STAPHYLOCOCCAL COLONIZATION OF A VENTRICULO-VENOUS CEREBROSPINAL-FLUID SHUNT

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The merits of ventriculo-venous cerebrospinal-fluid drainage in the control of common forms of progressive infantile hydrocephalus are such that, since effective techniques of achieving this drainage were devised,[1,2] it has superseded all methods used in the past to shunt fluid beyond the subarachnoid space. The shunt consists essentially of a catheter which is led from a lateral cerebral ventricle, to leave the skull through a posterior temporoparietal burr hole, thence subcutaneously to the anterior triangle of the neck, where the internal jugular vein is entered. The catheter descends within this vein and the superior vena cava, to discharge at its tip suspended in the right atrium. This catheter system incorporates a non-return valve through which the rate of flow of cerebrospinal fluid is hydrostatically governed by the fluid pressure within the lateral ventricle.

This form of shunt promises to be a successful counter to a dismaying condition in many of these children, and will be used increasingly often. Therefore, the complications of so hopeful a procedure assume an added importance.

We report here a case of bacteraemia due to staphylococcal colonization of such a shunt in a hydrocephalic child. This syndrome has recently been described by Cohen and Callaghan for the first time, in 5 cases.[3] We add this case because of differences shown, and because the syndrome has some unusual pathological interest.

CASE REPORT

History

A female hydrocephalic child was first seen by us at the age of 39 months. She was a third child, born after a full-term, normal pregnancy, but with difficult labour and delivery. There had been jaundice from the 2nd to the 8th days of life. During the next few weeks she was said to have been well, but at 6 weeks of age vomiting had occurred, associated with hemilateral seizures. Xanthochromic cerebrospinal fluid was now found, and in the following months it became evident that hydrocephalus was developing.

When she was 4 months old, a ventriculo-atrial shunt was performed, using a Spitz-Holter type valve and catheter.

The first 3 postoperative weeks were said to have been trouble-free, but from that time there was slowly progressive ill-health. At first there were periods of unmanageable irritability and refusal of food. At the age of 18 months pyrexia with profuse sweating began to occur coincidently with these times of fractiousness. Five months later the mother noticed that the child's abdomen was enlarging, that at times respiration was grunting, and that a rash appeared intermittently on the legs. At this time enlargement of liver and spleen and anaemia were reported. These symptoms pro-

gressed very gradually, punctuated irregularly by recurrent exacerbations of pyrexia.

She was now readmitted to hospital, where searching investigations of her symptoms were made, but were fruitless. In particular, normal cerebrospinal fluid was repeatedly found, and no pathogenic bacteria were isolated from the many blood cultures. Full, three-week courses of erythromycin, of chloramphenicol, and of penicillin were given in an attempt to obliterate an occult source of infection. Her condition improved, and on discharge from hospital antibiotic therapy was continued with tetracyclines. Because of a positive tuberculin test, INH and streptomycin were also given for 6 months. These antibiotics were said to suppress her symptoms with varying success during the periods of administration only.

During the month before admission to Groote Schuur Hospital, nearly 3 years after the ventriculo-venous shunt, she steadily lost weight, and there was continuous pyrexia in spite of her receiving antibiotics.

Examination

The child was ill, underweight (23 lb.), and pale, and had a continuous pyrexia of 102 - 104°F. Purpuric spots were present on the pectoral region, and on the legs in a stocking distribution, and bruising had occurred on the trunk and limbs. There were signs of recent epistaxis, and the lips were fissured and excoriated at the angles. The abdomen was tensely distended by a greatly enlarged, firm liver and a large spleen, 3½ and 3 fingers below the costal margins respectively.

The head was large, with a circumference of 21½ inches, and was bossed in typical hydrocephalic manner. The subcutaneous part of the Spitz-Holter shunt on the right side of the head and neck showed no signs of inflammation along its course, and the valve-pump seemed to function properly. The patient was listless and irritable, but all other neurological responses were normal. Radiographs showed that the skull was large without diastasis of sutures. Lumbar cerebrospinal fluid chemical analysis was normal; it was acellular and sterile.

Special Investigations

Haematological examination showed a haemoglobin level of 8·1 G. per 100 ml., PCV 23%, MCHC 35%, reticulocyte count 1·7%, WBC 11,500 cells per c.mm., and platelets 113,000 per c.mm.; the bone marrow was normal. The serum-electrolyte concentrations were normal; the serum-protein level was 6·4 G. per 100 ml., with an albumin/globulin ratio of 0·94; the prothrombin index was 90; there were no LE cells; and the direct Coombs' test was negative. Liver-function tests were normal, and the blood-urea level was 45 mg. per 100 ml. A non-specific cold agglutinin was present in the serum in low titre; no auto-immune antibody was demonstrable. Bacteriological examinations of urine, stool and throat were negative. Radiographs of the chest and long bones, and the ECG were normal. Other negative investigations performed elsewhere during the 6 months before admission included: intravenous pyelography, liver biopsy, multiple blood cultures, and a full range of serological tests. The tuberculin test was strongly positive.

During the first week after admission, staphylococci were isolated from blood cultures on 3 occasions. In 2 cultures the organism was coagulase positive, in 1 coagulase negative; all were insensitive only to penicillin and sulphonamides.

Course

A diagnosis of bacteraemia originating in the ventriculo-venous shunt prosthesis was made. A trial of parenteral antibiotics for a week, with albamycin and erythromycin, gamma-globulin 4 ml. IM, and transfusion with fresh blood, had no effect on the clinical condition, and it was then decided to remove the shunt.

At operation there was no evidence of any reaction or inflammation external to the tubing throughout its extent. The distal catheter entered the internal jugular vein neatly through a sleeve of tissue continuous with the side of the vein wall. The vein itself was patent and contained fluid blood. On exteriorizing the catheter its free end was found to be quite clean, and clear cerebrospinal fluid drained from it under normal pressure. Samples of cerebrospinal fluid were taken from the ventricular and atrial ends of the shunt system, before disturbing it further. The entire catheter and valve system was then carefully removed and preserved for bacteriological analysis.

This analysis confirmed that the valve unit and catheter distal to it harboured in its lumen the staphylococci found on blood culture. The ventricular cerebrospinal fluid sampled at operation was sterile; that from the distal end of the catheter system yielded a strong culture of coagulase-positive staphylococci.

After operation the child promptly became apyrexial, bright and alert. The petechiae disappeared. During the following month the hepatosplenomegaly steadily regressed and the haemoglobin level was well maintained. This clinical improvement was paralleled by haematological changes, steady rises in the platelet and reticulocyte counts being the most striking features (Table I).

TABLE I. HAEMATOLOGICAL FINDINGS BEFORE AND AFTER REMOVAL OF THE SHUNT

Date	*Haemoglobin (G. per 100 ml.)*	*PCV %*	*MCHC %*	*WBC (per c.mm.)*	*Platelets (per c.mm.)*	*Reticulocytes %*
Dec.						
8	8·1	23	35	11,700	113,000	1·7
12	12·0					
14					16,000	
19			Removal of the shunt			
27					160,000	
Jan.						
2	10·0	26	31	6,880	378,000	1·2
8					555,000	
12	10·4			10,000	520,000	6·0
19	11·1	34	33	6,760	230,000	3·0

This progressive improvement was interrupted from the 9th to the 15th postoperative days by a period during which the patient again became anorexic, listless and irritable. There was low-grade pyrexia and some neck stiffness. The lumbar cerebrospinal fluid was transitorily pleocytic, but sterile on culture. Blood cultures during this time were negative. This meningitic episode was thought to be a reaction to the disturbance of removing the shunt's intraventricular catheter, perhaps by bacterial contamination of the ventricular cavities. Vigorous courses of chloramphenicol, methicillin and erythromycin, given during the postoperative period, may have suppressed overt meningitis.

There were no signs to suggest progression of the hydrocephalus after the shunt was removed.

During 4 postoperative months, to the time of writing, the patient has remained in excellent health, has been apyrexial, and has gained weight rapidly; the hepatosplenomegaly has continued to subside.

THE CLINICAL SYNDROME

This child showed, in common with the previously reported patients, prolonged persistent pyrexia, anaemia, splenomegaly, and repeatedly positive blood cultures of staphylococci. In addition, our patient developed, after 19 months of illness, purpura, and progressive hepatomegaly. The first clinical effects of the bacteraemia appeared within 3 weeks of insertion of the shunt. The subsequent course was one of grumbling ill-health for 35 months, a very slow progression of signs, and intermittent exacerbation. The longest course among the previous patients was 24 months.[3]

The exceptionally low-grade, insidious character of this chronic bacteraemia suggests perhaps that the special nature of their nidus plays some part in limiting the pathogenicity of the organisms. Although coagulase-negative staphylococci, and the *Proteus vulgaris* cultured from one previous patient, have relatively low virulence, coagulase-positive staphylococci were found in mixed growth with coagulase-negative staphylococci in the other patients.

A failure of intensive appropriate antibiotic therapy

occurred in all these patients, including the injection of methicillin into the cerebral ventricles. During the periods of antibiotic administration the symptoms were suppressed to some degree, but they reappeared relentlessly when the antibiotic was withheld. This suppressive effect of antibiotics presumably follows a suppression of those organisms that have escaped into the blood from the catheter system.

It has been found necessary to remove the entire shunt to eradicate the source of bacteraemia. Prompt and permanent regression of all clinical signs has followed this procedure. It need not be done urgently, but if clinical deterioration dictates that the bacteraemia be controlled before the hydrocephalus is thought to have been arrested, a second shunt can be inserted either on the same or the other side of the neck. This should be done preferably after a staged removal of the infected shunt: a period of drainage through an exteriorized cardiac end of the catheter system gains control of the bacteraemia without interrupting decompression of the hydrocephalus.

THE ORGANISM AND ITS NIDUS

The generally accepted[3] incidence of sepsis complicating the procedure of ventriculo-venous shunt is 10%, which is very high. This usually takes the form of pyogenic staphylococcal or streptococcal postoperative wound infection, surrounding the prosthetic tubing where this underlies the incisions in scalp and neck. Meningitis rarely follows; a rapidly fatal septicaemia may, however, be brought about by extension to the venous end of the system.

In contrast, the peculiar characteristic of the infection seen in this patient is the intraluminar nidus of organisms within the valve and catheters of the shunt. The organisms appear to colonize this lumen and give rise to a chronic bacteraemia by contaminating the sterile cerebrospinal fluid as it passes through the shunt. This was well demonstrated by Cohen and Callaghan,[3] who initially exteriorized the distal catheter in their patients. Although the ventricular cerebrospinal fluid was sterile, that draining from the shunt system was heavily contaminated by organisms. Diversion of the stream of organisms in this way, before they entered the blood, resulted in immediate clinical recovery. Bacteriological analysis of the shunt components indicated that this colonization begins in the valve chamber of the Spitz-Holter shunt and extends distally, but not proximally to the first valve of the system, i.e. not into the catheter which enters the ventricular cavity.

The organisms found were similar to those previously reported. These staphylococci are commonly part of the bacteriological environment of surgical theatres. No special source need be looked for. Their entry into the prosthesis, however, is puzzling, and of some practical importance. There is no inflammation outside the tubing, which suggests that simple wound contamination does not play a part. The intraventricular cerebrospinal fluid is found to be sterile before and after the operation; there is perhaps the small possibility that the organisms are introduced into the cerebrospinal fluid by pre-operative ventriculography or encephalography. The possibility that the organisms ascend from endocarditis about the tip of the catheter is not supported by the immediate clinical improvement in those children from whom the shunt has been removed.

It seems most likely that the tubing is contaminated at the time of operation, before it is placed in the tissues. A factor which may also help to explain the excessively high overall wound-sepsis rates encountered with the use of this prosthesis, is the electrostatic property of silicone rubber, of which these shunts are constructed. While this tubing is being handled at operation its surface is commonly seen to acquire adherent motes of dust, glove powder and lint. These are likely to act as fomites. Usually, one may postulate, such surface contamination is destroyed by contact with the tissues. Within the lumen, however, the organisms are insulated from the antibacterial activity of tissue fluids. It seems clear that an extraordinarily meticulous aseptic operative technique should be observed during this procedure. The shunt components should be kept moist with normal saline continuously while they are exposed to the air, to neutralize the electrostatic rubber.

The perpetuation of this intraluminar colony of organisms raises further questions, which we will only propound. Does the construction of the valve provide a hydrostatic niche from which the organisms cannot easily be dislodged? Are the organisms so difficult to eradicate because they are inaccessible to tissue fluids and high concentrations of antibiotics? Finally, there is the interesting speculation that these colonies are nourished only by normal cerebrospinal fluid, although the occasional entry into the shunt of ventricular debris probably contributes to their support.

SUMMARY

1. The high incidence of infection complicating ventriculo-venous cerebrospinal fluid drainage is of some concern.

2. An unusual form of infection in such a shunt is reported, that of staphylococcal colonization within the lumen of the shunt components, resulting in an intractable chronic bacteraemia.

3. The special nature of the nidus of the organism is commented on, and it is concluded that particular precautions should be taken to avoid contamination of the shunt during operation.

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