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# The significance of bacteriologically positive ventriculoperitoneal shunt components in the absence of other signs of shunt infection

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The purpose of this study was to determine the significance of "asymptomatic bacteriological shunt contamination" (ABSC), defined as a positive bacteriological culture found on a ventricular shunt component in the absence of bacteria in the cerebrospinal fluid (CSF) culture and/or clinical evidence of infection.

Of 174 ventriculoperitoneal shunt revisions, 19 cases of ABSC were identified and reviewed retrospectively. In all but one case, no antibiotic medications were instituted because of the positive bacteriological culture. The most common infecting organisms were coagulase-negative staphylococci (seven) and propionibacteria (eight). A comparison of the 19 study cases with the authors' overall shunt experience, as documented in the British Columbia's Children's Hospital shunt database for the time period of the study, lead the authors to suggest that ABSC was not of significance in causing the shunt failure at which contamination was identified and, more importantly, did not increase the risk of future shunt malfunction.

The results of this study indicate that in the absence of clinical evidence of shunt infection or a positive bacteriological culture from CSF, bacteria in a shunt component removed at revision in a child almost always represents a contaminant that may be ignored. Therefore, the authors advise that routine culture of shunt components removed at revision of a shunt is not indicated.

**KEY WORDS • ventricular shunt • shunt infection • shunt contamination • *Propionibacterium acnes***

THE finding of a positive bacteriological culture in cerebrospinal fluid (CSF) withdrawn from a ventriculoperitoneal shunt is usually indicative of a shunt infection and is typically treated as such, particularly when symptoms suggestive of infection exist. Occasionally, a positive bacteriological culture is obtained from a piece of shunt tubing or valve material that is removed at the time of a shunt revision, in the absence of symptoms that would normally indicate shunt infection. We were concerned that such a finding might be a sign of shunt infection, and in January 1990 we initiated routine bacteriological cultures of shunt components removed at the time of shunt revision. A review of the literature yielded only one paper that specifically addressed this problem,[4] and in that report the significance of a positive bacteriological culture in the asymptomatic patient was not studied.

This study was designed to determine the significance of "asymptomatic bacteriological shunt contamination" (ABSC), defined as the finding of positive bacteriological culture on a ventricular shunt component in the absence of a positive CSF culture and/or clinical evidence of infection. It was hypothesized that there were two possible ways in which the ABSC could be significant: 1) the presence of the ABSC on the shunt might contribute to shunt malfunction, which would lead to a revision at which the organism is identified; and 2) the presence of ABSC might result in a higher failure rate for the revised shunt than would normally be expected. It was further hypothesized that if bacterial contamination was a significant factor in causing shunt failure, it could produce shunt blockage, but would not be expected to cause a mechanical problem such as a disconnected or broken shunt. If so, a positive bacteriological culture obtained in a blocked shunt would be significant and could result in future shunt failure, whereas a positive culture found in a shunt malfunctioning for mechanical reasons or in one that was functioning well and was being lengthened electively would represent an inconsequential contaminant with no prognostic implications.

TABLE 1

*Etiology of hydrocephalus in 18 patients with asymptomatic shunt contamination*

| Etiology | No. of Patients |
|---|---|
| meningomyelocele | 7 |
| intraventricular hemorrhage | 4 |
| congenital communicating | 2 |
| aqueductal stenosis | 1 |
| tumor | 1 |
| encephalocele | 1 |
| interhemispheric cyst | 1 |
| craniosynostosis | 1 |

## Clinical Material and Methods

The records of the Division of Pediatric Neurosurgery and those of the Health Records Department at British Columbia's Children's Hospital (BCCH) were searched to identify all patients who underwent ventriculoperitoneal shunt revisions between January 1, 1990, and June 30, 1993. From this group of cases were identified those index operations associated with a positive bacteriological culture on shunt tubing or a shunt valve that had been removed at the time of shunt revision in the face of either negative cultures of the CSF or no cultures of CSF. The cut-off date of January 1, 1990, was chosen because prior to that date, shunt components were not sent to the laboratory routinely for bacteriological examination in asymptomatic patients, but tended to be sent only when there was concern about possible infection, based on intraoperative findings such as excessive debris or discoloration of the shunt component. Beginning in January 1990, shunt components removed at the time of shunt revision were routinely sent to the laboratory for culture analysis.

We reviewed the records of these index cases to obtain information concerning the age of the patient at the time of the operation, the cause of the hydrocephalus, the reason for the shunt revision, what components of the shunt were removed at revision, the results of cultures of the CSF and shunt components, the use of perioperative and postoperative antibiotic medications, the date of the immediately preceding shunt operation and the reason for it, the date of the shunt revision immediately following the index event if a shunt revision was performed and the reason for it, and the time of the last follow-up assessment.

We hypothesized that if bacterial contamination was a significant factor in causing shunt failure, one could expect the contamination to be the cause of a shunt blockage but not of a mechanical problem such as a disconnected or broken shunt. If so, a positive bacteriological culture obtained from a blocked shunt could be clinically significant and might be associated with future shunt failure, whereas a positive culture found in a shunt malfunctioning for mechanical reasons or in one that was functioning well and was being lengthened electively might represent an inconsequential contaminant with no prognostic implications. The data were analyzed to test this hypothesis.

A database previously established for pediatric shunt procedures in the Division of Pediatric Neurosurgery at BCCH was made available for analysis.

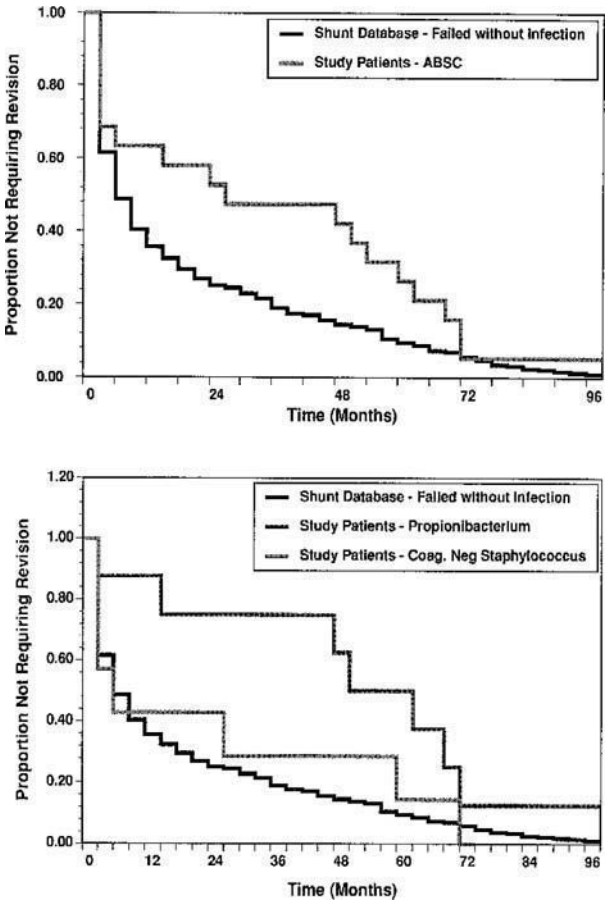


FIG. 1. Graphs showing time to revision in shunts reviewed in this study and those listed in the shunt database at British Columbia's Children's Hospital (BCCH). *Upper:* The time to revision of the 19 study shunts that at revision were found to be "contaminated" is compared with the overall BCCH experience of shunts that were revised for reasons other than infection during the time period of the study. *Lower:* The time to revision of the study shunts that at revision were found to be "contaminated" with coagulase-negative *Staphylococcus* species is compared with those contaminated with *Propionibacterium acnes* and with the overall BCCH experience of shunts that were revised for reasons other than infection during the time period of the study. ABSC = asymptomatic bacteriological shunt contamination.

Data collection and analysis were performed using commercially available software programs (Excel, Microsoft Corp., Bothell, WA, and Statview, Abacus Concepts Inc., Berkeley, CA, respectively). Shunt survival curves were compared using a log-rank test.

In the operating room, either the whole or part of the shunt was placed into a capped sterile tube and transported "dry" to the laboratory, with no special measures undertaken to preserve anaerobic bacteria. If removed, the entire valve or reservoir was sent for culture, but often only the distal end of the peritoneal catheter and the tip of the ventricular catheter were cut off and cultured. Cerebrospinal fluid was usually, but not always, cultured; in this case, the sample was collected into a capped sterile tube and sent directly to the laboratory. Sometimes, a separate sample of CSF was examined for cell count. Shunt tracts and wounds were not cultured routinely.

TABLE 2

*Relationship of organism cultured from shunt component in 19 cases of asymptomatic shunt contamination to incidence and timing of further shunt revisions**

| Organism | No. of Patients | Repeat Shunt Revisions | Time to Next Shunt Revision (mos) Average (range) | No Repeat Shunt Revision | Duration of Follow Up if No Further Revision (mos) Average (range) |
|---|---|---|---|---|---|
| coagulase-negative *Staphylococcus* species | 7 | 4 | 6.5 (0.2–18.2) | 3 | 18.2 (9.6–25.1) |
| *Propionibacterium acnes* | 8 | 2 | 9.5 (0.4–18.6) | 6 | 26.6 (15.6–49.2) |
| *Corynebacterium* species | 1 | 1 | 0.9 | 0 | — |
| *Corynebacterium* species & *Moraxella* species | 1 | 0 | — | 1 | 45.2 |
| *Staphylococcus aureus* & *Micrococcus* species | 1 | 1 | 0.8 | 0 | — |
| *Peptostreptococcus* species | 1 | 0 | — | 1 | 26.2 |

* — = not applicable.

Throughout the duration of the study, the bacteriological laboratory protocol for the handling of CSF specimens was generally uniform. For each sample of CSF, four culture media were used. These media included two types of enrichment media (brain–heart infusion broth and prereduced thioglycolate broth) and two solid media (blood agar and enriched chocolate agar media). The liquid media were maintained for 7 days and the solid media were examined for 5 days after incubation in a $CO_2$-enhanced atmosphere. Shunt components were generally cultured in prereduced thioglycolate broth alone.

## Results

Between January 1, 1990, and June 30, 1993, 19 shunt revisions were identified at which positive bacteriological cultures were obtained from shunt components that were removed in the absence of a positive bacteriological CSF culture and in the absence of clinical evidence of shunt infection (index revisions). There were 174 shunt revisions performed during that time, giving the rate of ABSC at 10.9%; the shunt infection rate was 4.1% of the total 291 shunt insertions and revisions performed during that period.

### *Etiology of Hydrocephalus*

The 19 shunt revisions were performed in 18 patients; the etiology of the hydrocephalus in those patients was in keeping with the distribution of usual causes of hydrocephalus at our institution (Table 1).

### *Bacteriological Results*

Of the 19 instances of ABSC, 14 had negative CSF cultures and five had no CSF cultures performed at the time of shunt revision. The most common organisms cultured from a shunt component were coagulase-negative *Staphylococcus* species and *Propionibacterium acnes* (Table 2). In one patient there were two episodes of ABSC; in this case the organism cultured from the shunt component at the time of the second revision was different from the organism cultured at the first shunt revision. In four operations CSF cell counts were made, and in one of these there was an elevation in the total number of white blood cells with an associated increased eosinophil count. In this child, whose shunt was contaminated with *Corynebacterium* species, the shunt had to be revised elsewhere 4 weeks later when the ventricular catheter migrated into the subgaleal space.

### *Duration of Shunt Function Prior to Index Revision*

The duration of shunt function, prior to the index revision at which bacteriological contamination was identified, was examined and compared with data from the BCCH shunt database for the same time period. The time to revision of the 19 shunts that were found at revision to be contaminated was no shorter than that of shunts listed in the BCCH database that were revised for reasons other than infection (Fig. 1 *upper*). When the analysis was repeated, subdividing the shunts according to contamination with coagulase-negative *Staphylococcus* species versus *P. acnes*, the duration of prior function of these shunts in each of these two groups was no shorter than that of the shunts in the overall database (Fig. 1 *lower*). There was no statistical difference using the log-rank test between the survival curves for the two different organisms.

### *Time to Failure of Shunt Following Index Revision*

The time to failure following revision of the shunt at which ABSC was identified was compared with the failure rate of ventriculoperitoneal shunts at our institution using the BCCH shunt database for the same time period, and there was no difference (Fig. 2 *upper*).

### *Correlation of Bacteriological Findings and Need for Further Shunt Revision*

For shunt revisions that were associated with positive growth of coagulase-negative *Staphylococcus* species, four of seven had a repeat shunt operation at a mean time of 6.5 months after the index shunt revision (Table 2). When the infecting organism was *P. acnes*, two of eight cases underwent a later shunt revision at a mean time of 9.5 months. In the one case in which there was a combination of *S. aureus* and *Micrococcus* species, a repeat shunt operation was necessary within 1 month. Shunt survival curves for coagulase-negative *Staphylococcus* species and *P. acnes* are compared with the overall shunt

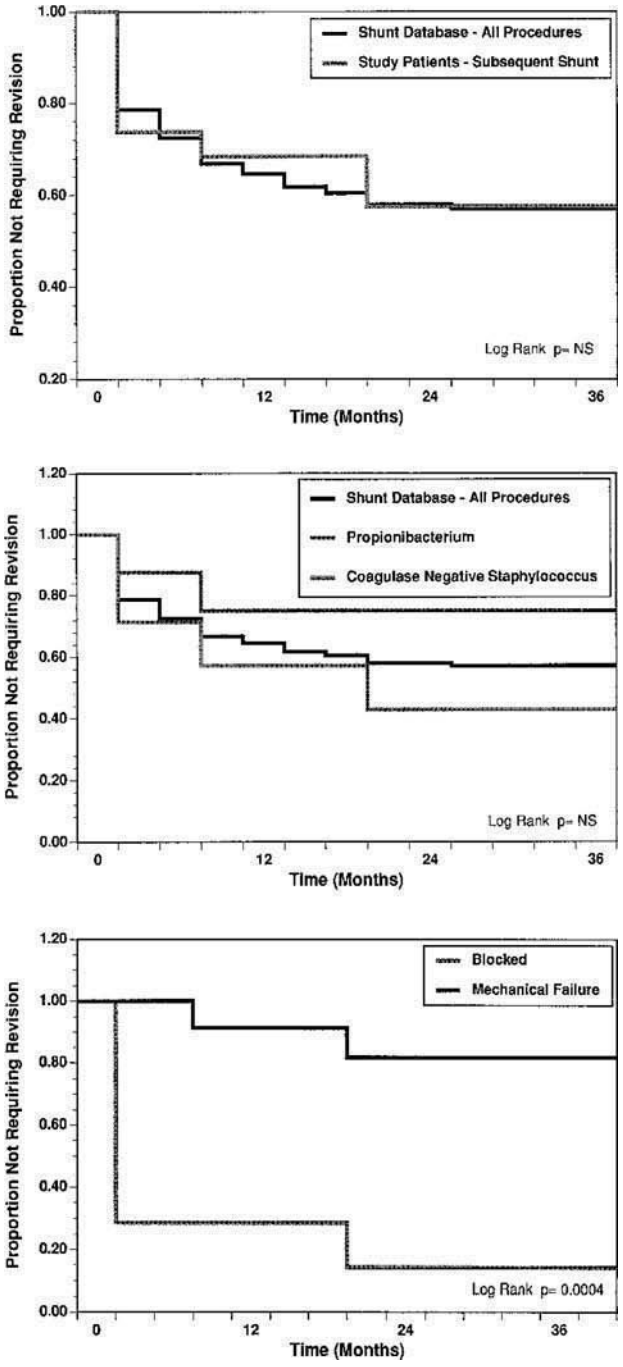


FIG. 2. Graphs depicting time to failure in shunts reviewed in this study and those listed in the shunt database at British Columbia's Children's Hospital (BCCH). *Upper:* The time to failure of the 19 shunts revised at the time asymptomatic bacteriological shunt contamination (ABSC) was identified is compared with the overall BCCH shunt experience for the time period of the study. *Center:* The time to failure of the shunts revised at the time ABSC was identified is plotted for shunts contaminated with coagulase-negative *Staphylococcus* species and *Propionibacterium acnes*, and comparison is made with the overall BCCH shunt experience for the time period of the study. *Lower:* The time to failure of the shunts revised at the time ABSC was identified is plotted for shunts revised for blockage (blocked) and for shunts revised for mechanical dysfunction and elective lengthening combined (mechanical failure).

survival curve for the BCCH shunt database in Fig. 2 *center*. There was no statistical difference between the three curves.

*Relationship Between Reason for Shunt Revision and Need for a Repeat Shunt Revision in the Future*

The reasons for the index shunt revisions were tabulated under three separate categories, namely: elective lengthening; some type of shunt blockage; or mechanical dysfunction of the shunt, such as disconnection, fracture of the shunt tubing, or inappropriate pressure of the valve. The data were analyzed to determine whether there was any correlation between the reason for the shunt revision and the need for further shunt revision; this is tabulated in Table 3. Six of the seven cases in which shunt revision was performed because of a shunt blockage required a further shunt revision. There were four patients who had elective lengthening operations, two with coagulase-negative *Staphylococcus* species and two with *P. acnes*, and none required a further shunt revision. Of the eight patients who had mechanical problems with their shunt, one of two patients, in whom coagulase-negative *Staphylococcus* species was isolated from the shunt component, required another operation on the shunt, as did one of five with *P. acnes*. Using survival curves, the rate of shunt failure after revision for shunt blockage was compared with that for shunts revised for mechanical dysfunction and elective lengthening combined (Fig. 2 *lower*). There was a significant difference between the two groups ($p = .0004$, log-rank test).

*Reasons for Shunt Revision After the Index Case of Shunt Revision*

Four patients in whom the shunt component was infected with coagulase-negative *Staphylococcus* species had a further revision. One of these went on to have a repeat revision for infection with *S. aureus*. Two patients had revisions for a blocked shunt and one for chronic intermittent headaches in the face of multiple negative CSF cultures; in these three cases the bacteriological cultures from the shunt components removed at the time of the revisions were negative. The patient with *S. aureus* and *Micrococcus* species contamination of the shunt component returned with a frank shunt infection with *S. aureus*. Two patients with *P. acnes* had a shunt revision; one for an abdominal pseudocyst with a further positive culture of *P. acnes* from the peritoneal catheter, and the other for a blocked shunt, at which time the removed ventricular catheter proved negative on bacteriological culture.

*Treatment of Patients With Asymptomatic Shunt Contamination*

In only one case in this study was treatment specifically directed at eradicating the bacterial organism that might exist in the shunt that had been left *in situ*. In this case of coagulase-negative *Staphylococcus* species, vancomycin was administered intravenously for 1 week in addition to perioperative cephalothin, which had been used prophylactically. This patient went on to have the shunt revised at the end of this course of antibiotic medications for blockage of the ventricular catheter. At that procedure the entire

TABLE 3

*Relationship between the reason for shunt revision in 19 cases of asymptomatic shunt contamination and the incidence of further shunt revisions for each infecting organism**

| Organism | Reason for Shunt Revision | | | | | |
|---|---|---|---|---|---|---|
| | Shunt Blockage | | Elective Lengthening | | Mechanical Dysfunction | |
| | No. of Patients | Further Revision | No. of Patients | Further Revision | No. of Patients | Further Revision |
| coagulase-negative *Staphylococcus* species | 3 | 3 | 2 | 0 | 2 | 1 |
| *Propionibacterium acnes* | 1 | 1 | 2 | 0 | 5 | 1 |
| *Corynebacterium* species | 1 | 1 | 0 | — | 0 | — |
| *Corynebacterium* species & *Moraxella* species | 1 | 0 | 0 | — | 0 | — |
| *Staphylococcus aureus* & *Micrococcus* species | 1 | 1 | 0 | — | 0 | — |
| *Peptostreptococcus* species | 0 | — | 0 | — | 1 | 0 |
| total | 7 | 6 | 4 | 0 | 8 | 2 |

* — = not applicable.

shunt was replaced and cultures from the removed shunt were negative. One patient was given no antibiotic medications; all others received prophylactic cephalothin in the perioperative period as the only antibiotic therapy. In these 17 cases a single dose of cephalothin was given after induction of anesthesia and before the incision was made. This was followed by a single postoperative dose in 15 patients, and no postoperative antibiotic medications in two.

In two patients the entire shunt system was removed and replaced at the time of the index ventriculoperitoneal shunt. In both patients an additional shunt revision had to be performed in the future.

## Discussion

Most ventricular peritoneal shunt infections are characterized by a positive bacteriological culture from the CSF removed from the shunt. Some patients have relatively occult shunt infections, presenting as abdominal pain or an abdominal pseudocyst in the face of persistently negative CSF cultures from the shunt reservoir; the infection in these cases is identified only by positive cultures from a shunt component.[8,13] In these patients treatment is generally directed at eradicating the infection. The cases described in this report, like the occult shunt infections described above, were characterized by a positive bacteriological culture from a shunt component in the absence of a positive culture from CSF. Unlike the occult infections, however, there were no clinical features suggestive of infection. In this situation, which we have termed "asymptomatic bacteriological shunt contamination" (ABSC), the questions that arise are: 1) whether the positive culture, which is typically that of a nonvirulent skin organism, such as coagulase-negative *Staphylococcus* species or *P. acnes*, simply represents a contaminant; 2) if not a contaminant, whether the shunt colonization had a role in causing the shunt to malfunction; 3) whether the positive culture has any prognostic implications for the future function of the revised shunt; and 4) whether any treatment is indicated.

In the only report that specifically addressed this problem, Fokes[4] reported six patients who underwent ventriculoatrial shunt revisions because of shunt malfunction or for elective lengthening, in whom either coagulase-negative *Staphylococcus* species or diphtheroids were cultured from the shunt catheter. These patients had negative CSF cultures and there was no clinical suspicion of a shunt infection. No specific treatment was instituted at that time. Because the longest follow-up period in that group of patients was 7 months, the long-term outcome and, hence, the possible significance of the contamination with respect to shunt failure are not known. In a series of 14 patients with diphtheroid shunt infections described by Rekate, *et al*.,[7] 25% had positive bacterial cultures found only in shunt tubing. Three of the 14 patients were said to be "asymptomatic": two with a ventricular drain and one with a ventricular peritoneal shunt. However, it is not clear whether these asymptomatic patients had positive cultures from the shunt tubing, from CSF, or from both. All patients were treated with revision of the shunt and antibiotic therapy; the long-term outcome was not reported.

In our study, the significance of ABSC was examined specifically. In 18 of the 19 cases of ABSC we reviewed, the bacteria were nonvirulent skin commensal organisms, including coagulase-negative *Staphylococcus* species, *P. acnes*, and *Corynebacterium* species; and it may be argued that these positive cultures represented a contaminant without any significance. However, shunt infections typically are caused by normal skin commensal organisms, with coagulase-negative *Staphylococcus* species being the most commonly involved,[5,10] *P. acnes* less so (although well documented),[2,3,9,12] and *Corynebacterium* rarely implicated.[1,11] There are two possible ways in which the ABSC could be significant: 1) if the presence of the bacterial organism on the shunt contributed to shunt malfunction and led to revision at which the organism was identified; and 2) if the presence of ABSC resulted in a higher failure rate for the revised shunt than would normally be expected.

### *Malfunction of Prior Shunt*

To address whether or not ABSC might have been a cause of shunt malfunction leading to shunt revision, the

longevity of the shunt immediately preceding the index revision was compared with our overall experience of shunts that were revised for reasons other than infection, as documented in the BCCH shunt database for the time period of the study. The time to revision of the 19 shunts was no shorter than that of BCCH database shunts in general. This suggests that the bacterial contamination of the shunt did not cause the shunt to malfunction prematurely, resulting in the revision at which the bacterial contamination was identified. In the shunts contaminated with *P. acnes*, the longevity of the shunt prior to identification of ABSC was greater than that of shunts contaminated with coagulase-negative *Staphylococcus* species or the general population of shunts in our overall database. It is known that *P. acnes* may cause shunt malfunction and infection after a longer interval than might be the case for coagulase-negative *Staphylococcus* species[2,7,9] and it may be that positive cultures of *P. acnes* in ABSC also require that the shunt has been *in situ* for a long time.

*Prognostic Implications for Future Shunt Function*

To address whether a finding of ABSC might predispose the patient to future shunt malfunction, the time to failure of the 19 shunts revised at the time ABSC was discovered was compared with our overall experience with shunts during the time period of the study. The time to failure of the 19 "contaminated" shunts was similar to that of our overall population of shunts, suggesting that in general the finding of ABSC has no prognostic implications for future shunt malfunction. It is still possible that the occurrence of ABSC may have a negative influence on future shunt function but that effect may be obscured by the high background failure rate of shunts for other reasons. Therefore, the data were examined further to determine if there were any factors associated with the ABSC that correlated with an increased risk of future shunt failure.

*Influence of Bacterial Organism*

The likelihood of shunt failure during the follow-up period was analyzed relative to the organism that was cultured from the removed shunt components. Except for the single case in which the organism was virulent, namely *S. aureus*, there was no evidence that ABSC with a nonvirulent organism increased the risk of future shunt malfunction.

*Influence of Reason for Index Shunt Revision*

In this study, there was a significantly increased shunt failure rate after revision for shunt blockage compared to that after revision for elective lengthening and mechanical dysfunction. The patients with blocked shunts were younger than those whose shunts were revised for mechanical reasons or elective lengthening and were generally children less than 1 year of age, with the previous shunt operation done less than 6 months prior to the identification of shunt contamination. Even without the presence of a positive culture from a shunt component, this group of patients would be expected to have the highest risk of requiring a future shunt revision.[6] Thus, the increased failure rate after revision of blocked shunts compared to that after revision for mechanical dysfunction or elective lengthening may simply reflect the younger age of the patient and the shorter duration of the prior shunt procedure, and it is not clear whether the presence of the positive culture in these patients increased the risk of shunt failure.

*Reason for Future Shunt Revision*

The reason for failure of shunts revised at the time of identification of ABSC was examined, because it was thought that if the shunts failed as a result of infection with the same organism, this would indicate that the "contamination" was of importance. Of the eight revised shunts that failed, two failed because of infection with the same organism: one the case with *S. aureus* and the other with *P. acnes*. In the other six shunt failures bacterial shunt contamination could not be directly implicated.

## Conclusions

The results of this study of ABSC failed to show that shunt colonization had a role in causing the shunt to malfunction or that the positive culture had any negative prognostic implications for the future function of the revised shunt. The findings lead us to suggest that a positive bacteriological culture from a shunt component removed at revision in a child, in the absence of clinical evidence of shunt infection or a positive bacteriological culture from CSF, almost always represents a contaminant; however, no treatment is required. Therefore, we advise the reader that routine culture of shunt components removed at revision of a shunt is not indicated and constitutes an unnecessary expense.

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