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Hearing loss in pediatric temporal bone fractures: Evaluating two radiographic classification systems as prognosticators

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ABSTRACT

Introduction: Temporal bone fractures (TBF) are traditionally classified by their angle of fracture relative to the petrous ridge, and more recently by whether or not they violate the otic-capsule. This study compared rates of hearing loss (HL) and signs of otologic dysfunction among fracture types of both classification systems, within the pediatric population.
Methods: Pediatric patients were retrospectively characterized from a previously identified cohort of TBF patients, diagnosed from 2000 to 2014. CT scans were reviewed and TBFs were classified first as longitudinal (L), transverse (T) or mixed (M), and then as otic-capsule sparing (OCS) or otic-capsule violating (OCV). Medical records were reviewed, and rates of HL and presenting signs were compared among L, T and M fractures, and OCS and OCV fractures.
Results: Forty-three patients with 47 TBFs met the inclusion criteria. Eighteen, 4 and 25 TBFs were classified as L, T and M fractures, respectively. Thirty-three and 9 were classified as OCS, and OCV, respectively. Among 24 cases of HL: 20, 3, and 1 were conductive HL (CHL), sensorineural HL (SNHL) and mixed HL, respectively. Two cases of SNHL were found among OCV fractures, with none in OCS fractures (estimated difference 0.22; 95% confidence interval 0.01–0.60). Similar rates of CHL were found across L, T and M fractures (range 36–50%), and across OCV and OCS fractures (range 42–44%). Hemotympanum was the most common presenting sign, found in 68% of TBFs and 80% of CHL cases. There were no significant differences in the incidence of signs or symptoms between fracture types.
Conclusions: In our cohort, both the traditional and otic-capsule radiographic classification systems failed to predict the incidence of CHL and other otologic signs in the pediatric population. Though OCV fractures conferred an increased risk for developing SNHL, we found a lower incidence than anticipated given violation to the bony labyrinth.

1. Introduction

The temporal bone safeguards vital structures of the middle and inner ear, and its violation is often accompanied with severe complications including hearing loss (HL), facial nerve paralysis, cerebrospinal fluid leak, balance disturbance and other serious intracranial injuries. HL following temporal bone fracture (TBF) is particularly challenging to manage; losses take the form of conductive (CHL), sensorineural (SNHL) or mixed HL, with each arising from physical or inflammatory injuries to different components of the middle or inner ear [1].

In adults, radiographic classifications of TBFs help to better prognosticate HL and guide management decisions by helping to select for patients who would benefit from early intervention over more conservative management. Traditionally, TBFs have been classified according to their plane of fracture; simple fractures are described as coursing longitudinal (L) or transverse (T) to the petrous ridge, while comminuted or oblique fractures are characterized as having a mixed (M) pattern [2]. A more recent classification gaining popularity describes fractures according to whether they penetrate the bony labyrinth (i.e. the cochlea, vestibule or semi-circular canals), wherein

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fractures are classified as otic-capsule violating (OCV), or otic-capsule sparing (OCS) [3]. In adults, the otic-capsule classification better predicts clinical outcomes when compared to the traditional classification; namely, OCV fracture are associated with higher rates of SNHL, CSF otorrhea and facial nerve paralysis [4,5].

In children, the temporal bone is more flexible, mastoid pneumatisation is less developed, and the mechanisms of temporal impacts may differ from those in adults [6,7]. Consequently, pediatric TBFs present with different constellations of symptoms. For example, Kang et al. described that SNHL and FN paralysis are more common among adult TBFs while children present more frequently with CHL [6].

To date, the few pediatric studies aimed at correlating radiographic classifications with HL and signs of middle or inner ear dysfunction offer conflicting results [8,9]. The current study examined whether the traditional or otic-capsule classification systems meaningfully associate with the incidence of HL and other otologic signs or symptoms among pediatric TBFs.

2. Methods

2.1. Patients and data collection

Pediatric patients diagnosed with a TBF from January 1, 2000 to December 31, 2014 were retrospectively characterized from a previously identified cohort of patients from the Montreal Children's Hospital (Montreal QC, Canada) [10]. Patients aged 18 years or less with a CT diagnosed TBF were included in the study. Patients with incomplete medical or imaging records, TBF isolated to the squamous portion of the temporal bone, or no TBF on secondary review were excluded. Patient Institutional research ethics board approval was obtained, and patient consent was sought for inclusion in the study. Fig. 1 summarizes patient inclusion and exclusion.

Full head or dedicated temporal bone CT scans were independently reviewed by 2 high-volume radiologists (one attending pediatric radiologist, LC, and one senior radiology resident, BAQ), both blinded to clinical outcomes. When available, dedicated temporal bone studies (protocoled as temporal bone axial images of 0.625 mm with a DFOV of 9.6 cm with coronal and sagittal reformats) were used. Fractures were stratified per the traditional and otic-capsule classification systems. In the traditional classification, TBFs running strictly parallel or perpendicular to the long-axis of the petrous ridge were defined as longitudinal (L) and transverse (T), respectively. Mixed (M) fractures were defined as all other fractures not fulfilling criteria for L or T fractures. In the otic-capsule classification, fractures involving the cochlea, semi-circular canals, vestibule and/or vestibular aqueduct were defined as otic-capsule violating (OCV), while those sparing these structures were classified as otic-capsule sparing (OCS) [6,11]. CT scans were also reviewed for presence of inflammation within the temporal bone, ossicular chain disruption, and other associated intracranial injuries.

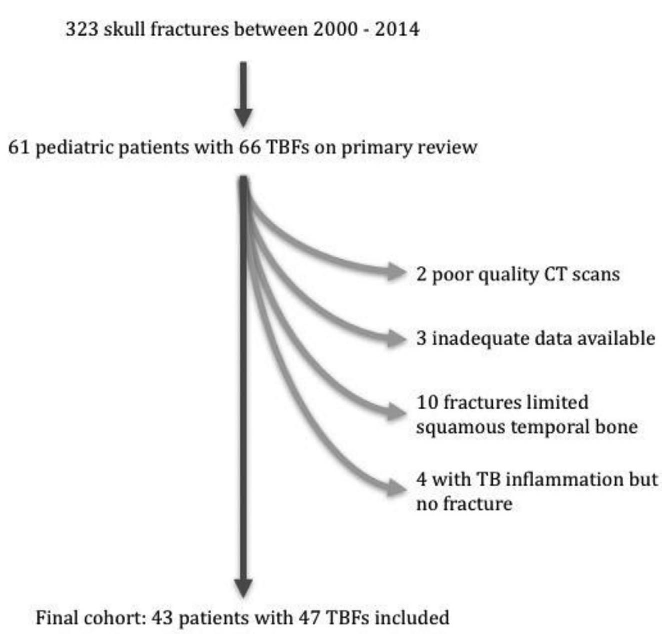

Fig. 1. Patients included and excluded from a previously identified cohort of TBF patients. Abbreviations: TBF, temporal bone fracture; TB temporal bone.

2.2. Primary and secondary outcomes

The primary outcome was hearing loss (HL), ascertained from patient medical charts. Pure tone audiometry, measured at the initial assessment and follow-up visits, was used to detect the presence and severity of hearing loss. Pure-tone audiograms were performed with the standard air and bone conduction thresholds. HL was classified as conductive hearing loss (CHL), sensorineural hearing loss (SNHL), or as a mixed subtype. Severity of hearing impairment was stratified, according to WHO standards, as normal (audiometry ISO ≤ 25 dB), mild (audiometry ISO 26–40 dB), moderate (audiometry ISO 41–60 dB), severe (audiometry ISO 61–80 dB) and profound (audiometry ISO ≥ 80 dB) [12]. Given their low incidence, severe and profound HL were grouped together. In the absence of audiometric data, oto-acoustic emission (OAE) results were used to assess for presence but not severity of HL.

Secondary outcomes were reviewed from the patient medical charts, and included the following presenting signs and symptoms: facial nerve dysfunction, CSF otorrhea, hemotympanum, otalgia, TM perforation and dizziness/vertigo.

2.3. Statistical analysis

Statistical analysis was performed with the Fisher exact test, comparing presence of HL, severity of HL and other otologic signs between L, T and M, and between OCS and OCV fractures. Point estimates for the difference among groups (PE) were calculated, along with their 95% confidence intervals (95%CI). Significance was defined as a 95%CI that excluded 0.

3. Results

A total of 61 pediatric patients met the inclusion criteria of CT-diagnosed TBF on initial review (Fig. 1). Of these, 19 patients were excluded; 10 fractures were limited to the squamous portion of the temporal bone, 4 had temporal bone inflammatory signs but no fracture, 2 had poor quality CT scans due to movement and 3 had incomplete data available. Fifteen cases had CT scans with slices > 2.5 mm, though TBF classifications were made confidently. Four patients presented with bilateral TBFs. The final cohort included 43 patients with 47 TBFs.

The majority (n = 33; 77%) of our cohort was male, with ages ranging from 0 to 17 years (mean: 11.0 years). Among the 47 TBFs, 18 (38.3%), 4 (8.5%) and 25 (53.2%) were classified as L, T and M fractures, respectively. Of those categorized as M fractures, 24 were oblique and 1 was comminuted. 33 (70.2%) were classified as OCS, and 9 (19.1%) as OCV fractures. Five TBFs had fracture lines lying along the otic-capsule and could not be assessed definitively for otic-capsule involvement. These TBFs were excluded from our calculations involving the otic-capsule classification. Patient and TBF characteristics are summarized in Table 1.

Motor vehicle accidents were the most common mode of injury, present in 51% (n = 24) of cases. Falls, Bicycle or skateboard accidents and assaults were responsible for 23% (n = 11), 13% (n = 6) and 6% (n = 3) of TBFs respectively. In all 6 cases involving bicycle or skateboard accidents, patients were not wearing helmets. There were no