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The Epidemiology of Upper Airway Injury in Patients Undergoing Major Surgical Procedures

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Abstract

Background—Airway injury is a potentially serious and costly adverse event of anesthesia care. The epidemiologic characteristics of airway injury have not been well documented.

Methods—The American College of Surgeons National Surgical Quality Improvement Program (NSQIP) is a multicenter, prospective, outcome-oriented database for patients undergoing major surgical procedures. Using the NSQIP data for the years 2005–2008, we examined the incidence of, and risk factors for, airway injury.

Results—Of the 563,190 patients studied, 1202 (0.2%) sustained airway injury. The most common airway injury was lip laceration/hematoma (61.4%), followed by tooth injury (26.1%), tongue laceration (5.7%), pharyngeal laceration (4.7%) and laryngeal laceration (2.1%). Multivariable logistic modeling revealed an increased risk of airway injury in patients with Mallampati class III [adjusted odds ratio (OR) 1.69, 99% confidence interval (CI) 1.36 – 2.11, relative to patients with Mallampati classes I and II], or class IV [adjusted OR 2.6, 99% CI 1.52 – 4.02], and in patients aged 80 years or older (adjusted OR 1.50, 99% CI 1.02 – 2.19, relative to patients aged 40–49 years).

Conclusions—The risk of airway injury for patients undergoing major surgical procedures is approximately 1 in 500. Patients with difficult airways as indicated by Mallampati classes III and IV are at significantly increased risk of sustaining airway injury during anesthesia for major surgical procedures.

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DISCLOSURES:

Name: May Hua, MD

Contribution: This author helped design the study, conduct the study, analyze the data, and write the manuscript.

Attestation: May Hua has seen the original study data, reviewed the analysis of the data, approved the final manuscript, and is the author responsible for archiving the study files.

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Airway injury is a recognized complication of tracheal intubation. The literature exploring this postoperative complication suggests that airway injury has the potential to be both harmful and costly. An analysis of the American Society of Anesthesiologists (ASA) closed claims database found airway injury to be the fourth most common type of injury, accounting for 6% of all claims.¹ The majority of injuries were nonserious; however, 13% of injuries were considered to be permanent and disabling, with 8% resulting in death.¹ Studies of dental injury estimate that it accounts for approximately one-third of anesthetic malpractice claims.² Although the remuneration for each claim is relatively small (approximately 2000 United States dollars per patient), the large number of claims makes dental injury a significant source of expense and patient dissatisfaction.³ Because these studies were limited to case reports and case series analyses, accurate incidence data and risk factors for airway injury are not currently known. Thus, the purpose of this study was to examine the epidemiologic patterns of this complication in a large cohort of patients undergoing major surgical procedures.

Materials and Methods

Patients and Data Collection

The study protocol was reviewed and approved by the IRB of Columbia University Medical Center (New York, NY). Data for this retrospective study came from the multicenter, outcome-oriented database of the American College of Surgeons' National Surgical Quality Improvement Program (ACS NSQIP) for the years 2005–2008.^{*} The ACS NSQIP prospectively collected data from 251 participating hospitals for patients undergoing major surgical procedures. Major surgical procedures included any surgery performed under general, spinal or epidural anesthesia, as well as the following procedures, regardless of anesthetic technique: carotid endarterectomy, inguinal herniorrhaphy, parathyroidectomy, thyroidectomy, breast lumpectomy and endovascular abdominal aortic aneurysm repair. Excluded from the ACS NSQIP were cases performed under monitored anesthesia care, peripheral nerve block or local anesthesia, patients younger than 16 years of age, trauma cases, and solid organ transplant cases. In each participating hospital, a trained surgical nurse extracted information for 135 variables, including demographic characteristics, preoperative and intraoperative variables and 30-day postoperative morbidity and mortality outcomes from medical records using a standardized protocol with strict definitions.

In order to participate in the ACS NSQIP, hospitals must submit a minimum of 900 cases annually. The following sampling protocol is used to ensure that a wide variety of cases are included and that the preponderance of common, low-risk procedures does not bias the data. Surgical cases are sampled in 8-day cycles, with the first 40 consecutive general or vascular surgery cases included. No more than 5 breast lumpectomies or inguinal herniorrhaphies are included in any 8-day sampling period, because these are considered to be low-risk but high-volume cases. Case selection and case mix are monitored weekly to ensure proper sampling.

There are several measures to ensure that only data of the highest quality are recorded in the participant use data file. Hospitals must have 30-day follow-up data on at least 80% of their cases. Furthermore, the consistency in data recording and reporting is checked with the Inter-Rater Reliability Audit, which is a process involving the review of 20 charts, with some cases selected randomly and some cases selected based on predetermined criteria; an interrater agreement rate of 95% or more is deemed acceptable. Combined results of the audits for the 2005–2008 data revealed an interrater agreement rate of 98%.[†]

^{*}The American College of Surgeons National Surgical Quality Improvement Program and the hospitals participating in the ACS NSQIP are the source of data used herein; they have not verified and are not responsible for the statistical validity of the data analysis or the conclusions derived by the authors.

Airway injury was operationally defined in the ACS NSQIP as the development of lip laceration or hematoma, tooth injury, tongue laceration, pharyngeal laceration and laryngeal laceration as a result of tracheal intubation. The presence of airway injury was determined by the surgical clinical nurse reviewer upon review of the anesthesia record and physician notes. If more than one airway injury was present, the more severe injury was recorded for each patient, with laryngeal laceration considered as the most severe outcome. Because the ACS NSQIP does not record data regarding the technique of securing the airway or the type of airway device used, these data likely represent injuries related to placement of both tracheal tubes and supraglottic airway devices. The modified Mallampati classification and ASA physical status classification were used according to the standard definitions. Both Mallampati class and ASA classifications were abstracted by the surgical clinical nurse reviewer from the anesthetic record. A case was defined as an emergency if reported as such by the attending surgeon or anesthesiologist, when the surgical procedure was required to be performed as soon as possible and no later than 12 hours after the patient was admitted to the hospital.

Statistical Analysis

The incidence of airway injury and 99% confidence intervals (CIs) were calculated according to demographic and clinical characteristics, such as age, sex, race, body mass index (BMI), Mallampati classification, ASA physical status classification, emergent status and surgical specialty. Multivariable logistic regression was used to examine risk factors for airway injury and to adjust for potential confounding factors. Factors included in the multivariable regression included age, sex, BMI, ASA classification, Mallampati classification and surgical specialty. Mallampati class I and II patients were grouped together as the reference group given their similar incidence of airway injury. To account for the large sample size, 99% CIs, instead of the conventional 95% CIs, are reported. Statistical analysis was performed using SAS version 9.2 (SAS Institute, Cary, NC).

Results

For the years 2005–2008, the NSQIP database included 635,265 patients. Excluded from the study population were 15,292 patients with missing data on airway injury, 272 patients that had a “failure to intubate” outcome, because airway injury and failure to intubate were coded within the same variable in the NSQIP database, as well 56,511 patients who did not receive general anesthesia. Of the 563,190 patients included in the study, 1202 (0.2%) had a recorded airway injury. The most common airway injury was lip laceration/hematoma (61.4%), followed by tooth injury (26.1%), tongue laceration (5.7%), pharyngeal laceration (4.7%) and laryngeal laceration (2.1%).

The results of univariate analyses are presented with 99% CIs in Table 1. Multivariable analysis revealed two independent risk factors: relative to patients with Mallampati classes I and II, the odds of airway injury increased by 69% for those with Mallampati class III [adjusted odds ratio (OR) 1.69, 99% CI 1.36 – 2.11] and 147% for those with Mallampati class IV (adjusted OR 2.47, 99% CI 1.52 – 4.02), and relative to patients aged 40–49 years, the odds of airway injury increased by 50% for those aged 80 years or older (adjusted OR 1.50, 99% CI 1.02 – 2.19) (Table 2).

The overall mean hospital length of stay (LOS) ($\pm$ standard deviation) was 4.9 ($\pm$ 11.1) days. The mean LOS for patients with airway injury was 0.2 days (99% CI –0.4 – 0.9) longer than

[†]American College of Surgeons National Surgical Quality Improvement Program User Guide for the Participant Use Data file. August 2008. Accessed at www.nsqip.org, April 6th 2010.

for patients without injury. The 30-day mortality was similar between patients with airway injury (1.8%, 99% CI 0.8 – 2.7) and those without (1.8%, 99% CI 1.8 – 1.9), with a rate ratio of 1.0 (99% CI 0.6 – 1.5).

Discussion

Our study is a comprehensive analysis of prospectively collected data on airway injury. Based on the ACS NSQIP's definition of airway injury, our results are an analysis of clinically documented upper airway injury. The novel findings of this study are that upper airway injury occurs in approximately 1 per 500 major surgical procedures, and that difficult airways as indicated by higher Mallampati classes and advanced age (≥ 80 years) are two independent risk factors for airway injury during general anesthesia. We also found that airway injury was not associated with increased mortality or hospital LOS.

Our analysis identified the Mallampati classification as a predictor of the occurrence of airway injury. The risk of injury was increased for Mallampati class III patients, but greatest for Mallampati class IV patients, a trend which parallels the relationship of Mallampati with difficult intubation. Prior studies have consistently reported difficult intubation as a risk factor for airway injury,^{1, 3–5} and one might assume that there is a relationship between Mallampati and airway injury because difficult intubation causes injury. However, because larger amounts of oropharyngeal soft tissue may make intubation more difficult and airway injury more likely, the Mallampati classification may independently be associated with both outcomes. With regards to age, the risk for airway injury was increased in patients aged 80 years or older in comparison to patients age 40–49 years. This is consistent with results from the ASA closed claims analysis and with a study of dental injury, both of which found that older patients were predisposed to injury.^{1,3} However, given the modest level of association and the lack of a dose-response relationship, our results do not provide convincing evidence for an association between age ≥ 80 years and the risk of airway injury.

This study has several limitations inherent in the data system. First, the incidence of upper airway injury found in this study is susceptible to information bias. The method of data collection in the NSQIP database relies on clinicians to first recognize and then document the complication in the patient's chart, which is likely to lead to underreporting of less severe injuries and a lower overall incidence of airway injury. Furthermore, the coding of airway injury and failure to intubate within the same variable in the database precludes analysis of patients who are most likely to have injury secondary to airway manipulation. Second, NSQIP does not collect information for all the variables that may influence the risk of airway injury. Thus, our study may have missed other significant factors, such as the experience level of the anesthesiologist, the hospital type, other components of the airway examination (e.g., thyromental distance, neck extension, interincisor gap or neck circumference) and the technique used for securing the airway. Third, the operational definition of airway injury used by NSQIP does not include lower airway injury, the type of injury that is rarer but is associated with more severe clinical outcomes than upper airway injury.¹ Finally, participation in the NSQIP is voluntary and thus the study sample is unlikely representative of all surgical patients. As a result, it might be unwise to extrapolate the findings of this study into other study populations and geographical regions.

Nevertheless, the NSQIP is a unique resource that enables us for the first time to examine the epidemiology of upper airway injury using uniformly and prospectively collected clinical data from a large, multicenter sample of patients undergoing major surgical procedures and general anesthesia. The incidence of and risk factors for airway injury reported in this study may be useful for preoperative risk stratification.

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References

1. Domino KB, Posner KL, Caplan RA, Cheney FW. Airway injury during anesthesia: a closed claims analysis. *Anesthesiology*. 1999; 91:1703–11. [PubMed: 10598613]
2. Yasny JS. Perioperative dental considerations for the anaesthesiologist. *Anesth Analg*. 2009; 108:1564–1573. [PubMed: 19372337]
3. Givol N, Gershtansky Y, Halamish-Shani T, Taicher S, Perel A, Segal E. Perianesthetic dental injuries: analysis of incident reports. *J Clin Anesth*. 2004; 16:173–6. [PubMed: 15217655]
4. Warner M, Benenfeld SM, Warner M, Schroeder DR, Maxson PM. Perianesthetic dental injuries. *Anesthesiology*. 1999; 90:1302–1305. [PubMed: 10319777]
5. Newland M, Ellis S, Peters K, Simonson JA, Durham TM, Ullrich FA, Tinker JH. Dental injury associated with anesthesia: a report of 161,68 anesthetics given over 14 years. *J Clin Anesth*. 2007; 19:339–345. [PubMed: 17869983]

Table 1

Incidence of Airway Injury by Patient Characteristics, American College of Surgeons National Surgical Quality Improvement Program, 2005–2008

Characteristic	No. of patients [‡] (n=563,190)	No. of airway injuries (n=1,202)	Incidence Rate % (99% Confidence Interval)
Age (in Years)			
16–29	51,914	74	0.14 (0.10 – 0.19)
30–39	64,880	102	0.16 (0.12 – 0.20)
40–49	99,266	192	0.19 (0.16 – 0.23)
50–59	118,197	315	0.27 (0.23 – 0.31)
60–69	105,826	228	0.22 (0.18 – 0.25)
70–79	79,742	176	0.22 (0.18 – 0.26)
≥ 80	43,363	115	0.27 (0.20 – 0.33)
Sex			
Female	325,371	709	0.22 (0.20 – 0.24)
Male	237,793	493	0.21 (0.18 – 0.23)
Race			
Caucasian/Non-Hispanic	404,525	881	0.22 (0.20 – 0.24)
African-American/Non-Hispanic	55,119	113	0.21 (0.16 – 0.25)
Hispanic	40,273	76	0.19 (0.13 – 0.24)
Asian/Pacific	10,702	20	0.19 (0.08 – 0.29)
Islander			
Other	52,571	112	1.21 (0.16 – 0.26)
Body mass index			
<25	162,014	312	0.19 (0.16 – 0.22)
25–29	166,236	361	0.22 (0.19 – 0.25)
30–39	152,728	332	0.22 (0.19 – 0.25)
≥ 40	65,437	168	0.26 (0.21 – 0.31)
Mallampati class			
1	148,661	268	0.18 (0.15 – 0.21)
2	214,393	433	0.20 (0.18 – 0.23)
3	51,349	184	0.36 (0.29 – 0.43)
4	5743	30	0.52 (0.28 – 0.77)
ASA class			
1	56,729	108	0.19 (0.14 – 0.24)
2	257,322	486	0.19 (0.17 – 0.21)
3	209,380	500	0.24 (0.21 – 0.27)
4 or 5	39,253	104	0.26 (0.20 – 0.33)
Emergency case			
No	485,003	1057	0.22 (0.20 – 0.24)

Characteristic	No. of patients [‡] (n=563,190)	No. of airway injuries (n=1,202)	Incidence Rate % (99% Confidence Interval)
Yes	78,187	145	0.19 (0.15 – 0.23)
Surgical Specialty			
General/Other	552,044	1155	0.21 (0.20 – 0.22)
Cardiac [§]	2119	11	0.52 (0.21 – 0.83)
Ear/Nose/Throat [†]	3849	18	0.47 (0.25 – 0.68)
Neurosurgery [†]	5178	18	0.35 (0.19 – 0.51)

[‡]Totals within variables may vary due to missing data.

[§]Patients undergoing cardiac surgery, ear, nose and throat surgery, and neurosurgery accounted for less than 2% of the study sample.

Table 2

Estimated Odds Ratios (ORs) and 99% Confidence Intervals (CIs) for Airway Injury from Multivariate Logistic Regression Modeling by Patient Characteristics, American College of Surgeons National Surgical Quality Improvement Program, 2005–2008

Variable	OR	99% CI
Age (in years)		
16–29	0.83	0.54 – 1.27
30–39	0.89	0.62 – 1.28
40–49	1.00	-
50–59	1.37	1.04 – 1.81
60–69	1.23	0.91 – 1.65
70–79	1.18	0.85 – 1.64
≥ 80	1.50	1.02 – 2.19
Sex		
Female	1.00	-
Male	0.93	0.77 – 1.11
Body Mass Index		
<25	1.00	-
25–29	1.04	0.82 – 1.31
30–39	1.11	0.88 – 1.41
≥ 40	1.31	0.98 – 1.77
Mallampati class		
1–2	1.00	-
3	1.69	1.36 – 2.11
4	2.47	1.52 – 4.02
ASA class		
1	1.00	-
2	0.88	0.62 – 1.25
3	0.97	0.67 – 1.42
4 or 5	1.02	0.63 – 1.67
Surgical Specialty		
General/Other	1.00	-
Cardiac	1.82	0.67 – 4.99
Ear/Nose/Throat	2.15	0.98 – 4.71
Neurosurgery	1.94	0.99 – 3.80