Isolated Pneumocephalus in Pediatric Minor Head Trauma

Background:

Traumatic brain injuries (TBIs) are among the most common serious injuries sustained by children, resulting in more than 35,000 hospital admissions and 2,100 deaths annually (Faul 2010). Pneumocephalus is one type of TBI, defined as air trapped within the cranial cavity[14]. An estimated 3.9-9.7% of patients with blunt head trauma evaluated with CT scans display pneumocephalus, though estimates in well-described populations of children are lacking [16, 22]. There are two proposed mechanisms for the development of pneumocephalus. The first is the ball-valve theory, where air enters the intracranial spaces through a bony or dural defect via positive pressure. The second proposed mechanism is the "inverted-soda-bottle-effect" where negative intracranial pressure caused by cerebrospinal fluid (CSF) leakage results in the movement of air through a defect into the subdural, subarachnoid, epidural, or intraventricular space [Webber-Jones 2005].

Little research exists which describes the acute outcomes of pneumocephalus in children with minor blunt head trauma. In studies performed mainly on adults, pneumocephalus typically resolves spontaneously and requires only conservative management [2]. However, CSF leakage via otorhinorrhea, which occurs in 32-47% of pneumocephalus cases, brings a significantly increased risk of meningitis requiring antibiotic or surgical intervention [16, 6, 23]. The number and size of air bubbles can also be an indication for intervention, with multiple small air bubbles associated with much less favorable outcomes than larger single air pockets [11, 6]. In rare cases, larger pneumocephali cause mass effect requiring surgical decompression [24, 11]. We aim to determine the prevalence of acute adverse outcomes of pneumocephalus in children with minor blunt head trauma who have no other traumatic brain injuries (isolated pneumocephalus) on CT, particularly in children with normal neurological examinations. This data would help clinicians make appropriate decisions regarding further acute management and disposition of children with isolated pneumocephalus.

Comment [CU1]: Please reword/clarify ---- Very high %, do you mean that only if they have otorhinorrhea then the risk of meningitis is high? But that the majority with pneumocephalus don't have this, correct?

Comment [CU2]: What intervention? Surgery?

Study Design:

We will conduct a retrospective analysis from a de-identified public use data set. The public use data set is titled "Identification of children at very low risk of clinically-important brain injuries after head trauma: a prospective cohort study." The data are from a prospective cohort study that both derived and validated clinical prediction rules to identify children at low risk of clinically important traumatic brain injury (ciTBI) after head trauma [1]. The data set includes 42,412 patients from the 25 emergency departments in the PECARN (Pediatric Emergency Care Applied Research Network) who were 18 years old or younger with minor head trauma, as defined by a Glasgow coma scale score of 14 or 15. The enrollment period lasted from June of 2004 to September of 2006. Exclusion criteria included patients with trivial injuries, penetrating head trauma, preexisting brain tumors, or other neurological disorders that complicated assessment. Patients were initially evaluated within 24 hours of head trauma using a standardized tool to identify mechanism of injury, and signs and symptoms of head trauma. CT scans were obtained at the discretion of the provider.

Patients were then followed to determine if ciTBI (clinically important brain injury) was present. ciTBI was defined as death, neurosurgical intervention for TBI, intubation for >24 hours for TBI, or positive CT scan associated with hospital admission of 2 nights or more. Records of admitted patients were reviewed to evaluate CT results and the presence of ciTBIs. Research coordinators also conducted telephone surveys of guardians of patients discharged directly from the emergency department 7-90 days after discharge to ensure a ciTBI was not missed. In the event that follow-up interviews could not be conducted, emergency room medical records and county morgue records were reviewed to ensure no discharged patients were later diagnosed with ciTBI.

Dataset acquisition:
We will acquire the dataset per the PECARN website (www.pecarn.org) instructions: "The data coordinating center will provide the data set on a CD or DVD as SAS datasets or CSV text files. Electronic copies of the data worksheets, the final study protocol, and a data dictionary will be provided on the disks. No further support will be provided by the data coordinating center, network investigators, or HRSA, to the recipient investigator. Investigators will request the use of a specific dataset by submitting a formal request that includes; a research plan describing the proposed research, a signed data Research Data Use Agreement (RDUA) approval from the researcher's IRB for use of the dataset or documentation that the use of public data sets is exempt from IRB review by institutional policy. The data coordinating center will disseminate the dataset after receipt of the aforementioned items."

Study population
For this subset analysis, we will include patients with isolated pneumocephalus on CT, defined as pneumocephalus without other TBIs. We will, however, include those with pneumocephalus who have non-depressed skull fractures. We will exclude patients in the present analysis if they had Glasgow Coma Scale (GCS) scores of less than14 or did not receive cranial CT scans. Additionally, we will exclude patients with bleeding diatheses or ventricular shunts.

We consider a patient to have had pneumocephalus based on the specific TBI coding in the provided data dictionary. As per the dataset description, each participating site's radiologist made the determination as to the presence or absence of TBI on CT, and the specific finding. Local radiologists received no prior definitions or guidance regarding the definition of what constituted a cerebral contusion. Equivocal CT scans were adjudicated centrally by a lead study radiologist. (Kuppermann, 2009)

As non-depressed linear skull fractures rarely require further intervention (Rollins, 2011), we will categorize patients with pneumocephalus and linear skull fractures as having isolated pneumocephalus. We will review the radiologic impressions of all patients who had both pneumocephalus and skull fractures (available in the public dataset) to determine if any skull fractures were depressed. If we are unable to determine whether the fracture was depressed, we will categorize the patient as having non-isolated pneumocephalus. Patients with skull fractures whose radiologic impressions are missing from the dataset will be excluded from further analysis. We will review the radiologic impressions of all patients with isolated pneumocephalus to determine the number and location of the air pockets and any presence of mass effect. We will categorize the location of the pneumocephalus as epidural, subdural, subarachnoid, intracerebral, or intraventricular.

Acute Adverse Outcomes
We will define acute adverse outcomes as any of the following: death due to TBI, neurosurgery for TBI, or intubation for 24 hours or more for the head trauma. (Kuppermann 2009)

Variables and Definitions
In addition to standard demographic data, we will obtain data on the following variables that are potentially associated with acute adverse outcomes:

Patient factors:

- Neurologic status – We define a normal neurological examination to be the combination of all of the following three clinical findings available in the data set: GCS scores of 15, no other signs of abnormal mental status, and no focal neurological deficits.
- Presence of otorhinorrhea
- Low or not low risk of acute adverse outcomes based on the two age-specific PECARN prediction rules [7].

CT findings:

- Location of the pneumocephalus - epidural/subdural/subarachnoid/intracerebral/intraventricular
- Number of pockets of intracerebral air
- Evidence of mass effect from intracranial air

Statistical Analysis:
We will conduct standard descriptive analyses, including frequencies and proportions for categorical data and means (+/- SD) and medians (with IQRs) for continuous data.

Confidentiality:
The dataset is completely de-identified. It will be provided as a CD or DVD (as SAS datasets) or CSV text files. The study investigators will not share the dataset with others and will maintain the dataset in a locked file.

Consent:
This retrospective study uses a de-identified public use data set.

Potential Benefits:
The clinical implications of pneumocephalus are poorly understood, especially in the

pediatric population. The results of this study may help guide clinicians in the clinical management of pneumocephalus on CT by determining the risk of acute outcomes.

References:

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