Clinical Pathways

Suspected Neurosurgical Shunt Malfunction

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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

- Improve recognition of shunt malfunction on presentation to ED
- Initiate appropriate care for patient with suspected shunt malfunction
- Prevent delay in treatment and management
- Improve patient and family satisfaction
- Improve standard of care!

Why do we need this pathway?

- To change practice for these select group of patients with early recognition of potential shunt malfunction and early appropriate imaging and care
- To guide care for these children
- To ensure standard of care is successfully implemented for the safety of the patient

Background Info

- Ventriculoperitoneal (VP) shunt insertion remains the mainstay of treatment for hydrocephalus despite a high rate of complications
- In the United States alone, more than 30,000 procedures to relieve hydrocephalus are performed every year
- The 1-year failure rate for VP shunts had been reported at around 40-50% for pediatric patients
- VP shunt malfunction remains the most frequent reason for shunt revisions and one of the most frequent complication
- Early recognition and treatment improves patient outcomes and decreases hospital stays

The Shunt Malfunction pathway has 2 areas of care: Emergency Department and Inpatient.

We will be reviewing each component in the following slides.

CLINICAL PATHWAY:

Suspected Neurosurgical Shunt Malfunction

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

Inclusion Criteria: A child that presents with a pre-existing shunt (VP/VA/Vpleural) AND has symptoms associated with malfunction (see below)

- Infants: Enlargement of head, full and tense fontanelle while positioned upright and calm, prominent scalp veins, swelling along the shunt tract, vomiting, irritability, sleepiness, downward deviation of the eyes
- Toddlers: enlargement of head, vomiting, headache, irritability, sleepiness, loss of previous abilities (sensory or motor function)
- Children and adults: vomiting, headache, vision problems, photophobia, irritability, sleepiness, personality change, difficulty in waking up or staying awake

Exclusion Criteria: Concern for neurosurgical shunt infection (see Suspected Neurosurgical Shunt Infection Clinical Pathway), identification of alternate source for symptoms, or symptoms not related to shunt malfunction as defined

ED Evaluation

Triage:

- Vitals: BP, HR, O2 sat, RR, temperature
- Weight
- Head circumference (if age <2 years)
- Pain score
- Place on continuous cardiac and respiratory monitoring
- Notify Neurosurgery attending immediately if bradycardia, hypertension, depressed level of consciousness (LOC)

Initial evaluation:

- Obtain a detailed history and initial exam (see Appendix A)

Initial Management

Labs:

- CBC, CRP, BMP
- Shunt tap by Neurosurgery (at the discretion of Neurosurgery attending)
  - If tapped, send STAT cerebrospinal fluid culture and gram stain

Imaging:

- Head ultrasound if fontanelle is open **or**
- Reduced shunt protocol MRI brain without contrast is preferred imaging modality if can confirm patient has a *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
- Abdominal ultrasound if abdominal symptoms are present
- Order VP Shunt series at the discretion of the neurosurgery attending

FEN/GI:

- NPO
- IVF D5 NS with 20 mEq KCl/L at maintenance rate

Medications:

- **Ondansetron** 0.1 mg/kg/dose q8hr PRN nausea (max 4 mg/dose)
- **Acetaminophen** 15 mg/kg/dose q6hr PRN pain/headache (max 75 mg/kg/day or 4,000 mg/day)

Notify Neurosurgery attending via Intellidesk

Pre-Op:

Admit to Neurosurgery service on the floor if stable, or to the PICU if unstable

- OR case request for shunt revision to be completed by Neurosurgery attending or APP
- Continuous CR monitoring (close monitoring for bradycardia)
- NPO and IVF at maintenance
- Neurosurgery to consent to OR

To OR

Post-Op:

See Suspected Neurosurgical Shunt Malfunction Inpatient Pathway

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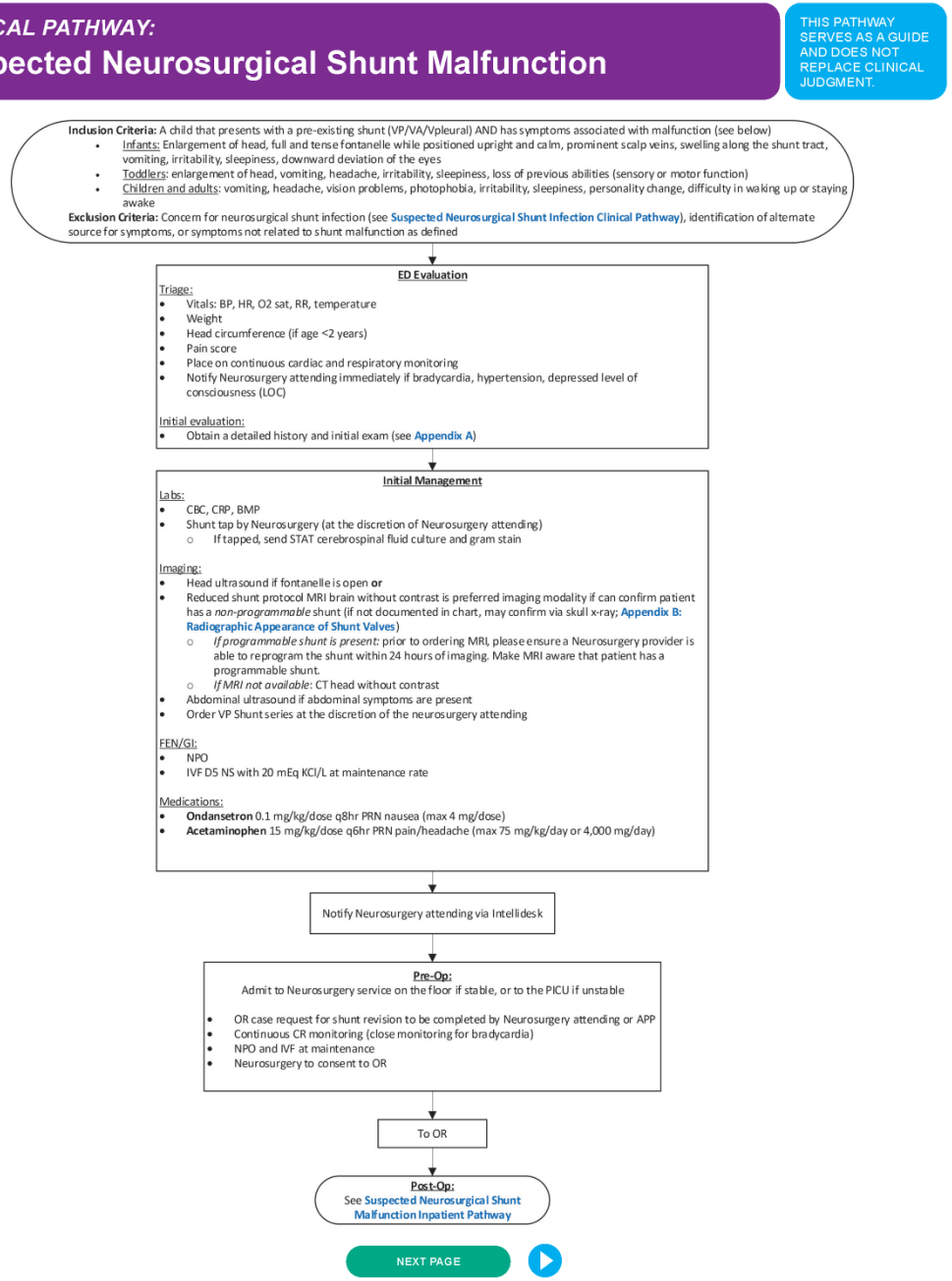
Shunt Malfunction – ED

We will start with reviewing the Emergency Department pathway.

The goal of the Emergency Department Pathway is to rapidly identify and diagnose patients with shunt malfunction so they can be prepared for surgery as soon as possible.



Shunt Malfunction – ED

If there is concern for shunt infection, please follow the Shunt Infection Clinical Pathway.

CLINICAL PATHWAY:
Suspected Neurosurgical Shunt Malfunction

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

Inclusion Criteria: A child that presents with a pre-existing shunt (VP/VA/Vpleural) AND has symptoms associated with malfunction (see below)

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Exclusion Criteria: Concern for neurosurgical shunt infection (see Suspected Neurosurgical Shunt Infection Clinical Pathway), identification of alternate source for symptoms, or symptoms not related to shunt malfunction as defined

Note: Any bradycardia, hypertension, and depressed level of consciousness (LOC) are signs of increased intracranial pressure (ICP) and should prompt immediate notification of the Neurosurgery attending

ED Evaluation

Triage:

- Vitals: BP, HR, O2 sat, RR, temperature
- Weight
- Head circumference (if age <2 years)
- Pain score
- Place on continuous cardiac and respiratory monitoring
- Notify Neurosurgery attending immediately if bradycardia, hypertension, depressed level of consciousness (LOC)

Initial evaluation:

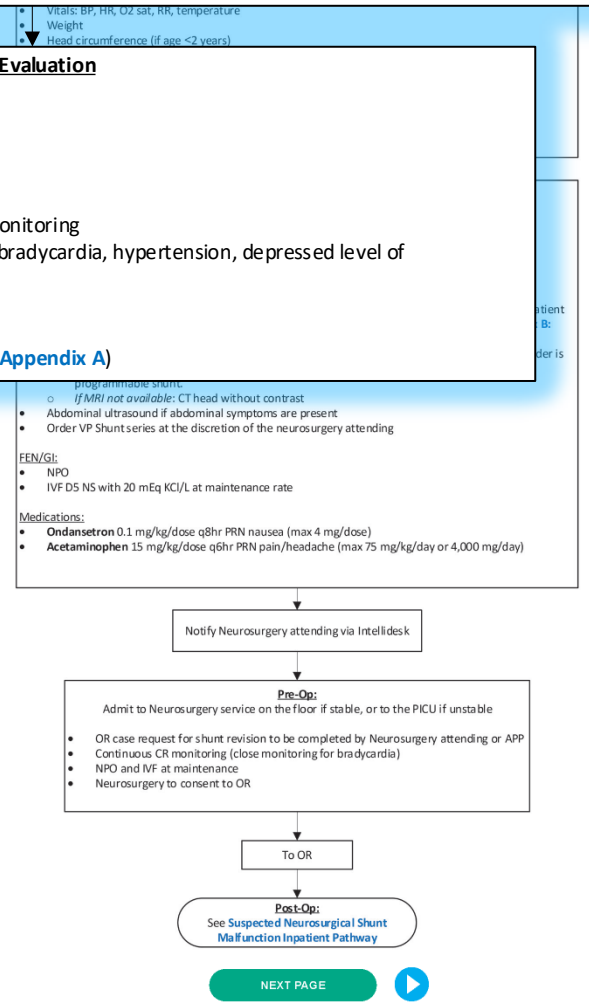
- Obtain a detailed history and initial exam (see Appendix A)

Children may present with different symptoms based on their age.

- All children under 2 years of age should have a head circumference documented

Providers should complete a thorough history and physical exam

- See Appendix A



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Shunt Malfunction – ED

CLINICAL PATHWAY:
Suspected Shunt Malfunction
Appendix A: Obtaining a Detailed History

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

Important factors to include:

- Shunt history, including:
  - Location of shunt (ventricular-atrial shunt, ventricular-pleural shunt, ventricular-peritoneal shunt)
  - Date of shunt placement
  - Date of last shunt revision
  - Signs/symptoms present at presentation/last revision
- Headache history, including:
  - Quality
  - Duration
  - Location
  - Past treatment
- Vomiting history, including:
  - Timing
  - Any precipitating events
- Neurological symptoms, including:
  - Change in LOC
  - Increased irritability
  - Weakness
  - Seizures
  - Upward or downward gaze
  - Increased lethargy
- Abdominal symptoms, including:
  - Significant increase in abdominal girth
  - Pain
  - Tenderness
  - Mass
- Trauma history
- Physical exam findings:
  - Fontanels
  - Head circumference
  - Decreased breath sounds for pleural shunt

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Appendix A provides guidelines for pertinent history and physical exam factors which will be important for correct diagnosis.

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- Vitals: BP, HR, O2 sat, RR, temperature
- Weight
- Head circumference (if age <2 years)

ED Evaluation

Triage:

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- Pain score
- Place on continuous cardiac and respiratory monitoring
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Initial evaluation:

- Obtain a detailed history and initial exam (see Appendix A)

programmable shunt.

- *If MRI not available:* CT head without contrast
- Abdominal ultrasound if abdominal symptoms are present
- Order VP Shunt series at the discretion of the neurosurgery attending

FEN/GI:

- NPO
- IVF D5 NS with 20 mEq KCl/L at maintenance rate

Medications:

- **Ondansetron** 0.1 mg/kg/dose q8hr PRN nausea (max 4 mg/dose)
- **Acetaminophen** 15 mg/kg/dose q6hr PRN pain/headache (max 75 mg/kg/day or 4,000 mg/day)

Notify Neurosurgery attending via Intellidesk

Pre-Op:
Admit to Neurosurgery service on the floor if stable, or to the PICU if unstable

- OR case request for shunt revision to be completed by Neurosurgery attending or APP
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Post-Op:
See Suspected Neurosurgical Shunt Malfunction Inpatient Pathway

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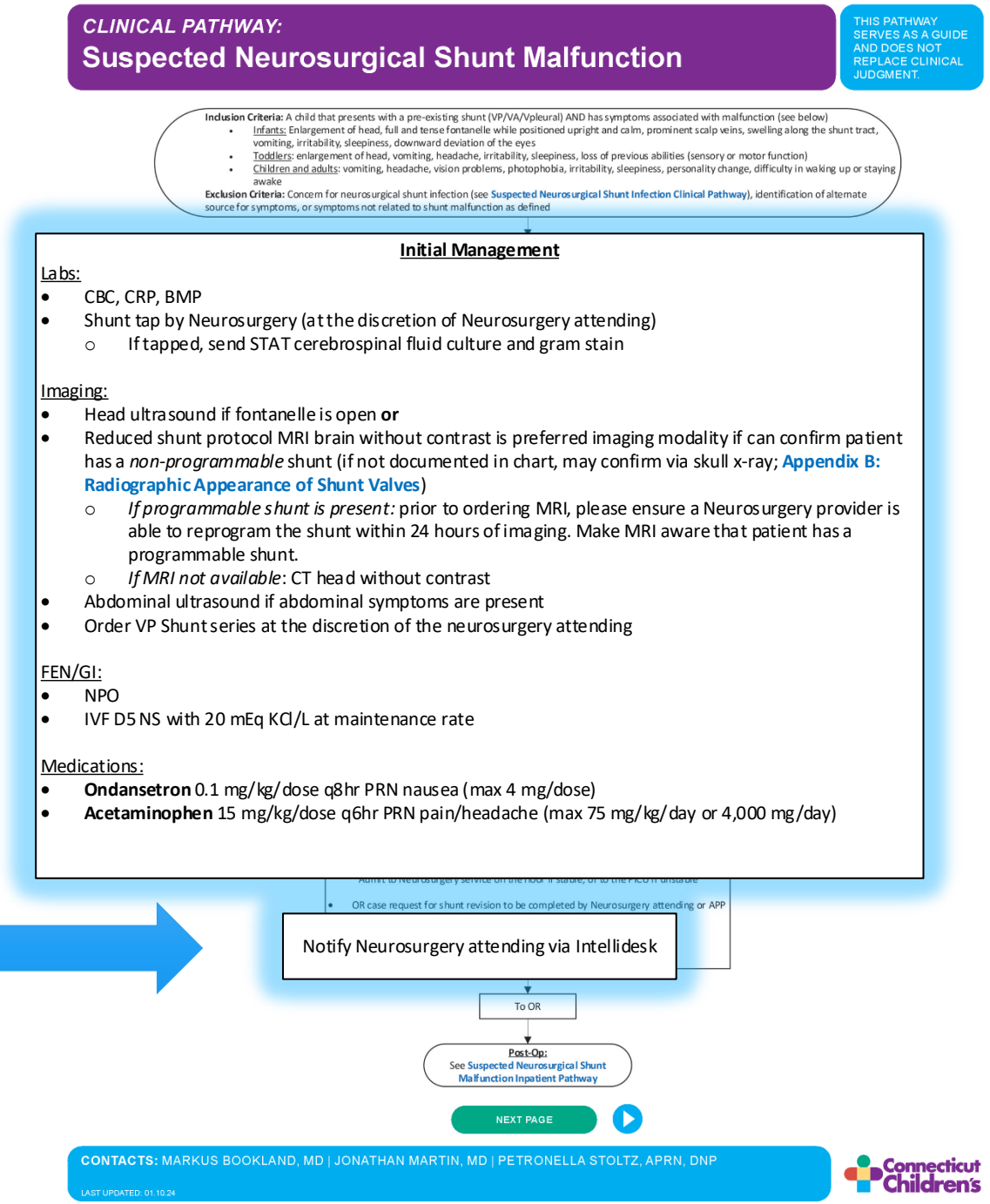
Shunt Malfunction – ED

Initial management includes obtaining imaging, sending screening lab work, and making the patients NPO in prep for surgery.

The neurosurgery attending should be notified after imaging is completed and with ANY signs of increased ICP



Shunt Malfunction – ED

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.

CLINICAL PATHWAY:
Suspected Neurosurgical Shunt Malfunction

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Initial Management

Labs:
- CBC, CRP, BMP
- Shunt tap by Neurosurgery (at the discretion of Neurosurgery attending)
  - If tapped, send STAT cerebrospinal fluid culture and gram stain

Imaging:
- ~~Head ultrasound if fontanelle is open~~ **or**
- Reduced shunt protocol MRI brain without contrast is preferred imaging modality if can confirm patient has a *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
- ~~Abdominal ultrasound if abdominal symptoms are present~~
- Order VP Shunt series at the discretion of the neurosurgery attending

FEN/GI:
- NPO
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Pre-Op:
Admit to Neurosurgery service on the floor if stable, or to the PICU if unstable

Notify Neurosurgery attending via Intellidesk

To OR

Post-Op:
See **Suspected Neurosurgical Shunt Malfunction Inpatient Pathway**

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Shunt Malfunction – ED

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

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

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/

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

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Pre-Op:
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Notify Neurosurgery attending via Intellidesk

To OR

Post-Op:
See **Suspected Neurosurgical Shunt Malfunction Inpatient Pathway**

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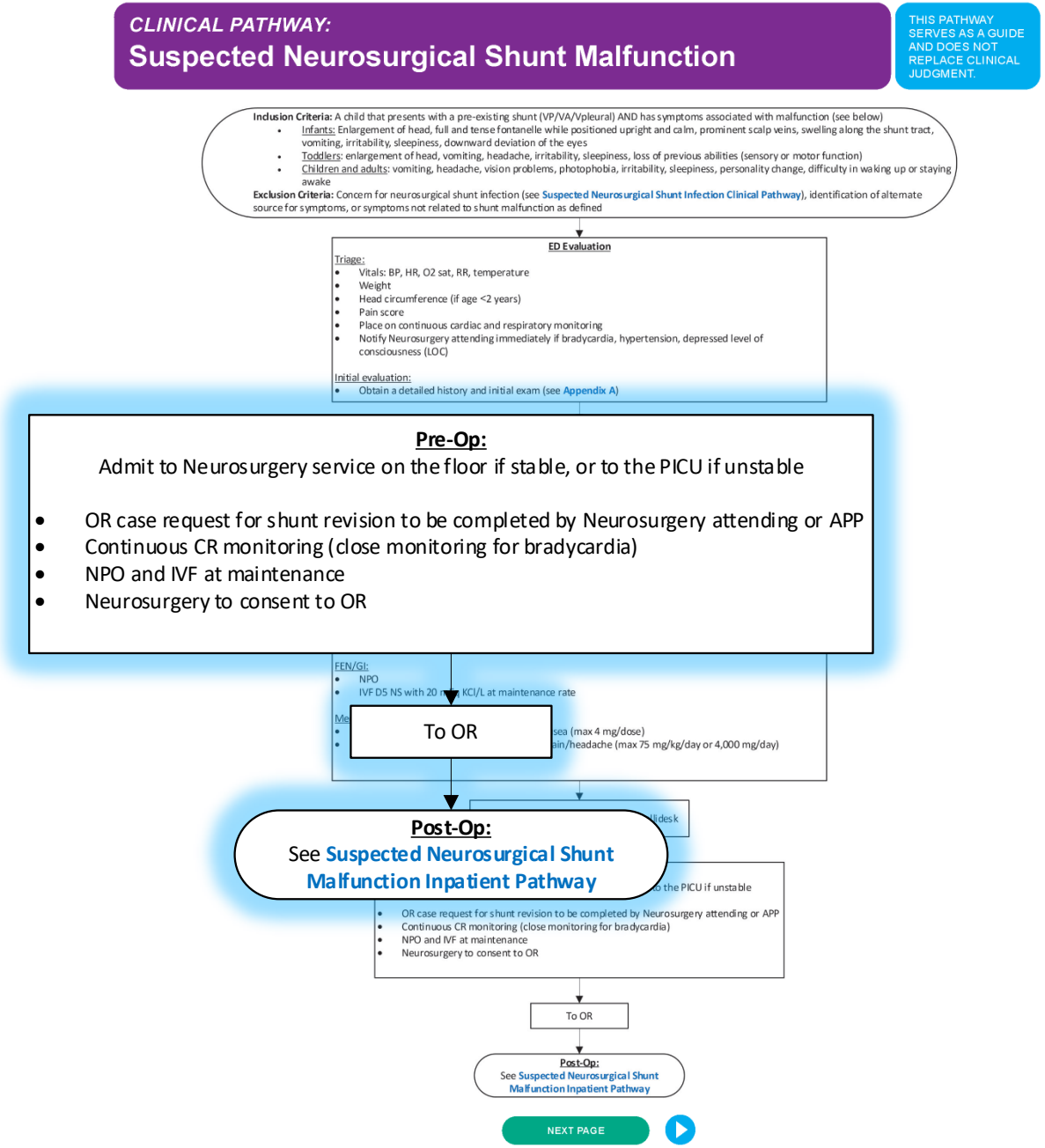
Shunt Malfunction – ED

Once a patient is identified as having a shunt malfunction, they will be admitted (to the Med/Surg unit or PICU depending on their clinical stability) or taken to the OR.

Post-operatively, the inpatient portion of the pathway will be launched.



Shunt Malfunction – Inpatient

The goal of the Inpatient pathway is to guide post-operative care of patients who underwent surgical correction of a shunt malfunction.

CLINICAL PATHWAY:
Suspected Neurosurgical Shunt Malfunction

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Inclusion Criteria: post-operative care for any patient diagnosed by Neurosurgery to have shunt malfunction requiring surgical correction
Exclusion Criteria: none

Post-operative Care:
- Transfer to Med/Surg floor if stable
- Transfer to PICU if unstable

Antibiotics

Antibiotics to be given for only 24 hours post-operatively unless otherwise indicated.

Cefazolin IV 100 mg/kg/day div q8hr (max 2000 mg/dose)
OR

Nafcillin IV 200 mg/kg/day div q6hr (max 12 g/day); adult dose 2g q6hr

If ß-Lactam allergy:
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

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

Pain Control

If acute kidney injury[1]: Avoid NSAIDs or discuss with Nephrology for approval.

- **Toradol IV** 0.5 mg/kg/dose q6hr x 6 doses (max 30 mg/dose)
  - 6 hours after 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 around the clock for 24 hours (max 1000 mg/dose)
  - After 24 hours of IV acetaminophen, switch to **acetaminophen PO:** 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.*

Nursing & Monitoring

Monitoring:
- Cardiopulmonary monitoring and pulse oximetry x 24 hours or for the duration of narcotic therapy
- Temperature, HR, RR, and BP q4hr x 24hrs, then q8hr

Incision Care:
- Telfa and tegaderm to abdominal incision
- Bacitracin to scalp incision x 48hrs

Other:
- Incentive spirometer or bubbles 4-10x/hr while awake
- Sequential compression device (SCD)/stockings while in bed

Activity

- Head of bed at 30 degrees
- 24 hours post-op: OT, PT consults
- POD 3: may shower

Fluids, Electrolytes, Nutrition

Fluids:
- D5 NS with 20 mEq KCl/L at maintenance rate; wean as PO improves

Diet:
- Clear liquid diet, advance as tolerated when recovered from anesthesia per PACU

Bowel regimen:
- **Polyethylene glycol** 17 g daily or BID PRN constipation
- **Docusate** 50-100 mg PRN constipation

Anti-emetics:
- **Ondansetron IV** 0.1 mg/kg/dose q8hr (max 4 mg/dose) PRN nausea/vomiting

Discharge Criteria:
- Baseline neurological examination
- Pain well-controlled on oral medication
- Afebrile x 24 hours
- Bowel movement
- Taking adequate fluid and nutrition orally
- Cleared by PT & OT

Discharge 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

Discharge Instructions:
- Call Neurosurgery for fever >101.5, vomiting >3x in 12 hr period, excessive irritability or sleepiness, severe headache
- Follow up outpatient 2-3 weeks after discharge

[1]**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

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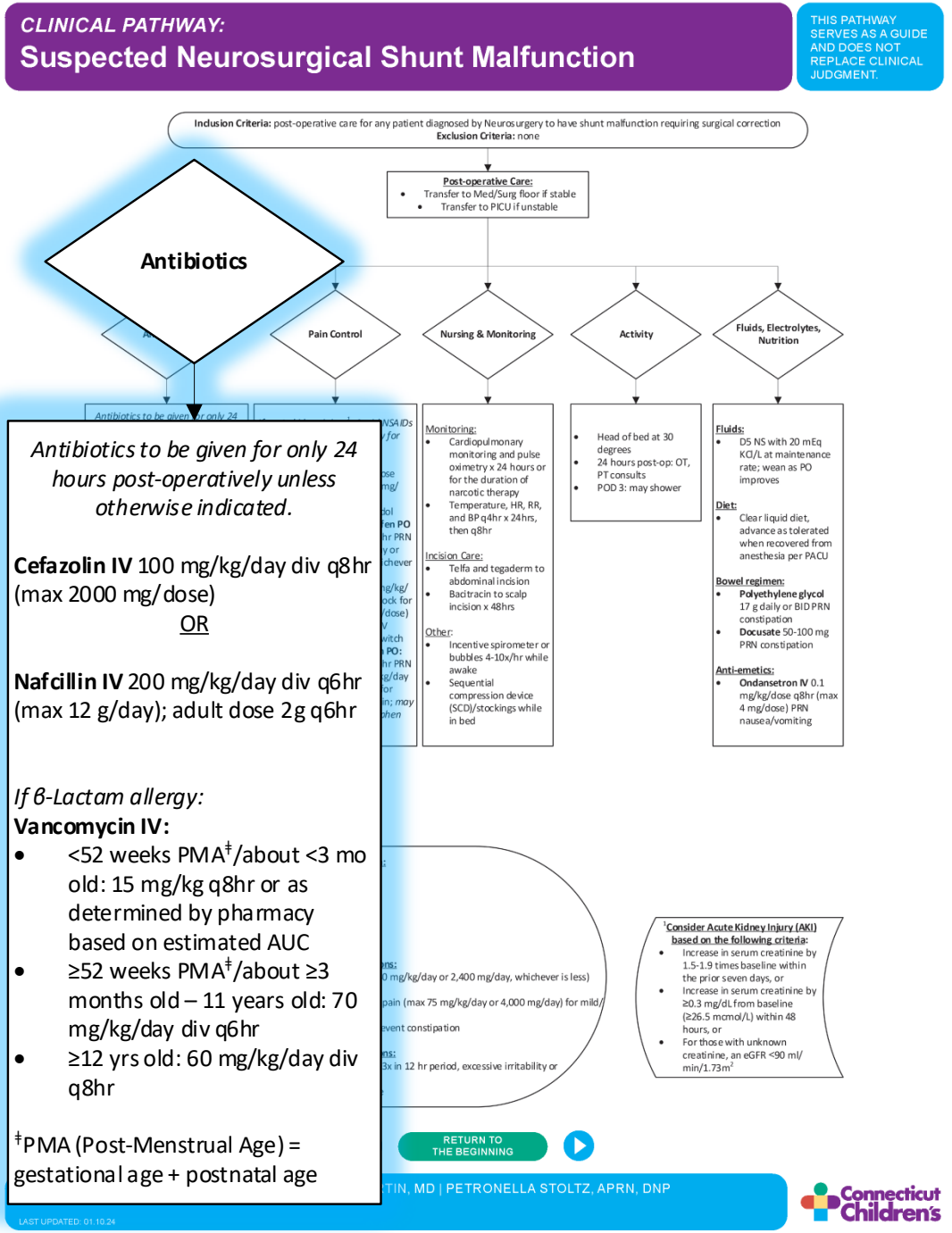
Shunt Malfunction – Inpatient

Antibiotics are only given for the first 24 hours post-operatively, unless otherwise indicated.



Shunt Malfunction – Inpatient

Pain can typically be managed by toradol/ibuprofen and acetaminophen.

However, those with renal disease or impairment should avoid the use of NSAIDs.

Note: the definition of AKI has been updated and is available as a key.

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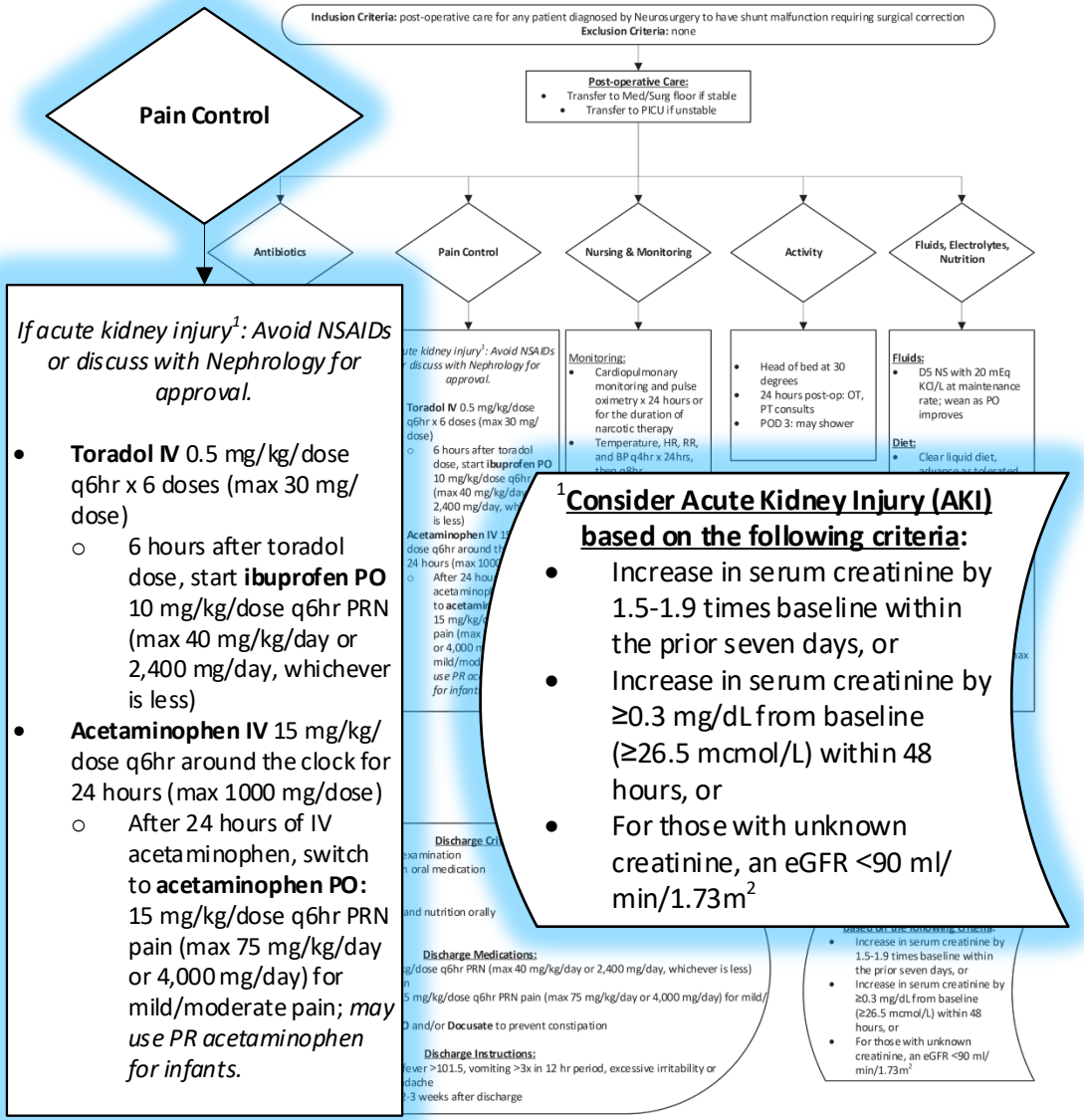

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Shunt Malfunction – Inpatient

Patients will need typical post anesthesia nursing care but with close observation of the surgical sites for leakage.

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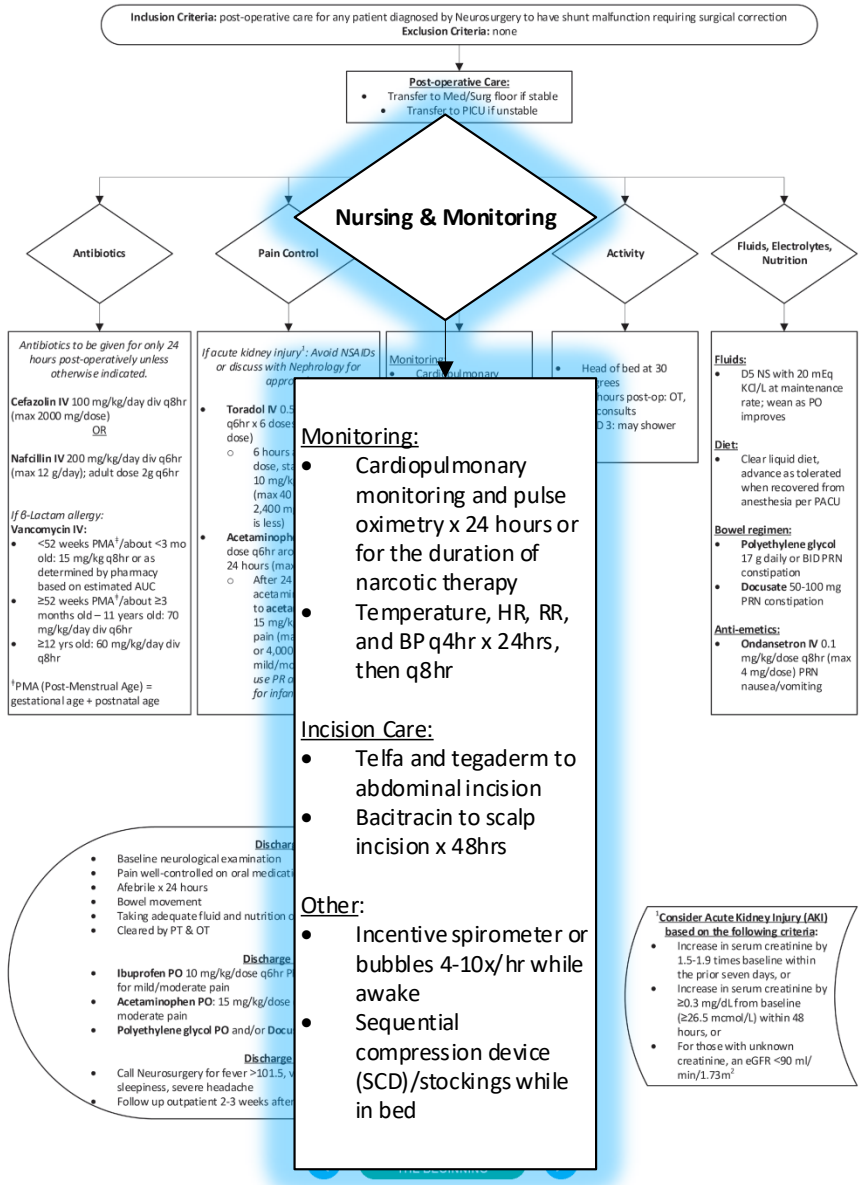

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Shunt Malfunction – Inpatient

PT and OT are initiated on post operative day 1 to encourage early movement.

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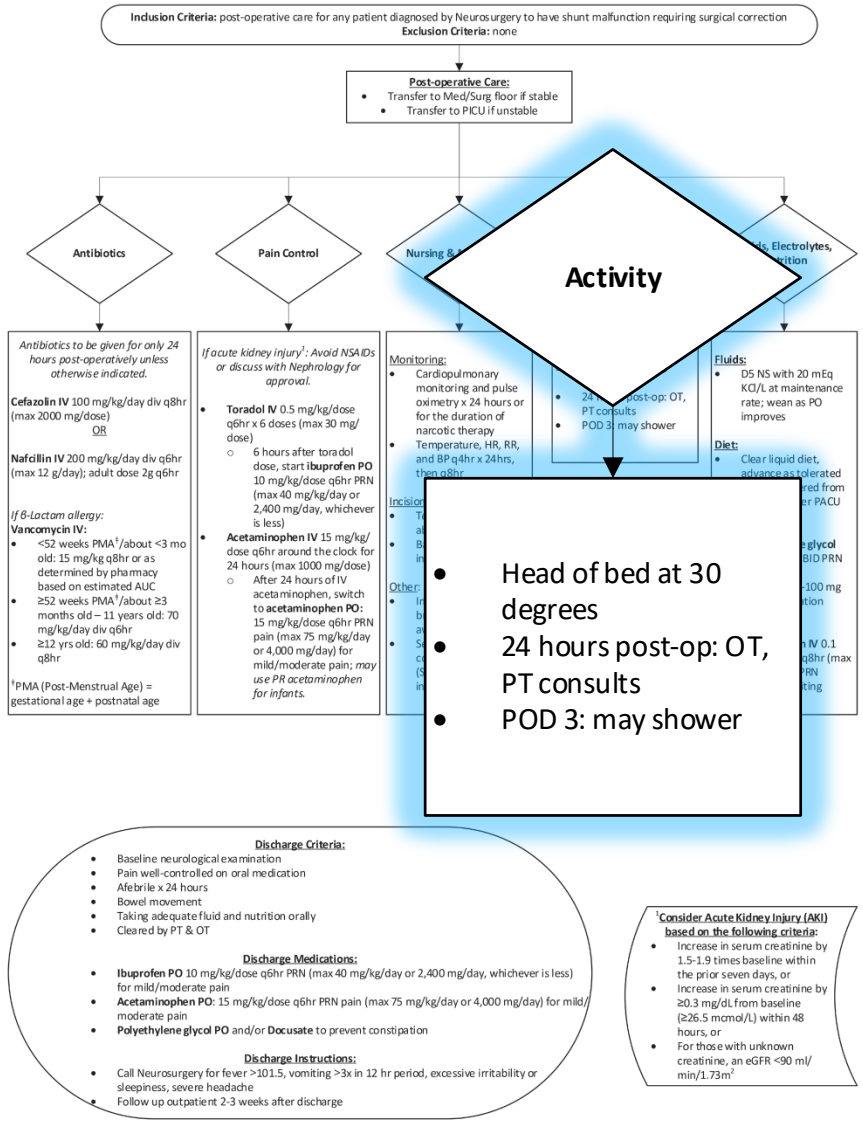

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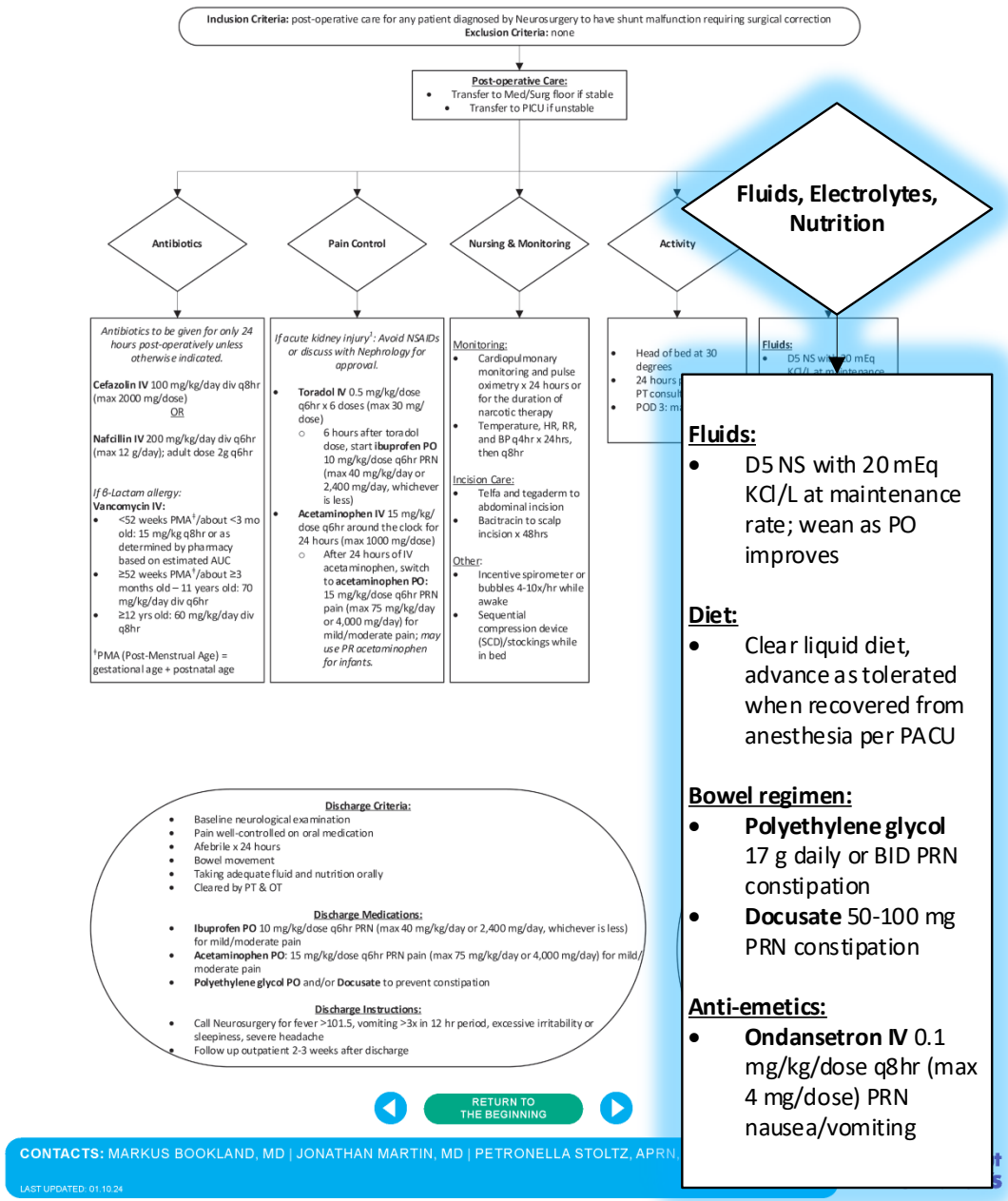
Shunt Malfunction – Inpatient

There is NO routine blood work required post operatively.

Diet is advanced as tolerated.

Bowel regimen is essential and should be started as soon as possible post procedure.



Shunt Malfunction – Inpatient

Certain criteria must be met prior to discharge, including adequate pain control and bowel movements.

Medications focus on pain management and maintaining adequate bowel movements.

Education regarding when to call neurosurgery post discharge is very important to ensure no complications exist post operatively. Early recognition is important.

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Vancomycin IV:
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[†]PMA (Post-Menstrual Age) = gestational age + postn

Pain Control

If acute kidney injury[1]: Avoid NSAIDs or discuss with Nephrology for approval.

- **Toradol IV** 0.5 mg/kg/dose q6hr x 6 doses (max 30 mg/dose)
  - 6 hours after 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 around the clock for 24 hours (max 1000 mg/dose)
  - After 24 hours of IV acetaminophen, switch to **acetaminophen PO:** 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*

Nursing & Monitoring

Monitoring:
- Cardiopulmonary monitoring and pulse oximetry x 24 hours or for the duration of narcotic therapy
- Temperature, HR, RR, and BP q4hr x 24hrs, then q8hr

Incision Care:
- Telfa and tegaderm to abdominal incision
- Bacitracin to scalp incision x 48hrs

Other:
- Incentive spirometer or bubbles 4-10x/hr while awake
- Sequential compression device (SCD)/stockings while

Activity

- Head of bed at 30 degrees
- 24 hours post-op: OT, PT consults
- POD 3: may shower

Fluids, Electrolytes, Nutrition

Fluids:
- D5 NS with 20 mEq KCl/L at maintenance rate; wean as PO improves

Diet:
- Clear liquid diet, advance as tolerated when recovered from anesthesia per PACU

Bowel regimen:
- **Polyethylene glycol** 17 g daily or BID PRN constipation
- **Docusate** 50-100 mg PRN constipation

Anti-emetics:
- **Ondansetron IV** 0.1 mg/kg/dose q8hr (max 4 mg/dose) PRN nausea/vomiting

Discharge Criteria:
- Baseline neurological examination
- Pain well-controlled on oral medication
- Afebrile x 24 hours
- Bowel movement
- Taking adequate fluid and nutrition orally
- Cleared by PT & OT

Discharge 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

Discharge Instructions:
- Call Neurosurgery for fever >101.5, vomiting >3x in 12 hr period, excessive irritability or sleepiness, severe headache
- Follow up outpatient 2-3 weeks after discharge

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Review of Key Points

- Appropriate imaging to rule out shunt malfunction is imperative to determine need for surgical intervention
- Timely pre operative care helps facilitate timely transfer to OR
- Standardized post-operative care assists in management, discharge planning and follow up

Quality Metrics

- Percent of patients with pathway order set usage
- Percent of patients with deep wound infections
- Percent of patients with superficial wound infections
- Number of patients with organ space infection within 30 days of principal operative procedure
- Number of patients with shunt malfunction within 90 days of principal operative procedure
- Percentage of patients with cerebrospinal fluid leak
- Number of readmissions within 30 days
- Number of patients with return to the OR within 30 days

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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.