Minimally Invasive Craniosynostosis

Nella Stoltz, APRN, DNP
Markus Bookland, MD
Jonathan Martin, MD

Connecticut Children's

MAGNET RECOGNIZED

BEST CHILDREN'S HOSPITAL

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

- To improve and standardize post-operative care of patients undergoing minimally invasive craniosynostosis surgery
- To avoid unnecessary admission to the PICU
- To reduce hospital length of stay
- To improve patient and family satisfaction

Why is Pathway Necessary?

- To change practice for the post operative care of this select group of patients who mostly do not require admission to the Pediatric Intensive Care Unit
- To ensure standard of care is successfully implemented for the safety of these patients

Background

- The minimally invasive, endoscopic-assisted craniosynostosis surgery utilizes a small camera to assist with removal of the abnormal bone that causes skull deformity through one or two one-inch incisions.
- The surgery is performed in one to two hours; children rarely need a blood transfusion; and they typically go home the next day.
- No reshaping is done in surgery. A helmet is measured about three to four days after surgery and is used in the period following the procedure to contour the head shape

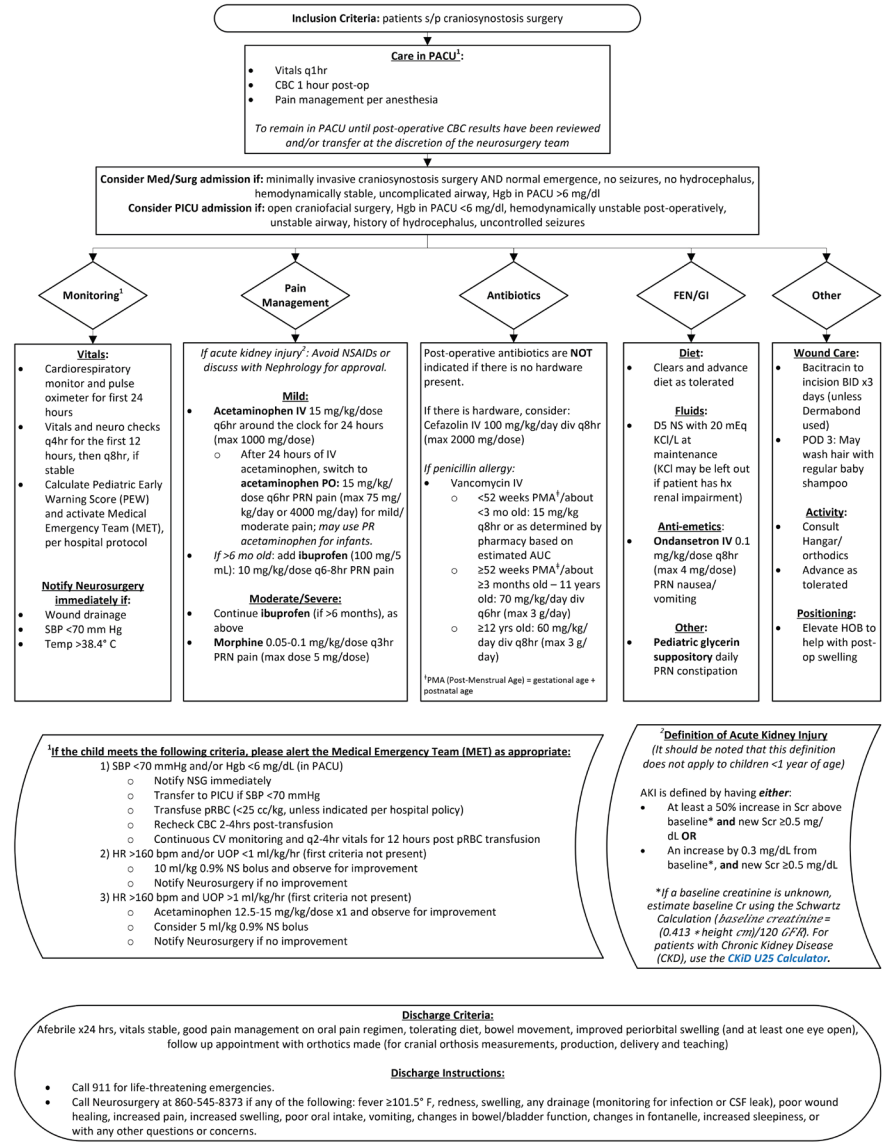
This is the Craniosynostosis Clinical Pathway.

We will be reviewing each component in the following slides.

CLINICAL PATHWAY:

Minimally Invasive Craniosynostosis

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



CONTACTS: MARKUS BOOKLAND, MD | JONATHAN MARTIN, MD | NELLA STOLTZ, APRN, DNP

LAST UPDATED: 07.23.25

CLINICAL PATHWAY:

Minimally Invasive Craniosynostosis

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

Inclusion Criteria: patients s/p craniosynostosis surgery

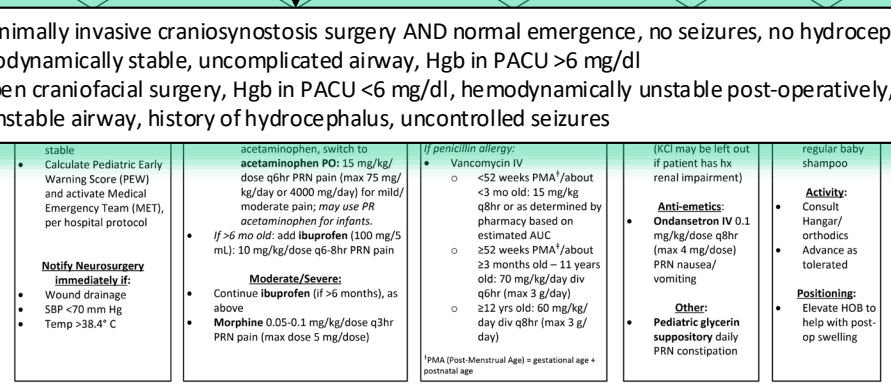
Care in PACU[1]:

- Vitals q1hr
- CBC 1 hour post-op
- Pain management per anesthesia

To remain in PACU until post-operative CBC results have been reviewed and/or transfer at the discretion of the neurosurgery team

Consider Med/Surg admission if: minimally invasive craniosynostosis surgery AND normal emergence, no seizures, no hydrocephalus, hemodynamically stable, uncomplicated airway, Hgb in PACU >6 mg/dl

Consider PICU admission if: open craniofacial surgery, Hgb in PACU <6 mg/dl, hemodynamically unstable post-operatively, unstable airway, history of hydrocephalus, uncontrolled seizures



[1]**If the child meets the following criteria, please alert the Medical Emergency Team (MET) as appropriate:**

1) SBP <70 mmHg and/or Hgb <6 mg/dL (in PACU)
   - Notify NSG immediately
   - Transfer to PICU if SBP <70 mmHg
   - Transfuse pRBC (<25 cc/kg, unless indicated per hospital policy)
   - Recheck CBC 2-4hrs post-transfusion
   - Continuous CV monitoring and q2-4hr vitals for 12 hours post pRBC transfusion
2) HR >160 bpm and/or UOP <1 ml/kg/hr (first criteria not present)
   - 10 ml/kg 0.9% NS bolus and observe for improvement
   - Notify Neurosurgery if no improvement
3) HR >160 bpm and UOP >1 ml/kg/hr (first criteria not present)
   - Acetaminophen 12.5-15 mg/kg/dose x1 and observe for improvement
   - Consider 5 ml/kg 0.9% NS bolus
   - Notify Neurosurgery if no improvement

[2]**Definition of Acute Kidney Injury**

(It should be noted that this definition does not apply to children <1 year of age)

AKI is defined by having ***either***:

- At least a 50% increase in Scr above baseline* **and** new Scr ≥0.5 mg/ dL **OR**
- An increase by 0.3 mg/dL from baseline*, **and** new Scr ≥0.5 mg/dL

**If a baseline creatinine is unknown, estimate baseline Cr using the Schwartz Calculation (baseline creatinine = (0.413 * height cm)/120 GFR). For patients with Chronic Kidney Disease (CKD), use the CKiD U25 Calculator.*

Discharge Criteria:

Afebrile x24 hrs, vitals stable, good pain management on oral pain regimen, tolerating diet, bowel movement, improved periorbital swelling (and at least one eye open), follow up appointment with orthotics made (for cranial orthosis measurements, production, delivery and teaching)

Discharge Instructions:

- Call 911 for life-threatening emergencies.
- Call Neurosurgery at 860-545-8373 if any of the following: fever ≥101.5° F, redness, swelling, any drainage (monitoring for infection or CSF leak), poor wound healing, increased pain, increased swelling, poor oral intake, vomiting, changes in bowel/bladder function, changes in fontanelle, increased sleepiness, or with any other questions or concerns.

- Patient's who have undergone minimally invasive surgery are eligible for transfer to Med/Surg unit the flowing criteria must be met:
  - Normal emergence from anesthesia
  - No history of seizures
  - No hydrocephalus
  - Hemodynamically stable
  - Uncomplicated airway
  - Hemoglobin in PACU above 6.0 mg/dl
- Patients who underwent an open procedure, or do not meet above criteria will be admitted to the PICU post-operatively.

CONTACTS: MARKUS BOOKLAND, MD | JONATHAN MARTIN, MD | NELLA STOLTZ, APRN, DNP

LAST UPDATED: 07.23.25

Connecticut Children's

CLINICAL PATHWAY:

Minimally Invasive Craniosynostosis

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

Inclusion Criteria: patients s/p craniosynostosis surgery

Care in PACU[1]:

- Vitals q1hr
- CBC 1 hour post-op
- Pain management per anesthesia

To remain in PACU until post-operative CBC results have been reviewed and/or transfer at the discretion of the neurosurgery team

Consider Med/Surg admission if: minimally invasive craniosynostosis surgery AND normal emergence, no seizures, no hydrocephalus, hemodynamically stable, uncomplicated airway, Hgb in PACU >6 mg/dl

Consider PICU admission if: open craniofacial surgery, Hgb in PACU <6 mg/dl, hemodynamically unstable post-operatively, unstable airway, history of hydrocephalus, uncontrolled seizures

stable
- Calculate Pediatric Early Warning Score (PEW) and activate Medical Emergency Team (MET), per hospital protocol

Notify Neurosurgery immediately if:
- Wound drainage
- SBP <70 mm Hg
- Temp >38.4° C

acetaminophen, switch to **acetaminophen PO:** 15 mg/kg/ dose q6hr PRN pain (max 75 mg/ kg/day or 4000 mg/day) for mild/ moderate pain; *may use PR acetaminophen for infants.*
- *If >6 mo old:* add **ibuprofen** (100 mg/5 mL): 10 mg/kg/dose q6-8hr PRN pain

Moderate/Severe:
- Continue **ibuprofen** (if >6 months), as above
- **Morphine** 0.05-0.1 mg/kg/dose q3hr PRN pain (max dose 5 mg/dose)

If penicillin allergy:
- Vancomycin IV
  - <52 weeks PMA[1]/about <3 mo old: 15 mg/kg q8hr or as determined by pharmacy based on estimated AUC
  - ≥52 weeks PMA[1]/about ≥3 months old – 11 years old: 70 mg/kg/day div q6hr (max 3 g/day)
  - ≥12 yrs old: 60 mg/kg/ day div q8hr (max 3 g/ day)

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

(KCl may be left out if patient has hx renal impairment)

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

Other:
- **Pediatric glycerin suppository** daily PRN constipation

regular baby shampoo

Activity:
- Consult Hangar/ orthodics
- Advance as tolerated

Positioning:
- Elevate HOB to help with post-op swelling

[1]If the child meets the following criteria, please alert the Medical Emergency Team (MET) as appropriate:

1) SBP <70 mmHg and/or Hgb <6 mg/dL (in PACU)
   - Notify NSG immediately
   - Transfer to PICU if SBP <70 mmHg
   - Transfuse pRBC (<25 cc/kg, unless indicated per hospital policy)
   - Recheck CBC 2-4hrs post-transfusion
   - Continuous CV monitoring and q2-4hr vitals for 12 hours post pRBC transfusion
2) HR >160 bpm and/or UOP <1 ml/kg/hr (first criteria not present)
   - 10 ml/kg 0.9% NS bolus and observe for improvement
   - Notify Neurosurgery if no improvement
3) HR >160 bpm and UOP >1 ml/kg/hr (first criteria not present)
   - Acetaminophen 12.5-15 mg/kg/dose x1 and observe for improvement
   - Consider 5 ml/kg 0.9% NS bolus
   - Notify Neurosurgery if no improvement

[2]Definition of Acute Kidney Injury

(It should be noted that this definition does not apply to children <1 year of age)

AKI is defined by having ***either***:
- At least a 50% increase in Scr above baseline* **and** new Scr ≥0.5 mg/ dL **OR**
- An increase by 0.3 mg/dL from baseline*, **and** new Scr ≥0.5 mg/dL

**If a baseline creatinine is unknown, estimate baseline Cr using the Schwartz Calculation (baseline creatinine = (0.413 * height cm)/120 GFR). For patients with Chronic Kidney Disease (CKD), use the CKiD U25 Calculator.*

Discharge Criteria:

Afebrile x24 hrs, vitals stable, good pain management on oral pain regimen, tolerating diet, bowel movement, improved periorbital swelling (and at least one eye open), follow up appointment with orthotics made (for cranial orthosis measurements, production, delivery and teaching)

Discharge Instructions:
- Call 911 for life-threatening emergencies.
- Call Neurosurgery at 860-545-8373 if any of the following: fever ≥101.5° F, redness, swelling, any drainage (monitoring for infection or CSF leak), poor wound healing, increased pain, increased swelling, poor oral intake, vomiting, changes in bowel/bladder function, changes in fontanelle, increased sleepiness, or with any other questions or concerns.

A transfusion given intra-operatively is not an automatic PICU admission as long as the post-transfusion Hemoglobin is greater than 6.0 mg/dl, there is no active bleeding, and the child has been hemodynamically stable since transfusion was given.

CONTACTS: MARKUS BOOKLAND, MD | JONATHAN MARTIN, MD | NELLA STOLTZ, APRN, DNP

LAST UPDATED: 07.23.25

Connecticut Children's

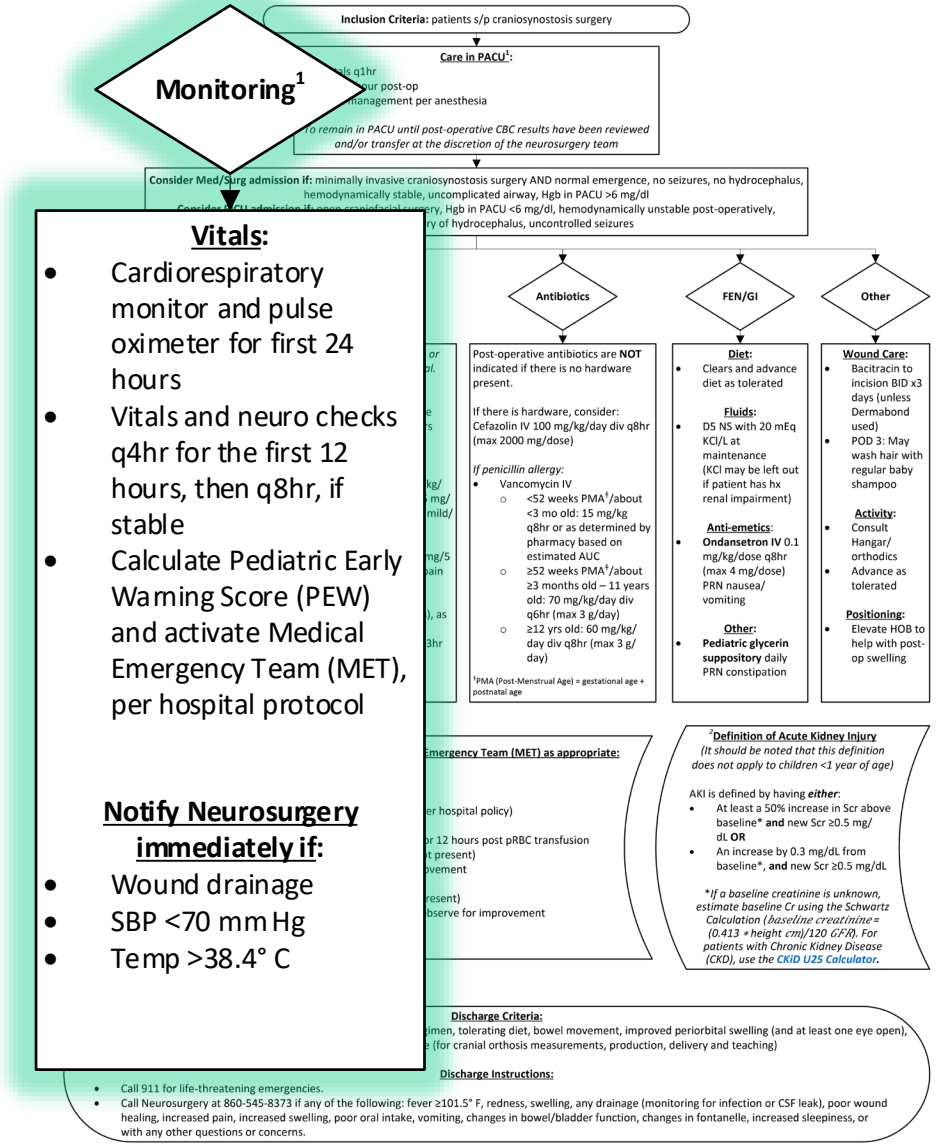
- No blood work is required post-operatively unless the patient is unstable

- Notify Neurosurgery immediately for any:
  - Wound drainage
  - Systolic blood pressures less than 70mmHg
  - Temperature greater than 38.4 C

CLINICAL PATHWAY:

Minimally Invasive Craniosynostosis

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



CONTACTS: MARKUS BOOKLAND, MD | JONATHAN MARTIN, MD | NELLA STOLTZ, APRN, DNP

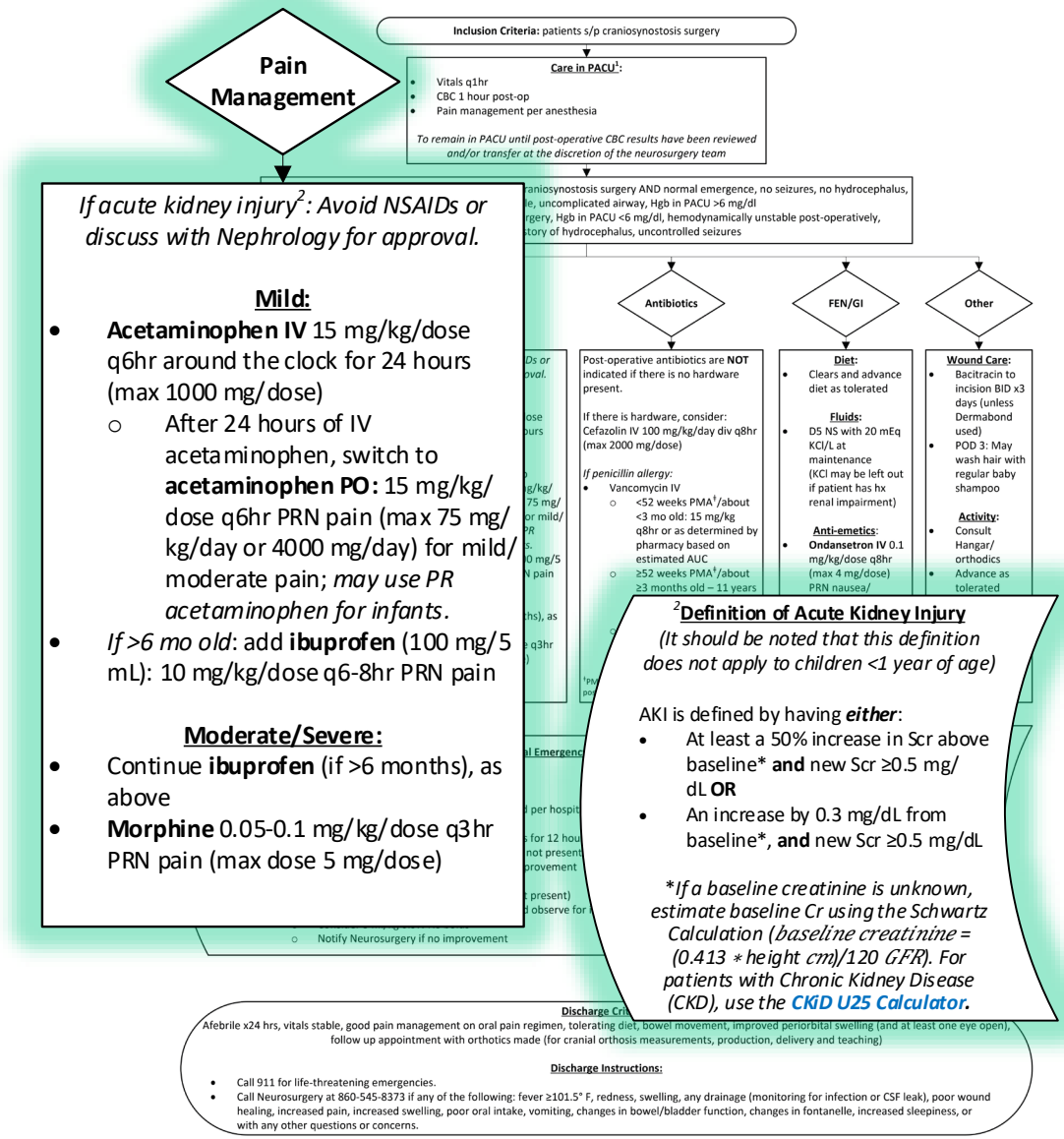
LAST UPDATED: 07.23.25

- Take note of those patients with history of renal dysfunction/ impairment.
- The definition of AKI has been updated and is available as a key.
  - Discuss the case with nephrology if needed

CLINICAL PATHWAY:

Minimally Invasive Craniosynostosis

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



CONTACTS: MARKUS BOOKLAND, MD | JONATHAN MARTIN, MD | NELLA STOLTZ, APRN, DNP

LAST UPDATED: 07.23.25

Connecticut Children's

- Antibiotics should only be given for 24 hours post-operatively.

CLINICAL PATHWAY:
Minimally In[illegible] Craniosynostosis

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

Antibiotics

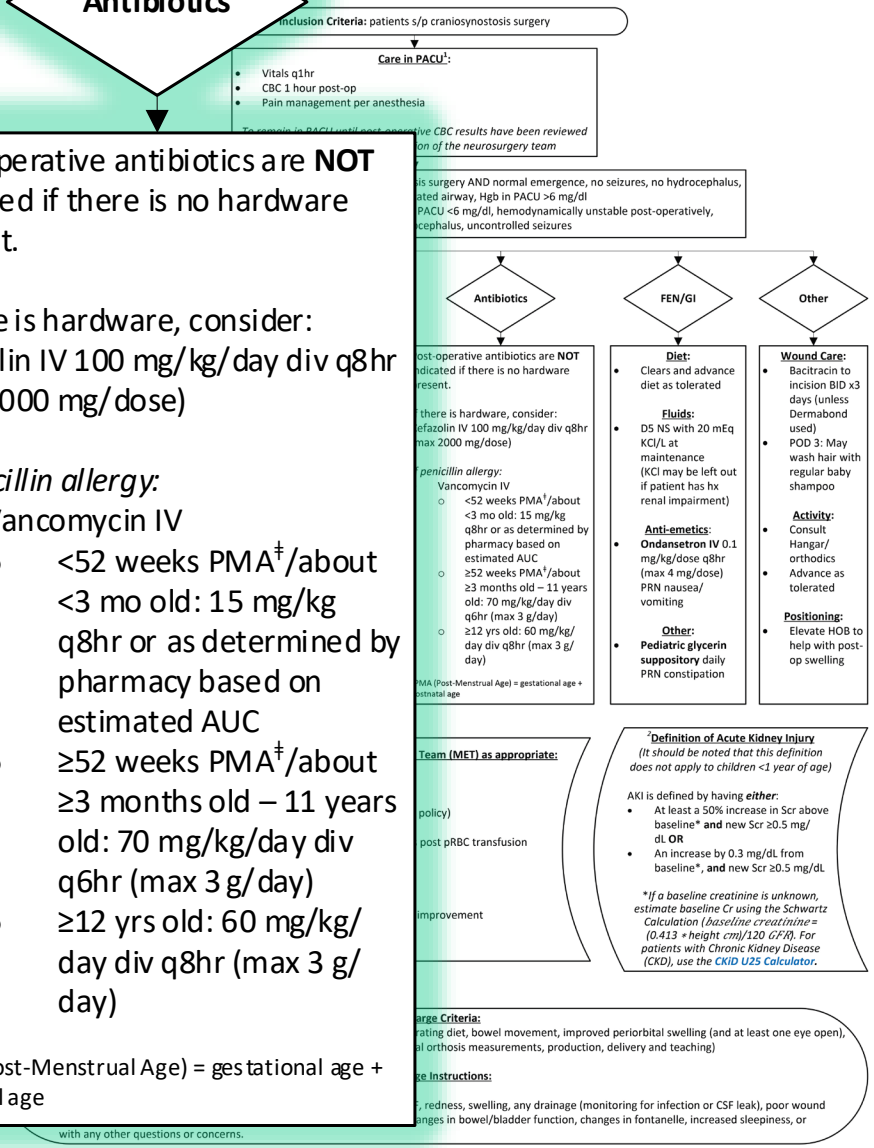
Post-operative antibiotics are **NOT** indicated if there is no hardware present.

If there is hardware, consider: Cefazolin IV 100 mg/kg/day div q8hr (max 2000 mg/dose)

If penicillin 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 (max 3 g/day)
  - ≥12 yrs old: 60 mg/kg/day div q8hr (max 3 g/day)

‡PMA (Post-Menstrual Age) = gestational age + postnatal age



CONTACTS: MARKUS BOOKLAND, MD | JONATHAN MARTIN, MD | NELLA STOLTZ, APRN, DNP

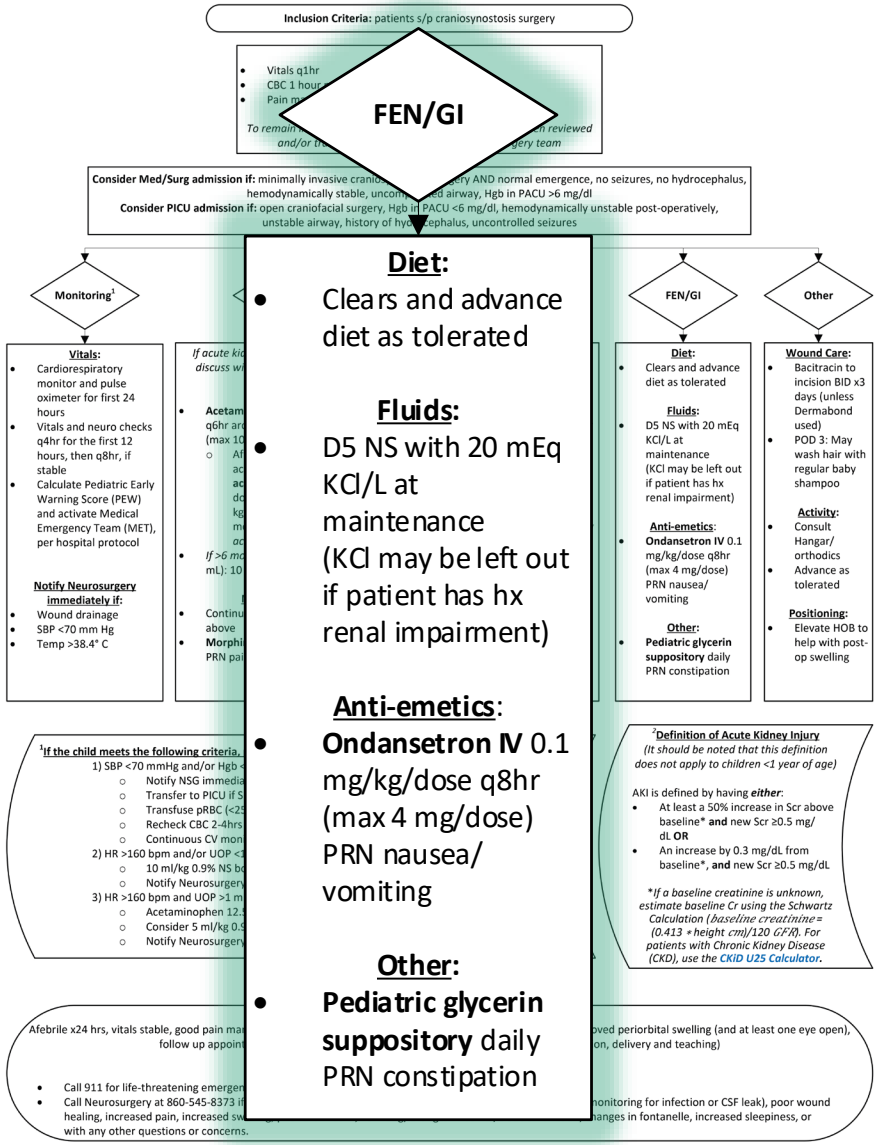
LAST UPDATED: 07.23.25

- Patients can advance their diet as tolerated
- Those with a history of renal dysfunction/impairment should not have KCl in their fluids

CLINICAL PATHWAY:

Minimally Invasive Craniosynostosis

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



CONTACTS: MARKUS BOOKLAND, MD | JONATHAN MARTIN, MD | NELLA STOLTZ, APRN, DNP

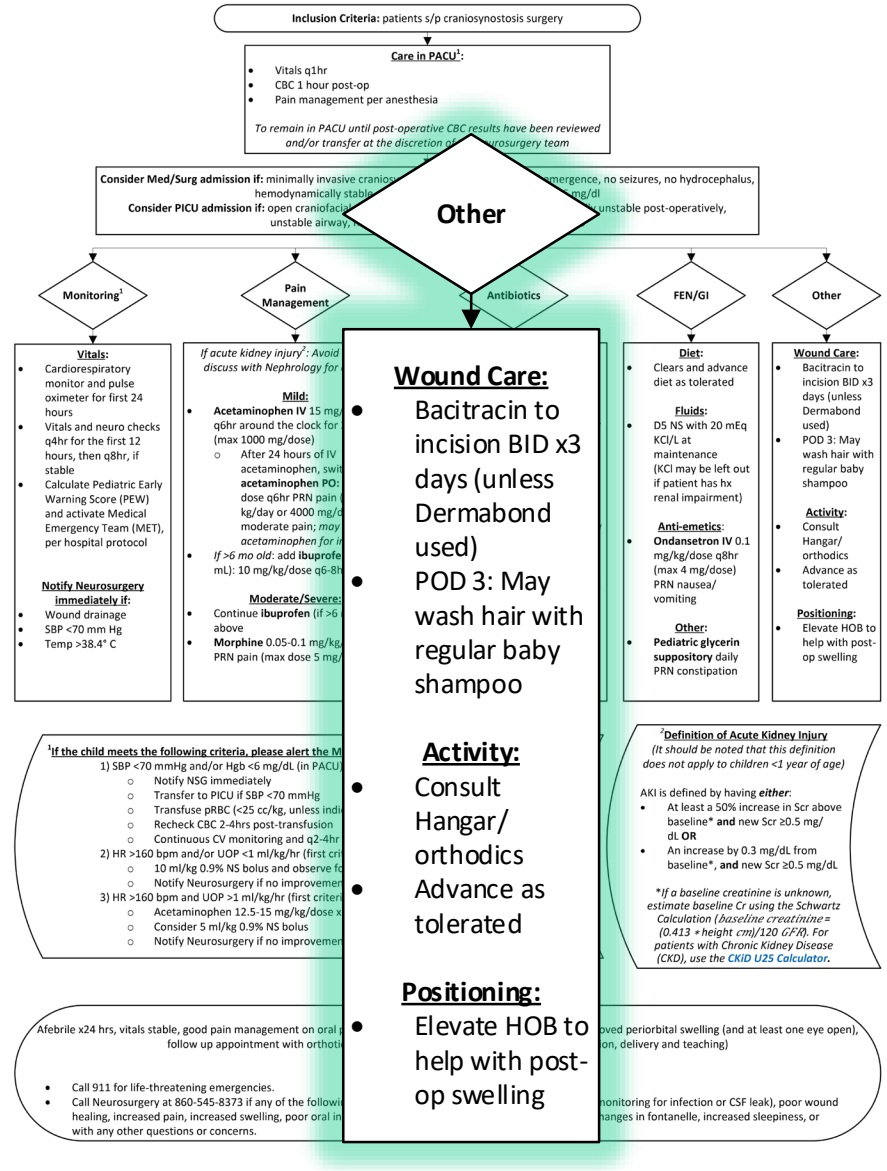
LAST UPDATED: 07.23.25

- Bacitracin is applied to surgical incisions that do not have dermabond on them.
- Hanger orthothotics is consulted for helmet fitting

CLINICAL PATHWAY:

Minimally Invasive Craniosynostosis

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



CONTACTS: MARKUS BOOKLAND, MD | JONATHAN MARTIN, MD | NELLA STOLTZ, APRN, DNP

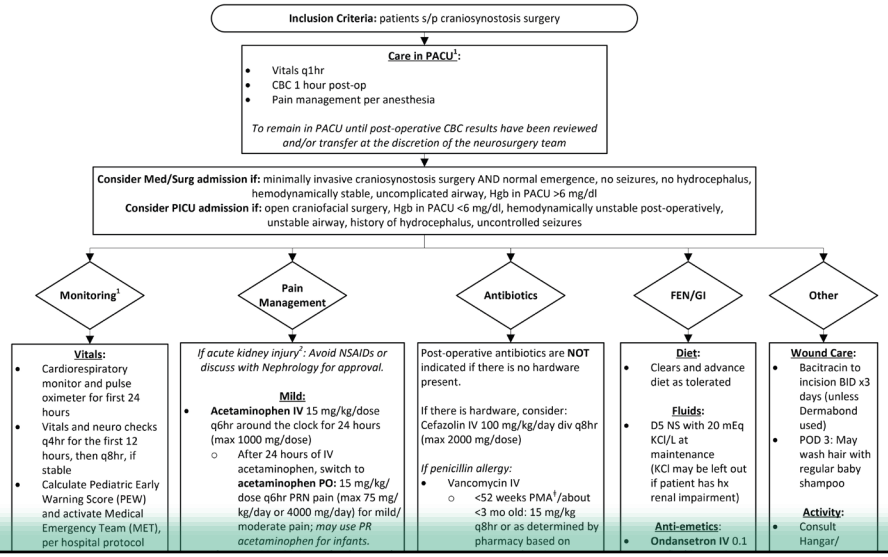
LAST UPDATED: 07.23.25

CLINICAL PATHWAY:

Minimally Invasive Craniosynostosis

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

If patient becomes unstable at any point, utilize the Medical Emergency Team (MET) as appropriate



[1]If the child meets the following criteria, please alert the Medical Emergency Team (MET) as appropriate:

1) SBP <70 mmHg and/or Hgb <6 mg/dL (in PACU)
   - Notify NSG immediately
   - Transfer to PICU if SBP <70 mmHg
   - Transfer pRBC (<25 cc/kg, unless indicated per hospital policy)
   - Recheck CBC 2-4hrs post-transfusion
   - Continuous CV monitoring and q2-4hr vitals for 12 hours post pRBC transfusion
2) HR >160 bpm and/or UOP <1 ml/kg/hr (first criteria not present)
   - 10 ml/kg 0.9% NS bolus and observe for improvement
   - Notify Neurosurgery if no improvement
3) HR >160 bpm and UOP >1 ml/kg/hr (first criteria not present)
   - Acetaminophen 12.5-15 mg/kg/dose x1 and observe for improvement
   - Consider 5 ml/kg 0.9% NS bolus
   - Notify Neurosurgery if no improvement

CONTACTS: MARKUS BOOKLAND, MD | JONATHAN MARTIN, MD | NELLA STOLTZ, APRN, DNP

LAST UPDATED: 07.23.25

CLINICAL PATHWAY:

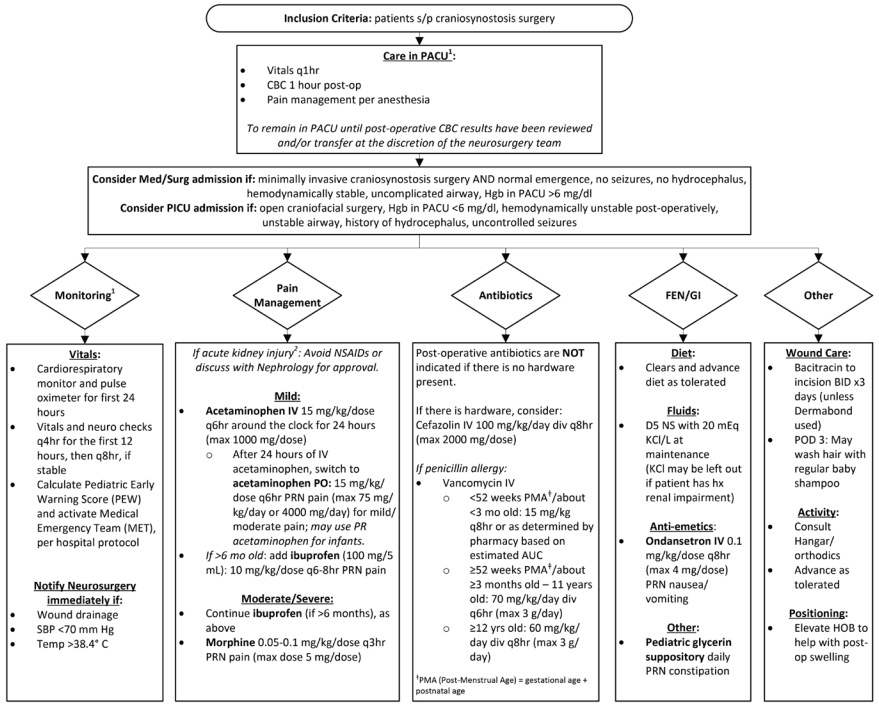
Minimally Invasive Craniosynostosis

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

Patient should be afebrile for 24 hours prior to discharge and able to open at least one eye.

Follow up appointment with Hanger orthotics should be set up.

Discharge instructions include when to call Neurosurgery post-discharge.



Discharge Criteria:

Afebrile x24 hrs, vitals stable, good pain management on oral pain regimen, tolerating diet, bowel movement, improved periorbital swelling (and at least one eye open), follow up appointment with orthotics made (for cranial orthosis measurements, production, delivery and teaching)

Discharge Instructions:

- Call 911 for life-threatening emergencies.
- Call Neurosurgery at 860-545-8373 if any of the following: fever ≥101.5° F, redness, swelling, any drainage (monitoring for infection or CSF leak), poor wound healing, increased pain, increased swelling, poor oral intake, vomiting, changes in bowel/bladder function, changes in fontanelle, increased sleepiness, or with any other questions or concerns.

CONTACTS: MARKUS BOOKLAND, MD | JONATHAN MARTIN, MD | NELLA STOLTZ, APRN, DNP

LAST UPDATED: 07.23.25

Connecticut Children's

Review of Key Points

- For patients who underwent Minimally Invasive Craniosynostosis surgery, the following criteria must be met for transfer to Med/Surg unit
  - Normal emergence from anesthesia
  - No seizure history
  - No hydrocephalus
  - Hemodynamically stable
  - Uncomplicated airway
  - Hemoglobin in PACU greater than 6.0 mg/dl
- Vital signs and neuro checks every 4 hours for the first 12 hours then every 8 hours if patient stable
- No blood work is required for patient post operatively unless unstable.
- Pain control
- Post-operative antibiotics are **NOT** indicated if there is no hardware presen
- Notify neurosurgery attending for any bleeding, instability (e.g., SBP <70 mm Hg, febrile), or wound drainage immediately

Quality Metrics

- Percentage of eligible patients treated per pathway
- Percentage of patients with use of order set
- Percentage of patients transferred to the PICU within 24 hours
- Percentage of patients requiring blood transfusion within 24 hours of surgery
- Readmissions within 30 days
- Returns to the OR within 30 days

Pathway Contacts

- Petronella Stoltz, APRN, DNP
  - Department of Pediatric Neurosurgery
- Marcus Bookland, MD
  - Department of Pediatric Neurosurgery
- Jonathan Martin, MD
  - Department of Pediatric Neurosurgery

References

- Allareddy V. Prevalence and impact of complications on hospitalization outcomes following surgical repair for craniosynostosis. *J Oral Maxillofac Surg*. 2014 Dec;72(12):2522-30.
- Arts S, Delye H, van Lindert EJ. Intraoperative and postoperative complications in the surgical treatment of craniosynastosis: Minimally invasive verses open surgical procedures. *J Neurosurg Pediatr.* 2018 Feb;21(2):112-118.
- Burokas L. Craniosynastosis: Caring for infants and their families. *Crit Care Nurse*. 2013 Aug;33(4):39-50; quiz 51.
- Han RH, Nguyen DC, Bruck BS, Skolnick GR, Yarbrough CK, Naidoo SD, Patel KB, Kane AA, Woo AS, Smyth MD. Characterization of complications associated with open and endoscopic craniosynostosis surgery at a single institution. J Neurosurg Pediatr. 2016 Mar;17(3):361-70.
- Proctor MR. Endoscopic craniosynostosis repair. Transl Pediatr. 2014 Jul;3(3):247-58.

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.