

Clinical Article



Case Series of Ventriculoatrial Shunt placement in Hybrid Room: Reassessment of Ventriculoatrial Shunt

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OPEN ACCESS

Received: Jul 6, 2020

Revised: Sep 15, 2020

Accepted: Sep 29, 2020

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Conflict of Interest

The authors have no financial conflicts of interest.

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ABSTRACT

Objective: Ventriculoatrial shunt (VAS) remains an alternate option for treatment of hydrocephalus in patients with ventriculoperitoneal shunt (VPS) failure. Unfamiliar anatomy for a neurosurgeon has resulted in the VAS falling out of favor as a treatment option. However, there are unsatisfactory reports on the long-term result of VPS, and VAS has been recently re-evaluated. We are to report the simple way to do the VAS using a peel-away sheath in a hybrid operation room.

Methods: A jugular vein path was drawn by ultrasound, a small incision was made above the clavicle, and a shunt catheter was tunneled into it. The jugular vein was punctured beside the tunneled catheter with a Seldinger needle under ultrasound guidance. A flexible guide wire was introduced into the vein and 6-Fr peel-away sheath was advanced into the vein along the wire. Under fluoroscopic guidance, the catheter was cut to position approximately mid-level in the atrium. After the guide wire was removed, the distal shunt catheter was passed down. After confirming proper position of the distal catheter under the fluoroscope, the catheter-guiding sheath was pulled out as a peeling-away manner. We performed this surgical procedures in 5 cases.

Results: All the procedures of the VAS using a peel-away sheath were performed in a hybrid operation room. Of 5 patients, 3 patients had the distal catheter failures in the peritoneal cavity and 2 patients had shunt A distal catheter was successfully indwelling in all the cases without any difficulties. After the surgery, neither shunt infection nor thromboembolic event happened.

Conclusion: VAS using fluoroscopy and a peel-away sheath is a good alternative option for hydrocephalus patients with shunt failure related to peritoneal cavity complications.

Keywords: Hydrocephalus; Ventriculoatrial shunts; Ventriculoperitoneal shunt; Fluoroscopy; Hybrid; Operating room

INTRODUCTION

In recent decades, the peritoneum has been used as a suitable place for cerebrospinal fluid (CSF) diversion. The ventriculoatrial shunt (VAS) was first introduced in 1952 by Nulsen and Spitz, followed by the ventriculoperitoneal shunt (VPS) by Scott in 1955. However, due to various complications in the peritoneum caused by the polyethylene-distal catheter, VAS became the preferred choice for treatment of hydrocephalus until the 1970s.^{8,40)} Nevertheless,

problems such as difficulty of access to the atrium, arrhythmia, thromboembolic complication, and pulmonary hypertension have been continuously reported in VAS. The development of a distal catheter made of silicon reduced the peritoneal complications and VPS became the preferred first-line of choice for the treatment of hydrocephalus. As a result, VAS became the second-line of choice and fell out of favor.¹⁶⁾

Although VPS is performed as the primary treatment for hydrocephalus, there is some hesitation to perform it in patients with peritoneal problems. In addition, new evaluations of VAS are being made in children and adults.^{7,16)} In the comparison of VAS and VPS in normal pressure hydrocephalus patients, Hung et al.⁷⁾ reported that the shunt obstruction and revision rate were lower in VAS, and that severe complications such as cardiopulmonary problem did not occur in VAS. Particularly, in reports of the long term outcome of VPS performed in pediatric patients, the revision rate was over 80% for VPS, with about half of them undergoing multiple revisions.^{15,17)} As the cause of revision, the distal catheter problem was reported as 40%.¹⁵⁾ Even though the silicon distal catheter has fewer peritoneal complications than the previous type of catheter, complications such as peritoneal scarring, adhesion, pseudo-cyst, abscess, and ascites continue to occur. These problems resulted in hesitancy to place the distal catheter in the peritoneum during the revision operation.

Recent advances in technology and devices have helped develop a method of percutaneous placement of the distal catheter in the atrium. Appropriate placement of the distal catheter can be confirmed by intraoperative fluoroscopy using C-arm or angio-machine. We report cases of patients who underwent VAS due to various peritoneal problems in the hybrid operating room.

MATERIALS AND METHODS

Eligible patients included those who underwent VAS in our institute between January 2017 and June 2020. VAS surgery was performed in collaboration with the vascular general surgeon, under general anesthesia. Distal catheter was inserted by Seldinger technique with the use of 6-Fr peel-away sheath (Distri-cath®; Districlass Medical SA, Chaponnay, France). A floor-mounted multi-axis robotic C-arm monoplane DSA system in hybrid operating room was used to confirm the proper position of distal catheter in all cases.

RESULTS

During the study period, 5 patients (2 women) underwent VAS in hybrid operating room by using 6-Fr peel-away sheath. Demographic and clinical characteristics are summarized in

TABLE 1. Of five patients, three patients had a problem with the peritoneal cavity and two

Table 1. Patient demographic data and cause of VAS

Case No.	Sex	Age	Primary diagnosis	Cause of VAS
1	F	24	Traumatic SAH	Pan-peritonitis due to PEG leakage Recurrent pneumonia and pleural effusion after ventriculopleural shunt
2	M	58	Pontine hemorrhage	Massive ascites due to liver cirrhosis
3	M	58	SAH	Abdomen incisional hernia and small bowel adhesion on hernia site
4	F	70	SAH	VPS infection and severe ileus and peritoneum adhesion
5	M	32	Traumatic SDH	VPS infection and severe ileus and peritoneum adhesion

VAS: ventriculoatrial shunt, SAH: subarachnoid hemorrhage, PEG: percutaneous endoscopic gastrostomy, SDH: subdural hemorrhage, VPS: ventriculoperitoneal shunt.

patients had a history of shunt infection and associated peritoneal adhesion. There was no shunt infection after VAS in all cases.

Case 1

A 24-year-old female patient with a VP shunt who was admitted to our rehabilitation hospital was referred for distal catheter externalization. The patient was diagnosed with traumatic subarachnoid hemorrhage and subdural hemorrhage at another hospital. She underwent bilateral craniectomy, cranioplasty, and VPS. The patient was bed ridden (E4M4Vt on the Glasgow Coma Scale) and was admitted to our rehabilitation hospital for PEG (Percutaneous Endoscopic Gastrostomy) tube change. The patient had high fever, vomiting, and abdominal tenderness after the PEG tube change. Peritonitis was diagnosed, caused by extensive contamination of the peritoneum due to leakage through the PEG tube. Surgery for peritonitis was carried out and for this purpose, shunt externalization was performed at the clavicle level.

Peritonitis was resolved after approximately eight weeks of antibiotic use, but the general surgeon expressed concerns about placing the distal catheter in the peritoneum due to adhesion of peritoneum and inflammation. After discussion, we decided to place the distal catheter into the pleural cavity. The patient underwent a ventriculopleural shunt operation in consultation with the thoracic surgeon and had no specific problems for 3 months. Eventually, pleural effusion was observed caused by the development of pneumonia. Pneumonia and pleural effusion were treated with antibiotics and PCD (Percutaneous Catheter Drainage), but effusion and pneumonia reoccurred after PCD removal. In this patient, the pleura was not appropriate for placement of the distal catheter, and the atrium was finally determined to be a suitable location. In consultation with a vascular general surgeon, surgery was performed in a hybrid operating room.

The surgery used the existing proximal catheter and valve (Codman Hakim programmable valve; Codman/Johnson & Johnson, Raynham, MA, USA). Only the distal catheter was replaced. Under ultrasound guidance, the path of the right jugular vein was drawn. In the path of the jugular, a small incision was made about 2 cm above the right clavicle, and the shunt catheter was tunneled into the incision. The jugular vein puncture was performed beside the tunneled catheter with an 18-gauge Seldinger needle under ultrasound guidance. A 0.035-in flexible guide wire was introduced into the vein and the needle was withdrawn over the wire. 6-Fr peel-away sheath was advanced into the vein along the wire. Under fluoroscopic guidance, the catheter was cut to a length of 14 cm so that it could be positioned approximately at the atrium mid-level. The dilator and guide wire were removed, the shunt distal catheter was passed down the sheath, cut to a length of 10 cm, and placed back into the sheath. After confirming that the catheter was properly positioned by fluoroscopy, the peel-away sheath was removed.

After successful surgery, considering the bed ridden state of the patient, rivaroxaban 10 mg was used to prevent thromboembolic events. The patient was followed-up for two years after VAS placement without significant problems.

Case 2

A patient with a history of alcoholic liver cirrhosis visited the emergency room in an altered conscious status (E1M3Ve on the Glasgow Coma Scale). CT brain examination revealed a large pontine hemorrhage and intraventricular hemorrhage. Emergency extraventricular

drainage (EVD) and conservative management were undertaken. The patient underwent conservative treatment for 4 weeks in the intensive care unit; nevertheless, EVD failed to taper. The caregiver wanted to shift to a nursing hospital for economic reasons, but it was not permitted when the patient had EVD. Although shunt OP was considered, it was difficult to implement VPS due to ascites. Therefore, VAS was placed in this patient.

A proximal catheter and valve (Certas programmable valve, Codman/Johnson & Johnson) were positioned at the right parieto-occipital point using a non-framed navigation technique using an angio-machine (Artis Zeego, Siemens Healthcare, Forchheim, Germany) in the hybrid room. A distal catheter was connected to the valve and tunneled to the neck for insertion into the jugular vein. Under ultrasound guidance, venous puncture was performed with 18-gauge Seldinger needle. A guide wire was passed through the needle and the wire tip was placed in the mid-level atrium under fluoroscopic guidance. In this case, it was possible to confirm the exact length to the mid atrium using a guide wire which was marked with 10 cm increments. The needle was withdrawn and 6-Fr peel-away sheath was advanced over the wire. The catheter was cut to a length of 10 cm. The dilator and guide wire were removed, and the shunt catheter was passed down the sheath. After confirming under fluoroscopic guidance that the catheter was properly positioned, the peel-away sheath was removed.

The patient underwent CT scan a week later and the ventricle was reduced in size. The stitches were removed and he was transferred to a nursing hospital.

Case 5

A 32-year-old male patient underwent surgery for traumatic acute subdural hematoma in a local hospital and VPS surgery for hydrocephalus. However, a shunt infection occurred, the shunt system had to be removed, and the patient received antibiotics with EVD. At the end of antibiotic treatment, VPS reoperation was considered, but due to peritoneal adhesion and severe ileus, another option for CSF diversion had to be considered. The patient was transferred to our hospital for VAS.

The VAS with the right Frazier's point was considered and designed to send the distal catheter to the ipsilateral jugular vein (**FIGURE 1**). Under ultrasound guidance, the path of right jugular vein was drawn. In the path of the jugular, a small incision was made about 4 cm above the



FIGURE 1. Ventriculoatrial shunt with the right Frazier's point was considered and designed to send the distal catheter to the ipsilateral jugular vein.

right clavicle. The jugular vein puncture was performed with 18-gauge Seldinger needle under ultrasound guidance. A 0.035-in flexible guide wire was introduced into the vein and the needle was withdrawn over the wire. 6-Fr peel-away sheath (Distri-cath[®]; Districlass Medical SA) was advanced into the vein along the wire (**FIGURE 2**). Under fluoroscopic guidance, the distal catheter was cut to a length of 14 cm so that it could be positioned approximately at the mid-level of the atrium. The dilator and guide wire were removed, the shunt distal catheter was passed down the sheath, cut to a length of 10 cm (**FIGURE 3**), and put back into the sheath (**FIGURE 4**). After confirming that the catheter was properly positioned by fluoroscopy (**FIGURE 5**), the peel-away sheath was removed (**FIGURE 6**).

DISCUSSION

We present five cases in **TABLE 1** wherein we performed VAS when the patient directly had a problem with the peritoneal cavity (Case 1–3), or in cases with a high potential for a problem in the peritoneal cavity in future (Case 4 and 5). The incidence of peritoneal cavity complications related to VPS ranges from 5%–47%.¹⁾ Some well-known peritoneal complications after VPS are shunt infection, pseudo-cyst, adhesion, malposition (scrotum, bladder, small bowel), and hernia.²⁾ After distal catheter externalization due to these



FIGURE 2. Peel-away sheath (Distri-cath[®]; Districlass Medical SA, Chaponnay, France) was advanced into the vein along the wire.



FIGURE 3. The shunt distal catheter was cut according to the wire length. Sheath dilator had not been removed yet.

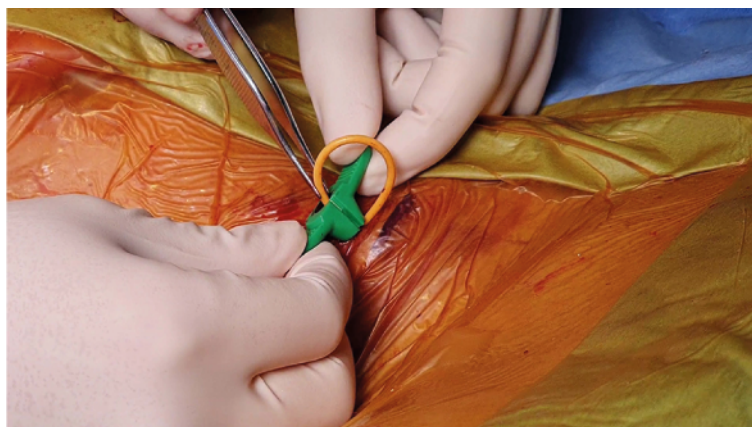


FIGURE 4. The dilator was removed and the shunt distal catheter was carefully pushed into the sheath.

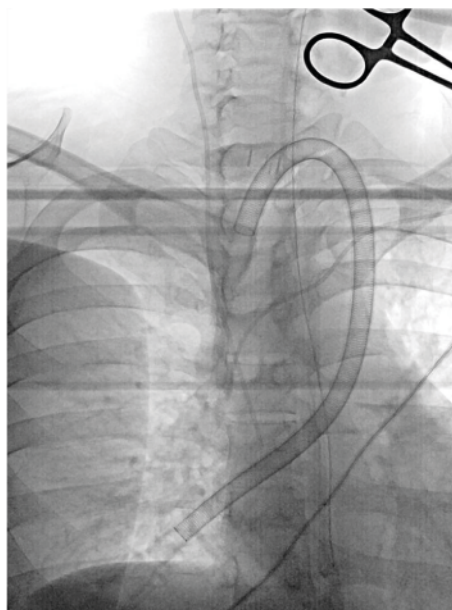


FIGURE 5. After inserting the catheter to the end of the sheath, fluoroscopy was used to confirm that the catheter was properly positioned.

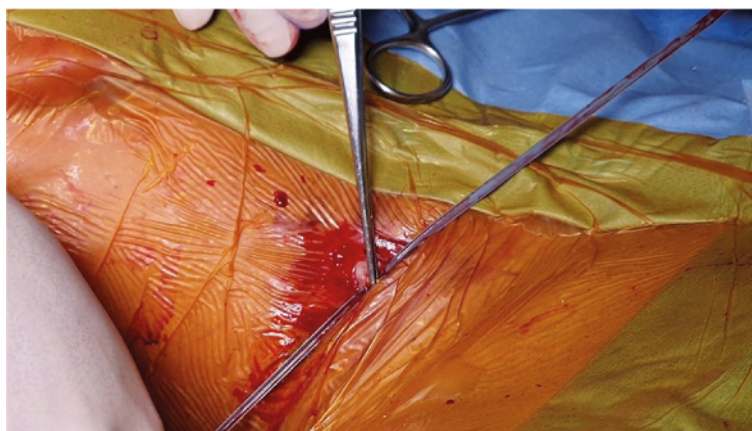


FIGURE 6. The sheath was carefully peeled away, being careful not to allow the shunt distal catheter to fall backwards.

problems, it is difficult to reselect the peritoneal cavity for placing the distal catheter for CSF diversion. Although pleural placement can be considered, it may also have complications such as hydrothorax, pneumonia, and pleural effusion. The pleura is also not a good option for long term distal catheter placement.³⁾ Of course, placement in the atrium can also have complications similar to other distal placements; obstruction, infections, and malfunction can occur. However, in a recent comparative study on long term outcome of VPS, the incidence of complications of VAS is not higher than VPS.^{6,7,10)} Hung et al.⁷⁾ reported that VA shunted patients were less likely to experience shunt obstruction and require shunt revision compared to VP shunted patients in the idiopathic normal pressure hydrocephalus group.

The most important thing in considering VAS is placement of the distal catheter tip in the proper position.^{5,11)} Serious complications such as migration thrombosis or arrhythmia can result from an improper positional relationship between the distal catheter tip and vessel wall or endocardium.¹²⁾ The correct position of the catheter tip is considered to be in the lower third of the superior vena cava, close to its entrance to the right atrium.⁴⁾ A well-known method for placing the distal catheter tip in the appropriate position is to use an intraoperative radiographic assessment (fluoroscopy) or an electrocardiographic-guided method.^{4,13)} The method of placing the distal catheter using fluoroscopy is the same for inserting the central venous catheter. Using sonography, the location of the internal jugular vein (IJV) can be identified, and the distal catheter connected to the valve can be placed by tunneling to the IJV puncture site. In the Seldinger technique, the wire is placed in its proper position, the length of the distal catheter is measured, and the peel-away sheath (Distri-cath[®]; Districlass Medical SA) is placed. Care should be taken to place the peel-away catheter of sufficient length in the subclavian vein so that the distal catheter does not go to the wrong location. We performed this process using an angio- machine in a hybrid operating room, confirmed the distal catheter tip was in the proper position, carefully removed the peel-away catheter, and then closed the wound. In collaboration with an experienced vascular surgeon, the procedure time was reduced and the wound was small compared to the peritoneal approach. As far as we know, this is the first report of VAS using the peel-away sheath. As this method is used in the chemo-port insertion procedure, we decided to see if it could be applied in VAS.

Despite the easy approach using the peel-away sheath, a concern about VAS is the possibility of thromboembolic complications. Cardiac thrombus formation, pulmonary artery thromboembolism, and pulmonary hypertension have been reported as complications of VAS in previous studies.^{12,14)} High incidence of thromboembolic complications can be explained on the basis of CSF altering the endothelium, leading to in situ thrombosis and perpetuating endothelial damage.¹²⁾ These thromboembolic complications have high mortality and morbidity rates, but their prevalence is less than 1% in VAS.^{7,14)} Rivaroxaban was used in our patients to prevent these complications. However, to date, there is no clear medical management strategy to prevent thromboembolic events.

CONCLUSION

Historically, VAS has maintained its reputation as an alternate treatment for VPS in hydrocephalus patients. However, the current generation of neurosurgeons is reluctant to perform VAS since they are unfamiliar with the atrium approach. The classical approach to expose the jugular vein by incision in the neck was considered time consuming, and it was difficult to expose major vessels. However, approaching the atrium using fluoroscopy and

peel-away sheath is a very easy and useful method. Although the peritoneal approach is more familiar to the neurosurgeon, understanding and experience with VAS using fluoroscopy and peel-away sheath is a good alternative option for hydrocephalus patients with previous peritoneal cavity problems.

ACKNOWLEDGMENTS

This work was supported by a 2-year Research Grant of Pusan National University.

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