Published in final edited form as:

J Clin Neurosci. 2016 March ; 25: 46–49. doi:10.1016/j.jocn.2015.07.022.

Risk factors associated with distal catheter migration following ventriculoperitoneal shunt placement

Kingsley O. Abode-Iyamah^{a,*}, Ryan Khanna^b, Zachary D. Rasmussen^c, Oliver Flouty^a, Nader S. Dahdaleh^b, Jeremy Greenlee^a, and Matthew A. Howard III^a

^aDepartment of Neurosurgery, Carver College of Medicine, The University of Iowa, 200 Hawkins Drive, Iowa City, IA 52242, USA

^bDepartment of Neurosurgery, Northwestern University, Feinberg School of Medicine, Chicago, IL, USA

^cThe University of Iowa, Carver College of Medicine, Iowa City, IA, USA

Abstract

Ventriculoperitoneal (VP) shunt placement is used to treat hydrocephalus. Shunt migration following VP shunt placement has been reported. The risk factors related to this complication have not been previously evaluated to our knowledge. In this retrospective cohort study, we aimed to determine risk factors leading to distal catheter migration and review the literature on the current methods of management and prevention. Adult patients undergoing VP shunt placement from June 2011 to December 2013 at a single institution were identified using electronic health records. The records were reviewed for demographic and procedural information, and subsequent treatment characteristics. The parameters of patients with distal shunt migration were compared to those undergoing new VP shunt placement for the same time period. We identified 137 patients undergoing 157 new VP shunt procedures with an average age of $57.7 \pm$ standard deviation of 18.4 years old. There were 16 distal shunt migrations. Body mass index $>30 \text{ kg/m}^2$ and number of previous shunt procedures were found to be independent risk factors for distal catheter migration. Obesity and number of previous shunt procedures were factors for distal catheter migration. Providers and patients should be aware of these possible risk factors prior to VP shunt placement.

Keywords

Distal shunt revision; Shunt complication; Shunt malfunction; Shunt migration; Shunt revision; VP shunt

1. Introduction

Since first being described in 1908 by Kausch, ventriculoperitoneal shunt (VPS) has become one of the most common procedures performed by neurosurgeons [1]. VPS is placed in

*Corresponding author. Tel.: +1 319 356 7482; fax: +1 319 353 6605., kingsley-abode-iyamah@uiowa.edu (K.O. Abode-Iyamah).

Conflicts of Interest/Disclosures

The authors declare that they have no financial or other conflicts of interest in relation to this research and its publication.

patients with hydrocephalus which ranges in etiology from normal pressure hydrocephalus and idiopathic intracranial hydrocephalus to congenital cases such as aqueductal stenosis. During the placement of a VPS, a proximal catheter is placed in the ventricle and is connected to a valve. A distal catheter is connected to the distal end of the valve and then tunneled subcutaneously and placed in the peritoneal cavity, pleural space or atrium. The most common location for distal catheter placement is the abdominal cavity. [2] VPS is thought to be associated with reduced complications compared to ventriculoatrial and ventriculopleural shunts which contributes to its popularity [2–5].

However, complications following VPS shunt are not uncommon and are reported at a rate of 40 to 50% [2,6,7]. Shunt malfunction is reported at a rate of 40%, the majority of which are due to distal shunt failure [2,8–11]. Distal shunt migration where the peritoneal portion of the shunt is extruded from the peritoneal cavity into the subcutaneous soft tissue has also been reported [12–16]. This process leads to cerebrospinal fluid collection in the subcutaneous tissue, building pressure and ultimately resulting in a distal shunt malfunction.

To our knowledge the existing literature on the complication of distal catheter migration is limited to case reports. Here we perform a retrospective review of distal catheter migration to identify the risk factors predisposing to these complications. Additionally, we perform a literature review on the current techniques to eliminate these complications.

2. Method

This is a retrospective review investigating distal catheter migration. All adult patients (≥ 18 years old) undergoing a VPS placement from June 2011 to December 2013 were identified using electronic health records. Patients who were over 18 years of age at the time of their VPS placement were included. Those who were less than 18 years of age, underwent VPS placement at a different institution, or had incomplete information, were excluded from the study.

University of Iowa's Institutional Review Board approval was obtained for this retrospective chart review. The electronic medical record, including the procedure and follow-up notes, were reviewed for demographic and procedural information, and subsequent treatment characteristics. The parameters of patients with distal shunt migration were compared to those undergoing new VPS placement for the same time period.

2.1. Surgical procedure

In our institution, all distal VPS placements are performed with a small laparotomy. A purse-string suture is placed in the peritoneal layer and tied down around the catheter as it enters the peritoneal cavity. The abdominal content (liver) is identified prior to placement of the catheter in the abdominal cavity.

2.2. Imaging

Following each shunt procedure a shunt series radiograph is obtained to confirm placement of the catheter in the abdominal cavity. All patients presenting with shunt malfunction are

evaluated with a shunt series. When there is concern for migration of the distal catheter an abdominal CT scan is obtained to confirm the diagnosis.

2.3. Statistical analysis

Categorical variables are presented as number and percentage. Continuous variables are presented as mean $\pm$ standard deviation. Six different factors were proposed as potential predictors of distal shunt migration: age, body mass index (BMI; separated into <25 , $25\text{--}30$, and >30 kg/m²), sex, presence of liver failure, presence of constipation, and number of prior shunt procedures. For continuous variables, univariate analysis was performed using a two-tailed Student's *t*-test. For nominal variables, univariate two-tailed chi-square analysis was performed. Multivariate analysis to identify possible predictors was conducted using binary logistic regression with the backward stepwise method. Statistical significance was determined as $P < 0.05$ for a 95% confidence interval (CI). All statistical analyses were performed by using the Statistical Package for the Social Sciences version 22.0 (IBM, Armonk, New York).

3. Results

3.1. Demographic

From June 2011 to December 2013 we identified a total of 150 patients who had new shunt placement or shunt revision for distal catheter migration (Fig. 1). Of these there were 137 patients undergoing 157 new VPS procedures with an average age of 57.7 ± 18.4 years. In this same time period there were 68 distal shunt revisions identified. Sixteen (23.5%) of the 68 distal shunt revisions were in 13 patients who had a shunt migration at an average age of 46.6 ± 14.9 years (Table 1). Of the 16 procedures with distal shunt migration, 68.8% were in patients undergoing new shunt revision in this time period. The majority of the shunt malfunctions (68.8%) occurred within 3 months of the initial procedure (Fig. 2).

3.2. BMI

The average BMI at the time of the procedure was 30.0 ± 9.8 kg/m² and 39.4 ± 8.7 kg/m² ($P < 0.001$) in the control and distal catheter migration group, respectively. The BMI of both groups were divided into normal (<25 kg/m²), overweight ($25\text{--}30$ kg/m²) and obese (>30 kg/m²). In the normal and overweight group, BMI was not a risk factor for shunt migration. In the obese group, BMI was found to be an independent risk factor for shunt migration (odds ratio = 6.38, 95% CI = 1.16–35.21; $P = 0.033$).

3.3. Previous shunt procedures

The number of previous shunt procedures was also recorded in each patient. There were 11 patients with a history of previous shunt placement of the 158 new shunt procedures that were performed, with the total number of previous procedures ranging from one to five. In the group with shunt migration, all 13 patients had a previous shunt procedure, which ranged from one to six. Previous shunt surgery was a risk factor for catheter migration, increasing with each prior shunt operation after adjusting for BMI (odds ratio = 2.17, 95% CI = 1.47–3.22; $P < 0.001$).

3.4. Liver failure and constipation

Patients were assessed for constipation based on both clinical history and radiological diagnosis of constipation on abdominal portion of the shunt series radiograph. There were a total of five patients identified to have constipation, none of whom suffered a shunt malfunction. After multivariate analysis, this was not a significant risk factor for shunt migration in this study. Patients were also evaluated for liver failure based on past medical history. Only one patient in this series was identified with liver failure.

4. Discussion

Although VPS is an effective treatment of hydrocephalus, it is plagued by shunt related complications. The first year survival rate of a shunt is 40%, while 50% fail by the second year [2,6,7,17]. While shunt dysfunction can result from both proximal and distal malfunctions, 40% occur as a result of distal shunt malfunction [2,8–11]. Distal migration is a recognized complication of VPS placement and has been reported in up to 8.6% of cases [12,18]. In our study we identified 16 shunt migrations during a period where 157 new VPS were implanted for a rate of 10.1%. The majority of the literature on distal shunt migration are case reports which may underreport the true rate of this complication. Additionally to our knowledge there have not been any studies to identify the risk factors for this complication.

It is not unknown that distal catheter migration is seen in obese patients [12–16]. Numerous case reports have reported this complication although, to our knowledge, none have determined at what BMI a patient is more prone to this complication [12–16]. In this study, our findings support previous reports on this complication in obese patients [12–16]. Obesity was identified as an independent risk factor in development of catheter migration. Those with BMI of $<30 \text{ kg/m}^2$ were not at any significant risk of developing catheter migration ($P = 0.962$) while individuals whose BMI was $>30 \text{ kg/m}^2$ are at risk of catheter migration.

In addition to obesity, prior shunt procedures may predispose to shunt migration as it creates intra-abdominal adhesion. This study supports the number of prior shunt procedures as an independent risk factor leading to catheter migration into the subcutaneous space. Additionally, each additional shunt procedure involving abdominal manipulation further increased the risk of catheter migration.

Other factors reviewed in this study included liver failure and constipation. There were a small number of patients with both of these comorbid conditions in our study. Although not surprising that liver failure numbers were low, the low number of patients with constipation was surprising. This may be the result of under-reporting of constipation and undertreatment of this comorbid condition. We identified only five patients with constipation, which was not statistically significant as a risk factor for catheter migration. Likewise, only one patient with liver failure was identified, who did not have a shunt migration.

There are numerous theories on the cause of distal catheter migration into the subcutaneous tissue. The leading theory of an increased intra-abdominal pressure leading to gradual extrusion of the catheter is the most accepted. One reason for this theory is that the

complication in the adult population is seen almost exclusively in obese patients [14]. Given the known increase in intra-abdominal pressure in obese compared to the non-obese population, it is plausible that this increase may lead to extrusion of the catheter from the peritoneal cavity [19]. Additionally, it has been suggested that the change to catheters with hydrophilic surface and less friction may contribute to the phenomenon of catheter migration [14,20]. The actual cause may be a combination of these and isolating any one of these factors may prove difficult.

As this complication is increasingly recognized as the cause of distal shunt malfunction, numerous surgical techniques have been suggested to minimize the complication [14,16]. Morrison et al. have reported the successful treatment of three obese patients with distal catheter migration with a hernia patch [14]. In this technique, the catheter is passed through both layers of the polypropylene hernia patch to increase the friction and thereby reducing the risk of recurrence of the extrusion of the catheter into the subcutaneous tissue [14]. Other techniques such as distal catheter placement with the use of laparoscopic approach have also been reported [16]. The limiting factor of such approaches to this problem is that (1) it does not address preventing this complication before it occurs, (2) it requires additional expertise from a general surgeon, (3) it adds to the overall cost of the procedure, and (4) it could potentially increase the complication rate. Furthermore, to our knowledge no large study evaluating the effectiveness of these techniques in preventing catheter migration has been performed and the use of laparoscopic placement of the distal catheter does not guarantee retainment of the catheter in the peritoneal cavity as reported by Kavic et al. [9].

To solve such a complicated problem, a new approach for retaining the distal catheter in the peritoneal cavity must be developed. Such a solution needs to take the criticism of the previous suggested solution into account. It therefore should prevent catheter migration while not requiring additional technical skills. Additionally, the solution should eliminate the need for involving additional surgeons. Finally, minimizing additional cost and surgical time should also be a priority. Solutions that do not meet these criteria may prove costly and detrimental to the already complicated management of hydrocephalus.

5. Conclusion

Distal catheter migration into the subcutaneous space leading to shunt malfunction is a common complication of VPS placement. Obesity and number of previous shunt placements are independent risk factors leading to shunt migration. To our knowledge there is currently no proven method to prevent this complication.

References

- [1]. Pudenz RH. The surgical treatment of hydrocephalus—an historical review. *Surg Neurol* 1981;15:15–26. [PubMed: 7256520]
- [2]. Patwardhan RV, Nanda A. Implanted ventricular shunts in the United States: the billion-dollar-a-year cost of hydrocephalus treatment. *Neurosurgery* 2005;56:139–44 [discussion 144–5]. [PubMed: 15617596]
- [3]. Ernst A, Radonic M, Belicza M. The syndrome of long-standing *Staphylococcus albus* bacteremia, bacterial endocarditis and diffuse membranoproliferative glomerulonephritis complicating

ventriculoatrial shunt infection—case report and review of literature. *Acta Med Jugosl* 1980;34:137–52. [PubMed: 7405619]

- [4]. Lam CH, Villemure JG. Comparison between ventriculoatrial and ventriculoperitoneal shunting in the adult population. *Br J Neurosurg* 1997; 11:43–8. [PubMed: 9156017]
- [5]. Olsen L, Frykberg T. Complications in the treatment of hydrocephalus in children. A comparison of ventriculoatrial and ventriculoperitoneal shunts in a 20-year material. *Acta Paediatr Scand* 1983;72:385–90. [PubMed: 6880724]
- [6]. Borghjerg BM, Gjerris F, Albeck MJ, et al. Frequency and causes of shunt revisions in different cerebrospinal fluid shunt types. *Acta Neurochir (Wien)* 1995;136:189–94. [PubMed: 8748853]
- [7]. Sells CJ, Shurtleff DB, Loeser JD. Gram-negative cerebrospinal fluid shunt-associated infections. *Pediatrics* 1977;59:614–8. [PubMed: 850601]
- [8]. Esposito C, Porreca A, Gangemi M, et al. The use of laparoscopy in the diagnosis and treatment of abdominal complications of ventriculo-peritoneal shunts in children. *Pediatr Surg Int* 1998;13:352–4. [PubMed: 9639615]
- [9]. Kavic SM, Segan RD, Taylor MD, et al. Laparoscopic management of ventriculoperitoneal and lumboperitoneal shunt complications. *JSLs* 2007; 11:14–9. [PubMed: 17651550]
- [10]. Khosrovi H, Kaufman HH, Hrabovsky E, et al. Laparoscopic-assisted distal ventriculoperitoneal shunt placement. *Surg Neurol* 1998;49:127–34 [discussion 134–5]. [PubMed: 9457261]
- [11]. Lortat-Jacob S, Pierre-Kahn A, Renier D, et al. Abdominal complications of ventriculo-peritoneal shunts in children. 65 cases. *Chir Pediatr* 1984;25: 17–21. [PubMed: 6375883]
- [12]. Chung JJ, Yu JS, Kim JH, et al. Intraabdominal complications secondary to ventriculoperitoneal shunts: CT findings and review of the literature. *AJR Am J Roentgenol* 2009;193:1311–7. [PubMed: 19843747]
- [13]. Kast J, Duong D, Nowzari F, et al. Time-related patterns of ventricular shunt failure. *Childs Nerv Syst* 1994;10:524–8. [PubMed: 7882375]
- [14]. Morrison JF, Sung KE, Bergman AM, et al. A novel solution to reduce the complications of distal shunt catheter displacement associated with obesity. *J Neurosurg* 2010;113:1314–6. [PubMed: 20617878]
- [15]. Nfonam V, Chand B, Rosenblatt S, et al. Laparoscopic management of distal ventriculoperitoneal shunt complications. *Surg Endosc* 2008;22: 1866–70. [PubMed: 18175181]
- [16]. Shao Y, Li M, Sun JL, et al. A laparoscopic approach to ventriculoperitoneal shunt placement with a novel fixation method for distal shunt catheter in the treatment of hydrocephalus. *Minim Invasive Neurosurg* 2011;54:44–7. [PubMed: 21506068]
- [17]. Browd SR, Ragel BT, Gottfried ON, et al. Failure of cerebrospinal fluid shunts: part I: obstruction and mechanical failure. *Pediatr Neurol* 2006;34:83–92. [PubMed: 16458818]
- [18]. Rainov N, Schobess A, Heidecke V, et al. Abdominal CSF pseudocysts in patients with ventriculo-peritoneal shunts. Report of fourteen cases and review of the literature. *Acta Neurochir (Wien)* 1994;127:73–8. [PubMed: 7942187]
- [19]. Sanchez NC, Tenofsky PL, Dort JM, et al. What is normal intra-abdominal pressure? *Am Surg* 2001;67:243–8. [PubMed: 11270882]
- [20]. Nakahara K, Shimizu S, Oka H, et al. Migration of the distal end of a ventriculoperitoneal shunt into the abdominal wall in an obese patient: case report. *Neurol Med Chir (Tokyo)* 2009;49:490–2. [PubMed: 19855151]

Fig. 1. Etiology of need for ventriculoperitoneal shunt placement. IIH = idiopathic intracranial hypertension, NPH = normal pressure hydrocephalus, SAH = subarachnoid hemorrhage.

Fig. 2. Incidence of distal catheter of ventriculoperitoneal shunt migration over time. The majority of shunt migrations (68.8%) occurred within the first 3 months after the procedure.

Table 1

Demographics of control and distal catheter migration group procedures

	Control group (N = 146)	Distal catheter migration group (N = 16)	P value
Age, mean $\pm$ SD	57.7 $\pm$ 18.4 years	46.6 $\pm$ 14.9 years	0.03
Female, N (%)	70 (47.9%)	11 (68.8%)	0.147
BMI, mean $\pm$ SD	30 $\pm$ 9.8 kg/m ²	39.4 $\pm$ 8.7 kg/m ²	<0.001
Liver failure, N (%)	1 (0.01%)	0	0.732
Constipation, N (%)	5 (0.03)	0	0.438
Prior shunt malfunction, N (range)	20 (1–5)	16(1–6)	<0.001

BMI = body mass index, SD = standard deviation.