



Imaging for Pediatric Headache: Clinical Algorithms to Guide Imaging Decision Making

Developed and Contributed by:

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Algorithm Development Background

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Our goal for this project is to guide imaging use in children with headaches through visual representation of evidence-based clinical algorithms. We identified three types of headache in need of guidance: general, trauma, infection, and sinus headaches. We developed an algorithm for each type based on existing consensus statements and clinical practice guidelines by professional medical societies, including the American College of Radiology Appropriateness Criteria[®]. The information was conveyed as visual algorithms featuring clinical yes-no decision trees that ultimately lead to either an imaging recommendation or an alternative workup without imaging.

Each algorithm was reviewed by a specialist in the field at our institution: neurology for the general algorithms, emergency medicine for the trauma algorithm, otolaryngology for the sinus algorithm, and neuroradiology for all algorithms. These specialists along with community pediatricians and pediatric specialists provided feedback that resulted in modifications and ultimately algorithm approval.

We are sharing the initial and the adapted algorithms as a starting point for practitioners throughout the U.S. who would like to adapt these to their local practice needs. The algorithms represent the state of evidence in 2019 and a process for continuous monitoring of emerging evidence and changes to the algorithms should be implemented. The algorithms incorporate clinical as well as radiologic information, cover a broad spectrum of pediatric headache, and can be adapted to multiple practice contexts (e.g., primary care office, emergency department, inpatient). For example, during our adaptation process the "infection" algorithm was folded into the general algorithm because the next step would be imaging or a lumbar puncture and those procedures are not performed in our community pediatrician offices and would require referral to the hospital as the next step. Also, we modified red flags for headache according to our neurologists' practice preferences, although some of these changes are not supported (yet) by scientific evidence.

The adapted algorithms are currently part of a quality improvement project in our community where we are tracking various interventions geared towards improved imaging use, starting with educating referring physicians and providing access to these algorithms. I encourage other pediatric radiologists to consider similar projects within their healthcare setting to include using an R-SCAN quality improvement project to track progress.



Algorithm Disclaimer

The algorithms in their current form are not intended for clinical use, instead they should be reviewed and adapted to local practice needs and local expert opinions. Both the original algorithms and the post-interdisciplinary team review adopted algorithms are presented to demonstrate changes that may result from working with a multi-disciplinary team on local adaption.

Implementing the Tools

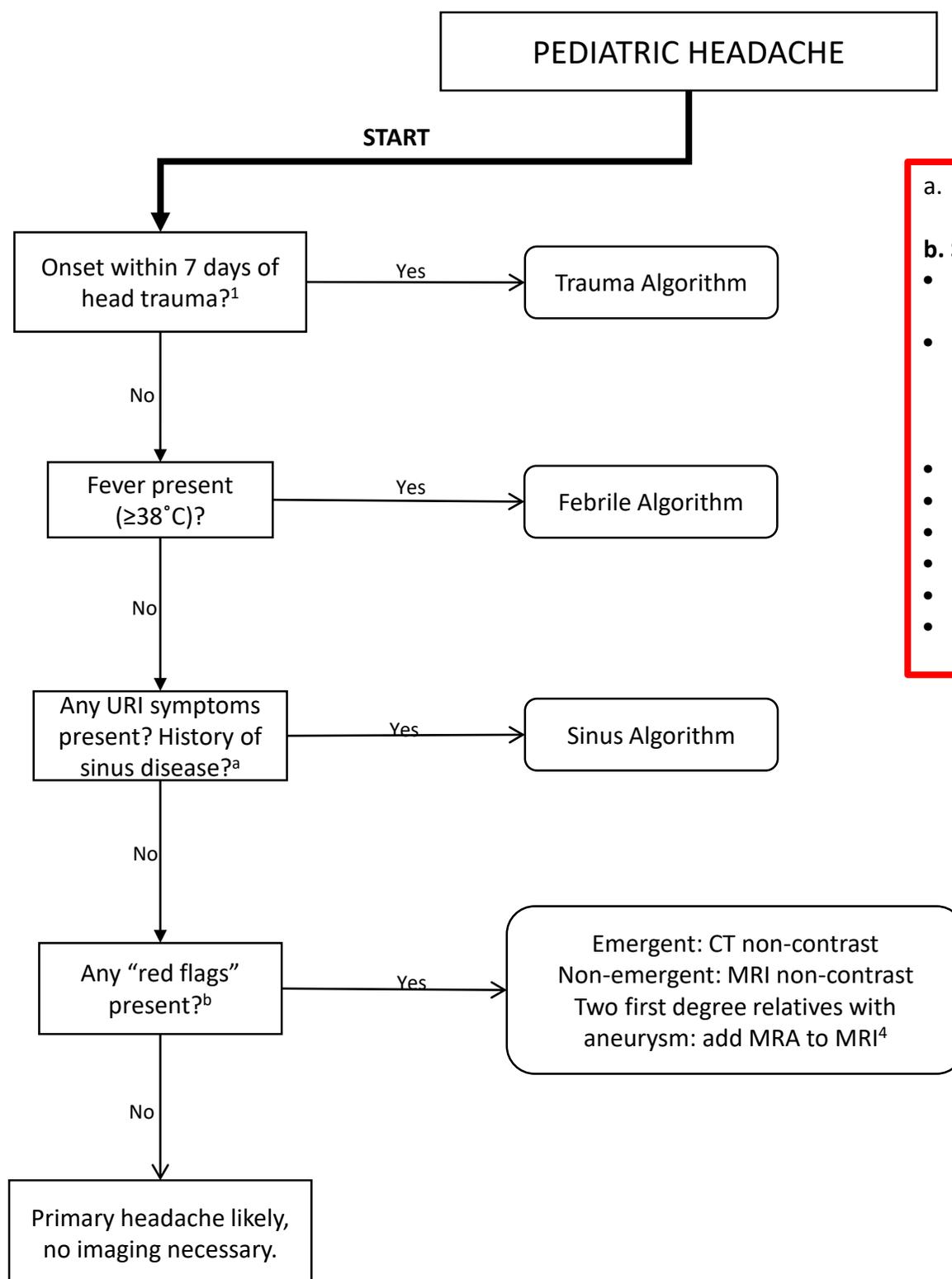
Algorithms:

- Assemble interdisciplinary teams
- Review and revise algorithms as desired
- Implement as guidance materials

Associated Quality Improvement Project:

- Set SMART goals: Specific, Measurable, Attainable, Relevant and Timely
- Measure baseline and outcomes after algorithm implementation and adoption by all stakeholders
- Use continuous improvement methodology to achieve the desired results
- Use an R-SCAN QI Project template to track progress for participants to earn 20 performance improvement CME. Contact: rscaninfo@acr.org for more information.

ORIGINAL OVERALL HEADACH ALGORITHM (Prior to multi-disciplinary team review)

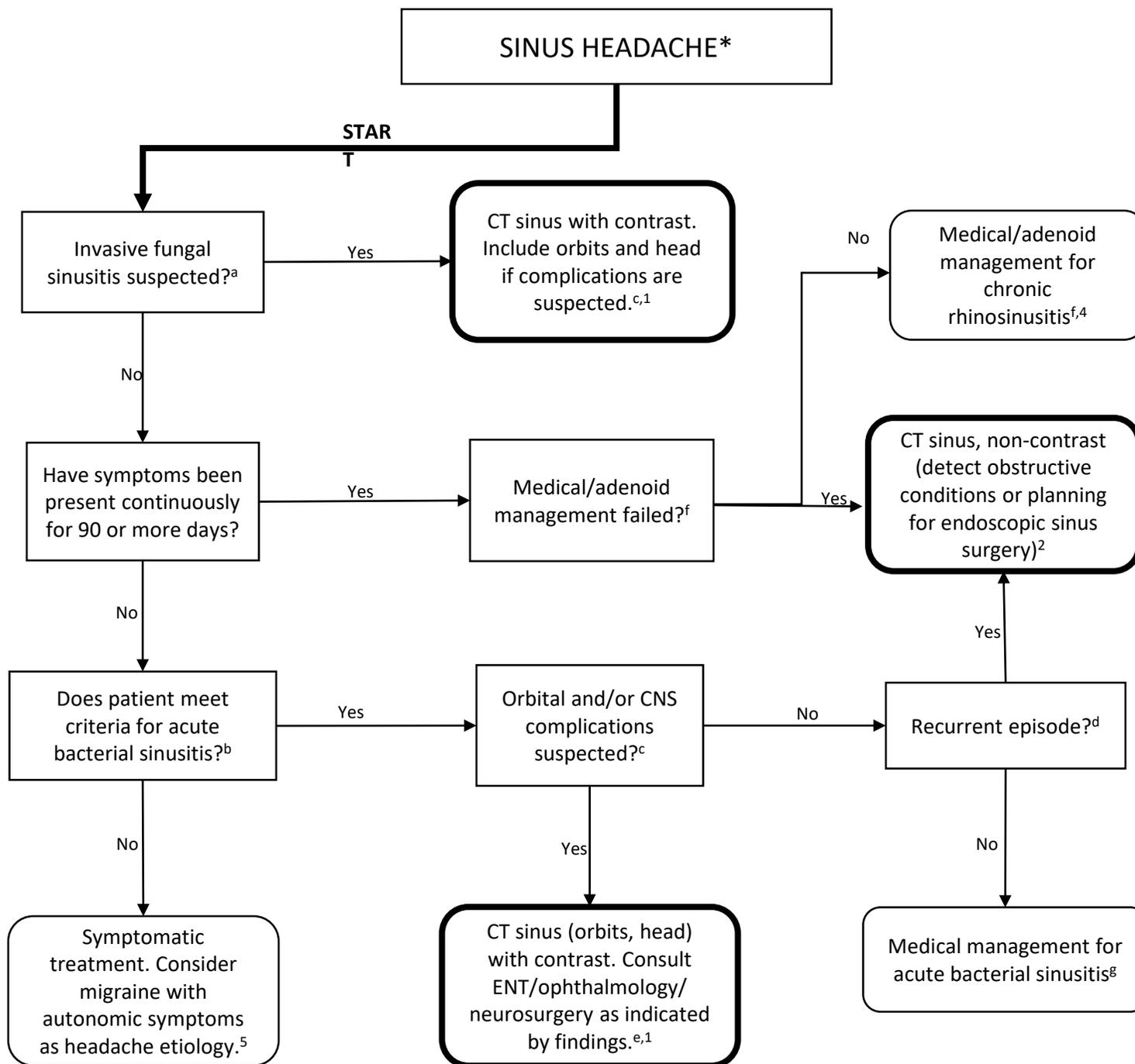


- a. Daytime cough, nasal congestion or obstruction, nasal discharge of any quality
- b. **SNOOPPPY "Red Flags":**^{2,3}
- **S**ystemic condition: anticoagulation, pregnancy, malignancy, HIV
 - **N**eurologic signs & symptoms: including papilledema, altered mental status, gait abnormality, seizure. *Not* including fully reversible signs part of regular HA pattern and otherwise consistent with migraine aura.
 - **O**nset new (<1 month) or sudden
 - **O**ccipital location
 - **P**ositional or *p*recipitated by Valsalva
 - **P**rogressive in frequency, duration, or severity
 - **P**arents: lack of family headache history
 - **Y**ears: age <6

References

1. The International Classification of Headache Disorders, 3rd edition (beta version). (2013). *Cephalalgia*, 33(9), 629-808. doi:10.1177/0333102413485658
2. Gofshteyn, J. S., & Stephenson, D. J. (2016). Diagnosis and Management of Childhood Headache. *Curr Probl Pediatr Adolesc Health Care*, 46(2), 36-51. doi:10.1016/j.cppeds.2015.11.003
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4. Hayes, L. L., Palasis, S., Bartel, T. B., Booth, T. N., Iyer, R. S., Jones, J. Y., . . . Karmazyn, B. K. (2018). ACR Appropriateness Criteria Headache-Child. *J Am Coll Radiol*, 15(5s), S78-s90. doi:10.1016/j.jacr.2018.03.017

ORIGINAL SINUS HEADACHE ALGORITHM (Prior to multidisciplinary team review)



- a. Seen in immunocompromised patients, especially with hematologic malignancy. Classic presentation is painless septal necrosis.^{1,2}
- b. Persistent illness ≥ 10 days; OR worsening course after initial improvement; OR concurrent purulent nasal discharge and fever for 3+ days.³
- c. Signs of orbital complications: proptosis, impaired function or pain of extraocular muscles. Signs of CNS complications: photophobia, seizure, *very severe* headache, focal neurologic deficit.³
- d. Defined as discrete episodes of <30 days, separated by >10 symptom-free days. Some experts only consider 4+ episodes within 1 year to be "recurrent."³
- e. Consider adding CTA or MRA/MRV, either as follow-up or part of initial imaging protocol, if vascular complication (e.g. venous thrombosis, mycotic aneurysm) is suspected.¹
- f. Antibiotics, topical nasal steroid spray, nasal saline irrigation. Children under 6 may benefit from adenoidectomy, with no prior imaging required.⁴
- g. Oral amoxicillin +/- clavulanate. Follow up after 72h to tailor therapy if necessary and reassess for complications. Use IV cefotaxime or ceftriaxone in acutely ill/toxic patients.³

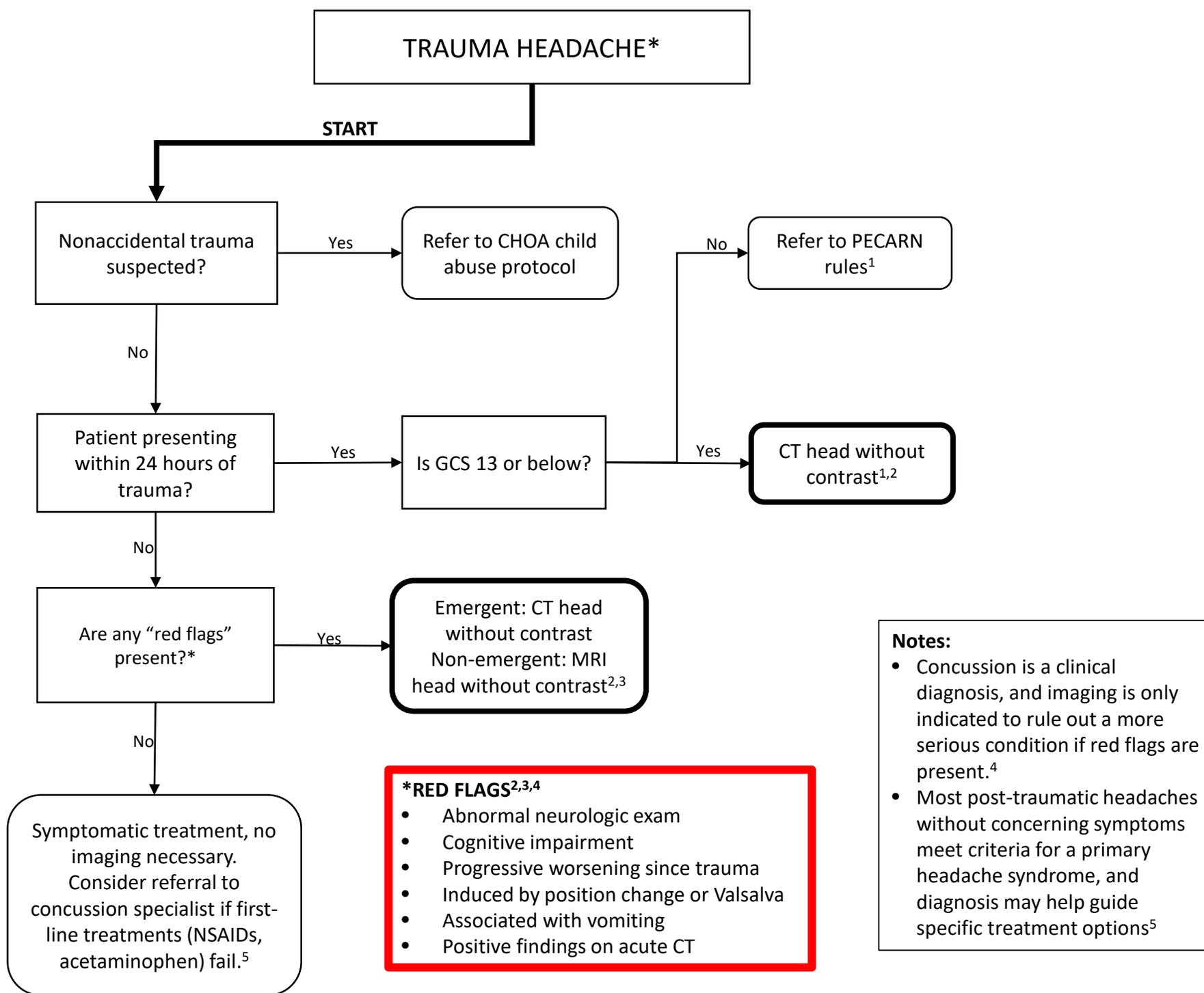
Notes:

- No imaging studies can reliably distinguish viral URI and acute bacterial sinusitis and are thus not recommended for this purpose.^{1,2,3}

References

1. Tekes, A., Palasis, S., Durand, D. J., Pruthi, S., Booth, T. N., Desai, N. K., . . . Karmazyn, B. K. (2018). ACR Appropriateness Criteria Sinusitis--Child. Retrieved from <https://acsearch.acr.org/docs/69442/Narrative/>
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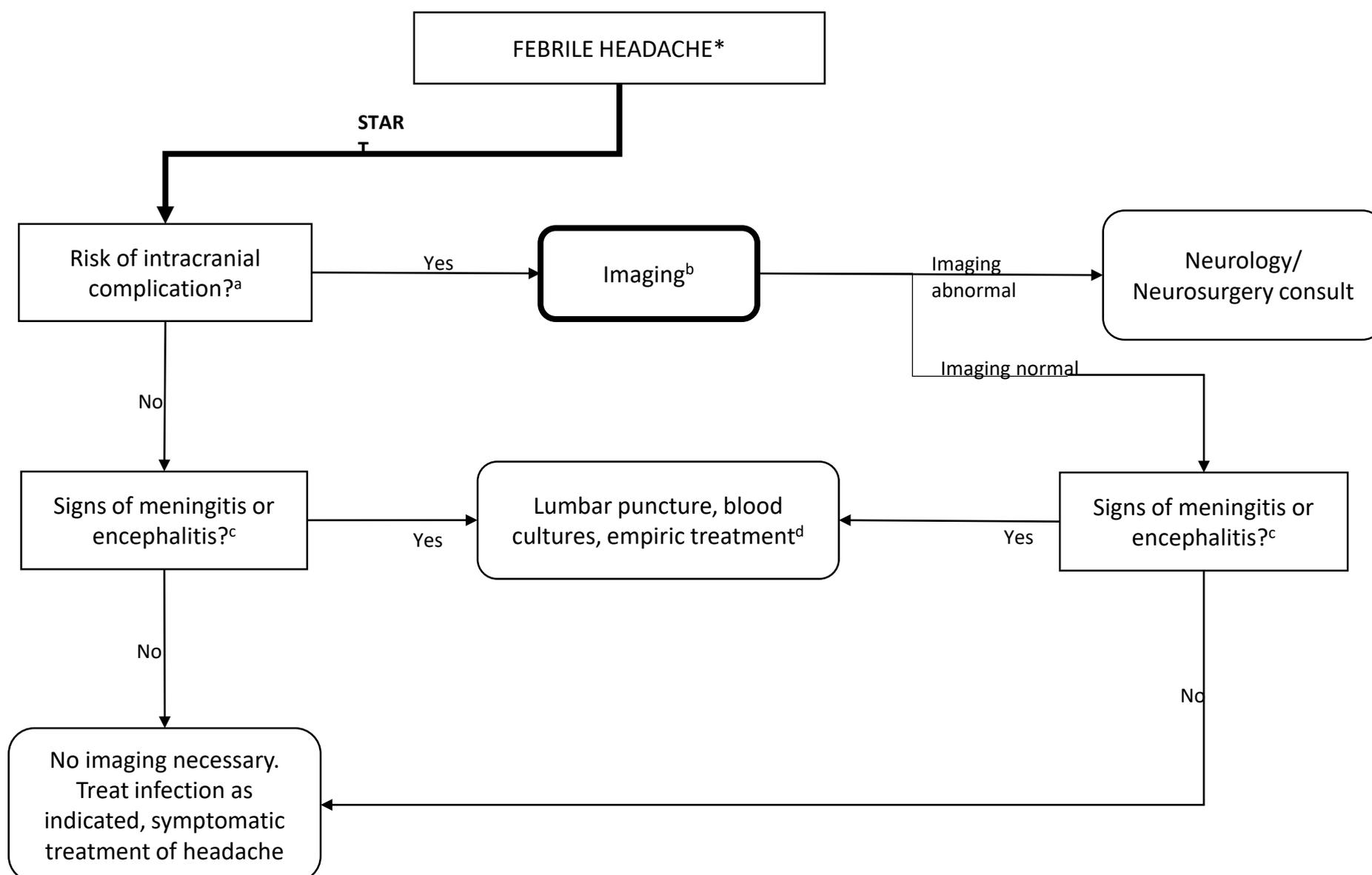
ORIGINAL TRAUMA HEADACHE ALGORITHM (Prior to multidisciplinary team review)



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1. Kuppermann, N., Holmes, J. F., Dayan, P. S., Hoyle, J. D., Jr., Atabaki, S. M., Holubkov, R., . . . Wootton-Gorges, S. L. (2009). Identification of children at very low risk of clinically-important brain injuries after head trauma: a prospective cohort study. *Lancet*, *374*(9696), 1160-1170. doi:10.1016/s0140-6736(09)61558-0
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ORIGINAL INFECTION HEADACHE ALGORITHM (Prior to multidisciplinary team review)



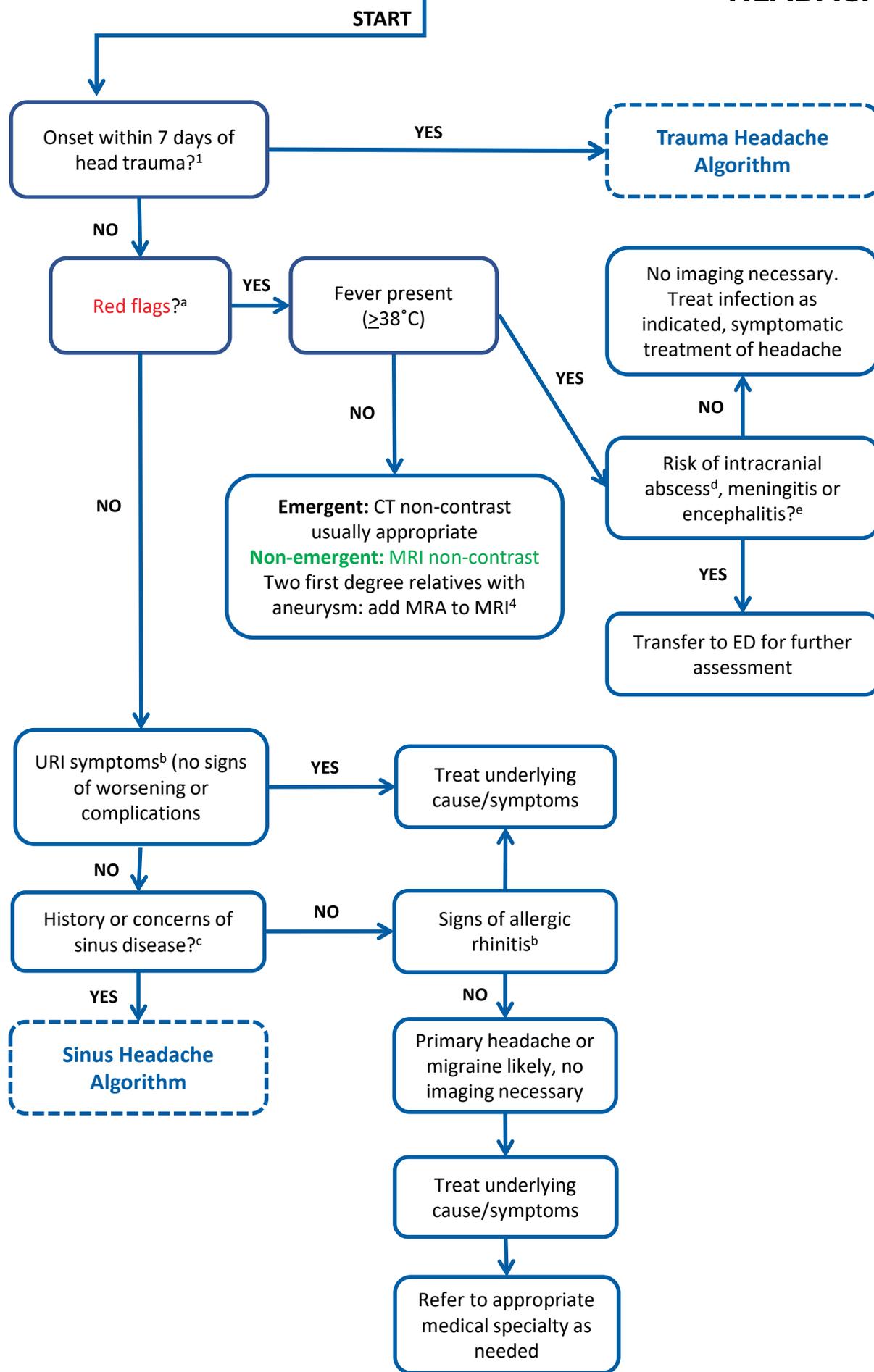
- Immunocompromise, papilledema, focal neurologic deficit, history of CNS disease (mass lesion, stroke, or focal infection including those associated with CSF shunt, hydrocephalus, trauma, and neurosurgery). Seizures, altered mental status, nausea/vomiting, and palsy of cranial nerve VI or VII may suggest intracranial abscess, but are also seen in meningitis so are not reasons to delay LP if indicated.^{1, 2, 3}
- If meningitis suspected, noncontrast CT (to r/o space-occupying lesion before performing LP).² If not, MRI with and without contrast.¹
- Meningitis: nuchal rigidity, stiffness of the hamstring to knee extension (Kernig sign), involuntary hip & knee flexion with passive neck flexion (Brudzinski sign). Encephalitis: acute cognitive dysfunction, behavioral changes, focal neurologic signs, seizures. Specific etiologies may be further suspected based on exposures (e.g. foods, travel, animal contact)⁴
- If encephalitis suspected or if LP findings are benign, add MRI with and without contrast.^{2, 4}

References

- Hayes, L. L., Palasis, S., Bartel, T. B., Booth, T. N., Iyer, R. S., Jones, J. Y., . . . Karmazyn, B. K. (2018). ACR Appropriateness Criteria Headache-Child. *J Am Coll Radiol*, 15(5s), S78-s90. doi:10.1016/j.jacr.2018.03.017
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Pediatric Headache Algorithm

FINAL APPROVED OVERALL HEADACHE ALGORITHM



^a Headache red flags^{2,3}

- Systemic condition: anticoagulation, pregnancy, malignancy, HIV, sickle cell, hypertension, neurofibromatosis (known or suspected), arteriovenous malformation, congenital heart disease
- Neurologic signs and symptoms: including papilledema, altered mental status, gait abnormality, seizures. Not including fully reversible signs part of regular HA pattern and otherwise consistent with migraine aura
- Nighttime onset headache
- Morning headache without explanation (for example sleep apnea could be considered an explanation)
- Intractable (=refractory)
- New or sudden onset
- Precipitated by Valsalva
- Progressive in frequency, duration, or severity

- Occipital location
 - Positional
 - No family headache history
 - Years: age <6
- Non-emergent

Emergent: Needs to be imaged within 24 hours

Non-emergent: Needs to be imaged within 1 month (Expert opinion)

^b Daytime cough, nasal congestion or obstruction, nasal discharge of any quality, scratchy or sore throat, rhinorrhea, sneezing

^c Persistent illness ≥10 days; OR worsening course after initial improvement; OR concurrent purulent nasal discharge and fever for 3+ days.³

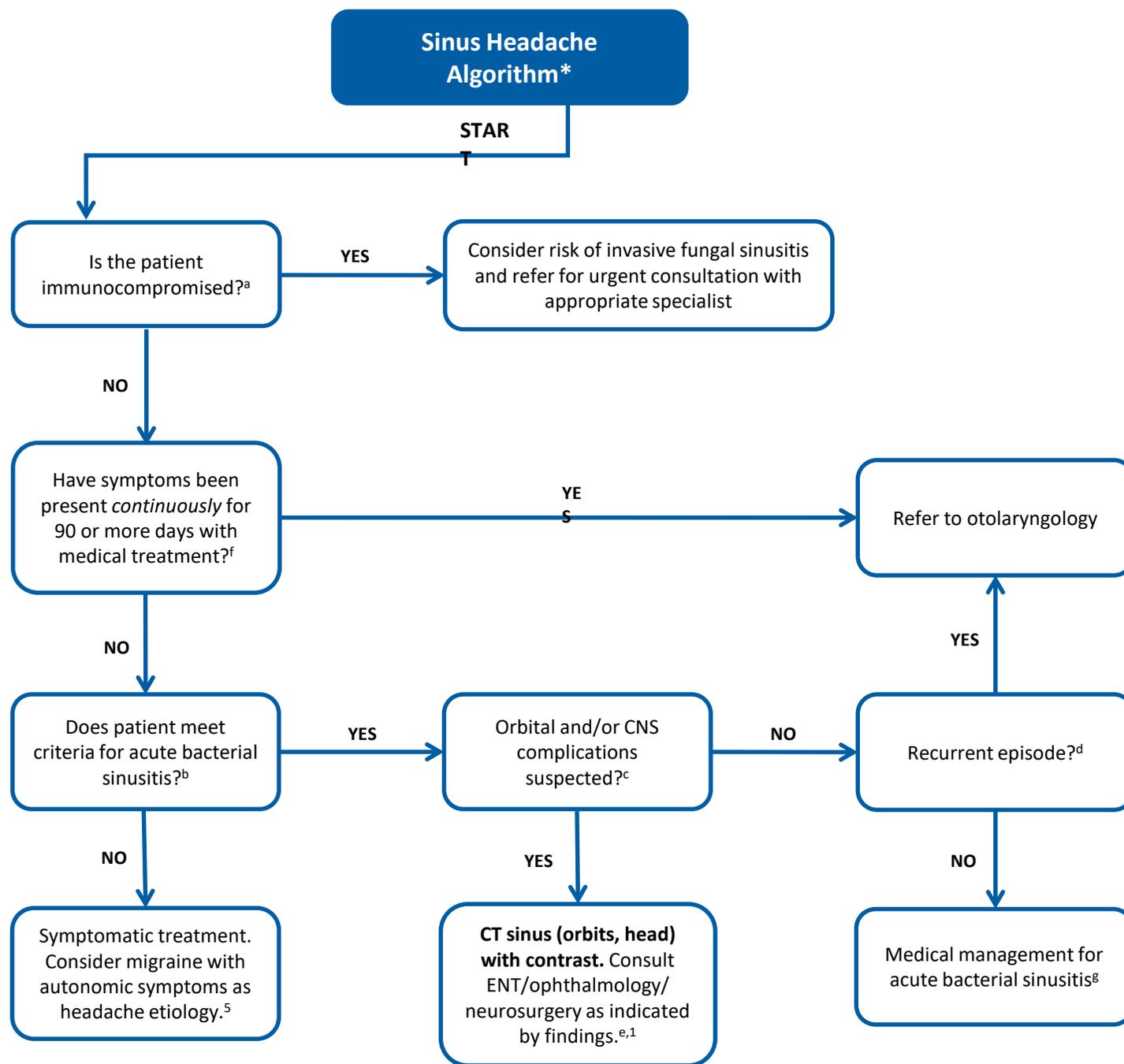
^d Immunocompromised; papilledema; focal neurologic deficit; history of CNS disease (mass lesion, stroke or focal infection, including those associated with CSF shunt, hydrocephalus, trauma and prior neurosurgery). Seizures, altered mental status, nausea/vomiting, and palsy of cranial nerve VI or VII may also suggest intracranial abscess. They may also be seen in meningitis, so it may not be reason to delay LP, if indicated.^{4,6,7}

^e Meningitis: Nuchal rigidity, stiffness of the hamstring to knee extension (Kernig sign), involuntary hip and knee flexion with passive neck flexion (Brudzinski sign). Encephalitis: Acute cognitive dysfunction, behavioral changes, focal neurologic signs, seizures. Specific etiologies may be further suspected based on exposures (e.g. foods, travel, animal contact)⁸

References

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FINAL APPROVED SINUS HEADACHE ALGORITHM



* From the Overall Headache Algorithm question is "history or concerns of sinus disease"?

^a Seen in immunocompromised patients, especially with hematologic malignancy. Classic presentation is painless septal necrosis.^{1,2}

^b Persistent illness ≥ 10 days; OR worsening course after initial improvement; OR concurrent purulent nasal discharge and fever for 3+ days.³

^c Signs of orbital complications: proptosis, impaired function or pain of extraocular muscles. Signs of CNS complications: photophobia, seizure, very severe headache, focal neurologic deficit.³

^d Defined as discrete episodes of <30 days, separated by >10 symptom-free days. Some experts only consider 4+ episodes within 1 year to be "recurrent."³

^e Consider adding CTA or MRA/MRV, either as follow-up or part of initial imaging protocol, if vascular complication (e.g. venous thrombosis, mycotic aneurysm) is suspected.¹

^f Antibiotics, topical nasal steroid spray, nasal saline irrigation. Children <6 may benefit from adenoidectomy with no prior imaging required.⁴

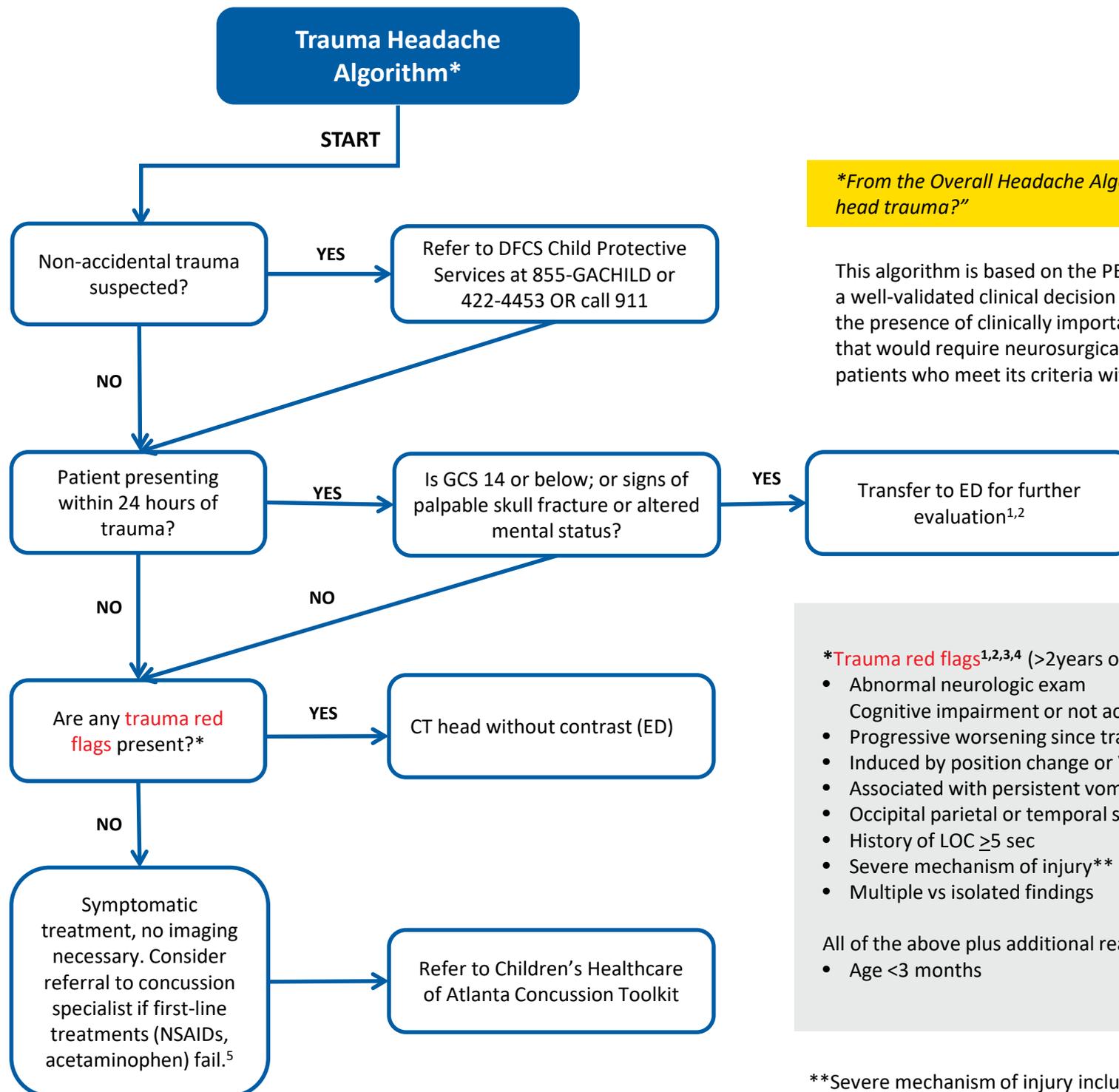
^g Recommend antibiotic treatment. Follow-up after 72 hours to tailor therapy if necessary and reassess for complications. Use IV therapy in acutely ill/toxic patients.³

Note: No imaging studies can reliably distinguish viral URI and acute bacterial sinusitis and are thus not recommended for this purpose.^{1,2,3}

References

1. Tekes, A., Palasis, S., Durand, D. J., Pruthi, S., Booth, T. N., Desai, N. K., . . . Karmazyn, B. K. (2018). ACR Appropriateness Criteria Sinusitis--Child. Retrieved from <https://acsearch.acr.org/docs/69442/Narrative/>
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FINAL APPROVED TRAUMA HEADACHE ALGORITHM



**From the Overall Headache Algorithm question is "onset within 7 days of head trauma?"*

This algorithm is based on the PECARN Pediatric Head Injury Prediction Rule, a well-validated clinical decision aid that allows physicians to safely rule out the presence of clinically important traumatic brain injuries, including those that would require neurosurgical intervention among pediatric head injury patients who meet its criteria without the need for CT imaging.

- *Trauma red flags^{1,2,3,4} (>2years of age)**
- Abnormal neurologic exam
 - Cognitive impairment or not acting normally, GCS <15
 - Progressive worsening since trauma or after ED observation
 - Induced by position change or Valsalva
 - Associated with persistent vomiting
 - Occipital parietal or temporal scalp hematoma
 - History of LOC ≥5 sec
 - Severe mechanism of injury**
 - Multiple vs isolated findings
- All of the above plus additional reasons for getting imaging (<2 years of age):
- Age <3 months

**Severe mechanism of injury includes: motor vehicle crash with patient ejection or death of another passenger; rollover; pedestrian or bicyclist without helmet struck by a motor vehicle; falls of more than 3 ft (<2y) or 5 ft (>2y); head struck by high impact object

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