TREATMENT

Meningitis acquired in the community in the non-immunocompromised host is most often caused by *H. influenzae*, meningococci or streptococci. It should be remembered that meningococci are becoming increasingly resistant to sulphonamides and *H. influenzae* to ampicillin. Benzylpenicillin can be used to initiate treatment in meningococcal and pneumococcal infections and when gram-negative organisms are responsible for meningitis in school going or older subjects. Chloramphenicol should be used in *H. influenzae* infections or when gram-negative organisms are causative in children below five.

Many physicians prefer to combine chloramphenicol (100 mg/kg/day) with either penicillin (150 mg/kg/day) or ampicillin (200 mg/kg/day) as the first line of treatment. These drugs are preferably given intravenously, although the intramuscular route can also be used. Chloramphenicol crosses the blood-brain barrier readily. Rarely, intrathecal administration of antibiotics is justified if deterioration continues despite use of appropriate antimicrobials given in adequate doses. Meningitis complicating a neurosurgical procedure is usually caused by gram-negative bacilli or *Staphylococcus aureus*. Treatment with an aminoglycoside (gentamycin, tobramycin) preferably given intrathecally, combined with a penicillinase-resistant penicillin (nafcillin), is appropriate. Cephalosporins such as cefotaxime and ceftazimide are very effective against gram-negative bacilli and should be used when the disease is caused by chloramphenicol-resistant organisms. Other promising drugs include the quinolones. Table IV lists the doses of some drugs used in meningitis.

Therapy should be continued for at least 10 to 14 days. By this time the patient has usually been afebrile for 3 to 4 days and is totally asymptomatic. A repeat lumbar puncture is not essential to determine whether therapy can be stopped as quite often the CSF does show raised cells and proteins for several weeks after clinical recovery.

Recurrent meningitis is often seen with compound skull fractures or congenital malformations such as dermal sinuses or neuroenteric cysts. These patients require early surgical repair of the communication between the neuroaxis and the exterior soon after the meningitis has been eradicated with appropriate antimicrobial drugs.

An occasional patient with bacterial meningitis develops marked brain swelling. In such instances, intravenous mannitol (0.25 to 5.0 g/kg) given over half an hour may be life saving. If seizures develop, these should be treated with diazepam (5 to 10 mg intravenously) or with phenytoin. Sedation should be avoided because of the risk of aspiration pneumonia.

TABLE IV. Antibiotic dosages for bacterial meningitis

Antibiotic	Adults		Children	
	Total (per day)	Interval (hours)	Total (per day)	Interval (hours)
Ampicillin	12 g	4	200–300 mg/kg	6
Carbenicillin	30–40 g	4–6	400–500 mg/kg	4
Nafcillin	12–18 g	4	150–200 mg/kg	4–6
Penicillin G	20–24 × 10^6 units	2–4	20–30 × 10^4 units	4–6
Cefotaxime	12 g	4	150–200 mg/kg	4–6
Ceftazimide	6 g	8	100–150 mg/kg	8
Cefuroxime	4.5–9 g	8	200–240 mg/kg	6
Chloramphenicol	4 g	6	100 mg/kg	6
Amikacin				
Intravenous	15 mg/kg	8–12	15 mg/kg	8–12
Intraventricular	20–30 mg	24	4–5 mg	24
Gentamicin				
Intravenous	5 mg/kg	8	5–7 mg/kg	8
Intraventricular	8–10 mg	24	2–2.5 mg	24

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Surgical management of bacterial meningitis

Although antimicrobial therapy is the mainstay of management of bacterial meningitis, surgical intervention is sometimes necessary for the indications given in Table I.

TABLE I. Indications for surgery in bacterial meningitis

Complications of meningitis	*Eradication of focus of infection*
1. Hydrocephalus	1. Otitis media
2. Subdural effusion/empyema	2. Paranasal sinusitis
3. Rarer complications	3. Miscellaneous
a. Brain abscess	a. Cranial osteomyelitis
b. Optochiasmatic arachnoiditis	b. Pulmonary
	c. Cardiac
Closure of fistulae	*Miscellaneous*
1. CSF rhinorrhoea/otorrhoea	1. Removal of foreign bodies
2. Dermal sinuses	a. Shunt tubes
a. Lumbosacral	b. Cranioplasty plates
b. Occipital	c. Dural substitutes

COMPLICATIONS OF MENINGITIS

Hydrocephalus

This is probably the commonest indication for operation in a patient with bacterial meningitis. Ventricular enlarge-

ment in these patients is because of obstruction to the cerebrospinal fluid (CSF) pathways by exudates around the 4th ventricular outlets (the foramina of Magendie and Luschka) in the basal cisterns, and in the aqueduct of Sylvius. Nearly all patients with tuberculous meningitis who have survived the first 4 to 6 weeks of their illness and about 65% of patients with pyogenic meningitis develop hydrocephalus which is demonstrable on computerized tomography (CT) (Fig. 1). However, only a few patients develop hydrocephalus-related symptoms which require surgical intervention.

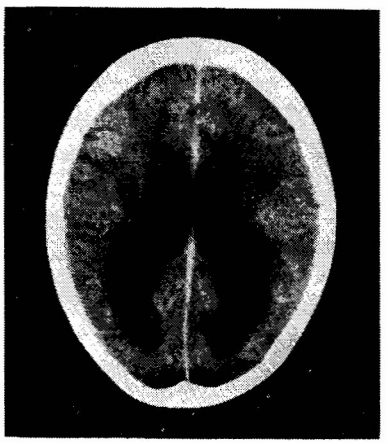

FIG 1. CT scan showing hydrocephalus following tuberculous meningitis

Hydrocephalus may produce symptoms either during the acute phase of meningitis or after many weeks or months. It should be suspected in these patients if there is symptomatic and clinical deterioration despite adequate and appropriate antimicrobial therapy. In late onset hydrocephalus, the patient usually has progressive worsening of headache, blurring of vision and diplopia—symptoms of raised intracranial tension. A CT scan of the head is the investigation of choice. If CT scan facilities are not available, we have to rely on less sensitive investigations such as ventriculography or carotid angiography.

Pyogenic meningitis: Acute onset hydrocephalus is rare in patients with pyogenic meningitis. If it occurs, repeated ventricular taps or an external ventricular drainage (EVD) are often adequate. EVD is performed by placing a ventricular catheter in the lateral ventricle (most often the right frontal horn) and draining the CSF into a sterile closed system outside the body. This should be performed under strict aseptic conditions by a trained surgeon. These drains should not be left in place for more than 24 to 48 hours because of the risk of infection. In late onset hydrocephalus, also a rare complication, a ventriculoperitoneal (VP) shunt (Fig. 2) is effective and is the recommended treatment.

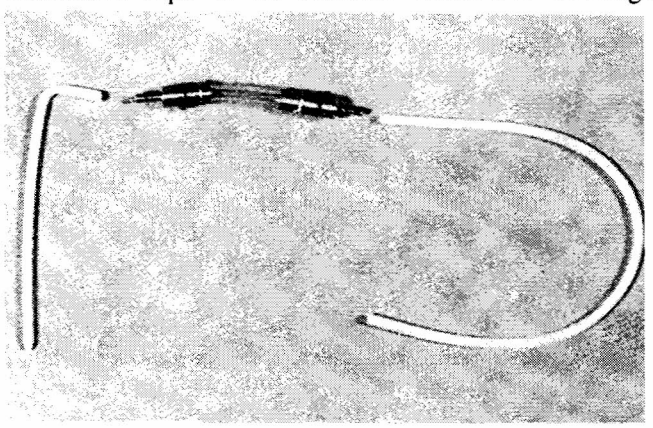

FIG 2. Ventriculo-peritoneal shunt

Uncommonly, multiloculated hydrocephalus develops in children with pyogenic meningitis and ventriculitis. In this form of hydrocephalus, adhesions develop between the ventricular walls causing the CSF to accumulate in multiple non-communicating cavities. In these patients a simple shunt will not decompress the ventricular system and surgical or endoscopic division of the adhesions is necessary.

Tuberculous meningitis: In tuberculous meningitis the results of shunt surgery are dependent on the neurological status of the patient at the time of operation. Patients in Medical Research Council (MRC) stages I and II (Table II) who develop hydrocephalus should have the procedure done early. Patients in MRC stage III, i.e. those who are comatose and decerebrate or decorticate, usually have a poor prognosis in spite of shunt surgery. The complications of shunts (Table III) in these patients are higher and their mortality approaches 50%. EVD may help identify such patients who will benefit from surgery. If patients in stage III improve to stage II or I following EVD, then shunt surgery is likely to be beneficial. It is important to remember that in stage III, factors other than hydrocephalus, such as arteritis and encephalitis, are responsible for the altered sensorium. Shunts may therefore not produce clinical improvement.

TABLE II. MRC staging of tuberculous meningitis

Stage I.	Non-specific symptoms. Minimal signs of meningitis.
Stage II.	Conditions between stage I and III.
Stage III.	Extremely ill. Deeply stuporous or comatose with gross paresis.

TABLE III. Complications of CSF shunts

1. Shunt obstruction
2. Shunt infection
3. Subdural collections
4. Shunt nephritis (mainly with ventriculoatrial shunts)
5. Peritoneal cyst with ventriculoperitoneal shunts
6. Perforation of a viscous
7. Shunt dependency
8. Intracerebral or intraventricular haemorrhage during surgery.

Subdural effusions and empyema

Subdural effusions usually occur following *H. influenzae* or pneumococcal meningitis and are usually seen in children below two. This complication should be suspected if the child remains febrile and toxic in spite of 72 hours of

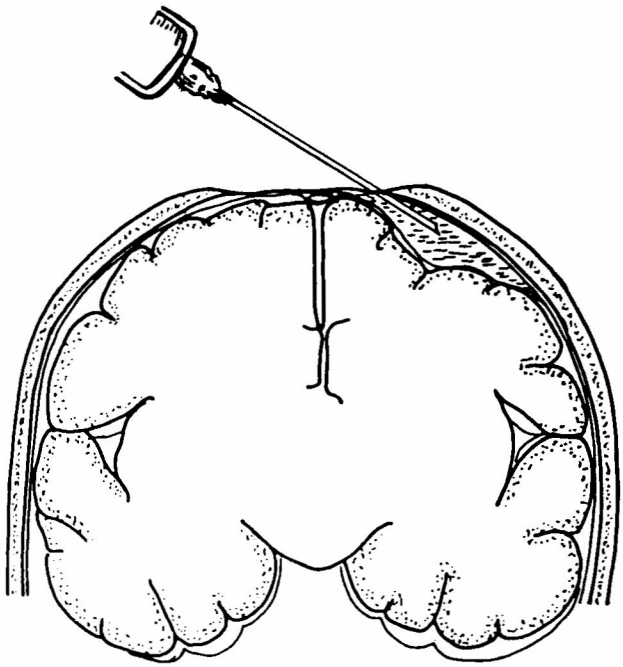

FIG 3. Subdural tap through anterior fontanelle

adequate antibacterial treatment, and if he vomits and develops seizures and focal neurological signs.

A subdural tap, using a special needle with a stylet, performed through the edge of an open anterior fontanelle (Fig. 3) may be both diagnostic and therapeutic. Repeated taps may be required. Injury to the cerebral vessels or the brain can occur especially if there is no effusion and for this reason the needle should not be pushed too deeply under the dura. The fluid is sterile in about 90% of patients. Surgery in the form of craniotomy and excision of the subdural membrane, or a subdural-peritoneal shunt, may be required in the very rare instances where repeated taps fail to clear the effusion or if the patient remains symptomatic.

It is common in adults who present with fever, seizures, focal neurological deficits and a CSF containing an excess of cells. This rare complication of meningitis can be lethal. Drainage of the pus through burr-holes or a craniotomy is necessary but diagnosis should first be confirmed by either an Echo or a CT scan.

Rare complications

Brain abscess occurs only rarely following meningitis. Aspiration of the abscess through a burr-hole or drainage following craniotomy is the recommended treatment.

Optochiasmatic arachnoiditis is a complication of tuberculous meningitis. In patients whose vision deteriorates in spite of steroid therapy, craniotomy and release of adhesions is sometimes performed. However, this is not always associated with good results because arachnoiditis causes ischaemic damage to the optic nerves.

CLOSURE OF FISTULAE

Recurrent meningitis may indicate the existence of a communication between the central nervous system and the exterior. Several kinds of communications exist.

CSF otorhinorrhoea (Dural fistulae)

The communication between the subarachnoid space and the paranasal sinuses or middle ear usually follows a basal skull fracture or surgery in that region; occasionally it may not be preceded by trauma. In 5% to 10% of patients there is no overt CSF leak. In these patients pneumococci are the commonest causative organisms of meningitis.

In patients with otorhinorrhoea, the leaking fluid is clear, watery and not sticky and a sugar value of >0.3 g/L in the leaking fluid confirms the diagnosis. X-ray of the skull may reveal a basal fracture, an opaque paranasal sinus or intracranial air (Fig. 4). However, the fistula site is best detected by performing a CT scan of the head including the sinuses, after injection of a water soluble contrast agent (metrizamide or iohexol) via a lumbar puncture. Surgery through either the intra- or extracranial route is required to close the fistula.

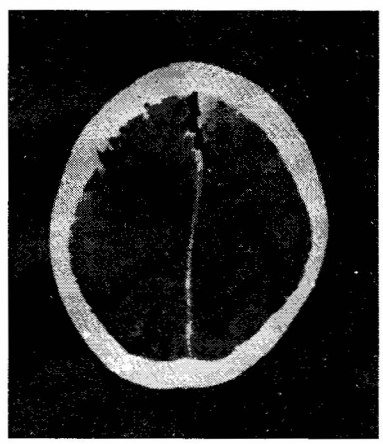

FIG 4. CT scan showing intracranial air in a patient with a dural fistula

Dermal sinuses

This should be suspected if coliform organisms are isolated in the CSF or the patient has recurrent meningitis. Detection of a dermal sinus in the lumbosacral area or in the region of the occiput requires careful clinical examination. The hair on the occipital region should be shaved to enable adequate examination. Investigations such as plain X-rays of the skull or myelography may be required before surgical intervention. These investigations will also help diagnose congenital tumours that are frequently associated with sinuses. If a tumour is present, it should be excised along with the whole sinus tract, to prevent recurrent meningitis and neurological deficits. It is important to distinguish lumbosacral dermal sinuses from pilonidal sinuses (Fig. 5). The latter are situated in the natal cleft, have many openings and contain hair.

ERADICATION OF A FOCUS OF INFECTION

Surgery may be required to eradicate a focus of infection which is responsible for meningitis. The infection may spread contiguously (e.g. from the ear, paranasal sinuses) or haematogenously (e.g. from the lungs or heart).

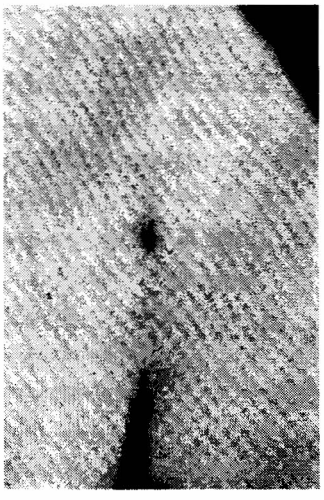

FIG 5a. Lumbosacral sinus

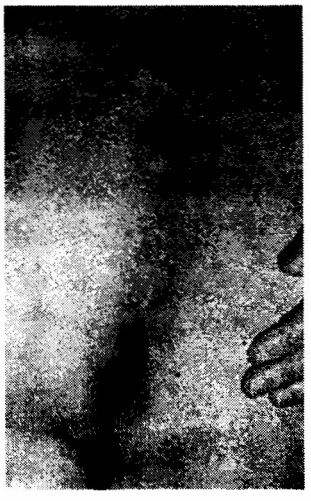

FIG 5b. Pilonidal sinus

FOREIGN BODIES

Meningitis which occurs because of the presence of foreign bodies after injury (such as wood splinters and old compound depressed skull fractures) is difficult to cure unless the foreign body is removed. Another common cause of meningitis due to a foreign body is shunt infection where the organisms (usually *Staphylococcus aureus* or *Staphylococcus epidermidis*) colonize the walls of the shunt tube. Parenteral and intrathecal antibiotic therapy are usually not adequate and shunt removal is often necessary.

DISEASES MASQUERADING AS MENINGITIS

Brain abscess

In patients with chronic suppurative otitis media (CSOM), a brain abscess may produce no localizing or lateralizing signs and the patient complains of non-specific symptoms such as headache and vomiting. Such a clinical picture can easily be mistaken for meningitis. A lumbar puncture in such a setting can lead to disastrous consequences because the raised intracranial pressure associated with abscesses frequently leads to uncal or tonsillar herniation and may result in the death of the patient if excess CSF is withdrawn from the lumbar theca. Hence all patients with CSOM and suspected intracranial complications should undergo funduscopy for papilloedema followed by a CT scan of the head to exclude a brain abscess. If CT scan facilities are not available, cerebral angiography or ventriculography can be performed. These latter investigations are, however, only useful in detecting large abscesses.

Tumours

Leakage of the contents of congenital tumours such as craniopharyngiomas and epidermoid or dermoid cysts can be confused with bacterial meningitis. Recurrent attacks of aseptic meningitis with a sterile CSF, focal neurological signs and a high index of suspicion will usually point to the correct diagnosis.

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