Trocar Site Hernia

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Objective: To review the relationship between the pathogenesis and clinical manifestations of trocar site hernias seeking to confirm the definition of trocar site hernias by classification.

Data Sources: We searched this subject in English on MEDLINE by combining the words “trocar,” “port,” “hernia,” and “laparoscopy.”

Data Extraction and Study Selection: We limited the main operations to cholecystectomy, colon and rectal surgery, fundoplication, and gastric surgery; finding 44 reports on these procedures. Of these, 19 were case reports, 18 were original articles (setting criteria; the incidence of the trocar site hernia was clarified, and involved >100 patients), and 7 technical notes on “how to do it” were collected. We obtained 19 additional reports using the references of those previously obtained. We, thus, reviewed 63 reports (24 case reports, 27 original articles, 7 technical notes, and 5 review articles).

Data Synthesis: Trocar site hernia was classified into 3 types. The early-onset type that occurred immediately after the operation, with a small-bowel obstruction, especially the Richter hernia, frequently developing. The late-onset type that occurred several months after the operation, mostly with local abdominal bulging with no small-bowel obstruction developing. The special type that occurred indicated the protrusion of the intestine and/or omentum. Trocar site hernias with fascial defects of 10 mm or larger should be closed, including the peritoneum. Opinion varied if a 5-mm trocar site defect should be closed.

Conclusion: It is useful to clearly classify trocar site hernias to improve management of laparoscopic procedures.

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As mentioned by Rosen and Ponsky,1 in 1987, Mouret performed the first laparoscopic cholecystectomy dramatically changing surgical practice. The performance of abdominal laparoscopic surgery increased and was widespread by the 1990s.2 The adoption of this new technique resulted in the emergence of new, specific operative complications. Incisional hernias at the site of entry of a trocar is a serious complication in laparoscopy3 because most trocar site hernias require further surgery.4

Fear5 first reported a trocar site hernia in his large series on laparoscopy in gynecological diagnosis. Many authors have recognized this as the first report on trocar site hernias.2,6-8 Maio and Ruchman9 then reported on the trocar site hernia with small-bowel obstruction occurring immediately after cholecystectomy; this being the first report on trocar site hernias in digestive surgery. Since then many reports have been published about cholecystectomy, and more recently on gastrointestinal surgery. In the published reports there is enormously wide variation in the clinical aspects of trocar site hernias; so much so that we became concerned about the meaning of the medical term “trocar site hernia,” as it is not clearly defined.

We reviewed earlier reports on digestive surgery to identify factors that might improve management of laparoscopic procedures. We hope to see the confirmation of a clearer definition for trocar site hernias and recommend our classifications to enable more accurate clinical identification.

Definition and Range of Search

Crist and Gadacz10 defined trocar site hernia as the development of a hernia at the cannula insertion site, and this term has been used in many articles; however, “port site hernia” has also been used in other articles in similar situations. First, we searched this subject on MEDLINE combining “trocar,” “hernia,” and “laparoscopy” and that resulted in 186 reports in

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English. Second, we combined “port,” “hernia,” and “laparoscopy” which resulted in 90 reports in English. We then limited the main operations to cholecystectomy, colon and rectal surgery, fundoplication (ie, operation for gastroesophageal reflux disease), and other gastric surgical procedures (eg, obesity surgery) that are supposed to result in the same operative insult as digestive surgery. Forty-four articles were found on these procedures. Of the 44 reports, 19 were case reports, 18 were original articles (setting criteria; the incidence of the trocar site hernia was clarified, and involved 100 patients), and 7 were technical notes on “how to do it.” We found an additional 19 articles using the references of those obtained (except for 3 gynecological articles). We, thus, reviewed 63 articles (24 case reports, 27 original articles, 7 technical notes, and 5 review articles). We finally chose trocar site hernia as the relevant medical term because it was the most frequently used and the one that most clearly expressed the condition.

CLASSIFICATION

We can classify trocar site hernias into 3 types according to the reported cases (Figure 1). Early-onset type indicates dehiscence of the anterior fascial plane, posterior fascial plane, and peritoneum. The early-onset type was recognized in many case reports as beginning to develop in the early stages after surgery, often presenting as a small-bowel obstruction.

The late-onset type indicates dehiscence of the anterior fascial plane and posterior fascial plane. The hernia sac of late-onset type is the peritoneum. The late-onset type has often been recognized, in many large series, to be related to complications of the trocar insertion. Late-onset type hernias almost always develop in the late stages several months after surgery.

The special type indicates dehiscence of the whole abdominal wall. Protrusion of the intestine and/or omentum (eg, greater omentum) is recognized. The first case, reported by Fear, was of the special type: a loop of the bowel came through a defect as the laparoscope and sheath were withdrawn. Therefore, this first report points us toward expressing a protrusion of the bowel and/or omentum as a “hernia,” although in this type there is no hernial sac. Three case reports of the special type have been published since then.

In morbidly obese patients, a thick preperitoneum predisposes the development of the Richter hernia, despite adequate fascial closure. This type was found in only 2 cases (noted above), and its clinical character is just like the early-onset type. Therefore, we did not create another classification for this type.

It was important to identify which type of trocar site hernia was discussed in a report because every author’s

![Figure 1. Classification of the 3 trocar site hernias. A, Normal stab wound of trocar site. B, Early-onset type: dehiscence of anterior and posterior fascial plane and peritoneum. C, Late-onset type: dehiscence of anterior and posterior fascial plane. Peritoneum constitutes hernia sac. D, Special type: dehiscence of whole abdominal wall. Protrusion on intestine and/or omentum.](1249)
concept regarding it might have been slightly different from another author’s. When we compare the incidence of trocar site hernias among several reports, we should consider the circumstances that the incidence might have been calculated from various kinds of denominators. So in this review we defined these 3 types as the trocar site hernia. We hope that this classification will clarify the definition of a trocar site hernia, enabling more accurate clinical identification and, thus, improving the care of patients.

INCIDENCE

Several large series have been reported related to postoperative complications of laparoscopic cholecystectomy, where the incidence of trocar site hernia was 1 in 500 cases, 17-3 in 1983 cases, 18 1 in 800 cases; 19 11 in 1300 cases; 20 and 10 in 1453 cases. 21 Callery et al7 mentioned that the overall incidence is very low, while Mayol et al22 stated that these figures represent the early results of laparoscopic surgery or gynecologic laparoscopy (ie, mostly diagnostic laparoscopy); currently an increasing number of publications have also drawn attention to this problem. Moreover the true incidence might be much higher than the reported figures as an unknown percentage of patients who are asymptomatic might not seek medical examination. 8,9 Coda et al14 noted that the onset of trocar site hernia occurs later rather than immediately after surgery and might elude a surgeon in many surveys unless an extended follow-up procedure has been established. Recently, the incidence of trocar site hernia has been written about as a postoperative complication in gastrointestinal surgery (colorectal surgery for cancer, 0.6%-23; colectomy for sigmoid diverticulitis, 0.9%24; Roux-en-Y gastric bypass, 0.3%25 and 1.0%26; and gastric banding, 0.5%27).

Since 1995, large series on digestive surgery that focus on the theme of complications of the trocar site have been published (Table 1). The incidence of trocar site hernia has shown to be 0.65% to 2.80%. The studies based on Mayol et al et al and Nassar et al were based on data collected prospectively, and patients have been followed up for a minimum of several months; therefore, it is supposed that the incidence reported by them (1.50%-1.80%) would be reasonably standard.

PATHOGENESIS

Technical Factors

Trocar Size. Crist and Gadacz10 regarded the use of a large trocar as one of the factors predisposing the develop-

<table>
<thead>
<tr>
<th>Source</th>
<th>Study</th>
<th>Follow-up</th>
<th>Original Surgery, No. of Patients</th>
<th>No. of Cases of TSH</th>
<th>Incidence, %</th>
<th>Delay After Laparoscopy, Mean (Range)</th>
<th>Main Clinical Manifestation, No. of Cases</th>
<th>Hernia Site</th>
<th>Trocar Size in TSH, mm</th>
<th>Fascia in TSH Site</th>
<th>Closed or Left Open, No. of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Azurin et al, 1995</td>
<td>Retrospective 1 surgeon</td>
<td>Postoperative visit</td>
<td>Cholecystectomy, 1300</td>
<td>10</td>
<td>0.77</td>
<td>8 mo (5 d-2 y)</td>
<td>Hernia without SBO, 6; Richter hernia, 1</td>
<td>Umbilical, all</td>
<td>10</td>
<td>Closed, all</td>
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<tr>
<td>Mayol et al, 1997</td>
<td>Prospective database</td>
<td>Range, 3-51 mo</td>
<td>Cholecystectomy, 373; fundoplication, 8; colon surgery, 9; other abdominal operations, 13</td>
<td>6</td>
<td>1.50</td>
<td>Not written</td>
<td>Hernia without SBO; all</td>
<td>Umbilical, all</td>
<td>10</td>
<td>Closed, 5, left open, 1</td>
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<tr>
<td>Nassar et al, 2001</td>
<td>Prospective Second appointment; 2-6 mo</td>
<td>Cholecystectomy, 870</td>
<td>16</td>
<td>1.8</td>
<td>6 mo (2-18 mo)</td>
<td>Hernia without SBO, 15; SBO, 1</td>
<td>Umbilical, 15; right side, 1</td>
<td>Closed, 1</td>
<td>10</td>
<td>Right side, 5</td>
<td></td>
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<tr>
<td>Sanz-Lopez et al, 1999</td>
<td>Prospective Mean, 3 y; range, 1-5 y</td>
<td>Cholecystectomy, 123</td>
<td>2</td>
<td>1.6</td>
<td>14 mo; (10-18 mo)</td>
<td>Hernia without SBO, all</td>
<td>Umbilical, 1; umbilical and xiphoid, 1</td>
<td>Closed, 2; left open, 1</td>
<td>10</td>
<td>Closed</td>
<td></td>
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<tr>
<td>Coda et al, 2000</td>
<td>Retrospective</td>
<td>Laparoscopic surgery, 1227 (94% biliary tract)</td>
<td>13</td>
<td>1.0</td>
<td>8.8 mo; (3-36 mo; except protrusion, 1)</td>
<td>Hernia without SBO, 11; strangulation, 1; protrusion of omentum, 1</td>
<td>Umbilical, 12; right side, 1</td>
<td>Closed, all</td>
<td>11-12</td>
<td>Closed</td>
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<tr>
<td>Bowrey et al, 2001</td>
<td>Retrospective Mean, 12 mo; range, 6 wk-81 mo</td>
<td>Fundoplication, 320</td>
<td>9</td>
<td>2.8</td>
<td>(4-21 mo)</td>
<td>Hernia without SBO, all</td>
<td>Umbilical, all</td>
<td>10</td>
<td>Closed</td>
<td></td>
<td></td>
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<tr>
<td>Susmallian et al, 2002</td>
<td>Retrospective Not written</td>
<td>Gastric banding, 459</td>
<td>3</td>
<td>0.65</td>
<td>3 wk-4 mo (6 mo)</td>
<td>Hernia without SBO, all</td>
<td>Left upper</td>
<td>11</td>
<td>Left open, all</td>
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<td></td>
</tr>
</tbody>
</table>

Abbreviation: SBO, small-bowel obstruction.
ment of a hernia. Many authors have mentioned that a direct relationship of trocar size to the risk of subsequent herniation seems reasonable. Although the following data are related to gynecologic surgery, in the survey of the American Association of Gynecologic Laparoscopists, 36 of 840 trocar site hernias, 725 (86.3%) occurred in sites where the diameter was at least 10 mm. Only 92 hernias (10.9%) occurred at a site of insertion of ports at least 8 mm in diameter but smaller than 10 mm, with 23 (2.7%) occurring in sites where ports were smaller than 8 mm. (They estimated that 41.3% of all ports used were at least 10 mm.)

In the large series summarized in Table 1, trocars 10 mm or larger were used at 58 of 59 hernia sites. In the case reports listed in Table 2, trocar size was recorded in 24 ports (23 cases). In these cases, 10-mm or larger trocars were used in 18 hernia sites, an 8-mm trocar was used in 1 site, and 5-mm trocars were used in 5 sites. Although it is plain that the larger the trocar size, the higher the incidence of trocar site hernia, we cannot ignore the fact that trocar site hernias still occurred at 5-mm ports.

Closing Fascial Defects or Leaving Them Open. Some authors have doubted that any effects of fascial closure are related to a trocar site hernia. Duron et al2 stated that although it has been stated that fascia closure of trocar holes, which is sometimes difficult, might preclude or decrease the incidence of obstructions, our experience as well as that reported in the literature indicates that adhesions or incarcerations, whether median or lateral, can still occur after fascial closure. It was reported that an incomplete closure might lead to a trocar site hernia; so it could be supposed that the doubt expressed by Duron et al might be related to improper suturing. However, many surgeons have advised fascial closure of the trocar site. Th24,30,31,34,35 Though the following result is related to gynecologic surgery, the closure of a fascial defect due to a 12-mm trocar significantly decreased the rate of developing a trocar site hernia compared with leaving it open.11

In the large series summarized in Table 1, port site fascia were closed at 55 sites and left open at 5 (1 case had 2 hernia sites). The 22 cases that identified whether the fascia was closed or not are listed in Table 2; the fascial defect was closed in 8 and left open in 14.

We think that leaving the fascial defect open is clearly correlated with a trocar site hernia. Probably insufficient closure, which sometimes occurs, will also increase the risk of a trocar site hernia.

Open or Closed Laparoscopy. The pneumoperitoneum is established by Veress needle (closed laparoscopy) or the Hasson trocar insertion (open laparoscopy). The incidence of trocar site hernia in closed laparoscopy was higher than in open in the series by Mayol et al.27 They commented that wound infection might be more common in closed laparoscopy, which increases the incidence of trocar site hernia. Wallace and O'Dwyer30 performed open laparoscopy in 568 patients with no postoperative hernias, although the interval of the examination was only 1 week. There were few reports on the subject which lead us to assume that whatever method is performed has little influence on the development of a trocar site hernia.

Location. Many authors have shown that most hernias appeared at the site of midline trocars, and that umbilical sites were most common. Several authors have commented regarding the anatomical and inherent weakness of the parambilical region. Azurin et al4 and Ahmad et al25 reported that an incidental umbilical hernia, which existed preoperatively, lead to a trocar site hernia. Nassar et al26 mentioned the incidence of umbilical or parambilical fascial defects in 12% of patients who had preoperative laparoscopic cholecystectomy. Plaus20 mentioned that puncture sites off the midline might be less susceptible to herniation due to the overlapping of muscle and fascial layers. Duron et al2 stated that the lateral wall is composed of 2 fascial planes and muscle, making it theoretically less prone to dehiscence. There have been 2 other explanations for this. First, that the frequent use of a large trocar in this area leads to a trocar site hernia in the parambilical region; and, second, that the small intestine is less often in contact with a lateral trocar site.3

In a survey of the American Association of Gynecologic Laparoscopists, umbilical hernia was the most common (75.70%), otherwise lateral hernias were found in 23.70% of 152 trocar site hernias.36 This survey included not only therapeutic but also diagnostic laparoscopy as well, and a 10-mm trocar was not used in the lateral port. Therefore, the incidence of trocar site hernias in the lateral region is thought to be higher in digestive surgery than indicated by the data of Montz et al.30 In Table 2, trocar site hernias in the lateral region (except at midline) developed in 13 port sites while those in the midline developed in 17 port sites. We believe that the incidence of trocar site hernia in the lateral region is no less than in the midline.

Stretching the Port Site for Retrieval. Umbilical wound enlargement to retrieve specimens might be involved in the occurrence of trocar site hernias.12,22 Nassar et al28 mentioned the extension of the umbilical fascial defect as the most significant risk factor in their prospective study. Koppelman et al11 emphasized fascial closure in stretching the trocar site, but McMillan and Watt57 illustrated the need for careful fascial closure of all 10-mm trocar site-related wounds whether or not the gallbladder has been removed through them, and whether or not they have been extended. It is certain that forced dilation of the fascial layer is proposed as an etiological mechanism.33

Effects of Compressed Air. Carbon dioxide might push the omentum or intestinal loops through the point of insertion in the fascia. The protruding structures might then be trapped by abdominal muscle contractions.6,32 Duron et al2 stated that a partial vacuum is created when the port is withdrawn, thus, drawing omentum and intestines into the fascial defect.

Host Problem

Ninety percent of the trocar site hernias in the series by Azurin et al4 occurred in patients with comorbidities such
<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Source</th>
<th>Original Surgery</th>
<th>Chief Complaint</th>
<th>Delay After Laparoscopy</th>
<th>Main Clinical Manifestation</th>
<th>Bowel Resection</th>
<th>Hernia Site</th>
<th>Trocar Size, mm</th>
<th>Fascia in TSH Site Closed or Left Open</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Maio and Ruchman, 1991</td>
<td>Cholecystectomy</td>
<td>Symptom of SBO</td>
<td>3 d</td>
<td>Incarceration of small intestine</td>
<td>Not written</td>
<td>Umbilical</td>
<td>11</td>
<td>Not written</td>
</tr>
<tr>
<td>2</td>
<td>McMillan and Watt, 1993</td>
<td>Cholecystectomy</td>
<td>Symptom of SBO</td>
<td>2 d</td>
<td>Richter hernia</td>
<td>Performed</td>
<td>Umbilical</td>
<td>10</td>
<td>Left open</td>
</tr>
<tr>
<td>3</td>
<td>Case 1</td>
<td>Cholecystectomy</td>
<td>Bulging of subxiphoid</td>
<td>3 mo</td>
<td>Herniation of omentum</td>
<td>Not performed</td>
<td>Subxiphoid</td>
<td>10</td>
<td>Not written</td>
</tr>
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<td>4</td>
<td>Case 2</td>
<td>Cholecystectomy</td>
<td>Bulging of abdomen 7</td>
<td>7 d</td>
<td>Herniation of omentum (2 trocars)</td>
<td>Not performed</td>
<td>Umbilical and suprapubic</td>
<td>12 and 5</td>
<td>Left open</td>
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<td>5</td>
<td>Case 3</td>
<td>Cholecystectomy</td>
<td>Asymptomatic lump</td>
<td>1 y</td>
<td>Incisional hernia</td>
<td>Not written</td>
<td>Subxiphoid</td>
<td>10</td>
<td>Left open</td>
</tr>
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<td>6</td>
<td>Case 4</td>
<td>Cholecystectomy</td>
<td>Asymptomatic lump</td>
<td>1 mo</td>
<td>Incisional hernia</td>
<td>Not written</td>
<td>Subxiphoid</td>
<td>10</td>
<td>Left open</td>
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<td>7</td>
<td>Hass and Schrager, 1993</td>
<td>Cholecystectomy</td>
<td>Symptom of SBO</td>
<td>3 d</td>
<td>Richter hernia</td>
<td>Performed</td>
<td>Umbilical</td>
<td>10</td>
<td>Not written</td>
</tr>
<tr>
<td>8</td>
<td>Case 1</td>
<td>Cholecystectomy</td>
<td>Protrusion of small intestine</td>
<td>5 d</td>
<td>Protrusion of small intestine</td>
<td>Not performed</td>
<td>Subumbilical</td>
<td>10</td>
<td>Left open</td>
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<td>Asymptomatic lump</td>
<td>1 y 6 mo</td>
<td>Herniation of omentum</td>
<td>Not performed</td>
<td>Subumbilical</td>
<td>12</td>
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<td>10</td>
<td>Patterson et al, 1993</td>
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<td>Umbilical</td>
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<td>McMurrick and Polglase, 1993</td>
<td>Repair of rectal prolapse</td>
<td>Bulging of abdomen</td>
<td>2 d</td>
<td>Herniation of small intestine</td>
<td>Not performed</td>
<td>R flank</td>
<td>12</td>
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<td>Cholecystectomy</td>
<td>Symptom of SBO</td>
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<td>Richter hernia</td>
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<td>R side</td>
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<td>Closed</td>
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<td>Symptom of SBO</td>
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<td>Incarceration of small intestine</td>
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<td>R side</td>
<td>10</td>
<td>Left open</td>
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<td>Not written</td>
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<tr>
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<td>Umbilical</td>
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<td>17</td>
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<td>Cholecystectomy</td>
<td>Paraumbilical pain</td>
<td>13 mo</td>
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<td>Incarceration of small intestine</td>
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<td>Not written</td>
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<td>Symptom of SBO</td>
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<td>Richter hernia</td>
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<td>R upper quadrant</td>
<td>5</td>
<td>Left open</td>
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<td>Fundoplication</td>
<td>Symptom of SBO</td>
<td>5 d</td>
<td>Richter hernia</td>
<td>Not performed</td>
<td>L lower quadrant</td>
<td>5</td>
<td>Left open</td>
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<td>21</td>
<td>Nakajima et al, 1999</td>
<td>Nissen procedure</td>
<td>Symptom of SBO</td>
<td>6 d</td>
<td>Richter hernia</td>
<td>Not performed</td>
<td>R lateral quadrant</td>
<td>5</td>
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<td>Fundoplication</td>
<td>Symptom of SBO</td>
<td>2 d</td>
<td>Incarceration of small intestine</td>
<td>Performed</td>
<td>L side</td>
<td>5</td>
<td>Left open</td>
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<td>23</td>
<td>Komuta et al, 2000</td>
<td>Splenectomy</td>
<td>Symptom of SBO</td>
<td>10 d</td>
<td>Richter hernia</td>
<td>Not performed</td>
<td>L lateral</td>
<td>10</td>
<td>Left open</td>
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<td>24</td>
<td>Ok and Sozuer, 2000</td>
<td>Cholecystectomy</td>
<td>Protrusion of small intestine</td>
<td>30 d</td>
<td>Spilled gallstones</td>
<td>Not performed</td>
<td>Umbilical</td>
<td>Not written</td>
<td>Not written</td>
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<td>Roux-en-Y gastric bypass</td>
<td>Symptom of SBO</td>
<td>12 d</td>
<td>Richter hernia</td>
<td>Not performed</td>
<td>Supraumbilical upper quadrant</td>
<td>10</td>
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<td>26</td>
<td>Cadeddu et al, 2002</td>
<td>Ventral hernia repair</td>
<td>Symptom of SBO</td>
<td>5 d</td>
<td>Richter hernia</td>
<td>Not performed</td>
<td>L upper quadrant subcostal area</td>
<td>Not written</td>
<td>Not written</td>
</tr>
<tr>
<td>27</td>
<td>Cottram et al, 2002</td>
<td>Roux-en-Y gastric bypass</td>
<td>Symptom of SBO</td>
<td>2 d</td>
<td>Richter hernia</td>
<td>Not performed</td>
<td>R upper quadrant</td>
<td>10</td>
<td>Closed</td>
</tr>
<tr>
<td>28</td>
<td>Case 1</td>
<td>Spleenectomy</td>
<td>Symptom of SBO</td>
<td>6 wk</td>
<td>Richter hernia</td>
<td>Not performed</td>
<td>Midclavicular</td>
<td>10</td>
<td>Closed</td>
</tr>
<tr>
<td>29</td>
<td>Case 2</td>
<td>Appendectomy</td>
<td>Symptom of SBO</td>
<td>13 wk</td>
<td>Richter hernia</td>
<td>Not performed</td>
<td>R upper quadrant</td>
<td>12</td>
<td>Closed</td>
</tr>
<tr>
<td>30</td>
<td>Case 3</td>
<td>Appendectomy</td>
<td>Symptom of SBO</td>
<td>16 wk</td>
<td>Richter hernia</td>
<td>Not performed</td>
<td>R upper quadrant</td>
<td>12</td>
<td>Closed</td>
</tr>
</tbody>
</table>

Abbreviation: SBO, small-bowel obstruction.
as wound infection, diabetes mellitus, and obesity, although none of these reached statistical significance.

**Obesity.** There was a trend for patients with trocar site hernias to have a higher body mass index (calculated as weight in kilograms divided by the square of height in meters). Although this did not reach statistical significance. The morbidly obese are at a high risk for preperitoneal hernias because of their substantially thicker preperitoneal space and elevated intra-abdominal pressure. There was a tendency to improperly close the fascial defect in obese patients. We consider that this technical flaw has had an influence on the high incidence of trocar site hernias in obese patients.

**Nutrition.** Consequent poor nutrition could be an important factor that might distinguish the various groups of patients for trocar site hernias; however, it had not been made apparent in a report.

**Infection.** A postoperative port site wound infection is one of the factors predisposing the development of a hernia. Callery et al reported that most often the umbilical incision is infected in laparoscopic procedures. Late-onset—type trocar site hernias might be related to infection from the stab wound, but there have been no large series reports clarifying any relationship between trocar site hernias and wound infection in digestive surgery.

**Summary of Pathogenesis**

We could not find a report that analyzed the factors related to trocar site hernia by multivariate analysis. Therefore, we could not indicate the only independent risk factor. However, we have referred to many reports that have logically indicated pathogenesis. The authors frequently point out that the main pathogenesis is not host factors but rather technical ones; besides, most asserted that a large trocar size, leaving the fascial defect open, and stretching the port site were closely related to the occurrence of trocar site hernias.

**Clinical Manifestation**

Sanz-Lopez et al noted that the onset of symptoms produced by trocar site hernia could range from a few to several months after intervention, although they generally occur within a few days after operation. Figure 2 shows the interval between laparoscopic surgery and onset in all cases in Table 2 and in selected cases in Table 1 (ie, all 53 cases where clinical detail was given). We found that this graphic data showed that the onset of one third of the cases was immediately after operation and that in the rest, it was more than 30 days after the surgical procedure. Therefore, the cases of trocar site hernias were divided into 2 groups according to the interval between the laparoscopic surgery and onset (21 early-onset cases and 32 late-onset cases). The dividing time was set at 2 weeks after surgery, which was delineated in the report by Velasco et al; a high degree of suspicion for incarcerated hernia and a low threshold for reoperation should be exercised when a patient presents symptoms and radiographic evidence of a small-bowel obstruction within 2 weeks of laparoscopy.

In the cases shown in Figure 2, the median interval in the late-onset cases was 5.5 months (21 days to 27 months). Twenty-eight (87.50%) in the late-onset cases presented a bulging abdomen without small-bowel obstruction. These cases correspond to the late-onset type. Only 1 in the late-onset cases presented strangulation at 27 months after laparoscopy. In Figure 2, the median interval in the early-onset cases was 5 days (range, 2-12 days). It was characteristic that the early-onset cases presented a small-bowel obstruction in 16 cases (76.20%). The protrusion of the small intestine or omentum was found in these cases. Early-onset cases correspond to the early-onset type and special type: most of these cases were of the early-onset type.

It was shown that the incidence of Richter hernia was high in the early-onset cases (10 cases, 47.60%). Boughey et al found that Richter hernia typically presents with vomiting or nausea and a distended and painful abdomen, most commonly within 2 weeks of surgery. Duron et al reported no Richter hernia in cases of small-bowel obstruction after laparoscopic abdominal surgery, but other reports have disagreed with this. For example, Richter hernias are particularly common in symptomatic patients, presumably due to the small size of the fascial defect. When complicated, trocar site hernia usually occurs as a Richter hernia. In our collected cases, the Richter hernia was the cause of about half the cases in the early-onset cases. We indicate the correlations between 3 types of trocar site hernia and their clinical characteristics in Table 3.

**Diagnosis**

We can diagnose the special type without any modalities. With the early-onset type we are able to locate the
site of incarceration by computed tomography and surgically reduce and repair the hernia with minimal enlargement of the puncture wound, thus avoiding a full laparotomy. In many other reports computed tomography was available to diagnose early-onset–type hernias and were effective in diagnosing them. A gastrointestinal contrast study was effective in at least 3 reports.

An unknown proportion of asymptomatic patients do not get physically examined, although asymptomatic lumps are sometimes found in late-onset–type hernias. There have been no reports on whether such insidious trocar site hernias in asymptomatic patients are worthy of any further examination.

### Prevention

Fascial defects created by 10-mm or larger trocar sites should be closed whenever possible to prevent hernia formation. Moreover, Crist and Gadacz mentioned that, in general, fascial defects created by 5.5-mm trocar sites do not require closure. However, Sanz-Lopez et al insisted that the general consensus is that trocar site hernias greater than 5 mm in diameter should be closed at the fascial level, and that especially in children defects of any size should be closed. Some authors have stated their views that it might not be necessary to recommend routine closure of all 5-mm ports sites, but in active manipulation during prolonged procedures, they should be closed to avoid complications.

The problem is how to properly close a fascial defect. Matthews et al reported that incomplete closure led to trocar site hernias and that the peritoneum should be incorporated into the fascial closure to obliterate the preperitoneal space, thereby preventing this postoperative complication. Velasco et al mentioned that closure should be done under direct vision, and it should incorporate all layers of the abdominal wall to eliminate the peritoneal defect. Callery et al stated that all large trocar sites should be closed meticulously, even if the incision requires extension at the skin level. We consider that a 10-mm or larger trocar site should be closed completely (meaning closure of all layers including the peritoneum) with adequate muscle relaxation. Thus, the lateral trocar cannot be excluded because the incidence of trocar site hernia at the lateral port cannot be disregarded.

Some surgeons recommended the use of a fascial closure device, a spinal cord needle, a suture carrier, a 2-mm trocar, or a Deschamps needle to close the fascia and the peritoneum together. It would be advantageous to try one of these techniques if a fascial defect were not completely closed in the usual manner. It is difficult to close a 5-mm trocar site properly without enlarging the incision, so it might be better to use a device like those mentioned earlier if the fascial defect must be closed.

Some authors have reported the usefulness of a new type of trocar: as 10- to 12-mm nonbladed trocar sites do not require fascial closure in nonmidline port sites above the arcuata line, so the frequency of trocar site hernias could be lowered significantly, from 1.83% to 0.17%, by switching from a sharp cutting device to a cone-shaped trocar tip; and a radially expanding trocar might be useful to prevent hernias. It is supposed that these devices are recognized as useful, but a randomized large prospective study of digestive surgery is needed before abandoning fascial closure.

Many authors have advised surgeons to open the trocar valve to deflate air before port removal so as not to draw omentum and intestines into the fascial defect. We should keep to this rule for deflating intrabdominal compressed gas.

Some reports recommended a paramedian skin incision and separate fascial incisions through the anterior and posterior rectus sheathes, with lateral retraction of the rectus abdominal muscle. In data by Lafullarde et al, laparoscopic digestive surgery was performed in 803 patients using the aforementioned trocar insertion with fascial closure. No patients developed trocar site hernia for 5 through 52 months after surgery. This method makes good use of the shutter mechanism of muscle and fascial layers, but we note that they added fascial closure to this method.

We believe that the only effective way is closing the fascial defect and peritoneum to prevent trocar site hernias, and that the other methods should be used after improper closure for the worst cases. When active manipulation through a 5-mm port has occurred during prolonged procedures, the fascial defect should be closed to avoid complications.

### Treatment

Duron et al investigated 24 cases of laparoscopic digestive surgery that were reoperated for mechanical intestinal obstruction; 11 (46%) were due to trocar site hernia, 8 (33%) to adhesions, 4 (17%) to gastric bands, and 1 to cecal volvulus. The median interval to reoperation was significantly shorter for trocar site hernias (8 days) than for adhesions (25 days) or gastric bands (22.5 days). This means that early onset of small-bowel obstruction is due to trocar site hernia. Velasco et al reported that...
all of their patients with early postlaparoscopic bowel obstruction required an operation to resolve small-bowel obstruction. They set 14 days after surgery to be the turning point for decision making. Moreover, some authors advised that correctly diagnosing Richter hernia in a postlaparoscopic patient with symptoms of small-bowel obstruction will help to lessen any delay.44,50 Therefore, surgeons need to be ready to perform further procedures on patients with a small-bowel obstruction within 2 weeks of laparoscopic surgery. If diagnosis of the obstruction cannot be verified, computed tomography will be effective. Nonoperative management (nasogastric suction and other methods) will often waste time and money, and they sometimes lead to critical conditions (ie, strangulation).

The onset of trocar site hernia without small-bowel obstruction happens later and might elude a surgeon unless an extended follow-up procedure is established.1 One in the late-onset type developed strangulation 27 months after the operation. Therefore, a late-onset surgical repair procedure for trocar site hernia was made by studying previous reports. We believe that a more accurate clinical identification is available from this categorization. It will be useful to prevent complications if the laparoscopist is aware of the correlation between the identified types and clinical manifestations before the surgical procedure.

CONCLUSIONS

In this review article, a classification of trocar site hernia was made by studying previous reports. We believe that a more accurate clinical identification is available from this categorization. It will be useful to prevent complications if the laparoscopist is aware of the correlation between the identified types and clinical manifestations before the surgical procedure.

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**Announcement**

The Archives of Surgery will give priority review and early publication to seminal works. This policy will include basic science advancements in surgery and critically performed clinical research.