



PRACTICE

UNCERTAINTIES

Is cranial computed tomography unnecessary in children with a head injury and isolated vomiting?

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What you need to know

- Computed tomography (CT) neuroimaging for children with head injury carries a small increased risk of malignancy
- There is limited low quality evidence that vomiting following head injury in children, in the absence of other clinical features, is not frequently associated with intracranial complications
- In children with minor head injuries and four episodes of isolated vomiting, including one during the observation period, offer review by a clinician experienced in head injury management to decide about further active observation or immediate CT imaging, and involve parents in the decision.

Nearly 35 000 children in the United Kingdom present to emergency departments with head injuries each year.¹ These are largely minor injuries with normal or minimally impaired consciousness level. Around 5% have intracranial complications with approximately 1% having clinically important traumatic brain injuries (box 1).^{1,2}

Box 1: Definitions

TBI-CT—Traumatic brain injury on CT²

Head injury with any of the following signs on CT:

- Intracranial haemorrhage or contusion
- Cerebral oedema, traumatic infarction, diffuse axonal injury, sigmoid sinus thrombosis
- Midline shift of intracranial contents or signs of brain herniation
- Diastasis of the skull, pneumocephalus, skull fracture depressed by at least the width of the table of the skull

ci-TBI—Clinically important traumatic brain injury²

Traumatic brain injury resulting in any of the following:

- Death
- Neurosurgical intervention such as intracranial pressure monitoring, elevation of depressed skull fracture, ventriculostomy, haematoma evacuation, lobectomy, tissue debridement, dura repair
- Intubation for more than 24 hours after injury
- Hospital admission for two nights or more in association with traumatic brain injury on CT

The use of cranial computed tomography (CT) scans to identify intracranial complications in children with head trauma has increased in developed countries. A third of children with head injuries presenting to emergency departments in the United States receive imaging.³ The associated radiation risk for an individual child is low, but it becomes important at a population level. For example, of 35 000 hospital episodes for children with a head injury in England,¹ 3500 children would have cranial CT performed based on a 10% CT rate suggested by the CHALICE rule study.⁴ A reasonable estimate is that one excess neoplasm may be expected per 3000-10 000 head CT examinations in children under 10.⁵ Other studies report a lifetime excess risk of 1 cancer for every 1000 to 5000 paediatric cranial CTs performed, with a higher risk in younger age groups.⁶

Identifying children at low risk of traumatic brain injury could potentially avoid unnecessary CT neuroimaging. Vomiting is a clinical risk factor taken into consideration when assessing children with head injuries. About 10-17% of children have vomiting following a head injury.⁷ It is uncertain how common traumatic brain injury is in children with vomiting following a head injury, and if the frequency of vomiting can stratify the risk to warrant CT imaging.

What is the evidence of uncertainty?

Sources and selection criteria

We searched Medline, PubMed, and the Cochrane Database of Systematic Reviews to identify observational studies that assessed isolated vomiting in paediatric head trauma and the risk of traumatic brain injury.

We used search terms: "head injury," "head trauma," "brain trauma," and "vomiting." We limited our search to studies in English. We found three relevant studies (one meta-analysis, two prospective studies) and three clinical decision making tools.

Differences in clinical practice guidelines

Clinical decision making tools (fig 1, 2), are used to determine which children with head injuries should undergo CT imaging, but they vary in recommendations.⁴ Isolated vomiting—that is, in the absence of other risk factors listed in fig 2—is an indication for CT imaging in the CATCH and CHALICE guidelines but not in PECARN for children under the age of 2. The National Institute for Health and Care Excellence (NICE) guidelines recommend a CT head scan in children with vomiting following head injury, albeit not until a minimum of four discrete episodes of isolated vomiting have occurred, including one during the observation period. PECARN uses two age ranges for children (less than and over two years) while NICE guidelines are for all children under the age of 16. The accuracy of PECARN, CATCH, and CHALICE have recently been prospectively evaluated (20 137 children under the age of 18 with head injuries) with all three decision tools showing high sensitivities when used as designed.¹⁰

Limited evidence with heterogeneity between studies

Few studies investigate isolated vomiting in children with minor head injury. Low quality evidence from observational studies suggests that vomiting following head injury in children is not frequently associated with traumatic brain injury. There is not enough evidence to suggest if repeated vomiting is more predictive of intracranial complications.

A meta-analysis (seven studies, 14 092 children with minor head injury) conducted in 2003 on predictive effect of various clinical symptoms and signs for intracranial pathology found that vomiting was not a predictor for intracranial haemorrhage.¹¹ There is considerable heterogeneity with variation between studies in the inclusion criteria and definition of intracranial haemorrhage. Many studies did not distinguish between single and repeated vomiting, making it difficult to assess if repeated vomiting is more predictive.

Two large prospective observational studies analysed the association of vomiting following head injury in children with the risk of traumatic brain injury (supplementary table).^{7,12} Isolated vomiting is seen in 15-30% of those presenting with vomiting.^{7,12} Around 0.2% of children with isolated vomiting following a minor head injury had ci-TBI.⁷ The prevalence of TBI-CT (0.36-1.7%) was also low in this group. Notably, none of the children with isolated vomiting required neurosurgical intervention.

Isolated vomiting is defined differently between studies. Both studies look at any vomiting, although data are available for the frequency of vomiting. NICE guidelines use less than or more than three episodes of vomiting. The age ranges may differ, with some studies differentiating between those under or over 2 and the upper age limit varying up to 18. Vomiting may not be as prevalent in older children, making the comparison of studies and application of findings difficult.

Is ongoing research likely to provide relevant evidence?

We searched clinicaltrials.gov and the PROSPERO database for studies planned to assess the importance of isolated vomiting in predicting ci-TBI in children. We identified one potentially relevant prospective observational study: Broad Validation Study of a Management Algorithm Mild Head Injury in Children. This multicentre study aims to recruit 10 300 children with minor head injuries and validate the PECARN criteria in a French population. Secondary analysis may provide further data on children with isolated vomiting.

Recommendations for further research

Randomised controlled trials are unlikely to be feasible because of the low incidence of ci-TBI following head injury. Future studies on paediatric head injuries will therefore be observational in nature and must include an analysis of isolated vomiting. Meta-analyses help determine the risk more precisely. Important questions to address in future studies are:

- How frequently does vomiting occur after a minor head injury in children? Is this age dependent?
- Validation of clinical decision making tools in different settings and populations
- How many children with a minor head injury receive a CT scan solely due to isolated vomiting?
- In children with minor head injuries and isolated vomiting, does the timing and frequency of vomiting correlate with ci-TBI or TBI-CT?

(Using a consistent definition of "isolated vomiting" and subgroup analysis of children younger than 2 and older than 2. Further age stratification for older children may determine whether older children follow an adult pattern of presentation)

What should we do in the light of the uncertainty?

Children with isolated vomiting following minor head injury may represent a subgroup which, at the population level, is placed at an increased risk of malignancy by immediate CT scanning, without CT providing any likely change in subsequent clinical management.

In practice, decisions regarding imaging or continued observation are often complex. Coincidental vomiting, due to a viral illness or other conditions in a child, may be mistakenly attributed to a head injury. Conversely, the child may have sustained a minor head injury in the days preceding the onset of vomiting. A thorough assessment is critical to identify other risk factors attributable to the head injury. We would advise following the current NICE guidelines (fig 1) and observing for four hours children who present with a minor head injury and three or more episodes of isolated vomiting. For children presenting with a minor head injury who have four episodes of isolated vomiting including one during a period of observation, we suggest:

Review by a senior clinician experienced in the management of head injuries to decide if a period of ongoing active observation for development of other signs or more persistent vomiting may be appropriate rather than immediate CT head

scan. This senior review is particularly important in the assessment of head injury in children under the age of 2.

Involving families in these decisions is vital. Many families are unaware of the risk CT scans pose. Parents may prefer avoiding CT scans when the risks are explained to them.¹³ This could reduce potential harm from unnecessary radiation in children with minor head injuries and isolated vomiting.

What children and parents need to know

If a child has vomiting following a head injury in the absence of other symptoms, the risk of them having intracranial complications is low

Radiation from head CT scans can result in a very small risk of malignancy in children

Current guidelines recommend a head CT scan where there are persistent episodes of vomiting if there are no other pointers towards an underlying brain injury

Evidence is limited to suggest the number of episodes of vomiting that could indicate brain injury; the development of other symptoms or persistence of vomiting is more important

Based on clinical assessment, in the absence of other risk factors, your doctor may advise a period of active observation with a CT scan performed if there are additional concerns

Education into practice

What factors will you consider on clinical assessment to make a decision regarding CT imaging in a child with a minor head injury?

If a child presents with isolated vomiting following head injury, how will you discuss with parents the likelihood of brain injury and further management?

How patients were involved in the creation of this article

We conducted a Twitter poll for parents stating: head injury guidelines recommend a CT scan of the head if a child vomits four times. If vomiting is the only symptom, the risk of a serious problem is very low. The cancer risk of a CT can be as high as 1 in 1000. Would you support monitoring, and opt for a scan only if symptoms persist?

Result of 350 votes:

84%—continue monitoring

16%—immediate CT

This suggests that parents are likely to avoid a scan if it is not required and the risks are explained to them.

Supplementary file: Evidence summary of observational studies

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Figures

Request CT head within one hour of the risk factor being identified in children who have sustained a head injury and

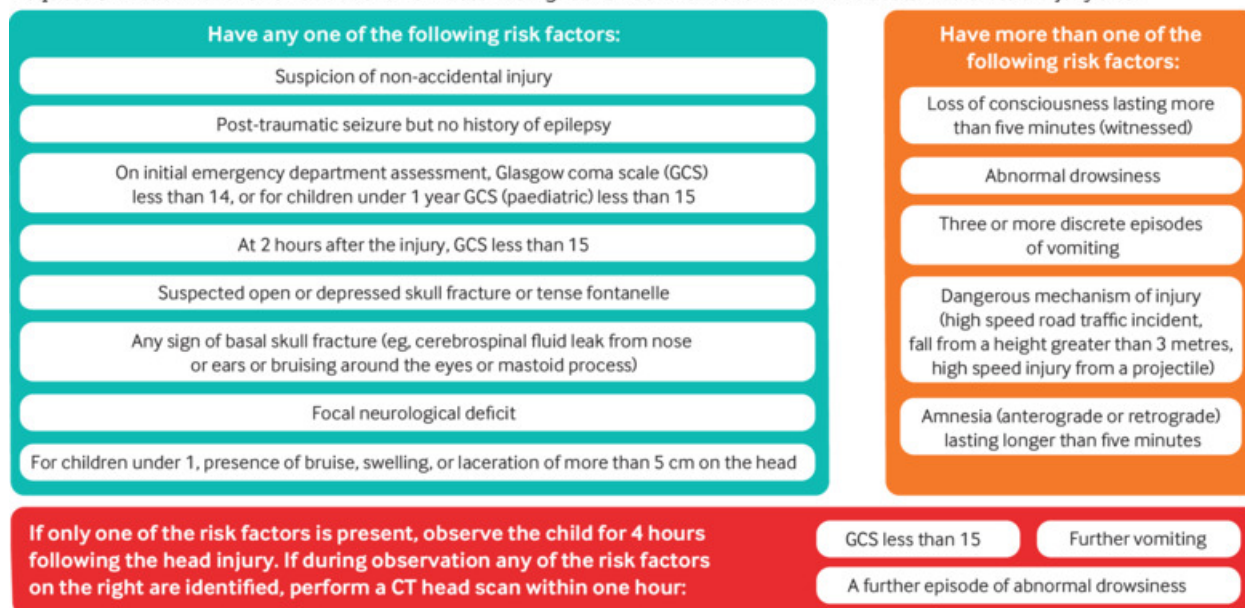


Fig 1 NICE guidelines on head injury in children

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PECARN
Paediatric Emergency Care Applied Research Network
head injury prediction aid

Decision rules for avoiding CT in children with head injury

Vomiting is not a criterion used for children under the age of 2

For children with GCS 14, other signs of altered mental status, or signs of basilar skull fracture, a cranial CT is indicated. If these signs are not present but there is a history of loss of consciousness, vomiting, severe mechanism of injury, or severe headache, the risk of ciTBI is 0.8%. A decision regarding a period of observation versus a cranial CT should be made on the basis of other clinical factors including:

- physician experience
- multiple versus isolated findings
- worsening of symptoms or signs after emergency department observation
- parental preference

CATCH
Canadian assessment of tomography for childhood head injury rule

Predicts clinically significant head injuries in children

A cranial CT is required for children with minor head injury and any one of the following:

- GCS less than 15 at 2 hours after injury
- Suspected open or depressed skull fracture
- History of worsening headache
- Irritability on examination
- Any sign of basal skull fracture
- Large, boggy haematoma of the scalp
- Dangerous mechanism of injury
- Four or more episodes of vomiting

Minor head injury is defined as a head injury within the past 24 hours associated with loss of consciousness, definite amnesia, witnessed disorientation, persistent vomiting (more than one episode) or persistent irritability (in a child <2 years) with GCS 13-15

CHALICE
The children's head injury algorithm for the prediction of important clinical events rule

A CT scan is required if any of the following criteria are present:

History

- Witnessed loss of consciousness of more than five minutes
- History of amnesia of more than five minutes (either antegrade or retrograde)
- Abnormal drowsiness
- Three or more single discrete episodes of vomiting
- Suspicion of non-accidental injury
- Seizure after head injury in a patient who has no history of epilepsy

Examination

- GCS <14 or GCS <15 if <1 year old
- Suspicion of penetrating or depressed skull injury or tense fontanelle
- Signs of basal skull fracture
- Positive focal neurology
- Presence of bruise, swelling, or laceration <5cm if less than 1 year old

Mechanism

- High speed road traffic incident—pedestrian, cyclist, or occupant >40 mph
- Fall >3 m height
- High speed injury from a projectile or an object

The CHALICE rule was derived with a sensitivity of 98% and a specificity of 87%

Fig 2 Clinical decision making tools

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