Laparoscopic versus non–laparoscopic-assisted ventriculoperitoneal shunt placement in adults. A retrospective analysis

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Abstract

\textbf{Background:} Ventriculoperitoneal shunts and distal shunt revisions bear a high risk of distal malfunction, especially in patients with previous abdominal pathologies as well as in obese patients. We performed laparoscopy-guided distal shunt placement or revision for patients with and without a positive abdominal history. We review the indications, techniques, complications, and long-term outcomes of these cases and compare the results to those of patients operated without laparoscopic guidance.

\textbf{Methods:} A total of 211 distal shunt procedures were performed in our institute between January 2001 and December 2005, 59 of which were laparoscopically guided, and 152 were not. Of the 211 procedures, 177 were placement of new shunt systems, and 34 were distal revisions. A total of 33 procedures were performed in 25 patients with a history of abdominal surgery or inflammatory bowel disease; 15 procedures were operated with laparoscopic guidance.

\textbf{Results:} The short-term complication and outcome rates were similar between the laparoscopy group and the other patients. Among the patients with new shunts, the long-term distal malfunction rate was lower in the laparoscopy group compared with the nonlaparoscopy group (4% vs 10.3%, respectively; \(P = .17\)). No patients in the laparoscopy group and 6 patients operated by other techniques had distal malfunction. There was 1 laparoscopy-related mortality and no morbidity.

\textbf{Conclusions:} Laparoscopy is not routinely indicated in distal shunt placement or revision. However, a laparoscopy-guided procedure may lower the rate of distal malfunction in patients with previous abdominal surgeries.

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Keywords: Laparoscopy; Minilaparotomy; Ventriculoperitoneal shunt; Distal revision; Complications

1. Introduction

Ventriculoperitoneal shunts are common procedures in neurosurgery. Shunts are placed for treatment of hydrocephalus, drainage of arachnoid cysts, and postcraniotomy chronic subcutaneous fluid collections. The most common organ recruited for draining is the peritoneum, but shunts may drain to the pleura or cardiac atrium [4,29]. Several techniques are used to place the distal end of the shunt into the peritoneal cavity, such as exposing various layers of the abdominal wall and sticking a trocar into the peritoneum, or performing a minilaparotomy, followed by placement of the distal end into the peritoneum. Shunt surgery bears an immediate and a delayed risk of perforating an abdominal organ, as well as a delayed risk of mechanical distal malfunction. Laparoscopy-guided placement of distal catheters and distal revisions have previously been described, but this technique is not routinely used. We present our experience with laparoscopic-assisted shunt placement and distal shunt revisions and compare the outcome and complications of this technique with other techniques in selected patient populations.

\textit{Abbreviations:} BMI, body mass index; CSF, cerebrospinal fluid; ICP, intracranial pressure; VPS, ventriculoperitoneal shunt.

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2. Methods

2.1. Inclusion criteria

All patients undergoing VPS procedures between January 1, 2001 and December 31, 2005 were included. Because the aim of the study was to evaluate the abdominal part of the procedure, we included all patients older than 18 years who underwent placement of a peritoneal catheter regardless of the proximal site of the shunt (ventricular, arachnoid cyst, or other cranial fluid spaces). Patients undergoing distal revisions were also enrolled if the procedure included dealing with the peritoneal end. The patients’ data were retrospectively collected from their medical files, surgical reports, and follow-up notes.

2.2. Technical aspects

Shunt procedures were performed by a neurosurgical resident and a senior neurosurgeon. The procedures aided by laparoscopy were performed in collaboration with a specialist general surgeon or a senior resident experienced in laparoscopic procedures.

2.2.1. Procedure description

The cranial part of the operation is performed concurrently with the abdominal part except in revision cases in which only the abdominal part was revised. Pneumoperitoneum is created using a closed technique with a Verres needle. Carbon dioxide is insufflated to a pressure of 12 mm Hg. A 5-mm subumbilical trocar is inserted, and a 5-mm videoscope is used. An additional 5-mm trocar is inserted for cases in which an intra-abdominal intervention of the distal tubing is needed. The peritoneal cavity is inspected, and a suitable place for the insertion of the distal part of the shunt is selected, usually in the right hypochondrium. The distal tubing is inserted and localized under videoscopic inspection, and distal CSF flow is verified (either spontaneously or after shunt valve pumping). The videoscope is then removed. The peritoneum is deflated, and the trocars are removed. Abdominal skin incisions are closed with intracutaneous absorbable stitches.

2.3. Data collection

Data that were collected included basic demographics, reason for the operation (including etiology of the hydrocephalus), type of procedure performed, method of abdominal shunt handling (laparoscopic, trocar based, or minilaparotomy), intraoperative findings, technical problems during operation, length of procedure, postoperative complications, and long-term complications (including the need for distal shunt revisions and infections). We also noted the patients’ preoperative abdominal status. Any patient who had undergone an abdominal operation in the past (e.g., appendectomy, cholecystectomy), regardless of the surgical technique and severity of the historical pathology, was considered to have a positive abdominal history. Other cases that were considered as having a positive abdominal history were patients with inflammatory bowel disease, patients with multiple (>5) previous shunt insertions to the abdomen, and patients with a history of peritonitis secondary to any reason.

2.4. Statistics

The data were recorded on Excel spreadsheets. Differences of outcome and complications between treatment options were evaluated using the $\chi^2$ test.

3. Results

A total of 211 procedures were performed during the 5-year study period on 173 patients who fulfilled the inclusion criteria. They included 96 men and 77 women; average age was 60 years (range, 19-88). Of these 211 operations, 177 involved the placement of new shunt systems, and 34 were distal revisions. Seven procedures included a proximal revision in addition to the distal revision at the same operation. Altogether, 59 distal shunts (28%) were placed with laparoscopic aid. The remaining 152 cases (72%) had the distal end placed either by using a trocar (22%) or by a minilaparotomy (52%). The technique was not specified in the reports on 38 (26%) patients. Based on the inherent intersurgeon variability of the trocar technique, all patients not operated by means of a laparoscope comprised one group. The distribution of the patients in the various groups is presented in Table 1. There were no significant differences in patients’ ages, percentage of positive abdominal history, and length of operation between the laparoscopy-aided and other subgroups.

3.1. Outcome and complications

Short-term (<1 month) and long-term (>1 month) outcomes and complications are summarized in Table 2. The average follow-up time was 22 months for the laparoscopy group and 25 months for patients treated using other techniques. The main outcome variables that were evaluated and compared between the laparoscopic and the other techniques were infection rate, distal malfunction, and

<table>
<thead>
<tr>
<th>Study groups</th>
<th>N</th>
<th>All procedures</th>
<th>Laparoscopy</th>
<th>Other techniques</th>
<th>Patients with positive abdominal history</th>
<th>Laparoscopy</th>
<th>Other techniques</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entire cohort</td>
<td>211</td>
<td>59</td>
<td>152</td>
<td>15</td>
<td>18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>New shunts</td>
<td>177</td>
<td>43</td>
<td>134</td>
<td>10</td>
<td>17</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distal revision</td>
<td>34</td>
<td>16</td>
<td>18</td>
<td>5</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
intraoperative findings. The short-term shunt infection rate was similar between the 2 techniques for the entire study population (5% in the laparoscopy group and 3.9% in the nonlaparoscopy group; \( P = .72 \)). Long-term shunt infections, however, were more common in the laparoscopy group (10%) compared with the group that used other techniques (3.4%), although the difference did not reach a level of significance (\( P = .07 \)). Early distal malfunctions occurred in 2 patients in the laparoscopy group and in 1 patient operated using a different technique. Long-term distal malfunctions were less common in the laparoscopy group (4% vs 10.3%; \( P = .17 \)). Noteworthy, there were 6 cases of distal malfunction because of migration of the distal end to the extraperitoneal area in the nonlaparoscopy group and none among the laparoscopy patients. There were no intra-abdominal injuries during any of the 211 procedures. There were 3 perioperative deaths. One death resulted from massive pneumothorax secondary to bronchial tear 12 hours postoperatively. This patient had a bronchial tumor and had ventilation difficulties during the abdominal distension stage of the laparoscopy. Ventilation improved after decompressing the abdomen, but the patient died from massive pneumothorax secondary to bronchial tear (evidenced by bronchoscopy). The other 2 deaths

Table 2
Complications and outcome

<table>
<thead>
<tr>
<th>Short-term (&lt;1 mo)</th>
<th>Long-term (&gt;1 mo)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of cases</td>
</tr>
<tr>
<td>New shunts</td>
<td>43</td>
</tr>
<tr>
<td>Distal revisions</td>
<td>36</td>
</tr>
<tr>
<td>All</td>
<td>79</td>
</tr>
</tbody>
</table>

No complications 136 128 16 18 59 152
Infection 1 6 2 0 3 6
Proximal malfunction 3 5 0 0 3 5
Distal malfunction 1 1\(^a\) 1 0 2 1\(^a\)
Deaths 1\(^e\) 2\(^d\) 1\(^e\) 2\(^d\)
Other 1\(^e\) 1\(^f\) 1\(^e\) 2\(^e,f\)

L indicates laparoscopy.

\(^a\) The distal end was in the abdominal wall 1 week postoperatively.
\(^b\) The distal end was in the abdominal wall in 5 cases (1, 1, 1.5, 1.5, and 4 months).
\(^c\) One death from pneumothorax secondary to lung tumor.
\(^d\) One death from unrelated sepsis, and one death from meningitis.
\(^e\) One case of over drainage.
\(^f\) One case of many adhesions, exteriorized the distal part of the shunt.

Table 3
Usage of laparoscopy in patients with positive abdominal history

<table>
<thead>
<tr>
<th>Previous abdominal pathology</th>
<th>Intraoperative findings</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appendectomy</td>
<td>No adhesions</td>
<td>Good</td>
</tr>
<tr>
<td>PEG</td>
<td>No adhesions</td>
<td>Good</td>
</tr>
<tr>
<td>Appendectomy(^1)</td>
<td>No adhesions</td>
<td></td>
</tr>
<tr>
<td>Appendectomy(^2)</td>
<td>Adhesions, adhesiolysis</td>
<td></td>
</tr>
<tr>
<td>Appendectomy(^2)</td>
<td>Adhesions, adhesiolysis</td>
<td></td>
</tr>
<tr>
<td>Appendectomy(^2)</td>
<td>Adhesions, adhesiolysis</td>
<td></td>
</tr>
<tr>
<td>Gastrectomy (peptic ulcer disease)</td>
<td>No adhesions</td>
<td></td>
</tr>
<tr>
<td>Pancreas + renal transplantation(^3)</td>
<td>Adhesions, adhesiolysis, removal of 2 old lumbopteroneal shunts</td>
<td>Late shunt infection (2m), shunt removed</td>
</tr>
<tr>
<td>Pancreas + renal transplantation(^3)</td>
<td>Adhesions, adhesiolysis</td>
<td></td>
</tr>
<tr>
<td>Colostomy (colon Ca)</td>
<td>Difficulty inserting the camera after abdominal distention; camera inserted through a new incision</td>
<td>Proximal malfunction</td>
</tr>
<tr>
<td>Multiple VPS revisions, S/P low-grade shunt infection, ascites</td>
<td>Multiple adhesions, adhesiolysis</td>
<td>Low-grade shunt infection, shunt removed, later ventriculopleural shunt</td>
</tr>
<tr>
<td>Appendectomy</td>
<td>Multiple adhesions, adhesiolysis</td>
<td></td>
</tr>
<tr>
<td>Shunt infection, secondary peritonitis</td>
<td>Multiple adhesions, shunt exteriorized because adhesiolysis not feasible: shunt removed 1 wk later</td>
<td>Distal malfunction</td>
</tr>
<tr>
<td>SRVG, low-grade shunt infection(^4)</td>
<td>Adhesions, adhesiolysis</td>
<td>Shunt removed</td>
</tr>
<tr>
<td>Appendectomy(^1)</td>
<td>Multiple adhesions, adhesiolysis. The distal end of the shunt was buried in an adhesion conglomerate: it was released and CSF flow was verified</td>
<td>Good</td>
</tr>
</tbody>
</table>

The superscript numbers indicate the same patients.
The first 10 patients had new shunts, and the last 5 patients had distal revisions.
PEG indicates percutaneous endoscopic gastrostomy; SP, state post; SRVG, silicone ring vertical gastroplasty.
The first 17 patients had new shunts, and the 18th patient had a distal revision. The superscript numbers indicate the same patients.

PEG7 Good
SRVG, low-grade shunt infection4 Proximal revision
Crohn disease, no previous Appendectomy Good
Laparoscopic cholecystectomy Proximal revision
Metastatic gastric Ca, ascites, Cholecystectomy, transabdominal Appendectomy Good
PEG7 Good
PEG7 Distal malfunction (9 mo)
Hemihepatectomy
Pancreatitis (conservatively treated)6 Good
Pancreatitis (conservatively treated)6 Local abdominal wound infection
Appendectomy5 Good
Appendectomy5 Local abdominal wound infection (5 m, shunt removed)
Appendectomy5 Good
Appendectomy5 Local abdominal wound infection (2 wk, shunt removed)
Appendectomy5 Proximal revision and shunt infection shortly later
Appendectomy5 Local abdominal wound infection
PEG7 Distal malfunction (9 mo)
PEG7 Good
Appendectomy Good
Appendectomy Good
Cholecystectomy, transabdominal hysterectomy Good
Metastatic gastric Ca, ascites, abdominal spread Good
Laparoscopic cholecystectomy Proximal revision
Appendectomy Good
Crohn disease, no previous abdominal operations Good
SRVG, low-grade shunt infection4 Proximal revision
PEG7 Good

The superscript numbers indicate the same patients.

The first 17 patients had new shunts, and the 18th patient had a distal revision.

involved patients operated using other techniques, one from unrelated sepsis and the other from meningitis. There was no other major morbidity in any group.

3.2. Patients with a positive abdominal history

Thirty-three operations were performed on 25 patients with a positive abdominal history. The type of abdominal pathology, intraoperative findings, and outcome are summarized in Tables 3 and 4.

Fifteen operations in 11 patients were performed using a laparoscope (Table 3). Adhesiolysis was usually performed whenever adhesions were found, and the shunt’s end was placed in an area free of adhesions. There were 2 distal malfunctions—both in patients who underwent appendectomy in the past: one patient had multiple adhesions and the other had none at all. Two cases posed some technical difficulties. One involved a patient who had a colostomy. Technical difficulty in entering the camera mandated an additional incision through which the camera could be inserted. The other patient had multiple peritoneal adhesions, and adhesiolysis was unsatisfactory. For that patient, the distal end was externalized, and the whole shunt system was removed 1 week later because of clinical stability after shunt closure.

Eighteen operations in 14 patients were done without laparoscopic assistance (Table 4). There were no technical difficulties during surgery in this group. There was one distal malfunction in a patient with a gastrostomy. The infection rate was lower compared with the laparoscopy group (16% vs 33%; \( P = .26 \)); however, 2 cases in the laparoscopy group had recurrent low-grade infection and so the infections were probably unrelated to the laparoscopy procedure per se.

3.3. Distal shunt revisions

Of the 34 distal revisions, 16 were laparoscopically assisted. The indications for distal revisions were preperitoneal placement in 6 cases, removal of migrated shunt in 1 case, and distal malfunction in the remaining cases. No intraoperative technical difficulties were encountered in the laparoscopy group, but 2 cases in the nonlaparoscopy group required a new minilaparotomy for distal insertion because of local peritoneal adhesions at the previous abdominal incision. The short- and long-term complication rates were not significantly different between the 2 groups (Table 2). Noteworthy, 5 of the 6 patients with a positive abdominal history were operated laparoscopically (Table 4).

3.4. Intraoperative technical aspects

Of the 211 cases, 10 had intraoperative technical difficulties, 4 of them were operated laparoscopically (Table 5). Two patients in the laparoscopy group needed an additional incision to facilitate abdominal inflation and camera placement. There was no associated morbidity. In one case, the shunt was externalized because of adhesions, and it was completely removed 1 week later after challenging the patient with a closed shunt. One mortality occurred secondary to bronchial tear intraoperatively. We assume that this was a fatal outcome of ventilation difficulties during the procedure (while the abdomen was distended) in the presence of a bronchial tumor.

Six technical difficulties occurred in patients treated using nonlaparoscopic techniques (Table 5), and none had a positive abdominal history. Two cases had previous shunts, and both had a new shunt placed. The abdominal incision was at the previous site and revealed local peritoneal adhesions, whereupon new incisions were done with no sequel. In another case, blood emerged through the abdominal trocar: a laparoscope was inserted, and intraabdominal injury was ruled out. In 2 cases, the technique was converted from a trocar insertion to an open exposure of the peritoneum because of uncertainty about penetration of the peritoneum by the trocar. No morbidity or mortality was attributed to the technical difficulties for any of these 6 cases.

3.5. Migration of distal ends

There were 6 migrations of distal ends to the abdominal wall, all in cases previously operated nonlaparoscopically. There were 3 cases that involved operations with a trocar and 3 that involved a minilaparotomy. The interval between the primary operation and the distal revision was 1 week in 1 case and 1 to 4 months in the other 5. A total of 2 revisions were done with laparoscopic guidance and 4 with other
techniques. No technical difficulties were encountered, and the outcome was good in all 6 cases.

4. Discussion

Placement of a VPS is a common procedure in neurosurgery, although the complication rate is high. The 2 main complications in the pediatric population are infection (10%) [22] and mechanical failure (70%) [31], whereas mechanical failure occurs more seldom among adults (10%-40%) [11,18]. Distal mechanical malfunctions comprise 25% to 30% of all mechanical failures [18] and include preperitoneal placing of the distal end, malabsorption with secondary ascites, and obstruction of the distal end secondary to intra-abdominal adhesions and pseudocysts [1,2,24]. Other rare complications include chronic erosions of the colon, bladder, and liver [3,8,12,34,35,37]. Immediate injuries to the abdominal viscera are extremely rare. Common techniques for placing the distal ends of shunts include open minilaparotomies and the use of trocars to penetrate abdominal wall layers and the peritoneum. The main drawbacks of these techniques are technical difficulties in obese patients and an uncontrolled placement of the distal end. This may pose a special problem in obese patients and in patients with peritoneal adhesions, such as those with a history of abdominal surgery. Over the past 2 decades, the use of laparoscopic surgery in many surgical procedures for treating intra-abdominal pathologies has gained popularity. The main advantages are smaller incisions and thus smaller peritoneal and fascia openings, less surgically induced trauma, faster postoperative recovery, and fewer secondary peritoneal adhesions [14,26]. Using laparoscopy in distal shunt procedures enables placement of the abdominal end of the shunt under vision and in a distended peritoneum, thereby supposedly lowering the risk of immediate injury to abdominal viscera and lowering the incidence of preperitoneal placement of the distal shunt end. Other advantages are adhesiolysis in cases of peritoneal adhesions and verification of CSF flow in the peritoneum, although spontaneous CSF flow may not be visible when the abdomen is distended possibly because of the abdominal pressure (10-15 mm Hg) lowering differential pressure on the shunt valve and precluding spontaneous flow. Thus, pumping of the valve may be needed to verify distal CSF flow.

4.1. Laparoscopic-assisted placement of new shunt systems

Two studies on laparoscopic-assisted peritoneal shunt insertion have recently been published. Bani and Hassler analyzed the results of that technique in 39 children [5], of whom 19 had previous laparotomies (5 for nonshunt reasons). There was no laparoscopy-related morbidity, and postoperative pain and analgesics use were decreased compared with non–laparoscopy-aided cases. Schubert et al [32] prospectively studied 50 children and adults who underwent laparoscopically assisted distal shunt placement and compared their results with a historical cohort of matched 50 patients undergoing distal shunt

<table>
<thead>
<tr>
<th>Previous abdominal pathology</th>
<th>Technical difficulty</th>
<th>Solution</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colostomy (colon Ca)</td>
<td>Difficulty entering the camera after abdominal distention</td>
<td>Entering the camera through a new incision</td>
<td>Proximal malfunction</td>
</tr>
<tr>
<td>No</td>
<td>Difficulty inflating the abdomen with a Verres needle through an infraumbilical incision</td>
<td>Entered the needle through a supraumbilical incision; entered the camera through the infraumbilical incision after inflating the abdomen</td>
<td>Good</td>
</tr>
<tr>
<td>Shunt infection, secondary peritonitis</td>
<td>Multiple adhesions, insufficient adhesiolysis</td>
<td>Exteriorized the shunt</td>
<td>Shunt removed 1 wk later after challenging the patient with a closed shunt</td>
</tr>
<tr>
<td>No</td>
<td>Ventilation difficulties during abdominal distention</td>
<td>Ventilatory improvement after decompression of distended abdomen</td>
<td>Patient died 12 h after surgery from massive pneumothorax secondary to bronchial tumor</td>
</tr>
<tr>
<td>Previous VPS surgeries</td>
<td>After entering the abdominal trocar bl emerged</td>
<td>Entered a laparoscope, no intraperitoneal bl</td>
<td>Good</td>
</tr>
<tr>
<td>Opening of old abdominal incision, many adhesions at the peritoneal cavity</td>
<td>New incision</td>
<td>Good</td>
<td></td>
</tr>
<tr>
<td>Previous VPS surgeries</td>
<td>Opening of old abdominal incision, local peritoneal adhesions</td>
<td>Manual opening of local adhesions</td>
<td>Distal malfunction</td>
</tr>
<tr>
<td>No</td>
<td>During trocar placement, not sure if penetrated peritoneum</td>
<td>Converted to open surgery to expose peritoneum</td>
<td>Good</td>
</tr>
<tr>
<td>No</td>
<td>During trocar placement, not sure if penetrated peritoneum</td>
<td>Converted to open surgery to expose peritoneum</td>
<td>Proximal malfunction</td>
</tr>
<tr>
<td>No</td>
<td>Epigastric artery injury</td>
<td>Local hemostasis</td>
<td>Shunt infection</td>
</tr>
</tbody>
</table>

First 4 cases—used a laparoscope. Remaining 6 cases—other techniques used to place distal end, 1 case converted to laparoscopy.
place through a minilaparotomy. Their results showed a slightly longer procedure when using the laparoscopy, but the laparoscopy group had a significantly lower distal malfunction rate. The authors suggested that the main reason for this is visual control of the catheter position and its function when assisted by laparoscopy and recommend its use in very obese patients or in those who had previously undergone abdominal surgery. Our results are in agreement with theirs and with others from smaller groups [7,10,19-21,30,38]. The long-term distal malfunction rate in general and the preperitoneal placement rate of the distal end in particular were lower in the laparoscopy group (albeit nonsignificantly). We suggest that in addition, the small abdominal wall incision and the small peritoneal opening lower the migration rate of the distal end to the abdominal wall, and that the performance of adhesiolysis in cases of peritoneal adhesions lowers the rate of distal malfunction.

4.2. Laparoscopic-assisted distal shunt revision

Shunt-related abdominal complications occur in 5% to 47% of cases [13]. These include obstruction, catheter disconnection and migration to the peritoneal cavity, pseudocysts, infections, ascites, injury of abdominal viscera, and hernias (inguinal and through the peritoneal entry point of the catheter). Laparoscopy has been used to treat pseudocysts, remove dislodged catheters, reposition distal tips placed in preperitoneal spaces, and release distal tips from adhesions [1,9,15,16,18,19,26,29,34,38,40,45,47]. These complications may be treated by externalization of the distal end and by repositioning via a minilaparotomy or, in some pathologies, by a formal laparotomy (such as for treating pseudocysts). A more logical attitude, however, would be to deal with the problem laparoscopically. Laparoscopy may also be used for repositioning misplaced distal ends under direct visualization, for releasing distal tips entrapped in peritoneal adhesions, and for performing adhesiolysis at the same session and opening pseudocysts without the need of extensive laparotomies. In our series, 5 of 6 patients with a positive abdominal history were operated with laparoscopic assistance. This may introduce a bias to the results, but it does represent natural selection, that is, using laparoscopy for potentially more problematic cases [21]. On the other hand, most procedures in cases of distal revision because of simple distal malfunction in patients with a negative abdominal history were performed without laparoscopy guidance, achieving similar short- and long-term results and complications. Thus, routine laparoscopy does not seem to be indicated for distal revisions in patients with a negative abdominal history.

4.3. Laparoscopy-related risks

Potential drawbacks of laparoscopy-assisted shunt surgery are laparoscopy-related complications (attributed mainly to peritoneal penetration techniques), anesthesia-related complications, and procedure-related costs. Vascular and visceral injuries secondary to the entry technique occur in fewer than 0.05% of the cases [15,16,27]. The complication rate is higher in patients with a history of open abdominal surgery [33]. The danger associated with anesthesia for laparoscopic procedures is remarkably small and includes cardiovascular and respiratory risks [9,17]. In our series, only one case of respiratory-related morbidity/mortality was documented, and it occurred in a patient with known bronchial carcinoma. This mortality may have been obviated had a minilaparotomy been done instead of laparoscopy.

The cost of a shunt revision must be taken into account when choosing surgical approaches [20,30]. About 50% of shunt-related admissions and costs are due to revisions [6,28]. As such, we speculate that the increased costs emerging from laparoscopic instrumentation and the addition of another surgeon to the operating team may be offset by the decreased rate of distal malfunction in the laparoscopy group. This issue is beyond the scope of the present work and warrants further study.

Performing laparoscopy in shunted patients for abdominal pathologies has been performed and was shown to elevate the ICP during abdominal inflation with carbon dioxide [36]. Reasons for elevated ICP may be secondary to elevated PaCO₂, lowered cranial venous drainage secondary to elevated intra-abdominal pressure, and a lowered pressure gradient across the shunt valve, decreasing antegrade CSF flow. Yu et al [38], however, found no clinical evidence of mechanical failure of the shunt valve or evidence of increased ICP in 17 children undergoing laparoscopic-guided shunt surgeries. Among the 59 patients in our own adult group, none had postoperative symptoms of elevated ICP. One in vitro study demonstrated the tolerability of valves to resist retrograde flow when distal pressures are elevated to 80 mm Hg [25].

In the current study, the short- and long-term infection rates were higher in the laparoscopy group (8 infections altogether, 13.5%) compared with the nonlaparoscopy group (11 infections, 7.2%; P = .15). There were 2 patients in the laparoscopy group, however, who had recurrent low-grade distal infections, 2 who had previous brain abscesses, and 1 who was immune-compromised after renal and pancreatic transplantation. In the nonlaparoscopic group, no patient had a recent low-grade distal infection, and there were no immune-compromised subjects. Analysis of the culture results for the 8 laparoscopic infections revealed that 7 were either Staphylococcus aureus or coagulase-negative staphylococci. These results are in accordance with the normal shunt infection flora and are atypical for abdominal flora [22]. The eighth patient was immune-compromised and had multibacterial meningitis and bacteremia. Our review of the literature failed to reveal any evidence of an increased infection risk attributed to laparoscopic use, despite the fact that the hardware is used routinely for abdominal surgery, including for cases of infectious diseases. Moreover, given that laparoscopy itself poses less infection risk compared with laparotomy [23], it would...
appear that the risk of infection is not related to the laparoscopic procedure.

4.4. Effect of previous abdominal pathologies on the preferred shunt placement technique

Laparotomies pose a greater risk for peritoneal adhesions compared with laparoscopic procedures [14]. Multiple previous distal shunt revisions—especially when there has been a prior infected shunt with peritonitis—often cause extensive abdominal adhesions as well [30]. Given the paucity of data on adhesions after various abdominal pathologies and the similarity between the surgical risk and long-term risk of laparoscopically assisted shunt placement and other techniques, we propose that a history of laparotomy, peritonitis, chronic inflammatory bowel diseases, and/or multiple distal shunt revisions (especially in cases of shunt infection) are indications for the use of laparoscopy. Patients who had undergone laparoscopic procedures for appendectomy or cholecystectomy may benefit equally from laparoscopic-assisted shunt placement and minilaparotomy.

4.5. Study limitations

The main limitations of the current study are the nonunified selection criteria for using laparoscopy and the study’s retrospective nature. In addition, the technique used, as well as the patients’ BMI, in the nonlaparoscopy group was not always documented. Thus, we could not correlate the patient selection or outcome to obesity. Stratification of the statistical significance of the difference in distal malfunction between the laparoscopy group and other groups requires a large prospective study in which variables such as abdominal history, BMI, and operative technique are reported in detail.

4.6. Conclusions

Based on the current study’s results and current literature, we suggest the following indications for laparoscopy-aided shunt surgery:

- removal of dislodged distal catheters
- distal shunt procedures in severely obese patients

Distal shunt placement in:

- patients who had undergone previous abdominal surgery (especially laparotomies)
- patients with a history of multiple distal shunt revisions
- patients with chronic inflammatory bowel diseases.

Patients with distal mechanical shunt failures and a positive abdominal history should undergo an exploratory laparoscopy to release the distal end and for performing adhesiolysis. Our results do not, however, support routine laparoscopic-aided distal shuntinsertion or revision in nonobese patients with a negative abdominal history.

References

Commentary

The authors provide a detailed, retrospective analysis of their experience with laparoscopic-assisted ventriculoperitoneal shunt placement. There are advantages and disadvantages in considering laparoscopic-assisted surgery. If it is possible to place the peritoneal catheter directly from the subcutaneous tissue into the peritoneal cavity without an overlying incision, this should eliminate the occasional complication of withdrawal of the catheter from the peritoneum into the subcutaneous pocket (created using a standard minilaparotomy approach). Second, inadvertent placement of the catheter in the preperitoneal fat space should likewise be eliminated. As the authors note, laparoscopic visualization and the ability of lysis of adhesions is advantageous for distal shunt revision operations. Prolongation of a surgery and the logistical issues associated with coordination with a general surgeon are potential disadvantages. Lastly, laparoscopy carries its own risks, albeit low in incidence. Laparoscopic-assisted shunt placement should be strongly considered in appropriate cases.

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