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Techniques for laparoscopic repair of major intraoperative vascular injury: case reports and review of literature

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Abstract
Background Laparoscopic surgery has become increasing popular, and its use has been proven safe. However, major vascular injuries during laparoscopic procedures can have devastating effects, and there is a paucity of information regarding their intraoperative management. Here we report our experience with laparoscopic vascular injury repair and analyze the available literature on this topic.
Methods Two cases of iliac vessel injury during laparoscopic colectomy were reviewed from a single surgeon's experience with of over 1,000 major laparoscopic procedures. The details of injury, techniques used, and outcomes were analyzed. A review of the literature was also conducted via PubMed.
Results An injury to the left common iliac artery in a 75-year-old man and an injury to the left external iliac vein in a 39-year-old man during laparoscopic sigmoid colectomy are described, with successful laparoscopic vascular repair in both. Estimated blood loss was 300 and 250 ml, respectively. Patients were discharged home on postoperative days 4 and 3 without complications. A review of the literature yielded descriptions of a total of 704 major vascular injuries, with 6 case reports of vascular injuries involving the iliac vessels and inferior vena cava with successful laparoscopic repair.
Conclusions Laparoscopic repair of major vasculature is feasible if sound techniques are followed. We describe a stepwise technique for dealing with intraoperative laparoscopic vascular injury.

Keywords Injury · Intracorporeal · Laparoscopic · Repair · Vascular

As the use of laparoscopy becomes increasingly more popular, surgeons need to be fully aware of all potential laparoscopic complications and master optimal techniques to deal with such adverse events. Vascular injury is a rare complication, with a reported incidence of 0.22–1.1 % [1] but with an associated mortality rate of 8–17 % [2]. Patients undergoing complex procedures, especially those involving dissection near major vascular structures and inflammatory processes, have a higher rate of vascular injury [3]. The most common vessels injured are in the vicinity of the distal aorta and iliac vessels, as well as the inferior vena cava and its branches [4]. Most injuries occur during placement of trocars or Veress needle insertion, with some injuries occurring during dissection. Most vascular injuries lead to conversion to laparotomy and immediate repair via an open technique [5]. However, given the standardization and advances of laparoscopic techniques, it may be feasible to repair some of these injuries without conversion.

Here we report what to our knowledge is the first description of successful laparoscopic repair of major vascular injuries during laparoscopic colectomy. We report two case of iliac vessel injury during laparoscopic sigmoid resection and review major vascular injuries reported in the literature with successful control and repair via laparoscopic intracorporeal techniques. A stepwise technique for managing laparoscopic vascular injury is described.

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Materials and methods

The PubMed database was searched for reported cases of vascular injury during laparoscopic cases. The review of the literature included any report describing vascular injury during laparoscopic procedures. Cases were included if a laparoscopic repair of the vessel was attempted. Reports of injuries to all types of vessels were analyzed, but cases involving control of bleeding via clips, electrocautery, sacrifice of vessel, and repair of vessel through an open incision, including extraction site, were excluded.

Results

Case 1

A 75-year-old man with a history diabetes mellitus and hypertension presented with a newly obstructing sigmoid mass. Colonoscopy revealed a nearly obstructing mass at 30 cm from the anus. A positron emission tomography computed tomographic scan revealed a hypermetabolic mass in the distal descending colon with a single hypermetabolic lesion in the liver consistent with metastatic disease. The patient was taken to the operating room for laparoscopic sigmoid colectomy.

Sigmoid colon mobilization was performed in a standard medial to lateral fashion. A small thermal injury to the left common iliac artery occurred while using the monopolar scissors to divide the peritoneum over the left pelvic brim. This resulted in brisk bleeding; control was promptly obtained via insertion of Ray-Tec and application of pressure over the bleeding artery. An additional port was placed so that a member of the surgical team could hold pressure while the colon was mobilized further. The rectum and sigmoid colon were mobilized away from the iliac vessels. The rectum was then divided, allowing for good visualization of the vessels. The area of thermal injury was identified as a 2 mm arteriotomy, and the decision was made to proceed with a primary repair. The defect was repaired via intracorporeal technique by the laparoscopic surgeon with two 5-0 Prolene stitches. The repair of the arteriotomy yielded perfect hemostasis. Intraoperatively patient remained hemodynamically stable with an estimated blood loss (EBL) of 300 ml. Postoperatively, the patient did well. He was discharged in stable condition on postoperative day 4 and was doing well at his last follow-up visit 12 months after surgery.

Case 2

A 39-year-old man with a history of HIV presented with 2 week history of obstipation. A colonoscopy was consistent with benign sigmoid stricture, for which he was taken to the operating room for a laparoscopic exploration and possible sigmoidectomy. Intraoperative findings were consistent with a sigmoid volvulus.

A sigmoid colectomy was performed in a standard medial to lateral fashion. A thermal injury to the left external iliac vein occurred during dissection of the peritoneum over the left pelvic brim (Fig. 1, video 1). Bleeding was controlled via direct pressure using Ray-Tec while the colon was mobilized, allowing for better visualization of the injury and the vessel (Fig. 2, video 2). Once visualization was obtained, a 3 mm venous laceration was noted. Hemostasis was achieved via application of pressure followed by intracorporeal 4-0 Vicryl sutures. Lapra-Ty® and Hem-o-Lok® clips were used in lieu of knot tying, given

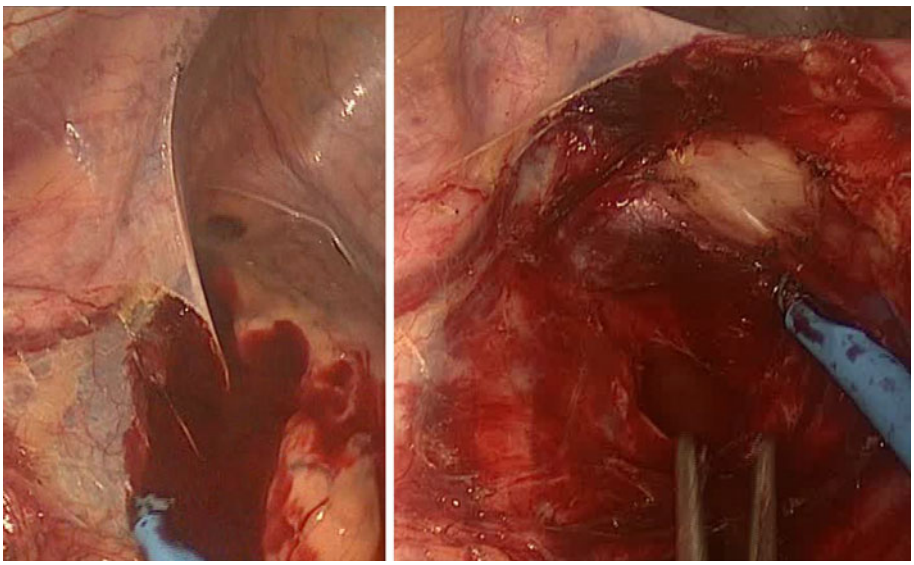

Fig. 1 Thermal injury to the left external iliac vein

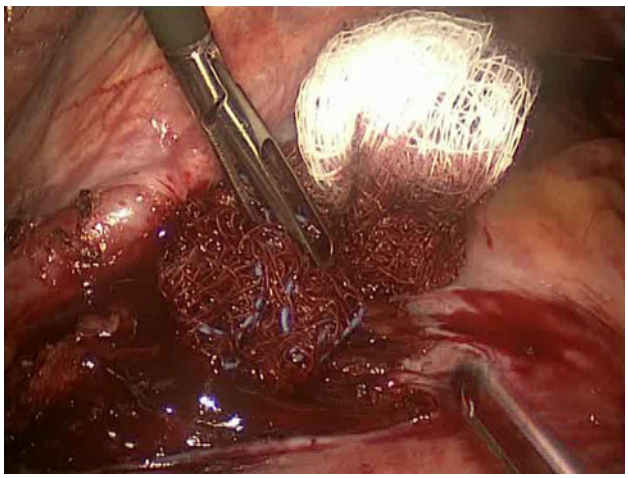

Fig. 2 Rapid control by direct pressure via introduction of Ray-Tec

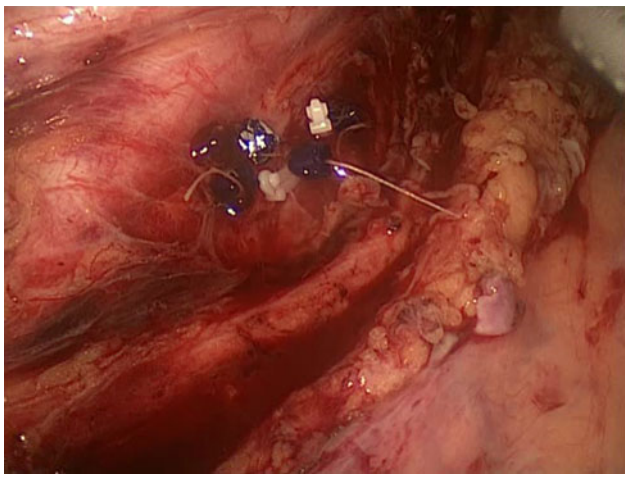

Fig. 4 Repaired iliac vein injury

that the injury was to a low-pressure system (Figs. 3, 4, video 3). The patient remained hemodynamically stable during the entire procedure, with an EBL of 250 ml. Postoperatively, the patient did well and was discharged home on postoperative day 3. He was doing well at his 3 month postoperative visit.

Literature review

A review of the literature yielded descriptions of 704 cases of major vascular injury during laparoscopy [1–48]. Technical details were available for 198 cases. Conversion was necessary in 136 of these cases, for a conversion rate of 69 % [1–4, 6–34] (Fig. 5). Of the 198 cases with technical details reported, 27 % achieved hemostasis laparoscopically via the use of clips, staplers, and electrocautery [7, 23, 24]. These cases were excluded because they did not involve repair of vessels. The remainder of the 136 cases were repaired via laparotomy. Only six reports for a total of nine injuries described major vascular repair via laparoscopic technique (Table 1) [1, 3, 6–9]. This included eight urological cases and one gynecological case. No colorectal cases of vascular injuries with attempt at repair via laparoscopic technique have been reported. Of the cases reported, four involved injury to the iliac vessels during pelvic dissection, and five involved injury to the inferior vena cava during nephrectomy or adrenalectomy. Average reported EBL, including our reported cases, is 545 ml. Mechanisms of injury included electrocautery, sharp dissection, and avulsion, along with one report of a malfunctioning instrument. Of the cases involving laparoscopic repair, only one postoperative complication involving pulmonary embolism after and inferior vena cava repair was reported [3].

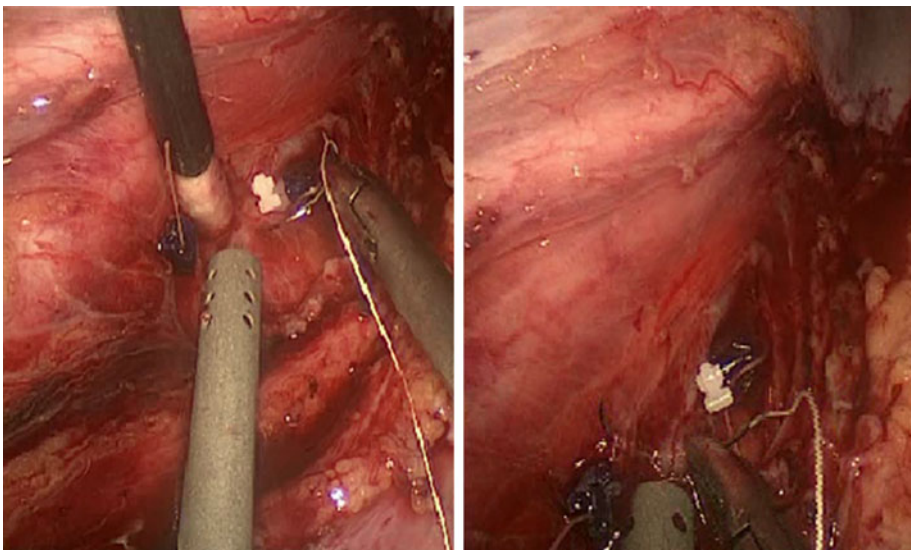

Fig. 3 Assessment and repair of injury

Table 1 Reports of major vascular injuries repaired via laparoscopic technique

Operation (study)	Vessel injured	Mechanism	Type of injury	Control	Laparoscopic technique	EBL
Radical cystectomy [6]	Left external iliac vein	Sharp dissection	1 cm tear	Unknown	Running 5-0 Prolene	550 ml
Nephrectomy with lymph node dissection [3]	Inferior vena cava/lumbar vein avulsion	Dissection	1 cm tear	Compression, exposure via right angle clamp	Fig. 8 ×2 with 3-0 Vicryl	637 ml
Radical prostatectomy [9]	Left external iliac artery	Sharp dissection	Complete transection	Proximal: endo-dissect (Rassweiler; Storz); distal: atraumatic intestinal clamp	End-to-end anastomosis via 4-0 PDS	Minimal
Radical cystoprostatectomy [1]	Right external iliac artery	Dissection via LigaSure	1 cm thermal tear	Proximal and distal control via bulldog clamps used in open surgery (introduced via 10 mm ports)	Fig. 8 ×2 with 5-0 Prolene	Unknown
Lymphadenectomy [8]	Right external iliac artery	Sharp dissection	Laceration	Proximal and distal control via Yasargil clamps	Interrupted 6-0 Prolene sutures ×2	Unknown
Right adrenalectomy [7]	Inferior vena cava	Clip applier malfunction	5 mm tear	Compression, placement of an additional 10 mm port	3-0 Prolene	1000 ml
Sigmoidectomy	Left external iliac vein	Dissection via Bovie	3 mm thermal injury	Compression, exposure via further dissection	Fig. 8 ×2 with 4-0 Vicryl	250 ml
Sigmoidectomy	Common iliac artery	Dissection via monopolar scissors	2 mm thermal injury	Compression, exposure via further dissection	Fig. 8 ×2 with 5-0 Prolene	300 ml

EBL estimated blood loss

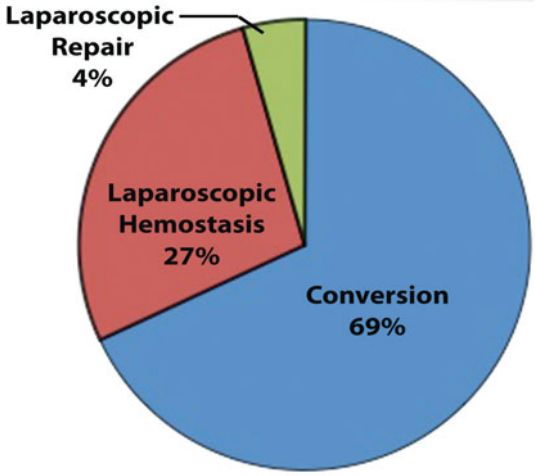

Fig. 5 Distribution of techniques used to achieve control during major vascular injury

Discussion

The most commonly injured major vessels during laparoscopic surgery are the aorta, iliac vessels, and inferior vena cava [49]. The majority of vascular injuries reported in the literature are a result of trocar or Veress needle placement [12]. Major vascular injury is the second most common cause of death during laparoscopy, after death from anesthesia, with a mortality rate of 6.37 % [11, 12]. To our knowledge, no cases of laparoscopic repair of major vascular injury have been reported in colorectal surgery. Colorectal, urological, and gynecological surgeons work close to the iliac vessels. Although vascular injuries are rare, given the increase use of laparoscopy over the years and the greater expertise of surgeons in these fields, it is feasible to consider repair of the injuries without conversion. The above case reports and the review of literature demonstrate that laparoscopic repair of major vascular structure is safe and feasible in experienced hands.

Management of major vascular injuries requires rapid and effective hemostasis, which can initially be accomplished without conversion to laparotomy following the same principles of vascular control used in an open operation: (1) immediate recognition of injury, (2) rapid control via direct pressure, (3) placement of extra port or ports if necessary to obtain pressure/control, (4) further mobilization and exposure of the vessel, (5) reassessment of the injury, and (6) repair of injury utilizing laparoscopic technique or open conversion. Pneumoperitoneum should be maintained with a resulting decrease in venous bleeding [3].

Multiple approaches are available for vascular control, which can be achieved via direct pressure versus introduction of vascular or atraumatic graspers, including bulldog clamps, right angle dissector, or Yasargil clamps (Table 2). This should be followed by exposure of the injured vessel with repair via intracorporeal suturing. It is important to attempt to obtain vascular control before proceeding with the surgical decision of conversion versus laparoscopic repair. Vascular control and repair through a laparotomy may be technically easier, but during conversion severe blood loss may be encountered. Barbosa Barros et al. [11] reported an average of 3.38 L EBL in a case series of seven vascular injuries repaired via conversion during gynecological laparoscopy. The average EBL during the nine cases of laparoscopic repair reviewed and the two cases reported here was 545 ml. Therefore, it should be reiterated that the first reaction after vascular injury should not be conversion, but rather assessment and possible control of the injury. This can be achieved successfully if the above principles are followed.

Table 2 Stepwise technique for laparoscopic repair of vascular injury

1. Immediate recognition of injury
2. Rapid control by direct pressure via introduction of Ray-Tec
3. Placement of extra port or ports to obtain the pressure/control
4. Further mobilization and exposure of the vessel
5. Reassessment of the injury
6. Repair of injury

In the hands of a skilled laparoscopic surgeon, laparoscopic intracorporeal repair of major vascular injury can be attempted. Vascular surgeons should be consulted so that even if the injury cannot be repaired laparoscopically, a minimally invasive method of repair via endovascular access can be attempted, provided that vascular control can be maintained and the patient remains stable.

Disclosures M. D. Jafari and A. Pigazzi have no conflicts of interest or financial ties to disclose.

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