INTRODUCTION

Hydrocephalus is a common pathology in daily practice of neurosurgery and the widely accepted approach in the treatment of this pathology is the insertion of a ventriculoperitoneal shunt (VPS). VPS application may be performed nearly in all neurosurgery clinics. However, it has its own complications both in preoperative and postoperative periods. One of the most common complication is the ventriculoperitoneal shunt infection which is an important cause of morbidity and mortality in affected children.1–3 The incidence of shunt infection varies between 5–10%.4,5

In the management of infective cases, the preferred treatment strategy is the surgical removal of shunt, administration of antimicrobial therapy, installation of an external ventricular drainage device.
device, and placement of a new shunt when CSF become sterile. Although it is an established procedure, the frequency of EVD replacement during prolonged antibiotic therapy has not defined clearly in the literature.

In the presenting retrospective study, we aimed to describe how frequently EVD should be changed until CSF becomes sterilized.

METHODS

This retrospective study (Noninvasive Ethics Committee of Yuzuncu Yil University School of Medicine at its meeting of 30 January 2014 the number 10) included 25 children who were hospitalized due to ventriculoperitoneal shunt infection in Yuzuncu Yil University Hospital between January 2012 and December 2013. Data about the patients were obtained from the hospital recordings. All of these children had communicating hydrocephalus. 5 children with inadequate data, 8 children with non-communicating hydrocephalus and 2 children who were failed during treatment due to sepsis were excluded from the study.

In our clinic as a routine practice, the diagnosis of VP shunt infection is performed with the patient’s complaints (headache, nausea, vomiting and seizure), medical history and physical examination findings (fever, changes in level of consciousness, wound discharge, neck stiffness, and Kerning and Brudzinsky’s signs), and laboratory findings (view of CSF, cell number, cell type, protein and glucose levels, and culture) as in the literature.4,5,7

Patients diagnosed with shunt infection were operated in 6 hour of admission under local or general anesthesia according to the general status of the child. In the operation VP shunt surgically removed and EVD device was installed from right Kocher’s point. After that intravenous antibiotic therapy was started according to CSF culture results.

Until CSF become sterilized, data noted about how frequently EVD had been changed, and the number of cells, glucose and protein levels, and culture of CSF at every change were noted.

**Installation of the Pressure Controlled Ventricular Drainage Catheter:** Patient was positioned supine with thirty degrees flexion to neck and shoulder. A frontal burr-hole (2 to 3 cm lateral to midline and 1cm anterior to coronal suture in the midpupillary line = Kocher’s point) was opened. Ventricular catheter was placed into the frontal horn of same sided lateral ventricle. CSF drainage system was connected to the manometer after observing CSF flow. Drainage pressure was adjusted to be 10 to 15 cm H2O. This pressure was achieved by elevating the drainage catheter above 10-15 cm of foramen Monro. CSF samples were taken periodically every 3 days and glucose, protein, and cell counts were performed. Daily CSF volume and appearance (such as clear or xanthochromic) were noted. All of these applications are performed in our clinic as a part of routine process in patients presenting with shunt infection.

**RESULTS**

Total 25 children were included in the study. The median age of them was three months (ranging between one month and 65 months). Thirteen of them were female (52%) and 12 were male (48%). In 11 (44%) children, S. Epidermidis was isolated in culture. Results of CFF culture are demonstrated Table-I.

We detected that in the treatment of children whose CSF culture results revealed gram-positive microorganisms, vancomycin, rifampicin, linezolid were used. In the management of children with gram-negative bacterial growth in culture, meropenem, ceftriaxone, cefaperazone-sulbactam were used in according to the consultation of pediatric infectious diseases.

During treatment period, EVD catheter has changed one to six times. Totally, 68 times EVD catheter was changed (Table-II). The average duration of a ventriculostomy catheter was 12.62±4.10 days. 19 (30%) of them were stayed less than 10 days. However, 47 (70%) of them were stayed more than 10 days.

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**Table-I: Causative agents in infected children.**

| Causative agent           | Frequency | Percent |
|---------------------------|-----------|---------|
| Staf epidermidis          | 11        | 44.0    |
| Klebsiella Pneu.          | 3         | 12.0    |
| Strep. Pneum              | 3         | 12.0    |
| Enterococcus faecium      | 3         | 12.0    |
| E.Coli                    | 2         | 8.0     |
| Methcillin resistant staf. auereus | 2 | 8.0 |
| Psödomanas                | 1         | 4.0     |
| Total                     | 25        | 100.0   |

**Table-II: EVD change numbers.**

| No. of EVD changing | No. of patients | Percent |
|---------------------|-----------------|---------|
| 1                   | 4               | 16.0    |
| 2                   | 9               | 36.0    |
| 3                   | 5               | 20.0    |
| 4                   | 5               | 20.0    |
| 5                   | 1               | 4.0     |
| 6                   | 1               | 4.0     |
| Total               | 25              | 100.0   |
When duration of a ventriculostomy catheter and leukocyte count in CSF were evaluated on a daily basis, we saw that leukocyte count decreased 5 units per day in children whose catheter remained less than 10 days. However, in children whose catheter remained more than 10 days leukocyte count decreased 21.2 units per day. In the detection of daily decrease of leukocyte count, leukocyte count difference between on the day of insertion of the EVD catheter and on the day of removal of the catheter divided to length of stay of EVD catheter (Grap.1).

**Statistical Analysis:** Descriptive statistics for studied variables (characteristics) were presented as median mean, standard deviation, minimum and maximum values. Mann-Whitney U test was used to compare groups’ median for the studied variables. Statistical significance levels were considered as 5%. The SPSS (ver. 13) statistical program was used for all statistical computation (Table-III).

**DISCUSSION**

With the advent of valve shunt system in 1949 by Nulsen and Spitzer, a revolution has been experienced in the management of hydrocephalus. Despite the constantly evolving shunt technology, about 70% of patients who are inserted ventriculoperitoneal shunt are faced with shunt dysfunction within ten years. The most common complications are the mechanical shunt obstruction and shunt infection.

Yogev et al. reported that 50% of shunt infections developed within the two weeks after operation and causative agent was the Staphylococcus epidermidis in 60% of cases. In a different study, Telhan et al. reported the causative agent Staphylococcus epidermidis and staph aureus in 30% of cases. In our study, the most common causative agent was the Staphylococcus epidermidis in 44% of cases (Table-I). The most probable cause of this causative agent is the contamination from the skin during surgical procedure.

There are three different approaches when faced with VP shunt infection. These are; giving intravenous antibiotic therapy without removing shunt infected shunt, giving antibiotic regiment after surgical removal of shunt, and installation of EVD after removal of shunt and giving antibiotic regiment. Schreffler et al. compared these three methods and they concluded that the best result was gained with antibiotic regiment after the removal of infected shunt with establishment of EVD. In our clinic, we also perform the same approach composed of removal of infected shunt with establishment of EVD and giving antibiotic regiment according to culture results. Literature does not contain definite information about how frequently EVD should be changed in infected cases. In our study we detected that EVD had been changed in 6 to 22 days (mean 12.62 ± 4.10 days).

On the literature search, we found that in non-infected cases with ventricular hemorrhage authors reported the relationship between the development of infection and drainage change frequency. Wong et al. found that regular changes of ventricular catheter at five day intervals did not reduce the risk of CSF infection. They also stated that a single external ventricular drain can be employed for as

**Table-III: Statistical results of blood and cerebrospinal fluid.**

|                      | 0-10 (day) |                       |                      | 11-50 (day) |                       |                      |
|----------------------|------------|------------------------|----------------------|------------|------------------------|----------------------|
|                      | Median     | Mean                   | Std. dev             | Min        | Max                    | Median               | Mean                   | Std. dev             | Min        | Max        | p         |
| CSF protein          | 160,00     | 291,68                 | 364,92               | 45,00      | 1539,00                | 210,00               | 351,83                 | 362,90               | 19,00      | 2039,00    | 0.54      |
| CSF glucose          | 25,00      | 26,47                  | 19,39                | 1,00       | 65,00                  | 23,00                | 26,48                  | 16,69                | 0,45       | 84,00      | 0.99      |
| CRP                  | 45,00      | 52,60                  | 61,19                | 3,00       | 154,00                 | 55,00                | 50,43                  | 39,73                | 3,00       | 120,00     | 0.92      |
| WBC in blood         | 18,00      | 19,00                  | 9,27                 | 9,00       | 35,00                  | 12,70                | 12,87                  | 3,99                 | 6,00       | 22,00      | 0.59      |
| CSF leucocyte        | 50,00      | 84,41                  | 92,02                | 10,00      | 400,00                 | 65,00                | 68,15                  | 33,54                | 10,00      | 150,00     | 0.30      |
| Leucocyte difference | 40,00      | 46,18                  | 30,49                | 10,00      | 150,00                 | 30,00                | 29,78                  | 9,83                 | 10,00      | 50,00      | 0.002     |
| Leucocyte decrease/day | 5,00   | 5,45                   | 2,89                 | 2,00       | 15,00                  | 2,21                 | 2,20                   | 0,94                 | 0,91       | 4,55       | 0.001     |
In children with VP shunt infection, infected shunt should be removed and external ventricular drainage should be added. Additionally, for the rapid resolution of infection EVD should be changed at every 10 days independently from the causative agent. However, future prospective multicentered studies containing larger number of patients is needed to prove our results.

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