Clinical Pathways

Suspected Shunt Infection

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MAGNET RECOGNIZED AMERICAN NURSES CREDENTIALING CENTER

BEST CHILDREN'S HOSPITAL WOMEN'S CHOICE AWARD 2023

What is a Clinical Pathway?

An evidence-based guideline that decreases unnecessary variation and helps promote safe, effective, and consistent patient care.

Objectives of Pathway

- Early recognition and appropriate care for suspected shunt infection patients
- Decrease unnecessary antibiotic usage
- Ensure appropriate lab tests are ordered for suspected shunt infection
- Ensure appropriate antibiotic initiation in the emergency department
- Ensure timely surgical interventions
- Ensure appropriate adjustment of antibiotics post operatively in consultation with Infectious Disease physicians

Why is Pathway Necessary?

- The goal of this pathway is to standardize care, improve outcomes and reduce cost.
- Recognizes and initiates early intervention and care for patients improving outcomes

Background

Effectiveness of a clinical pathway for patients with cerebrospinal fluid shunt malfunction:

- Patients with CSF shunts often present to the emergency department (ED) with suspected shunt malfunction. Timely assessment and treatment are important factors affecting patient outcomes. A protocol was implemented at a tertiary children's hospital ED to expedite the care of these patients. This study evaluated the effectiveness of this protocol. Effectiveness of a clinical pathway for patients with cerebrospinal fluid shunt malfunction:.
- Clinically, more patients underwent surgery in the expedited pathway than the default pathway (36% vs 17%), and patients in the expedited pathway had a shorter hospital stay (3.4 ± 0.9 days vs 5.7 ± 4.0 days; p = 0.02).An ED-based protocol helped identify patients at risk for shunt failure early in the triage process and shortened the assessment process prior to neurosurgical intervention. Improving the timeliness of care for patients with shunt failure is important because morbidity and mortality associated with shunt failure are time dependent. Effectiveness of a clinical pathway for patients with cerebrospinal fluid shunt malfunction:

[1] Journal of Neurosurgery Pediatrics

This is the Suspected Shunt Infection Clinical Pathway.

We will be reviewing each component in the following slides.

CLINICAL PATHWAY:

Suspected Neurosurgical Shunt Infection

THIS PATHWAY SERVES AS A GUIDE AND DOES NOT REPLACE CLINICAL JUDGMENT.

Inclusion Criteria: Clinical suspicion of shunt infection by Emergency Department physician based on clinical judgment and/or presence of ≥1 risk factors for shunt infection[1]
Exclusion Criteria: alternative source for fever identified

Notify Neurosurgery attending at first suspicion of shunt infection

TRIAGE:

- Vital signs q1hr then q2hr when more stable: temperature, BP, HR, RR, O2 sat, neuro check
- Weight, head circumference (for <12 month old)
- Place on continuous CR monitoring

Notify Neurosurgery attending immediately if bradycardia, hypertension or depressed LOC is noted

Obtain detailed history/initial exam: See Appendix A.

INITIAL MANAGEMENT:

Labs:

- CBC w diff, CRP, iStat chem 7, procalcitonin, blood culture, UA, urine culture
- Shunt tap by NSG: send STAT CSF for cell count, glucose, protein, gram stain, aerobic culture and anaerobic culture

Imaging:

- Reduced shunt protocol MRI brain without contrast is preferred if imaging modality if confirmation patient has *non-programmable* shunt (if not documented in chart, may confirm via skull x-ray; Appendix B: Radiographic Appearance of Shunt Valves)
  - *If programmable shunt is present:* prior to ordering MRI, please ensure a Neurosurgery provider is able to reprogram the shunt within 24 hours of imaging. Make MRI aware that patient has a programmable shunt.
  - *If MRI not available:* CT head without contrast
- *If suspected abdominal pseudocyst or abdominal symptoms:* limited ultrasound of abdomen
- *If large or complex pseudocyst:* CT of the abdomen with contrast

Antibiotics and Fluids:

- Start both empiric antibiotics listed after obtaining blood culture, UA/urine culture, and CSF culture, if possible:
  - **Ceftazidime IV:** 150 mg/kg/day divided q8hr (max 2 g/dose) *AND*
  - **Vancomycin IV:** <52 weeks PMA[†]/about <3 mo old: 15 mg/kg q8hr or as determined by pharmacy based on estimated AUC; ≥52 weeks PMA[†]/about ≥3 months old – 11 years old: 70 mg/kg/day div q6hr; ≥12 yrs old: 60 mg/kg/day div q8hr
- NPO and start **IVF at maintenance** (with 0.45 or 0.9% NaCl depending on serum Na levels)

[†]*PMA (Post-Menstrual Age) = gestational age + postnatal age*

[1]**Risk Factors for Shunt Infection**

- Shunt surgery within previous 6 months
- Clinical signs of infection involving shunt hardware including skin erosion, cellulitis, incisional drainage or abdominal pseudocyst
- Clinical signs of meningitis
- No other obvious source of fever
- Previous shunt infection

Pre-Op: Admit to PICU on Neurosurgery service

- OR case request for externalization (Neurosurgery to obtain consent for OR)
- Continuous CR monitoring (close monitoring for bradycardia)
- Continue NPO and IVF

Post-Op: admit back to PICU

- EVD/externalized shunt parameters per surgeon; follow post-op care below

[2]**Consider Acute Kidney Injury (AKI) based on the following criteria:**

- Increase in serum creatinine by 1.5-1.9 times baseline within the prior seven days, or
- Increase in serum creatinine by ≥0.3 mg/dL from baseline (≥26.5 mcmol/L) within 48 hours, or
- For those with unknown creatinine, an eGFR <90 ml/min/1.73m^2

Antibiotics

- Consult Infectious Disease (ID)
- Continue empiric antibiotics (**Vancomycin** and **Ceftazidime**) x24 hours or per ID recs
- Adjust antibiotics based on culture and ID recs

If >5 day antibiotics expected, consider long term IV access.

Labs/Monitoring

Labs:

- CSF studies: cell count and culture to lab per Neurosurgery and/or ID
- If CSF culture positive, repeat in 24-36 hours to document sterilization.
- If persistently febrile or clinical deterioration: repeat CSF culture is warranted. Consider blood, urine and respiratory evaluation.

Monitoring:

- Continuous CR monitoring
- Vitals q1hr if unstable; q2hr in PICU if stable; q4hr on MS floors

Pain/Fever

If acute kidney injury[2]: Avoid NSAIDs or discuss with Nephrology for approval.

- **Toradol IV** 0.5 mg/kg/dose q6hr (max 30 mg/dose) x6 doses
  - 6 hours after last toradol dose, start **ibuprofen PO** 10 mg/kg/dose q6hr PRN (max 40 mg/kg/day or 2,400 mg/day, whichever is less)
- **Acetaminophen IV** 15 mg/kg/dose q6hr ATC for 24 hours (max 1,000 mg/dose)
  - After 24 hours of IV acetaminophen, switch to **PO acetaminophen:** 15 mg/kg/dose q6hr PRN pain; (max 75 mg/kg/day or 4,000 mg/day) for mild/moderate pain; *may use PR acetaminophen for infants.*
- **Morphine IV** 0.05 – 0.1 mg/kg/dose IV q3hr PRN severe pain (max 5 mg/dose)

FEN/GI

IVF:

- Maintenance IVF
- NS 1:1 replacement with CSF output

Medications:

- **Ondansetron** 0.1 mg/kg/dose q8hr (max 4 mg/dose) PRN nausea/ vomiting
- **Polyethylene glycol** 17 g daily or BID PRN constipation
- **Docusate sodium** 50 mg/day PRN constipation

Other

- OT/PT: activity to include OOB with EVD clamped for therapies if stable and tolerating clamping
- SCD/compression boots for DVT ppx per hospital policy
- Incentive spirometer or bubbles for atelectasis/PNA prevention

Internalization Criteria:

If CSF culture is positive, discuss timing of shunt replacement and duration of antibiotics with Neurosurgery and ID based on clinical status and response to therapy. Terminal sites dependent on clearance of end-organ space infections. If still present, will consider alternate site if possible.

Post-Op care:

Transfer to MS floors and resume all pre-internalization care and start:

- **Bacitracin** to scalp incision, **Tegaderm/Telfa** to abdominal/chest/clavicular/neck incision; may shower POD 3; no further CSF replacement or daily cultures needed unless persistently febrile >36 hours, clinically deteriorating

Discharge Criteria: stable neuro exam; pain well controlled on PO meds; afebrile x24 hrs; bowel movement; adequate PO

Discharge Instructions/Medications:

- **Ibuprofen PO** 10 mg/kg/dose q6hr PRN (max 40 mg/kg/day or 2,400 mg/day, whichever is less) for mild/moderate pain, **Acetaminophen PO**: 15 mg/kg/dose q6hr PRN pain (max 75 mg/kg/day or 4,000 mg/day) for mild/moderate pain; **Polyethylene glycol PO** and/or **Docusate** to prevent constipation
- **Follow Up:** 2-3 weeks post discharge
- **Call NSG if**: fever >101.5°F, vomiting >3 times in a 12 hours period, excessive irritability or sleepiness, severe headache

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CLINICAL PATHWAY:

Suspected Neurosurgical Shunt Infection

THIS PATHWAY SERVES AS A GUIDE AND DOES NOT REPLACE CLINICAL JUDGMENT.

Inclusion Criteria: Clinical suspicion of shunt infection by Emergency Department physician based on clinical judgment and/or presence of ≥1 risk factors for shunt infection[1]
Exclusion Criteria: alternative source for fever identified

Notify Neurosurgery attending at first suspicion of shunt infection

TRIAGE:

- Vital signs q1hr then q2hr when more stable: temperature, BP, HR, RR, O2 sat, neuro check
- Weight, head circumference (for <12 month old)
- Place on continuous CR monitoring

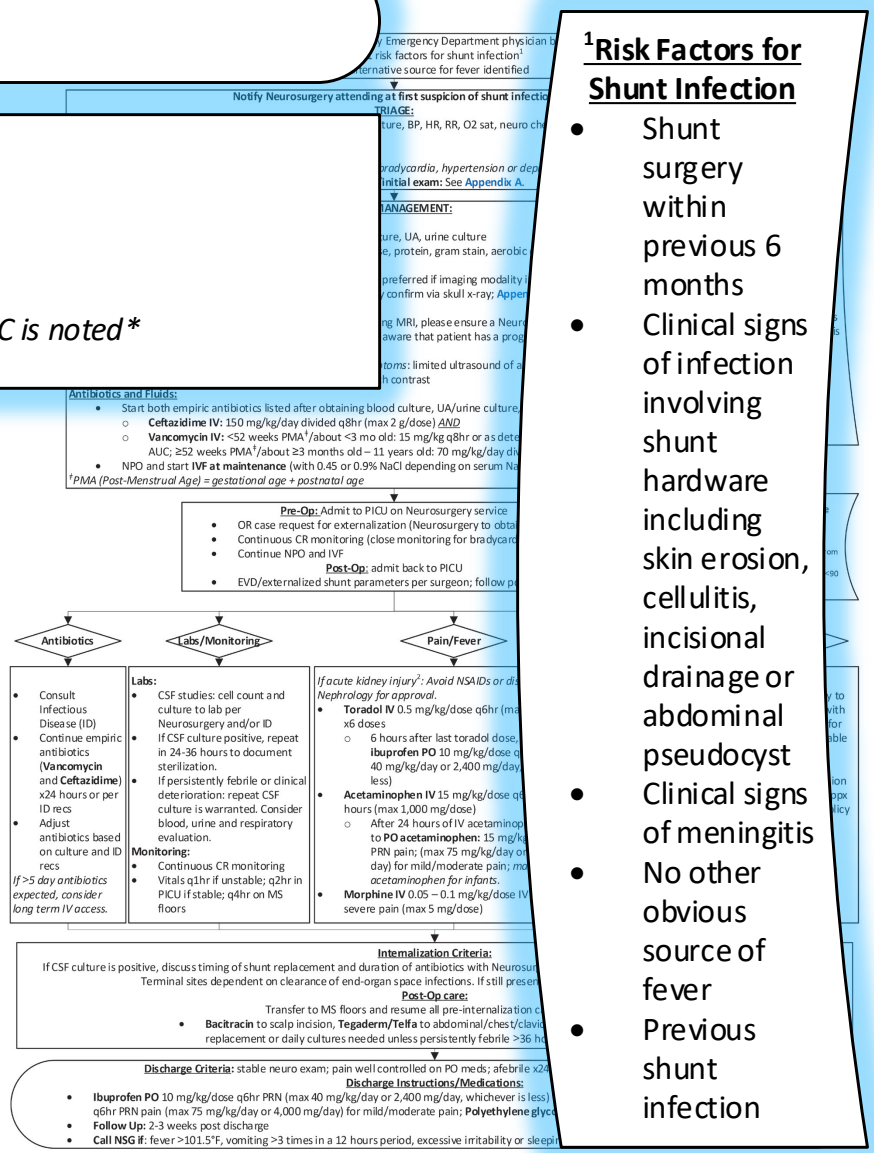
Notify Neurosurgery attending immediately if bradycardia, hypertension or depressed LOC is noted

Obtain detailed history/initial exam: See Appendix A.

Inclusion criteria:

- Clinical suspicion of shunt infection **and/or**
- At least 1 risk factor for shunt infection
  - See risk factors box
  - New for 2024: "previous shunt infection" has been added as a risk factor for current shunt infection

Neurosurgery attending should be notified as soon as a shunt infection is suspected.



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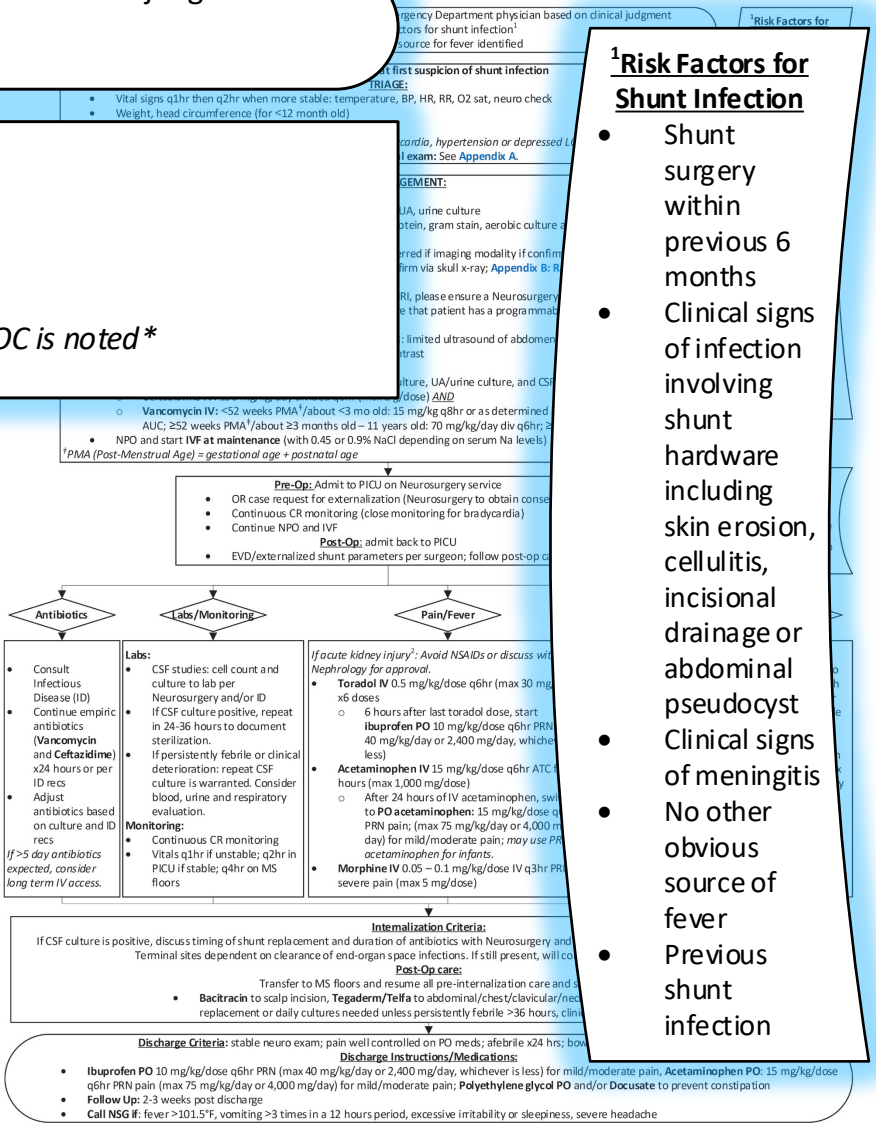
Notify Neurosurgery attending immediately if bradycardia, hypertension or depressed LOC is noted

Obtain detailed history/initial exam: See **Appendix A**.

Initial Triage:

- Vital signs and neuro score hourly
- Head circumference if less than 1 year
- Continuous cardio-respiratory monitoring

Neurosurgery attending should be notified immediately if any bradycardia, hypertension, or depressed Level of Consciousness is noted, as these could be signs of impending herniation.



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CLINICAL PATHWAY:
Suspected Neurosurgical Shunt Infection
Appendix A: Obtaining a Detailed History and Physical

THIS PATHWAY SERVES AS A GUIDE AND DOES NOT REPLACE CLINICAL JU

Important factors to consider include:

- **Shunt Type**:
  - ventricular-atrial shunt
  - ventricular-plural shunt
  - ventricular-peritoneal shunt
- **Headache History:**
  - location
  - quality
  - duration
  - treatment
- **Vomiting History**:
  - timing
  - any precipitating events
- **Neurological symptoms:**
  - change in LOC
  - ↑ irritability
  - weakness
  - seizures
  - up/downward gaze
  - ↑ lethargy
- **Abdominal symptoms:**
  - significant ↑ abdominal girth
  - pain
  - tenderness
  - mass
- **General:**
  - trauma
  - fontanels
  - head circumference
  - ↓ breath sounds for pleural shunts

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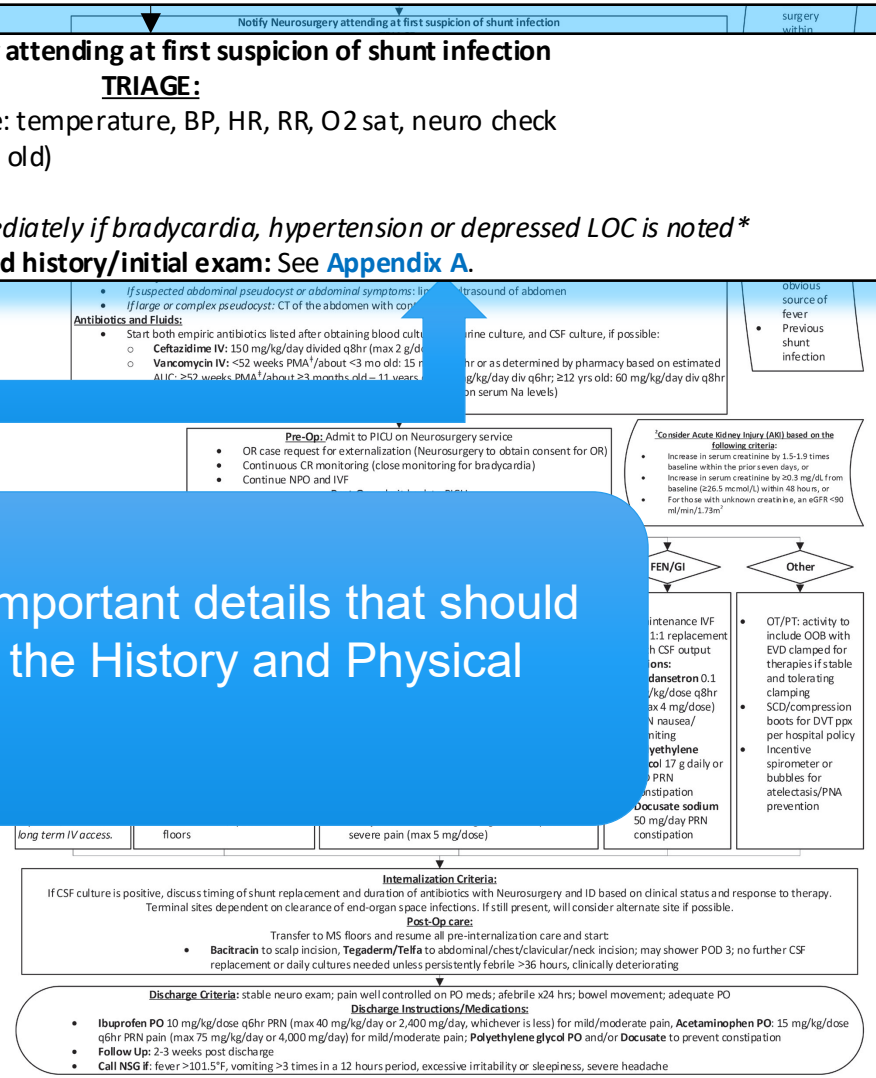

Appendix A includes important details that should be included as part of the History and Physical exam.

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Initial Management:

- Labs are directed to assess for infection and includes studies from CSF
- New for 2024:
  - Procalcitonin can assist in determining if a bacterial infection is present.
  - In addition to aerobic cultures, anaerobic cultures should be sent to ensure proper organism isolation if present.

INITIAL MANAGEMENT:

Labs:

- CBC w diff, CRP, iStat chem 7, procalcitonin, blood culture, UA, urine culture
- Shunt tap by NSG: send STAT CSF for cell count, glucose, protein, gram stain, aerobic culture and anaerobic culture

Imaging:

- Reduced shunt protocol MRI brain without contrast is preferred if imaging modality if confirmation patient has *non-programmable* shunt (if not documented in chart, may confirm via skull x-ray; **Appendix B: Radiographic Appearance of Shunt Valves**)
  - *If programmable shunt is present:* prior to ordering MRI, please ensure a Neurosurgery provider is able to reprogram the shunt within 24 hours of imaging. Make MRI aware that patient has a programmable shunt.
  - *If MRI not available*: CT head without contrast
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Antibiotics and Fluids:

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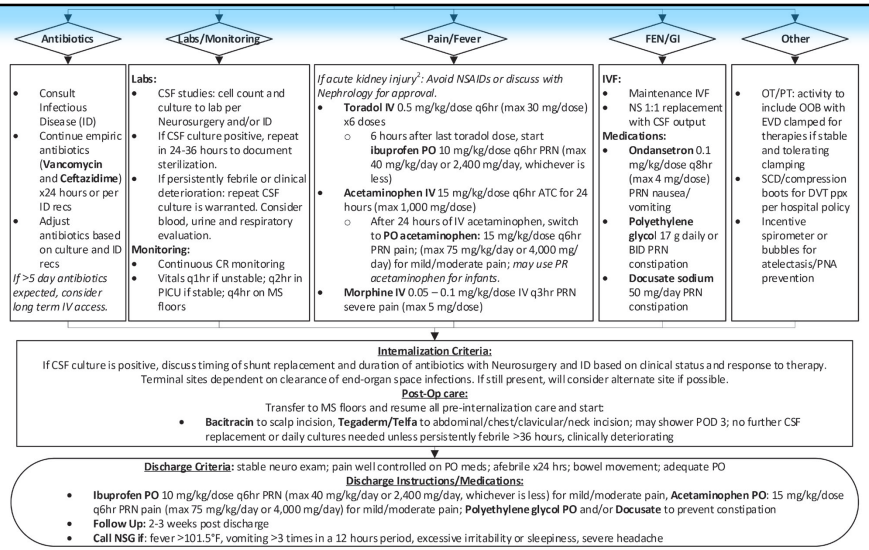

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Initial Management:

Imaging includes reduced shunt protocol MRI brain without contrast.

Before MRI, confirm that the patient has a non-programmable shunt.

If there is a programmable shunt present, check with the Neurosurgery team and ensure they are able to reprogram the shunt within 24 hours of imaging.

INITIAL MANAGEMENT:

Labs:

- CBC w diff, CRP, iStat chem 7, procalcitonin, blood culture, UA, urine culture
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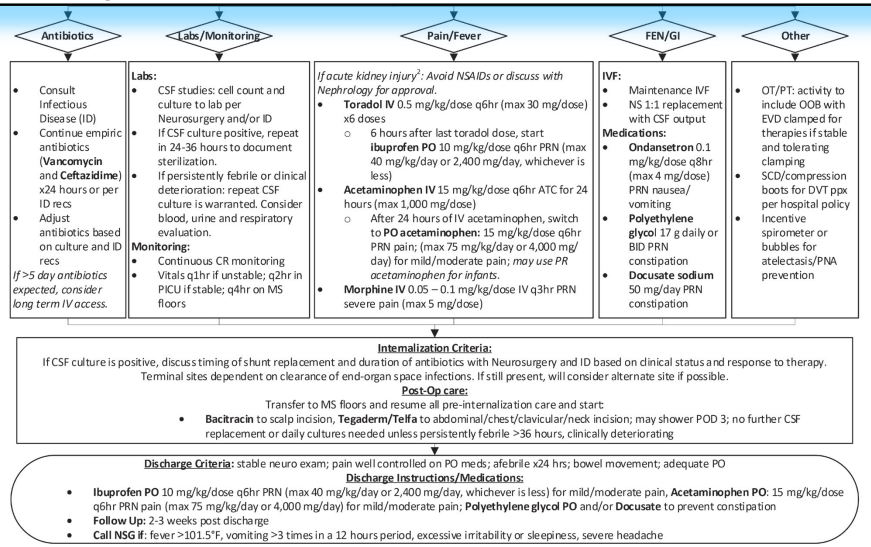

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CLINICAL PATHWAY:
Suspected Neurosurgical Shunt Infection
Appendix B: Radiographic Appearance of Shunt Valves

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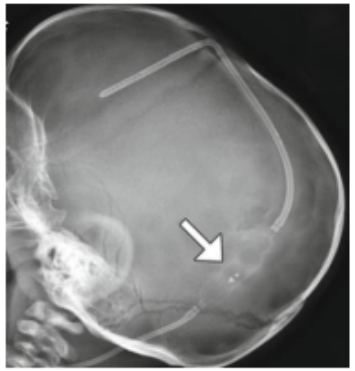
When evaluating the radiographic markings of any implanted device, it is important to recognize that the veracity of your interpretation depends on the quality of the radiographic images. For the best results, x-rays should be taken orthogonally to the plane of the shunt valve. The positioning of the valve relative to the skull base may also obscure the valve markings, as overlapping radiodensities along the skull base can blur valve markings. In more difficult cases, fluoroscopy or 3D CT reconstruction may be used to properly identify the radio-opaque markings on a shunt valve.

It is important to realize that an exhaustive list of all shunt valve radiographic markings is beyond the scope of this appendix. For additional information regarding common shunt valve markings found in North American neurosurgical patients, you may also reference the ISPN's website on the same topic.

Please see the next several pages for examples of radiographic images of non-programmable and programmable shunts. The sources of these images are:

- http://www.kinderneurochirurgie-leipzig.de/therapeuticfocus/hydrocephalus/radiologic-identification-of-vp-shunt-valves-and-adjustment/
- https://www.ispn.guide/
- https://www.medtronic.com/us-en/index.html
- https://radiopaedia.org/

Non-Programmable Valve Examples:



Medtronic Delta Fixed Pressure Valve

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CLINICAL PATHWAY:

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INITIAL MANAGEMENT:

Labs:

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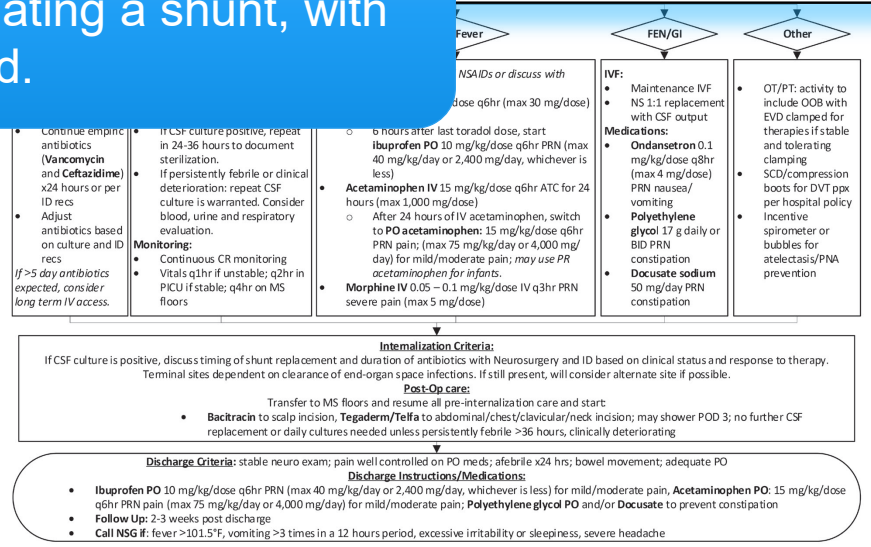
Appendix B outlines radiographic considerations when evaluating a shunt, with imaging examples provided.



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Initial Management:

- Antibiotics:
  - Start vancomycin and ceftazidime for adequate coverage *after* obtaining cultures, if possible
- Fluids:
  - All patients are made NPO and given IVF in preparation for the Operating Room
  - Ask about the last PO - last meal, snack, drink

INITIAL MANAGEMENT:

Labs:

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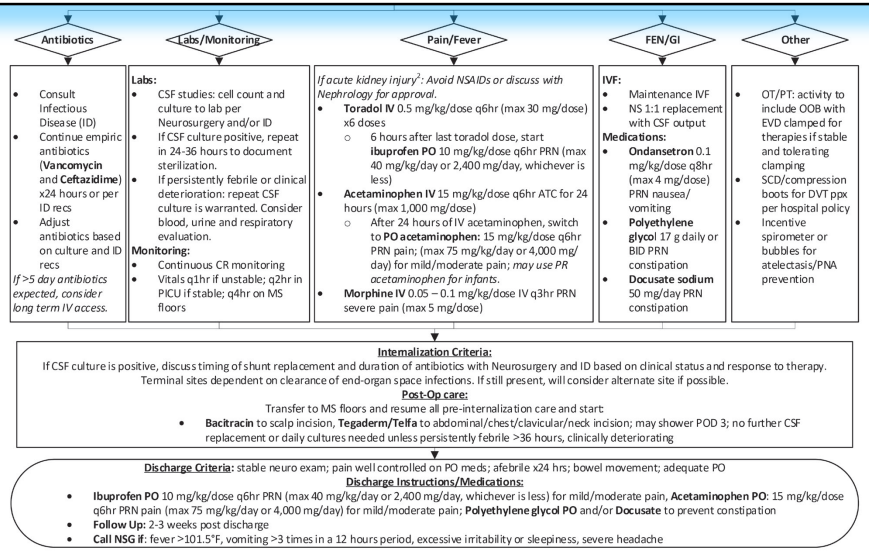

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Pre-Op:

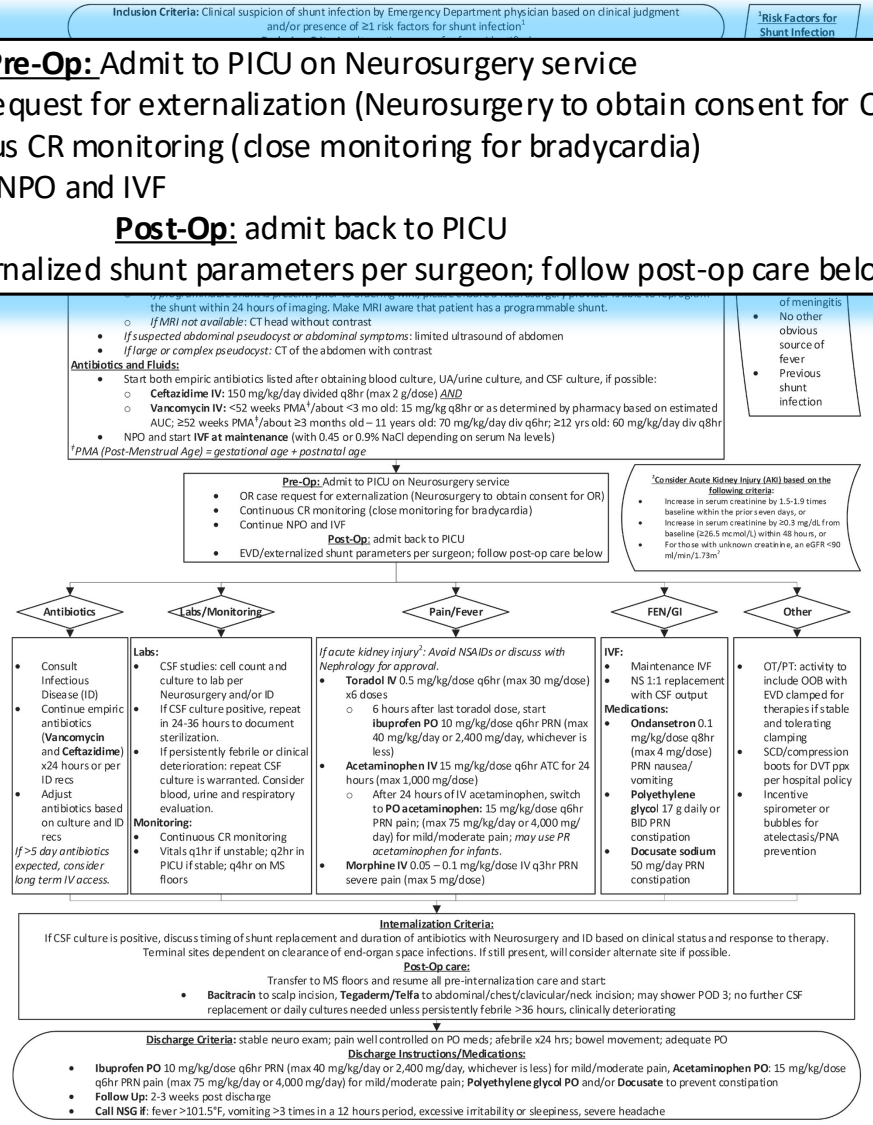
- Admit to PICU on Neurosurgery service
- Enter case request for the OR
- Continuous Cardiorespiratory monitoring
  - Be alert for bradycardia

Pre-Op: Admit to PICU on Neurosurgery service

- OR case request for externalization (Neurosurgery to obtain consent for OR)
- Continuous CR monitoring (close monitoring for bradycardia)
- Continue NPO and IVF

Post-Op: admit back to PICU

- EVD/externalized shunt parameters per surgeon; follow post-op care below



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Post-Op:

- Patient will return to the PICU with an externalized shunt
  - Shunt parameters are set by the surgeon

Pre-Op: Admit to PICU on Neurosurgery service

- OR case request for externalization (Neurosurgery to obtain consent for OR)
- Continuous CR monitoring (close monitoring for bradycardia)
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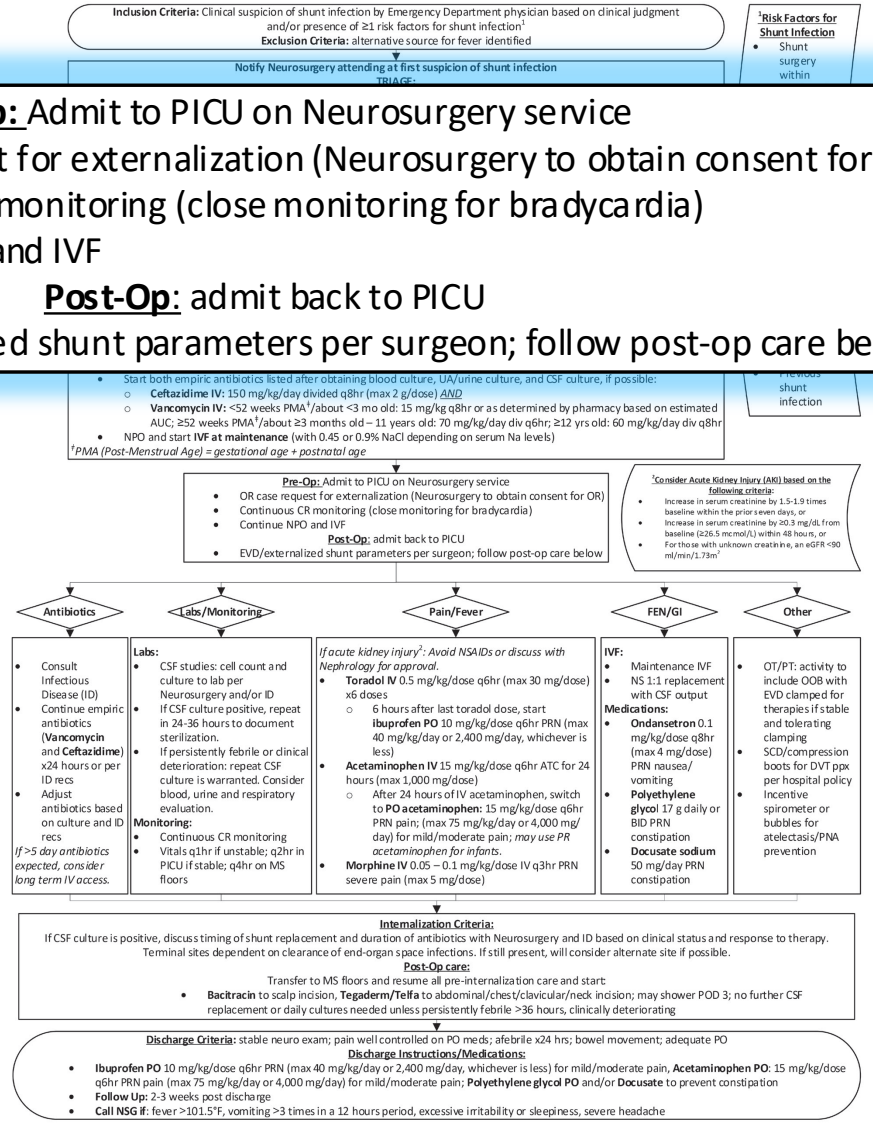

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Post-Op Management: Antibiotics

- Consult with Infectious Disease (ID)
- Continue empiric antibiotics for 24hr or per ID direction
  - Adjust antibiotics based on culture results.

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Suspected Neurosurgical Shunt Infection

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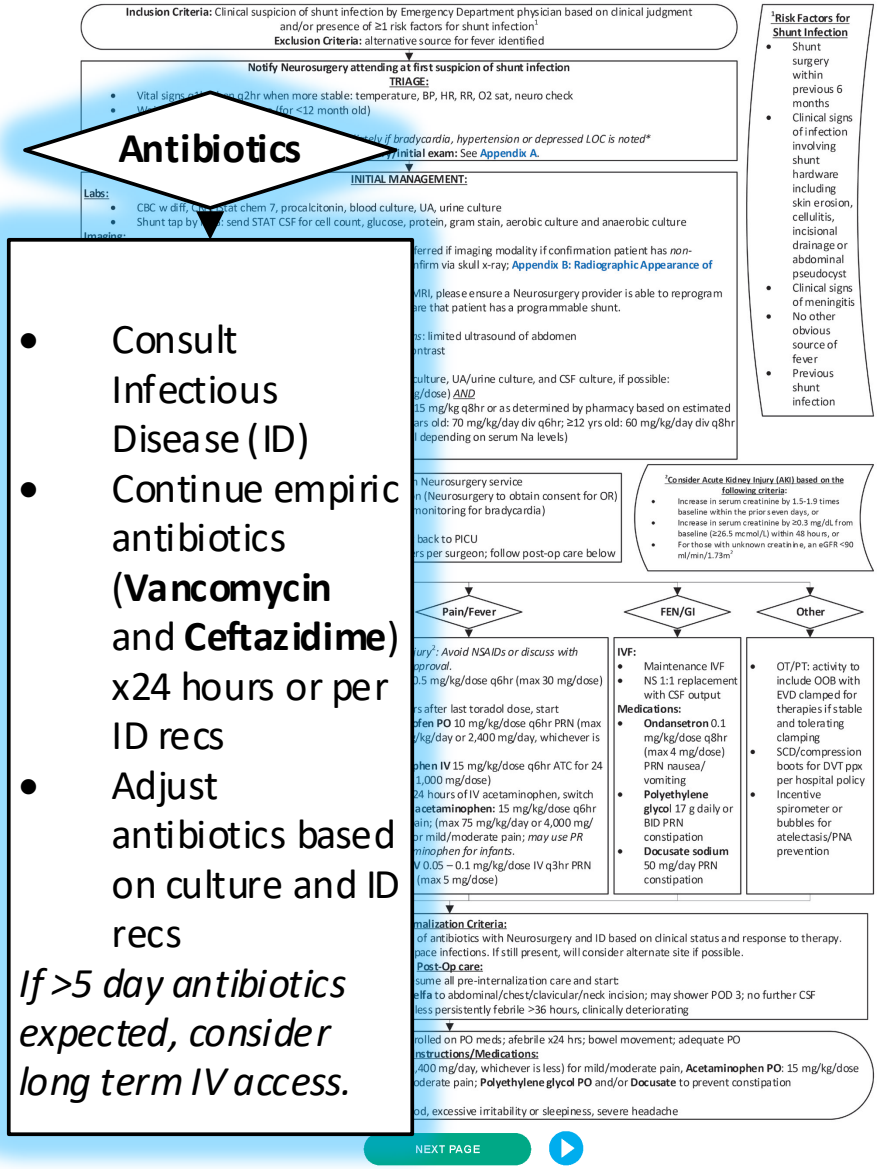

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CONTACTS: JONATHAN MARTIN, MD | PETRONELLA STOLTZ, APRN

LAST UPDATED: 01.10.24

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Post-Op Management: Labs/Monitoring

- Ongoing CSF studies will be pulsed per the Neurosurgery and/or ID teams.
- New for 2024:
  - If the CSF culture is positive, it should be repeated every 24-36 hours to document when it becomes negative.
  - If the patient is persistently febrile, repeat investigation should occur.

- Monitoring is based on patients clinical status

CLINICAL PATHWAY:
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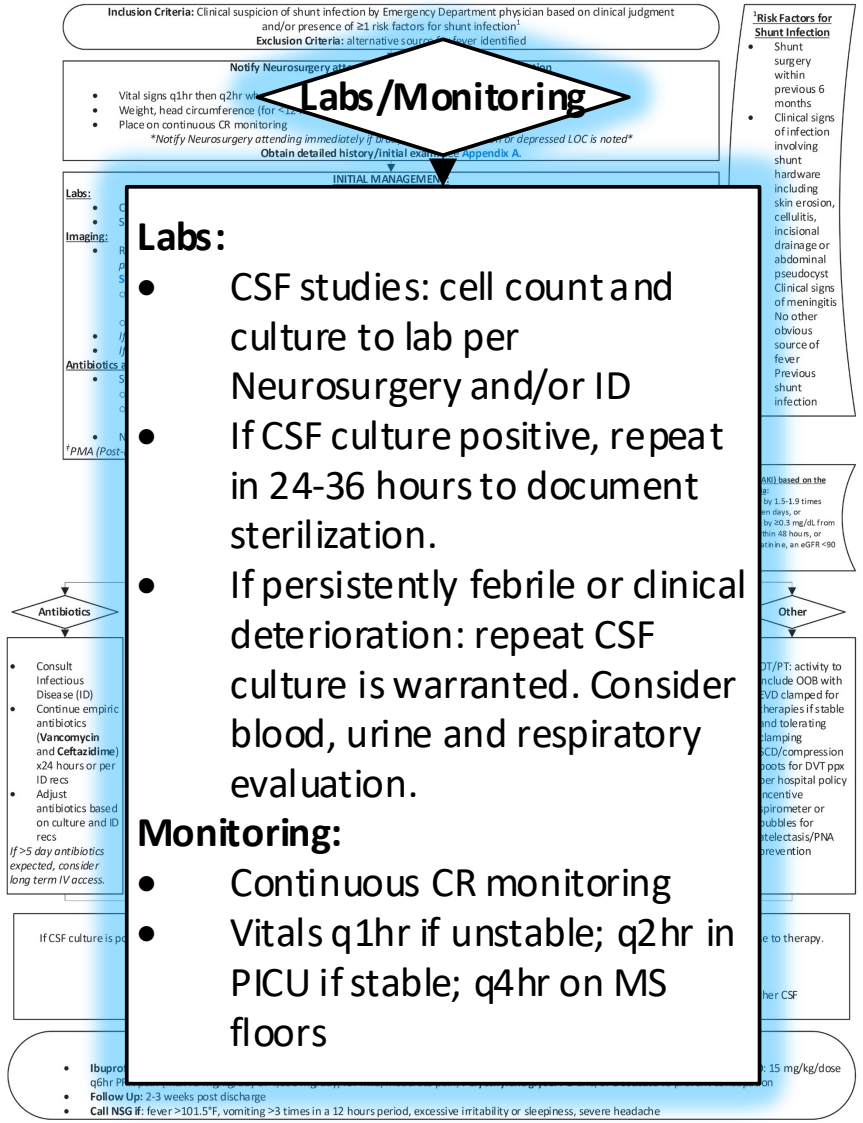

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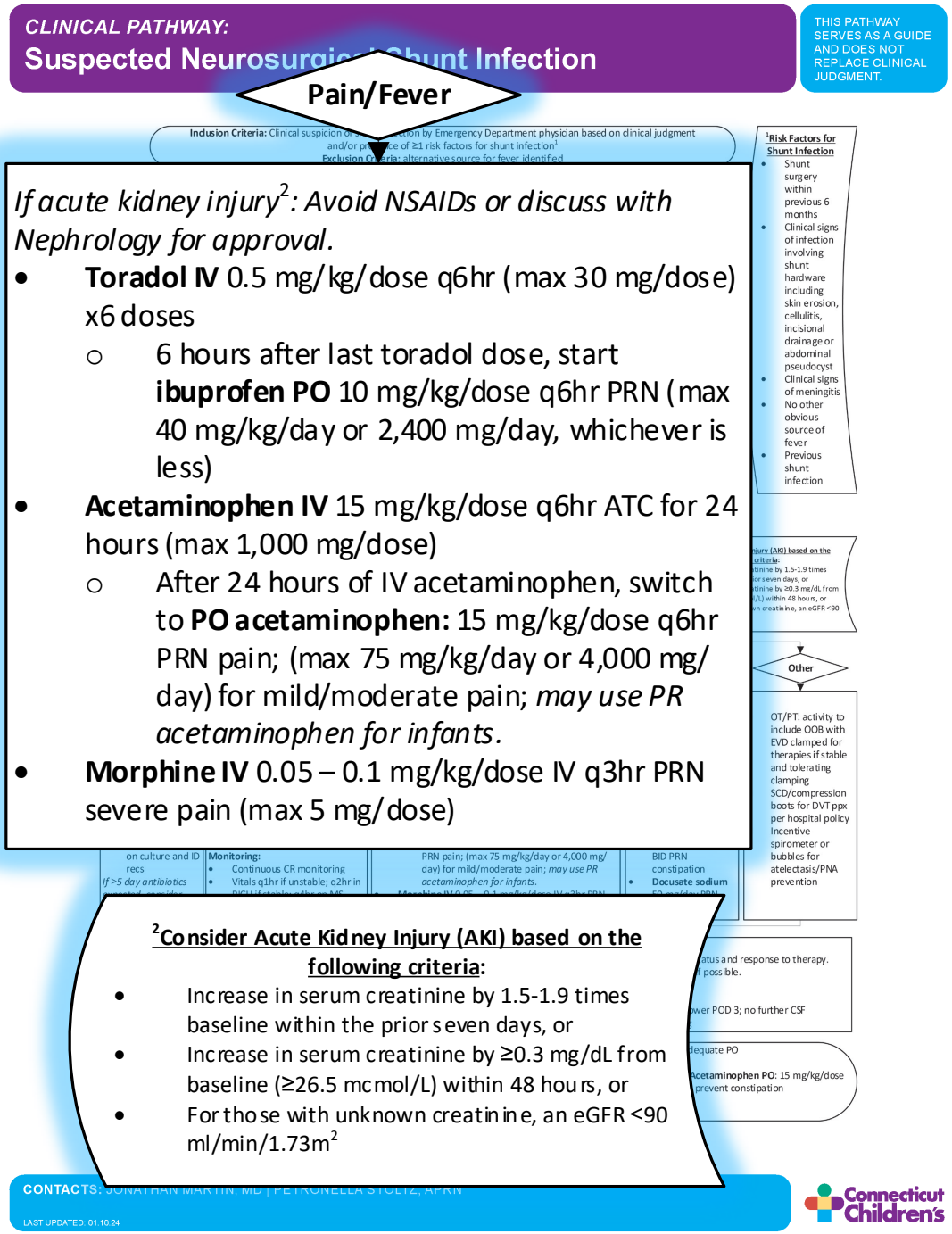
Post-Op Management:

Pain and fever:

- NSAIDS should be used as first line for pain and fever management
- Narcotics are for use with severe pain only
- Note: the definition of AKI has been updated and is available as a key.



Post-Op Management:

Fluids, Nutrition, and Bowel management:

- Patients need both maintenance fluid and 1:1 replacement of CSF output
- Anti-nausea medications should be ordered in addition to a bowel regimen

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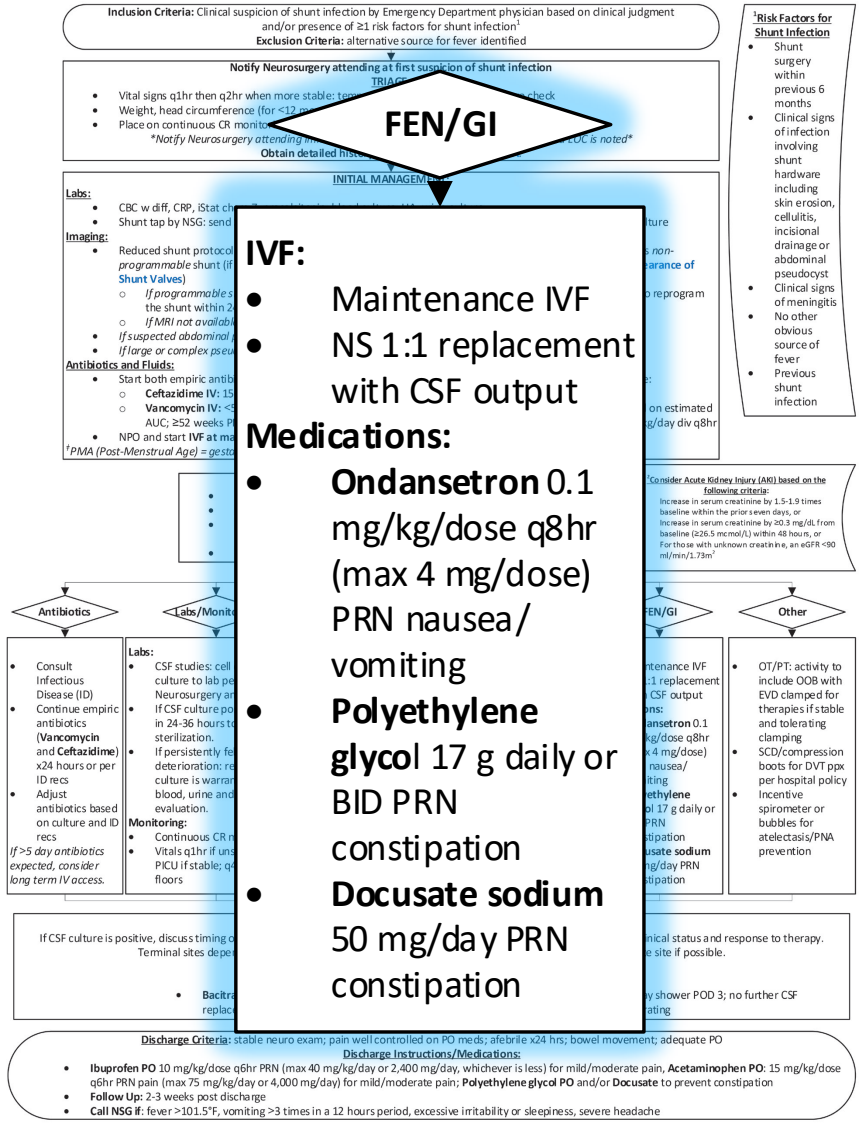

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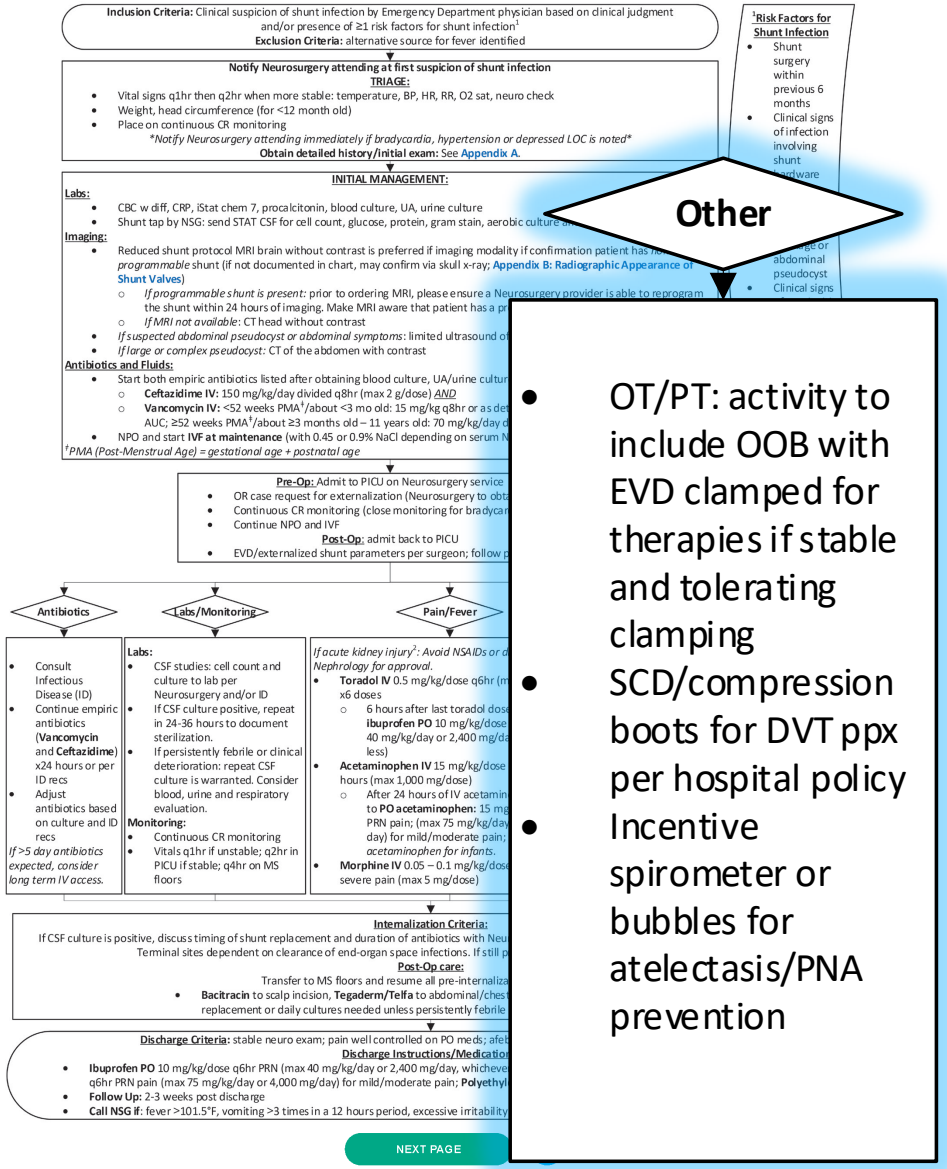
Post-Op Management:

- PT and OT should be involved once stable and tolerating clamping
- SCD boots and Incentive spirometry should be used when patients remain with limited mobility



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CLINICAL PATHWAY:

Suspected Neurosurgical Shunt Infection

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Internalization Criteria:

If CSF culture is positive, discuss timing of shunt replacement and duration of antibiotics with Neurosurgery and ID based on clinical status and response to therapy. Terminal sites dependent on clearance of end-organ space infections. If still present, will consider alternate site if possible.

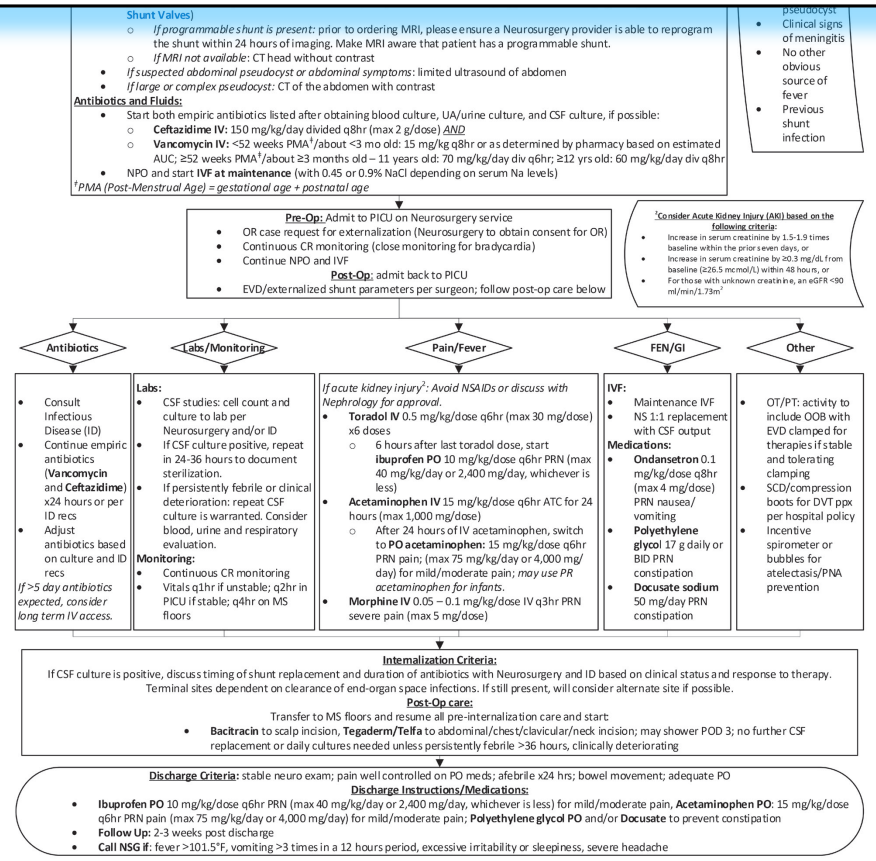
Post-Op care:

Transfer to MS floors and resume all pre-internalization care and start:

- **Bacitracin** to scalp incision, **Tegaderm/Telfa** to abdominal/chest/clavicular/neck incision; may shower POD 3; no further CSF replacement or daily cultures needed unless persistently febrile >36 hours, clinically deteriorating

Internalization criteria:

- New for 2024:
  - If the CSF culture is positive, shunt replacement and antibiotic duration will be determined on a case-by-case basis.



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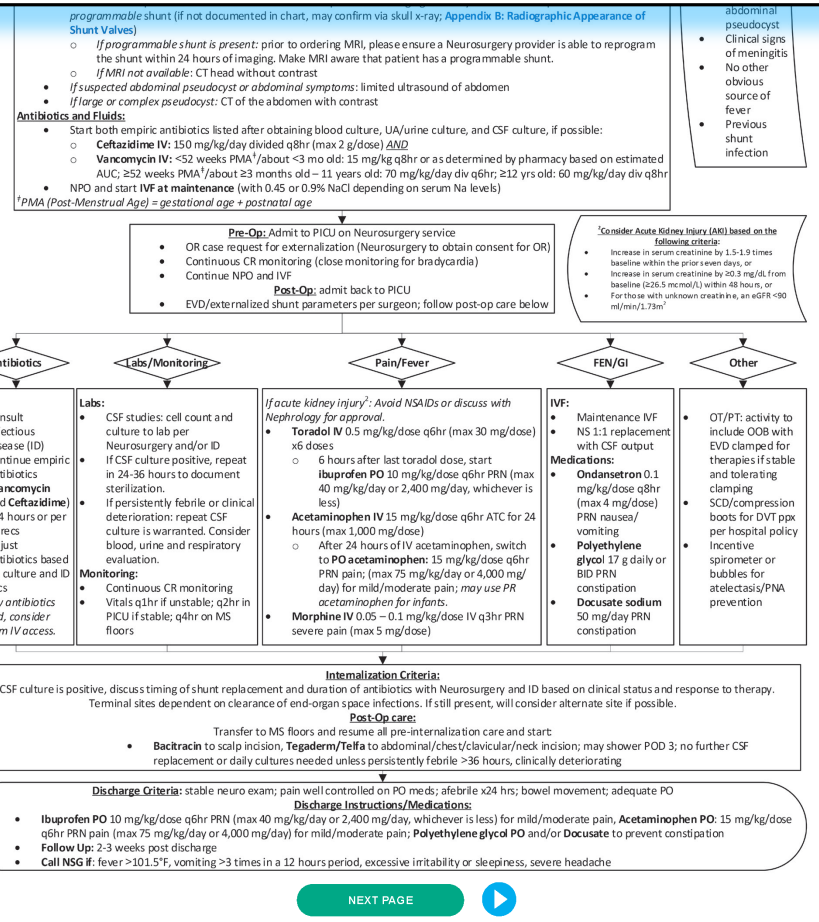
Post-Op internalization:

- Patient will transfer to a Med-Surg unit
- Resume pre-internalization care EXCEPT:
  - No further CSF replacements
  - New for 2024: No further daily CSF cultures unless persistently febrile or clinically deteriorating
- Wound care and observation of all surgical incisions
- Patient may shower on POD #3



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Discharge Criteria: stable neuro exam; pain well controlled on PO meds; afebrile x24 hrs; bowel movement; adequate PO

Discharge Instructions/Medications:

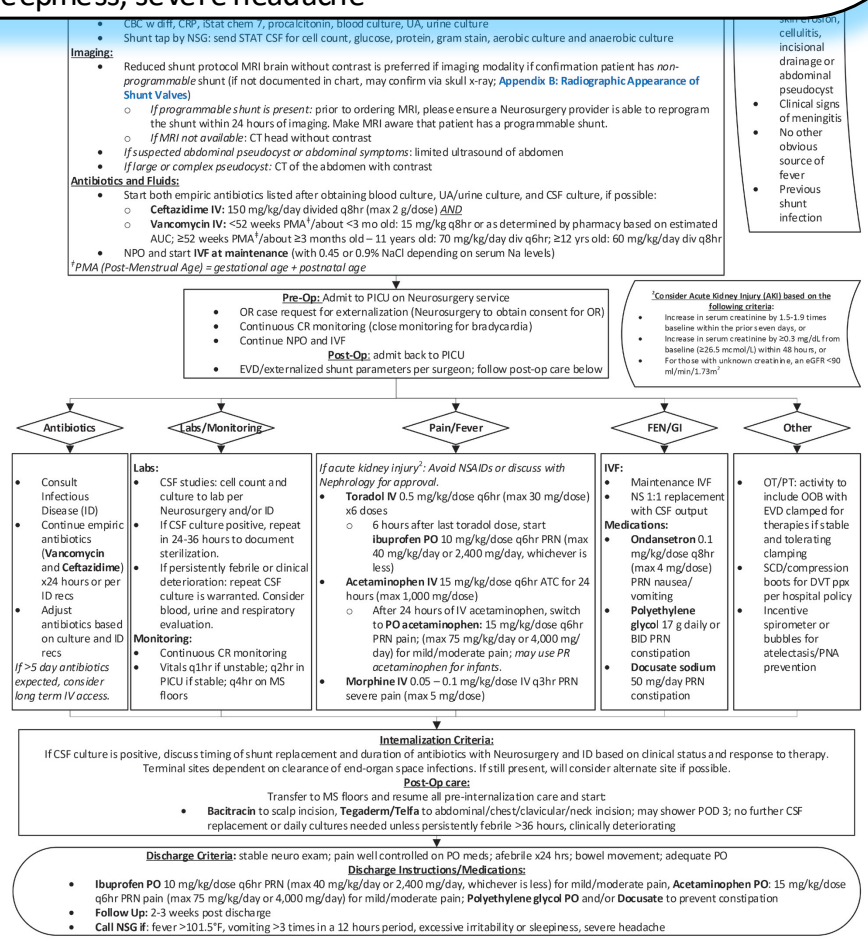
- **Ibuprofen PO** 10 mg/kg/dose q6hr PRN (max 40 mg/kg/day or 2,400 mg/day, whichever is less) for mild/moderate pain, **Acetaminophen PO**: 15 mg/kg/dose q6hr PRN pain (max 75 mg/kg/day or 4,000 mg/day) for mild/moderate pain; **Polyethylene glycol PO** and/or **Docusate** to prevent constipation
- **Follow Up:** 2-3 weeks post discharge
- **Call NSG if**: fever >101.5°F, vomiting >3 times in a 12 hours period, excessive irritability or sleepiness, severe headache

Discharge Criteria:

- Stable neuro exam
- Pain well controlled on enteral medications
- Afebrile for over 24 hours
- Adequate oral intake
- Bowel movement has occurred

Discharge Instructions:

- Include provisions for:
  - Pain control
  - Constipation prevention
  - Follow-up
  - When to call Neurosurgery



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Review of Key Points

- Neurosurgery attending should be notified immediately upon suspicion of a shunt infection
- Patients should have continuous Cardio-respiratory monitoring and every 1 -2 hr vital sign and neuro checks
  - Watch closely for bradycardia, hypertension, or decreased LOC
- Empiric antibiotics are Vancomycin AND Ceftazidime
  - Adjust antibiotics based on culture and ID recommendations

Quality Metrics

- Percentage of patients with pathway order set usage
- Percentage of patients with correct empiric antibiotic choice per pathway
- Percentage of patients with antibiotics adjusted based on culture results and Infectious Disease recommendations
- Length of stay in ED (hours)

Pathway Contacts

- Jonathan Martin, MD
  - Pediatric Neurosurgery
- Petronella Stoltz, DNP, APRN
  - Pediatric Neurosurgery

References

- Simon TD, Hall M, Riva-Cambrin J, Albert JE, Jeffries HE, LaFleur B, Dean MJ, Kestle JRW, and in collaboration with the Hydrocephalus Clinical Research Network. Infection rates following initial cerebrospinal fluid shunt placement across pediatric hospitals in the United States. *J Neurosurg Pediatr*. 2009 Aug;4(2):156 -65.
- Simon TD, Hall M, Dean JM, Kestle JR, Riva-Cambrin J. Reinfection following initial cerebrospinal fluid shunt infection. *J Neurosurg Pediatr*. 2010 Sept;6(3):277-85.
- Duhaime AC. Evaluation and management of shunt infections in children with hydrocephalus. *Clin Pediat*. 2006 Oct; 45(8):705-13.
- Sarmey N, Kshettry VR, Shiver MF, Habboub G, Machado AG, Well RJ. Evidence-based interventions to reduce shunt infections: a systematic review. *Childs Nerv Syst*. 2015 Apr;31(4):541-49.
- Kestle JR, Riva-Cambrin J, Wellons JC 3rd, Kulkarni AV, Whitehead WE, Walker ML, Oakes WJ, Drake JM, Luerssen TG, Simon TD, Holubkov R, and in collaboration with the Hydrocephalus Clinical Research Network. A standardized protocol to reduce cerebrospinal fluid shunt infection: The Hydrocephalus Clinical Research Network Quality Improvement Initiative. *J Neurosurg Pediatr.* 2011 Jul;8(1):22-9.

Thank You!

About Connecticut Children's Pathways Program

Clinical pathways guide the management of patients to optimize consistent use of evidence-based practice. Clinical pathways have been shown to improve guideline adherence and quality outcomes, while decreasing length of stay and cost. Here at Connecticut Children's, our Clinical Pathways Program aims to deliver evidence-based, high value care to the greatest number of children in a diversity of patient settings. These pathways serve as a guide for providers and do not replace clinical judgment.