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LAPAROSCOPIC VASCULAR SURGERY IN 2007
Jean Picquet, Oscar J. Abilez, Jérôme Cau, Olivier Goëau-Brissonnière, and Christopher K. Zarins

Vascular surgery has been one of the last fields in surgery to incorporate laparoscopy. This may largely be the result of the fact that laparoscopic control of bleeding remains challenging and vascular procedures inherently involve bleeding. However, recent improvements in laparoscopic approach, exposure, and instrumentation have resulted in an increase in the number of surgeons performing laparoscopic vascular surgery (LVS). Here, we present an overview of the current advantages, disadvantages, and special considerations of LVS and provide a description of the laparoscopic technique for aorto-bifemoral bypass.

CURRENT INDICATIONS AND LIMITATIONS

Laparoscopy is a surgical approach and must not change the indications or contraindications for surgery. This means that the same type of operation is performed laparoscopically as it is performed conventionally (e.g., the proximal and distal targets of a bypass are independent of the surgical approach). Currently, LVS is mainly performed for the treatment of aorto-iliac occlusive disease and abdominal aortic aneurysms. For aorto-iliac occlusive disease, LVS has become complementary to endovascular repair. The Transatlantic Society Consensus (TASC) has described the respective indications for conventional and endovascular repair for occlusive diseases. From these guidelines, patients not amenable to endovascular repair (TASC types C and D) [1], and with nonmassive aortic calcifications, represent the most suitable candidates for LVS. It should be noted that major calcifications represent the largest limitation to laparoscopy. However, such barriers can be overcome with surgeon experience and skill, as has been the case for other newly introduced techniques. For example, the tortuous character of the iliac arteries was first considered a major limitation for endovascular aortic aneurysm repair, but this became less important with increasing operative volume.

ADVANTAGES OF LAPAROSCOPY

The specific advantages of laparoscopy have been demonstrated in comparison with open procedures. Greater magnification, less risk of adhesion formation, less abdominal wall injury, less risk of hernia development, better cosmetic outcome, less pain, shorter hospital stay, and faster recovery after major procedures are the main advantages.[2]

Furthermore, the same vascular grafts are used in laparoscopy and in open repair. Therefore, their long-term patency rates are expected to be similar.

SPECIFIC CONSIDERATIONS

Laparoscopy in vascular surgery presents special challenges when compared with laparoscopy in other specialties. Procedures in vascular surgery are about reconstruction instead of extirpation. Moreover, major bleeding risk (without the possibility of aspiration due to loss of pneumoperitoneum and visibility) is inherent to operating on large vessels. Special instrumentation is required and has been developed for LVS. The need for sutures and laparoscopic clamps to be safe and powerful enough to be used on calcified vessels has also been addressed.[3,4]

DISADVANTAGES OF LAPAROSCOPY

The history of LVS emphasizes the difficulties met by the pioneers. Dion and Gracia [5–7] were the first to perform and report total laparoscopic aorto-bifemoral bypass and abdominal aortic aneurysm repair and much is due to them and their team in this field. But before becoming a reliable technique, two kinds of problems arose: inadequate aortic exposure [8] and difficulty creating anastomoses.[9,10]

A direct intraperitoneal approach of the aorta was first used. The major difficulty was the management of the small bowel that blocked the operative field. Some surgeons created complex retractors that were never proven to be usable except by their designers.[11,12]

In addition, creating anastomoses presented a big challenge. Surgeons recorded their anastomoses-related times to determine their learning curve and tried to approach the conventional procedure standards. Some found other means to avoid these problems. Laparoscopic hand-assisted procedures allowed some surgeons to feel more comfortable with the time required for anastomosis; this came at the price of a minilaparotomy, which reduced the interest of laparoscopy.[13,14] Others used a minilaparotomy to perform the anastomosis with an open approach after laparoscopic dissection [15], also reducing significantly the advantages of laparoscopy.

Then the concept of the intraperitoneal plus extraperitoneal approach was introduced. This approach gives a large and stable aortic exposure without the need for any specific retractors, thus greatly improving the procedure.[16–18] This approach is described below for aorto-bifemoral bypass.

The tension of oversewing was also considered a problem because most vascular surgeons need an assistant to maintain good tension on the suture during a conventional open procedure. Specific sutures with fixed pledgets now help the surgeon perform
Figure 19.1. Port placement for laparoscopic aorto-bifemoral bypass.

The disadvantages of LVS have been addressed with better laparoscopic exposure along with improved anastomosis technique; these improvements have recently resulted in an increase in the number of surgeons performing LVS, and now larger series have been reported.[19]

**CURRENT LAPAROSCOPIC TECHNIQUE FOR AORTO-BIFEMORAL BYPASS**

The laparoscopic procedure begins with the patient placed in the supine position. All the ports are introduced as shown in Figure 19.1, and pneumoperitoneum is established up to 15 mm Hg. An inflated pillow placed under the left flank of the patient provides a 45° rotation and allows the surgeon to make an incision of the peritoneum along the left paracolic gutter from the sigmoid to the splenic flexure. A right rotation of the operative table adds 45° of rotation to the patient who is now in a complete right lateral decubitus position. While rotating the patient, the left arm is moved to the right, in front of the patient’s face to avoid any brachial plexus injury (Figure 19.2). The descending colon is mobilized to the right by dissection along the avascular line of Toldt. The small bowel is then retracted safely out of the operative field. The procedure then continues in the retroperitoneal space. Particular attention is given to staying anterior to the left kidney during the dissection. The left renal vein is identified as an important landmark to find the infrarenal aorta. Dissection of the aorta is performed down to its bifurcation. The operative field can be maintained by fixing the left colon to the mid-anterior abdominal wall by one or two stitches. The left kidney will tend to obscure the operative field and can be fixed by a stitch to the left abdominal wall. When complete exposure is achieved, a bifurcated graft is introduced inside the abdominal cavity through a trocar. The graft has been previously fashioned for an end-to-end or end-to-side anastomosis, and its left limb has been temporarily ligated at its end. The right limb of the graft is brought into the right groin region (which has been previously dissected free) alongside the right iliac arteries and under video- scopic control. The left limb is left inside the abdomen while performing the anastomosis, allowing the surgeon to rotate the graft during this time or, after declamping, to control any leak by adding other sutures. After systemic heparinization, the aorta is occluded proximally and distally by two laparoscopic clamps (Figure 19.3). The aorta is opened as required. An end-to-end or end-to-side anastomosis is performed with two semicircular running sutures beginning at the distal end of the aortic incision for an end-to-side anastomosis, and at the posterior aortic wall for an end-to-end anastomosis. Figure 19.4 shows the initial suture

Figure 19.2. Patient in right lateral decubitus for laparoscopic aorto- bifemoral bypass.

Figure 19.3. Suprarenal occlusion with laparoscopic clamps. LRA, left renal artery; IRA, infrarenal aorta.

Figure 19.4. Initial suture being placed in an end-to-side anastomosis.
being placed in an end-to-side anastomosis. Pledged sutures make it possible to maintain good tension for creating a leak-free anastomosis. To complete the anastomosis, the two sutures are tied together at the proximal end of the aortic incision or at the anterior aortic wall. After declamping the aorta, the left limb is brought into the left groin region. The proximal anastomosis is inspected for leaks while returning the patient to the supine position under direct videoendoscopic observation. During rotation, the left colon falls into its anatomic position, covering the aorta and the graft. It is naturally maintained in place by the overlying small bowel. Figure 19.5 shows the graft in place after removal of the aortic clamps. Distal femoral anastomoses are then performed after flattening the table. The trocars are removed and the puncture sites are reapproximated.

THE ROLE OF LAPAROSCOPY IN VASCULAR SURGERY

As in any relatively new technique, laparoscopy’s place in vascular surgery remains to be defined. We can hypothesize that it should not replace endovascular repair in the TASC A and B indications for aorto-iliac occlusive diseases as endovascular techniques have shown excellent results with minimal adverse events. However, laparoscopy competes with open repair for the treatment of TASC C and D occlusive diseases in select patients who are typically younger and at lower risk. For instance, a 60-year-old patient with complete aortic bifurcation occlusion without major operative risks would be a good candidate for LVS.

Laparoscopic aneurysm repair has also been demonstrated to be feasible and reliable.[20] However, with the emergence of endovascular repair as the standard for aneurysm disease, laparoscopy will face difficulty in finding its place.

More complex and varied laparoscopic vascular procedures have already been performed [21–23], demonstrating the potential for laparoscopy in replacing most conventional open procedures, as in other fields of surgery.[24] Over the last decade, endovascular repair has taken such an important place that all vascular surgeons absolutely have had to learn it, and it is now a part of most residency and fellowship programs. Specific training,

which remains particularly important to reach technical success in laparoscopy, now needs to be conveyed to the young generation of vascular surgeons.[25]

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1. Management of peripheral arterial disease (PAD), TransAtlantic Inter-Society Consensus (TASC). J Vasc Endovasc Surg. 2000;19(supp1 A):S1–SXXVII.


COMPlications in laparoscopy

section 20.1. major vascular injury

oscar j. abilez, jean picquet, and christopher k. zarins

introduction

laparoscopy is an accepted method of treatment in gynecology, general surgery, urology, and pediatric surgery. it is generally safe, is usually well tolerated by patients, and, when compared to its open surgical counterpart, offers the advantages of less postoperative pain, reduced surgical trauma, and a shortened postoperative hospital stay.[1–5] however, as with any surgical procedure, laparoscopy has technique-related complications. one of these complications is major vascular injury (mvi), of which consequences can be quite serious. injuries to the large vessels (aorta, vena cava, iliac vessels, and mesenteric vessels) are commonly referred to as mvi and occur in a variety of laparoscopic fields (see figure 20.1.1, table 20.1.1).[4–11] many of these injuries occur while inserting the veress needle and/or trocars through the abdominal wall and, as a result, do not occur in conventional procedures.[5] while the reported incidence may be low, ranging from 0.05% to 0.14% [9,10,12–15], the mortality arising from these injuries is substantially higher and has been reported to reach up to 17% (see table 20.1.2).[12–14,16] therefore, the rare occurrence of mvi carries with it the risk of a potentially catastrophic outcome.

incidence

mvi 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.[4,5,11,14,16–19] bleeding from the veress needle or trocar insertion sites is specific to laparoscopic surgery, while bleeding from surgical dissection can also occur during conventional surgery (see table 20.1.3).

mvi during diagnostic and therapeutic laparoscopy have been reported since the 1970s.[5–7,12,20–23] though rare, the occurrence of mvi leads to mortality in a high proportion of cases. an analysis of more than 77,000 laparoscopic cholecystectomies identified 36 cases of retroperitoneal great vessel lesions (0.05% of all complications) and carried a mortality rate of 8%.[12] another study involving more than 103,000 laparoscopic procedures confirmed the same incidence of mvi (0.05%), but with a higher mortality rate (13%).[13] in other studies, mvi have been reported with similar figures (see table 20.1.2).[10,14–16,24–28]

several reports have raised the possibility that the incidence of mvi is underreported and underestimated.[11,29–34] in addition, a review of mvi points out the inaccuracy of collected data.[5] in 1992, one study[12] reported 36 cases of mvi, and then 3 years later, in 1995, another study[4] cited only 20 reports in the literature. however, in 1995, a third study[13] reported that 47 mvi had occurred in over 103,000 laparoscopic procedures.

presentation

mvi can present in different manners, with rapid intra-operative evidence of hemodynamic instability, to the development of a retroperitoneal hematoma with no apparent clinical signs or symptoms. some cases of mvi have also been identified during the postoperative course.[4,5,7,14,35]

early diagnosis is important for reducing mortality and other morbidities.[4,7,17,20,35,36] a delay in diagnosis can be due to a number of reasons, such as absence of blood in the peritoneal cavity or the presence of a large undetected retroperitoneal hematoma. several deaths due to delayed diagnosis of mvi have been reported.[7,17,33,37] in a handful of such cases diagnostic laparotomy was delayed because the condition was diagnosed as carbon dioxide (co2) gas embolism.[7,33,38] the probability of co2 embolism has been estimated to be approximately 100 lower than the probability of having an mvi; therefore, mvi should be considered first.[5]

injuries to multiple major vessels (such as to the aorta and iliac vessels, or to the aorta and vena cava) or even simultaneous anterior and posterior vessel wall injuries may occur. in general, these injuries are harder to manage and may necessitate the assistance of a vascular surgeon to place grafts and/or patches.[4,5,17,19]

etiology

more than three quarters of mvi occur during insertion of the veress needle and/or trocars at the beginning of a laparoscopic procedure.[5,9,13,25] the most frequently reported causes are inexperience of the surgeon[10,13,17,30,39]; insufficient acquaintance with anatomical landmarks[10,11,33,40]; the position of the patient during access to the peritoneal cavity[30,32,41]; and surgeon position in inserting the veress needle and/or trocars.[5,16]

surgeon experience

the relevance of a surgeon's experience in preventing the occurrence of mvi is mixed among published reports. many studies consider experience to be an important factor for preventing mvi, which occur more frequently during a surgeon's first 100 laparoscopic operations.[30] however, other
studies [32,42] claim that MVI occur sporadically, even throughout the careers of experienced laparoscopic surgeons. Therefore, care should be taken to avoid MVI, regardless of experience.

Anatomic Landmarks

Knowledge of anatomic landmarks and relationships is very important in helping to avoid MVI. In one study, the aortic bifurcation was found to be cephalad to the umbilicus in more than 50% of nonobese patients.[40] This percentage gradually decreased as the body mass index (BMI) increased; however, the aortic bifurcation remained cephalad to the umbilicus in less than or equal to 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.[5,16] In a study reporting an aortic lesion that occurred during the incision of the skin at the umbilicus, the distance between the umbilicus and the aorta was found to be reduced to around 2 cm.[33] This reduction in distance occurred after the induction of general anesthesia and the subsequent muscular relaxation and lateral displacement of the bowel.

Patient Position

The position of the patient on the operating table is also important.[5] In patients of medium height with an estimated distance of 6 cm between the skin and retroperitoneal vascular structures, the Trendelenburg position causes an anterior rotation of the sacral promontory, which shifts the aortic bifurcation nearer to the skin.[32,40,43] Therefore, this shift should be kept in mind when performing laparoscopy on patients with this body habitus.

Surgeon Position

Another important factor is the position of the surgeon. In one reported case of MVI [5], 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. A simple but effective recommendation is that the surgeon stand on the same side of the patient in which the trocar is being placed to avoid any loss of balance that may occur.

TREATMENT

Treatment usually consists of conversion to open repair, but laparoscopic repair has also been described. In either case, prompt recognition of a vascular injury is key in performing beneficial treatment.

Open

If blood is returned or seen at the needle/trocar insertion site or a retroperitoneal hematoma is identified with the laparoscope, preparation for immediate laparotomy should be made.[4] With a retroperitoneal hematoma, it is not uncommon to have minimal free blood in the intraperitoneal space. Initial control should be obtained with direct pressure on the bleeding site (with hands, packs, or vascular clamps) and then the peritoneum overlying the bleeding site should be opened.[17] At this point, atraumatic control of the injured vessel should be achieved, free blood should be suctioned, and repair accomplished. The bleeding site should be fully exposed and inspected to exclude injury to the back wall of the vessel.[14] For extensive or complicated injuries, it may be necessary to obtain the expertise of a vascular surgeon to assist in the repair.[4,5,17,19]
Table 20.1.2: Literature Reports of Laparoscopic Major Vascular Injuries (MVI)

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Patients</th>
<th>MVI</th>
<th>% MVI</th>
<th>Deaths</th>
<th>% Deaths</th>
<th>Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deziel</td>
<td>1993</td>
<td>77,604</td>
<td>36</td>
<td>0.05</td>
<td>3</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td>Sigman</td>
<td>1993</td>
<td>1,028</td>
<td>1</td>
<td>0.10</td>
<td>0</td>
<td>0</td>
<td>29</td>
</tr>
<tr>
<td>Saville</td>
<td>1995</td>
<td>3,951</td>
<td>4</td>
<td>0.10</td>
<td>0</td>
<td>0</td>
<td>42</td>
</tr>
<tr>
<td>Geers</td>
<td>1996</td>
<td>2,201</td>
<td>3</td>
<td>0.14</td>
<td>0</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>Champault</td>
<td>1996</td>
<td>103,852</td>
<td>47</td>
<td>0.05</td>
<td>6</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>Fruhwirth</td>
<td>1997</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>10</td>
</tr>
<tr>
<td>Chapron</td>
<td>1997</td>
<td>–</td>
<td>17</td>
<td>0.06</td>
<td>0</td>
<td>0</td>
<td>25</td>
</tr>
<tr>
<td>Hashizume</td>
<td>1997</td>
<td>15,422</td>
<td>10</td>
<td>0.06</td>
<td>0</td>
<td>0</td>
<td>26</td>
</tr>
<tr>
<td>Usal</td>
<td>1998</td>
<td>2,589</td>
<td>2</td>
<td>0.08</td>
<td>0</td>
<td>0</td>
<td>26</td>
</tr>
<tr>
<td>Bhojpur</td>
<td>2001</td>
<td>–</td>
<td>407</td>
<td>0.26</td>
<td>6</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Schafer</td>
<td>2002</td>
<td>14,243</td>
<td>12</td>
<td>0.08</td>
<td>2</td>
<td>17</td>
<td>14</td>
</tr>
<tr>
<td>Roviaro</td>
<td>2002</td>
<td>3,545</td>
<td>2</td>
<td>0.06</td>
<td>0</td>
<td>0</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 20.1.3: Vascular Injuries due to Laparoscopic Trocar Placement (from the Medical Device Reports (MDR) of the U.S. Food and Drug Administration (FDA), 1993–1996) [16]

<table>
<thead>
<tr>
<th>Vascular Injury</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-fatal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aorta or IVC</td>
<td>69</td>
<td>17</td>
</tr>
<tr>
<td>Iliac</td>
<td>151</td>
<td>37</td>
</tr>
<tr>
<td>Mesenteric</td>
<td>32</td>
<td>8</td>
</tr>
<tr>
<td>Other</td>
<td>129</td>
<td>32</td>
</tr>
<tr>
<td>Subtotal</td>
<td>381</td>
<td>94</td>
</tr>
<tr>
<td>Fatal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aorta or IVC</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>Iliac</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Other</td>
<td>13</td>
<td>3</td>
</tr>
<tr>
<td>Subtotal</td>
<td>26</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>407</td>
<td>100</td>
</tr>
</tbody>
</table>

Laparoscopic

MVI have been treated via a direct laparoscopic approach, although in many of these cases the injury occurred under direct laparoscopic vision.[9,17,19,44] This differs from the unwitnessed, but clinically suspected, MVI sustained during access to the peritoneal cavity; in the latter case, an open approach is recommended.[4,5,14,17,19] Several reports have shown that in instances where patients were not managed with laparotomy, a significant proportion resulted in death; the only survivor had a small hematoma located at the aortic bifurcation that was discovered intraoperatively.[33,43,44]

Prevention

Trocar Design

In attempts to avoid MVI, new designs for trocars and new techniques for access to the peritoneal cavity have been devised. The main improvements have been in the development of trocars with blunt tips, trocars with protective sleeves, and optical trocars that allow direct recognition of each layer of the abdominal wall during access to the peritoneal cavity.[45–53] However, without good technique, none of these safety devices can eliminate the risk of an MVI.[10] In 1996, the Food and Drug Administration (FDA) advised manufacturers to avoid the term “safety trocar” when describing cannulas with a blunt tip or a retractable sleeve and use the term “shielded cannula” because a number of MVI had occurred despite the use of these instruments.[5,9,13,30,32] The FDA’s advice was justified as subsequently there were several reports of MVI that had occurred despite the introduction of these shielded cannulas (see Table 20.1.3).[5,33,39,54,55]

Trocar Placement

Other precautions employed by surgeons to avoid MVI include applying clamps to the anterior abdominal wall and lifting anteriorly to increase the distance from the trocar insertion site to the iliac vessels.[9,16]

Another precaution is to incline the Veress needle in the sagittal plane caudally at 45 degrees with respect to the anterior abdominal wall to avoid the aortic bifurcation (see Figure 20.1.2).[4,10,11,16,33,56]

In a recent study based on computed tomography (CT) and ultrasonography, the recommendations for the primary trocar

Figure 20.1.2. Angle of insertion of Veress needle and/or trocar to avoid aortic bifurcation. [4,10,11,16,33,56]
Figure 20.1.3. Recommended primary port site in anterior superior iliac spine (ASIS) plane in the midline and recommended lateral port site in the same plane greater than 6 cm from midline.[11] These recommendations are based on the notion that the ASIS represents more of a fixed point when compared to the umbilicus.

Some surgeons induce a high pressure (25–30 mmHg) in the peritoneal cavity 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.[13,16,29,32,39,41] The Hasson trocar has gained the approval of many surgeons because it is simple to use and has yielded excellent results.[15,16] In addition, the combination of inducing pneumoperitoneum with the open technique has been effective in avoiding MVI.

The few cases of MVI that have occurred despite the use of an open technique and a Hasson trocar illustrate that the risk of MVI is always present, even when good technique and instruments with improved designs are used.[41,57,58]

**Surgeon Position**

The operating table should be at a height that allows slight abduction of the surgeon's elbow. The technique for inserting the trocar should rely on the force generated with the entire arm and shoulder. With a twisting motion, the hand, arm, and shoulder should advance the trocar as one unit. By going slowly, the strength of the entire upper extremity can be employed to stop penetration when fascial resistance ceases after the trocar enters the intraperitoneal space.[16] In all cases, the trocar should be directed away from the aorta and iliac vessels in the event the trocar penetrates more deeply than intended.

**CONCLUSIONS**

Major vascular injury (MVI) in laparoscopy commonly refers to injury of the large vessels (aorta, vena cava, iliac vessels, and mesenteric vessels). Although its reported incidence is low, the mortality arising from these injuries is significant. In addition, the true incidence of MVI may be underestimated due to underreporting.

MVI can present in several ways, including, at the extremes, intraoperatively with abrupt hemodynamic instability or postoperatively with no initial accompaniment of clinical signs or symptoms. Whatever the presentation, it is important to identify MVI as soon as possible because delayed diagnosis has been shown to end in a high proportion of deaths.

The etiology of MVI is mainly due to the insertion of the Veress needle and/or trocars at the beginning of the laparoscopic procedure. The main treatment for MVI is conversion to open repair, although there have been successful descriptions of laparoscopic repair by experienced laparoscopic surgeons. The important point in either treatment is identifying the MVI as soon as possible. In some instances it may be necessary to obtain the expertise of a vascular surgeon to assist in the repair.

Prevention of MVI has been aided by trocar design, specific techniques for trocar placement, establishment of pneumoperitoneum, and the use of an open technique to gain access to the peritoneum. However, despite these improvements, new cases of MVI still occur.

Although no single factor has been shown to eliminate MVI, knowledge of its presentation, etiology, treatment, and steps for prevention gives insight on how to avoid this potentially catastrophic event.

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