The management of hydrocephalus is common to the practice of every neurosurgeon, and has been estimated to cost as much as $1 billion per year in the US. Fortunately, as our overall health care improves, many of the patients requiring VP shunts now live longer and more productive lives. This has led to an increased desire for better, and especially more cosmetic, approaches to shunt placement. This trend mirrors similar trends in other aspects of neurosurgical care. Because the majority of shunt revisions involve only the ventricular portion of the device, a good cosmetic technique for initial insertion of the abdominal catheter can have a lifelong benefit. Because laparoscopy is being used with increasing frequency in the pediatric population, and the number of pediatric surgeons comfortable with laparoscopic techniques is increasing, it is logical that it be considered for shunt placement in this population as well.

Recently, several authors have introduced new methods to improve shunt placement, especially by using laparoscopy for placement of the peritoneal catheter. The use of laparoscopy in VP shunt placement has led to a reduction in operating time, blood loss, and infection while maintaining shunt viability. It has special efficacy in patients who have had multiple previous abdominal surgeries, because the surgeons are able to verify visually that the shunt is within the peritoneum. In addition, avoidance of infection is the aspiration of any surgeon who deals with shunts. Piatt and then Turner et al. developed techniques that protected the shunt catheter from the abdominal wound and the possible spread of a superficial infection to the hardware below. They accomplished this by placing physical distance between the cutaneous incision and the catheter’s entry into the peritoneum.

Ventriculoperitoneal (VP) shunt placement is the most common surgical treatment for hydrocephalus. Laparoscopic techniques to aid in the placement of the peritoneal portion have been reported previously. Laparoscopic shunt placement has been associated with decreased operating time, less blood loss, and shorter hospital stays. The authors describe a single-incision laparoscopic shunt (SILS) insertion technique that facilitates directed placement of the peritoneal portion of the catheter in children. A total of 6 pediatric patients underwent the SILS procedure between December 2008 and March 2009. This cohort included 5 girls and 1 boy; the average age was 6 years (range 1 day–16 years). One patient had previously undergone a VP shunt placement, but all other patients were undergoing the initial creation of their shunt. The most common pathological condition encountered was posttraumatic hydrocephalus (2 patients). All patients underwent successful placement of the peritoneal catheters. All catheters were seen to have CSF flowing freely within the peritoneal space.

The authors’ recent experience shows that SILS placement is safe and feasible in children. It allows accurate, directed placement of the VP shunt with a single, almost invisible, umbilical incision. The shunt tubing is remote from this incision.

**Key Words** • hydrocephalus • ventriculoperitoneal shunt • laparoscopy • minimally invasive surgery

**Abbreviations used in this paper:** SILS = single-incision laparoscopic shunt; VP = ventriculoperitoneal.
Single-incision laparoscopic shunt

We present a new shunt placement technique, which we have termed SILS placement, and we discuss the initial results in a pediatric cohort. This technique offers several advantages over other procedures, as follows: 1) it requires only 1 abdominal incision, which is located within the umbilicus so that it is completely invisible; 2) it allows complete separation of the peritoneal catheter from this incision; and 3) it has been used in patients as young as 1 day old as well as in older, obese patients.

Methods

Patient Population

A total of 6 pediatric patients underwent the SILS procedure between December 2008 and March 2009 (Table 1). This cohort included 5 girls and 1 boy. The average age was 6 years (range 1 day–16 years), and the weight ranged from 3–54 kg (mean 21 kg). One patient had previously undergone a VP shunt placement; all other patients were undergoing the initial creation of their shunt. The most common pathological condition encountered was posttraumatic hydrocephalus (2 patients).

Surgical Technique

Following general endotracheal intubation, all patients were placed supine on the operating table, with a small bolster placed under the shoulder ipsilateral to the intended shunt site. Preoperative antibiotics were administered as per the protocol at our institution. A small amount of hair was shaved from the intended scalp incisions, and the entire shunt tract, including the abdomen past the umbilicus, was prepared and draped in a sterile fashion. For frontal catheters, the primary incision was made at or in front of the coronal suture, and a small second incision was made just behind the ear. For occipital trajectories, a secondary releasing incision was not needed. The cranial portion of the shunt was placed in the standard fashion. For older patients, a bur hole was created using a high-speed pneumatic drill, and for infants the catheter was placed through an opening in the corner of the anterior fontanel. The ventricular catheter was then placed within the ventricle and connected to the valve. If a posterior auricular incision was used, the catheter was brought out through this incision by using a Carroll tenon passer. At this point, CSF flow was verified down the distal catheter. The entire shunt system was then placed in sponges soaked with antibiotic saline as attention was turned to the abdomen.

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age, Sex</th>
<th>Weight (kg)</th>
<th>Pathological Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1 day, F</td>
<td>4</td>
<td>myelomeningocele</td>
</tr>
<tr>
<td>2</td>
<td>10 yrs, F</td>
<td>25</td>
<td>posthemorrhagic</td>
</tr>
<tr>
<td>3</td>
<td>9 yrs, M</td>
<td>27</td>
<td>congenital</td>
</tr>
<tr>
<td>4</td>
<td>2 yrs, F</td>
<td>14</td>
<td>posttraumatic</td>
</tr>
<tr>
<td>5</td>
<td>16 yrs, F</td>
<td>54</td>
<td>posttraumatic</td>
</tr>
<tr>
<td>6</td>
<td>1 day, F</td>
<td>3</td>
<td>Dandy-Walker</td>
</tr>
</tbody>
</table>

The abdomen was accessed with a single 5-mm port via the umbilicus (Covidien, Inc.). For neonates this was performed by blunt dissection along the remnant umbilical vessels, and for older patients an umbilical incision was made. After the 5-mm port was introduced and the abdomen was insufflated to 10 mm Hg, a laparoscope with integral forceps or optical grasper (Karl Storz GmbH) was inserted and used for both visualization and manipulation of the catheter.

As shown in Video 1, the catheter was tunneled to the abdomen with the aid of a plastic-sheathed shunt tunneler.

Video 1. Clip showing the SILS technique, which allows placement of a peritoneal shunt catheter with no visible scars in a manner that physically separates the shunt catheter from the incision. Click here to view with Windows Media Player. Click here to view with Quicktime.

Prior to its use, the sheath was split lengthwise by using Metzenbaum or Mixter scissors, leaving a few millimeters uncut at the front end. Leaving the very end intact prevents the sheath from snagging on tissue or coming off the obturator during tunneling. The obturator was contoured with a slight bend near the tip to aid in entering the peritoneal cavity. The tunneler was then passed into the subcutaneous fat, with care taken to avoid passing it subjacent to the clavicle, and also to avoid levering it against the skull, particularly in neonates, in whom this might cause a skull fracture. Once the tip was located in the right or left upper quadrant and could be visualized by the laparoscope through the peritoneum, the shunt passer was then rotated so that the tip pointed inward. Under direct laparoscopic visualization, the peritoneum was then punctured by the tip of the tunneler. If needed to assist with peritoneal puncture, the laparoscopic forceps may be used to apply countertraction.

Once the obturator tip and distal sheath were visualized within the peritoneal cavity, the obturator was removed and the insufflation stopped to facilitate passing of the catheter. Once the majority of the catheter had been advanced into the peritoneum, the insufflation was restarted and the catheter was grasped with the optical forceps.

While the distal catheter was held within the peritoneum, the tunneler sheath was removed via the scalp incision. Spreading the longitudinal slit of the sheath by using the tip of an instrument such as forceps or a hemostat allows for easy removal of the sheath without damage to the catheter. The end of the sheath, which was left intact originally, was cut at this time, with care taken not to damage the catheter. The remaining slack in the catheter was then pulled into the peritoneum by the optical grasper forceps. The CSF flow from the tip of the catheter within the peritoneal cavity can then be visualized. In addition, the tip of the catheter can be verified to be free within the peritoneum and not trapped in a hernia or other blind corner.

At this point, the abdomen was desufflated and then closed using dissolveable sutures. The scalp incisions were irrigated with antibiotic saline and reapproximated using multiple layers of absorbable sutures. In all cases, intrathecal vancomycin was instilled into the ventricular system via the Rickham reservoir.
Results

In all 6 patients, the SILS procedure successfully facilitated intraperitoneal placement of the distal shunt catheter. No postoperative distal catheter obstructions were observed. One patient had a proximal obstruction on postoperative Day 1. Intraoperative evaluation showed that this patient’s peritoneal catheter was functioning properly.

No perioperative infections were noted in this group. One patient had an infected cranioplasty 9 months after shunt placement that required concomitant shunt removal. In 1 patient, the decision was made to withdraw life support on postoperative Day 1 due to multiple chromosomal anomalies and a poor overall prognosis.

Discussion

Refinements in laparoscopic techniques have made the laparoscopically assisted placement of intraperitoneal shunt catheters safer and more efficacious. These techniques have proven to be an acceptable option in children as well. The benefits of these procedures include decreased operating room time, less blood loss, and minimal access incisions. In addition, the distal catheter may be visualized within the peritoneal cavity. One potential drawback is that this approach requires a surgeon experienced in general laparoscopic access techniques.

The original concept for intraperitoneal shunt placement without the shunt being exposed to the abdominal wound was described by Piatt more than 15 years ago. Piatt described making an abdominal incision large enough for the surgeon’s finger. Once the tunneling device could be felt by the surgeon’s fingers, both forward force and the finger directed the tunneler downward. Using this technique, the catheter is never exposed in the abdominal wound. Turner and colleagues modified the technique to include a laparoscope for direct visualization of the shunt within the peritoneal cavity. Our technique is similar to that described by Turner and colleagues, with the main difference being that only 1 abdominal incision is used, and this is located entirely within the umbilicus. In addition, this technique may be used on younger and smaller patients. After a large number of cases had been treated using his open technique, Piatt reported a small number of bowel perforations (0.6% in 540 cases). This has not occurred in our experience, nor is it reported by Turner et al., but obviously these series are much smaller than that of Piatt, so care must be taken to watch for this rare but disturbing complication. We believe that the participation of pediatric general surgeons, who routinely perform laparoscopic procedures on children, will minimize this risk. Only a larger case series will show for sure.

There are several appealing aspects of this new technique. First, there is the reduction of shunt contact with skin flora by the elimination of an abdominal incision overlying the catheter, because the abdominal puncture by the trocar occurs at a distance from the site where the shunt catheter penetrates the peritoneum. Second, although the abdominal scar can be helpful by pointing the neurosurgeon to the location of the peritoneal catheter during a revision, the complete absence of visible scars is appealing in those patients for whom cosmesis is a concern. In a situation in which the catheter needs to be localized where it enters the peritoneum, C-arm fluoroscopy may be beneficial. This technique, like other laparoscopic and trocar access techniques, also offers an advantage in obese patients, in whom “minilaparotomy” incisions are often quite long. The chief drawback appears to be the need for a competent laparoscopic approach surgeon, which may be less of a problem in larger centers. In addition, as other authors have reported, neurosurgeons are capable of learning this access technique just as they have learned the basics of laparotomy for more traditional catheter insertion techniques.

In this small series, all catheters were successfully placed in the peritoneal space and confirmed with laparoscopic visualization. Neither distal catheter failures nor perioperative infections were encountered. One patient required revision of a failed proximal catheter, but the peritoneal catheter was found to be functioning well. In 1 patient an infection related to cranioplasty necessitated removal of the shunt. This shunt was replaced at a later date without incident. Parents and patients voiced satisfaction with this technique, although a formal prospective survey was not performed. Future evaluations of this technique, however, might include an Institutional Review Board–approved survey of this type to assess not only overall satisfaction, but also other variables such as incision sensitivity and discomfort.

Conclusions

We describe the application of a novel laparoscopic shunt placement technique in patients as young as 1 day old. Although further study is needed, initial results show the feasibility of this technique. In this initial series no perioperative infections or distal shunt failures were reported, although a much larger series would be necessary to demonstrate a clear benefit in this regard. Improved cosmesis from a lack of visible incision is also of notable importance.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: Spinks, Prince, Kane. Acquisition of data: all authors. Analysis and interpretation of data: Spinks, Tormenti. Drafting the article: Spinks, Tormenti, Kane. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Spinks. Administrative/technical/material support: Spinks. Study supervision: Spinks.

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