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TECHNICAL NOTE - NEUROSURGICAL TECHNIQUE EVALUATION

Introduction of a self-holding retractor for optimized abdominal visualization in ventriculoperitoneal shunt surgery: first experiences at a single center

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Abstract

Objective Ventriculoperitoneal shunt implantation is a common procedure in general neurosurgery. The patient population is often fragile, ranging from elderly to pediatric patients, and avoidance of perioperative complication is of utmost importance. Abdominal catheter dislocation has been found to be a common cause for early shunt dysfunction and needs to be avoided by optimal visualization of the abdominal catheter insertion zone. Here, we introduce a self-holding wound retractor system Alexis® and demonstrate its use for abdominal shunt surgery in a series of patients.

Methods We explain the use of the Alexis® self-holding wound retractor during open ventriculoperitoneal shunt surgery in a series of 16 patients operated at our institution.

Results The self-holding retractor consists of two polymer rings connected by a polymer membrane. The deep ring is easily placed on the internal fascia of the straight muscle and circular retraction is achieved by twisting the upper ring. Free hand working can then be performed by a single surgeon with good abdominal exposure. No case of abdominal dislocation or infection occurred in our series, although no properly powered statistical analysis can be performed regarding the sample size.

Conclusion We demonstrate the Alexis® Wound Retractor, which is an easy tool for optimal visualization of the abdominal catheter insertion zone. We believe it can facilitate surgical practice of shunt surgery, especially in obese patients.

Keywords Hydrocephalus · Ventriculoperitoneal shunt · Wound retractor · Surgical technique

Abbreviations

A S A score	American Society of Anesthesiologists physical status classification system
BMI	Body mass index
CDG	Clavien–Dindo classification grade
CHF	Swiss franc
CSF	Cerebrospinal fluid
f	Female
H . comm.	Communicating hydrocephalus
ICH	Intracerebral hemorrhage
iNPH	Idiopathic normal pressure hydrocephalus
kg	Kilogram
KPS	Karnofsky performance status scale
m	Male
m^2	Square meter
min	Minute
mRS	Modified ranking scale
NPH	Normal pressure hydrocephalus
OP	Operation
SAH	Subarachnoid hemorrhage
TBI	Traumatic brain injury
VP	Ventriculoperitoneal
y	Years

This article is part of the Topical Collection on *Neurosurgical technique evaluation*

HIGHLIGHTS
- Safe and easy visualization of the abdominal catheter insertion zone for VP-shunting.
- Optimizing minimal invasive exposure in obese VP-shunt patients.
- Facilitating single-surgeon shunt implantation

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Introduction

Chronic cerebrospinal fluid (CSF) diversion is a common treatment for hydrocephalic state in a variety of neurosurgical diseases ranging from congenital malformations to idiopathic normal pressure hydrocephalus [16]. If endoscopic third ventriculostomy is not an option, CSF diversion to a body cavity can be achieved via a shunting device. Nowadays, the ventriculoperitoneal (VP) shunting, a CSF diversion from the lateral ventricle to the intraperitoneal space, represents the most common surgical technique and VP-shunt surgery is a standard neurosurgical intervention [1].

As shunt surgery is regularly performed in fragile patients for various indications, safe surgery is of utmost importance in order to keep perioperative complications to a minimum. Up to 24% of VP-shunt patients experience shunt-related complications and the type of dysfunction can vary according to the shunt age [5, 13].

Abdominal shunt dislocation regularly leads to revision surgery and may occur in 0.5–8% of patients [7, 9, 11, 12]. It was shown that during the early postoperative phase, abdominal catheter misplacement or dislocation can account for up to 22% of shunt dysfunctions [13]. During surgery, proper abdominal catheter insertion can be complicated by excessive abdominal subcutaneous fat or scarred tissue from prior abdominal surgery obscuring the catheter insertion zone. Accordingly, a high body mass index (BMI) was hypothesized to be associated with abdominal catheter misplacement [8]. Here, we report our first experiences with a simple tool enabling optimized abdominal visualization and minimal invasive catheter placement for VP-shunt surgery in a series of patients.

Technique

The device: the Alexis® O Wound Retractor/Protector

The Alexis® O Wound Retractor/Protector (Applied Medical Technology, Modesto, CA, USA) is a self-holding, single-use wound retractor (Fig. 1a). Its application has been described in different surgical procedures including thoracic, visceral, and maxillofacial surgery as well as cesarean section [2, 6, 14, 15]. The retractor is formed by two polyurethane rings, interconnected via a slack polymer membrane. By placing the lower ring at the respective deep layer of the surgical site, it creates a tunnel via soft circular tissue retraction. At the same time, the polymer membrane seals and protects the exposed tissue and even provides hemostasis of small venous bleedings. The device exists in different ring sizes matching various surgical procedures. The model used in this article has a 4-cm ring diameter.

Application in abdominal VP-shunt catheter insertion

VP-Shunt surgery at our department is regularly performed by a single or two surgeons. The cranial catheter is mostly inserted via burr hole trepanation at Kocher's point followed by subgaleal placement of a differential pressure valve and one additional retroauricular incision to facilitate subcutaneous tunneling. A 2–3-cm periumbilical skin incision is performed followed by blunt exposure and perpendicular incision of the anterior lamina of the rectus sheath. The rectus muscle is split atraumatically, and the posterior lamina of the rectus sheath, together with the parietal layer of the peritoneum, is visualized. The shunt catheter and valve are implanted subcutaneously and reach the abdominal insertion zone. Now, the Alexis® retractor is introduced by placing the deep ring below the rectus muscle onto the parietal peritoneum (Fig. 1b and c). Placement of the deep ring through a very small skin incision is facilitated by tearing it into a figure 8 shape for insertion (Fig. 1b). To ensure proper manipulation of the distal catheter tip for insertion, it is mandatory to pull it through the device from deep to superficial once before final retractor placement (Fig. 1c). Circular wound retraction and sealing is achieved by twisting the upper ring and therefore rolling the polymer membrane around it in order to tighten the membrane onto the exposed tissue (Fig. 1d). After retractor placement, the distal catheter can easily be inserted under sight through a pinpoint incision of the posterior lamina of the rectus sheath and parietal peritoneum (Fig. 2). To avoid catheter displacement, a semi-tight peritoneal suture is placed to increase friction of the abdominal catheter without constriction. Now, the retractor can be pulled out using the string which is prefixed at the lower ring.

Case series

Between May 2018 and November 2018, we operated on 16 patients for VP-shunt implantation using this technique (Table 1). The majority of patients were male (14 males vs. 2 females), with a mean age of 67.4 ± 15.3 years at surgery. Three patients had prior abdominal surgery (patients 4, 8, and 9). From 16 patients, 15 were first implantations and one received a completely new shunt system for shunt dysfunction (patient 6). Patients suffered from normal pressure hydrocephalus (NPH, $n = 10$) or malresorptive communicating hydrocephalus (H. comm., $n = 6$). The patients' median BMI was 25.9 (range 17.2–40.0) kg/m^2. The median American Society of Anesthesiologists (ASA) physical status classification system score was 3 (2–4). Mean surgery time was 45 ± 8 min. All patients are continuously followed up after surgery at the outpatient clinic including clinical examination or valve adjustment if needed (mean follow-up time 80 ± 62 days after surgery). Complications were registered in a standardized manner during hospitalization and follow-up consultations

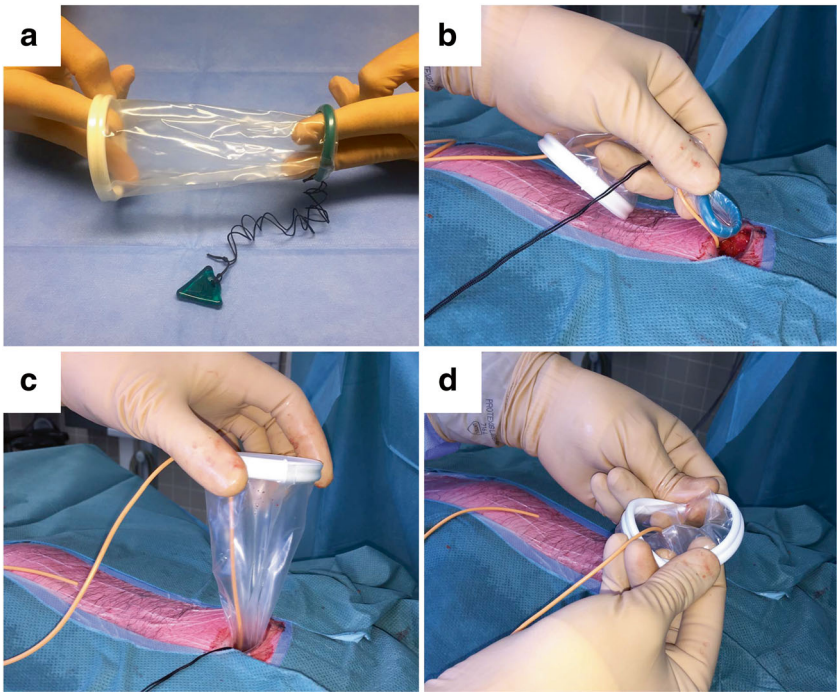

Fig. 1 Placement of the Alexis® Wound Retractor/Protector. **a** The device consists of two semi-rigid polymer rings (white, superficial; dark, deep) connected by a transparent polymer membrane and an extraction wire fixed to the deep ring. **b** Insertion of the deep ring is facilitated by forming a figure 8 shape. **c** After insertion of the inner ring, the membrane is still flaccid. Note that the catheter has to be inserted in the membrane tunnel from the inside (dark/not visible) to the outside (white). **d** The membrane is spanned to induce retraction by rolling the outer ring

according to the Clavien–Dindo Grading (CDG) scale for complications in surgery [3]. Three out of 16 patients experienced complications including one cranial shunt misplacement (patient 9), one cranial catheter kinking (patient 11), and one overdrainage (patient 15). Patients 9 and 11 were reoperated on immediately and developed no permanent deficits. Patient 15 received non-invasive valve pressure adjustment and became free of symptoms. No infections or abdominal complications occurred in our series. Every patient received a postoperative abdominal radiography (anteroposterior and lateral) which confirmed a good intraabdominal catheter placement in all 16 patients.

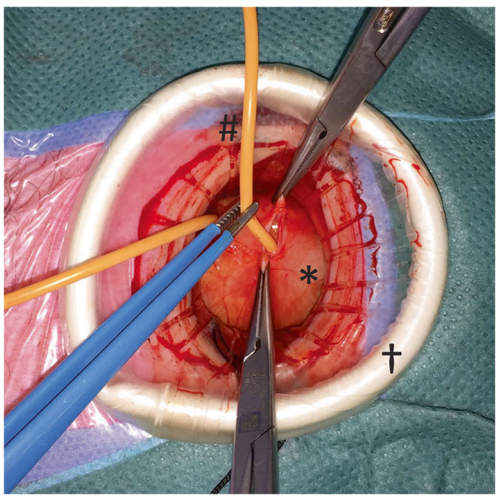

Fig. 2 The abdominal exposure after installation of the Alexis® Wound Retractor/Protector. Subcutaneous fat/tissue, outer rectus fascia, and muscle are retracted. The distal catheter can easily be inserted intraabdominally (the asterisk indicates the parietal leave of the peritoneum; the number sign, the abdominal shunt catheter; the dagger, the superficial wound retractor ring)

Ethics

All data and images mentioned in this manuscript were acquired from our institutions' neurosurgical outcome quality and safety registry, based on local ethics committee approval (Kantonale Ethikkommission KEK-ZH 2012e0244). All patients signed an informed consent for the described procedures.

Discussion

The Alexis® retractor demonstrated here, which has already been introduced to different surgical procedures, is now used for the first time in a neurosurgical procedure. In our series of 16 patients operated on with this technique, 25% had shunt- or surgery-related complications without permanent deficits (1 cranial misplacement, 1 cranial catheter kinking, 1 overdrainage, and 1 local allergic skin reaction to the disinfectant). More importantly, no abdominal surgical complications or catheter dislocations occurred. Surgery was performed within a reasonable timeframe between 30 and 55 min duration. The retractor is easily used and provides excellent visualization of the catheter insertion zone in the region of the rectus muscle. This may enhance control for the risk of abdominal shunt complications such as extraperitoneal catheter placement or incidental incision of superficial intestines. Its circular retraction provides a maximized field of vision even through minimized skin

Table 1 List of patient characteristics

Patient number	Sex	Age (y)	Diagnosis	OP duration (min)	ASA score	BMI (kg/m^2)	Pre-OP KPS	Pre-OP mRS	Complication	CDG
1	m	71.7	iNPH	50	3	28.7	90	1	–	–
2	m	53.8	iNPH	49	3	24.8	70	2	–	–
3	m	34.0	H. comm. (post TBI)	48	3	25.4	70	2	–	–
4	m	77.4	iNPH	44	3	27.8	80	3	–	–
5	m	65.5	H. comm. (post TBI)	55	3	26.0	40	5	–	–
6	m	81.8	iNPH	38	3	21.6	50	4	–	–
7	f	70.3	H. comm. (post ICH)	54	3	17.2	70	3	–	–
8	m	81.4	iNPH	36	3	31.4	90	2	–	–
9	m	37.0	H. comm. (congenital)	55	2	32.8	90	1	Cranial catheter misplacement	3
10	m	76.7	NPH (post ICH)	45	3	27.6	80	2	–	–
11	m	75.4	iNPH	35	2	24.5	80	2	Cranial catheter kinking	3
12	m	79.2	H. comm. (brain tumor)	50	3	24.3	50	3	–	–
13	f	79.0	iNPH	34	3	25.8	80	1	–	–
14	m	51.0	H. comm. (post SAH)	55	3	23.8	80	2	–	–
15	m	75.2	iNPH	30	4	33.1	60	3	Overdrainage	1
16	m	69.3	iNPH	46	3	40.0	90	1	Allergic reaction to disinfectant	1

ASA score, American Society of Anesthesiologists physical status classification system; *BMI*, body mass index; *OP*, operation; *y*, years; *m*, male; *m*^{2}, square meter; *min*, minute; *f*, female; *KPS*, Karnofsky performance status scale; *mRS*, modified ranking scale; *CDG*, Clavien–Dindo classification grade; *NPH*, normal pressure hydrocephalus; *iNPH*, idiopathic normal pressure hydrocephalus; *H. comm.*, communicating hydrocephalus; *kg*, kilogram; *TBI*, traumatic brain injury; *ICH*, intracerebral hemorrhage; *SAH*, subarachnoid hemorrhage

incisions, enables minimal invasive catheter placement, and limits excessive focal tissue compression that could interfere with wound healing. Moreover, the tight polymer membrane seals the wound surface which has been claimed to reduce surgical site infections in abdominal surgery [4]. Use of the device results in moderate additional costs (185.50 CHF for a set of 5). A benefit in risk reduction by the Alexis® retractor remains to be shown for VP-shunt surgery to justify its regular use. The present cohort consisted mostly of patients with a good Karnofsky performance score, favorable BMI, and a high proportion of idiopathic normal pressure hydrocephalus, and only three patients with prior abdominal surgery. Therefore, this could not be considered as a high-risk population. Still, in special conditions such as severely obese patients, heavily scarred abdominal tissue, or surgery by a single surgeon, the Alexis® retractor can provide easy and excellent visualization of the abdominal insertion zone. In these cases, improving the visualization of the insertion point could sometimes be enough to ensure proper catheter placement and therefore be a simple method before considering a laparoscopy-assisted approach, which needs more complex instrumentation and the presence of an additional visceral surgeon [7]. Nevertheless, in very complex cases, the use of an endoscopy-assisted catheter placement can still be necessary to control for extensive intraabdominal adhesions that cannot be handled from extraperitoneally [10]. Given the actual rates of shunt dysfunction, and here especially abdominal dislocation, our cohort is not sufficiently large to draw conclusions based on statistical analysis. With the present series, we aim to share our technique in a detailed way and demonstrate the feasibility and safety of this approach. In order to properly investigate the impact of using the Alexis® retractor for VP-shunt surgery on abdominal dislocation and infection rates, a prospective trial with a larger sample size will be needed. Still, we are convinced that this simple technique can be a helpful tool in the neurosurgeon's armamentarium and should be considered in the surgical planning.

Conclusion

The Alexis® Wound Retractor represents a simple tool that can improve the exposure of the abdominal catheter insertion zone during VP-shunt surgery. It can be useful in cases of obese or heavily scarred patients, if abdominal exposure can be laborious or manual retraction by a second surgeon is not possible.

Author contributions All authors confirm that the manuscript and the order of listed authors have been read and approved by all the named authors. L.H.S., M.F.O., and P.K. documented and analyzed the patient data, wrote the manuscript, and performed surgeries.

Compliance with ethical standards

All data and images mentioned in this manuscript were acquired from our institutions' neurosurgical outcome quality and safety registry, based on local ethics committee approval (Kantonale Ethikkommission KEK-ZH 2012e0244). All patients signed an informed consent for the described procedures.

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

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Comments

The authors present what seems to be an easy-to-use self-holding retractor visualization of the abdominal wall/peritoneum in shunt surgery. This device has already been used in several surgical procedures, but so far not in neurosurgery.

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