

# Traumatic Tympanic Membrane Perforations Diagnosed in Emergency Departments

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**IMPORTANCE** Tympanic membrane perforations (TMPs) are frequent events leading to evaluation in the primary care and otolaryngology offices or the emergency department (ED). Despite specific warning labels on packaging of cotton-tipped applicators regarding the risk of injury to the ear canal with personal use, these products are commonly used to remove ear cerumen.

**OBJECTIVE** To analyze the mechanism of injury for traumatic TMPs among patients presenting to the ED.

**DESIGN, SETTING, AND PARTICIPANTS** Cross-sectional analysis of cases from 100 emergency departments in the United States. The National Electronic Injury Surveillance System was searched on April 3, 2015, for ear-related injuries with analysis information regarding patient age, patient sex, time and date of injury, specific injury diagnoses, and specific injury mechanisms that occurred across 5 years, from January 1, 2010, through December 31, 2014.

**MAIN OUTCOMES AND MEASURES** Diagnoses of traumatic TMP documented in the ED visit record as well as patient demographics, diagnoses, and other aspects of the injury, including mechanism of injury.

**RESULTS** There were 949 case entries in the database for traumatic TMP, which extrapolates to 4852 ED visits nationally. Of 949 patients evaluated, 568 (59.8%) were men and 381 (40.2%) were women resulting in a male to female ratio of 1.49:1. Most injuries occurred in patients 18 years or younger (602 of 949 [63.4%]) with children younger than 6 years most at risk (331 of 949 [34.9%]). Ear canal instrumentation including foreign bodies was noted in 581 of 949 cases (61.2%), with cotton-tipped applicators noted in 261 (44.9%) of these cases. While foreign body instrumentation represented the leading cause of traumatic TMP in patients aged 0 to 5 years (284 of 331 cases [85.8%]), 6 to 12 years (108 of 158 [68.4%]), 19 to 36 years (85 of 223 [38.1%]), 37 to 54 years (48 of 91 [52.7%]), and 55 years or older (22 of 33 [66.7%]), water trauma was the leading cause of TMP in patients aged 13 to 18 years (43 of 113 cases [38.1%]).

**CONCLUSIONS AND RELEVANCE** Traumatic TMP represents a common reason for evaluation in the ED. Despite common warnings regarding risk of injury to the tympanic membrane with use of a cotton-tipped applicator, it is still a major cause of traumatic TMPs. Other injury mechanisms also play an important role in the teenage and young adult populations.

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The tympanic membrane is a thin structure that measures only 81 mm<sup>2</sup> and that transmits sound from the external ear canal to the ossicles residing in the middle ear.<sup>1</sup> A tympanic membrane perforation (TMP) results in hearing loss by diminishing the impedance mismatch and decreasing the pressure differential induced by sounds, leading to decreased ossicular coupling.<sup>2</sup> Multiple factors, such as perforation size, sound frequency tested, middle ear space dimensions, and mastoid volume, determine the degree of hearing loss associated with TMP.<sup>3</sup> When TMP occurs, patients may experience substantial pain, hearing loss, and drainage of fluid (including blood) from the ear.

Otologic complaints are estimated to represent 2.21% of all emergency department (ED) visits.<sup>4</sup> Concern for TMP is a common reason for presentation to the ED or for an appointment at a primary care office or otolaryngology office, affecting patients of all ages, ethnicities, and sexes. Infection and trauma are the leading causes of TMPs.<sup>5</sup>

Traumatic TMP is commonly caused by barotrauma, a slap or strike to the ear, or penetration of the ear canal by foreign objects, including cotton swabs or cotton-tipped applicators. The generic term for these products is derived from the brand name, Q-tips (Unilever).<sup>6</sup> In the case of penetrating injuries, the foreign object enters the ear canal and may directly pierce the tympanic membrane. However, in barotrauma or concussive blows, the compression of air against the tympanic membrane leads to the TMP.

Q-tips were created about 100 years ago by Leo Gerstenzang and gained popularity by the 1950s.<sup>7</sup> Although many manufacturers make similar products, most people associate the term *Q-tips* with cotton-tipped applicators. By the 1970s, otologic complications associated with removal of ear cerumen using Q-tips were realized.<sup>8,9</sup> These injuries remain common 40 years later, and more than half of patients visiting otolaryngology clinics regardless of the medical issue report the use of cotton-tipped applicators at home.<sup>10-12</sup> Cotton-tipped applicator use is a common cause of impacted cerumen in the external ear canal, and otolaryngologists spend substantial time counseling and treating patients for cotton-tipped applicator-related issues.

Several retrospective cohort studies describing the prevalence of different causes for traumatic TMPs have been reported, but a large national study regarding this issue is lacking.<sup>13,14</sup> The present study used a national database to comprehensively analyze the mechanisms of injury for traumatic TMPs among patients presenting to the ED in the United States.

## Methods

The Consumer Product Safety Commission's National Electronic Injury Surveillance System (NEISS) was accessed on April 3, 2015, for data regarding ED visits for ear-related injuries. This national database provides a representative sample of injuries from 100 participating EDs. National estimates are extrapolated using an algorithm created by the NEISS that is based on a national probability sample and sample weights. Included in the information are patient age, sex, race/ethnicity,

## Key Points

**Question** What are the leading causes of traumatic tympanic membrane perforation in the United States?

**Findings** In this cross-sectional analysis of 949 emergency department visits, foreign body instrumentation (including cotton-tipped applicators) was the most frequent cause of traumatic tympanic membrane perforations.

**Meaning** The leading cause of traumatic tympanic membrane perforations may be preventable, and patient education may prevent this frequent cause of injury.

location of the incident, patient disposition, consumer product associated with injury, and a brief narrative of the incident. This database has shown tremendous value in previous analyses.<sup>15-17</sup>

Two authors (E.T.C. and K.S.) searched the database for ED visits January 1, 2010, through December 31, 2014, using the term *ear* as the body part affected; individual entries were searched to include the diagnosis of TMP. Individual entries were further screened for patient demographics, diagnoses, and other aspects of the injury, including mechanism of injury. This database, organized by the US Consumer Product Safety Commission,<sup>18</sup> qualifies as nonhuman subject research and did not require institutional review board approval per the standing policy of the Rutgers New Jersey Medical School in Newark. Calculations including 2-tailed *t* test and  $\chi^2$  analysis were conducted using Excel, version 2008 (Microsoft).

## Results

From January 1, 2010, through December 31, 2014, there were 949 case entries recorded for TMP. Using the NEISS algorithm, these data are extrapolated to 4852 ED visits nationwide during this period. Of 949 patients evaluated, 568 (59.8%) were male and 381 (40.2%) were female, resulting in a male to female ratio of 1.49:1. Most injuries occurred in patients 18 years or younger, representing 602 of 949 cases (63.4%). Children younger than 6 years were most at risk, representing 331 (34.9%) of all patients (Table).

The most common mechanism of traumatic TMP presenting to the ED was foreign body instrumentation (581 of 949 cases [61.2%]). Other causes of traumatic TMP included water trauma, strikes to the head, blast injuries, and falls (Figure). Water trauma injuries included forced pressure of water to the head (ie, during diving or waterskiing), barotrauma (including scuba-related injury), and episodes of otitis media or otitis externa following swimming or water trauma.

Foreign body instrumentation of the ear canal was the most common mechanism of traumatic TMP in all age groups (excluding patients aged 13-18 years): 284 of 331 patients (85.8%) aged 0 to 5 years, 108 of 158 (68.4%) in those 6 to 12 years, 85 of 223 (38.1%) in those 19 to 36 years, 48 of 91 (52.7%) in those 37 to 54 years, and 22 of 33 (66.7%) in those 55 years or older

(Figure). Water trauma was the most common mechanism of TMP in those aged 13 to 18 years, representing 43 of 113 (38.1%) of patients.

In the 581 cases (61.2%) overall that occurred following foreign body instrumentation into the ear canal, cotton-tipped applicators were the identified instrument in 263 cases (44.9%). Other common instruments used were hair pins (62 cases [10.6%]), toys (44 [7.6%]), combs (32 [5.5%]), pencils (31 [5.3%]), straws (13 [2.2%]), toothpicks (10 [1.7%]), and lollipop sticks (10 [1.7%]).

## Discussion

To our knowledge, this data set of 949 cases is the largest published cohort of patients with traumatic TMP and demonstrates that foreign body instrumentation was the most common mechanism for TMP presenting to the ED in the United States.

These findings reflect a much higher prevalence of foreign body instrumentation (60.6%) compared with strikes to the head (11.4%) as a cause of traumatic TMP than several

previous single-institution studies in other countries. In those studies, interpersonal violence, including slapping the side of the head, represented a common cause of traumatic TMP. A large series by Lou et al<sup>19</sup> reported that, in a Chinese population, the overwhelming cause of traumatic TMP was slap injuries (78.4%), while instrumentation was responsible for only 5.0% of injuries. A recent study from Germany demonstrated that an open-handed slap led to 37.4% of injuries, while cotton-tipped applicators represented 19.3% and barotrauma from high diving represented 13.0% of injuries.<sup>14</sup> A study from Nigeria demonstrated that the most common causes of traumatic TMP were slaps to the head (35.9%) and road traffic injuries (23.5%).<sup>13</sup> Differences in the cause of traumatic TMPs may reflect cultural and behavior differences among populations. In our analysis, 45.3% of foreign body instrumentation causing traumatic TMP was from cotton-tipped applicators.

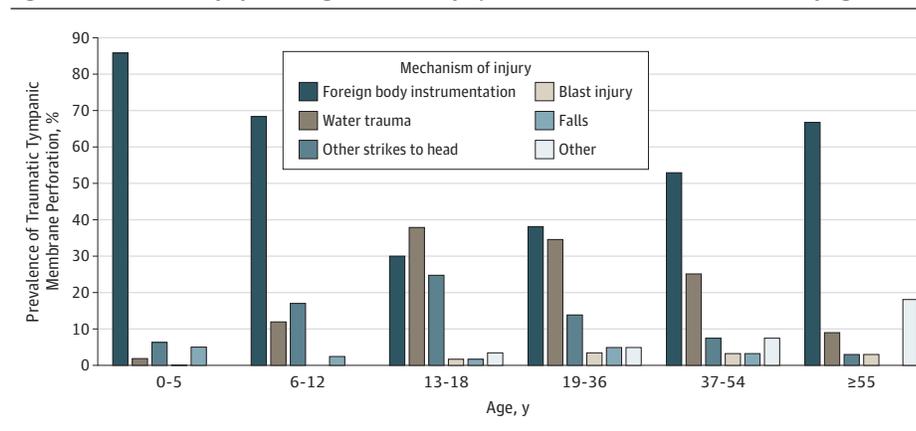
A recent analysis demonstrated that otitis media, otitis externa, and otalgia were the most common otologic diagnoses made by physicians in the ED.<sup>4</sup> Although TMP was not among the top diagnoses, it is an important concern for patients and can be a risk factor for developing otitis media. Fortunately, the most common management of uncomplicated traumatic TMP is observation with use of topical antibiotic ear drops if there is associated active otorrhea. Only a small percentage of patients require further treatment. Several large series have demonstrated traumatic TMP closure rates of 78% to 97% without surgical intervention.<sup>17,19,20</sup> Closure of the TMP was noted between the third and fourth week after injury but was a significantly longer period for larger perforations.<sup>19,20</sup>

It is important that the staff of the ED arrange outpatient follow-up with an otolaryngologist for follow-up evaluation of the TMP. Instructions provided at discharge from the ED should include strict precautions to keep the ear canal dry and to prevent water from entering the ear canal. Swimming should be avoided and a cotton ball coated with petroleum jelly (eg, Vaseline) can be placed in the ear canal during bathing. If there is otorrhea, topical antibiotic ear drops can be prescribed. It is generally accepted that an audiogram be performed 3 months after the injury to confirm the normalcy of the patient's hearing and no ossicular chain discontinuity.

**Table. Prevalence of Traumatic Tympanic Membrane Perforation Cases by Age Group and Cause Over 5-Year Study Period**

Variable	No. (%) (N = 949)
Age of patient, y	
0-5	331 (34.9)
6-12	158 (16.6)
13-18	113 (11.9)
19-36	223 (23.5)
37-54	91 (9.6)
≥55	33 (3.5)
Cause	
Foreign body instrumentation	581 (61.2)
Water trauma	172 (18.1)
Other strikes to head	115 (12.1)
Blast injury	15 (1.6)
Falls	37 (3.9)
Other	29 (3.1)

**Figure. Mechanisms of Injury Resulting in Traumatic Tympanic Membrane Perforation Stratified by Age**



Cotton-tipped applicators represent a leading cause of traumatic TMP; thus, it is important for otolaryngologists, as well as primary care physicians, to counsel patients on their proper use. This study accessed the largest nationwide database in the United States representing traumatic TMPs. Damage from foreign body instrumentation remains a substantial burden to patients, and counseling them about proper aural care could save substantial health care costs.

### Limitations

There are several important limitations to using a national database for this study. This data set represents only patients who sought care in the ED, and urgent care center or outpatient clinic visits were not captured. The clinical management of the patients is unknown. In addition, there may be an overestimation of the reporting of TMPs because the examiner identity (eg, ED physician, otolaryngologist, resident physician, nurse, or physician assistant) and diagnostic criteria (eg, pneumatic otoscopy vs tympanic membrane visualization) are unknown. Lacerations of the ear canal without traumatic TMP

from foreign body instrumentation may have been included in the TMP diagnostic code. Information pertaining to the management of these TMPs and the long-term outcomes of these patients is outside the purview of this type of analysis.

### Conclusions

Traumatic TMP occurs most commonly in children 18 years or younger. Foreign body instrumentation is the leading cause of traumatic TMP overall (60.6%), and the use of cotton-tipped applicators is responsible for 45.3% of these injuries. Other important mechanisms of TMPs include water trauma, strikes to the head, blast injuries, and falls. Water trauma was the leading cause of TMPs in teenagers and young adults aged 13 to 18 years. Otolaryngologists should coordinate with primary care physicians, particularly those clinicians involved with pediatric patients, to educate patients regarding the dangers of foreign body instrumentation of the external ear canal.

#### ARTICLE INFORMATION

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