Original Article

An evaluation of factors associated with intraoperative blood loss in tonsillectomy using a novel grading system

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Background: There is no standardized method for estimating intraoperative blood loss (IBL) in tonsillectomy. The aims of this study were: (I) to develop a new grading system to estimate IBL and standardize its reporting in tonsillectomy that could be used in clinical and research settings, and (II) to identify the factors associated with IBL.

Methods: This was a double-staged study. An experimental study was first conducted to develop a new grading system to estimate IBL in tonsillectomy, ranging from 1 (minimal) to 5 (severe), based on the number of gauze swabs used, the volume of blood in the suction canister, and the use of rescue measures to achieve haemostasis. This grading system was used in a retrospective analysis of 538 tonsillectomy patients (age range 1–57) to identify the factors associated with IBL.

Results: Tonsillectomies were performed by argon plasma coagulation (APC) (n=232), coblation (CB) (n=38) and cold steel (CS) (n=268). APC and CB tonsillectomies were combined as electrosurgery (ES) (n=270) for statistical analysis. ES group had decreased IBL compared with CS group (P<0.001). Patients with recurrent or chronic tonsillitis (RT/CT) had increased IBL compared to those with obstructive sleep apnoea (OSA) or asymmetrical tonsils (AT) (P=0.0002). Adults had increased IBL and there was no statistically significant difference between genders.

Conclusions: We developed a new grading system for standardizing the reporting of estimated IBL in tonsillectomy. Factors associated with increased IBL include age, indication for surgery and surgical technique. These factors could be taken into consideration in preoperative planning for high risk patients.

Keywords: Tonsillectomy; intraoperative blood loss; grading; factors

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Introduction

Intraoperative blood loss (IBL) in surgery is an important predictor of perioperative outcome (1-5). In tonsillectomy, it is used as an indicator of safety when evaluating new tonsillectomy techniques (6-8). However, there is no standardized method for quantifying IBL in tonsillectomy. This leads to difficulties in its interpretation in the published literature (9,10).

Volumetric and gravimetric methods have been commonly used with the data presented as a numerical continuum. These measurements can be directly used in

statistical analysis but does not truly reflect what occurs in clinical practice.

In practice, the accurate quantitative assessment of IBL is difficult for a number of reasons: the small volumes lost in the tubing of suction canisters and drying of gauze swabs result in inaccurate measurements of volume and weight; the loss of blood into tissues cannot be measured; and the measurement of haemoglobin levels pre- and postoperatively is both an impractical and potentially misleading method for assessing IBL (1). These difficulties have been highlighted in a study by Brecher *et al*. (9), which demonstrated that blood loss estimated by clinicians was consistently 2.1 times less than blood loss calculated using a mathematical model. To address these issues, a number of alternative methods such as haemoglobin colorimetry, electrical conductivity and osmolality have been evaluated but have been shown to have limited applicability in clinical practice (9).

As there is no standardized method for the reporting of IBL in tonsillectomy, studies that quote IBL within a fraction of a millilitre may be inherently erroneous. Such errors may significantly alter study outcomes when the total IBL is minimal, as is in tonsillectomy, and can become important when used as a marker to compare different tonsillectomy techniques.

There is also a lack of research on the factors that contribute to IBL in tonsillectomy. Thus far, only one study has examined IBL in adenotonsillectomy and the risk factors for increased bleeding (10). In this study of 100 patients, volumetric and gravimetric methods were used to evaluate IBL. Increased bleeding was associated with increased age, male gender, fibrosed tonsils, lower preoperative haemoglobin levels, longer clotting times and pre-operative antibiotic use (10). Although a number of risk factors were examined, the conclusions were drawn from observed trends of IBL without statistical analysis. Therefore, a type 1 error was not excluded for each of the risk factors identified.

We present the largest study to date, with the primary objective of investigating IBL in tonsillectomy. The aims of this study were to develop a new grading system to estimate IBL and standardize its reporting in tonsillectomy which could be used in clinical and research settings, and to identify the factors associated with increased IBL. We present the following article in accordance with the STROBE reporting checklist (available http://dx.doi.org/10.21037/ajo-19-67).

Methods

This study had two components: (I) an experimental study to develop a grading system to estimate IBL in tonsillectomy and (II) a retrospective case series to examine factors (demographic, clinical and surgical) that affect IBL.

Experimental study

The amount of blood required to saturate one standard surgical gauze was estimated, using a similar method to that described by Ghettas in the orthopaedic setting (11). The standard surgical gauze swab used in tonsillectomy was selected (Ray-tec® 10 cm × 10 cm). Ten percent povidone-iodine solution was used because it mimics the consistency of blood and has a specific gravity of 1.03–1.05 g/mL at room temperature, which is similar to that of whole blood (1.0506 g/mL, 95% CI: 1.0537–1.0475) and plasma (1.0205 g/mL, 95% CI: 1.0216–1.0193) at 37 ℃ (12,13). Four plastic containers of different sizes and shapes with irregular surfaces were each filled with 20 mL of 10% povidone-iodine solution.

Ten clinicians with varying levels of surgical experience (three resident medical officers, four registrars and three consultants) participated in the study. They were asked to fold or scrunch the surgical swabs and use forceps to completely absorb the povidone-iodine solution from each container onto the swabs, as they would absorb blood being lost from small surgical fields during tonsillectomy. The number of swabs used to completely absorb the solution from each container was recorded. A total of 40 measurements were obtained. A mean of two 10 cm × 10 cm Ray-tech® swabs were required to absorb 20 mL of solution, equating to 10 mL per swab. Differences in the surface area of the containers, the depths of solution and the levels of surgical experience did not significantly alter the number of swabs used.

Using a combination of this experimental data and our clinical experience, a five-tier grading system was developed to describe the severity of IBL in tonsillectomy (*Table 1*). The grade assigned to the amount of bleeding during each operation was based on a combination of the following criteria: the number of swabs used, the volume of blood in the suction canister, and the use of rescue measures to achieve haemostasis and/or haemodynamic stability. For each grade, a corresponding range of volumes was

Table 1 Grading of intraoperative blood loss in tonsillectomy*

Grade	Number of Ray-tech® swabs used†	Volume of blood in suction canister (mL)	Rescue measures
Grade 1: minimal			
1a	<50% of 1 swab	0	None
1b	Up to 1	<5	None
Grade 2: mild	1–2	<50	None
Grade 3: moderate	2–5	<100	None
Grade 4: moderately severe	5–7	<200	None
Grade 5: severe	7 or more	>200	Intra- or postoperative blood transfusion, and/or ligation of the external carotid artery

*, based on the experimental observation that each 10 cm × 10 cm Ray-tech® swab absorbed approximately 10 mL of 10% povidone-iodine solution; †, nearest whole number of saturated swabs. Approximated corresponding volumes of blood loss for each grade are as follows: grade 1a =0–5 mL, grade 1b =6–15 mL, grade 2 =16–70 mL, grade 3 =71–150 mL, grade 4 =151–270 mL, grade 5 =>270 mL.

estimated, to allow comparisons between this grading system and the volumetric blood loss reported in other studies.

Retrospective case series

Patients

We used a multi-institutional database of tonsillectomies performed in Adelaide, South Australia. Demographic and clinical data were collected by the senior author (Shaw CKL) prospectively over a period of five years, and included age, gender, surgical technique, indication for surgery and severity of IBL. The severity of IBL was assessed by both the surgeon and the scrub nurse, based on the number of Ray-tech® gauze swabs used, the volume of blood in the suction cannister, the use of rescue measures (if any) during the operation, and a grade was recorded by the surgeon at the time of surgery (*Table 1*).

All patients who underwent elective bilateral tonsillectomies were retrospectively identified. Patients were excluded if they had a known bleeding diathesis, had been taking anticoagulants or non-steroidal anti-inflammatory drugs (NSAIDs) within 10 days of their operation, or underwent other concurrent oral or oropharyngeal procedures, including adenoidectomy.

This study was approved by the local Human Research Ethics Committee.

Surgical techniques

Five hundred and thirty eight patients who underwent elective bilateral tonsillectomies were included in the study. All operations were performed under general anaesthesia with oral endotracheal intubation, Boyle Davis gag and a dose of intravenous dexamethasone on induction. No patient received prophylactic antibiotics or steroids during their inpatient stay or on discharge.

Three surgical techniques were used for the tonsillectomies: argon plasma coagulation (APC), coblation (CB) and cold steel (CS). All tonsillectomies were performed by a single consultant otolaryngologist (Shaw CKL), who was experienced with all three techniques. The choice between APC, CB and CS tonsillectomy was largely based on the availability of surgical equipment at the local institution.

APC tonsillectomy was performed as follows: the anterior pillar was dissected under continuous activation of the APC electrode in a one-step coagulation and dissection process, in a non-contact fashion. The tonsil was dissected from the tonsillar fossa until the lower pole was reached and excised. In cases of intensive vascularisation, the speed of dissection was reduced to allow sufficient coagulation. Bipolar coagulation was used for further haemostasis if there was a large visible vessel or brisk bleeding. The ExplorAr® ST700-311EI disposable electrode (ConMed Linvatec Australia Pty Ltd) with a 10 mm medium tungsten needle and a 5 mm insulated extension was used for all APC tonsillectomies.

CB tonsillectomy was performed as follows: the anterior pillar was dissected under continuous activation of the CB wand in a one-step coagulation and dissection process.

Table 2 Patient demographics, indications for surgery and surgical techniques used in elective bilateral tonsillectomies

Variable	No. of patients (%)
Age (years)	
0–10	326 (60.6)
11–20	115 (21.4)
>21	97 (18.0)
Gender	
Male	219 (40.7)
Female	319 (59.3)
Surgical technique	
CS	268 (49.8)
APC	232 (43.1)
CB	38 (7.06)
Surgical indication (ES only)	
RT/CT/QT	168 (62.2)
SDB/OSA/AT	102 (37.8)

APC, argon plasma coagulation; AT, asymmetrical tonsils; CB, coblation; CS, cold steel; CT, chronic tonsillitis; ES, electrosurgery; OSA, obstructive sleep apnoea; QT, quinsy tonsillectomy; RT, recurrent tonsillitis; SDB, sleep disordered breathing.

The Procise EZ Wand and EVAC 70 XTRA Wand (Smith and Nephew Australia Pty Ltd) were used for all CB tonsillectomies.

CS tonsillectomy was performed as follows: a mucosal incision was made with scissors. The anterior pillar was dissected away from the tonsillar fossa using a Gwynne Evans Dissector until the lower pole was reached and excised. The tonsil stalk was ligated with silk ties and the tonsillar fossa was packed with gauze swabs. Bipolar coagulation was used to achieve complete haemostasis when required.

For subsequent analysis in this study, APC and CB groups were combined as electrosurgery (ES).

Outcome measures

Four factors were examined in relation to the severity of IBL:

(I) Surgical technique, categorised into ES (APC, CB) and CS groups;
(II) Age, categorised into three subgroups: 0–10 years (infants to young children), 11–20 years (teens to young adults), and 21 years or over (adults);
(III) Gender (male, female);
(IV) Indication for surgery, categorised as recurrent tonsillitis (RT), chronic tonsillitis (CT), quinsy tonsillectomy (QT), sleep disordered breathing (SDB), obstructive sleep apnoea (OSA) and asymmetrical tonsils (AT).

Other demographic and clinical factors such as body mass index (BMI), mean arterial pressure and preoperative haemoglobin levels were not analysed as these variables were not consistently recorded at the time of data collection.

Statistical analysis

Data was analysed using GraphPad Prism version 6.00 (GraphPad Software, La Jolla California USA, www.graphpad.com). Statistical analysis was performed using Chi Square test and a P value <0.05 was considered statistically significant.

Results

The median patient age was 9 years, with range between 1 to 57 years. Female patients accounted for 59.29% of the study cohort. Over half (62.2%) of the tonsillectomies were performed for inflammatory conditions (RT, CT or QT), and 37.7% were for non-inflammatory conditions (SDB, OSA or AT) (*Table 2*).

Surgical technique

For statistical analysis, APC (n=232) and CB (n=38) groups were combined as ES. Therefore, the numbers of patient in ES and CS groups were 270 and 268, respectively.

There was significantly less IBL in the ES group compared with the CS group (X^2=493, P<0.001), as demonstrated in *Table 3*. The majority of ES group patients had grade 1 (minimal) bleeding, equivalent to 0–15 mL based on our experimental data. None of the patients in the ES group had grade 3–5 bleeding events. In contrast, the majority of CS group patients had grade 2–3 (mild to moderate) bleeding, equivalent to 16–150 mL and two patients in the CS group had grade 4 (moderately severe) bleeding, equivalent to 151–270 mL. No patient required blood transfusions or ligation of the external carotid artery.

Due to the significant impact of surgical technique on IBL, patients were stratified into ES and CS groups for subsequent analyses of age, gender and indication for surgery.

Table 3 Comparison of intraoperative blood loss between ES and CS techniques

Variable	Grade of intraoperative blood loss						
	1a	1b	2	3	4	5	Total
ES, n (%)	166 (61.5)	92 (34.1)	12 (4.4)	0	0	0	270
CS, n (%)	0	0	174 (64.9)	92 (34.3)	2 (0.75)	0	268

ES, electrosurgery; CS, cold steel.

Table 4 Comparison of intraoperative blood loss between three age groups by surgical technique

Age	Grade of intraoperative blood loss						
	1a	1b	2	3	4	5	Total
0–10, n (%)							
ES	112 (67.5)	48 (28.9)	6 (3.6)	0	0	0	166
CS	0	0	138 (86.3)	22 (13.8)	0	0	160
11–20, n (%)							
ES	35 (62.5)	19 (33.9)	2 (3.6)	0	0	0	56
CS	0	0	18 (30.5)	40 (67.8)	1 (1.7)	0	59
>21, n (%)							
ES	19 (39.6)	25 (52.1)	4 (8.3)	0	0	0	48
CS	0	0	18 (36.7)	30 (61.2)	1 (2.0)	0	49

ES, electrosurgery; CS, cold steel.

Age

There were statistically significant differences in the severity of IBL among the three age groups, with older patients having more severe bleeding than the 0–10-year age group (*Table 4*). This difference was significant for both the ES (X^2=12.57, P=0.0136) and CS groups (X^2=80.29, P<0.001).

Gender

There were no statistically significant difference in IBL between males and females in either group: ES (X^2=5.00, P=0.082), CS (X^2=5.33, P=0.0695) (*Table 5*). However, there was a trend for increased bleeding in males compared with females.

Indication for surgery

The association between indication for surgery and IBL was analysed for the ES group only (n=270), as data on the indication for surgery in the CS group was incomplete. For the purpose of statistical analysis, indications for surgery were grouped into inflammatory conditions (RT, CT, QT) and non-inflammatory conditions (SDB, OSA, AT). There was a statistically significant difference in the severity of IBL between the two groups, with the inflammatory conditions being associated with more bleeding than non-inflammatory conditions (X^2=19.6, P=0.0002) (*Table 6*).

Discussion

Factors associated with increased IBL

This study showed that the use of ES techniques significantly reduced IBL compared with CS. In particular, there were no grade 3–4 (moderate and moderately severe) bleeding events during ES tonsillectomies compared with 94 during CS tonsillectomies. This represented an absolute risk reduction of 35.1%, equivalent to a number needed to treat of 2.8. Therefore, the choice of surgical technique may be an important consideration in patients with a bleeding

Table 5 Comparison of intraoperative blood loss in males and females by surgical technique

Sex	Grade of intraoperative blood loss						
	1a	1b	2	3	4	5	Total
M, n (%)							
ES	61 (54.0)	45 (39.8)	7 (6.2)	0	0	0	113
CS	0	0	60 (56.6)	45 (42.5)	1 (0.9)	0	106
F, n (%)							
ES	105 (66.9)	47 (29.9)	5 (3.2)	0	0	0	157
CS	0	0	114 (70.3)	47 (29.0)	1 (0.6)	0	162

ES, electrosurgery; CS, cold steel; F, female; M, male.

Table 6 Comparison of intraoperative blood loss between inflammatory and non-inflammatory indications for surgery (ES group only)

Variable	Grade of intraoperative blood loss					
	1a	1b	2	3	4–5	Total
RT/CT/QT, n (%)	42 (25.0)	119 (70.8)	5 (2.98)	2 (1.19)	0	168
SDB/OSA/AT, n (%)	52 (51.0)	48 (47.1)	2 (1.96)	0	0	102

AT, asymmetrical tonsils; CT, chronic tonsillitis; ES, electrosurgery; OSA, obstructive sleep apnoea; QT, quinsy tonsillectomy; RT, recurrent tonsillitis; SDB, sleep disordered breathing.

diathesis, in patients who cannot receive blood products, and in paediatric patients who have lower physiological reserves.

It should be noted that post-tonsillectomy haemorrhage (PTB) is a dangerous complication and CB have been found to be associated with a 3.2-fold increase in the risk of PTB (14). Therefore, depending on a surgeon's personal rate of PTB with CB, the risk of PTB may out-weight the benefit of decreased IBL. The focus of the present study was to validate a simple and reproducible tool to standardize the reporting of IBL so that future studies could build on this and investigate possible associations between IBL and postoperative outcomes. As such, we recommend that a surgeon's choice of tonsillectomy technique still be primarily based on their expertise and the risk of PTB in their hands.

Secondly, we found that age was significantly associated with IBL, with adults bleeding more than children, which is consistent with a previous report (10).

In addition, gender does not appear to be a significant factor in IBL. While there was a trend towards increased in bleeding in males compared with females, the difference was not statistically significant. Increased bleeding in males was also reported by Prasad and Prasad (10), with blood loss of 106.9 mL for males and 96.3 mL for females during CS tonsillectomy. Similarly, in the present study, conversion to approximate volumes indicated a mean IBL of 107 mL for males and 85 mL for females during CS tonsillectomy.

Finally, the indication for surgery was a factor that significantly affected the severity of IBL. Patients with a previous history of tonsillitis and quinsy had increased IBL, which may be attributed to poorly defined tissue planes, friable tonsillar tissue and increased vascularity of the tonsillar beds. This finding has not been previously reported but would be consistent with our understanding of pathophysiology and clinical experience.

A grading system for IBL in tonsillectomy

We developed a categorical system for the assessment and the reporting of IBL in tonsillectomy. By reporting IBL on a categorical scale, we adopt a wider confidence interval around the true value. Given that there is no gold standard method for measuring the true quantity of IBL in clinical practice, reporting on a graded scale may be preferable to reporting in a numerical continuum.

A simple grading system can be easily incorporated

into clinical practice as it requires no advanced training or additional equipment. The inclusion of rescue measures in this grading system allows severe haemorrhagic events to be identified, irrespective of the volume of blood loss. We found this to be an accurate, reliable and user-friendly method of estimating IBL in tonsillectomy. It can be used as a tool to standardize the reporting of IBL and allow data to be more reliably compared between surgeons, techniques and institutions. This grading system has been adopted for research purposes at our local institution, and has allowed meaningful comparison of IBL in other tonsillectomy studies (15,16).

Limitations

We did not include IBL as a percentage of total blood volume in order to keep the current grading system simple and easy to use. In most patients, the IBL in tonsillectomy represented a small percentage of their total blood volume and was of minimal clinical significance. It was beyond the scope of this study to examine the association between IBL as a percentage of total blood volume and patient morbidity.

It is possible that weight was a confounding factor in the age group analysis, as was the seperation of patients into evenly distributed biological age groups rather than physiological age groups. We acknowledge that the impact of 50 mL blood loss is greater in a toddler than in an older child. However, the scope of this study was limited to estimating IBL and identifying factors associated with increased bleeding, rather than its influence on patient morbidity. Future studies could try to correlate the grade of IBL in tonsillectomy with the percentage of total blood volume and perioperative outcomes.

In addition, we did not examine the effect of surgical experience on IBL, as our data was based on tonsillectomies performed by a single consultant surgeon who was experienced in the use of all three surgical techniques (CS, CB, APC).

Finally, there could be a degree of bias as the surgeon was not blinded. However, the number of Ray-tech® swabs used was also counted by theatre scrub nurses, who were not part of the study, and recorded by at the time of surgery.

Conclusions

A new, five-tier grading system was developed as a tool to standardize the reporting of IBL in tonsillectomy. CS tonsillectomy, a history of tonsillar inflammation and increased age were associated with increased IBL. These factors could be taken into consideration for high risk patients, who may need preoperative counselling and preparation for perioperative blood replacement.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at http://dx.doi.org/http://dx.doi.org/10.21037/ajo-19-67

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at http://dx.doi.org/10.21037/ajo-19-67). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study protocol was approved by the local Human Research Ethics Committee and was conducted in accordance with the Helsinki Declaration (as revised in 2013). Due to the retrospective nature of this study, the need for informed consent was waived.

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