Original Article

Ventriculoperitoneal Shunt Dysfunction

Complications and Risk Factors Associated with Ventriculoperitoneal Shunt Dysfunction: A Systemic Literature Review

Sumreen Anwar[1], Hassan Nawaz Yaqoob[1], Masooma Ahmad[2], Maria Ilyas[4], Abdul Hanan Jawad[5] and Ambreen Anjum[3]

ABSTRACT

Objective: This study aimed at assessing rates of shunt failure and to determine the incidence and causes of VP shunt malfunction to establish firm evidence-based protocols to prevent VP shunt malfunction.

Study Design: Cross sectional study.

Place and Duration of Study: This study was conducted at the Services Institute of Medical Sciences, Lahore from June 2016 to July 2017.

Materials and Methods: Electronic databases PubMed, NCBI, Elsevier, Up To Date, Research Gate, Medline, Embase, CINAHL, Cochrane and Web of Science were evaluated. The search strategy involved the key terms pertaining to the concepts; to reach maximum sensitivity, a combination of the terms "Ventriculoperitoneal shunt" OR "VP shunt malfunction"; "risk factors of shunt failure" AND "shunt infection"; AND "shunt revision surgery" were considered. Randomized controlled trials, case-control studies, and cohort studies which fulfilled the following criteria were included.

Results: The results showed that the most common causes of VP shunt malfunction were shunt obstruction and infection. This study suggests that VP shunt malfunction is frequent in young individuals, mostly caused by shunt obstruction and infection.

Conclusion: Future researches should focus on techniques designed to prevent these complications or on alternative management for hydrocephalus.

Key Words: Malfunction, infection, obstruction, ventriculoperitoneal shunt

Citation of article: Anwar S, Yaqoob HN, Ahmad M, Ilyas M, Jawad AH, Anjum A. Complications and Risk Factors Associated with Ventriculoperitoneal Shunt Dysfunction: A Systemic Literature Review. Med Forum 2021;32(3):15-19.

INTRODUCTION

Ventriculoperitoneal (VP) shunt placement is the most common technique for cerebrospinal fluid (CSF) diversion. In majority of patients who present with hydrocephalus, the primary surgical intervention is the placement of shunt. This is an effective CSF diversion procedure. It shunts CSF in the cerebral ventricles towards the peritoneal cavity.[1]

1. Services Institute of Medical Sciences, Lahore.
2. Department of Anatomy / Physiology[3], Al Aleem Medical College, Lahore.
4. Department of Anatomy, Allama Iqbal Medical College, Lahore.
5. DHQ Hospital, Narowal.

Correspondence: Dr. Maria Ilyas, Assistant Professor Anatomy, Allama Iqbal Medical College, Lahore.
Contact No: 033275172
Email: mariawaqas0802@gmail.com

Received: June, 2020
Accepted: November, 2020
Printed: March, 2021

The placement and revision of ventriculoperitoneal shunt remains a procedure of choice in surgically managing the hydrocephalus. This procedure is relatively less complicated and can easily be performed on patients of all ages with hydrocephalus due to any cause like meningitis, myelomeningocele, post-operative adhesions, head injury, subarachnoid hemorrhage leading to hydrocephalus, tumor, stenosis of aqueduct, congenital malformations and any other acquired etiologies.[2] The prognosis of hydrocephalus patients after treatment with ventricular shunts is good and majority patients acquire a normal intellectual level.

Despite a higher success rate, Shunt malfunctioning is still an important factor in causing increased patient morbidity, mortality and higher procedure costs. In previous decade, overall shunt survival in patients with shunt-dependent hydrocephalus has increased only slightly, despite recent advancements in shunt valves, techniques and imaging procedures. In many healthcare facilities, the proportion of shunt placement to later surgical revision is 1 to 2.5.[3]The failure rate of shunt in the first year after implantation is approximately 25 to 40%. The 10-year actuarial survival rate of VP shunt is documented to be only 30 to 37%.[4]

In majority of the population main cause of shunt failure is the proximal shunt malfunctioning. It is caused by obstruction of the shunt tip by choroid plexus, glial or connective tissue, and any other tissues both natural and pathologic.[5] It is observed that placement of the shunt in the anterior horn of the lateral ventricle and anterior to the foramen of Monro decreased the chances of shunt obstruction and later shunt malfunction. Regardless of the extensive usage of radiological imaging techniques including the endoscopy, ultrasonography, and contrast guidance, the failure rate within few years of the techniques exceeds only 30%.[6]Other reasons of shunt malfunction can be shunt infection, fracture, shunt displacement, shunt migration, or its over-drainage. Some cases of shunt malfunctioning involve distal shunt migration in which the peritoneal portion of the shunt is withdrawn from the peritoneal cavity towards the subcutaneous soft tissue.[7]As a result of this, CSF is collected in the subcutaneous tissue, developing a rising pressure and ultimately distal shunt malfunction. Fatal outcomes of shunt failure are more prominent in children than adults. Factors responsible for the overall success rate of a shunt surgery also include the surgical procedure, surgeon's expertise, post-operative wound care, nature and type of shunt used, and general wellbeing of the patient.[8]

Infection of the wound or the shunt is quite a common cause of shunt malfunction, which causes significantly a higher mortality and morbidity. In many recent studies, the case incidence of shunt infection has increased from 8% to 40% and the postoperative incidence has ranged from 2.8to 14%. Early postoperative period is more prone to infection presentation. This clearly indicates that the perioperative infection from the patient's skin during the surgical procedure could be a causative mechanism. [9, 10]

This systematic literature review aimed at assessing the rates of VP shunt dysfunction, main causes of its failure and to assess the frequency and etiology of ventriculoperitoneal shunt failure in general population. It will be helpful to establish stable evidence-based guideline to help prevent shunt failure. We also conducted a review to identify the high risk factors predisposing to recurring CSF shunt malfunction and to evaluate if subsequent shunt malfunction are associated to earlier episodes of failure.

MATERIALS AND METHODS

Review Construction: PRISMA protocol was utilized to ensure a standardized approach to develop this review.[10] This review takes the form of a descriptive analysis, as the studies present epidemiological data, of a cross-sectional design.

Data Sources and Searches: Electronic databases PubMed, NCBI, Elsevier, Up to Date, Research Gate, Medline, Embase, CINAHL, Cochrane and Web of Science were evaluated. The search strategy involved the key terms pertaining to the concepts; to reach maximum sensitivity, a combination of the terms "Ventriculoperitoneal shunt" OR "VP shunt malfunction"; "risk factors of shunt failure" AND "shunt infection"; AND "shunt revision surgery" were considered. Studies were retrieved and included after interpretation of the title and the abstract of the study. Authors further went through the reference lists of identified studies to evaluate any additional studies.

Study Selection: The study used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines as basis of selection criteria using the PICO (P Populations/People/ Patient/Problem, I - Intervention(s), C - Comparison, O - Outcome) worksheet and search strategy as shown in Table 1.

Randomized controlled trials, case-control studies, and cohort studies which fulfilled the following criteria were included:

1. English language
2. Studies from the last 10 years
3. Studies conducted on Humans only
4. Report of any considered outcomes (mortality, complications, and need for further intervention).

Only the most recent and complete trial or study was included, if numerous trials or studies were published by the same centre.

Exclusion criteria:

1. Studies with more than 10 years of publication (unless publication has extreme relevance up to this day).
2. Non relevant articles by abstract and content.
3. Case reports, editorials, letters, and studies comprising duplication of data or previously published data.

Data Extraction, Quality Assessment and risk of bias: Studies generated by the search were assessed for relevance and were selected. Potentially relevant papers were retrieved in full and evaluated by the author to minimize the risk of developing bias to the results reviewed. The complete literature of the articles included was reviewed thoroughly to assess the relevance and quality of the study. Studies that were not in the public domain were not included. Risk of bias evaluation was considered according to the Newcastle–Ottawa Quality Assessment Scale criteria.

Statistical Analysis: Data was combined into an overriding odd ratio and 95% CI using meta-analysis. All studies with retrievable data for Odds Ratio measure were considered. Data was retrieved from tables and from the related text which described the incidence of every major risk factor and shunt malfunction. The similarity of odds ratio was evaluated using Cochran's Q statistics. Publication bias was evaluated by measuring the standard errors of the odds ratio from each study and constructing funnel plots for each risk factor.

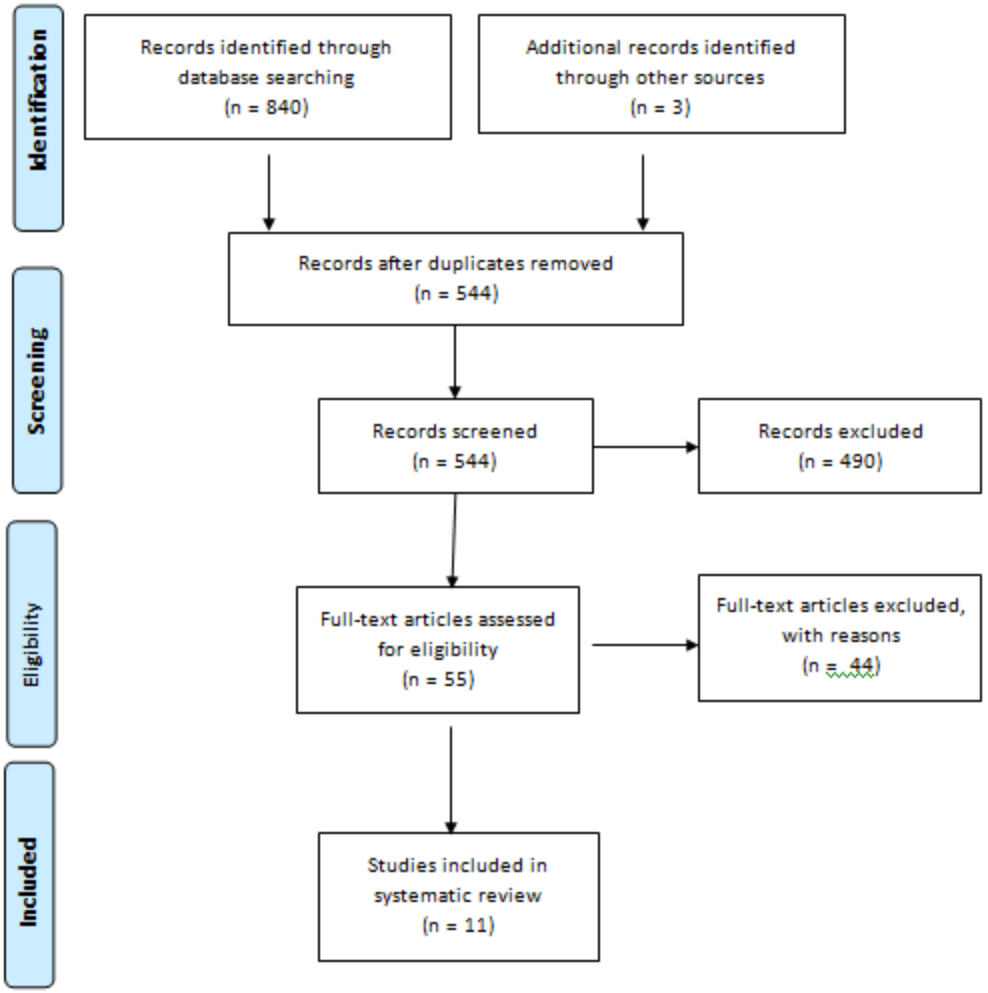

Chart:

RESULTS

Table No. 1: Patients, Intervention, Comparison, and Outcome (PICO) worksheet

Population	Patients with VP shunt failure
Intervention	Ventriculoperitoneal shunt
Comparison	Direct comparison with other management methods.
Outcome	Shunt failure due to any cause and whether need for further management; with no time limitation.

A total of 55 studies were retrieved that provided answers to the targeted questions. 44 of them were excluded after abstract re-evaluation. Exclusion was either due to insignificance to the study topic or lack of clear data required in this study's inclusion criteria. Thus, eleven researches were selected to be included in the final review (Table 2). These eleven articles were arranged in table which was formulated to aid data analysis and review. Data analysis was performed. The conclusion and implications for future research were made based on the review.

Table No. 2: List of researchers included in study

First Author	Year of Publication	Study Popu-lation(n)	Study Design
Khan et al.	2013	40	Prospective, randomized comparative trial
Kestle et al.	2011	344	Randomized controlled trial
Warf	2005	189	Prospective, randomized study
Turhan et al	2012	38	Single center, retrospective review
Mangano et al.	2005	66	Retrospective cohort review
Bakhsh	2007	100	Single center, retrospective review
Shannon et al	2014	237	Single center, retrospective review
Beez et al.	2012	23	Single center, retrospective review
Miranda et al.	2011	29	Retrospective review
McGirt et al.	2010	253	Retrospective cohort review.
Tuli et al.	2013	101	Prospective cohort study,

DISCUSSION

Shannon et al.[9] included 237 individuals in the study who underwent shunt placement procedure. It was reported that about half of these patients experienced shunt malfunctions within a follow-up time of two years.[9] Major causes of shunt malfunctions were either infection or a proximal occlusion. Beez et al, [11] evaluated shunt malfunction in thirty six individuals. He reported shunt failure in Twenty-three patients (64%) patients. Garber et al, evaluated the VP shunt functioning of patients who have undergone a fourth ventricle shunt insertion via trans-tentorial or sub-occipital stereotactic methods. It was reported that shunts malfunctioned in eighty two percent of the patients.[4] The causes included proximal obstruction, shunt infection and distal obstruction. It was the largest malfunction rate identified in this review and considers the impact of poor entry points and shunt-tip sited on VP shunt dysfunction. Miranda et al, [12] reported VP shunt malfunction in 103 patients due to post-hemorrhagic hydrocephalus. They documented that approximately forty two VP shunts (40.8%) led to an initial proximal obstruction within first few months of follow-up. Eight of these malfunctioning happened due to earlier shunt infections and very few cases (10%) developed occlusion without a prior infection. Turhan et al, evaluated thirty eight in whom multiple shunt malfunctions were developed. Infected shunt was found to be the most common etiology of shunt malfunction. Other causes included a distal or a proximal obstruction, valve malfunctions and pseudo-cysts. [13] Complete displacement of the VP shunt was reported in two patients. In one patient it was reported that the ventricular catheter was incorrectly placed. Bakhsh et al, studied a hundred cases of infantile hydrocephalus among which a total of 14 patients (14%) presented with shunt infection (including 4 with acute shunt infection), 10 patients (10%) developed shunt obstruction (4 within the first few months and 6 within the second year after procedure). This review assessed that the maximum cases of VP shunt failure were caused due to shunt obstruction and infection. [14]

A study conducted by Tuli et al, reported that there is no link between the type of valve and shunt malfunction in a post hoc analysis of a prospective cohort of patients who experienced basic shunt placement procedures. According to this report there is no association between malfunctioning of the shunt and any constituent of the shunt hardware.[15]

Retrospectively, McGirt et al studied 279 patients who underwent shunt placement surgeries. The authors described that programmable positioning of the valve was associated with a decreased risk of both complete shunt revision and proximal shunt obstructions.[17]

CONCLUSION

The danger of shunt malfunction is at its peak during the first few months after placing a VP shunt. There are many factors which contribute in having a direct effect on shunt malfunction, the most common one of which include VP shunt obstruction and shunt infection.

Mechanical malfunctions of VP shunt include proximal obstructions of catheter tip, distal obstructions, disconnections, kinking, disruptions, displacement and valve-malfunctions. Shunt malfunction was more frequent due to proximal or distal occlusion of catheter rather than valve related problems.

Shunt infection is the second most frequent cause of VP shunt malfunction, and this complication is most commonly observed in young individuals. Despite continuous efforts to reduce the incidence of shunt complications, including improved sterile techniques, use of antibiotic impregnated catheters, and programmable valves, VP shunt dysfunction still remains a huge problem.

Ongoing and future researches related to shunt malfunction should focus on preventing the two main etiologies of shunt malfunctions that this review has pointed out to alleviate the frequent hospital visits and the psychological effects on the young patients and their parents, as well as the frequent use of medical personnel and resources.

Limitations of the Study

The study comprises some limitations.

First of all, the retrospective nature of the studies which were included leads to a predictable selection bias.

Secondly, the collection or retrieval of data was based on searching all available clinical databases and electronic records. This excluded the potential for operations which were falsely coded and consequently may have been overlooked from the analysis.

Thirdly, concerning the complications, only a limited no. of studies showed a complication rate for the investigated procedures.

Lastly, decision of choice of shunt failure was made on an individual case-by-case basis by the attending physician, which made group allocation and randomization process difficult to achieve. It can cause reduced external validity.

Author's Contribution:

Concept & Design of Study:	Sumreen Anwar
Drafting:	Hassan Nawaz Yaqoob, Masooma Ahmad
Data Analysis:	Maria Ilyas, Abdul Hanan Jawad, Ambreen Anjum
Revisiting Critically:	Sumreen Anwar, Hassan Nawaz Yaqoob
Final Approval of version:	Sumreen Anwar

Conflict of Interest: The study has no conflict of interest to declare by any author.

REFERENCES

1. Reddy GK, Bollam P, Caldito G. Long-term outcomes of ventriculoperitoneal shunt surgery in patients with hydrocephalus. World Neurosurg 2014;81(2):404-10.
2. Bondurant CPJimenez DF: Epidemiology of cerebrospinal fluid shunting. Pediatr Neurosurg 1995;23:254–259.
3. Al-Tamimi YZ, Sinha P, Chumas PD, Crimmins D, Drake J, Kestle J. Ventriculoperitoneal shunt 30-day failure rate: a retrospective international cohort study. Neurosurg 2014;74:29–34.
4. Garber ST, Riva-Cambrin J, Bishop FS, Brockmeyer DL. Comparing fourth ventricle shunt survival after placement via stereotactic transtentorial and suboccipital approaches. J Neurosurg Pediatr 2013;11(6):623-629.
5. Jernigan SC, Berry JG, Graham DA, Goumnerova L. The comparative effectiveness of ventricular shunt placement versus endoscopic third ventriculostomy for initial treatment of hydrocephalus in infants. J Neurosurg Pediatr 2014;13 (03) 295-300.
6. Di Rocco C, Massimi L, Tamburrini G. Shuntsvs endoscopic third ventriculostomy in infants: are there different types and/or rates of complications? A review Childs Nerv Syst 2006;22 (12):1573-1589.
7. Guillaume D, Menezes A. Hydrocephalus in Chiari malformation and other craniovertebral junction abnormalities. In: Cerebrospinal Fluid Disorders. Boca Raton, FL: CRC Press; 2009.p. 300-317. Available at: http://www.crcnetbase.com/doi/abs/10.3109/9781420016284-18
8. Rabinstein AA. Year Book of Neurology and Neurosurgery e-book. Elsevier Health Sci 2011.
9. Programmlinie 4: Deutsch-Arabische Forschungs partners chaft - Al Tawasul - DAAD – Deutscher Akademischer Austauschdienst. Available at: Shannon CN, Acakpo-Satchivi L, Kirby RS, Franklin FA, Wellons JC. Ventriculoperitoneal shunt failure: an institutional review of 2-year survival rates. Childs NervSyst 2012;28(12):2093-2099.
10. Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gøtzsche PC, Ioannidis JP, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. J Clin Epidemiol 2009;62(10):e1-34. https://doi.org/10.1016/j. jclinepi.2009.06.006
11. Beez T, Sarikaya-Seiwert S, Bellstädt L, Mühmer M, Steiger HJ. Role of ventriculoperitoneal shunt valve design in the treatment of pediatric hydrocephalus—a single center study of valve performance in the clinical setting. Childs Nerv Syst 2014;30(2):293-297.
12. Miranda P, Simal JA, Menor F, Plaza E, Conde R, Botella C. Initial proximal obstruction of ventriculoperitoneal shunt in patients with preterm-related posthaemorrhagic hydrocephalus. Pediatr Neurosurg 2011;47(2):88-92.
13. Turhan T, Ersahin Y, Dinc M, Mutluer S. Cerebro-spinal fluid shunt revisions, importance of the symptoms and shunt structure. Turk Neurosurg 2011;21(1):66-73.
14. Bakhsh A. CSF shunt complications in infants—an experience from Pakistan. Pediatr Neurosurg 2011;47(2):93-98.
15. Tuli S, Drake J, Lawless J, Wigg M, Lamberti-Pasculli M. Risk factors for repeated cerebrospinal shunt failures in pediatric patients with hydrocephalus. J Neurosurg 2000;92:31–38.
16. McGirt MJ, Buck DW, Sciubba D, Woodworth GF, Carson B, Weingart J, et al. Adjustable vssetpressure valves decrease the risk of proximal shunt obstruction in the treatment of pediatric hydrocephalus. Childs Nerv Syst 2007;23:289–95.

.