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Postoperative Bleeding and Associated Utilization Following Tonsillectomy in Children: A Systematic Review and Meta-Analysis

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Abstract

Objective—To assess post-tonsillectomy hemorrhage (PTH), associated non-operative readmissions/revisits, and reoperations in children.

Data Sources—MEDLINE, EMBASE, and the Cochrane Library.

Review Methods—Two investigators independently screened studies against predetermined criteria and extracted key data. Investigators independently assessed study risk of bias and the strength of the evidence of the body of literature. We calculated unadjusted pooled estimates of PTH frequency and also conducted a Bayesian meta-analysis to estimate frequency of primary and secondary PTH and PTH-associated reoperation and revisits/readmissions by partial and total tonsillectomy and surgical approach.

Results—In meta-analysis, the frequency of primary and secondary PTH associated with total and partial tonsillectomy was below 4% for any technique and with overlapping confidence bounds. Pooled frequencies of PTH were also below 5% overall (4.2% for total tonsillectomy; 1.5% for partial tonsillectomy) in comparative studies. Fewer PTH occurred with tonsillectomy for obstructive sleep-disordered breathing than throat infection. In meta-analysis, frequency of PTH-associated non-operative revisits/readmission or reoperation ranged from 0.2% to 5.7% for total

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tonsillectomy and from 0.1% to 3.7% for partial tonsillectomy. At least four deaths were reported in case series including 1,778,342 children.

Conclusions—PTH occurred in roughly 4% of tonsillectomies in studies included in this review. Though studies typically did not report bleeding severity or amount, relatively few episodes of PTH necessitated reoperation for hemostasis. Nonetheless, tonsillectomy is not without risk of harm. Frequency of PTH across techniques was similar; thus we cannot conclude that a given technique is superior.

Keywords

tonsillectomy; adenotonsillectomy; post-tonsillectomy hemorrhage; postoperative bleeding

Introduction

Each year in the U.S. more than 500,000 children under age 15 undergo tonsillectomy or adenotonsillectomy (hereafter, tonsillectomy) making these among the most common surgeries performed on children.¹ Primary indications for tonsillectomy are obstructive sleep apnea and recurrent throat infections. While generally considered safe and straightforward, tonsillectomy has risks that vary in frequency and severity. Owing to the robust vascular supply of the tonsils, the primary risk of this operation is post-tonsillectomy hemorrhage (PTH), which can range from blood-tinged mucus to life-threatening bleeding. Definitions and classification of PTH and PTH severity vary across the tonsillectomy literature, as do methods for capturing instances of PTH.^{2–4} To mitigate PTH risks, surgeons are continually refining surgical approaches, comparing bleeding across various surgical techniques, and investigating patient and disease factors that may influence these risks.

The breadth of tonsillectomy literature makes a comprehensive understanding of the overall and technique-related risks difficult. Clear, evidence-based risk estimates are critical as families weigh the benefits and harms of undergoing this surgery. Understanding the relative risk of bleeding related to tonsillectomy for specific indications, partial (e.g., tonsillotomy, intracapsular tonsillectomy) vs. total tonsillectomy, and for tonsillectomy technique (e.g., cold, electrocautery) in children would aid clinicians and caregivers in making care decisions.

In this systematic review and meta-analysis we examined published evidence regarding PTH among children with obstructive sleep-disordered breathing (OSDB) or recurrent throat infections. This review is a component of an Agency for Healthcare Research and Quality (AHRQ)-commissioned comparative effectiveness review of tonsillectomy in children conducted by the Vanderbilt Evidence-Based Practice Center. The full comparative effectiveness review (which addresses broader questions of effectiveness and safety) and review protocol (PROSPERO registry number: CRD42015025600) are available at <http://www.effectivehealthcare.ahrq.gov>.

METHODS

Search Strategy and Study Selection

We searched the MEDLINE database via PubMed, EMBASE, and the Cochrane Library from January 1980 to June 2016 using a combination of controlled vocabulary and key terms related to tonsillectomy and OSDB or recurrent throat infections (e.g., tonsillectomy, adenotonsillectomy, obstructive sleep apnea, streptococcal pharyngitis). We also hand-searched the reference lists of included articles and recent reviews addressing tonsillectomy in children to identify potentially relevant articles. We used the broader term OSDB after extensive discussions with a multidisciplinary expert panel and key informants (including pediatric otolaryngologists and pediatric sleep specialists) who agreed that this term would be inclusive of disorders ranging from simple snoring to OSA, as each can have significant quality of life and health consequences.

We also developed inclusion criteria in consultation with an expert panel of clinicians and researchers (Table 1). We included comparative study designs (e.g., randomized controlled trials [RCTs], prospective or retrospective cohort studies) to address effectiveness and harms outcomes. We also included case series or database or registry studies with at least 1,000 children to evaluate rates of PTH, PTH-associated revisits or readmissions, and PTH-associated reoperation. We considered PTH to comprise any report of post-tonsillectomy bleeding, including the entire range of bleeding as reported in each study, from bloody sputum to frank bleeding requiring readmission or reoperation.

Data Extraction and Analysis

One investigator extracted data regarding study design, descriptions of study populations, intervention and comparison groups, and baseline and outcome data using a standardized form. A second investigator independently verified the accuracy of the extraction and revised as needed.

In order to account fully for PTH, readmission, and reoperation, we compiled all comparative studies and examined the frequency of harms by study arm in unadjusted analyses, then reviewed data in case series and database and registry studies. We present the data obtained from comparative studies that had low or moderate risk of bias followed by that of the case series and database studies (low or moderate risk of bias) and comment on their consistency. Finally, we conducted Bayesian mixed-effects, arm-based meta-analyses to assess the influence of different surgical procedures and the effect of partial and total tonsillectomy on the occurrence of PTH-related outcomes following surgery. Sensitivity analyses that estimated the effects of including high risk of bias studies in our analyses suggested no systematic effects of these studies; thus, we retained them in meta-analyses.

Assessment of Study Risk of Bias

Two investigators independently evaluated the risk of bias (methodologic quality) of studies using prespecified questions appropriate to each study design to assess risk of bias of RCTs and observational studies.⁵ Senior reviewers resolved discrepancies in risk of bias assessment through discussion to reach consensus.

Assessment of Strength of Evidence

Strength of the evidence reflects the confidence that we have in the stability of treatment effects in the face of future research.⁶ The degree of confidence that the observed effect of an intervention is unlikely to change - the strength of the evidence - is presented as insufficient, low, moderate, or high. Assessments are based on consideration of five domains: study limitations, consistency in direction of the effect, directness in measuring intended outcomes, precision of effect, and reporting bias. We determined the strength of evidence separately for major intervention-outcome pairs using a prespecified approach described in the full review.⁷

RESULTS

Overview of Included Studies

Our searches (conducted for the broader systematic review⁷) identified 9608 citations, of which 87 comparative studies (reported in multiple publications) met inclusion criteria and reported PTH data, which included all forms of bleeding. PTH may have been reported as primary (generally defined as occurring within 24 hours of surgery), secondary (generally defined as occurring more than 24 hours postoperatively), or at an undefined or unspecified time.^{8–108} Seventy-three studies contributed data to the meta-analysis (66 RCTs^{19,20,23,25,27,29,33,34,36,38–41,43,44,46,47,49,50,52–59,62–64,67,71,72,74–79,81–84,88–92,95,101–105,108–122}, 6 nonrandomized trials,^{24,35,37,45,48,94} and 1 prospective cohort study⁷⁰). The resulting subset of studies included the following tonsillectomy techniques: cold dissection, electrocautery, coblation, harmonic scalpel, laser, molecular resonance, thermal welding, and microdebrider.

In addition, we sought PTH reported in case series and database analyses to determine whether the frequency supported findings in the comparative literature, and to assess harms in larger study populations. We identified 46 unique database or registry studies or case series with 1000 children (reported in multiple papers) addressing PTH.^{3,4,123–176}

Unadjusted PTH-Related Outcomes in Comparative Studies

Total Tonsillectomy—Fifty-eight unique comparative studies (105 arms) reported on postoperative PTH.^{8–15,19,20,23,25,27,33–41,43–47,50–59,62–64,67,70–79,81–84,88,89,91,92,94–98,101,102,106–108,177} The 6299 children across studies who were treated with total tonsillectomy experienced 265 episodes (4.2%) of PTH (Table 2). PTH ranged from parent-reported bleeding that did not require accessing clinical care to reoperation for hemostasis. In all, 33 were primary (1.3%; typically occurring within 24 hours of tonsillectomy), 166 were secondary (4.8%; occurring more than 24 hours post-tonsillectomy), and for 66, timing was not specified (2.7%). Sixty-eight children required reoperation to control PTH (2.2%), and 80 had nonoperative revisits or readmissions for PTH (3.0%).

Children who underwent tonsillectomy with harmonic scalpel had the highest frequency of PTH (11.3%), although few children underwent this procedure (n=397). Few children had

laser tonsillectomy (n=189), with 5.3% experiencing PTH. Frequencies were similar among more commonly used techniques: cold dissection had a frequency of 3.8%; electrocautery had a frequency of 4.9%; and coblation had a frequency of 3.0%. The overall frequency of non-operative visits/readmissions for PTH was 3.0% (range 0.23 – 11.4 across modalities). Table 2 outlines data for each technique in each study arm.

Partial Tonsillectomy—The overall PTH frequency for partial tonsillectomy reported in arms of 16 studies was 1.5% (Table 3).^{25,29,39,47,49,50,53,56,58,63,81,88,91,99,100,103–107}

Primary and secondary PTH was observed in 0% and 1.6% of children overall, respectively. Non-operative revisits/readmissions for PTH occurred in 1.8% of cases, while reoperation to control bleeding was performed in 0.64% of children who had undergone partial tonsillectomy. Across surgical techniques, frequency was highest for partial coblation tonsillectomy (4.2%). No PTH was associated with laser approaches, but few, small studies (n=54 children total) assessed this modality.^{29,99,100}

PTH by Indication—Across all techniques and types of tonsillectomy (partial or total), the overall unadjusted frequency of PTH was 1.9% (Table 4) for children with OSDB. The overall frequency was higher in children with throat infection (3.7%). Primary PTH was similar between throat infection and OSDB (0.58% vs. 0.41%), while secondary PTH, non-operative revisit/readmission, and reoperation were higher among children with throat infection (Table 4).

Meta-Analysis Results

Total Tonsillectomy—Frequency of primary PTH associated with total tonsillectomy in the meta-analysis was similar between modalities, with overlapping confidence bounds (Table 5). Electrocautery and harmonic scalpel were associated with higher frequency of secondary PTH (occurring >24 hours post-procedure), with estimates of 4.2% to 4.3% and wide 95% Bayesian credible intervals (BCI). Non-operative readmissions or revisits for PTH ranged from 0.2% to 6% and reoperation for hemostasis from 0.2% to 5%. Although laser tonsillectomy was associated with the highest estimated risk of readmission/revisit (5.7%, 95% BCI: 0.7% to 12%) and reoperation (5.2%, 95% BCI: 0.2 to 13.7), the confidence bounds were wide.

Partial Tonsillectomy—Primary PTH associated with partial tonsillectomy was below 4% regardless of technique, and secondary bleeding at or below 3%. Data on revisits/readmissions and reoperations were sparse; thus confidence bounds are very wide, and it is difficult to predict frequencies with certainty (Table 6).

PTH by Indication—As in unadjusted analyses, lower frequencies of primary and secondary PTH were associated with OSDB as the indication for either partial or total tonsillectomy (Table 7). The frequency of primary PTH after total tonsillectomy in children with OSDB was 0.3% (95% BCI: 0% to 0.9%) and was 1.8% when recurrent throat infection was the indication (95% BCI: 0% to 5.9%). Primary PTH frequency after partial tonsillectomy in children with OSDB was 1.2% (95% BCI: 0% to 4.1%).

Few studies considered partial tonsillectomy for recurrent throat infection, so sample sizes were smaller and estimates are imprecise. Moreover, partial tonsillectomy involves leaving a cuff of tonsillar tissue, which is often accompanied by some mild oozing that is felt to be self-limited and not cauterized. Thus, the risk of minor PTH may be higher with this approach. As noted, this estimate of PTH frequency is imprecise, with wide credible intervals ranging from 0% to 28.7%.

Case Series and Database Analyses—Overall, 2.1% of children in large case series or database studies experienced a PTH episode (Table 8), a rate lower than that reported in comparative studies (4.2%). Comparative studies were typically prospectively conducted, which may have more accurately captured PTH episodes. Case series and database studies also had much larger sample sizes (>1000 children), which may account for the difference in rates.

Overall, few children required non-operative revisits/readmissions or reoperation for PTH, 0.7% and 0.4%, respectively. Case series and database studies infrequently specified the surgical technique or indication for tonsillectomy. In those studies that did report technique, total electrocautery tonsillectomy (6.3%) was associated with the highest frequency of total PTH (Table 8). Few case series or database studies reported indication. In two study arms reporting such data, OSDB as the indication for surgery was associated with a 0.8% frequency of PTH overall and throat infection (reported as the indication in 1 study) was associated with a 0.6% frequency.

At least four deaths were reported across four case series or database studies reporting mortality.^{134,141,172,174,175,178} In one study, a 10-year old child with muscular dystrophy, among other comorbidities, died from suspected ventricular fibrillation one month after tonsillectomy;¹⁷² investigators did not consider the death related to surgery. In another, a 42-month old child with recurrent PTH died from bleeding-related shock after he was discharged 6 days post-tonsillectomy.^{174,175,178} Another database study reported two deaths (out of 36,221 tonsillectomies, 0.006%) but did not report cause of death.¹⁴¹ Finally, a fourth database study did not report exact numbers or causes of death but compared tonsillectomy complications occurring in different hospital types (teaching or non-teaching children's hospitals, nonteaching hospitals)¹³⁴ in each hospital type 10 deaths occurred, but the study does not report specific figures.

Strength of the Evidence

We considered only data from meta-analyses and comparative studies in our assessment of the strength of the evidence. Strength of evidence is high for a low frequency of PTH and PTH-associated utilization (readmissions or revisits) associated with both partial and total tonsillectomy.

Discussion

PTH is a critical risk associated with tonsillectomy. Clinicians and researchers cite variable rates based on personal experience and/or understanding of the literature. This systematic review and meta-analysis synthesizes the available evidence in order to provide population-

level estimates of PTH and related health utilization (i.e., need for revisits/readmissions or reoperation). Our study found that PTH and associated utilization after tonsillectomy occurred in less than 5% of children and that readmission or reoperation rates for PTH were typically below 4%. While these rates are comparatively low, any bleeding may be serious and is certainly troubling to patients and their caregivers. Severity of bleeding and repeat bleeding may be more predictive of serious morbidity than simple frequency, but our ability to assess this was limited. Some studies have suggested that repeated PTH episodes can be considered warning signs of impending serious PTH,^{3,179–181} however, we could not assess timing of PTH beyond primary and secondary as few studies reported whether children experienced more than one episode. Nonetheless, severity of bleeding directs management decisions; specifically whether a child is seen and discharged from the emergency department, admitted for observation, or undergoes surgical hemostasis, which presumably would represent the most severe bleeding episodes. Several factors that may influence PTH are reviewed below.

Factors Influencing PTH

Technique Comparison—Tonsillectomy technique has long been discussed as a potential mitigating factor in reducing PTH risk. Otolaryngologists typically become facile with a particular technique(s) and use that preferentially. This preference may derive from training environment and years in practice among other sources.^{182,183} A significant literature is dedicated to comparing various surgical techniques. Overall, unadjusted PTH rates among comparative studies (i.e., including a treatment and comparison group) were similarly low among common techniques: cold dissection (3.8%) electrocautery (4.9%), and coblation (3.0%). In meta-analysis, electrocautery and harmonic scalpel were associated with higher rates of secondary PTH (occurring >24 hours post-procedure), with estimates of 4.2 to 4.3 percent. However, confidence intervals around these estimates were wide, indicating relative imprecision based on limited available data. Despite this finding, the differences in PTH rates among the various techniques were similar and whether differences seen are clinically significant remains uncertain.

Differences by Indication—Surgical indication is another commonly referenced factor that could influence the frequency of PTH.^{149,152,184} Standard teaching is that patients with recurrent throat infections are more likely to have postoperative bleeding. This is thought to relate to the inflammatory process occurring in and around the tonsil, less distinct dissection planes, and associated increased vascularity.^{130,152,185–187} Unadjusted analyses confirmed this suspicion. Across techniques and types of tonsillectomy (partial or total), children undergoing tonsillectomy for OSDB had lower rates of PTH than those whose indication was recurrent infection (1.9% vs. 3.9%).

Partial vs. Total Tonsillectomy—Controversy exists regarding whether bleeding rates differ between total and partial tonsillectomy. Proponents of partial tonsillectomy argue that it is as effective as total tonsillectomy at treating underlying pathology, with less pain and has a lower rate of PTH and other complications.^{124,188–192} Pooled rates (without adjustment) of PTH were also less than 5 percent overall (4.2% for total tonsillectomy; 1.5% for partial tonsillectomy) in comparative studies. In meta-analysis, we compared the

frequency of PTH between partial and total tonsillectomy and found that primary and secondary PTH associated with both approaches were below 4 percent for any surgical technique and across all techniques, with overlapping confidence bounds (total tonsillectomy: primary PTH=0.5% [95% BCI: 0.1%-1%], secondary PTH=2.9% [95% BCI: 1.5%-4.3%]; partial tonsillectomy: primary PTH=1.7% [95% BCI:0%-4.6%], secondary PTH=0.4% [95% BCI: 0%-1.2%]). Thus, evidence herein does support the supposition that partial tonsillectomy has a lower PTH rate. Potential differences in PTH risk must be considered within the broader risk-benefit ratio, including considerations of potential regrowth of tonsils, when considering approach. It is also important to note that few studies addressed partial tonsillectomy, which could influence effect size precision.

Though not formally assessed in the current review, other studies have addressed potential risk factors for PTH. Older age and male sex have variably been associated with greater risk of bleeding.^{124,126,129,137,142,143,157} Furthermore, we could not assess baseline severity of disease (e.g., Apnea Hypopnea Index or polysomnography for OSDB or infection severity [number or type of infections] as a risk factor in our review given limitations in reporting). Finally, effects of surgeon skill and experience on PTH are not clear and are difficult to measure and rarely reported in this literature.^{3,4,151,155,193}

Mortality and Tonsillectomy

Several large case series, databases, and clinical registries have been used to evaluate the harms associated with tonsillectomy. These studies are important because comparative studies like those used in meta-analyses often underestimate harms and/or may not capture more rare and serious consequences like death.^{194,195} Deaths were reported, albeit rarely. Specifically, at least four deaths were reported across case series or database studies (low or moderate risk of bias) including 1,778,342 children. This translates into a mortality rate of approximately 1/500,000, which is lower than that referenced for pediatric general anesthesia (<1/10,000).^{196,197} This difference may relate to the general overall health (i.e., as classified using the American Society of Anesthesiologists [ASA] Physical Status) of children undergoing tonsillectomy compared to the totality of children undergoing surgery with general anesthesia. Studies reporting ASA class in the current review consistently included children with ASA I or II status (i.e., healthy patients or those with mild systemic disease and no substantive functional limitations).¹⁹⁸

We limited our search to English publications; therefore applicable studies published in other languages were not captured. Other limitations relate to the state of the current literature. Heterogeneity in reporting was evident across studies, thereby reducing the ability to combine all candidate studies for meta-analyses. Contributing to imprecision of PTH estimates were lack of consistency or clarity in reporting 1) timing of bleeding, 2) utilization consequences (i.e., revisits/readmissions, re-operations), 3) severity of bleeding (generally not explicitly recorded), 4) stringency of methods for capturing instances of PTH, which could have varied from reporting blood-tinged sputum to reporting only frank bleeding; and 5) the modifying effect of severity of indication for tonsillectomy (infection or OSDB [e.g., AHI]). We attempted to overcome the absence of direct data on severity of bleeding by assuming that bleeding was progressively more severe if 1) reported and not requiring revisit

or readmission, 2) need for revisit and/or readmission, or 3) reoperation for hemostasis. Heterogeneity also precluded analyses that adjusted for the potential effects of differing anesthesia regimens, perioperative medication use, patient comorbidities, and surgeon-related factors. Nonetheless, the methodology used optimized estimates based on the state of the literature on this topic.

Conclusions

In conclusion, we found relatively low rates of PTH, with higher rates associated with total tonsillectomy vs. partial and with similar rates among commonly used techniques (e.g., cold dissection, coblation). The frequency of revisits or readmissions or reoperations to control hemostasis was generally below 5%. Evidence in this review does not support the superiority of one approach (partial vs. total) or any one technique over another. Finally, the clinical significance of PTH is inextricably tied to the severity of such bleeding, which influences both the risk to the patient and the potential need for intervention. The paucity of bleeding severity data also limits a comprehensive comparison between techniques.

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Figure 1.

Disposition of studies identified for this review

*Numbers do not tally as studies could be excluded for multiple reasons.

Abbreviations: n = Number.

Table 1

Inclusion criteria

Category	Criteria
Population	<ul style="list-style-type: none">• Children with OSDB or recurrent throat infection undergoing tonsillectomy age 3–18 years, inclusive
Intervention	<ul style="list-style-type: none">• Tonsillectomy, adenotonsillectomy, or tonsillotomy (partial removal of tonsil) using any surgical approach (e.g., coblation, laser, cold dissection)
Design	<ul style="list-style-type: none">• Comparative studies (RCTs, prospective or retrospective cohort studies with comparison groups, nonrandomized trials, case-control studies); database or registry studies or case series with at least 1000 participants
Other	<ul style="list-style-type: none">• Original research• Publication language: English• Publication year: January 1980–June 2016• Risk of bias: low or moderate (high risk of bias included in meta-analyses after sensitivity analyses)• Sufficiently detailed methods and results to enable data extraction• Reports outcome data by target population or intervention

Abbreviations: OSDB = Obstructive Sleep-Disordered Breathing; RCT = Randomized Controlled Trial

Table 2

Unadjusted PTH-related outcome rates in study arms evaluating total tonsillectomy

Technique (N arms)	N	PTH (%)	Primary PTH (%)	Secondary PTH (%)	Unspecified PTH (%)	Revisits/Readmissions for PTH (%)	Reoperations for PTH (%)
All arms (105)	6299	265 (4.2)	33 (1.3)	166 (4.8)	66 (2.7)	80 (3)	68 (2.2)
Electrocautery (29)	1668	82 (4.9)	5 (0.37)	62 (6.3)	15 (2.3)	36 (5)	21 (2.6)
Cold dissection (34)	1904	72 (3.8)	6 (0.54)	49 (4)	17 (2.7)	9 (1.6)	19 (2.3)
Coblation (19)	728	23 (3.2)	3 (2.1)	7 (2.4)	12 (2.7)	2 (1.1)	4 (2.5)
Unspecified/ other (5)	748	25 (3.3)	9 (3.1)	NR	16 (3.5)	8 (2)	10 (2.3)
Molecular resonance (5)	466	4 (0.86)	0 (0)	4 (1.22)	0 (0)	1 (0.23)	1 (0.31)
Harmonic scalpel (5)	397	45 (11.3)	1 (0.63)	38 (11.3)	6 (9.8)	15 (5.5)	9 (2.8)
Thermal welding (4)	199	5 (2.5)	0 (0)	5 (2.96)	0 (0)	NR	1 (0.96)
Laser (4)	189	10 (5.3)	9 (11.4)	1 (0.91)	NR	9 (11.4)	3 (2.8)

Note: Percentages for primary and secondary PTH, readmissions/revisits, and reoperations reflect the number of each instance of bleeding or reoperation divided by the total number of patients in the studies reporting such data, and not in the total number of participants across all studies in a given row.

Abbreviations: N = Number; PTH = Post-Tonsillectomy Hemorrhage

Table 3

Unadjusted PTH-related outcome rates in study arms evaluating partial tonsillectomy

Technique (n arms)	N	PTH (%)	Primary PTH (%)	Secondary PTH (%)	Unspecified PTH (%)	Revisits/ Readmissions for PTH (%)	Reoperations for PTH (%)
All arms (18)	599	8 (1.5)	0 (0)	2 (1.6)	6 (1.4)	5 (1.8)	1 (0.64)
Microdebrider (5)	252	3 (1.2)	NR	NR	3 (1.2)	3 (1.5)	NR
Coblation (6)	169	4 (4.2)	0 (0)	2 (6.3)	2 (2.2)	2 (2.8)	0 (0)
Cold dissection (4)	124	1 (0.81)	0 (0)	0 (0)	1 (1.4)	NR	1 (1.1)
Laser (3)	54	0 (0)	0 (0)	0 (0)	0 (0)	NR	NR

Note: Percentages for primary and secondary PTH, readmissions/revisits, and reoperations reflect the number of each instance of bleeding or reoperation divided by the total number of patients in the studies reporting such data, and not in the total number of participants across all studies in a given row.

Abbreviations: N = Number; PTH = Post-Tonsillectomy Hemorrhage

Table 4

Unadjusted PTH-related outcome rates by indication in study arms evaluating total or partial tonsillectomy

Indication (n arms)	N	PTH (%)	Primary PTH (%)	Secondary PTH (%)	Undefined PTH (%)	Revisits/ Readmissions for PTH (%)	Reoperations for PTH (%)
OSDB (28)	1219	22 (1.9)	2 (0.41)	11 (2.1)	9 (1.1)	8 (1.4)	3 (0.85)
Throat infection (34)	1764	88 (5)	12 (1.8)	64 (6.2)	12 (2.3)	29 (3.4)	10 (1.6)

Note: Percentages for primary and secondary PTH, readmissions/revisits, and reoperations reflect the number of each instance of bleeding or reencounter divided by the total number of patients in the studies reporting such data, and not in the total number of participants across all studies in a given row.

Abbreviations: N = Number; PTH = Post-Tonsillectomy Hemorrhage

Table 5

Rates of PTH and PTH-associated readmissions or revisits after total tonsillectomy, % (95% BCI)

Technique	Primary PTH	Secondary PTH	Readmission	Reoperation
Overall (Across all techniques)	0.5 (0.1 – 1)	2.9 (1.5 – 4.3)	1.8 (0.4 – 3.3)	1.6 (0.9 – 2.3)
Cold	0.7 (0.1 – 1.5)	3.3 (1.9 – 5.3)	2.7 (0.7 – 4.9)	1.3 (0.5 – 2.1)
Electrocautery	0.6 (0 – 1.5)	4.2 (2.4 – 6.5)	2.9 (0.7 – 5.3)	1.2 (0.5 – 1.9)
Coblation	1.1 (0 – 3.0)	2.3 (0.7 – 4.4)	1.4 (0.1 – 3.3)	1.2 (0.3 – 2.4)
Harmonic Scalpel	1.0 (0 – 3.3)	4.3 (1.8 – 7)	1.5 (0.2 – 3.1)	3.9 (1.6 – 6.9)
Laser	2.2 (1.0 – 5.8)	1.2 (0 – 3.4)	5.7 (0.7 – 12.6)	5.2 (0.2 – 13.7)
Molecular Resonance	0.6 (0 – 2.5)	1.1 (0.2 – 2.4)	0.2 (0 – 0.6)	0.2 (0 – 0.5)
Thermal Welding	0.5 (0 – 2.1)	3.6 (0.5 – 7.5)	2.7 (0 – 12.7)	0.8 (0 – 2.4)

Abbreviations: BCI = Bayesian Credible Interval; PTH = Post-Tonsillectomy Hemorrhage

Table 6
Rates of PTH and PTH-associated readmissions or revisits after partial tonsillectomy, % (95% BCI)

Technique	Primary PTH	Secondary PTH	Readmission	Reoperation
Overall (Across all techniques)	1.7 (0 – 4.6)	0.4 (0 – 1.2)	0.7 (0 – 1.9)	0.7 (0 – 1.7)
Cold	1.5 (0 – 4.7)	2.3 (1 – 5.9)	3.7 (0.1 – 10.3)	0.5 (0 – 1.3)
Electrocautery	1.5 (0 – 5.3)	3 (0.2 – 8)	4 (0.2 – 12.3)	0.4 (0 – 1.2)
Coblation	1.5 (0.1 – 4.2)	1.4 (1 – 3.5)	1.4 (0.1 – 3.1)	0.4 (0 – 1.1)
Harmonic Scalpel	2.2 (0 – 8.3)	3 (1 – 7.9)	2.1 (0 – 6.3)	1.4 (0 – 3.9)
Laser	3.9 (0 – 12.9)	0.7 (0 – 2.4)	7.3 (0.2 – 20.7)	1.8 (0 – 5.4)
Molecular Resonance	1.4 (0 – 6)	0.8 (0 – 2.3)	0.3 (0 – 1)	0.1 (0 – 2)
Thermal Welding	1 (0 – 4.5)	2.6 (0 – 7.7)	3.4 (0 – 17)	0.3 (0 – 1)

Abbreviations: BCI = Bayesian Credible Interval; PTH = Post-Tonsillectomy Hemorrhage

Table 7
Rates of PTH and PTH-associated readmissions or revisits by indication and approach, % (95% BCI)

Approach/Indication	Primary PTH	Secondary PTH	Readmission	Reoperation
Total Tonsillectomy				
OSDB	0.3 (0 – 1.0)	2.2 (0.3 – 4.8)	0.1 (0 – 2.7)	1.3 (0.3 – 2.7)
Recurrent throat infection	1.7 (0 – 5.6)	3.7 (0.9 – 7.1)	2.1 (0 – 6.6)	1.6 (0.2 – 4)
Partial Tonsillectomy				
OSDB	1.3 (0 – 4.3)	0.3 (0 – 1.2)	0.4 (0 – 1.4)	0.6 (0 – 1.6)
Recurrent throat infection	7.8 (0 – 28.7)	0.6 (0–2.1)	1.0 (0 – 3.5)	0.9 (0 – 2.8)

Table 8

Rates of PTH reported in case series or database studies

Technique or Indication	N	Total PTH, n (%)	Primary PTH, n (%)	Secondary PTH, n (%)	Unspecified PTH, n (%)	Nonoperative revisit or readmission for PTH, n (%)	Reoperation for PTH, n (%)
Overall Rates							
All studies	1151654	24323 (2.1)	1012 (0.09)	2149 (0.2)	21162 (1.8)	8296 (0.7)	4751 (0.4)
Technique							
Total Electrocautery (5)	20349	1286 (6.3)	105 (0.6)	734 (3.9)	447 (4)	216 (2.3)	65 (0.6)
Total Cold (10)	49580	1342 (2.7)	606 (1.3)	453 (1.2)	283 (2.3)	90 (0.6)	161 (0.6)
Coblation (4)	15875	487 (3.1)	53 (0.5)	246 (2.2)	188 (3.8)	109 (1.2)	214 (1.3)
Other Techniques (24)	1065850	21208 (2)	248 (0.9)	716 (2.7)	20244 (2)	7881 (1.3)	4311 (0.8)
Indication							
OSDB (2)	42754	352 (0.8)	74 (0.7)	118 (1)	160 (0.5)	NR	168 (0.4)
Throat Infection (1)	1500	9 (0.6)	NR	NR	9 (0.6)	NR	2 (0.1)

Abbreviations: N=number; NR=not reported; PTH = post-tonsillectomy hemorrhage