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Antibiotic prophylaxis for the hydrocephalic dental patient with a shunt

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Abstract

Surgically placed shunts have proven useful in diverting excess accumulation of cerebrospinal fluid. The properly functioning shunt prevents increased intracranial pressure, gross craniofacial distortion, and the development of mental retardation, all of which have always been associated with the untreated hydrocephalic patient. The postoperative complication of microbial colonization of shunts has been greatly reduced by perioperative antibiotic coverage. The most frequent colonizing bacteria are found in the flora of the mouth, oropharynx, and nasopharynx. The authors have presented a protocol for prophylactic antibiotic coverage during dental therapy.

Literature review

Hydrocephalus is a pathologic condition characterized by abnormal accumulation of cerebrospinal fluid (CSF) within the brain fluid pathways.[1]

In the normal brain, the choroid plexus and certain lining cells secrete cerebrospinal fluid into the ventricular system. The fluid bathes the neural tissue of the brain and cord and serves also to cushion and protect it. The ventricles are constantly being replenished with cerebrospinal fluid with a secretion rate of approximately 30 ml every 90 min.[1]

Cerebrospinal fluid is drained into the circulatory system at the sites of the arachnoid villi of the thin membranes covering the brain. The villi apparently function both as a result of pressure differentials between the brain fluid and venous circulation and also by the relative pore size of the villi, facilitating fluid drainage.[1]

When flow of CSF is increased or when normal flow pathways become altered or obstructed, abnormal fluid accumulation may result, swelling the ventricular system. Cerebral tissue may therefore be distorted, compressed, and/or displaced by the additional fluid pressure. Fig. 1 is a photograph of an untreated hydrocephalic child.

According to Schut and Bruno,[1] there are numerous causes for hydrocephalus. These include overproduction of CSF, obstruction in the aqueducts connecting ventricles, passive ventricular enlargement due to loss of surrounding brain tissue from aging or cerebrovascular accident, Dandy-Walker syndrome, abnormal development of the cisterna magna and its connections over the brain surface, and insufficient CSF circulatory absorption due to failure of either villi function or venous drainage of the arachnoidal spaces.

Hydrocephalus may be congenital or acquired. Acquired hydrocephalus may result from infection, hemorrhage, or tumorous growth.

There are terms which further describe the nature of the abnormality. Obstructive or noncommunicating hydrocephalus occurs when CSF is unable for some reason to flow from the ventricles into the cisterns. Nonobstructive or communicating hydrocephalus refers to abnormal fluid accumulation due to some disorder in circulatory reabsorption of CSF. In the latter type, there is free flow of fluid among the four ventricles, but normal CSF drainage is impeded.

There is no known way to prevent hydrocephalus, but great advances have been made in the last 20 years in controlling the disorder. Shunting techniques have been developed by surgically placing a small tube
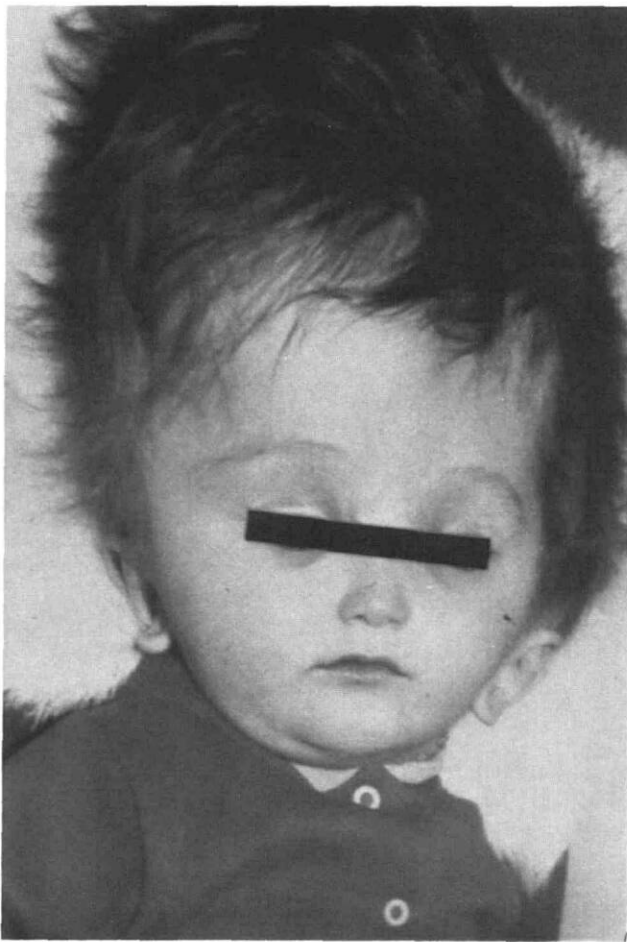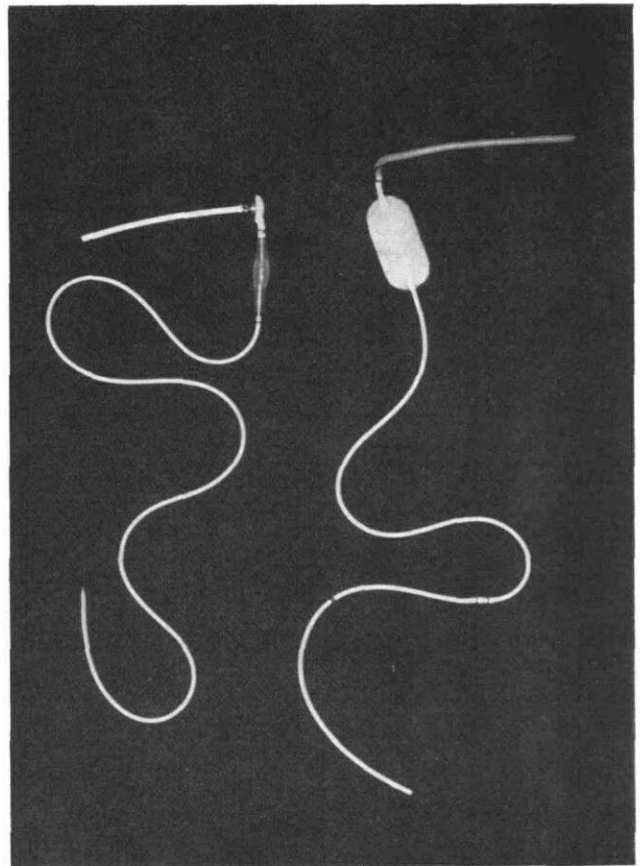
Fig. 1. An untreated hydrocephalic child is pictured. Note the gross craniofacial distortion and enlarged cranial dimensions.

Fig. 2. Two typical shunts are shown. Note the short proximal catheters, the valved pumping chambers, and the long distal catheters.

in a distended lateral ventricle and by diverting excess CSF through the tube into and through a valved pumping chamber to a distant absorption site somewhere in the body.[2]

The most common types of shunts are the ventriculo-peritoneal and ventriculo-venous shunts. The shunt system consists of three components which are connected at the time of surgical placement. Typical shunts are pictured in Fig. 2.

The shunt operation consists of insertion of a ventricular catheter through a parietal bur hole into a lateral ventricle, generally on the right side. The catheter's distal end is connected to a pumping chamber attached to the skull. The third component, a long distal catheter attached to the valved pumping chamber, runs, in the case of one shunt type, subcutaneously in the neck and enters venous circulation generally by way of the common facial or internal jugular vein or enters directly into the right atrium.

In the ventriculo-peritoneal shunt, the distal catheter continues on over the chest wall and enters the abdominal cavity through a subcostal incision.[1-3] The distal tip of the catheter ends in the pelvis where it is

least likely to be obstructed by the omentum.[2] The diagrams in Fig. 3 illustrate the most commonly used shunts.
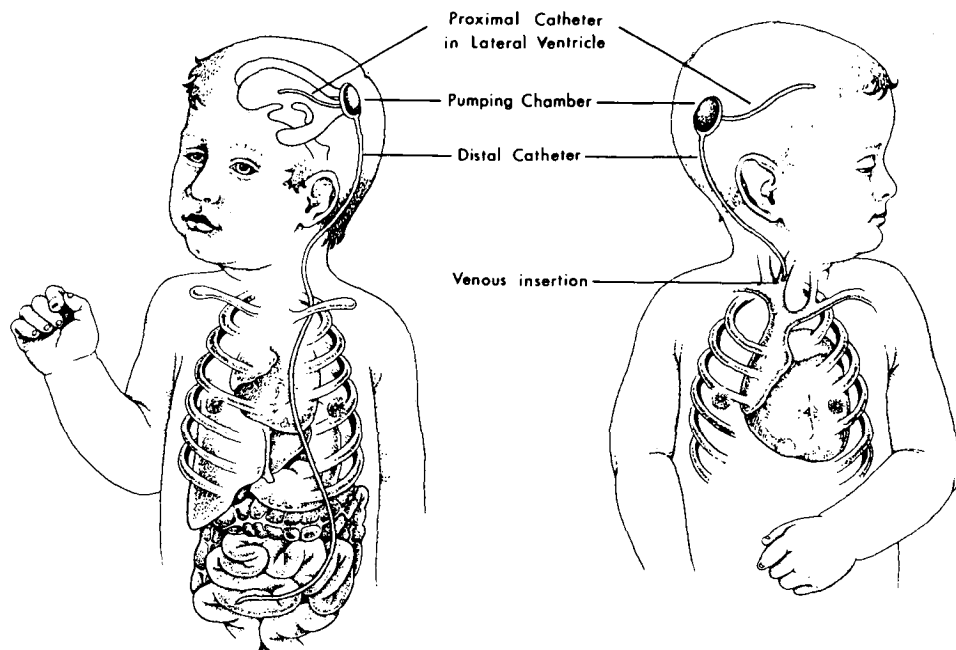
Carefully placed shunts are known to give many years of excellent service. However, due to human growth and development and to various types of complications, shunts must periodically be revised. Complications of shunts include obstruction of the shunt components by blood, debris, or anatomical meandering of the shunt tip;[4, 5] separation of shunt components; pressure necrosis of the tissues affected by the shunt; and an infection rate reported to be between 6% and 23%.[6]

The incidence of hydrocephalic disorders is about 1/750 births.[1] It is very often associated with other abnormalities of the spine and cord.[1] Since the shunt placement procedure is now the second must common of neurosurgical operations and some 10,000 new shunts and 6,000 revisions are expected each year, prevention of shunt infection is of utmost concern.

Shunt infection

Infection of a shunt system results when microorganisms "gain access at the time of valve insertion or

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Fig. 3. The two most commonly used shunts are depicted. On the left is pictured a ventriculo-peritoneal shunt, and on the right is a ventriculo-venous shunt.

Labels in figure: Proximal Catheter in Lateral Ventricle; Pumping Chamber; Distal Catheter; Venous insertion

during bacteremia at a later date."[2] The bacteria colonize the foreign material of the shunt, which leads to septicemia and ventriculitis with potentially fatal consequences. It is generally felt that ventriculo-peritoneal shunts are less susceptible to infection from bacteremia than are ventriculo-venous shunts, since the former have no intimate circulatory communication.[7] Ventriculo-peritoneal shunts, however, are not without risk of infection by staphylococci.[8] There is controversy as to whether microorganisms which infect ventriculo-peritoneal shunts are inoculated at the time of shunt placement, or whether they gain access during a subsequent bacteremia. This question is still open to academic debate.

Once a shunt infection has been diagnosed, the most widely accepted treatment is antibiotic chemotherapy in conjunction with shunt revision in a new anatomic site. Chemotherapy without shunt revision has had only limited success and is not a widespread mode of treatment.[2]

Problem

Due to inevitable bacteremia from gingival hemorrhage resulting from various dental procedures,[9, 10] dental practitioners prophylactically cover at-risk cardiac patients with specific antibiotics to prevent subacute bacterial endocarditis.[11] The antibiotic regimens are well documented in literature and have been recently altered to increase the antibiotic dosage and decrease the duration of therapy.[12]

A comprehensive review of the medical and dental literature of the past 20 years reveals a conspicuous absence of information regarding antibiotic coverage for the hydrocephalic dental patient with a surgically placed shunt in operation. No shunt infection has been directly related to dental procedures, but that does not preclude the possibility. Only Holt alludes to oral and nasopharyngeal sources of staphylococci and questions their role in possible etiology of shunt infections.[13]

The purpose of this paper is to examine the problem of shunt infection, offering a protocol for special care of the hydrocephalic dental patient. Since the most common shunts now being used are the ventriculo-peritoneal and ventriculo-venous shunts, the discussion will be limited to these types. Ventriculo-pleural, ventriculo-ureteral, lumbo-ureteral, and other shunt types are rarely performed in the United States.[1, 2]

Discussion

There are a number of important questions whose answers are crucial to the resolution of the problem at hand. (1) Are the organisms most often implicated in shunt infections available in the oral ecology for circulatory inoculation during a dental procedure? (2) Are there sufficient numbers of organisms to facilitate shunt colonization if bacteremia does occur? (3) Can an infective organism be transmitted to a patient from the hands of a dentist, hygienist, or dental assistant? (4) Does the severity of the dental procedure merit special attention? For example, should a dental prophylaxis be as much of a concern as multiple dental extractions? (5) If antibiotic coverage is deemed advisable, what organisms should be the target of therapy, and what is the antibiotic of choice?

Without the benefit of data from a carefully designed animal study or from a long-term evaluation of human subjects relating dental treatment history to

subsequent infection, we are compelled to conjecture some of the answers guided by information presently available.

As previously noted, 6–23% of shunts become infected and require surgical replacement for this reason.[6] The spectrum of microorganisms implicated is wide indeed. In a study of 289 human subjects, Schoenbaum et al.[8] demonstrated shunt infections with such varied flora as α- and β-streptococcus, Neisseria meningitidis, a diphtheroid species, enterococcus, and others.[8] The research of Schoenbaum et al. agrees with that of other researchers[4, 13–18] that the most common infective microorganisms are Staphylococcus aureus (coagulase-positive) and Staphylococcus epidermidis (coagulase-negative).

Burnett and Scherp[19] report that both the staphylococci are generally present in the mouth even though they constitute a minor fraction of the oral flora.

Peterson and Peacock[9] tested 80 children between the ages of 5–13 years who were undergoing dental extractions. Thirty-nine of them gave positive blood cultures after the surgical procedure. Of the 39 subjects, 18 had diseased teeth extracted while the other 21 had clinically healthy teeth removed for orthodontic considerations. The organisms cultured from the 39 patients included α-hemolytic streptococcus, peptostreptococcus, diphtheroids, coagulase-negative staphylococcus, bacteroides, veillonella, neisseria, and a vibrio.[9]

Even though there are researchers who deny bacteremia after oral manipulation in children,[20] data from Peterson's study[9] and from that of DeLeo et al.[10] make it apparent that microorganisms capable of shunt infection are available in the oral cavity for circulatory inoculation and that microorganisms have been shown to be introduced into the blood during dental treatment.

Presently, there is no way to be certain as to whether S. aureus or S. epidermidis exist in the mouth with sufficient number and virulence to colonize a shunt if bacteria are introduced into the oral vascular supply. As previously mentioned, a strictly controlled animal experiment may lend insight into this question. We can only surmise that this route of shunt colonization cannot be ruled out. We therefore must weigh the risks of covering the hydrocephalic dental patient with antibiotics versus the risk of not doing so until experimental data give us a definitive answer.

It is doubtful that the dental practitioner, hygienist, or dental assistant may act as carriers for staphylococcus transmission if usual hand washing and sterilization techniques are used. Shay and Clendenin[21] showed that in 19 attempts, a carrier dentist did not inoculate a noncarrier patient with S. aureus during a 30-minute dental prophylaxis.

The question of severity of dental operation also has no absolute answer. However, DeLeo's group studied 39 children who demonstrated a 5% positive blood culture prior to oral prophylaxis and a 28% positive blood culture after the procedure. The preoperative bacterial strains were identified as two anaerobic diphtheroids and two aerobic, coagulase-negative staphylococci. Twenty-eight separate strains were grown after the dental procedure, including 7 aerobes (two diphtheroids, two strains of Streptococcus viridans, and three coagulase-negative staphylococci); and 21 anaerobes (nine diphtheroids, five strains of Veillonella alcalescens, three of Bacteroides melaninogenicus, two of Peptostreptococcus anaerobius, one eubacterium, and one fusobacterium).[10] It is important to remember that these findings followed a procedure as innocuous as a routine dental prophylaxis.

It seems, therefore, that any procedure more extensive than a tray application of fluoride gel or solution may result in some amount of gingival bleeding with a possibility of bacteremia. Endodontic or surgical procedures obviously have this potential.

Tinanoff et al.[22] have raised a question as to the benefit of a pumice prophylaxis if only soft deposits of plaque exist on the teeth. With the exception of calculus and gross extrinsic stain removal in a patient with healthy gingiva, it is possible that a gentle, soft tooth brush or tray application of a fluoride preparation during each periodic visit may be the best service for the hydrocephalic patient not requiring other therapy involving gingival hemorrhage.

Prophylactic antibiotic coverage is used by many neurosurgeons[3, 6, 8, 15–17] at the time of shunt placement to prevent infection by S. aureus and S. epidermidis introduced during the operation. There is a general consensus that prophylactic coverage does decrease subsequent infection. The antibiotic agents most widely employed are oxacillin, methicillin, cloxacillin, or dicloxacillin, all of which are effective against the two staphylococci strains.

Recommendations

With the current state of knowledge concerning possible oral etiology of shunt infection in the hydrocephalic dental patient, the following recommendations are made.

1. The dentist should be familiar with the medical history of the hydrocephalic patient, including the type of shunt in place and its history. The patient's physician should be advised of the oral therapy required to keep all health care providers current on the patient's medical welfare.

2. As with all patients, meticulous hand washing and sterilization procedures are important.

3. If antibiotic coverage is to be employed, it is practical to achieve as much treatment as possible per visit. "Half mouth" or at least "quadrant" restora-

tive dentistry is advised, depending on the difficulty of the treatment and the comfort of the patient.

4. Extensive efforts by the dental practitioner should be made in preventive dentistry education for the hydrocephalic patient and his/her parents. Frequent professional reinforcement of preventive information and supervision of home care skills can be valuable aids in eliminating the need for recurrent corrective dental therapy.

5. For oral manipulative procedures that may cause gingival hemmorhage, an antibiotic regimen similar to that of the perioperative period for shunt surgery should be employed.

   a. For children weighing less than 40 kg (88 lb), 1 g dicloxacillin orally 30–60 min prior to the dental procedure and then 250 mg p.o. every 6 hr for 8 doses.

   b. For children over 40 kg (88 lb), an initial oral dose of 2 g dicloxacillin should be given 30–60 min prior to the procedure followed by 500 mg p.o. every 6 hr for 8 doses.

   c. For patients with a known allergy to the penicillins, we recommend the use of a cephalosporin. The dosage is 50 mg/kg of weight per day, divided into three doses. The regimen should be started one day prior to the procedure and continue through two days postoperatively.

There are cases reported of cross-sensitivity between the penicillins and the cephalosporins, and while this must be considered, the cephalosporins are still the safest alternative at the present time. Some synthetic cephalosporins are currently being tested which show great promise with no penicillin cross-sensitivity, but these products are not yet commercially available. In the extremely rare instance that a cross-allergenicity is known, further consideration of other effective antibiotics is advisable.

Even though ventriculo-peritoneal shunts may not be as susceptible to colonization from bacteremia as are ventriculo-venous shunts, it is unwise presently to presume that blood-borne bacteria are incapable of infecting the former type. Until research provides definitive data which prove that ventriculo-peritoneal shunts cannot be infected by bacteremia unrelated to neurosurgical procedures, the above antibiotic prophylactic regimens should be employed for both shunt types.

Summary

A cursory review of hydrocephalus and of surgically placed shunts to control the disorder is presented. A subjectively devised protocol is offered for prophylactic antibiotic coverage for the hydrocephalic dental patient with a shunt in place.

It is recognized that more definitive knowledge concerning this problem is needed, and research to answer questions posed in this discourse is suggested by the authors.

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