AUCTORES globalize your research

Journal of Neuroscience and Neurological Surgery

Adrian Kelly [1*]. J Neuroscience and Neurological Surgery
http://dx.doi.org/ 10.31579/ jnns.18/1.10016

Research Article Open Access

Evaluating the Incidence and Risk factors for ventriculo-peritoneal shunt sepsis

Adrian Kelly [1*], Patrick Lekgwara [1], Brian Pandaram [1], Dion Otto [1]

[1]Dr George Mukhari Academic Hospital, Sefako Makhatho Health Sciences University, Pretoria, South Africa.

[*]Corresponding Author : Adrian Kelly, MMed Neurosurgery cum laude (SMU); FC Neurosurgery (SA),Dr George Mukhari Academic Hospital, Sefako Makhatho Health Sciences University, Pretoria, South Africa, **E-mail : adriankelly1000@yahoo.co.uk**

Received date: July 17, 2018; Accepted date : August 16, 2018; Published date: August 27, 2018.

Citation for this Article: Adrian Kelly, Evaluating the Incidence and Risk factors for ventriculo-peritoneal shunt sepsis, J Neuroscience and Neurological Surgery. Doi: 10.31579/2578-8868/035

Abstract

Introduction

Patients with increased pressure hydrocephalus are a common referral to the Department of Neurosurgery at Dr George Mukhari Academic Hospital (DGMAH) in Pretoria, South Africa.

Aim

Our study aimed to establish our incidence and evaluate the known risk factors for ventriculo-peritoneal shunt sepsis in all patients whom had a ventriculo-peritoneal shunt inserted during the study period and whom completed 12 months of post-operative follow-up.

Methods

A retrospective cross-sectional study was performed considering all ventriculo-peritoneal shunt procedures performed between the 01 January 2013 and the 31 December 2015, consecutively drawn from the Neurosurgical operating room operative logbook.

Results

Overall 172 ventriculo-peritoneal shunts were inserted during the study period, 106 (62%) of which were inserted in children and 65 (38%) were inserted in adults. With regards the children (n=106) the most common etiology of hydrocephalus was congenital in 48 (45%) of patients while in adults (n=65) the commonest etiology was tuberculous meningitis in 15 (23%) of cases. Of the 172 patients whom had a ventriculo-peritoneal shunt inserted, 39 (23%) were deceased before completion of the one year post-operative follow-up period. The most common cause of death in this deceased group was progressive neoplastic disease in 20 (51%) of patients and tuberculous meningitis not responsive to cerebrospinal fluid diversion in 12 (31%) of patients. Of the 134 subjects whom had a ventriculo-peritoneal shunt inserted and completed the 1-year post-operative follow-up, 7 (5.2%) developed ventriculo-peritoneal shunt sepsis within the one year follow-up period. The presence of a cerebrospinal fluid leak post the ventriculo-peritoneal shunt procedure (p=0.02) and having had more than two prior ventriculo-peritoneal shunt surgeries (p=0.027) were statistically associated with an increased chance of developing ventriculo-peritoneal shunt sepsis in our study.

Conclusion

Our study confirmed our institutional ventriculo-peritoneal shunt sepsis rate to be 5.2% and furthermore confirmed the significance of two of the known risk factors as taken from the literature. A further finding was that in our setting this procedure was often palliative. Thirty nine (23%) of subjects, despite being afforded the benefit of CSF diversion, demised within 1 year of the procedure due to progression of their underlying disease.

Keywords

Ventriculo-peritoneal shunt; Sepsis; Hydrocephalus; Risk factors ventriculo-peritoneal shunt sepsis

Abbreviations

DGMAH = Dr George Mukhari Academic hospital

Declaration

I declare that this article has not been published previously, nor is it under consideration for publication elsewhere, and that, if accepted, will not be published elsewhere in the same form, in English or in any other language, without the written consent of the publisher

Introduction

Patients with increased pressure hydrocephalus are a common referral to the Department of Neurosurgery at Dr George Mukhari Academic Hospital (DGMAH) in Pretoria, South Africa.

The department placed 172 of these shunts in patients between 2013 and 2015, all of whom have now had the opportunity to complete 12 months of post-operative follow–up.

No study to date has specifically evaluated the ventriculo-peritoneal sepsis rate at our institution over a comprehensive one year post-operative follow-up period and hence the importance of this study cannot be overemphasized.

Our study aimed to identify specific risk factors, within the sub-population of ventriculo-peritoneal shunts that developed shunt sepsis, that can be targeted for intervention to reduce our local ventriculo-peritoneal shunt sepsis rate.

Hydrocephalus is defined as the clinical condition resulting from either increased production or decreased absorption of cerebrospinal fluid within the brain. This can result in serious neurological sequelae which range for example from developmental delay and blindness in infants, brain herniation and death in acute adult cases, to the more benign difficulty walking, dementia and incontinence in a more chronic form of the condition seen in the elderly. Ventriculo-peritoneal shunt procedures have been the mainstay in the management of this condition for the last 70 years. While seemingly a straight forward procedure up to 40% of ventriculo-peritoneal shunts fail within the first year of placement, often presenting as shunt sepsis, and have to be revised or replaced [1].

Although a globally accepted ventriculo-peritoneal sepsis rate of below 7% is commonly referenced [1; 2; 3], a considerable range is reported from as low as 1.3% in a North American study from the Hershey Medical Centre in Pennsylvania [3] to as high as 24.6% cited in a Kenyan study [4].

In considering the North American continent as a whole most studies report a ventriculo-peritoneal shunt infection rate of between 8-10% [5]. A large North American study by Davis looked at 2325 consecutively placed shunts over a 10 year period in the state of California and found an infection rate of 3.2% [6]. Another North American study done by Kanev and Sheehan considered 526 shunts placed over a 5 year period and reported an even more optimistic 1.3% shunt infection rate. This study admits it is a retrospective review of the operative procedures performed by a single surgeon [3]. A further North American study done in North Carolina by McGirt et al considered the shunt infection rate in 442 pediatric patients whom underwent ventriculo-peritoneal shunting procedures over a 6 year period. Here a shunt infection rate of 11% was reported. This study supports premature birth and previous shunt infection as statistically significant risk factors for shunt infection [7].

In affording a more global perspective, a Turkish study completed a decade ago by Sacar et al retrospectively considered 124 consecutively placed shunt operations performed over a 4 year period. Here the shunt sepsis rate was reported to be 14.5% [8]. A Kenyan study done by Mwang'ombe and Omulo (2000) considered 345 ventriculo-peritoneal shunt insertion operations performed over a 10 year period during the 1980's. This study reports a 24.6% shunt infection rate. Limited resources necessitating the sharing of operating rooms for general surgical and neurosurgical procedures where septic and clean cases were both performed, limited human capital and large patient numbers are all factors that contributed to this study result [4].

Several South African studies evaluating our local ventriculo-peritoneal shunt sepsis rates have been performed.

Govender in a study from the University of KwaZulu Natal compared the sepsis rate between antibiotic impregnated shunts and standard shunts and noted an overall sepsis rate of 11%. Govender admits that immunosuppression was not identified and refusal to be tested for HIV was not an exclusion criteria. The cause of hydrocephalus also was not standardized between the two groups despite this having serious implications as a risk factor for shunt infection in itself [9]. Nadvi in another study from the University of KwaZulu Natal looked specifically at the role of ventriculo-peritoneal shunting in patient's dual infected with HIV and tuberculous meningitis whom now have developed hydrocephalus. Although Nadvi did not specifically assess the shunt sepsis rate, his study confirms a statistically significant relationship between a patients CD4 count and their outcome [10].

Nadvi's study hence criticizes the study by Govender [9] by confirming the importance of the patient's immunological status in ventriculo-peritoneal shunt sepsis [10].

Lamprecht et al from Tygerberg Hospital in the Western Cape looked specifically at the ventriculo-peritoneal shunt sepsis rate in patients with tuberculous meningitis whom have developed hydrocephalus. Lamprecht noted this to be a notoriously difficult group to treat and recorded a ventriculo-peritoneal shunt sepsis rate of 13.5%. Lamprecht recognizes the importance of identifying patients within this group that can be treated medically as essential to avoid this high complication rate [11].

The University of Cape Town has published several recent articles on the subject of ventriculo-peritoneal fluid shunting in the context of tuberculous meningitis that confirm the significant complication rate in this group of patients. Rohlwink specifically considered the neurodevelopmental outcomes of children with tuberculous meningitis and hydrocephalus and noted that both the medical and surgical treated group carried with them a statistically significant increased chance of incurring neurodevelopmental deficits relative to controls [12]. Figaji and Fieggan, also from the University of Cape Town, acknowledge the overall poor outcome in this patient group and identify the high complication rate in ventriculo-peritoneal shunted patients. Figaji and Fieggan note that 30%-43% of these shunted patients require re-operation for infection and blockage in the first 6 months [13]. Acknowledging the limitations of ventriculo-peritoneal fluid shunting, more recent studies from the University of Cape Town are now assessing alternatives to this procedure such as that by Figaji and Fieggan whom considered the role of endoscopic third ventriculostomy as an alternative to shunting, as well as the study by Padayachee whom considered a radiographic marker predicting outcome [14;15]. These recent studies do not address ventriculo-peritoneal shunt sepsis and are hence outside the boundaries of this review.

Identified risk factors for ventriculo-peritoneal shunt infection are firstly the age of the patient being shunted [1; 5; 7]. Preterm neonates are especially at risk due to several reasons that include an immature immune system [7; 8]. This increased risk was furthermore found, in this same North American study by McGirt et al, that considered 820 consecutively shunted patients, to persist throughout the first year of life, but equalize with the sepsis rates seen in adults thereafter [7].

The etiology of the hydrocephalus is a further identified risk factor for increasing the shunt infection rate. Hydrocephalus in association with an open meningomyelocoele (MMC) is for example a commonly cited risk factor as the MMC serves as a port of entry into the central nervous system for the infecting organisms [5]. Causes of hydrocephalus that result in significantly increased CSF protein levels (and thereby increase CSF viscosity) make the shunt prone to blockage and thereby increase the shunt infection rate [16;1].

Previous shunt failure is a further cited risk factor for the development of shunt infection across several studies [17; 4; 1]. This risk factor can be explained by the fact that scarring at the previous surgical site impairs the local immune response and thereby predisposes to an increased shunt infection rate [1].

The duration of the shunt surgery increases the likelihood of shunt infection [18]. The mechanism behind this is that by extending the length of the surgery there is an increase in the window period during which the wound can become colonized by circulating organisms in the operating room atmosphere [1]. A Thailand study found this to be a statistically significant risk factor once the operation lasts more than 59 minutes [18].

The operative experience of the surgeon has been shown to be inversely proportional to the risk of shunt infection [5; 1]. This risk factor was directly researched by the large Canadian study which considered 3794 shunts inserted by 254 surgeons across the country over 12 years. The findings of this study reported that the risk of developing ventriculo-peritoneal shunt infection was lower with more experienced surgeons and higher when less experienced surgeons performed the shunt insertions [19].

The occurrence of a post-operative shunt CSF leak is a further risk factor predisposing the patient to an increased shunt infection risk [8; 1]. This problem is avoided by a meticulous opening of the dura intra-operatively in an attempt to limit any CSF escaping alongside the shunt into the scalp tissues and layered scalp wound closure [1].

The type of shunt used is a further implicated risk factor for shunt infection [9; 20]. Research using the Clinical Laboratory Standards Institute's Method for Kirby Bauer disk diffusion susceptibility test protocol [14] has shown that antibiotic impregnated shunt catheters have statistically significant gram positive bactericidal properties as compared to a control group [21]. The specific species tested in this study were staphylococcus aureus and Staphylococcus epidermidis which are the two species that commonly cause shunt infections [21].

An additional risk factor identified from the McGirt et al study is the use of a neuro-endoscope to assist in shunt placement which has been found to increase the shunt infection rate [7; 1]. McGirt et al (2003) found that the use of a neuro-endoscope, "which has become routine practice" at the Duke University Medical Centre where the study was conducted since 1995, "to increase the risk of shunt infection 1.6 fold" [7: 860].The reasons afforded by this same author under the discussion are that "the observed association between neuro-endoscope use and increased risk of VP shunt infection include increased duration of surgery, increased complexity of procedure necessitating endoscopic guidance and contaminated endoscopic equipment" [7].

A further risk factor for ventriculo-peritoneal shunt infection, as taken from the Thailand study by Sacar mentioned above, is patient immunosuppression [18]. This study actively excluded immune-compromised patients secondary to retroviral disease by considering this a special group. This was done so as not to confound their results by mis-matching the two groups compared [18].

Our study aimed to establish the ventriculo-peritoneal shunt sepsis rate at our institution over a three year study period from January 2013-December 2015 considering all patients whom had the procedure performed and whom completed the comprehensive one year post-operative follow-up period. We secondarily aimed to statistically evaluate the known risk factors as taken from the literature by establishing their significance in our setting. We hoped that once identified the significant risk factors could be targeted to reduce our local ventriculo-peritoneal shunt sepsis rate.

Materials and methods

Our study was approved by the Sefako Makgatho Health Sciences University Research and Ethics Committee (SMUREC/M/102/2017: PG).

A retrospective cross-sectional study was performed considering all patients whom, over the three year study period from the 01 January 2013-31 December 2015, had a ventriculo-peritoneal shunt inserted, as recorded consecutively from the Neurosurgical operating room operative logbook. A unique Study number was ascribed to each patient whom underwent the insertion of a ventriculo-peritoneal shunt during the study period for the purpose of maintaining participant anonymity. These patient files were individually reviewed and the relevant data was transcribed onto a Data Collection sheet. These Data collection sheets were entered into an Exel spreadsheet for analysis with descriptive and inferential statistics. All statistical procedures were be done on SAS (SAS Institute Inc, NC, USA), Release 9.4 or higher, running under Microsoft Windows.

Results

Considering the 172 ventriculo-peritoneal shunts inserted during the study period the mean age of these patients was 14.8 +/- 18.9 years. The youngest patient was 0.01 years and the oldest was 74 years. Further sub-group analysis revealed that 13 (7.6%) of patients were neonates, 64 (37%) of patients were infants, 29 (17%) of patients were children and 65 (38%) of patients were adults. In terms of gender 77 (45%) were female and 94 (55%) were male.

Considering time of insertion 89 (52%) of ventriculo-peritoneal shunts were inserted in the morning, 29 (17%) were inserted in the afternoon, and 53 (31%) were inserted at night . Considering the cause of hydrocephalus the commonest cause seen in the pediatric population was congenital hydrocephalus in 48 (45%) of children while in adults the commonest cause was tuberculous meningitis in 15 (23%) of patients. Of the 172 patients included in the study 39 demised before completing the one year follow-up period. In the deceased group the most common causes of death were progressive neoplastic disease in 20 (51%) of patients and tuberculous meningitis not responsive to cerebrospinal fluid diversion in 12 (31%) of patients.

Of the 134 remaining patients whom had a ventriculo-peritoneal shunt inserted and completed the one year surveillance period for the development of ventriculo-peritoneal shunt sepsis, 7 (5.2%) developed this complication. All of these patients were in the pediatric age group and 5 (71%) were less than one year of age. All 7 (100%) of these patients developed ventriculo-peritoneal shunt sepsis within one month of the ventriculo-peritoneal shunt insertion procedure.

Evaluating the known risk factors for ventriculo-peritoneal shunt sepsis neither (1) patient age (p=0.16), (2) having a ventriculo-peritoneal shunt revision in the last three months (p=0.09), (3) having a history of ventriculo-peritoneal shunt sepsis (p=0.18), (4) having a prior external ventricular drain (p=0.06), (5) the surgeons years of experience (p=0.23) , nor the (6) length of the surgery (p=0.60) were statistically significant in increasing a patients chance of developing this complication.

The presence of a cerebrospinal fluid leak post the ventriculo-peritoneal shunt insertion procedure (p=0.02) and having more than two prior ventriculo-peritoneal shunt procedures (p=0.03) were statistically associated with an increased chance of developing ventriculo-peritoneal shunt sepsis in our study.

Discussion

Our study revealed a ventriculo-peritoneal shunt sepsis rate of 5.2% which is in keeping with the globally accepted value of below 7% [1,2,3,4,5,6].

Considering patient age all 7 (100%) of our patients whom developed ventriculo-peritoneal shunt sepsis were children and 5 (71%) were less than one year of age. This finding is supported extensively in the literature where infants are noted in several studies to have an increased chance of developing ventriculo-peritoneal shunt sepsis as compared to adults [7,8]. While in our study patient age was not statistically associated with an increased chance of developing ventriculo-peritoneal shunt sepsis (p=0.16), this clinical trend was demonstrated.

Being one of the commonest procedures performed in our Department translates into surgeon familiarity with this procedure and as such is a further factor explaining our ventriculo-peritoneal shunt sepsis rate. This is in keeping with the literature where the operative experience of the surgeon is a statistically significant variable in reducing ventriculo-peritoneal shunt sepsis [19]. Considering the mean length of our ventriculo-peritoneal shunt procedure to be 75 +/- 29 minutes, this does however fall outside of the 59 minute threshold for reducing ventriculo-peritoneal shunt sepsis as concluded by the Thailand study which specifically considered this variable [18]. In our study the length of the surgery was not statistically associated with an increased ventriculo-peritoneal shunt sepsis rate (p=0.60).

In terms of the etiology of hydrocephalus a significant portion of our patients had congenital hydrocephalus with normal cerebrospinal fluid protein values. This is another factor responsible for explaining our ventriculo-peritoneal sepsis rate due to the sheer number of these pediatric patients where the risk of developing ventriculo-peritoneal shunt sepsis is comparatively low compared to for example ventriculo-peritoneal shunt procedures performed for tuberculous meningitis which dominated in the adult group. This is supported by the literature where a high cerebrospinal fluid protein value is statistically associated with an increased ventriculo-peritoneal shunt sepsis rate and a normal or low cerebrospinal fluid protein value does not share this association [16].We never use a neuro-endoscope to confirm shunt placement and as such this risk factor for increasing ventriculo-peritoneal shunt sepsis is alleviated from our setting [7].

In our study the presence of a post-operative surgical site cerebrospinal fluid leak was statistically associated with an increased chance of developing ventriculo-peritoneal shunt sepsis (p=0.02). This is supported in the literature as a recognized risk factor for this complication and is supported by our study [8].

A further statistically significant risk factor in our study was two or more previous ventriculo-peritoneal shunt surgeries (p=0.027). This finding is supported by the literature [1,4,17] and our study supports this as a statistically significant risk factor.

In conclusion our study finding was a ventriculo-peritoneal shunt sepsis rate of 5.2% and a statistically significant association was demonstrated between the presence of a cerebrospinal fluid leak (p=0.02) and two or more previous ventriculo-peritoneal shunt surgeries (p=0.027) and an increased chance of developing ventriculo-peritoneal shunt sepsis.

A further finding in our study was that this procedure was often palliative. Thirty nine (23%) of our subjects, despite being afforded the benefit of CSF diversion, demised within 1 year of the procedure due to progression of their underlying disease.

Conflict of interest

None of the authors have any financial nor personal relationships with other people, or organizations, that could inappropriately influence (bias) their work, all within 3 years of the beginning the work submitted.

References

1. Winn, R. Youmans Neurological Surgery, 6th Ed. 2011:494-524. Elsevier Saunders publishers.
2. Choux M, Genitori L, Lang D, Lena G. Shunt implantation: reducing the incidence of shunt infection. J Neurosurg 1992;77:875-80.
3. Kanev P, Sheehan J. Reflections on Shunt Infection. J Paed Neurosurg 2003;39:285-290.
4. Mwang'ombe N, Omulo T. Ventriculo-peritoneal shunt surgery and shunt infections in children with non tumour hydrocephalus at the Kenyatta National Hospital, Nairobi. J East Afr Med 2000;77(7):386-90.
5. Bisno A, Sternau L. Infections of central nervous system shunts. In Infections Associated with Indwelling Medical Devices. American society of Microbiology, Washington; 1994:91-109.
6. Davis S, Levy M, McComb J, Masri-Lavine L. Does age or other factors influence the incidence of ventriculo-peritoneal shunt infections? J Paed Neurosurg 1999;30(5):253-7.
7. McGirt M, Zaas A, Fuchs H, George T, Kaye K, Sexton D. Risk factors for Pediatric Ventriculo-peritoneal Shunt Infection and Predictors of Infectious Pathogens. Clinical Infec Dis 2003; 36:858-62.
8. Sacar S. A retrospective study of central nervous system shunt infections diagnosed in a university hospital during a 4-year period. Infec Dis 2006;6:43-5.
9. Govender S, Nathoo N, Van Dellen J. Evaluation of an anti-biotic impregnated shunt system for the treatment of hydrocephalus. J Neurosurg 2003;99:831-839.
10. Nadvi S, Nathoo N, Annamalai K, van Dellen JR, Bhigjee AI. The role of cerebrospinal fluid shunting for human immunodeficiency virus-positive patients with tuberculous meningitis and hydrocephalus. Neurosurg 2000;47(3):644-9.
11. Lamprecht D, Schoeman J, Donald P, Hartzenberg H.. Ventriculo-peritoneal shunting in childhood tuberculous meningitis. Br J Neurosurg.2001 Apr:15(2):119-25.
12. Rohlwink S, Donald K, Gavine B, Padayachy L, Wilmshurst J, Fieggen G, Figaji T. Clinical characteristics and neurodevelopmental outcomes of children with tuberculous meningitis and hydrocephalus.Dev Med Child Neurol. 2016;58(5):461-468.
13. Figaji A, Fieggan G. Endoscopic challenges and Applications in Tuberculous Meningitis. 2013;S24.e9-S24.e14.
14. Padayachee L, Kilborn T, Carrara H, Figaji A, Fieggen G. Change in optic nerve sheath diameter as a radiological marker of outcome from endoscopic third ventriculostomy in children. Childs Nervous sys 2015;31(8):1219-20.
15. Roytowski D. Intracranial pressure monitoring as an early predictor of third ventriculostomy outcome. 2013. 80(5):605-611.
16. Serlo W, Tuli S, Drake J, Lawless J, Wigg M, Math M, Lamberti-Pasculli M. Functions and complications of shunts in different aetiologies of childhood hydrocephalus. Childs Nerv System 1990; 6:92-94.
17. Renier D, Lacombe J, Pierre-Kahn A, Sainte-Rose C, Hirsch J. Factors causing acute shunt infection: computer analysis of 1174 operations. J Neurosurg 1984; 61:1072-8.
18. Ratanalert S, Musikawat P, Oearsakul T, Saeheng S, Chowchuvech V . Non-shaved ventriculo-peritoneal shunt in Thailand. J ClinNeurosci 2005; 12(2):147-9.
19. Cochrane D, Kestle J. The influence of Surgical Operative Experience on the Duration of Ventriculo-peritoneal Shunt Function and Infection. J Paed Neurosurg 2012; 38:295-301.
20. Bayston R, Ashraf W, Bhundia C. Mode of action of an antimicrobial biomaterial for use in hydrocephalus shunts. J Antimicrob Chemother. 2004; 53(5):778-782.
21. Clinical Laboratory Standards Institute. Performance Standards for Antimicrobial Disk Susceptibility Tests; Approved Standard- 9th Ed. 2006;26(1).