What is the risk of infecting a cerebrospinal fluid–diverting shunt with percutaneous tapping?

Clinical article

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Object. Most CSF-diverting shunt systems have an access port that can be percutaneously tapped. Tapping the shunt can yield valuable information as to its function and whether an infection is present. The fear of causing a shunt infection by tapping may limit the physician's willingness to do so. The authors of this study investigate the risk of infecting a shunt secondary to percutaneous tapping.

Methods. Following institutional review board approval, CSF specimens obtained from tapping an indwelling CSF-diverting shunt during the 2011 and 2012 calendar years were identified and matched with clinical information. A culture-positive CSF sample was defined as an infection. If results were equivocal, such as a broth-only-positive culture, a repeat CSF specimen was examined. The CSF was obtained by tapping the shunt access port with a 25-gauge butterfly needle after prepping the unshaven skin with chlorhexidine.

Results. During the study period, 266 children underwent 542 shunt taps. With 541 taps, no clinical evidence of a subsequent shunt infection was found. One child's CSF went from sterile to infected 11 days later; however, this patient had redness along the shunt tract at the time of the initial sterile tap.

Conclusions. The risk of infection from tapping a shunt is remote if the procedure is done correctly.
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KEY WORDS • cerebrospinal fluid–diverting shunt • ventriculoperitoneal shunt •
shunt infection • shunt tapping • hydrocephalus

GENERALLY, the most common clinical issue that pediatric neurosurgeons encounter is the management of hydrocephalus. If the obstruction to normal CSF circulation is not amenable to surgical correction, the hydrocephalus is treated with insertion of a CSF-diverting shunt. Shunt obstruction and infection comprise the vast majority of problems associated with shunts in pediatric patients. Most CSF-diverting shunts have an access port that can be tapped percutaneously. Tapping the shunt can yield valuable information about its function and whether an infection is present. The fear of causing a shunt infection may limit the physician's willingness to do so. This study investigates the risk of infecting a shunt secondary to percutaneous tapping.

Methods

Study Population

With institutional review board approval, a retrospec-

tive review of all patients at Children's Hospital Los Angeles in whom CSF was submitted for analysis between January 1, 2011, and December 31, 2012, were initially screened. Inclusion into the study required the presence of a CSF-diverting shunt and documentation that a shunt tap was the source of the CSF specimen. The charts of the patients with this group of CSF specimens were then reviewed; we checked that these charts included the dates of all shunt taps, all patients with shunt infections, the infecting organism, and the etiology of the hydrocephalus. Surveillance for shunt infection of the tapped patients was continued for the first 6 months of 2013, beyond which time the likelihood of a missed shunt tap–related infection would be remote. Those patients with shunt infections were examined in depth.

Shunt Tap Protocol

The unshaven scalp over the reservoir was prepared with chlorhexidine, which was allowed to permeate the

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scalp for 2 minutes. A 25-gauge butterfly needle was used to tap the reservoir. If the tap was initially unsuccessful, a new 25-gauge butterfly needle was used so that the needle penetrated the scalp only once. The opening pressure was noted by the column of CSF that filled the clear plastic tubing attached to the butterfly needle. Some CSF was then aspirated and submitted for cell count with differential, Gram stain, and culture on agar plates and a broth medium. Both culture media are reported to be sterile for aerobic organisms by 72 hours. If the initial aerobic cultures were sterile and there still was a concern for infection, repeat CSF specimens were sent to include anaerobic cultures that were held for 5 additional days after the aerobic cultures were reported to be sterile. Only neurosurgical personnel did the taps, and they included physician assistants, residents, fellows, and attending physicians.

Criteria for Infection

A shunt infection was defined as a positive culture. If the results were equivocal, such as a broth-only-positive specimen, pleocytosis, or a positive Gram stain, one or more additional CSF specimens were submitted for complete analysis, with anaerobic cultures often being done in situations in which there was suspicion for such an infection.

Results

Between January 1, 2011, and December 31, 2012, a total of 542 shunt taps were performed in 266 patients. The clinical data are summarized in Tables 1 and 2. There were 14 shunt infections during this 2-year period, during which 339 operative procedures involving shunts were done for a 4.1% incidence of infection. The distribution of the infecting organisms is noted in Table 3. The data

TABLE 1: Demographic data in 266 patients who underwent CSF shunt tapping

Variable	No.
total patients	266
2011	147
2012	119
total shunt taps	542
2011	239
2012	303
time btwn shunt taps	
1 wk	72
2 wks	24
1 mo	23
3 mos	43
6 mos	20
>6 mos	32
shunt taps/patient/yr*	
2011	1.6
2012	2.0

* Thirty-one of the patients seen in 2011 had shunt taps in 2012.

TABLE 2: Etiology of hydrocephalus in 266 patients

Etiology of Hydrocephalus	No. (%)
neural tube defects	61 (23)
intraventricular hemorrhage	40 (15)
congenital	48 (18)
CNS tumors	57 (21)
trauma	7 (3)
infection	9 (3)
other/unknown	31 (12)

on those patients with shunt infections were further analyzed to see if a prior shunt tap might be the source of the infection. Only 1 patient's shunt infection may have been secondary to a previous shunt tap. This child was admitted to the hospital with a 4-day history of chest and abdominal redness along the shunt tract. The CSF obtained by tapping the shunt had 2 WBCs/dl and a negative Gram stain and was sterile on culture. On admission this patient was started on antibiotics, but was discharged 3–4 days later when the redness abated and the CSF proved sterile.

The child was seen 11 days after the initial shunt tap because she was febrile and irritable. This time the CSF obtained from tapping the shunt had pleocytosis, positive Gram stain, and grew out *Staphylococcus aureus*. Assuming that this patient's shunt infection was secondary to the shunt tap, the infection rate would be 1 (0.18%) in 542. If one removes the 14 infected shunts, because theoretically a shunt tap leading to another infection might be masked by the antibiotics used to treat the first diagnosed infection, the rate would be 1 (0.19%) in 528. Because there were often multiple taps in the same patient, the incorporation of a time separation between the first and second tap can be used to ensure that the second tap was indeed negative. If one assumes a reasonable time interval to be 3 months, that would eliminate 162 taps, changing the incidence to 1 (0.27%) in 366.

During the first 6 months of 2013 there were 3 patients with shunt infections, none of whom had an antecedent shunt tap in 2012.

TABLE 3: Infecting organisms in patients who underwent shunt tapping

Pathogen Type	No. of Infections
<i>Candida albicans</i>	1
<i>Enterobacter cloacae</i>	1
<i>Enterococcus faecalis</i>	2
<i>Escherichia coli</i>	1
<i>Haemophilus influenzae</i>	1
<i>K. pneumoniae</i> subsp <i>pneumoniae</i>	1
<i>S. aureus</i>	4
<i>S. epidermidis</i>	2
<i>S. hominis/S. epidermidis</i>	1

Discussion

A shunt tap is often not an isolated event, so careful analysis of all relevant information regarding a shunt infection was undertaken. This study was retrospective; we were limited to data that were obtained by reviewing the medical records. It is possible that a shunt was tapped but not recorded in the medical record; however, a CSF specimen sent for evaluation would be evidence that such a tap did occur. The probability that a shunt was tapped and not recorded and the CSF was not sent for analysis is much less likely. Even if the ventricles are small and the amount of CSF obtained is only a fraction of a deciliter, the fluid is at least submitted for culture. It is also possible that the shunt was tapped at our institution, causing an infection, but the patient was seen and treated elsewhere. This could happen, but based on decades of experience and the established referral patterns, the incidence of this would be very low. Putting all the above factors together, it would be unlikely that the incidence of shunt tap-related infection would be even double what we have documented in our study.

The only literature examining infection associated with percutaneous tapping is limited to that of ventricular catheter reservoirs used to treat progressive hydrocephalus in premature neonates who sustained an intraventricular hemorrhage. We initially reported on 20 such patients who were serially tapped, usually daily, for 10–45 days, without an infection.⁵ A follow-up study that included an additional 56 preterm infants treated in a similar fashion also found no infections secondary to tapping of the reservoir.⁴ A more recent study has reported the same outcome.³ The assumption is that the risk of infection with tapping the reservoir in a CSF-diverting shunt is analogous to that of a catheter reservoir in a premature neonate, there being no reason to suspect otherwise.

To ensure that a uniform shunt-tapping protocol was consistently used, this procedure was limited to neurosurgical staff at our institution, because it is a teaching facility with a significant turnover of personnel. At another hospital where catheter reservoirs are inserted for a similar indication, the neonatologists also do the tapping without incurring any infections.

The question arises as to the possibility of inoculating the shunt at the time of the tap with an organism of low virulence that does not become clinically apparent until 1 or 2 years later. The 2 bacterial organisms that are repeatedly reported to cause shunt infections are coagulase-negative staphylococci and *Propionibacterium* species, usually *P. acnes*. All coagulase-negative staphylococci are facultative anaerobes, indicating that they will grow aerobically as well as anaerobically and are not difficult to culture. As Westergren et al.⁷ have reported, *P. acnes* infections are underdiagnosed secondary to inadequate culture techniques and can be overdiagnosed as a result of skin contamination, and the presence of this organism does not necessarily indicate a shunt infection. Shunt infections with *P. acnes* are reported to occur in 0%–2% of all shunting procedures and comprise 0%–15% of such infections.^{1,2}

Schiff and Oakes⁶ reviewed 1500 shunting proce-

dures performed over a 9-year span and identified 12 patients with an infection more than 6 months later. Seven of the infections were identified following another surgical procedure or infection not related to the brain or spine. Only 5 had no antecedent cause, of which 3 were *P. acnes* and 2 were coagulase-negative staphylococci. Their risk of a late infection with no known cause was 5 (0.3%) of 1500. Baird et al.² compiled information on 957 shunting procedures over a 10-year period and documented 94 infections, with only 8 infections occurring 9 months or more later. None of the 8 were secondary to *P. acnes*, whereas 4 were from coagulase-negative staphylococci.

Of note, none of the 11 *P. acnes* infections, all occurring before 9 months, were in children younger than 10 years. Of the patients in our series, 158 (59%) of 266 were less than 10 years old. In reviewing their series, Arnell et al.¹ documented 39 shunt infections in 474 procedures, with 6 cases of *P. acnes* (1.3%); only 1 infection was found in a child younger than 6 years, and the other 5 were in the 7- to 15-year age group. The *P. acnes* infections became manifest 1–28 weeks after a procedure. Of the 19 coagulase-negative staphylococcal infections, 11 were in infants younger than 1 year, and only 1 infection occurred more than 6 months after the procedure. One would think that the risk of a *P. acnes* or coagulase-negative staphylococcal infection would be more likely at the time of shunt insertion or revision in comparison with a minimally invasive shunt tap.

The time span of our study was a minimum of 6 months and a maximum of 2.5 years. No *P. acnes* infections were identified over this time interval, but there were 3 coagulase-negative staphylococcal infections, none of which followed a shunt tap. Based on what has been reported in the literature and on our results, it appears unlikely that we have missed a number of indolent shunt infections caused by shunt tapping.

Conclusions

The risk of infection from tapping a shunt is remote if the procedure is done correctly.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: McComb, Da Silva. Acquisition of data: Spiegelman, Asija. Analysis and interpretation of data: McComb, Spiegelman, Da Silva. Drafting the article: McComb, Spiegelman, Da Silva, Krieger. Critically revising the article: McComb, Da Silva, Krieger. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: McComb. Study supervision: McComb.

References

1. Arnell K, Cesarini K, Lagerqvist-Widh A, Wester T, Sjölin J: Cerebrospinal fluid shunt infections in children over a 13-year period: anaerobic cultures and comparison of clinical signs of infection with *Propionibacterium acnes* and with other bacteria. *J Neurosurg Pediatr* 1:366–372, 2008

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2. Baird C, O'Connor D, Pittman T: Late shunt infections. **Pediatr Neurosurg** **31**:269–273, 1999
3. Kormanik K, Praca J, Garton HJ, Sarkar S: Repeated tapping of ventricular reservoir in preterm infants with post-hemorrhagic ventricular dilatation does not increase the risk of reservoir infection. **J Perinatol** **30**:218–221, 2010
4. Levy ML, Masri LS, McComb JG: Outcome for preterm infants with germinal matrix hemorrhage and progressive hydrocephalus. **Neurosurgery** **41**:1111–1118, 1997
5. McComb JG, Ramos AD, Platzker ACG, Henderson DJ, Segall HD: Management of hydrocephalus secondary to intraventricular hemorrhage in the preterm infant with a subcutaneous ventricular catheter reservoir. **Neurosurgery** **13**:295–300, 1983
6. Schiff SJ, Oakes WJ: Delayed cerebrospinal-fluid shunt infection in children. **Pediatr Neurosci** **15**:131–135, 1989
7. Westergren H, Westergren V, Forsum U: Propionibacterium acnes in cultures from ventriculo-peritoneal shunts: infection or contamination? **Acta Neurochir (Wien)** **139**:33–36, 1997

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