Intracranial Subdural Empyema – A Mini Review

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Abstract
Intracranial subdural empyema is a rare but devastating infection of the brain. With improvements in investigations and treatment, the previously seen mortality of 100% has now been reduced to 4-9%. The underlying factor in this improvement is the reduction in time to treat. To achieve this, the first barrier is identifying the possibility of the condition. There have been multiple case reports, series, and retrospective studies on the matter, but over time the clinical epidemiology has changed. In this report, we give a up to date review of the infection and highlight the important features clinicians should consider when assessing patients with possible intracranial subdural empyema.

Introduction
Intracranial subdural empyema (ISE) is a rare but serious infection of the brain with the purulent collection located within the space between dura and arachnoid mater. Prior to the advent of antibiotics, morbidity, and mortality affected near 100% of patients within 24-48 hours of presentation1-7. The combination of improvement of investigations and management strategies have decreased mortality to 4-9%6–9. This is largely credited to decreased time to diagnosis and a subsequent reduction in the time to treatment7,10,11. The aim of this report is to summarize the key clinical features of ISE and assist in management for clinicians faced with this challenging condition.

Epidemiology
ISE can occur in any age group, gender or population3,6,8,12–15. Studies have shown two distinct populations at risk of ISE. The first group are children and young adults (<20 years of age) with males being at a higher risk2–4,6,15–17. This demographic has a strong association with sinusitis and otogenic infections (41-78% of cases) highlighting the likely pathogenic roles of these diseases to ISE6,13,15–18. Other, but less frequently mentioned causes included meningitis, neurosurgical procedures, and head trauma15,19,20. The relationship of the younger population, sinus/otogenic infections and ISE can be explained by a combination of anatomical and behavioral risk factors. The younger male population possesses a relatively higher risk to develop sinusitis, meningitis, otitis media and undergo trauma compared to their older and female counterparts4,17,21. Some authors deduct this to be a possible consequence of the male population’s greater risk of neglecting infections and higher risk taking behaviour5,6,22. Anatomical differences in the greater vascularity of the diploic veins in the younger male may also increase the risk of septic embolism and subsequent ISE compared to the older and female counterparts12.
The symptoms experienced are secondary to the presence of the infective collection causing mass effect to adjacent brain structures with associated inflammation. Within the subdural compartment, due to lack of physical constraints, the empyema is relatively free to spread over a larger area. The infection then poses a significant risk of venous stasis, venous thrombosis, cerebritis, and stroke over a large area of brain. This can lead to rapid deterioration with symptoms presenting as early as 1 day or late as 6 weeks, with mean time of 15 days prior to clinical presentation. Patients commonly experience headaches (77-83%), fevers (72-96%), altered sensorium (56-67%), vomiting (50%) and seizures (29-56%). The clinical triad commonly described of fevers, headaches and vomiting is only present in half of patients. Depending on the location of the disease, mass effect can lead to symptoms including papilledema, cranial nerve palsies and hemiparesis (48-96%). In contrast to the subdural empyema, epidural abscesses are walled off by strong dural adhesions and therefore tend to present later and are associated less with fevers, loss of consciousness and seizures.

The pathogenesis and clinical presentation of precursor infections and associated conditions is outside the scope of this report. It is however, important to understand that the risk of developing ISE from sinusitis and otogenic infections remains significantly low &gt; 0.1%. Regardless, in cases of sinus and otogenic complications cranial imaging and thorough examination of ear, nose and throat should be carried out to exclude concurrent intracranial infections.

**Investigations**

Laboratory analysis of blood tests are non-specific and can show raised white cell count, C-reactive protein and erythrocyte sedimentation rate. Blood cultures, although recommended, can have poor yield as low as 5%. This is likely a consequence of the blood brain barrier and significant localization of infection within the intracranial compartment. As a result, it is recommended that intra-operative sampling and cultures are performed in all surgeries. These too can render a negative result and fail to yield growth in 7-53% of cases but, if not acquired might preclude vital pathogenic information. Failure of such growth can be secondary to sterile empyema from early administration of antibiotics or improper use of culture medium. Invasive procedures such as lumbar puncture (LP) are not recommended as previous reports have shown significant risk of neurological deterioration and herniation. When LP is indeed done, cerebrospinal fluid (CSF) gram stains, cultures, and cell counts indicate inflammation but lack any specific pattern for ISE.

Diagnosis is confirmed radiologically with computed tomography (CT) scans being the initial recommended modality as they provide a prompt assessment. If an ISE is evident on CT scans there is usually appreciable visualization of the collection including associated brain injury, bony destruction and adjacent sinus and otogenic pathology. The empyema appears as a thin, hypodense subdural lesion with linear enhancement of the medial surface. The mass effect that is present is usually disproportionate to the volume of the abscess as the cerebritis and cerebral ischemia contribute greatly to oedema and subsequent mass effect than the volume of abscess itself. Unfortunately, the CT scans can be normal in 63% of cases. The false negative scans can be a consequence of early symptomology without appreciable evidence of change. In these cases, a routine repeat CT scan or magnetic resonance imaging (MRI) is warranted. MRI has greater sensitivity (93%) and is therefore the preferred modality for diagnosis.
gold standard in all patients with suspicion of ISE. It provides accurate information regarding the extent of infection as more than half of patients will have more than one intracranial complication at time of diagnosis. MRI appearances show similar patterns as shown in CT scans. The empyema is represented as a T2 hyperintense collection in the subdural compartment with associated T1 hypointensity. Addition of gadolinium highlights the surrounding membrane of the empyema and diffusion weighted imaging typically demonstrates restricted diffusion. Simultaneously, a magnetic resonance venography (MRV) can be done to assess for venous sinus thrombosis. The extent of cerebral oedema may also be more apparent on the MR.

**Management**

Like many infections of the central nervous system, implementation of antibiotics should not be delayed and patients should be promptly treated with broad spectrum antibiotics in accordance to local hospital guidelines. Prior to the advent of antibiotics mortality reached near 100% within 24-48 hours of presentation even after surgical drainage. Introduction to antibiotics has decreased mortality and reduced the rates of complications in ISE to 15-41%. Further improvements of investigations, such as CT scans, has reduced this lower to 4-15% which has been credited to assisting in early diagnosis.

Infections are commonly polymicrobial. *Streptococcus milleri* group is over-presented in cultures but other streptococcus species, staphylococcus species and anaerobic gram positive and negative species are also present and have been cultured. In certain population groups, fungal empyema are also a possibility. In Australia, most departments would use a combination of a third-generation cephalosporin with metronidazole and vancomycin. This would provide broad spectrum cover for most pathogens including aerobic and anaerobic organisms.

In tropical areas such as our department in the Northern Territory, Australia, the prevalence of fungal infections and melioidosis has prompted the use of vancomycin. In cases of concurrent sinus or otogenic infections we would recommend definitive treatment of underlying pathology. Craniotherapy has the benefit of providing the option of assessment of loculations, removal of membranes, repair of dural breach as well as an adequate washout in the subdural compartment.

Intraoperatively, decision to remove the bone flap should be done by case to case basis. If there is contamination of bone with evident osteomyelitis, we would recommend closure without bone. This is the same if there are signs of raised intracranial pressure (ICP). In cases of concurrent sinus or otogenic infections we would recommend definitive treatment of underlying pathology preferable at the same time as the ISE treatment.

**Conclusion**

Intracranial subdural empyema is an uncommon intracranial infection. Like other cranial infections, the morbidity and mortality are significantly high, but this can be reduced with prompt diagnosis and subsequent implementation of antibiotics and surgical drainage. The time to diagnosis is dependent on a high degree of suspicion and a good understanding of the clinical risk factors associated with ISE. Over the years the epidemiology and risk profile for our patients have shifted and understanding the reason behind this can help the clinician's approach their patients on a case by case basis and improve patient outcomes.

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