aggressive enough. It is possible that higher doses of antivenom, given sooner, may have prevented some deaths. Children must receive the same dose of antivenom as adults. The SAIMR recommends 4 - 10 ampoules, depending on the type and severity of envenoming (Polyvalent Antivenom package insert). The high rate of significant adverse reactions is of concern and emphasises the need for antivenom to be given only when full resuscitation facilities are available. No cases of serum sickness were noted.

Statistical analysis showed that the condition of the patient on arrival at the hospital was a very significant predictor of progress and outcome. Young children are at high risk. The degree of local swelling on admission strongly predicts the presence of systemic envenoming, the progression of local swelling and later development of signs of systemic envenoming. The degree of local swelling on admission could therefore be used as one of the factors determining the need for antivenom; if given at this stage, antivenom could prevent the development of later systemic envenomation. Patients who present early must be monitored closely for progression of symptoms.

This study has prompted the development of standing orders and management guidelines for use in the hospital. It is hoped that these guidelines will allow a more structured and rational management of snakebite and a reduction in the mortality rate. A prospective study is planned to clarify a number of issues raised by this study. A serological survey to define the species involved would be of interest. The effects of snakebite on blood coagulation in outpatients merit further study, as do the reasons for the severe local effects reported. The effectiveness of the antivenom used also needs formal evaluation.

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# Rhinogenic subdural empyema in older children and teenagers

**J. C. Peter, A. P. L. Bok**

**Forty-five patients under the age of 20 years with rhinogenic subdural empyema were treated at Groote Schuur Hospital and Red Cross War Memorial Children's Hospital between 1979 and 1991. Thirty-two were male and 13 female. The majority were between 13 and 19 years of age. Headache was the predominant symptom in 41 patients. Vomiting occurred in 15 and 21 presented with seizures, 2 in status epilepticus. Thirty had swinging pyrexias and 26 neck stiffness while only 14 had focal neurological signs. Swelling of the face or orbit was seen in 24. Twenty-two had depressed levels of consciousness and 7 had Glasgow Coma Scale (GCS) values below 11/15. White cell counts and erythrocyte sedimentation rates were raised in all cases. Twenty-three patients underwent lumbar punctures despite the inherent danger in this procedure. Cerebrospinal fluid analysis showed a pleocytosis in all cases; no organisms were cultured in any of the specimens. The diagnosis in all cases was made by contrast-enhanced computed tomography. Twenty-five patients underwent multiple burrholes, 9 small craniectomies and 11 craniotomies. Thirty-four patients made an excellent recovery. All of the 6 patients who died had GCS values below 11 at the time of their surgery.**

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Subdural empyema can result from the spread of bacterial infection from the paranasal air sinuses, middle ear and, occasionally, peripheral septic foci. It may also complicate penetrating head injury and, rarely, meningitis. Since computed tomography (CT) became available (1979 - 1991), we have treated more than 90 patients of all ages with subdural empyema from all causes, excluding trauma and meningitis. In our environment the commonest cause of subdural empyema is sinusitis and the group most at risk is male teenagers (Table I).[1] As most patients with subdural empyema present with meningitic signs and symptoms, it is very easy to miss the significance of sinusitis. We present our experience with rhinogenic subdural empyema in older children and teenagers as we believe it is only with a high index of suspicion in this group that early enhanced CT can be performed, avoiding the danger of premature lumbar puncture and delayed surgical treatment of this potentially lethal condition.

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**Table I. Source of infection related to age (yrs)**

| | 0 - 5 | 6 - 10 | 11 - 20 | 21 - 30 | 31 - 40 | 41 - 50 | 51 - 70 |
|---|---|---|---|---|---|---|---|
| Paranasal sinus | — | 11 | 34 | 4 | 2 | 2 | — |
| Middle ear | 5 | 5 | 4 | 4 | 1 | — | — |
| Superficial sepsis | 5 | — | — | 1 | 1 | — | 1 |
| Unknown | 3 | 1 | 2 | 2 | 2 | — | — |

## Patients and methods

The clinical records, haematological and biochemical tests, radiological findings and operative notes of all patients under 19 years of age who were operated on for rhinogenic subdural empyema at Groote Schuur Hospital and Red Cross War Memorial Children's Hospital between 1979 and 1991 were retrospectively analysed.

### *Findings*

There was a total of 45 patients, of whom 32 were male and 13 female. Thirty-two were between 13 and 19 years of age and 7 were between 6 and 12 years of age at the time of operation. There were no patients under the age of 6 years.

### *Clinical presentation*

The majority of patients had had symptoms for more than 5 days, although 11 presented after 1 - 2 days. Headache was the most common symptom (41/45), vomiting occurred in 15 and seizures in 21, 2 patients presenting in status epilepticus. Thirty had high swinging temperatures, and 26 neck stiffness, but only 14 had focal neurological signs. Swelling of the face or orbit was prominent in 24. Twenty-two presented with depressed levels of consciousness and 7 had Glasgow Coma Scale (GCS) values below 11. White cell counts and erythrocyte sedimentation rates were invariably raised.

### *Lumbar puncture*

Despite the inherent dangers of this procedure 23 patients had lumbar punctures before neurosurgical consultation. No organisms were seen on any cerebrospinal fluid smears and no organisms were cultured. All showed a pleocytosis and in 14 of the 23 specimens the cell count was more than 50/mm$^3$.

### *Radiological studies*

Ten patients showed evidence of opacification of the air sinuses on plain radiographs but in most only CT was performed as the initial investigation.

### *CT*

The definitive diagnosis of subdural empyema was made in all cases by enhanced CT. The standard axial projections of the brain and sinus views were performed. The majority of patients had 3 - 4 scans during the course of their illness.

### *Surgery*

All patients underwent emergency neurosurgical drainage of the subdural empyema on diagnosis. This was achieved either by means of multiple burrholes (25), small craniectomy (9) or craniotomy (11) depending on the preference of the attending neurosurgeon, usually followed by sinus washouts or drainage by an otolaryngologist. Subdural drainage was repeated as indicated on follow-up CT performed on the first postoperative day and determined by the clinical progress of the patient.

### *Antibiotic therapy*

All patients received an intravenous antibiotic regimen of penicillin, chloramphenicol and metronidazole on diagnosis until culture results became available. The most common change of antibiotic was to cloxacillin in cases of penicillin-resistant staphylococcal infections. This intravenous regimen was continued for 10 - 14 days until the clinical, haematological and CT improvements were maintained, and then replaced by an oral regimen. When the erythrocyte sedimentation rate and CT were normal, antibiotic treatment was discontinued.

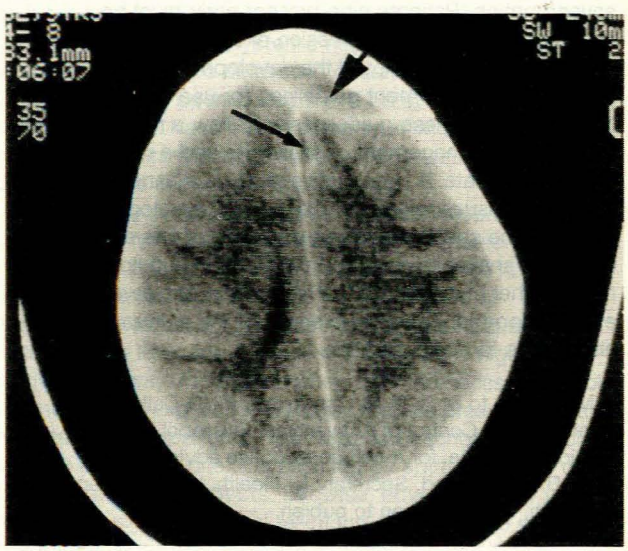

**Fig. 1. Enhanced CT scan of parafalcine subdural and frontal extradural empyema.**

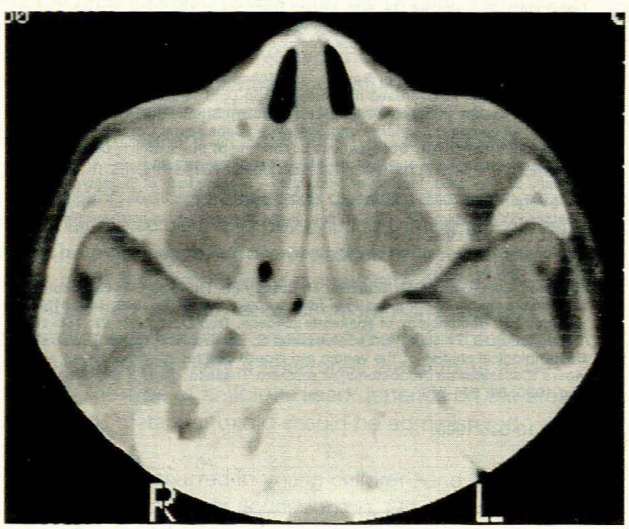


**Fig. 2. Pansinusitis associated with subdural empyema.**

# Results

## Anatomical site of empyema

When the subdural empyema was situated in more than one site in the same patient, these sites were recorded separately.

The lateral hemisphere was the commonest site (20 patients). Sixteen had interhemispheric collections lying in the parafalcine space, 11 predominantly frontal polar collections (6 of these associated with extradural pus) and 2 bilateral collections.

## Sinus involvement

All patients had evidence of ethmoid air cell opacification on CT, and most had other sinus involvement as well. There was no correlation between the degree of opacification on CT and the development of empyema.

## Bacteriology

*Streptococcus milleri* was cultured in 20 patients, *S. mittior* in 3 and β-haemolytic streptococci in 1. *Staphylococcus aureus* was found in 6 patients, micro-aerophilic diphtheroids in 3 and pneumococcus in 1. Seven patients had mixed organisms and there was no growth in 8. All the *S. milleri* infections were sensitive to penicillin, but the *S. mittior* and *S. aureus* infections were resistant. Micro-aerophilic diphtheroids were resistant to penicillin, but sensitive to chloramphenicol, and the *S. aureus* infections were sensitive to cloxacillin.

## Neurological outcome

Thirty-four patients made an excellent recovery with normal neurological function. Three had residual neurological signs, but were able to function normally in society. Two were neurologically severely handicapped and 9 had post-operative seizures. All the 6 patients who died had GCS values below 11 at the time of surgery.

# Discussion

The overall survival rate of subdural empyema has steadily improved from 50% 30 years ago to 90% in most large series reported today.[2-4] The most significant contribution to these improving results is early clinical suspicion of the condition coupled with early enhanced CT of the brain and sinuses before lumbar puncture is performed and before the level of consciousness has deteriorated. CT allows precise localisation of the pus and its reaccumulation, and this accuracy of diagnosis has contributed to the improved mortality rate in the same way as has been accomplished with cerebral abscesses.[5]

Lumbar puncture contributes little to the diagnosis of this condition as it usually reveals a nonspecific pleocytosis with no organisms visible on microscopy or culture. Apart from being dangerous in its own right because of the very real risk of precipitating transtentorial herniation, it gives the clinician a false sense of security as cerebrospinal fluid analysis often suggests a viral meningitis or partially treated bacterial meningitis. We feel that in any child or teenager with evidence of sinusitis, especially those with swelling of the face or peri-orbital area and meningitic signs, it is safer to perform an enhanced CT scan or, if this is not possible, arbitrarily to treat with triple antibiotics until CT becomes possible.

The type of neurosurgical procedure used to drain the empyema does not alter the outcome.[1] What is important is the accurate localisation of the pus when and where it occurs and its immediate surgical drainage together with the drainage of the sinuses.[6] We feel in our environment that multiple appropriately placed burrholes guided by repeat CT is the simplest and most judicious method.[1]

We use a triple antibiotic regimen of penicillin, chloramphenicol and metronidazole, although the majority of *S. milleri* infections respond well to penicillin alone. In all studies of rhinogenic empyema there are a significant number of patients with mixed infection and anaerobic and micro-aerophilic bacteria which, we have found, are better treated with chloramphenicol and metronidazole. All our patients with *S. aureus* infections have had organisms resistant to penicillin, and have consequently required a change to cloxacillin.

Although only 21 patients in this series presented with seizures pre-operatively and 9 postoperatively, all were treated with phenytoin sodium because of the risk of epilepsy in this condition.

## Pathogenesis

The pathogenesis of rhinogenic empyema is thought to be retrograde spread via the emissary veins or from osteitis of the infected sinus. Significantly there were 6 patients in our study with associated extradural pus, sometimes with clinical osteitis of the frontal bone apparent at the time of surgery. There were also 5 intracerebral abscesses that developed postoperatively. Once infection reaches the subdural space the pus is not only located near the source of infection in the frontal area, but more frequently is found over the entire hemisphere and interhemispherically. The reason why rhinogenic empyema occurs between the ages of 6 and 19 years has to do with the relatively rudimentary state of these sinuses before this age. Why male teenagers are more prone to subdural empyema is not certain. Male sinuses tend to be more developed and larger than female sinuses, although size *per se* should not influence the propensity for retrograde spread. Males often have a more vigorous nose-blowing habit than their female counterparts, which may possibly account for this gender difference. The peak of our empyema admissions always occurs during the spring nasal allergy period.

There is no way of knowing which patient with sinusitis is at risk of developing subdural empyema. We feel, however, that in any patient with a known history of sinusitis who develops meningitic symptoms this diagnosis should be considered, particularly if there is swelling over the forehead or peri-orbital area. We believe that with the appropriate degree of vigilance in this high-risk group, the appropriate early investigation and surgical treatment can avoid the tragedy of permanent neurological sequelae or death from an eminently treatable disease.

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