



Minimal exposure maximal precision ventriculoperitoneal shunt: how I do it

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Abstract

Background Ventriculoperitoneal shunt is among the most frequent neurosurgical procedures, complicated by infection and obstruction. The first is influenced by number of skin incisions, catheter exposure and manipulation, and the latter by catheter position.

Method Presenting our neuronavigated laparoscopic-assisted minimal exposure shunt technique performed on 40 consecutive adults. No patient presented infection or distal catheter migration (mean follow-up 12 months). Ventricular catheter malpositioning associated with electromagnetic neuronavigation inaccuracy occurred in two patients with slit ventricles.

Conclusion This technique demonstrates low infection/malfunction rate, postoperative pain, and cosmetic advantages. Limiting factors are availability of laparoscopic surgeons and neuronavigation if not familiar with the approach.

Keywords Cerebrospinal fluid · General surgery · Hydrocephalus · Infection · Laparoscopy · Neuronavigation · Neurosurgery

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Key points

- Malfunction and infections are the most common shunt complications.
- Contact to the skin and number of incisions are associated with shunt infection.
- Single-pass tunneling decreases the infection rate.
- Catheter disconnection and/or malposition are causes of malfunction.
- Laparoscopic approach is increasingly used in shunts.
- Most laparoscopic approaches imply externalization of the distal catheter before peritoneal insertion.
- Octylcyanoacrylate, antibiotic impregnated sutures, and vancomycin powder reduce dehiscence and infection rate.
- This technique reduces the risks of infection, malpositioning, and malfunction.
- Cosmetic results, abdominal incisional pain, and length of hospital stay are improved.
- Limiting factors are availability of general surgeons and neuronavigation.

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Introduction

Ventriculoperitoneal shunting is the preferred treatment for most hydrocephalic patients; however, failure and infection rate are 51.4% and 8.4%, respectively [4].

Intraoperative factors associated with shunt infection are hardware contact to patients' skin and number of incisions. Reduced infection rates with a single-pass tunneling from the frontal to the abdominal incision have been reported [7].

Laparoscopic techniques have been described to avoid laparotomy-associated complications. However, most of these techniques imply externalization of the distal catheter prior to insertion into the peritoneum [2, 3, 5–8].

Octylcyanoacrylate (Dermabond®, Ethicon, Summerville, USA) has proven to reduce wound dehiscence from 24 to 2% and infection rate from 17 to 0% compared to non-absorbable sutures [1].

Relevant surgical anatomy

To perform a single cranial incision for single-pass tunneling from the head to the peritoneum, the length of the surgical area should be minimized by choosing a parietal or occipital approach. Preoperative studies are transferred

to the frameless stereotactic navigation system (Medtronic AxiEM™ Stealth®). The planned burr, surgical trajectory, and length of the proximal catheter are selected, paying attention to avoid important structures.

Two abdominal percutaneous laparoscopic stab incisions for optics and one grasping instrument are performed contralateral to the peritoneal catheter entry point to obtain optimal visualization and surgical maneuverability. The distance of the laparoscopic incisions from the peritoneal catheter access eliminates any hardware contact with the skin (Fig. 1).

Description of the technique

The patient is positioned supine with the head rotated contralateral from the burr hole. Perioperative antibiotics prophylaxis and local anesthetics along the incisions are administered.

A small retroauricular curvilinear incision is performed at the level of the planned burr hole, the skin and the underlying galea are dissected from the skull, and a distal pocket is created to allocate the shunt valve. A burr hole is made and a single-pass tunneling is performed from the cranial to the abdominal region with a gently bent 67 cm Codman® Hoffman passer (Johnson and Johnson Medical Limited).

Simultaneously, the general surgeon performs two percutaneous stab incisions (mid-abdominal and suprapubic) contralateral to the peritoneal shunt insertion to introduce the 5-mm optical trocar and obtain pneumoperitoneum (Fig. 1). Careful inspection of abdominal cavity and adhesiolysis are performed if necessary.

The abdominal fascia and peritoneal membranes are perforated above the arcuate line under laparoscopy by simultaneously pushing the passer handle with one hand and transcutaneously applying downward pressure on the passer tip with the other hand. The insertion site is inspected for any bleeding/perforation. Once removed, the stylet from the passer, the distal catheter, primed with saline to avoid outflow resistance due to the induced pneumoperitoneum, is advanced through the sheath. While removing the sheath, the intra-

abdominal catheter is held in place by with an atraumatic laparoscopic grasper in order to avoid migration (Fig. 2). It is then proximally connected and secured with silk to the valve.

The dura is cauterized and incised and a small corticectomy is performed with bipolars. Under neuronavigation, the ventricular catheter is progressively advanced with the stylet along the planned trajectory until the ventricular system is reached with evidence of CSF (about 5 cm depth). The ventricular catheter is then advanced bluntly into the ventricles to the desired length, connected and secured to the valve with silk. The valve is optimally positioned in the retroauricular pocket by applying minimal retraction on the abdominal catheter with the laparoscopic grasper. The correct positioning of the distal catheter and competent intra-abdominal CSF flow by valve pumping is verified under laparoscopy. The trocars are removed and hemostasis is verified. The abdominal percutaneous wounds are closed with subcuticular Monocryl 4.0 and Dermabond (Fig. 2).

Vancomycin powder is used to cover the burr hole and shunt hardware before closure. The cranial wound is sutured with Vicryl 2.0 in the subcutaneous layer and skin staples.

Indications

Hydrocephalic patients including those with previous abdominal surgeries.

Limitations

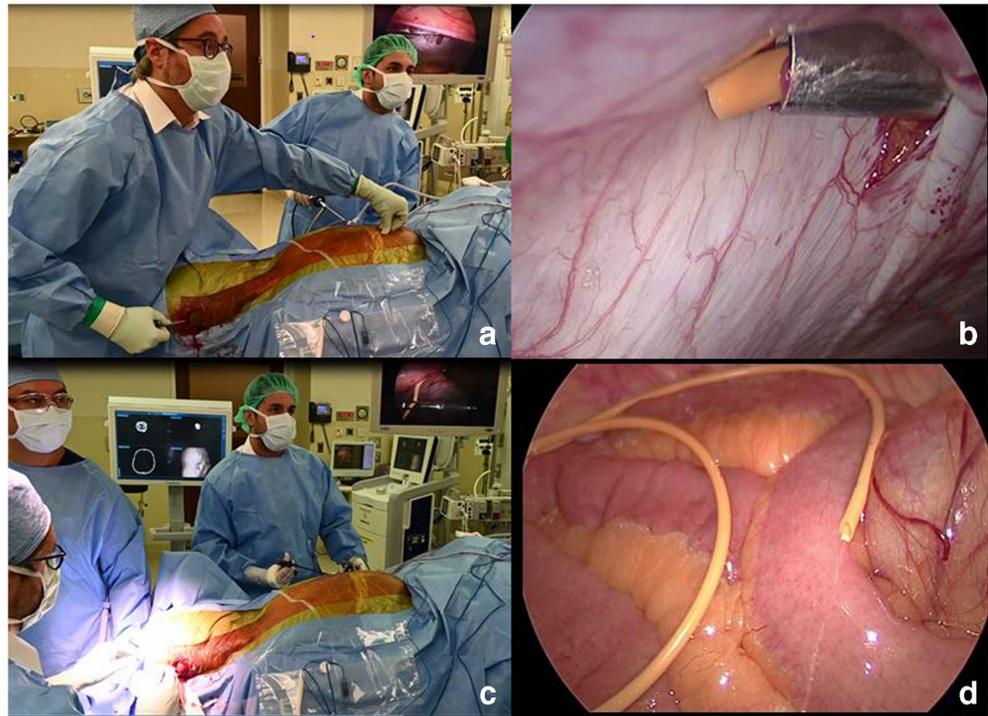
The parieto-occipital ventriculostomy can be more unfamiliar than the frontal approach.

This technique is only possible with shunt passers with inner shaft removable from the posterior (handle) site. Passers are usually straight and the surgical angle from the cranial incision is tangential to the abdominal wall.

Fig. 1 **a** One mid-abdominal and one suprapubic percutaneous incisions are performed contralateral to the peritoneal catheter entry point to obtain dual port laparoscopic access for the optics and the grasper. **b** The abdominal percutaneous wounds are closed with subcuticular Monocryl 4.0 and Dermabond



Fig. 2 **a** The abdominal fascia and peritoneal membrane are perforated by the neurosurgeon who applies pressure on the passer handle with one hand and on the tip with the other hand. **b** The catheter is advanced in the peritoneal cavity through the passer sheath. **c** While removing the sheath, the intra-abdominal catheter is held in place by the general surgeon with an atraumatic laparoscopic grasper to avoid migration in the suprafascial area. **d** The system distal functioning (CSF flow) and correct positioning is verified under laparoscopic view



Perforating the peritoneum can therefore be more difficult than with other techniques.

Performing this technique is subject to the availability of a general surgeon with expertise in laparoscopy, which might be limited in some centers.

The use of laparoscopy and neuronavigation increases the setup time and equipment expenses, which are likely outweighed by the reduced costs of complications management (shunt infection, malfunction and revision rate, increased length of hospital stay).

How to avoid complications

Neuronavigation reduces the risk of shunt malpositioning [9]. As stainless steel self-retractors might interfere with the electromagnetic neuronavigation system and give inaccurate information, they should be replaced by temporary tacking sutures to retract the skin flap.

Individualizing the shape of the malleable passer to adapt to patient physiognomy offers a more perpendicular orientation of the tip to the abdominal wall. During the abdominal insertion, the general surgeon can apply some counter-resistance with a laparoscopic grasper from inside the peritoneal wall and increase the pneumoperitoneum. The laparoscopic view and pneumoperitoneum reduce the risk of organs perforation.

Reducing the induced pneumoperitoneum might be necessary to verify CSF flow throughout the system, which can be counteracted by increased abdominal pressure.

In our institution, we established an excellent collaboration with the Digestive Disease Department, which is essential to perform this technique. General surgeons guarantee full-time coverage for emergency abdominal shunt revisions (which have not been yet reported in our case series) as also discussed by Stoddard et al. [8].

Given the reduced size of the peritoneal wall defect and the lack of abdominal incisions, the risk of catheter migration is extremely low.

Specific perioperative considerations

The possibility to perform laparoscopic adhesiolysis allows shunting in patients who underwent previous abdominal surgeries.

The use of reabsorbable antibiotic impregnated monofilament sutures and Dermabond® for the laparoscopic incisions allows early mobilization, less postoperative pain, and easier hygiene management (patients can shower on the first postoperative day).

Surgical timing is comparable to other standard shunting techniques. Our mean case length is 60 min.

Specific information to give to the patient about surgery and potential risks

The risks of this procedure are not different from standard techniques.

Evident advantages are the reduced risks of shunt infection, selection of the ventricular tip positioning, and verification of the correct positioning of the distal catheter and system functioning.

The patients appreciate the cosmetic impact of a single cranial incision, the reduced abdominal incisional pain, and length of hospital stay.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee (name of institute/committee) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Patient consent statement The patient next of kin has consented to the submission of this How I Do It for submission to the journal.

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