Occult infections of ventriculoatrial shunts

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Organisms usually considered nonpathogens have been implicated with increasing frequency as the cause of infected ventriculoatrial shunts. Often the signs of infection are minimal, with no evidence of inflammation; but there may be low-grade fever, anemia, leukocytosis, and variably present hepatosplenomegaly. By routinely culturing all shunts electively revised, a form of infection completely unapparent clinically has been recognized. Coagulase-negative staphylococcus or diphthenoids were grown from the cardiac or ventricular catheters of each patient. Pre- and postoperative spinal fluid and blood cultures were sterile, and there was no other clinical or laboratory evidence of infection. Six such cases are discussed in detail. It is suggested that prophylactic use of appropriate antibiotics at the time of surgery may have a place in the control of the problem.

Key Words · occult infection · cerebrospinal fluid · ventriculoatrial shunt

Coagulase negative staphylococci (Staphylococcus albus, Staphylococcus epidermidis) and other organisms usually considered nonpathogens have assumed new importance in neurosurgery since the introduction of ventriculoatrial shunts for the treatment of hydrocephalus.\(^7,14,17-19,29\) Many authors have discussed the problem of infected shunts,\(^5,7,11,13,22,35,37,42,49,53,56,59\) and Perrin and McLaurin\(^41\) have proposed an apparently effective form of treatment. The incidence of shunt infection reported ranges from 6% to 23%.\(^3,20,23,36,40,48,57,62\) Even so, Bruce, \textit{et al.},\(^7\) in 1963, stated that the incidence of persistent bacteremia following insertion of a ventriculoatrial shunt had not been accurately determined, either by themselves or by previous writers, and that the rate of infection was much higher.

Noonan and Ehmke\(^55\) also indicated that the exact rate of infection was not known, and placed it in the range of 15% to 20% “in the early postoperative period.” They added further emphasis to the problem by saying that the long-term incidence of infection was unknown, but with a foreign body in the bloodstream, the risk of infection was constant. Furthermore, indolence of an infection adds complexity, for as Schimke, \textit{et al.},\(^49\) reported, the patient’s fever may disappear with treatment but recur months later. These authors also noted the absence of signs and cerebrospinal fluid findings of bacterial meningitis in six of 11 patients with shunts with positive cerebrospinal fluid cultures.

The management and prevention of similar infections following insertion of foreign bodies into the bloodstream have been discussed in the literature on cardiovascular disease.\(^1,12,15,24,25,28,30,31,33,34,47,52,54,63\)

To date, two forms of ventriculoatrial shunt infection have been recognized. The first is an acute sepsis occurring shortly after insertion of a valve and associated with in-
flammation at the operative site. The second is more subtle, often appearing early in the postoperative period, without associated inflammation but with low-grade fever, anemia, leukocytosis, and variable presence of hepatosplenomegaly. By routinely culturing all shunts at the time of elective revisions, the spectrum of the disease has now been expanded and a third and clinically inapparent form of ventriculoatrial shunt infection has been recognized. Six patients in this latter category constitute the basis of this report.

Materials and Methods

Patients

All patients were studied on the Neurosurgical Service of the Medical College of Georgia, Eugene Talmadge Memorial Hospital. During the course of the study all shunt revisions for any reason were included in the series. Four cases were obvious infection and are not listed here. The six cases reported were operated on because of malfunction of the shunt or for planned revision of either the cardiac or ventricular end, and represent the total number of elective revisions performed on patients without clinical evidence of infection during the period October, 1968, to March, 1969. Although we were not able to demonstrate clinical evidence of infection in these patients, each had organisms cultured from the valve or the tubing or both. The shunts had been inserted by different surgeons and had been in place from 1 month to 4 years.

Bacteriological Identification

Following recognition that contaminated shunts were being removed from individuals previously unsuspected of having an infection, a protocol for a thorough preoperative bacteriological investigation was adopted and applied to each patient admitted for a shunt or elective shunt revision.

A blood culture was obtained on 3 consecutive days. One cerebrospinal fluid (CSF) specimen was obtained for culture preoperatively from each patient by lumbar puncture or ventricular tap, frequently via a Rickham reservoir. Additional cultures were obtained, if indicated by abnormalities in CSF cell count or chemistries or if the first cultures were positive. Each patient having a positive culture before shunt revision was considered to have clinically apparent infection and thus was not included here.

Bacteria Studies of Removed Tubing

At the time of shunt revision, all sections of the removed tubing and valves were cultured separately. Proximal and distal segments of cardiac catheters were cultured separately and these in turn were kept apart from the ventricular tubing and Holter valve, if removed. The contents of the valve were placed in one culture tube and the valve was placed in another. A CSF specimen was obtained at the time of operation. During the study only two organisms have been isolated: Staph. coagulase negative and diphtheroids.

Results

The first three patients in the series (Table 1) did not have preoperative blood cultures because at the time we were not fully aware of the problem. It is possible that cultures would have been positive had they been done and the three patients then treated for an infected shunt. None showed clinical signs of infection, although the preoperative hemoglobin of Case 2 was only 10.5 gm; this child was the only fatality.

In Cases 1 and 3, CSF cultures taken before surgery were sterile, with normal chemistries. It was the ventricular ends of these catheters that were contaminated; postoperative CSF and blood cultures on these patients were sterile at 3 and 7 months after surgery respectively.

Cases 4, 5, and 6 had thorough pre- and postoperative blood and CSF evaluations. Case 4 had three negative blood cultures prior to surgery, but the jugular vein was occluded distal to the shunt and this may have resulted in sterile cultures. The CSF was diverted into the peritoneal cavity and the valve was not changed. Postoperative cultures of blood and CSF were sterile.

Case 5 had sterile cultures of blood and CSF prior to operation. The cardiac catheter was patent and diphtheroids (Corynebacterium) were grown from it. Postoperative CSF and blood cultures were sterile as were repeat blood and spinal fluid cultures 5 months later. However, when the shunt was revised, diphtheroids were again cultured from the tubing at the cardiac end.

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<table>
<thead>
<tr>
<th>Case No.</th>
<th>Time Since Last Shunt</th>
<th>Shunt Level by X-ray*</th>
<th>Clinical Symptoms</th>
<th>Admission Data</th>
<th>Culture</th>
<th>Treatment†</th>
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*1st number indicates level at time of surgery; 2nd number indicates level at time of revision.
†Abbreviations indicate: OX = oxacillin, st. = sterile, ICP = increased intracranial pressure, anaer. diph. = anaerobic diphtheroids, aer. diph. = aerobic diphtheroids, NA = no antibiotic, perit. = peritoneal, and atr. = atrial.
Case 6 had been treated 8 months earlier for septicemia due to coagulate-positive staphylococci, and the shunt had been revised during antibiotic coverage. This patient was admitted later for elective revision of both the cardiac and ventricular ends of his shunt. The cardiac catheter was sterile, but diphtheroids were grown from the portion of ventricular tubing attached to the Holter valve.

Cases 4, 5, and 6 were operated on with oxacillin coverage and are the first cases in which we have used prophylaxis. Callaghan, et al.,9 provided ample evidence for the futility of systemic therapy in the presence of an infected foreign body. One patient in their series was given systemic methicillin for 150 days without resolution of the infection. Their experience, and the suggestion of Bruce, et al.,7 that it is the inner surface of the valve that is colonized, make it seem quite likely that patients in the present series still harbor an infecting organism.

Case 2 was admitted to a community hospital shortly after shunt revision. This patient presented an unexplained fever and was treated with methicillin for suspected staphylococcal shunt infection. Fever subsided, and the child improved but died suddenly following several seizures. Permission for postmortem examination was denied. This patient had a ventriculoperitoneal shunt, and it is interesting to speculate on the importance of this in the light of the work of Smith and associates53 indicating that it was only when a large number of Staphylococcus albus organisms were deposited intraperitoneally that they produced a significant number of deaths in mice.

Discussion

Bruce, et al.,7 in their discussion of the difficulty of determining the exact incidence of shunt infection, related some of the problem to neglect of the significance of finding Staphylococcus albus or other nonpathogenic organisms in blood cultures and failure to do routine cultures. Smith and associates53 have defined their criteria for a diagnosis of Staphylococcus albus septicemia as follows: "...the organism should be isolated on two or more occasions from the blood of a sick person with evidence of generalized disease and that no other pathogens should be isolated from the blood." Schimke, et al.,49 have pointed out that Staphylococcus albus septicemia is compatible with a relatively active life, good appetite, and absence of toxic effect; in view of our experience the same may be said for diphtheroids. (One patient, not included in the present series, had blood and CSF cultures and even CSF smears that were positive for diphtheroids for 4 months prior to shunt removal. She remained clinically well, and CSF chemistries, peripheral, white blood cell count and hemoglobin all remained normal.) Stein and associates,54 in reviewing the problem of prosthetic valve endocarditis, stated that the chance of a particular blood culture's being falsely positive is not greater than 2%, on the basis of the fact that there were six positive blood cultures out of 300 cultures obtained routinely in 63 patients not suspected of having endocarditis.

One of our cases (not included in this series) had coagulate-negative Staphylococcus cultured from the cardiac segment of tubing at the time of a revision 8 years after a shunt was inserted at another hospital. Cultures from blood and CSF produced no growth in this case.

In the light of this and in view of the present findings and the known high incidence of shunt infections, we feel that any positive blood or CSF culture under proper sterile conditions is strongly suggestive of shunt infection.

Jasper and Merrill59 concluded their article on hydrocephalus and myelomeningocele by saying: "The striking predominance of CNS infection due to the staphylococcus in patients with a shunt in place suggests that when ventriculitis is evident in one of these patients, it is most likely due to the staphylococcus. It follows that specific prophylaxis against the staphylococcus in this group warrants study."

Nulsen and Becker46 described their prophylactic regimen as consisting of intravenous followed by intramuscular injections of penicillin; oxacillin or lincomycin were used when a history of allergy to penicillin was obtained. Schimke and associates49 also recommended large doses of penicillin in the treatment of Staphylococcus albus septicemia. However, Callaghan, et al.,9 and Stewart50 have discussed Staphylococcus albus re-
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Assistance to penicillin, and in our cases where this was the infecting organism penicillin resistance was demonstrated in each, probably implying a nosocomial source of infection.

Callaghan and Stewart were able to increase the resistance of Staphylococcus albus to methicillin by prolonged exposure to the drug, and Stewart noted that these organisms showed cross resistance to penicillin but did not form penicillinase.

Oxacillin was given parenterally as prophylaxis for each of our patients in whom a shunt or shunt revision was planned. This drug was elected instead of methicillin because of its increased bacterioidal activity; it is not degraded by an acid pH, thereby permitting easier use when given intravenously. It also has been shown to have less nephrotoxicity.6,8,16,22

Five of our six patients found to be harboring infection at the time of surgery had sterile postoperative blood and CSF cultures; however, in three of these the blood and CSF were sterile preoperatively, and in the other three the CSF was sterile before surgery. We feel that this may be only additional evidence of the difficulty in diagnosing an infected shunt. It is possible that the shunts are now sterile, but in five instances only a portion of the assembly was removed and in each of these the valve was left in place, only a catheter being changed, thereby increasing the likelihood of residual infection.

Summary

A form of shunt infection that is not clinically apparent has been described. This suggests that the incidence of infected atrial portions of ventriculoatrial shunts may be higher than has been previously reported or suspected. Recognition of infection requires routine culture of all portions of removed shunts. Pre- and postoperative cultures of blood and CSF should be a part of each patient's evaluation. Prophylactic antibiotic coverage at surgery may help reduce the incidence of infection when used in conjunction with scrupulous aseptic technique.

References


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