Chapter 86
Central Nervous System Infection in Neurosurgical Critical Care

Mary K. Sturaitis

Overview

Postoperative central nervous system infection is a serious complication with potential disastrous morbidity and mortality, requiring immediate recognition and treatment. Superficial craniotomy wound site infections, while not uncommon, are of significance due to potential contiguous spread to the bone flap or the meninges. Intracranial infection commonly manifests as meningitis, subdural empyema, or brain abscess. In recent large studies the incidence of postneurosurgical infection has been reported from less than 1% to greater than 10% and is dependent on how the data are collected and percentages are calculated.

It is difficult to assign proof that a given factor contributes to infection. Cerebrospinal fluid (CSF) leakage (commonly associated with posterior fossa and transnasal approaches), entry into the paranasal sinuses (clean-contaminated) and the use of external ventricular drainage consistently impact infection risk. Certain general patient characteristics have been associated with an increased risk of surgical infection and include extremes of age, diabetes mellitus, immunocompromised states and malignancy, as well as the presence of concomitant remote site infection such as pneumonia or urinary tract infection. The routine use of prophylactic preoperative antibiotic administration for the prevention of surgical site infection has become common practice in many institutions.

Spinal surgical infections are commonly of the incisional or soft tissue type. The incidence of postoperative intervertebral disc space infection (discitis) or osteomyelitis is less than 1%. Although postoperative spinal epidural abscess is rare, rapid deterioration to paralysis can occur.

M.K. Sturaitis, MD (✉)
Departments of Anesthesiology and Neurosurgery,
Rush University Medical Center, Chicago, IL, USA
e-mail: mary_sturaitis@rush.edu

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Prevention

The routine use of prophylactic antibiotics can promote microbial resistance and is not without potential adverse consequences. Antibiotic administration carries the risk of fatal anaphylaxis and allergic reactions; aminoglycosides can cause ototoxicity; hypotension and flushing can be seen with vancomycin.

Most neurosurgical operations are considered clean, and therefore inherently have the lowest risk of developing a surgical site infection. Nevertheless, the potential adverse effects of central nervous system infection accentuate any possible risk.

The efficacy of antimicrobial prophylaxis for clean neurosurgical procedures has been studied over several decades, and has been established in the neurosurgical literature. Current practice mandates coverage against gram-positive cocci, the most common skin contaminants being *Staphylococcus aureus* and *Staphylococcus epidermidis* (methicillin-susceptible). In procedures traversing the paranasal sinuses and that may be complicated by a postoperative CSF leak, *Streptococcus pneumoniae* becomes the common pathogenic species. However, the case for prophylaxis in these *clean-contaminated* (e.g., complex cranial base, transphenoidal) procedures has not been analyzed in the neurosurgical literature, and the assumption for efficacy has extended *primarily from the general surgical literature* (e.g., cholecystectomy, bowel resection) where benefit from preoperative antibiotics has been validated. In neurosurgical patients who have had an extended hospitalization prior to surgery, the incidence of postsurgical infections due to resistant organisms (methicillin-resistant *S. aureus*, vancomycin-resistant *Enterococcus*) and gram-negative organisms rises. Recent evidence has suggested that although perioperative antibiotic prophylaxis is clearly effective for the prevention of incisional infections, it does not appear to prevent postcraniotomy meningitis. The bacteria responsible for meningitis in those patients having received prophylactic antibiotics were predominantly noncutaneous, tended to be resistant to the antibiotic given and had a higher mortality risk, whereas in the patients not having received prophylaxis the microorganisms were cutaneous. Additionally, aseptic meningitis appears to be more frequent in prophylaxis patients.

Of note, the evidence for the timing and duration of prophylactic antibiotic administration also has been derived *primarily from the general surgical literature* where the maximum benefit for elective clean or clean-contaminated procedures was achieved when the drug was given within 30 min but no longer than 2 h of incision. Similarly in well-designed studies of clean cases from other specialties, there has been no additional benefit shown to extending antimicrobial prophylaxis past the operation.

Surgical duration, CSF leakage, and early reoperation are established risk factors for nosocomial meningitis, and preventative operative techniques may help limit this risk exposure.

Maintenance of a physiologic milieu in terms of perfusion, temperature, metabolism, and nutrition is recommended. Data generally is supportive of tight blood glucose management in the range of 80 to 140 mg/dl to prevent systemic infections and possible seeding from remote infection sites. In the setting of neural tissue at

Table 86.1 Prevention of postsurgical infections

Specific indication	Efficacy of prophylactic antibiotics
Placement of CSF shunt	• Efficacy established • ~ 50% reduction in infection rate
Basilar skull fractures with or without CSF leak	• Available data do not support routine use of prophylactic antibiotics
External ventricular drain (EVD)	• Controversial – some studies suggest beneficial effect but no clear evidence • Single dose at time of insertion more common than continued coverage (avoid resistant microorganisms) *Other preventative measures* • No difference in infection rate for ICU vs. operating room insertion • Strict aseptic technique, tunneling of catheter away from insertion site and minimal entry into system (i.e., CSF sampling only when clinically indicated) associated with decreased infection rates • Routine catheter change at specific intervals of no benefit (leave catheter in situ if not infected)

risk, however, overaggressive management causing hypoglycemia can be detrimental. Furthermore, serious hyperglycemia associated with severe CNS infections and poor outcome (e.g., meningitis), may actually be reflective of the severity of the infection.

For additional specific considerations regarding prevention of postsurgical infections see Table 86.1.

Crisis Intervention

Postoperative Meningitis

Pathophysiology and Clinical Presentation

- Incidence of postoperative bacterial meningitis <1% in clean neurosurgical procedures.
- Increased risk associated with CSF shunts, ventricular drainage catheters.
- Common organisms in healthy patients reflective of skin flora; *Staph aureus* (90%); *S. epidermidis*; *proprionobacteri* seen with ventriculoperitoneal shunts.
- Consider gram-negative organisms in patients with extended hospital stays and organisms prevalent to hospital environment.
- Clinical manifestations may overlap with neurological abnormalities expected in the postoperative period.
- Unexplained fevers, headache, altered level of consciousness with or without signs of meningeal irritation.

Patient Assessment

- CNS imaging prior to lumbar puncture in patients who have undergone recent craniotomy.
- CT – expected postsurgical changes in most patients, may show leptomeningeal enhancement.
- MRI – vascular enhancement, associated complications, e.g., sagittal sinus thrombosis.
- *CSF Analysis*
  - Polymorphonuclear leukocytosis >100 cells/mm^3. However, in CSF that is blood contaminated, that is, contains more than a few RBC (e.g., status post traumatic puncture, subarachnoid hemorrhage, etc.), the ratio of leukocytes to erythrocytes in CSF versus whole blood (cell index) should be considered. (Based on CSF analysis alone, a cell ratio of WBC:RBC £ 1:100 indicates that an acute bacterial infection of the CSF is very unlikely; but a CSF WBC:RBC ratio ³ 1:100 should trigger further work-up).
  - ↑ protein (nonspecific, present with disruption of blood–brain barrier).
  - ↓ glucose (may be nonspecific, CSF/serum glucose ratio <0.4 suggestive).
  - Gram stain and culture for diagnosis (60 and 80% yield, less with perioperative prophylaxis).
- Initiating antimicrobial therapy prior to obtaining CSF sample should *not* significantly alter CSF WBC count (can see ↑ within 18–36 h) or CSF glucose concentration (return to normal within 3 days).

Aseptic meningitis is a chemical irritation of the meninges from blood introduced into the subarachnoid space at time of surgery and is a diagnosis of exclusion. Patients do not respond to antibiotics but show significant clinical improvement with corticosteroids.

Intervention

- Removal of hardware (e.g., shunts) and other suspicious material (bone flap).
- Empiric antibiotic coverage: gram-positive (Vancomycin) and gram-negative (third-generation cephalosporin, e.g., Cefotaxime, Ceftazidine). Add aminoglycoside if suspect Pseudomonas. Use Vancomycin with Cefepime or Meropenem with resistant strains.
- Efficacy of Vancomycin is hampered by poor CSF penetration. IV Vancomycin at usual dosages can achieve therapeutic concentration in CNS for at least 72 h postoperatively (possibly due to damage to blood–brain barrier that occurs during neurosurgical procedures and lasts for days). Some advocate the administration of intraventricular Vancomycin for EVD-associated staph ventriculitis given these patients may have less blood–brain barrier disruption compared to

postoperatively. Others argue the intraventricular inflammatory reaction in response to the local application is counterproductive.
- Watch for neurologic complications: seizures from focal areas of cortical irritability (e.g., subdural effusion/parenchymal abscess, septic thrombophlebitis); hydrocephalus secondary to inflammatory exudates.

Craniotomy Site or Bone Flap Infection

Pathophysiology and Clinical Presentation

- Associated with surgery of long duration, exposure involving air sinuses, reoperation, prior irradiation, immunosuppressive medical conditions, use of drains/foreign body, scalp devascularization involving the occipital or superior temporal artery.

Patient Assessment

- Fever, local erythema, tenderness, wound dehiscence, ± purulent discharge.

Intervention

- Fluctuance deep to the wound requires surgical drainage and debridement of tissue.
- Treat empirically for *Staphylococcal* infection ± gram-negative.
- Await cultures if patient is not toxic appearing.
- Bone flap is devascularized and consequently more at risk for infection therefore warranting aggressive therapy: removal of bone flap, prolonged systemic antibiotics (4–6 weeks), and followed by cranioplasty when infection eradicated.

Cranial Epidural Abscess and Subdural Empyema

Pathophysiology and Clinical Presentation

- Associated with craniotomy wound site infection, suppuration of paranasal sinuses or foreign body from trauma.
- Epidural abscesses alone may not cause neurologic symptoms, but 10% of epidural abscesses associated with subdural empyema.

- Subdural empyema is a surgical emergency progressing to death if untreated (20% mortality, 30% neurologic morbidity).

Patient Assessment

- Fever, mild mental changes in some patients.
- Lab data are nondiagnostic.
- Epidural abscess seen as lentiform (biconvex) and subdural empyema seen as crescentic on imaging.
- Enhanced MRI can usually differentiate from other subdural collections (effusion, hematoma) – increased signal adjacent to cerebral cortex due to inflammatory edema suggests empyema; MRI may demonstrate complications such as cortical/dural vein thrombosis.

Intervention

- Seizure prophylaxis for subdural empyema.
- Initial empiric IV antibiotic therapy should be broad spectrum.
- Surgical debridement and removal of bone flap.
- Operative cultures positive in 90%; extended IV antibiotics 4–6 weeks.
- Serial imaging following evacuation to monitor for reaccumulation of pus.

Cerebral Abscess

Pathophysiology and Clinical Presentation

- Incidence approximately 0.1% of clean neurosurgical procedures.
- Often associated with abnormal host defenses.
- Solitary lesion from bacteria introduced intracranially at the time of surgery, from trauma, or via contiguous spread from a parameningeal focus.
- Multiple lesions associated with systemic infection and hematogenous spread (grey–white junction, often in MCA artery distribution).

Patient Assessment

- Laboratory findings are generally nondiagnostic.
- Ring enhancing lesion – CT/MRI findings confounded by postoperative changes; steroids may decrease enhancement in early stages.

Intervention

- Nonoperative management considered in early cerebritis stage (without mass effect and with known organism), in cases with multiple small abscesses or abscess in eloquent brain region.
- Most cases require surgical intervention in addition to IV antibiotics (6 weeks).
- Aspiration (open vs. stereotactic, ultrasound guidance).
- Steroids only in cases with severe edema; rapid taper.
- Prophylactic anticonvulsants if near cortex.

Postoperative Spinal Infections (Table 86.2)

Pathophysiology

- Incidence of postoperative spinal infection increases with complexity of procedure: discectomy <1% risk; spinal fusion 1–5% without instrumentation, >6% with instrumentation.
- *S. aureaus* (>50%), many patients with multiple organisms.
- Patient risk factors include advanced age, obesity and diabetes, prolonged hospital bed rest, remote infection.
- Surgical risk factors include prolonged surgery, hardware, use of microscope.
- Spinal epidural abscess after decompression is rare, but rapid neurologic deterioration to paralysis occurs; associated with osteomyelitis; mortality for cervical spinal epidural abscess approaches 18%.

Table 86.2 Postoperative spinal infection

Spinal infection	Clinical presentation	Assessment	Intervention
Wound Infection	• Persistent temperature elevation several days postop • Tenderness, erythema, swelling, drainage	• Gram stain, culture	• Antibiotic therapy • Wound debridement and irrigation for deep tissue or persistent infection despite antibiotic therapy

(continued)

Table 86.2 (continued)

Spinal infection	Clinical presentation	Assessment	Intervention
Discitis	• Typically asymptomatic immediately after surgery • Excruciating back pain or spasms with or without radiation to legs within 2 weeks • Extreme local tenderness and fever	• Spine XR, temperature, WBC with differential is often normal • ↑ESR ↑CRP • CT sensitive early • Bone scan/MRI sensitive but may be falsely positive early in postop period	• Early recognition and treatment to prevent chronic infection • Disc space aspiration (CT-guided) often negative • 4–6 weeks antibiotics until normalization of ESR/CRP • Spinal immobilization • Uncomplicated discitis rarely requires surgery (vs. osteomyelitis requiring surgical intervention)
Spinal epidural abscess	• *Classic triad*: localized back pain, progressive neurologic deficit, fever • *Progression and time course of symptoms uniform*: radicular symptoms within 3 days, followed by weakness within 36 h, paralysis over the next 24 h • Cervical epidural abscesses develop more rapidly and with severe neurologic deficits (smaller epidural space)	• ↑WBC and fever is *absent* in over half of cases • ↑ESR (>75 mm/h) common, nonspecific • MRI can localize	• Emergent spinal decompression • IV antibiotic therapy 4–6 weeks followed by oral therapy

WBC white blood cell count, *ESR* erythrocyte sedimentation rate, *CRP* C-reactive protein

Key Points

- Postoperative neurosurgical infections occur despite best practice. However, the incidence can be minimized. Patients of advanced age, those with diabetes/hyperglycemia or with immunocompromised medical conditions are at higher risk.
- Intracranial subdural empyema is an immediate life-threatening condition; extradural empyema is typically a more subacute condition requiring removal of bone plate.

- Prophylactic antibiotics are clearly beneficial in patients undergoing ventricular peritoneal shunting. Available data do not support routine antibiotic prophylaxis for basilar skull fractures.
- External ventricular drains may be left in place until clear evidence of infection develops. Routine CSF sampling is not indicated. Intraventricular antibiotics may be indicated in certain EVD-related infections.
- Antibiotic coverage should be tailored to prevalent institutional flora.

Suggested Reading

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