Société belge d'infectiologie et de microbiologie clinique
Belgische vereniging voor infectiologie en klinische microbiologie

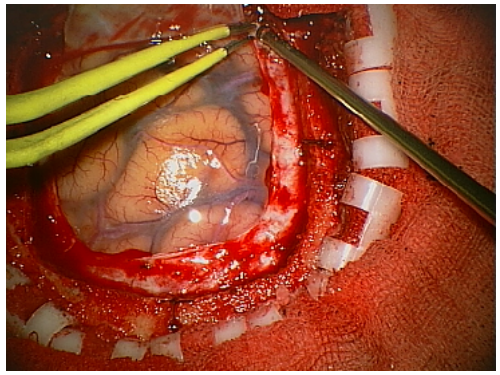
Post-neurosurgical infections

F. Jacobs
Infectious Diseases Clinic
Erasme Hospital

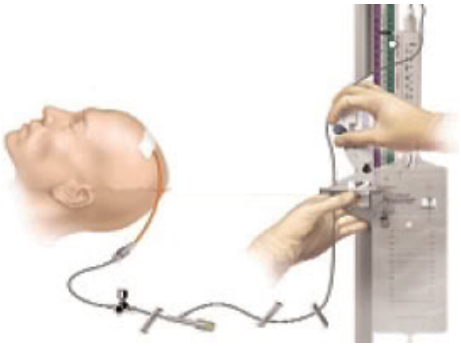
Hôpital Erasme

ULB

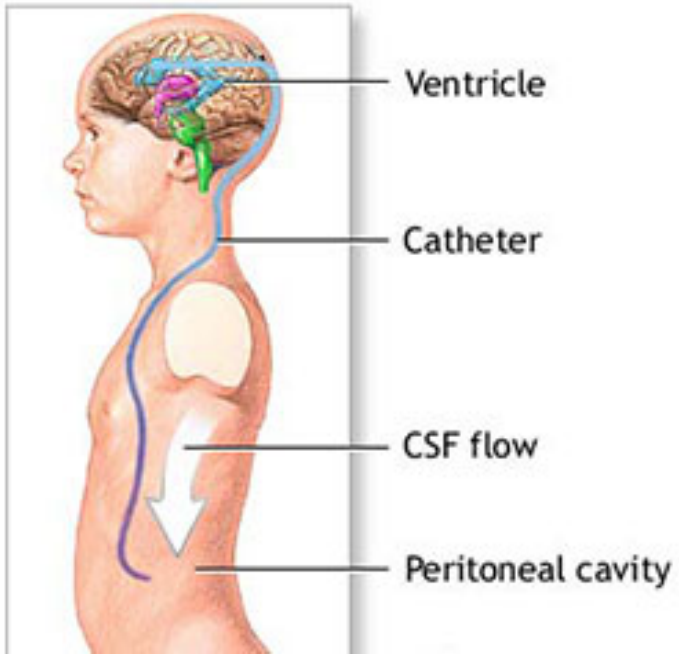
Infection after neurosurgery



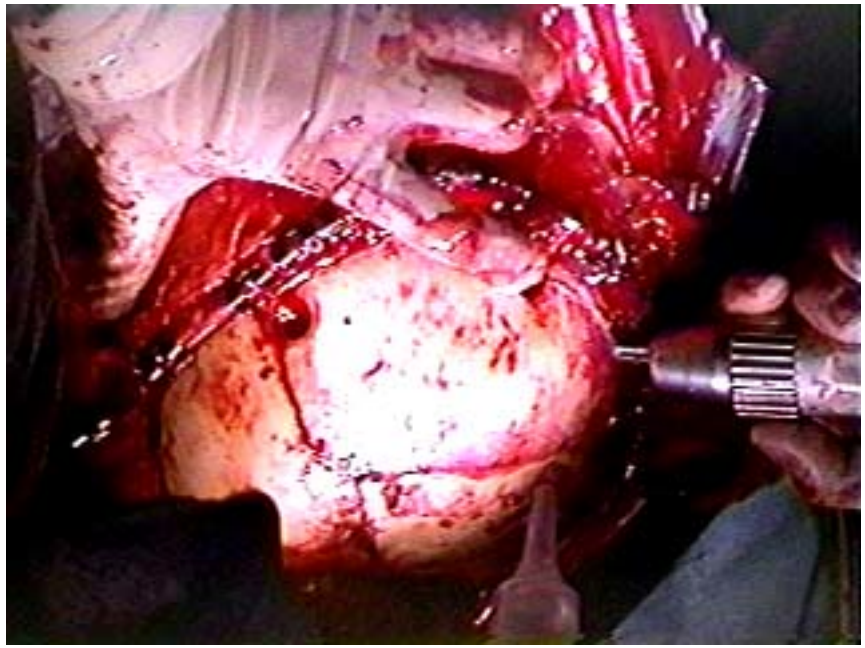
Craniotomy

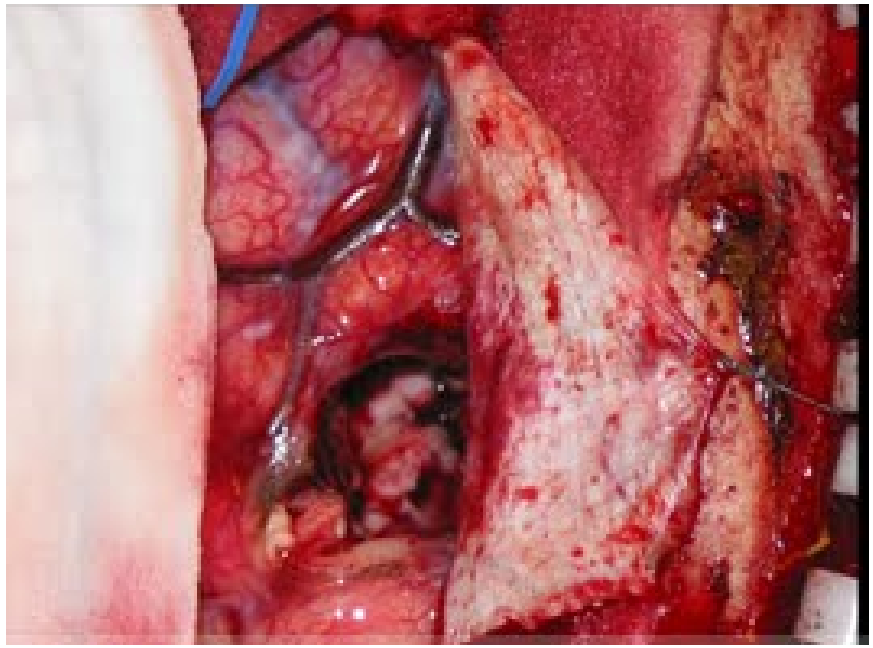


External ventricular derivation



Ventricular shunts





INFECTION AFTER CRANIOTOMY

Postoperative central nervous system infections

- Meningitis, epidural abscess, subdural empyema, brain abscess
- Incidence: <1% (recent series) to >8% (10% without prophylaxis)
- Cranial > spinal >> peripheral nerve (0%) procedures
- Risk factors:
  - Implantation of foreign body (associated with one-half of the infection)
  - CSF leakage
  - Previous neurosurgical infection
  - Absence of antibiotic prophylaxis
  - Duration of surgery over 4 h
  - Interventions involving nasal sinuses
  - Emergency surgeries
  - Prior radiation therapy

McClelland CID 2007; 45, 55-59

Postoperative meningitis

- Rare but life-threatening complication of intracranial surgery
- Diagnosis is difficult
  - The clinical manifestations are often mild and non specific during the early postoperative period
  - CSF protein and cell composition are modified by the surgical procedure itself
  - Direct bacteriological examination results are often negative
- Rapid diagnosis and antimicrobial chemotherapy are crucial because the mortality rate may exceed 20%
- Differential diagnosis: aseptic meningitis

Postoperative aseptic meningitis

- Comprises 60-75% of all cases of postoperative meningitis
- Risk factors
  - Occurs more frequently in children and after surgery involving the posterior fossa
  - But can occur after any procedure associated with a breach in the blood-brain barrier
- Pathogenesis: results of a local inflammatory reaction to blood breakdown products or to tumor antigens
- Clinical manifestations and CSF findings: very similar to those associated with postoperative bacterial meningitis
  - mean CSF PMN count higher in bacterial meningitis than aseptic meningitis but overlap
- Distinction: based on the results of CSF cultures (provided the samples are taken before antibiotic therapy is started).
- Clinical outcome:
  - generally favorable, despite a lengthy period of convalescence.
  - Steroid therapy is advocated by some authors

Zarrouk CID 2007; 44, 1555-9

Comparison of bacterial and aseptic meningitis

Table 1. Initial presentation of patients with postoperative meningitis.

Clinical feature	All patients (n = 75)	Patients with bacterial meningitis (n = 21)	Patients with aseptic meningitis (n = 54)	P[a]
Age, mean years ± SD	48 ± 16	47 ± 17	49 ± 15	.7
Sex				.4
Male	45	11	34	
Female	30	10	20	
Type of disease				.08
Vestibular schwannoma	55 (73)	12 (57)	43 (80)	
Supratentorial tumor	9	4	5	
Spine disease	5	3	2	
Arnold-Chiari	3	1	2	
Other	3	1	2	
Surgical approach				.81
Transpetrosal	52 (69)	12 (57)	40 (80)	
Craniotomy	15	5	10	
Other	5	1	4	
Previous neurosurgical procedure	13 (17)	7 (33)	6 (11)	.024
Duration of surgery, mean h (range)	4.1 (1–11)	3.3 (1–6)	4.2 (1–11)	.015
CSF leakage	41 (55)	13 (62)	28 (52)	.68
Time between surgery and meningitis, mean days (range)	10 (1–120)	12 (2–120)	9 (1–25)	.53
Symptom				
Headache	64 (85)	19 (90)	45 (83)	.12
Vomiting	33 (44)	8 (38)	25 (46)	.73
Meningeal stiffness	23 (31)	5 (24)	18 (33)	.26
Fever				
Temperature, >38°C	50 (67)	16 (76)	34 (63)	.28
Temperature, >39°C	21 (28)	6 (29)	15 (28)	.59
Focal neurologic defect	2	2	0	.15

NOTE. Data are no. or no. (%) of patients, unless otherwise indicated.

[a] Comparison between bacterial and aseptic meningitis.

- No significant differences with regard to
  - Comorbidities
  - Surgical indications
  - Surgical approach
- Differences
  - Previous neurosurgical procedure more frequent in case of bacterial meningitis
  - The mean operating time was longer in the aseptic meningitis group

Zarrouk CID 2007; 44, 1555-9

Comparison of bacterial and aseptic meningitis

Table 2. Biological findings in CSF samples from patients with bacterial or aseptic postoperative meningitis.

Biological variable	Patients with bacterial meningitis (n = 21)	Patients with aseptic meningitis (n = 54)
Leukocyte count, mean leukocytes/mm^3 (range)	1560 (200–4500)	1511 (180–4200)
Erythrocyte count, mean erythrocytes/mm^3 (range)	2430 (20–8500)	2100 (15–6050)
Glycorrachia, mean mmol/L (range)	1.1 (0–3.8)	1.8 (0–7.3)
Proteinorrachia, mean g/L (range)	4.7 (1.6–1.7)	3.2 (1.2–12.5)

CSF did not differ between the 2 groups

- The degree of pleiocytosis was similar
- CSF glucose < 50% of blood glucose concentration in >75% of patients (The glucose value was 0 in similar proportions of the patients in the 2 groups)
- CSF protein level was not different

Microbiology

Table 3. Bacterial isolates in 21 cases of postoperative bacterial meningitis.

Bacterial isolate species	No. (%) of isolates (n = 21)
Staphylococci	8 (38)
Staphylococcus aureus	5
Coagulase-negative staphylococci	3
Bacterial isolates from endogeneous upper respiratory origin	6 (29)
Haemophilus influenzae	2
Streptococcus penumoniae	2
Other *Streptococcus* species	2
Gram-negative bacilli	7 (33)
Escherichia coli	2
Serratia marcescens	1
Klebsiella pneumoniae	1
Enterobacter cloacae	1
Morganella morganii	1
Unindentified[a]	1

[a] Positive direct examination results and negative culture results.

Treatment of postoperative meningitis

In 2000, consensus conference organized by the british Society of Antimicrobial therapy:

- Empirical antibiotic therapy for all patients with signs of postoperative meningitis
- Vancomycin + ceftazidim or meropenem
- Treatment withdrawal after 48 or 72 hours if CSF cultures are negative

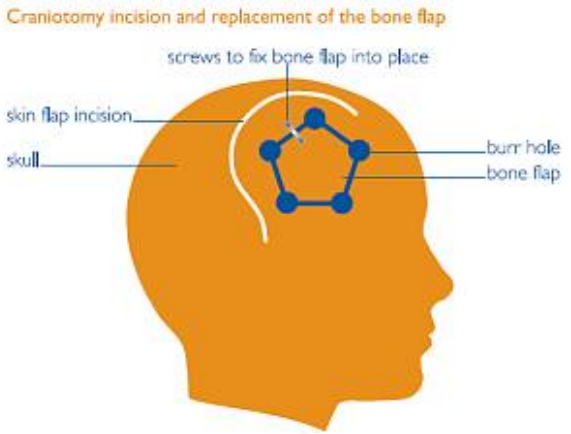
Intracranial infection following craniotomy

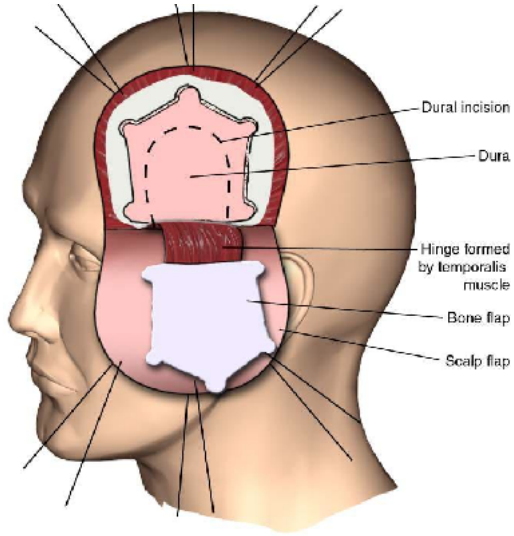
- Once diagnosed, postoperative meningitis can often be treated with a course of IV antibiotics.
- In contrast, cases that involve a bone flap infection, subdural empyema or cerebral abscess usually require a repeated operation
- Goal of surgery:
  - To removed and discard infected bone flaps
  - To evacuate pus and infected debris as much as possible
- Sometimes multiple operations are required for reaccumulation of subdural or intraprenchymal pus

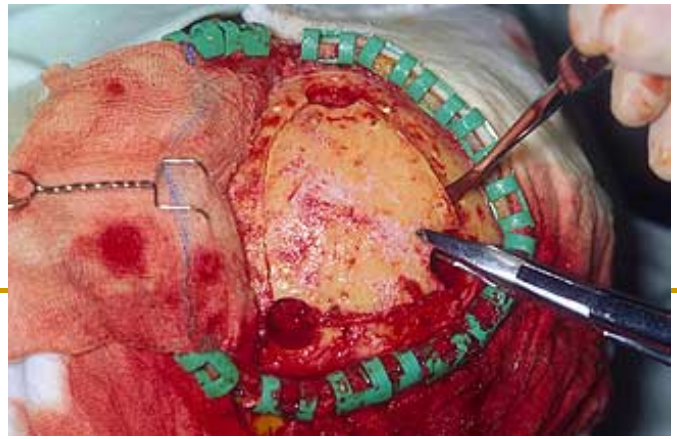
Bone flap removal

- Free craniotomy flaps are devascularized bones with a reduced resistance to infection (comparable to a foreign body)

- The standard management of bone flap osteitis includes
  - wound debridement,
  - bone removal and discarding and
  - delayed cranioplasty with acrylic material or other once the infection is cleared







Infection post craniotomy

After reintervention

28/07/2011 Resection of frontal meningioma

Chronic wound infection with purulent discharge. Afebrile

07/10/2011 Tumefaction of left hemiface

07/10/2011 Resection of bone flap and drainage of the cerebral abscess and the empyema

Microbiology: *P. acnes* and *Streptococcus mitis*

Review of 16540 cranial surgeries from January 1997 to December 2007

- 82 (0.5%) were performed to treat a postoperative infection in a total of 50 patients.
- The median duration between craniotomy and presentation of postoperative infection: **1.5 months** (range 4 days–5 years).

Type of Infection	No. of Patients (%)
wound infection	26 (52)
subdural empyema	7 (14)
epidural empyema	27 (54)
cerebral abscess	8 (16)
posterior fossa abscess	2 (4)
bone flap infection	22 (44)

Most patients had > 1 type of post-operative infection

Dashti Neurosurg. Focus. 2008, 24

Signs and symptoms

- Change in mental status: the most common presenting symptom
- Many patients had >1 symptom at presentation
- Although wound infections alone were not included in this series, 26 of the 50 patients presented with gross evidence of wound infection

Wound dehiscence
with purulent material

TABLE 1

Presenting symptoms in 50 patients with intracranial infections

Symptoms	No. of Patients (%)
fever	11 (22)
purulent drainage	17 (34)
mental status change	18 (36)
headache	10 (20)
swelling	7 (14)
seizure	2 (4)

Dashti Neurosurgery Focus 2008

Microbiology

Types of organisms causing infection

Organism	No. of Patients (%)
Staphylococcus spp.	
methicillin-resistant	2 (4)
methicillin-sensitive	10 (20)
coagulase-negative	6 (12)
gram-negative	
Enterobacter	3 (6)
Pseudomonas	4 (8)
Serratia	2 (4)
other	6 (12)
Streptococcus spp.	2 (4)
Propionibacterium spp.	2 (4)
multiple organisms	5 (10)
Candida spp.	2 (4)
culture-negative	6 (12)
total	50 (100)

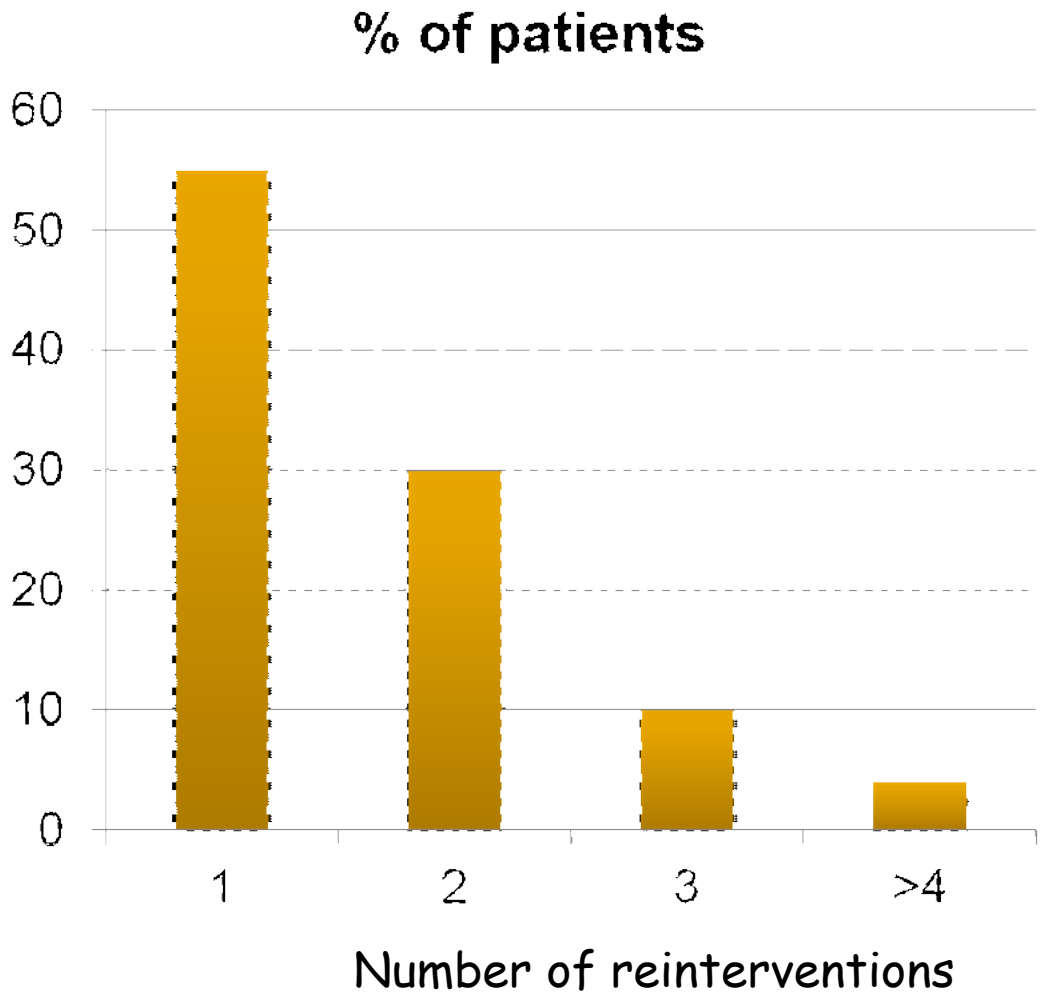
36% → up to 50% in other series

30%

Dashti Neurosurg Focus 2008; 24

Surgical treatment

- Only 22 of 50 patients had bone flap removal at the time of surgery for infection.
- The most common reason was the assessment at time of surgery that the bone flap was not grossly infected



Superficial and deep wound infections

- The distinction between superficial cranial wound infection and deep wound infection seems only theoretical since the subgaleal and epidural compartments are in contiguity when a craniotomy is performed.
- Any craniotomy infection can be considered a bone flap osteitis as far as the treatment is concerned.
- Also, some degree of bone resorption can be ascertained in the x-ray films or CT scans in many cases, depending on the latency until the infection is diagnosed.

Bone flap removal

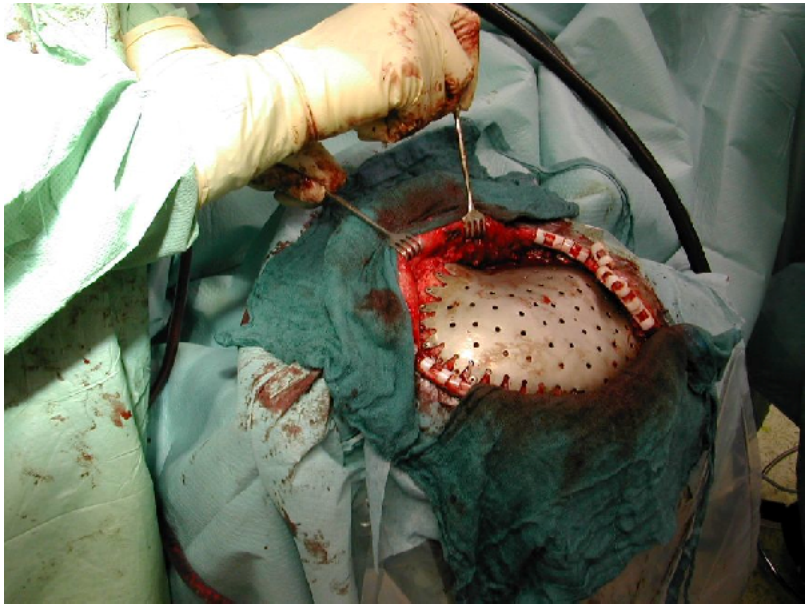
Time interval (weeks or months) in which

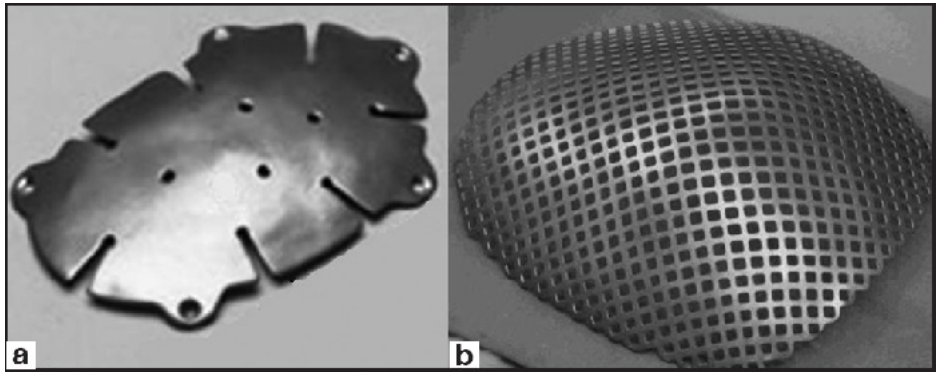
- the underlying brain is exposed to injury and
- the patient exhibits a somehow disfiguring deformity.

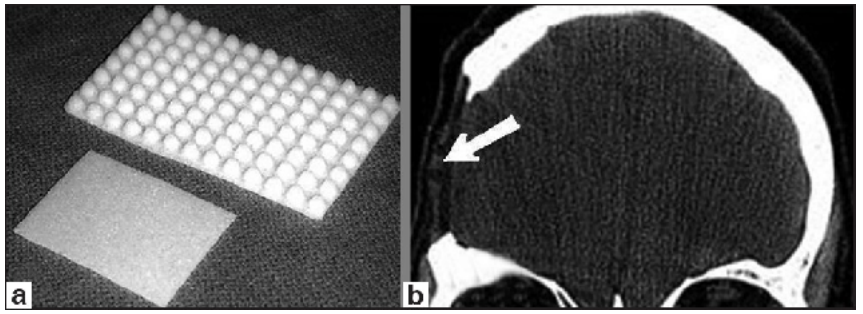
Cranioplasty

Several simple-to-use cranioplasty materials have been developed (acrylic material or other substitute),

BUT excellent cosmetic results are not always easy to achieve.



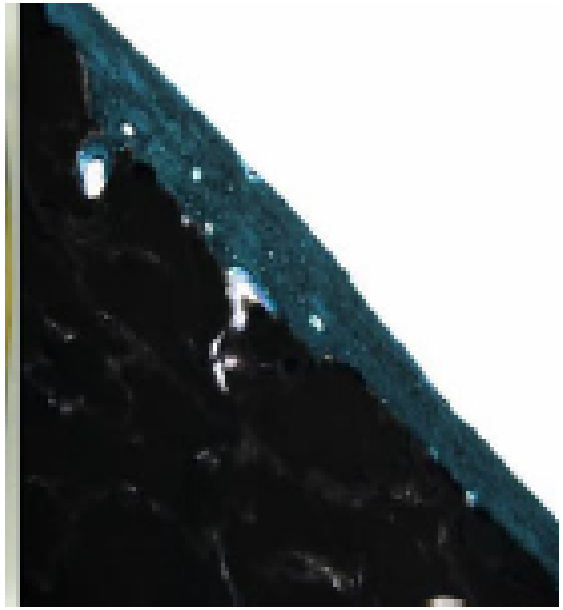




Skull bone integration in a hydroxyapatite prosthesis

Osteoinductivity: promotion of osteoblastic migration across the prosthesis

Implanted hydroxyapatite prosthesis surrounded by bone after surgical removal



Frontal section of the prosthesis: bone growth at the interface

Infected bone flap preservation

- Several reports of successful preservation of infected flap

- Simple debridement,
- Suction-irrigation systems or wash-in, wash-out indwelling antibiotic irrigation methods

TABLE 3: Published reports on preservation of contaminated avascular bone flaps

Authors & Year	No. of Attempts at Flap Preservation	No. of Successes (%)
Erickson et al., 1974	8	6 (75)
Chou & Erickson, 1976	25	15 (60)
Blomstedt, 1985	5	2 (40)
Bruce & Bruce, 2003	13	11 (85)
Josan et al., 2005	3	2 (67)
Auguste & McDermott, 2006	12	11 (92)
Dashti et al., 2008	28	unknown
current study	14	14 (100)

Widdel J Neurosurg Pediatrics 2009; 4, 378-382

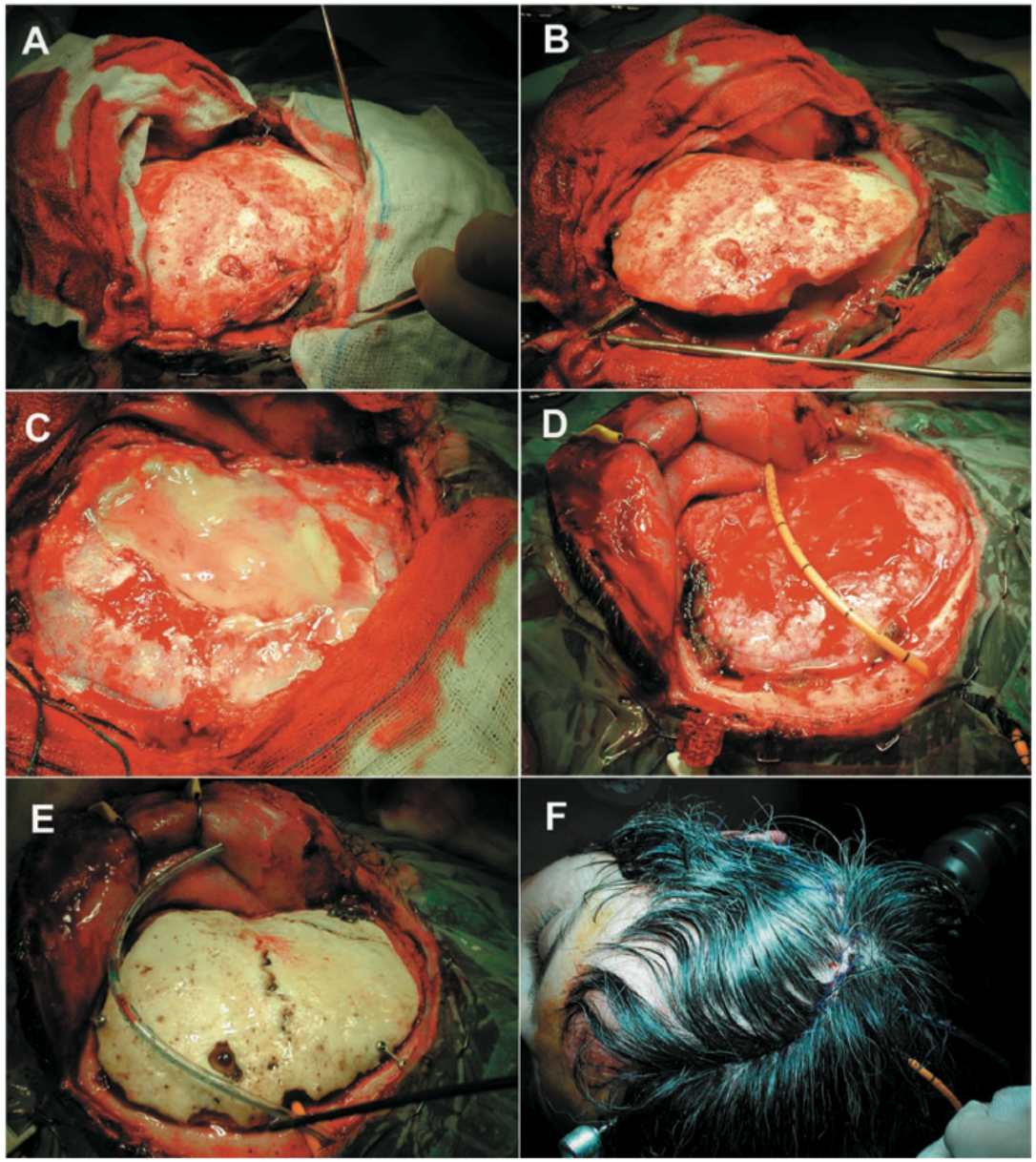


Figure 2. *A: the wound is reopened (images correspond to case number 1). B: when the bone flap is elevated, an abundant purulent collection is observed as it flows outward. C: yellowish pus is adherent to a Gore-Tex dural plastia implanted in the previous operation. D: after cleaning the purulent material, an antibiotic-impregnated external ventricular drain is inserted epidurally for antibiotic irrigation. E: the bone is sent for autoclave sterilizing (note the pale colour of the bone after the procedure) and the replaced with new skull fixation material. A second drain is inserted on the subgaleal space for antibiotic and debris evacuation. F: the scalp is closed with a single-layer suture. Drains are properly secured with non-absorbable suture.*

Widdel J Neurosurg Pediatrics 2009; 4, 378-382

Bone flap sterilization

- Various methods of bone flap sterilization are available.
  - Commonly, they may be autoclaved or soaked in sterilizing solutions.

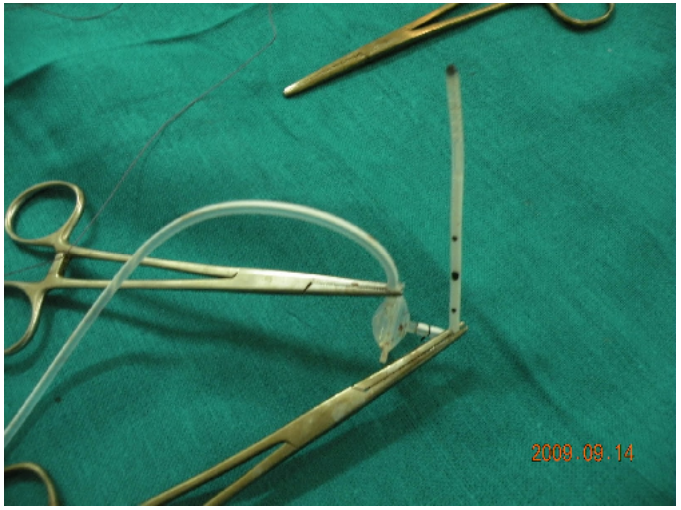
- Parameters for autoclave procedure or which type of solution (hydrogen peroxide, povidone-iodine, clorhexidine or others) is optimum are not well-defined features.

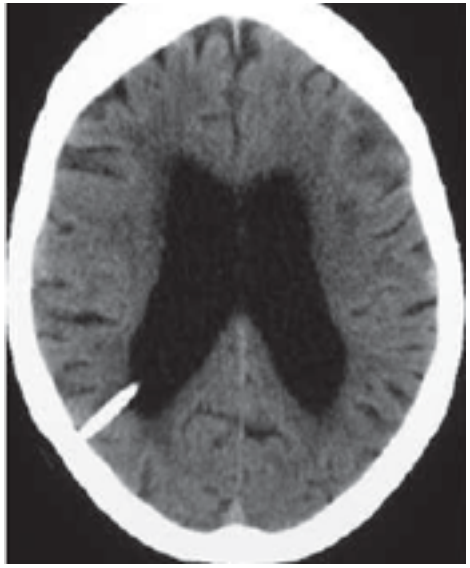
When the bone flap hits the floor

- Accidental dropping to the floor during craniotomy → infections can be avoided by autoclaving or soaking the flap in betadine and/or antibiotic solution

- Only a minority of patients needed discarding of the bone and cranioplasty.

Jankowitz. Neurosurgery 2006; 59: 585-590.





CEREBROSPINAL FLUID SHUNT ASSOCIATED INFECTIONS

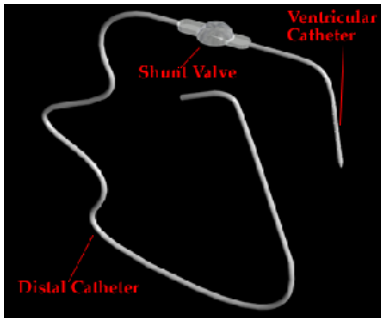
Cerebrospinal fluid shunt

- Major indications: ventricular hydrocephalus
- CSF shunt procedures:

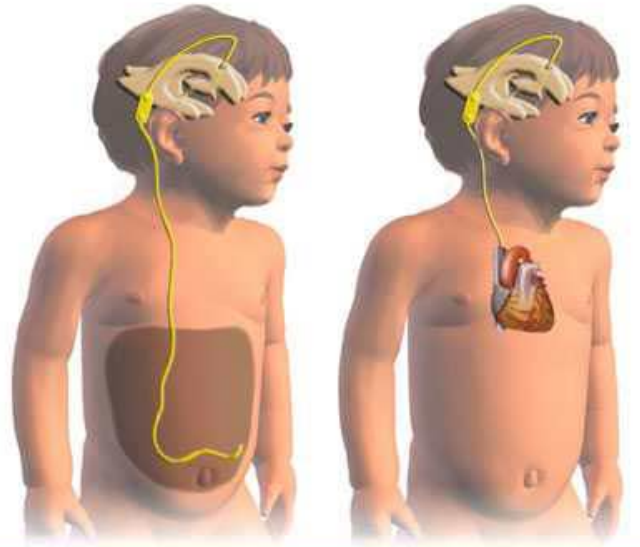
  = the most common surgical procedure performed by pediatric neurosurgeons (> 30.000 shunt procedures performed in USA annually)

- Most shunt devices consist of
  - A proximal catheter
  - A reservoir
  - A valve

    (to regulate pressure and flow)
  - A distal catheter



- Some patients require « complex shunts » with many proximal catheters draining separate spaces that have become loculated



Ventriculoperitoneal Ventriculoatrial

CSF Shunt-associated infection

- Incidence of infection: 4-15% (mean 10%)
- Sources of infection
  - The most likely source; bacterial contamination **at the time of surgery** (3/4 of the infections)
  - **Through the skin**: exposure of hardware and external ventricular drainage
    - ✓ nonhealing incision,
    - ✓ the patient scratches the open wound (infants and small children),
    - ✓ decubitus ulcer,
    - ✓ infections of tissues near the shunt
  - **Hematogenous seeding** (ventriculoatrial shunt)
  - **Retrograde infection** from the distal end of the shunt
    - ➢ Bowel perforation
    - ➢ Peritonitis,..

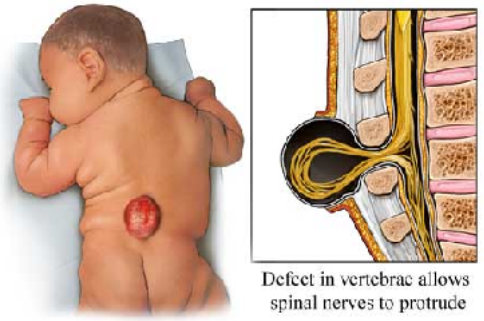
Sources of infections

- Peritonitis, appendicitis, ruptured viscus and visceral shunt erosion
  - VP catheter can become infected due to contamination from an intraabdominal process
  - These organisms can be more deleterious to the developing brain than are most resident skin flora

  → prudent to remove the shunt from the abdominal cavity promptly to decrease the chance of ascending infection

- Open neural tube defect (myelomeningocele)

  → special risk of shunt infection due to potential contamination of the CSF with skin or bowel organisms through the spine defect.



Defect in vertebrae allows spinal nerves to protrude

Risk factors

- Several independent risk factors:
  - Previous shunt-associated infection
  - Shunt revision for dysfunction
  - Post-operative CSF leakage
  - Advanced age; premauture birth and younger age
  - Duration of the shunt placement operation
  - Experience of the neurosurgeon
  - Use of a neuroendoscope

- In adults: in one-third of patients, a shunt revision needed for non infectious reason preceded the infectious episode

Shunt infection: signs and symptoms

Quite variable:
depend on
•the pathogenesis of infection,
•organism virulence and
•type of shunt

In children

- Fever: the most common sign (14-92%).
  - Low grade or intermittent
  - Often the child does not appear acutely ill
  - Exception in case of more aggressive organisms (GNB)
- Shunt malfunction (65%): headache, nausea, lethargia, change in mental status
- Local signs: erythema, warmth, or tenderness over the shunt
- Proximal portion of the shunt: meningitis or ventriculitis
- Distal portion:
  - Abdominal pain or tenderness in case of frank peritonitis or CSF pseudocysts
  - Malabsorption and even frank ascites (distal catheter infection)
- Glomerulonephritis (rare) in case of ventriculoatrial shunts

In adults

Table 2. Clinical characteristics of patients with episodes of CSF shunt–associated infection.

Variable	Episodes (n = 78)
Temperature >38°C	61 (78)
Neurological signs and symptoms	
Headache	16 (21)
Nausea	11 (14)
Neck stiffness	35 (45)
Decrease in GCS from baseline, points	
Any decrease	24 (31)
1	8
2	4
3	2
4	5
≥5	5
No neurological signs or symptoms	28 (36)
Local signs and symptoms	
Erythema	23 (29)
Local pain	15 (19)
Swelling	10 (13)
Purulent wound discharge	10 (13)
No local signs or symptoms	40 (51)
No fever or neurological or local signs or symptoms	2 (3)

- Usually non specific clinical signs and symptoms
  - Typical neurological manifestations are present in less than one-half of the episodes
  - In case of low virulence microorganisms (CNS): no fever and no neurological abnormalities
  - Often, only signs of intracranial hypertension attributable to shunt malfunction are present (headache, nausea, vomiting)

Conen CID 2008, 47, 73-82

Delay of infection

Table 2. Clinical characteristics of patients with episodes of CSF shunt–associated infection.

Variable	Episodes (n = 78)
Duration of symptoms before diagnosis of infection, median days (range)	5 (0–21)
Time between implantation or last surgery and manifestation of infection	
<1 month	48 (62)
1–12 months	22 (28)
>12 months	8 (10)

NOTE. Data are no. (%) of episodes, unless otherwise indicated. The percentages were rounded and may not sum 100%. GCS, Glasgow Coma Scale.

Mean: 17 days

- Delay
  - The probability of infection is highest in the **first 8 weeks** after surgery
  - 90% of infections becoming apparent in the first 6 months.

Conen CID 2008, 47, 73-82

Propionibacterium acnes Osteomyelitis Occurring 23 Years After Craniotomy: Case Report and Review of Literature

Michael R. Levitt, MD*
Patrik Gabikian, MD§
Paul S. Pottinger, MD‡
Daniel L. Silbergeld, MD*

*Department of Neurological Surgery and ‡Division of Allergy and Infectious Diseases, University of Washington School of Medicine, Seattle, Washington; §Division of Neurological Surgery, University of Chicago School of Medicine, Chicago, Illinois

Correspondence:
Michael R. Levitt, MD,
Department of Neurological Surgery,
Box 359924,
University of Washington Medical Center,
1959 NE Pacific Street,

BACKGROUND AND IMPORTANCE: *Propionibacterium acnes* is an uncommon pathogen in delayed surgical site infection, and its indolent course can complicate diagnosis and treatment. We report the longest delay between neurosurgery and *P acnes* infection reported.

CLINICAL PRESENTATION: Asymptomatic postoperative *P acnes* osteomyelitis and tumor recurrence occurring 23 years after initial craniotomy. Initial presentation was of tumor recurrence only, without signs or symptoms of infection. Calvarial osteomyelitis was unexpectedly discovered intraoperatively. Craniectomy and débridement were performed, and there was prolonged antibiotic therapy.

CONCLUSION: The longest delay between neurosurgery and asymptomatic *P acnes* infection is reported. We review the literature for *P acnes* infection and discuss biofilm formation and its role in delayed surgical infection.

KEY WORDS: Biofilms, Central nervous system infection, Osteomyelitis, *Propionibacterium*

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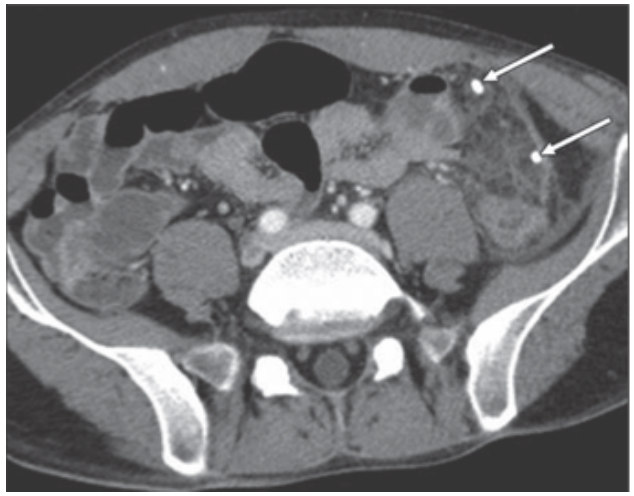
Neurosurgery 2011

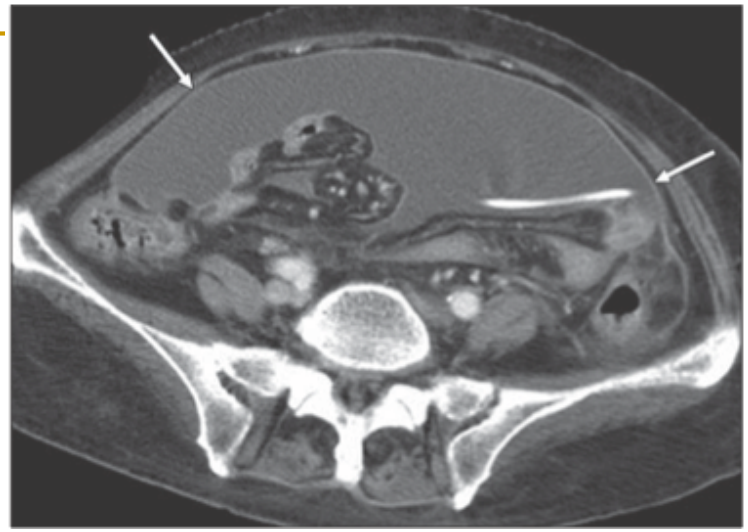
Radiological characteristics

- Cranial CT: positive in 12%
  - Meningeal enhancement
  - Brain abscess

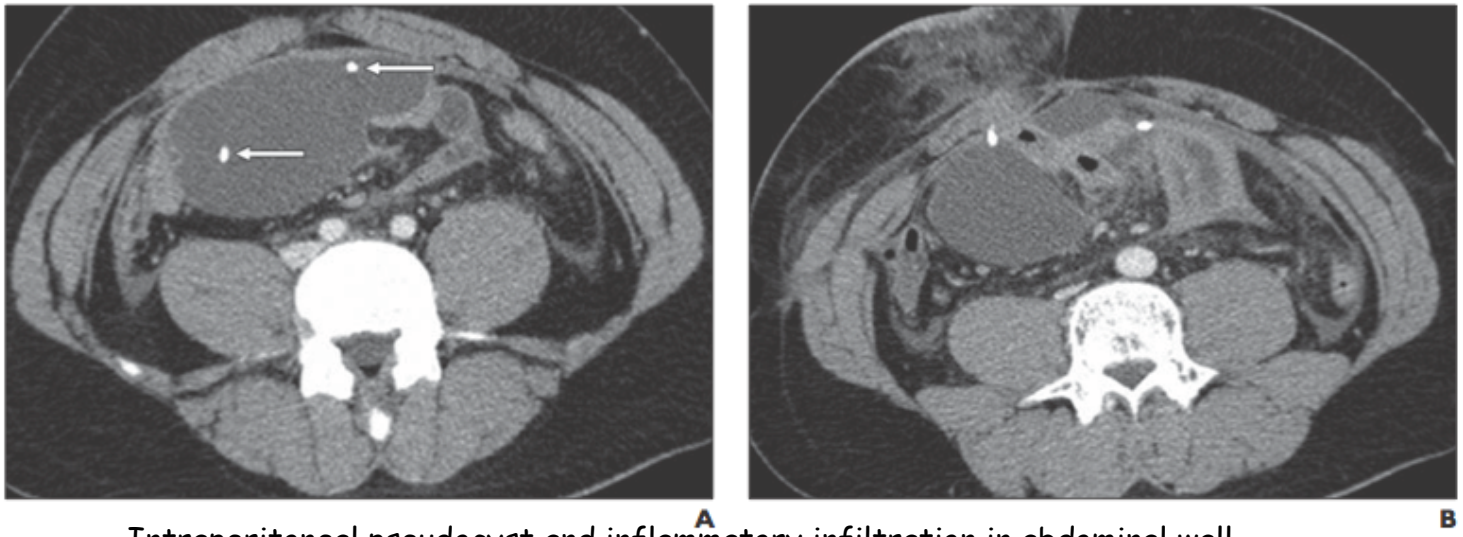
- Abdominal CT:
  - Detection of infection associated with the abdominal part of the shunt: positive in 77% (> echography 50%)
    - Inflammation of fat or muscle tissue around the shunt
    - Thickened gut wall
    - Intraabdominal abscess
    - Intraintestinal shunt dislocation
    - Peritoneal cyst



localized dirty infiltration in omentomesentery
of abdominal left lower quadrant with
adjacent peritoneal thickening and minimal fluid collection



large amount of ascites with thickened and
enhanced peritoneum



Intraperitoneal pseudocyst and inflammatory infiltration in abdominal wall

Laboratory characteristics (CSF)

Variable	Finding
Leukocyte count	
>5 × 10^6 cells/L, no. (%) of episodes	48/60 (80)
Median value, ×10^6 cells/L (range)	61 (0.3–5010)
Granulocyte count	
≥1 × 10^6 cells/L, no. (%) of episodes	46/60 (77)
Median value, ×10^6 cells/L (range)	32 (0–3006)
Lactate level	
>1.9 mmol/L, no. (%) of episodes	34/42 (81)
Median value, mmol/L (range)	4 (1–14)
Total protein level	
>0.45 g/L, no. (%) of episodes	36/62 (58)
Median value, g/L (range)	0.8 (0.1–36)
CSF-to-blood glucose ratio	
<0.5, no. (%) of episodes	16/31 (52)
Median value (range)	0.4 (0.1–1)

Leukocytes: normal in 20%

Microbiology

Because some organisms may take time to appear, CSF specimens obtained for the diagnosis of shunt infection should be held for 10 days.

Table 4. Microbiological findings for episodes of CSF shunt–associated infection.

Pathogen	Overall (n = 78)	Infection onset: Early[a] (n = 48)	Infection onset: Delayed[b] (n = 22)	Infection onset: Late[c] (n = 8)
Coagulase-negative staphylococci[d]	29 (37)	19	9	1
Staphylococcus aureus[d]	14 (18)	9	5	…
Propionibacterium acnes	7 (9)	5	2	…
Viridans group streptococci	3 (4)	2	1	…
Enterobacteriaceae[e]	3 (4)	3	…	…
Nonfermenters[f]	2 (3)	…	1	1
Enterococcus species	1 (1)	…	1	…
Polymicrobial[g]	12 (15)	4	2	6
Culture negative	7 (9)	6	1	…

2/3

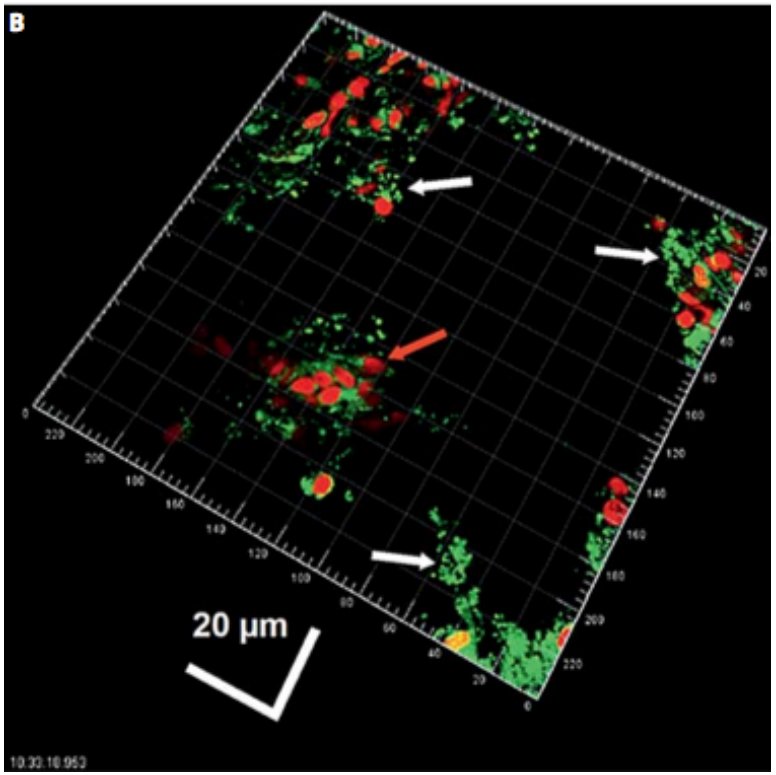
Polymicrobial: when the shunt tip perforated the gut or patients with head wounds overlying the shunt

False-negative culture

- Previous antibiotics
  - when shunt tape done after antibiotics have been given
  - when children are treated with chronic antibiotics (suppression of bladder infection)
- Contamination of a shunt below a one-way valve (in the setting of pseudocysts and other abdominal processes) →require exteriorizing and culturing the intra-abdominal portion of the shunt assembly directly.

Role of biofilms

- Organisms causing shunt-associated infections typically adhere to the device surface and form biofilms, which makes the clinical and laboratory diagnosis difficult and the treatment challenging



The material occluding the catheter consisted of biofilm cell clusters of live cocci (white ar- rows) interspersed with host cells (gray arrow, red arrow online: representative cell).

Treatment

- To date, only one prospective randomized trial has investigated the outcome of 3 different surgical treatment strategies among 30 children *(James Neurosurgery 1980; 7, 459-63)*
  - 1 stage shunt replacement — 65-75%
  - 2 stages shunt replacement with temporary external ventricular drainage — >85%
  - Without shunt removal — 30%

- A 2- (or 1-) stage shunt replacement with concomitant administration of intravenous antibiotics is the current recommended treatment strategy

(The ventriculitis of shunt infections appears to clear more quickly with external drainage)

- The timing for reimplantation is dependent upon
  - The isolated organism
  - The extend of infection (as defined by cultures of samples obtained after externalization)
  - On CSF findings

Duration of antimicrobial therapy before reshunting

- The timing for reimplantation is dependent upon
  - The isolated organism
  - The extend of infection (as defined by cultures of samples obtained after externalization)
  - On CSF findings

- Delay after negative cultures
  - CNS or P. acnes
    - Normal CSF findings → 3 days
    - Anormal CSF findings → 10 days
  - Staph aureus: 10 days
  - GNB: (10-) 21 days

Antibiotics

- **Antimicrobial therapy** for CSF shunt infections: same principles as those for the treatment of acute bacterial meningitis.
- **The optimal duration** of antibiotic administration after the shunt has been replaced also is unknown, and practice is variable.
- **Intraventricular route:**
  - in patients who have shunt infections that are difficult to eradicate or
  - who cannot undergo the surgical components of therapy

Table 7. Recommended dosages of antimicrobial agents administered by the intraventricular route (A-III).

Antimicrobial agent	Daily intraventricular dose, mg
Vancomycin	5–20[a]
Gentamicin	1–8[b]
Tobramycin	5–20
Amikacin	5–50[c]
Polymyxin B	5[d]
Colistin	10 =125.000IU
Quinupristin/dalfopristin	2–5
Teicoplanin	5–40[e]

IDSA guidelines

Conservative treatment

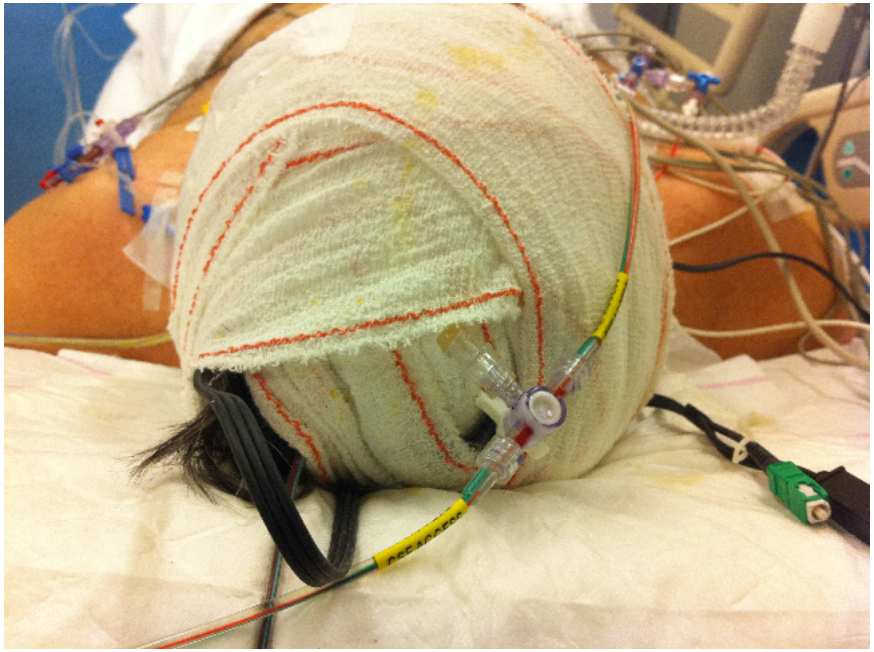
- For selected patients with CSF shunt infections caused by less virulent microorganisms such as coagulase-negative *staphylococci* or *P. acnes*
  - Conservative management may be appropriate
  - Systemic and intraventricular antimicrobial agents (instilled via a separate ventricular access device)
  - Success rate 93%

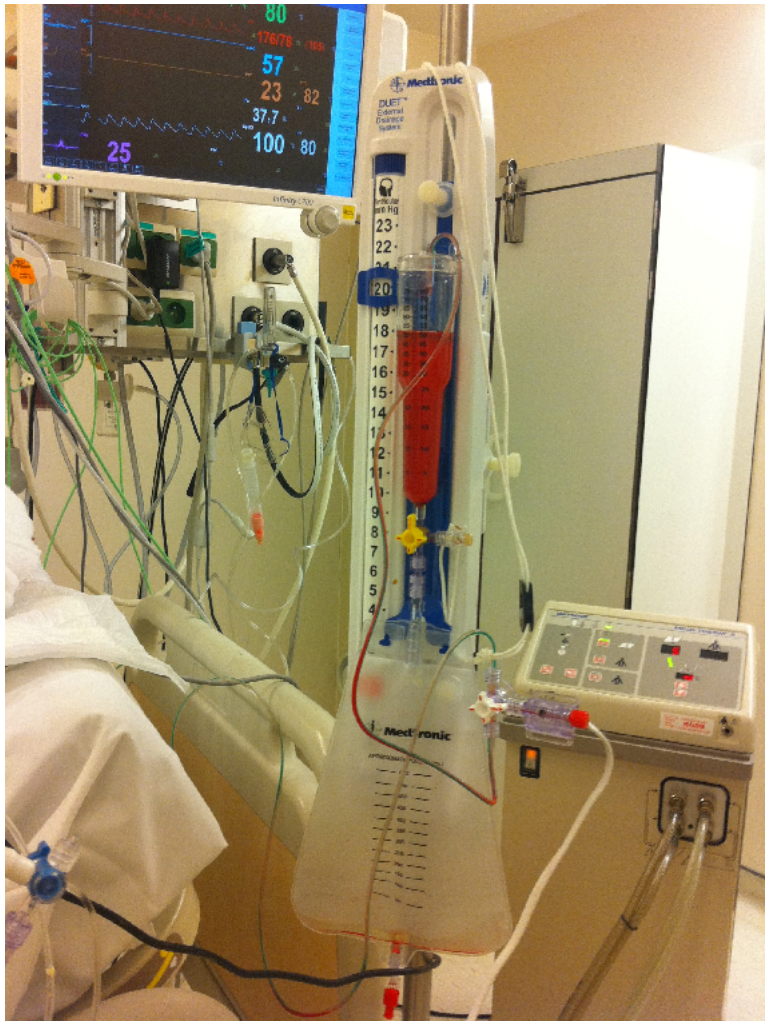
(Brown Neurosurgery 2006; 58, 657-65 and Thompson Childs Nerv Syst 1998; 14, 378-80)

- 15 infections treated conservatively (Conen CID 2008; 47, 73-82): 2/15 failure (rifampin-R)

Prevention

- Periprocedural antibiotic prophylaxis
  - No prospective randomized trials
  - Several meta-analysis: infection decreases by 50%
  - Recent Cochrane review: Odds ratio for decreased infection: 0.52 (95% confidential interval 0.36 to 0.74)
  - Duration: before incision and continued as long as 24 hours postoperatively (controversial)





External cerebrospinal fluid drainage

- External ventricular
- External lumbar drain

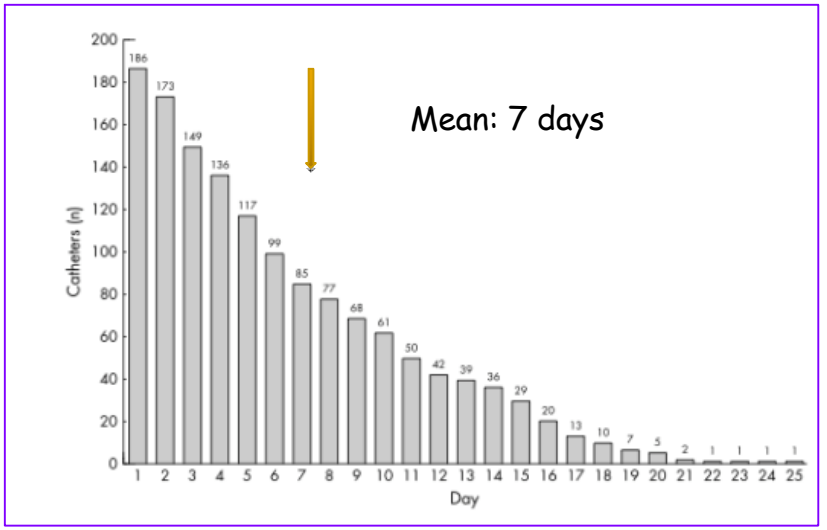
External ventricular drainage (and lumbar drains)

- Objectives:
  - External ventriculostomy for CSF drainage
  - Intracranial pressure monitoring

secondary to occlusive hydrocephalus primarily caused by

- subarachnoid and intraventricular hemorrhage
- traumatic brain injury

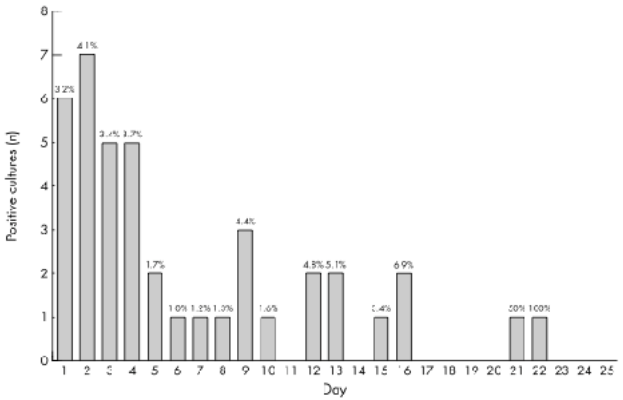
- Usually maintained for a mean duration of 7 days



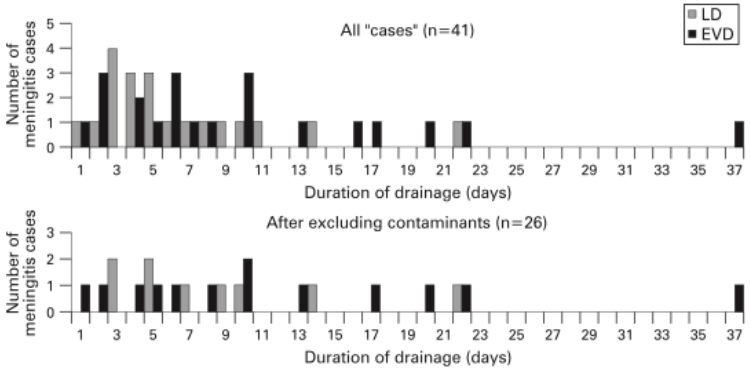
Total number of ventricular drain

Major complication: infection

- Incidence: 2 to 27% (mean 10%)
- Cumulative rate of positive CSF cultures:
  8.8% per patient or 8.1 per EVD
- Majority of infection occurs within the first **10 to 14** days after insertion
  < rarity of prolonged EVD duration



Pfisterer J Neurol Neurosurg Psychiatry 2003, 74, 929-932



Scheithauer J Neurol Neurosurg Psychiatry 2009; 80, 1381-1385

Possible Risk factors

- Duration of catheterization: debated
  - Significantly increased risk in patients with catheters in place for more than 5 days or longer with a peak at day 9 to 11
  - Marked decreased risk thereafter, despite a population that continued to be at risk
- Frequency of EVD manipulation (e.g., CSF sampling, irrigation)
- CSF leakage
- Intraventricular hemorrhage (culture medium for bacterial growth)
  - Insertion technique (non-adherence to rigid insertion and maintenance protocols)

Microbiology of EVD-related ventriculomeningitis

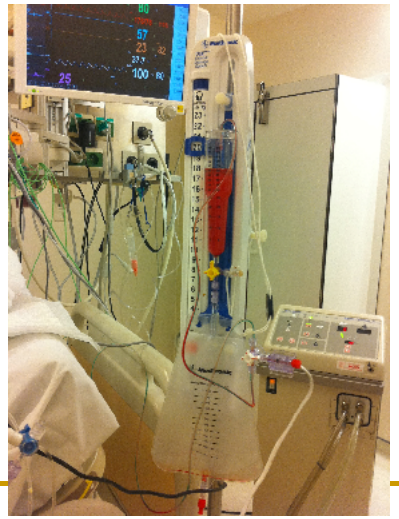
Staphylococcus epidermidis	70%
Staphylococcus aureus	10%
Gram negative rods (*Klebsiella, E. coli, Pseudomonas*,…)	15%
Anaerobes	rare
Candida spp	very rare

- Discrepancies in bacteriological profiles may be influenced by differences in antibiotic usage and local flora
- Important because inflammation of meninges and ventricular ependyma may be less pronounced when caused by Staphylococci

Diagnosis: infection versus contamination and catheter colonization

Spillage of blood into CSF provokes an invasion of leukocytes to clear the the intraventricular blood by phagocytosis

→ leading to aseptic inflammation



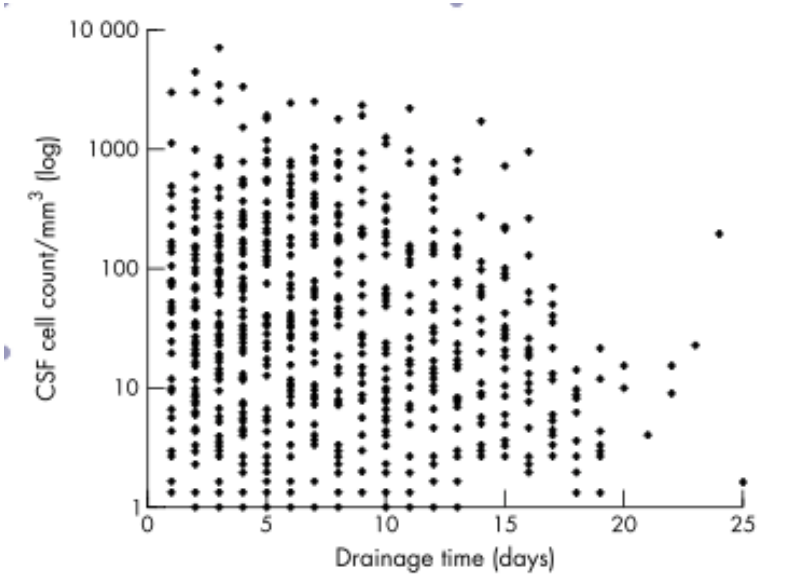


Figure 2 Distribution of CSF cell counts in relation to drainage day.

Clinical signs and laboratory parameters

- Clinical signs → may be a manisfestation of underlying disease
  - Fever → may be from other sources of infection
  - Meningism
  - Reduced level of consciousness
  - Photophobia, phonophobia

- Laboratory parameters < aseptic meningitis?
  - Reduced CSF glucose
  - Increased CSF protein
  - CSF pleiocytosis
  - Positive CSF culture or Gram's

No single parameter can relaibly predict or exclude EVD-related infection

Cell index

$$\text{Cell Index} = \frac{WBC_{CSF}\,[mm^3] \div RBC_{CSF}\,[mm^3]}{WBC_{blood}\,[mm^3] \div RBC_{blood}\,[mm^3]}$$

Fig. 1 Calculation of the cell index [31] in patients with hemorrhagic CSF

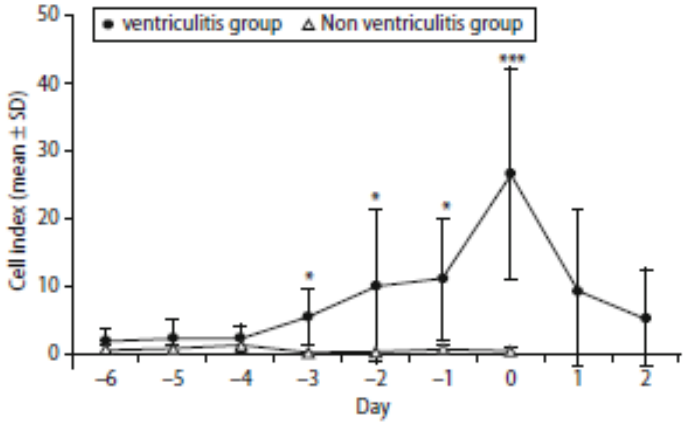


Fig. 2 Time course of mean cell index (± SD) of patients with EVD-related ventriculitis (filled circles) compared to patients without EVD-related ventriculitis (triangles). A statistically significant rise in the cell index preceded the diagnostic capacity by conventional means (i. e., positive CSF culture on day "0") on average by 3 days (adapted from [31] with permission)

- Based on hypothesis that intraventricular hemorrhage simply leads to dilution of CSF with blood.
- Because clearance of intraventricular blood by immigrating white blood cells is a physiologic process
  - → The level of the « cell index » is subjected to fluctuations
  - → Not possible to determine an absolute cut-off value for proven infection
  - → A significant increase of this index is highly indicative of infection

Pfausler Acta neurochir 2004; 146, 477-481

Contaminant versus true infection

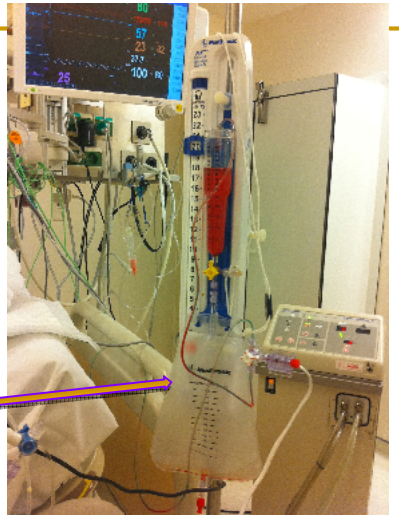
- Whether the detection of CoNS or other skin commensals in one single specimen is sufficient to diagnose drain associated meningitis is questionable

- In a recent study (Scheithauer), none of the patients in whom CoNS was detected only once showed clinical signs of meningitis

→ The number of CSF samples with isolation of CoNS is an additional criterion in discriminating true meningitis infection from contaminations

At Erasme hospital

- Daily CSF sampling, collected from the distal port (collected from the drip chamber)



- If positive, CSF sample collected from proximal port
  - If (-) → contamination of the external part of the drainage system
  - If (+) → shunt infection

Therapy

- Empirical treatment:
  - vancomycin + 3th generation cephalosporin

    or

    meropenem

- Direct instillation of antimicrobial agents
  - Amikacin 30 (-50)mg
  - Vancomycin 20 mg

- Rifampin in case of staphylococci
- Candida: voriconazole > lipid formulations of amphoB (not caspofungin)

Catheter

- The decision as to whether the catheter should be removed or retained largely depends on the causing organism
  - Coagulase negative staphylococci: ?
  - Staphylococcus aureus and GNB: removal strongly recommended
  - Candida: removal

- In our pratice: always removal of catheter if infection

Duration of antimicrobial therapy

- Not rigorously studied
- 10 to 14 days
- 5 to 7 if repeated cultures are negative

Prevention

- Routine prophylactic exchange of EVD
  - Elective revision itself might be causatively associated with an increased infection rate in the individual patient
  - Based on literature: little evidence to support the practice of prophylactic catheter exchange on an predefined interval
  - No randomised studies with large number of patients

- Prolonged prophylactic systemic antibiotics: predisposes the patient to infections by more resistant pathogens with a higher mortality rate.
- Periprocedure antibiotics: retrospective studies: no advantages

- Antimicrobial-impregnated catheters: reduce the risk of infection (risk of resistance)
- Catheters impregnated with silver: significant reduction of infection rates (Lackner 2008)

Conclusions