

Microbial infection as a complication of shunt surgery in a sample of Iraqi patients suffering from hydrocephalus

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ABSTRACT

Objectives. In this study, we aimed at assessing shunt infections in a sample of Iraqi patients who have been surgically treated with ventriculoperitoneal shunt.

Materials and methods. A total of 208 patients were enrolled in this study. All of the patients have been submitted to diversion technique, namely ventriculoperitoneal shunt, due to hydrocephalus, with subsequent shunt infection. This work is conducted in specialized hospital for neurosurgery in Baghdad during the period extended from June 2018 to September 2022. Ten milliliters of cerebrospinal fluid (CSF) obtained during surgical removal of the shunt were, thereafter, investigated for bacterial infections as expected complications.

Outcomes. Fifty six CSF samples (26.92%) out of the 208 examined ones showed positive bacterial culture. Among the studied samples, the most affected age group was 1-5 years. The predominant bacteria were *Staphylococcus aureus* (37.5%), followed by *Klebsiella spp.* (32.1%). All *Staphylococcus aureus* infections were sensitive to Vancomycin, 42% to oxacillin, 28.5% to Fusidic acid and 9.5% to Cefotaxime, while 88.8% of *Klebsiella* showed sensitivity to Ciprofloxacin and 72% showed sensitivity to Meropenem.

Conclusion. Ventriculoperitoneal shunt malfunction may result from different complications, and the bacterial infection represents an important one. *Staphylococcus spp.* is more commonly seen as causative agent of these infections, with gram negative rods come next.

Keywords: Ventriculoperitoneal shunt, complications, bacterial infection, Iraqi patients

INTRODUCTION

Hydrocephalus refers to an increase in the volume of the cerebrospinal fluid (CSF) within the ventricular system. This disorder most often is a consequence of impaired flow or decreased resorption of CSF [1].

This buildup of excess CSF in the ventricles of the brain results in active distension of the ventricular system [2].

As management of hydrocephalus, the most common neurosurgical procedure used is ventriculoperitoneal (VP) shunt surgery. Other surgical procedures include endoscopic third ventriculostomy (ETV), ventriculopleural (VPL) shunt, and ventriculoatrial (VA) shunt [3,4].

The rates of successful shunts within the first ten years of placement range between 30% and 37% [5]. Therefore, higher rates of shunt malfunction (failure) are seen. Shunt failure can result from certain complications as obstruction and shunt infection (most common being *Staphylococcus epidermidis*) [5-8].

The brain and its coverings can be sites of infection. Some infectious agents have a relative or absolute predilection for the nervous system (e.g., rabies), while others affect many other organs as well as the brain (e.g., *Staphylococcus aureus*) [1].

Shunt infection is a common complication of shunt surgery. A proportion of patients with shunt infection will have a blocked shunt; hence, it is important to consider shunt infection in anyone who presents with

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shunt blockage relatively early following VP shunt insertion. The majority of shunt infections occur within 3 months of the shunt surgery [9].

Shunt infections is reported in 4% to 30% of cases, varying according to patient history, presence of external drainage, and history of recent infection.

Gram-positive organisms cause most shunt infections, with coagulase-negative staphylococci reported in 17% to 78% of cases and *Staphylococcus aureus* found in 4% to 30% [10], while less common pathogens include gram-negative bacteria [11].

Risk factors for shunt infection are numerous and include prematurity and low birth weight, relative immunosuppression, repeat shunt revisions or aspirations, lack of compliance with established infection-control protocols both in the operating room and perioperative setting, obstructive hydrocephalus and trauma [10,12].

More commonly, the shunt infection is that of CSF or peritoneal infection where patients present with fever, malaise, meningism, or shunt malfunction. A CSF sample is essential for the diagnosis; the sample can be obtained by tapping the shunt reservoir under strict aseptic technique.

Treatment of shunt infection entails surgery plus antibiotic therapy [11].

Gram-negative bacterial infections of the central nervous system (CNS) have worse clinical outcomes. The most common bacteria include *Escherichia coli*, *Citrobacter species*, *Enterobacter species*, *Serratia species*, and *Pseudomonas aeruginosa* [12].

PATIENTS AND METHODS

Sampling

A total of 208 patients were enrolled in this study, taking the inclusion criteria in consideration, as all of the patients have been submitted to diversion technique, namely ventriculoperitoneal shunt, due to hydrocephalus. Besides, these patients suffered certain complications postoperatively, some of which were obstruction and infection, necessitating shunt re-

moval and reevaluation of the conditions. This work is conducted in specialized hospital for neurosurgery in Baghdad during the period extended from June 2018 to September 2022. Ten milliliters of cerebrospinal fluid (CSF) obtained during surgical removal of the shunt were, thereafter, investigated for bacterial infections as expected complications.

Isolation and identification of bacteria

To follow the standard microbial cultivation procedures, nutrient and differential media were used to identify and isolate bacteria with 48 hour incubation at 37° Celsius under aerobic conditions. Then sub-culturing of the isolated bacteria to assess the antibiotic susceptibility was carried out with proper interpretation.

Statistical analysis was done by using Chi-Square.

RESULTS

A total of 208 patients were enrolled in this study in respect to the inclusion criteria. The age of patients ranged from one year to 65 years (Figure 1). Of note, the age group 1-5 years showed the highest frequency of positive bacterial culture of CSF as compared to other groups. Unlike the age distribution, sex distribution showed non-significant difference in this study sample (Figure 2). Fifty six CSF samples (26.92%) exhibited positive bacterial culture, being *Staphylococcus aureus* is the most frequent causative agent (37.5%), followed by *Klebsiella spp* (32.1%).

In terms of antibiotic sensitivity, result showed that all *Staphylococcus aureus* infections (100%) were sensitive to Vancomycin, 42% to oxacillin, 28.5% to Fusidic acid and 9.5% to Cefotaxime. In the other hand, 88.8% of *Klebsiella* showed sensitivity to Ciprofloxacin and 72% showed sensitivity to Meropenem. The antibiotic resistance and intermediate sensitivity for these two bacteria are clarified in tables (1-3). The sensitivity of the remaining positive bacterial infections is shown in the same tables.

TABLE 1. Antibiotic sensitivity of yielded positive bacterial cultures obtained from CSF of the patients enrolled in the study

Sensitive bacteria	Antibiotics N (%)											
	Vancomycin	Oxacillin	Fusidic acid	Cefotaxime	Ciprofloxacin	Meropenem	Imipenem	Gentamicin	Piperacillin	Ertapenem	Penicillin	Nitrofurantoin
<i>Staphylococcus aureus</i>	21 (100)	9 (42)	6 (28.5)	2 (9.5)	0	0	0	0	0	0	0	0
<i>Klebsiella spp.</i>	0	0	0	0	16 (88.8)	13 (72)	0	0	0	0	0	0
<i>Pseudomonas aeruginosa</i>	0	0	0	1 (10)	0	0	10 (100)	5 (50)	4 (40)	0	0	0
<i>E. coli</i>	0	0	0	0	0	9 (90)	4 (100)	3 (75)	0	4 (100)	0	0
<i>Enterococcus spp.</i>	3 (100)	0	0	0	0	0	0	0	0	0	3 (100)	3 (100)

TABLE 2. Antibiotic resistance of yielded positive bacterial cultures obtained from CSF of the patients enrolled in the study

Resistant bacteria	Antibiotics N (%)							
	Ampicillin	Rifampine	Cephalothin	Methicillin	Trimethoprim	Nalidixic acid	Gentamicin	Cefixime
<i>Staphylococcus aureus</i>	15 (71)	12 (57)	11 (52)	5 (23.8)	4 (19)	0	0	0
<i>Klebsiella spp.</i>	7 (38.88)	9 (50)	15 (83)	0	2 (11)	1 (5.5)	0	0
<i>Pseudomonas aeruginosa</i>	6 (60)	0	9 (10)	0	1 (10)	5 (50)	0	5 (50)
<i>E. coli</i>	4 (100)	1 (25)	0	0	0	1 (25)	0	0
<i>Enterococcus spp.</i>	0	0	0	0	0	0	3 (100)	0

DISCUSSION

Ventriculoperitoneal (VP) shunting is a permanent form of cerebrospinal fluid (CSF) diversion that can be performed for hydrocephalus. Sterility of the CSF is an important prerequisite for permanent shunt placement [13].

The complications of VP shunting have been studied by many researchers [14]. Bacterial infection was one of the common encountered complications.

The ages of the studied patients ranged from one year to 65 years. This can be comparable to what was reported by G. Kesava Reddy [15].

In this study, children were the most affected age group, specially the group of 1-5 years of age. This finding is consistent with certain reports like the work of M. Paff et al. [7], who highlighted that infection comes second to obstruction as causes of VPS malfunction. Other scientists recorded similar data [16,17].

TABLE 3. Antibiotic intermediate sensitivity of yielded positive bacterial cultures obtained from CSF of the patients enrolled in the study

Intermediately sensitive bacteria	Antibiotics N (%)								
	Doxycycline	Levofloxacin	Amikacin	Cefotaxime	Ciprofloxacin	Meropenem	Augmentin	Gentamicin	Nitrofurantoin
<i>Staphylococcus aureus</i>	8 (38)	15 (71)		18 (85.7)	0	0	0	0	0
<i>Klebsiella spp.</i>	0	0	18 (100)	8 (44)	0	6 (33)	10 (55.5)	11 (61)	18 (100)
<i>Pseudomonas aeruginosa</i>	0	0	10 (100)	0	0	0	0	5 (50)	5 (50)
<i>E. coli</i>	0	0	4 (100)	4 (100)	0	0	0	0	0
<i>Enterococcus spp.</i>	0	0	0	0	3 (100)	0	0	0	0

One way to explain this high occurrence of infection in such ages may be through the fact that hydrocephalus cases are more common in this group or may be attributed to that immune system is not fully developed yet.

Among the 208 examined CSF samples, only 56 (26.92%) tested positive for bacterial culture. This can be in an agreement with records as James A. Stadler III et al.

[10], unlike Alia Hdeib and Alan R. Cohen who reported lower rates [18]. Positive bacterial cultures of cerebrospinal fluid (CSF) with *Staphylococcus aureus* appeared as the most common among the positive CSF cultures in this work, with rate of 37.5%. This is very near to what has been found by M.J. McGirt et al. and others [19,20].

Besides, McGirt et al. mentioned that the possibility of subsequent shunt infection with *S. aureus* is significantly higher if the patient has experienced this shunt infection by this causative agent before [19].

As well known, *Staphylococcus spp.* is common skin flora, hence it is highly expected for these patients to suffer these infections, possibly during applying the shunts

As frequency of the causative agents in this study, the second microorganism found was the gram negative bacilli, namely *Klebsiella spp* with rate of (32.1%). It can be considered as serious infection and may lead to shunt malfunction. *Pseudomonas aeruginosa* infection (17.8%) comes next to *Klebsiella spp* in this study.

Other reports disagree with our results regarding gram negative bacteria. They found *E.coli*, *Citrobacter species*, *Enterobacter species*, *Serratia species* and *Pseudomonas aeruginosa* as the most likely gram negative rods to be associated with such infection [12].

Researchers found that this type of shunt infection has worse outcome [21].

To establish a plan for medical treatment of these infections, great attention was paid for antibiotics administration (intravenously) and this may take long time of admission to hospital. However, shunt removal and subsequent proper replacement is a mandatory procedure along with antibiotic therapy, as emphasized by M. Paff et al. [7].

Antibiotic susceptibility test for the yielded positive cultures was studied in this work. All of the examined *Staphylococcus aureus* infections were sensitive to Vancomycin, with 42% to sensitivity Oxacillin, but they were intermediate to Cefotaxime (85.7%) and Levofloxacin (71%), and resistant to Ampicillin (71%) and Methicillin (23.8%).

The finding with *Klebsiella spp* infection was different. They exhibited the highest rate of sensitivity to Ciprofloxacin (88.8%) and Meropenem (72%). This is rather consistent with a review done Ahmad F et al. [12].

CONCLUSION

Bacterial infection of central nervous system is a common complication after placement of VP shunts with subsequent shunt failure. *Staphylococcus spp* was the most common bacteria affecting these shunts followed by *Klebsiella spp*.

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