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SURGICAL ENDOSCOPY
and Other Interventional Techniques

Major vascular injuries in laparoscopic surgery

Still of interest?

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Abstract
Background: Major vascular injuries (MVI) still occur in laparoscopic surgery.
Methods: We report our institution's experience of two MVI (aortic lesions) in a series of 3545 laparoscopies (July 1991–December 2000). We compared this experience with other series reporting MVI from Medline, Embase, Current Contents, and Best Evidence.
Results: There were no deaths, but we had 23 postoperative and eight intraoperative bleedings, including two hepatic vessel lesions during dissection and six vascular lesions (four minor vessels and two aortic) related to trocar insertion. Prevention and treatment options are also discussed.
Conclusions: The incidence of MVI reported in the literature is 0.05%, but the true incidence is difficult to estimate because results are not always comparable and there is a possibility of underreporting. The mortality rates (8–17%) are high. No technique or instrumentation is completely safe; therefore, a high level of alertness must be maintained at all times and precautions must be adopted to avoid major complications.

Key words: Major vascular injuries — Laparoscopy — complications — Iatrogenic lesions — Hemorrhagic events

Laparoscopy is now considered the approach of choice for the treatment of many surgical, gynecological, and urological diseases because it offers many advantages in comparison with conventional surgery. Reduced surgical trauma, minimal postoperative pain, and a shortened postoperative hospital stay have made these techniques so popular that the patients themselves now request them [8, 11, 34, 38].

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During the experimental phase and the early years following the introduction of laparoscopic approach into practice, many randomized trials were carried out to compare the validity of minimally invasive and conventional procedures, especially for those that have achieved the greatest acceptance such as video cholecystectomy [9, 12, 15, 18, 38]. The validity of the laparoscopic approach for procedures such as cholecystectomy, adrenalectomy, splenectomy and antigastroesophageal reflux is no longer debated, to the extent that these techniques now represent the so-called laparoscopic gold standard. Despite its popularity, a number of complications specifically related to the laparoscopic approach deserve to be considered with the utmost attention. These complications, such as vascular or visceral injuries that occur while inserting the Veress needle or trocars, are completely unknown in conventional procedures. Injury to the great vessels (aorta, vena cava, iliac arteries, and veins), commonly referred to as major vascular injuries (MVI), are the most severe complications that can occur. Even if the reported incidence is very low (0.05%) [5], the mortality arising from these lesions reportedly ranges between 8% [9] and 17% [5].

Many authors [1, 17, 27, 31, 32, 40] have expressed a degree of perplexity about the reliability of these figures and consider the incidence of MVI—surely the most dramatic event a surgical team can experience—to be underestimated. Therefore, following our personal experience of two aortic lesions [35], we reviewed the literature to study various aspects of these complications. Particular attention was paid to the manner of their occurrence, their prevention, and possible countermeasures that can be adopted.

Materials and methods

From July 1991 to December 2000 in our Department of General Surgery, 3545 laparoscopic operations were performed without operative or postoperative deaths. Among the 65 complications (1.8%) that occurred, the most significant were the hemorrhagic events.

Table 1. Major vascular injuries reported in the literature

First author [ref] (yr)	No. of patients	MVI	Deaths
Peterson [33] (1982)	1	1	1
Deziel [9] (1993)	77,604	36	3
Sigman [40] (1993)	1028	1	0
Apelgrena[a] [1] (1994)	2	2	0
Nordestgaard[a] [29] (1995)	3	4	0
Vasquez [44] (1994)	195	4	0
Saville [36] (1995)	3951	4	0
Champault [5] (1996)	103,852	47	6
Hashizume [19] (1997)	15,422	10	0
Fruhwirth[a] [14] (1997)	7	7	0
Pasic[a] [31] (1998)	4	5	1
Cogliandolo [7] (1998)	106	1	0
Usal [43] (1998)	2589	2	0
Hanney[a] [17] (1999)	2	2	0
Dixon[a] [10] (1999)	5	7	0
Roviaro [Present Series] (2002)	3545	2	0

The table includes only the 16 references (of the 46 in our reference list) in which the number of patients, the number of major vascular injuries, and the number of deaths recorded are clearly indicated

[a] Case report

We recorded 31 bleeds, 23 postoperative and eight intraoperative. Of the 23 early postoperative bleeds, four patients healed with conservative treatment and three required ultrasound-guided percutaneous drainage of the collection. The remaining 16 patients underwent redo operation; in 11 cases, the problem was resolved laparoscopically, but the other five patients required laparotomy. In nine cases, the bleeding source could not be identified, but clot removal and thorough rinsing of the cavity eliminated the bleed. Among the remaining patients, the bleeding source was found at the site of port insertion in four cases, whereas in three others, the bleeding originated from small vessels at the hepatic hilum.

Of the eight intraoperative bleeds, two occurred during isolation of the hepatic hilum, and laparotomy was necessary to identify the source of the bleeding. The remaining six bleeds occurred during the introduction of the Veress needle or the trocars. In four patients, the lesion involved omental or mesenteric vessels and was controlled through the same laparoscopic approach in three cases. In the fourth case, an accidental lesion of the middle colic artery produced a conspicuous hematoma; conversion to the open approach was required to control the bleeding with two transfixed stitches.

Finally, we recorded an aortic lesion in two patients during insertion of the trocars. In one case, a sudden fall of arterial pressure and increased heart rate when the operation was almost over prompted exploration of the cavity, which revealed a large mesentery hematoma. An emergency laparatomy was therefore performed. A linear lesion of the infrarenal aorta was discovered and sutured. In the second case, during the final routine exploration of the cavity, when we always look for possible bleeding from the trocar insertion sites, a conspicuous retroperitoneal hematoma with no leakage into the cavity and no alteration of the vital parameters was discovered. Emergency open laparotomy was performed. A punctiform lesion of the aortic carrefour was detected and repaired.

Since 1996, we have used an open technique to gain access to the peritoneal cavity. In this technique, the muscular fascia is incised at the umbilicus; alternatively, the trocar is inserted with an optical introductor, the trocar Optiview (Ethicon—Endo-surgery, Inc., Cincinnati, OH, USA). We have had no further major vascular injuries since that time.

References were searched in the major data banks available on the Internet (Best Evidence, Current Contents, Embase, and Medline). The available literature reports 1600 articles on general complications during laparoscopy, but only 46 of them describe MVI.

Discussion

Hemorragic complications can occur in laparoscopic surgery during the early maneuvers required to enter the peritoneal cavity, or during the surgical dissection required for the specific procedure. Bleeding from the Veress needle or trocar insertion sites is peculiar to laparoscopic surgery, while bleeding from dissection maneuvers can also occur during conventional surgery. MVI involving the aorta, the vena cava, and the iliac arteries during diagnostic laparoscopy were reported throughout the 1970s and 1980s. Since the advent of laparoscopic surgery, this type of injury is even more relevant and still represents the most fearsome complication [3]. Though rare, the occurrence of MVI is lethal in a high proportion of cases. As early as 1992, an analysis of >77,000 laparoscopic cholecystectomies identified 36 cases of retroperitoneal great vessel lesions (0.05% of all complications) and carried an 8.8% mortality [9]. A later review of different multicentric studies involving 103,852 laparoscopic procedures confirmed the same incidence of MVI (0.05%), but with a higher mortality rate (17%) [5]. In succeeding years, MVI were regularly reported with similar figures (Table 1) [13, 19, 43, 44, 45].

This incidence might seem almost insignificant in view of the considerable number of laparoscopic procedures carried out worldwide. However, a careful analysis of the literature shows that at least five authors believe that the incidence of MVI is seriously underestimated [1, 17, 27, 31, 40]. Besides surgeons who carry out scientific activity or take part in multicentric studies, there are those who do not publicize their experience or do so in local or national papers that are not cited in *Index Medicus* and are therefore destined to remain unknown. Furthermore, no country actually requires cumulative national records of specific diseases to be kept, and even when such records are kept, only selected centers are allowed to participate [6]. More precise data, again limited to the lethal cases, could be obtained from national statistics centers; however, this option, which is difficult enough to achieve nationwide, is almost unachievable on a worldwide scale.

Another problem derives from the inaccuracy of collected data. Although a historic work [9] reported 36

cases of MVI in 1992, 3 years later another paper [29] cited only 20 reports in the literature. However, in 1995, a third study [5] reported that 47 MVI had occurred in >100,000 laparoscopic procedures carried out by 135 teams in hospitals throughout France.

From the literature, it is impossible to estimate the precise incidence and death rate of MVI with a high degree of accuracy. In our review, we found only 16 authors who specifically mentioned MVI [1, 5, 7, 9, 10, 14, 17, 19, 29, 31, 33, 35, 36, 40, 43, 44] and reported complete and homogeneous data and were therefore comparable.

In view of these incongruities, we believe it is important to direct the attention of young surgeons in particular to this ever-present danger, which is a true sword of Damocles hanging over laparoscopic surgery. Access to the peritoneal cavity is the most crucial phase of laparoscopy. Over three-quarters of MVI occur during insertion of the Veress needle and especially of the trocars at the beginning of the procedure [5, 6, 19, 32]. The most frequently reported causes are inexperience of the surgeon [5, 14]; insufficient acquaintance with the relationship between anatomical landmarks, especially between the abdominal wall and retroperitoneal vascular structures [14]; physical characteristics of the patient; thickness of the fascial layer; the position of the patient on the operating table during access to the peritoneal cavity [1, 4, 31]; the direction of the Veress needle or of the trocars and the strength applied during their insertion.

Knowledge of anatomic relationships is very important to avoid lesions. In one study [20], the aortic carrefour was found to be cephalad to the umbilicus in >50% of nonobese patients. This percentage gradually decreased as the body mass index (BMI) increased; however, the aortic bifurcation remained cephalad to the umbilicus in ≤30% of obese patients. The same study demonstrated that the left iliac vein always crossed the median line cephalad to the umbilicus, regardless of the patient's physical characteristics.

Another important anatomic relationship concerns the distance between the skin and the retroperitoneal vascular structures. In a study reporting an aortic lesion that occurred during the incision of the skin at the umbilicus [17], the distance between the umbilicus and the aorta was analyzed. The study reported that, particularly during general anesthesia and the ensuing muscular relaxation and lateral displacement of the bowel, this distance could be reduced to a little over 2 cm.

The position of the patient on the operating table is also significant. In patients of medium height with an estimated distance of ~6 cm between the retroperitoneal vascular structures and the skin [20], the Trendelenburg position determines an anterior rotation of the sacral promontory, which brings the aortic bifurcation dangerously near the skin [31, 41].

Another important factor is the position of the surgeon, who must stand along the side of the patient where the trocar will be introduced. In our first case of MVI, the right lateral trocar was inserted by a surgeon who was standing on the left side of the patient. This position prevented accurate control of the direction and force of insertion, a problem that was further enhanced by the strong resistance of the fascia that is typical of young patients.

Different authors variably consider the relevance of a surgeon's experience in preventing the occurrence of MVI. Many authors consider experience to be important [5], even a crucial [10] factor for preventing MVI, which occur more frequently during a surgeon's first 100 laparoscopic operations [1]. However, others [36] claim that MVI occur sporadically, even throughout the careers of experienced laparoscopic surgeons, and assign less importance to the learning curve [31]. The statement that complications occur in inverse proportion to a surgeon's experience is generally true. However, both the young resident and the experienced surgeon are affected differently by having been personally involved in such a dramatic experience as a MVI, rather than just having read about it in the literature.

In an attempt to overcome this risk, trocars have undergone steady improvement, and new techniques for access to the peritoneal cavity have been devised since the mid 1990s. The main breakthroughs in this search for greater safety have been the development of a protective sleeve for trocars, blunt-tipped trocars, Veress needles, and "optical" trocars that allow direct recognition of each layer of the abdominal wall during access to the peritoneal cavity [37]. However, it is now clear that without a meticulous and cautious technique, none of these safety devices can eliminate the risk of a MVI [14]. In 1996, the Food and Drug Administration (FDA) admonished the manufacturers to use the term "shielded cannula" [31] and to avoid the term "safety trocar" when describing cannulas with a blunt tip or a retractable sleeve because a number of MVI had occurred despite the use of these instruments [1, 5, 6]. Significantly, in just two years (1998 and 1999), there were eight papers reporting that had occurred despite the introduction of these devices and the increasing international experience in laparoscopic surgery [7, 10, 17, 22, 28, 31, 43].

Other precautions employed by surgeons include, for normosomic patients, introducing the Veress needle inclined caudally at 45° to avoid the aortic carrefour [14, 17] and applying to the anterior abdominal wall with Bachaus forceps to increase the distance from the iliac vessels before starting the umbilical incision [6, 31]. Some surgeons [31] have advocated inducing a high-pressure (25–30 mmHg) peritoneum before inserting the first trocar; others prefer to use the open technique to gain access to the peritoneal cavity, with or without a Hasson trocar [4, 5, 10, 31, 40, 45]. The Hasson has apparently gained the approval of surgeons because it is simple to use and particularly because it yields excellent results [16].

It has been repeatedly stated that the only way to avoid an MVI is to induce the pneumoperitoneum with an open technique [4, 20, 24, 30, 35]. Statements such as "Major Vascular Injuries can be completely eliminated by routine use of laparoscopy" [24] are certainly not valid in common practice; indeed, such claims "may lead to a dangerously false feeling of security" [17]. Even

when a "perfect" technique is employed and innovative instruments are used, the risk of MVI is by no means eliminated, as proved by the few cases of MVI that occurred in 1999 despite the use of an open technique and a Hasson trocar [17, 45].

MVI can present in different manners, from the most serious and emblematic, as in our first case, with rapid evidence of initial stage hypovolemic shock, to the development of a retroperitoneal hematoma with no clinical symptoms or signs of hemodynamic alteration, as in the second case of our experience.

MVI have sometimes been treated via a direct laparoscopic approach [6, 28, 42], although in these cases the lesion was incurred under direct laparoscopic vision. This event differs from the unwitnessed but clinically suspected MVI sustained during access to the peritoneal cavity; according to the literature, these injuries have never been managed laparoscopically. The literature shows that five of six patients who had not been managed with laparotomy died; the only survivor had a small hematoma located at the aortic carrefour that had probably been caused by the Veress needle and was discovered intraoperatively [2, 17, 21, 41, 42].

There have been cases of evident hemoperitoneum and even cases of bleeding that are diagnosed during the postoperative course [25, 33]. Early diagnosis is crucial for reducing mortality and other consequences [23, 25, 29, 30, 33]. Several deaths due to delayed diagnosis of MVI have been reported [17, 28, 33, 46]. In at least three such cases [17, 33, 39], diagnostic laparotomy was delayed because the condition was ascribed to carbon dioxide (CO_2) gas embolism. Although it is a difficult differential diagnosis, CO_2 gas embolism occurs ~100 times less frequently than an MVI and to date has never been reported during an "open" laparoscopy [17]. A delay in diagnosis can be due to a number of factors, the most important being the absence of blood in the peritoneal cavity or the presence of a large retroperitoneal hematoma, which can easily go undetected.

The larger the lesion, the harder the management. Multiple lesions to major vessels (such as to the aorta and iliac vessels, or to the aorta and vena cava, etc.) or even contemporary anterior and posterior vessel wall lesions may occur. Clumsy clamping of the vessels can also lead to further injury [4, 14, 17, 23, 36, 39, 41, 46]. Specific competence in vascular surgery is sometimes required to apply artery patches or prostheses.

Legal implications are inevitable. The legal ramifications of major vascular injuries occurring during laparoscopic surgery were addressed in the surgical literature by a single French article that reported 21 cases of MVI, with a total of eight deaths and four serious sequelae were reported [26]. The author stated that "the surgeon was not inexperienced but rather well trained in this kind of surgery" and suggested that all surgeons who perform laparoscopic surgery should receive training in vascular surgery, or at least operate in centers that allow immediate emergency vascular surgery.

Conclusions

Laparoscopic surgery has proved to be a safe technique with lower morbidity and mortality rates than conventional surgery. Nevertheless, the risk of specific laparoscopic complications such as MVI that, however rare, are reported in the literature with a certain frequency, must therefore inspire the surgeon to proceed with the utmost caution.

MVI represent the second most common cause of death for laparoscopic procedures after anesthesia related causes, but it is commonly believed that the exact number and frequency of actual cases are underestimated, due to incomplete records.

No complication is a more severe and dramatic event than a MVI caused by the insertion of a needle or a trocar, especially if the patient dies. For the surgeon, this kind of event is psychologically equivalent to having stabbed the patient during anesthesia. None of the "tricks" that are adopted singly are totally safe; and, at present, no technique is so perfect as to ensure that the risk of MVI occurrence is completely obviated. In our opinion, in addition to several technical solutions that have been provided by modern industry and a number of innovative solutions determined by each surgeon's individual creativity, the best way to avoid such a dreadful event is simply to keep in mind that this catastrophe can in fact occur. The surgeon must always be wary of the dangerous sense of self-confidence and security that may be induced by the practice of routine procedures. Above all, surgeons must never ascribe these complications to their colleagues' inexperience or superficiality, but always bear in mind that such a catastrophe lies in wait during every moment of their daily practice.

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