were held on tension using 2 laparoscopic needle drivers and loosely cinched down around the catheter.

The abdomen was desufflated and the anesthesiologist repeatedly hyperinflated the lungs to expel all pleural CO_2.

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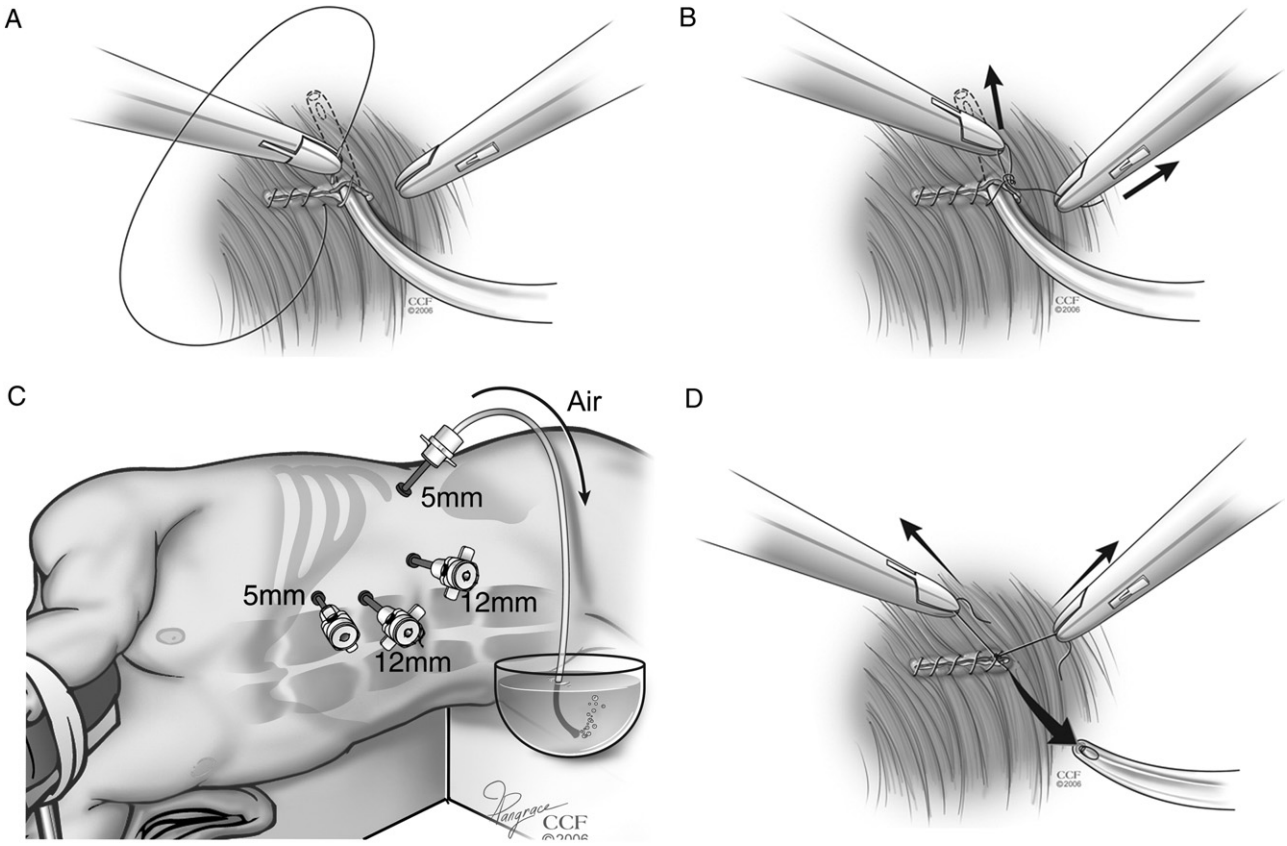

FIG. 1. Repair of iatrogenic diaphragmatic injury during upper abdominal laparoscopy. *A*, with lung deflated running suture is used to close diaphragmatic defect. *B*, 14Fr rubber catheter is introduced through lateral 5 mm port into diaphragmatic rent to enter ipsilateral pleural space. Knot is formed on running suture and held on tension. *C*, external end of catheter is placed under water seal below pleural cavity level. Anesthetist is asked to hyperinflate lung to expel all intrapleural CO_2 through catheter under water seal. *D*, after all CO_2 is expelled, as demonstrated by absent bubbles in water seal, abdomen is desufflated, catheter is rapidly removed and preformed knot is rapidly cinched down.

Evacuation of CO_2 was indicated by exiting air bubbles through the water seal at the external end of the catheter. After CO_2 was completely evacuated, as shown by the cessation of air bubbles despite continued hyperinflation, the external end of the catheter was reclamped with a hemostat. The catheter was rapidly removed and the preformed knot on the suture was cinched down firmly with the pre-positioned needle drivers to complete the knot (fig. 1, *D*). This step was performed blindly since pneumoperitoneum had been completely evacuated. Pneumoperitoneum was then reestablished and additional knots were placed, completing the repair.

Intentional Diaphragmatic Excision and Mesh Reconstruction

At the outset a double lumen endotracheal tube was placed for anesthesia, so that the ipsilateral lung could be selectively deflated and inflated. Under laparoscopic ultrasound guidance a 1 to 2 cm margin of resection was scored around the nodule or area of diaphragmatic involvement using hook electrocautery (fig. 2, *A*). The scored area was measured with a malleable plastic ruler inserted through a 12 mm port. On the bench the unstretched Gore-Tex® graft was sized 10% to 20% smaller than the scored area in the diaphragm to create a taut patch. The scored portion of the diaphragm was excised with J hook electrocautery (fig. 2, *B*). The prefashioned Gore-Tex graft was sutured into place using a running 2-zero Ethibond™ suture (fig. 2, *C*). Just before completing the repair all intrapleural CO_2 was evacuated using a 14Fr rubber catheter, as described. After all CO_2 was evacuated the catheter was rapidly removed and the final knot of the repair was cinched down (fig. 2, *D*).

TTA

Following double lumen endotracheal intubation a 4 port transthoracic approach was used with the patient prone without pneumo-insufflation, as previously described.[4] A 6 to 7 cm radial incision was made in the diaphragm directly over the adrenal under ultrasound guidance, maintaining a 2 cm distance from the chest wall. Adrenalectomy was performed and the specimen was retrieved through a thoracic port site in a specimen bag. The diaphragmatic incision was repaired using freehand laparoscopic suturing with a 2-zero polyglactin suture on a CT-1 needle. The initial 2 patients in this subgroup received a prophylactic chest tube because of no prior experience with this procedure. No chest tube was placed in the latter 2 patients.

RESULTS

In the 2 women and 5 men with a median age of 60 years who had inadvertent diaphragmatic injury 6 injuries occurred during transperitoneal laparoscopy, including partial