# Incidence of Morbidity From Penetrating Palate Trauma

**WHAT'S KNOWN ON THIS SUBJECT:** Reports of previous studies of oropharyngeal injury in children have described wound characteristics, injury vectors, and results from radiologic studies. The true risk of stroke and infection is unknown. Providers face decisions regarding which patients require computed tomographic angiography, an otorhinolaryngologist consultation, or hospitalization.

**WHAT THIS STUDY ADDS:** This study's results reveal an incidence of 0% for stroke and 0.9% for infection and confirm a wide variation in testing and treatment and an increase in the rate of computed tomographic angiography and hospitalization over time. Positive computed tomographic angiography results did not lead to significant interventions.

## abstract

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**BACKGROUND:** The true rate of neurologic sequelae and infection from penetrating palatal trauma in children is unknown, which leads to significant variation in testing and treatment.

**OBJECTIVES:** To (1) determine the incidence of stroke and infection in well-appearing children with penetrating palatal trauma and (2) describe patterns of testing and treatment for uncomplicated palatal trauma.

**METHODS:** We assembled a retrospective cohort of children aged 9 months to 18 years with palatal trauma seen in the emergency department (ED) at a tertiary care pediatric hospital. Patients met the following definition: well-appearing with normal neurologic examination and a palate laceration but no findings requiring immediate operative care. Stroke was defined as any abnormal neurologic examination secondary to palatal trauma. Infection was defined as cellulitis or abscess secondary to palatal injury. All abnormal computed tomographic angiography (CTA) findings, except for free air, were considered positive and potentially significant.

**RESULTS:** We identified 1656 potential subjects. A total of 995 of 1656 subjects were screened, and 205 of 995 met the case definition. A total of 122 of 205 had follow-up through at least 1 week after injury. The incidence of stroke in our study population was 0% (95% confidence interval [CI]: 0–2.5). One of 116 patients developed infection, for an incidence of 0.9% (95% CI: 0–5.3). A total of 90 of 205 (44%) subjects had CTA scans; the results of 9 (10%) were positive. No patients with positive CTA findings required operative care. No patients received anticoagulant medications.

**CONCLUSIONS:** The incidence of morbidity from penetrating palatal trauma in the well-appearing child is extremely low. Diagnostic evaluation in the ED did not prompt clinical interventions other than antibiotics. *Pediatrics* 2010;126:e1578–e1584

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**KEY WORDS**

trauma, oropharynx, palate, stroke, emergency medical services, pediatric, diagnostic tests

**ABBREVIATIONS**

ED—emergency department
CTA—computed tomographic angiography
CI—confidence interval

www.pediatrics.org/cgi/doi/10.1542/peds.2010-1059

doi:10.1542/peds.2010-1059

Accepted for publication Aug 11, 2010

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PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).



**FINANCIAL DISCLOSURE:** *The authors have indicated they have no financial relationships relevant to this article to disclose.*

Penetrating trauma to the head and neck accounts for 1% to 2% of pediatric trauma admissions.[1] Children have a propensity to place objects in their mouths, which leaves them at risk of trauma to the oral cavity. Penetrating injuries to the posterior palate can cause compression of the internal carotid artery and possible thrombosis.[2–8] Case reports have described palate lacerations causing internal carotid artery damage and leading to subsequent cerebrovascular injury.[4,9–13]

Reports of previous studies of oropharyngeal injury in children have described wound characteristics, injury vectors, and results from radiologic studies.[2–7,14] However, the true risk of stroke and infection is unknown. Primary care providers and emergency departments (EDs), uncertain of risk, face decisions regarding which patients require computed tomographic angiography (CTA) to identify vascular injury, an otorhinolaryngology consultation, and/or hospitalization. Given concerns for radiation-induced cancer, the true impact of CTA on management needs careful study.[15–21]

We sought to determine the incidence of stroke and infection in otherwise well-appearing patients with penetrating palatal trauma. As a secondary goal, we sought to describe patterns of testing and treatment for uncomplicated palatal trauma.

## METHODS

### Study Design

We performed a retrospective chart review of otherwise well-appearing children aged 9 months to 18 years with penetrating palatal injury who presented for emergency care at a single tertiary care children's hospital from 1995 to 2007. The study was approved by the institutional review board.

### Setting

The setting was an urban, tertiary care pediatric ED with ~55 000 visits per year. This institution has pediatric otorhinolaryngologists and pediatric radiologists available 24 hours/day. Emergency physicians document electronically using an electronic medical record system (EM station [Cerner, Kansas City, MO]). During the study period, consultants in the ED documented on paper.

### Selection of Participants

The patient case definition for this investigation was an otherwise well-appearing child who suffered primary oropharyngeal trauma to the hard or soft palate and who had a normal neurologic examination at the baseline ED visit. We excluded patients with additional injuries to the mouth or posterior pharynx other than the injury to the palate. Patients were excluded if they required immediate operative intervention to remove a retained foreign body, had persistent bleeding, showed signs of expanding hematoma, or needed immediate intubation during ED care. Records of all patients from October 1995 to December 2007 who presented to the ED with oral trauma were reviewed. We included transfer patients from outside hospitals who presented to our ED. Patients were identified through 2 case-finding methods applied to all available ED electronic visit records.

First, we used a computerized text-search method using regular expression.[22] This robust methodology is slightly different from a key-word search tool because it allows a more comprehensive search that includes misspelled and mistyped variations of different terms as well as the context in which these terms were documented. At its base, we used combinations of search terms, including but not limited to, "palate," "oropharynx," "oropharyngeal," "laceration," and "wounds." The methodology allows the code to read through every word and every sentence in the record. For example, it will flag the word "palate" and its mistyped forms yet ignore it in the setting of "cleft palate" and will identify text where "laceration" is used in close proximity to "palate."

The second method used a more traditional diagnostic code approach. An *International Classification of Diseases, Ninth Revision* code search was performed for codes 873.60 (open wound of the mouth, unspecified site, uncomplicated), 873.65 (open wound of the palate, uncomplicated), 873.70 (open wound of the mouth, unspecified site, complicated), and 873.75 (open wound of the palate, complicated).

### Data Collection and Processing

Records for the preliminary subset of patients were reviewed by Dr Hennelly to identify patients whose injury included the oral cavity. Patients with oropharyngeal injury were then formally screened, and, if eligible, abstraction as detailed below was completed. An initial abnormal neurologic examination documented by the ED physician excluded patients.

We performed an unblinded chart review by a single investigator. A standard form developed in SPSS Data Entry Builder 4.0 (SPSS Inc, Chicago, IL) was used for data abstraction. Data collected from the ED physician record included the history and physical examination at time of presentation, injury vector, imaging and results, management decisions based on imaging, disposition, antibiotic use, anticoagulation-medication use, need for sedation, and complications of sedation. If an otorhinolaryngology consultation was obtained, this record was separately abstracted. If the patient was taken to the operating room nonemergently, the record of this procedure was reviewed for description and timing of the procedure. We defined nonemergent operative intervention as operative care more than 8 hours from the time of arrival to the ED. In addition, the medical record was examined for evidence of follow-up visits to the ED, otorhinolaryngology clinic, or other hospital-based providers. For each of these visits, information was abstracted specific to the neurologic examination and for the presence or absence of cellulitis or abscess. Information across all follow-up visits was reviewed to make a final determination of the presence or absence of stroke or infection.

A second investigator, blinded to specific aims, completed a separate chart abstraction on 20% of the cases to determine interrater reliability for key procedures and treatments, test results, and outcomes, including whether operative intervention occurred, whether anticoagulation therapy was initiated, interpretation of CTA results, and the presence or absence of stroke or infection.

### Outcome Measures

The primary outcome measures were the incidence of stroke and infection. Stroke was defined as any abnormal neurologic examination documented in the medical record and interpreted to be secondary to carotid artery involvement from the palate laceration, or CTA findings consistent with stroke. Infection was defined as any abscess or cellulitis secondary to the palate laceration, as determined by the treating physician. Outcomes were assessed for cases in which a minimum of 7 days had elapsed between the ED visit and subsequent follow-up visits documented in the medical record. The 7-day interval was chosen a priori from a combined review of existing literature on oropharyngeal trauma and consultation with a local otorhinolaryngology expert (Dr Jones). There is what is called a "lucid interval" in previously described patients who developed neurologic sequelae; the interval ranged from 3 to 60 hours and is thought to be secondary to the time needed for an intraluminal thrombus to develop.[2,3,6,7,10,23,24]

Key secondary outcomes included CTA use, prevalence of positive CTA findings, and subsequent clinical actions (anticoagulation therapy, operative intervention, and admission) based on these findings. A positive CTA finding was defined as any thrombus, hematoma, intimal tear, edema, dissection, or pseudoaneurysm around the carotid. A priori, per discussion with an otorhinolaryngology expert, the finding of free air was determined to be of limited significance, because it would be an expected finding from these injuries.

We also assessed the percentage of patients who underwent sedation for CTA and the percentage of adverse events from sedation. Adverse events from sedation were defined a priori and included vomiting, supplemental oxygen for hypoxia, use of positive pressure ventilation, laryngospasm, intubation, and intravenous infiltration.

### Primary Data Analysis

The unit of analysis for this study was the patient. We evaluated data from patients who met the case definition, generated descriptive statistics for predictors of interest, and produced point estimates for the outcomes of interest with 95% CIs. We restricted the primary analysis to patients who presented within 1 day of injury to ensure that the main findings were specific to acute presentations after palatal trauma. In addition, we performed tests of association, including Pearson's $\chi^2$ and Fisher's exact tests, to explore the relationship between specific predictors and outcomes according to a list of candidate relationships established a priori. All analyses were completed by using SPSS 16.0 (SPSS Inc, Chicago, IL). All tests of significance were 2-sided, with the significance of $P$ set at $<.05$.

## RESULTS

### Characteristics of Study Patients

During the 12-year study period, there were 699 570 total ED visits, and we identified 1656 potentially eligible patients by using computerized screening techniques. A total of 661 of 1656 patients were excluded after a manual review of the chart revealed that oral trauma was not a final diagnosis, which left 995 patients with oral injury. A total of 774 of 995 patients were excluded because they had unknown injuries ($n = 175$), retained a foreign body ($n = 9$), did not meet age criteria,[23] or had other oral injuries such as dental ($n = 146$), buccal mucosa ($n = 35$), tongue ($n = 129$), or lip ($n = 68$) injuries. A total of 211 patients met the case definition and were studied further. A total of 205 of 211 patients presented within 24 hours of the injury and were considered to represent acute presentation of penetrating palatal trauma. A total of 122 of 205 (60%) patients had follow-up data through at least 1 week after injury. The median follow-up interval was 3.4 days, and the mode was 8 days.

Table 1 lists the demographics and wound characteristics of the study cohort. The median age of patients was 40 months (interquartile range: 19–64). Note that the majority of lacerations were located on the lateral soft palate and measured less than 2 cm. An otorhinolaryngologist was consulted in 172 of 205 (84%) cases. Of the patients who had an otorhinolaryngology consultation, 88 of 172 (51%) underwent a CTA scan.

The types and percentages of injury vectors, as reported by the parent, are listed in Table 2. Sticks, tools/household items, and kitchen utensils

**TABLE 1** Patient Demographics and Wound Characteristics

| Characteristics | |
|---|---|
| *n* | 205 |
| Age, median (IQR), mo | 40 (19–64) |
| Gender, male, % | 64 |
| Admitted, *n*/*N* (%) | 101/205 (49) |
| Length of admission, h | |
| <24 | 86/101 (85) |
| 24–48 | 12/101 (12) |
| >48 | 3/101 (3) |
| Laceration laterality, *n* (%) | |
| Right | 77 (38) |
| Left | 74 (36) |
| Midline | 41 (20) |
| Unknown | 13 (6) |
| Laceration location, *n* (%) | |
| Hard palate lateral | 14 (7) |
| Hard palate midline | 18 (9) |
| Soft palate lateral | 146 (71) |
| Soft palate midline | 25 (12) |
| Not described | 2 (1) |
| Wound length, *n* (%) | |
| <1 cm | 94 (46) |
| 1–2 cm | 56 (27) |
| >2 cm | 19 (9) |
| Unknown | 36 (18) |

**TABLE 2** Injury Vectors

| Object | *n* (%) |
|---|---|
| Sticks | 35 (17) |
| Tools/household items | 33 (16) |
| Kitchen utensils | 22 (11) |
| Toys | 21 (10) |
| Musical instruments | 21 (10) |
| Writing objects | 16 (8) |
| Straws | 16 (8) |
| Popsicle sticks | 9 (4) |
| Toothbrushes | 8 (4) |
| Hygiene items | 5 (3) |
| Rulers | 4 (2) |
| Flagpoles | 4 (2) |
| Not described | 11 (5) |

represented the majority of vectors. The types of materials that comprised the vectors were metal (7 [3%]), plastic (74 [36%]), wood (33 [17%]), and unknown (91 [44%]). The reliability of the abstraction process was confirmed across key variables, including the presence or absence of stroke or infection, CTA results, operative intervention, and anticoagulation therapy. All key variables demonstrated a raw agreement of 100% and a $\kappa$ statistic of 1.

## Incidence of Stroke

No patients in our study cohort developed signs or symptoms of stroke. The incidence of stroke, therefore, was 0 of 122 (0%) with an upper bound of the 95% CI of 2.5%. Because data abstraction did not identify any admissions or consultations for stroke subsequent to the ED visit for the 205 patients in our cohort, the upper bound of the CI may be as low as 1.4%.

## Incidence of Infection

To determine the incidence of infection, we considered 204 of 205 patients presenting within 24 hours and meeting the case definition who had no evidence of infection on their initial examination. Of 204 infection-free patients, we excluded 8 patients who went to the operating room during their hospitalization, because their infection risk would likely be influenced by this intervention. Of the remaining 196 patients, 116 of 196 had follow-up data of at least 7 days' duration. One of 116 patients developed infection, which results in an incidence of 0.9% (95% CI: 0.0–5.3).

Sixty-seven of 116 (58%) patients were prescribed antibiotics. Forty-seven of 67 patients (70%) received oral antibiotics only; for 5% of the patients, the antibiotic was given only intravenously. The most common antibiotics were amoxicillin (43%), amoxicillin-clavulanic acid (20%), ampicillin-sulbactam (15%), and clindamycin (12%).

When considering all patients who met our case definition, 3 of 205 (1.4%) were diagnosed with infection, and none of those 3 required operative intervention. One patient had fallen on a stick a day before ED care, was seen by a pediatrician the day of injury, and was prescribed amoxicillin-clavulanic acid but developed increasing pain and fevers. The CTA showed free air around the wound, and the patient was admitted for intravenous antibiotics with a diagnosis of cellulitis. The second patient was seen for a palate laceration from a fork and was discharged on amoxicillin but had increasing pain so returned the following day. He was diagnosed with pharyngitis. The antibiotic was changed to amoxicillin-clavulanic acid, and he was discharged. The third patient was seen in the ED 2 days after a snorkel injury to his palate and had erythema and tenderness to his palate. He was on amoxicillin at presentation, received a dose of intravenous ampicillin-sulbactam, and went home. All 3 patients had follow-up visits with no documented complications.

## CTA Imaging Results and Sedation-Related Complications

Ninety of 205 patients (44%) had computed tomography scans performed; 88 of 90 were CTA studies and 2 were computed tomography with intravenous contrast alone. Eighteen of 90 case subjects had isolated free-air findings on CTA. These patients were not considered to have a positive finding. Nine of 90 scans (10%) were interpreted as positive on the basis of findings of potential intimal tear ($n = 1$) or edema ($n = 8$) around the carotid.

Table 3 provides details regarding these patients. Eight of 9 patients with positive CTA findings were prescribed antibiotics. None developed infection. It should be noted that none of our patients with positive CTA findings went to the operating room or received anticoagulant medication. Only 2 patients with CTA scans performed subsequently went to the operating room, and these CTA scans were normal. We noted that the rate of CTA use and hospitalization increased over 3 equivalent 4-year periods of time, as shown in Fig 1. There was a significant difference in CTA use and hospitalization over time.

**TABLE 3** Subjects Who Had Positive CTA Findings

| CTA Description | Age, mo | Gender | Antibiotic | Vector | Wound Length, cm | Length of Admission, h | Wound Location |
|---|---|---|---|---|---|---|---|
| Edema | 60 | Male | Amoxicillin | Plastic tube | 1–2 | <24 | SP lateral |
| Edema | 46 | Female | No antibiotic | Flute | 1–2 | <24 | SP lateral |
| Edema | 18 | Female | Amoxicillin | Ballpoint pen | <1 | Discharged from ED | HP lateral |
| Edema | 96 | Male | Amoxicillin-clavulanic acid | Toothbrush | Unknown | Discharged from ED | SP lateral |
| Edema | 47 | Female | Ampicillin-sulbactam | Pen | >2 | <24 | SP lateral |
| Edema | 91 | Male | Ampicillin-sulbactam | Stick | 1–2 | >48 | SP lateral |
| Edema | 27 | Male | Ampicillin-sulbactam | Plastic tube | <1 | 36–48 | SP lateral |
| Edema | 65 | Female | Ampicillin-sulbactam | Flagpole | 1–2 | <24 | SP lateral |
| Intimal tear | 103 | Male | Ampicillin-sulbactam | Stick | >2 | <24 | SP lateral |

SP, soft palate; HP, hard palate.

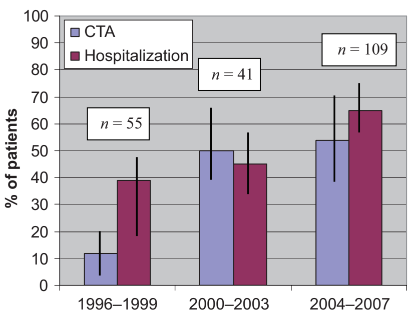


**FIGURE 1**
Rate of CTA use and hospitalization. *n* indicates the number of patients during the corresponding 4-year interval. The vertical bars for each column represent 95% CIs.

Fifty-three of 90 (59%) patients with CTA scans were sedated. Five of 53 (9%) patients suffered an adverse event related to the sedation. These adverse events included vomiting ($n$ = 3), nasal cannula oxygen therapy ($n$ = 1), and positive pressure oxygen therapy ($n$ = 1). Associations between wound length, wound location, and patient age were explored for positive CTA findings as a bivariate outcome (Table 4.) No significant associations were identified.

## Interventions

A total of 101 of 205 (49%) patients were admitted to the hospital. Eighty-six of 101 (85%) were admitted for less than 24 hours, 12 of 101 (12%) were admitted for 24 to 48 hours, and 3 of 101 (3%) were admitted for longer. Eight patients went to the operating room nonemergently. Six of 8 case subjects went to the operating room electively after admission, either for wound exploration or a large laceration repair. The other 2 of the 8 case subjects who went to the operating room were taken from the ED after more than 8 hours from arrival. Two patients who went to the operating room had normal CTA scans; the remainder was not imaged. Six of 8 (75%) patients had wounds on the lateral soft palate; the remainder had soft-palate midline wounds. Six of 8 (75%) patients who went to the operating room had wound lengths of 1 cm or greater.

Three patients underwent invasive angiography, the results of which were read as normal. One angiography was performed after CTA results were obtained with concern for free air around the carotid artery. The second was performed secondary to a neck bruit. The third angiography was performed for unclear reasons; a CTA scan was not performed. No abnormal neurologic examination findings were documented for this patient. No patients in the study cohort received anticoagulant medication.

**TABLE 4** Association Between Patient Characteristics and CTA Findings

| Characteristic | $CT^+$ ($n$ = 9), $n$ (%) | $CT^-$ ($n$ = 81), $n$ (%) | $P$ |
|---|---|---|---|
| Wound length, cm | | | .62 |
| <1 | 2 (22) | 31 (38) | |
| 1–2 | 4 (44) | 31 (38) | |
| >2 | 2 (22) | 8 (10) | |
| Unknown | 1 (11) | 11 (14) | |
| Location of wound | | | .70 |
| Soft palate, lateral | 8 (89) | 71 (88) | |
| Soft palate, midline | 0 (0) | 3 (4) | |
| Hard palate, lateral | 1 (11) | 5 (6) | |
| Hard palate, midline | 0 (0) | 2 (2) | |
| Age, mo | | | .79 |
| <19 | 1 (11) | 15 (19) | |
| 19–40 | 1 (11) | 17 (21) | |
| 40–60 | 3 (33) | 22 (27) | |
| >60 | 4 (44) | 27 (33) | |

CT indicates computed tomography.

## DISCUSSION

A lack of outcome data undermines an evidence-based approach to the evaluation and treatment of penetrating oropharyngeal trauma in children. Our study narrow this evidence gap by providing incidence data on the risk of stroke and infection after oropharyngeal trauma. We report an incidence of 0% for stroke and 0.9% for infection. Our analysis confirms a wide variation in testing and treatment patterns, as well as an increase in the rate of CTA use and hospitalization over time. Positive CTA results did not lead to significant interventions such as operative care or anticoagulation therapy. No patient after a positive CTA had subsequent positive angiography results.

Palate lacerations are not uncommon in children and generally do not result in serious injury. Reports of stroke after oropharyngeal trauma have come only from cases reported in isolation or in series. The first case of pediatric stroke from penetrating oropharyngeal trauma was described by Caldwell in 1956.[24] This patient had initial large bleeding and exhibited symptoms within hours, followed by death. There are 32 case reports in the literature describing stroke from compression of the internal carotid artery, thus causing intimal damage.[4,10,11] Although the case reports are infrequent, such a catastrophic outcome makes providers concerned about missing the rare case. However, the inherent risks in the diagnostic evaluation must be balanced against the benefit of information obtained from the test itself and the test's impact on subsequent actions.

Published cohort studies[3,5–7] have demonstrated the rarity of neurologic sequelae from these injuries but have been limited by a lack of follow-up data that allow for a true determination of incidence. Our rigorous case definition, a normal neurologic examination at presentation, and a sufficient follow-up interval all increase our confidence in the validity of the 0% incidence of stroke. If patients from our cohort are added to published data, it could be presumed that the incidence of neurologic sequelae is 0 of 513.[2,3,5–7,25,26]

Our results highlight a low incidence of infection, and the rate we report is lower than other published data on the subject.[3,7] The majority of our patients were treated with antibiotics, and we cannot directly comment on whether antibiotics are beneficial. It is possible that the low incidence of infection is because of the use of antibiotics, but it is notable that no infections developed among the subset of patients who were treated expectantly without the use of antibiotics. Studies evaluating infection risk with intraoral wounds have not shown definite benefit from antibiotics, but we recognize that cases of serious infectious complications from oropharyngeal trauma have occurred.[27,28] We believe our cohort is similar to others in the published literature and that our results are generalizable. Our data set is similar to those of previous studies on the basis of age and gender distribution and with a preponderance of injury to the lateral soft palate.[7]

Several limitations of our study deserve mention. The retrospective nature brings with it concerns for missing data and the need to interpret what is written in the record. There also is the possibility that some cases were missed, although the comprehensive search methodology guarded against this possibility. Not all patients had follow-up data to allow for a definitive statement of risk regarding stroke or infection. Although we present 13 years of data, our cohort size remains modest. We believe the true incidence of stroke to be much closer to 0% than to 2.5% (the upper limit of the CI from the cohort with complete follow-up), but a multicenter approach would be required to prove it.

## CONCLUSIONS

Neurologic sequelae from palate lacerations are rare, and the risk of infection is quite low. Pediatric providers should continue to warn parents about the dangers of children playing with objects in their mouths. The burden and benefit from the diagnostic evaluation for penetrating palatal trauma should be considered carefully in the well-appearing child with a palatal injury.

## ACKNOWLEDGMENT

We thank Jamie Nichols for assistance with data collection and administrative tasks.

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*Pediatrics* 2010;126;e1578
DOI: 10.1542/peds.2010-1059 originally published online November 1, 2010;