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Original research article

Epidemiology of late postoperative bleeding in OSA-related tonsil surgery: a multicentric retrospective study

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Abstract

Introduction: Tonsil-related procedures are considered fundamental and effective in the surgical treatment of obstructive sleep apnea (OSA). The range of techniques includes intratonsillar approaches, such as tonsillotomy (TT), as well as extracapsular procedures, such as tonsillectomy (TE) and uvulopalatopharyngoplasty (UPPP). Patients undergoing these procedures span all age groups, from children to seniors.

Methods: This multicentric retrospective study, conducted between 2014 and 2018, analysed data from 3,498 patients who underwent bilateral TT, TE, or UPPP for OSA or ronchopathy. The cohort included 2,221 men (63.49%) and 1,277 women (36.51%). Of these, 2,808 patients (80.27%) underwent TT, 226 (6.46%) underwent TE, and 464 (13.26%) underwent UPPP.

Results: Late postoperative haemorrhage (LPOH) occurrence was significantly associated with the type of surgery ($p < 0.0001$) and the hospital where the procedure was performed ($p < 0.0001$). The incidence of LPOH in the TT group ranged from 0% to 5.88% across hospitals ($p = 0.0068$); whereas in the TE and UPPP groups, rates ranged from 0% to 33.33% ($p = 0.0413$ and $p = 0.0409$, respectively). The occurrence of repetitive bleeding was not influenced by treatment choice (readmission vs. outpatient care, observation vs. surgical revision, general vs. local anaesthesia). The severity of bleeding in all three groups was not affected by age and gender. The use of anticoagulants negatively impacted LPOH severity ($p = 0.0166$) in the UPPP group. No deaths occurred in our sample; however, three cases of severe postoperative bleeding (grade "D") were observed.

Conclusion: Late postoperative haemorrhage remains a serious complication of tonsil-related surgery with the potential for life-threatening outcomes. The marked variability in bleeding incidence between surgical techniques and departments highlights the need

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for standardised perioperative protocols. Although no fatalities occurred, the occurrence of severe cases underlines the importance of vigilant postoperative monitoring. In our OSA cohort, tonsillotomy showed favourable safety, and recent evidence suggests it may represent a valuable alternative also in recurrent tonsillitis, warranting further research.

Keywords: Obstructive sleep apnea; Postoperative haemorrhage; Tonsillectomy; Tonsillotomy; Uvulopalatopharyngoplasty

Highlights:
- We conducted a multicenter study of 3,498 patients across 18 independent hospitals.
- Postoperative bleeding in obstructive sleep apnea-related surgery was analysed.
- Hospital choice and type of surgery were statistically significant risk factors.
- Three cases of severe bleeding and no deaths occurred in the studied time period.

Abbreviations:
LPOH, late postoperative haemorrhage; OSA, obstructive sleep apnea; PTA, peritonsillar abscess; TE, tonsillectomy; TT, tonsillotomy; UPPP, uvulopalatopharyngoplasty

Introduction

Obstructive sleep apnea (OSA) is a sleep disorder affecting both paediatric and adult patients, characterised by recurrent pauses in respiration or periods of reduced breathing during sleep (Slouka et al., 2018). OSA is diagnosed using the apnea-hypopnea index (AHI), which quantifies the number of apneas and hypopneas per hour of sleep. In adults, OSA is typically defined by an AHI ≥5 events/hour, with severity classified as mild (5–15), moderate (15–30), or severe (>30) (Berry et al., 2012). In paediatric patients, an AHI ≥1 event/hour is considered abnormal, and thresholds for severity are lower: mild (1–5), moderate (5–10), and severe (>10) (Marcus et al., 2012).

OSA may be accompanied by potentially serious comorbidities involving cardiovascular, cerebrovascular, pulmonary, and endocrine systems, as well as hormonal disorders (Slouka et al., 2024). Tonsil-related surgeries remain fundamental and widely utilised procedures in the surgical treatment of obstructive sleep apnea (OSA) (Kandasamy et al., 2013; Sundman et al., 2022). These include a spectrum of techniques, ranging from intratonsillar approaches such as tonsillotomy (TT) which aims to preserve the pharyngeal musculature, to more invasive extracapsular procedures like traditional extracapsular tonsillectomy (TE) and uvulopalatopharyngoplasty (UPPP) (Odhagen et al., 2019; Slouka et al., 2021; Windfuhr and Werner, 2013). National guidelines differ in their recommendations: the German S2k guideline endorses TT as a treatment option in paediatric OSA, whereas the American Academy of Otolaryngology – Head and Neck Surgery (AAO-HNS) recommends TE exclusively (Mitchell et al., 2019).

Remarkably, the palatine tonsils may represent the only human organ for which bilateral surgical intervention is more routinely performed than unilateral surgery (Russo et al., 2024; Windfuhr and Werner, 2013). These procedures are among the most common in head and neck surgery (Amoils et al., 2016; Russo et al., 2024), yet they remain associated with a relatively high morbidity rate (Odhagen et al., 2019; Windfuhr, 2003; Yelnoorkar and Issing, 2014). This has also been confirmed by a recent systematic review and network meta-analysis comparing different tonsillectomy techniques (Russo et al., 2024).

TT is predominantly used in paediatric patients, primarily due to the immaturity of the immune system and the aim of minimising disruption to its development (Asulin et al., 2024; Ryczer et al., 2015). While it is true that TT involves partial removal of the palatine tonsils, recent literature has demonstrated promising outcomes, even for its use in cases of recurrent or chronic tonsillitis (Asulin et al., 2024; Chrobok et al., 2012; Foki et al., 2017; Wu et al., 2023), although no consensus has been reached on its widespread application in this context (Çetin and Düzenli; 2019; Windfuhr and Werner, 2013). Currently, the most common indication for TT is hypertrophy of the palatine tonsils, which may result in snoring, OSA, speech impairment, or swallowing difficulties (Asulin et al., 2024; Odhagen et al., 2019; Ryczer et al., 2015; Zhang et al., 2017).

TE remains a frequently debated topic in head and neck surgery due to its broader range of indications and higher complication rates relative to TT (Densert et al., 2001; Helling et al., 2002). Indications span from urgent conditions like peritonsillar abscess (PTA) to elective reasons such as chronic or recurrent tonsillitis and sleep-disordered breathing, as well as less common indications like halitosis, malocclusion, dysphagia, elongated styloid process, nephropathy, and psoriasis (Hoddeson and Gourin, 2009; Mitchell et al., 2019; Slouka et al., 2020).

UPPP, the most extensive of these surgeries, is the primary surgical intervention for adult OSA, particularly in cases of mild to moderate severity, or in patients presenting with habitual snoring (Aksoy et al., 2014; Demars et al., 2008; Haavisto and Suonpää, 1994; Hsu et al., 2020; Kim et al., 2005; Riley et al., 1997).

Complications can be categorised as early (within 24 hours post-operation) or late (beyond 24 hours). Early complications include haemorrhage, pain, nausea, vomiting, and dehydration (Clark and Waddell, 2004; Riley et al., 1997; Zhang et al., 2017). Secondary complications may include late haemorrhage, dental trauma, temporomandibular dysfunction, soft palate perforation, palatal scarring, dysphagia, velopharyngeal insufficiency, infections, emphysema, altered taste, and changes in voice quality (Davidoss et al., 2018; Komínek et al., 2014; Liu et al., 2022). TT is considered the least invasive, although serious complications have been reported (Chrobok et al., 2012; McKeon et al., 2019; Zhang et al., 2017). UPPP, despite being the most extensive procedure, does not appear to have a significantly higher complication rate compared to TE (Sundman et al., 2022). Several modifications of the UPPP technique exist, though none have demonstrated a substantial impact on outcomes or complication rates (Haavisto and Suonpää, 1994; Kim et al., 2005; Riley et al., 1997).

All of these procedures are currently performed under general anaesthesia, although historical reports have described the use of local anaesthesia (Bredenkamp et al., 1990; Matovinović et al., 2018; Naik et al., 2014). Importantly, all three are typically classified as one-day surgery procedures, making the risk of late postoperative haemorrhage (LPOH) particularly relevant during home recovery. LPOH presents a critical dan-

ger due to unsecured airways and the potential delay between the onset of bleeding and specialist intervention.

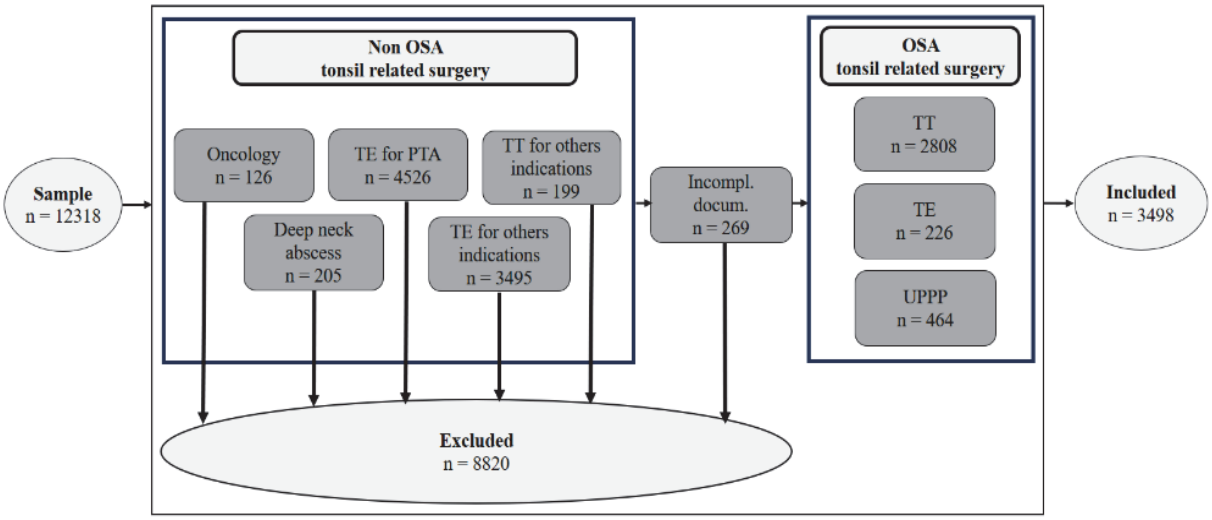
LPOH is the most feared complication following OSA-related palatine tonsil surgeries (TE, TT, and UPPP). The primary aims of this study were to evaluate the incidence and severity of LPOH and then subsequently to identify factors influencing these variables. The study is based on a nationwide multicenter retrospective cohort from 18 independent hospitals, covering the period of 2014 to 2018.

Materials and methods

Patient cohort

This retrospective, multicentre epidemiological study included 12,318 patients who underwent TE or TT, or UPPP, between 2014 and 2018. All procedures were performed as standalone interventions under general anaesthesia in tertiary or secondary hospitals. No patients were recruited from outpatient surgery clinics. Informed consent was obtained from all participants. Data were collected from 18 hospitals, including both tertiary and regional facilities. All data were anonymised. The study protocol was approved by the Ethics Committee of the University Hospital in Pilsen (Protocol Code: 326/24).

The initial cohort consisted of 6,412 males (52.05%) and 5,906 females (47.95%), with ages ranging from 1 to 94 years (mean age: 23.76 years; median: 20.00 years). Based on predefined exclusion criteria, 8,820 patients were excluded (see Fig. 1 for the study flowchart and Fig. 2 for age and gender distribution of the final study cohort).



Note: OSA – obstructive sleep apnea, TE – tonsillectomy, PTA – peritonsillar abscess, TT – tonsillotomy, UPPP – uvulopalatopharyngoplasty

Fig. 1. Flowchart of patient inclusion and exclusion

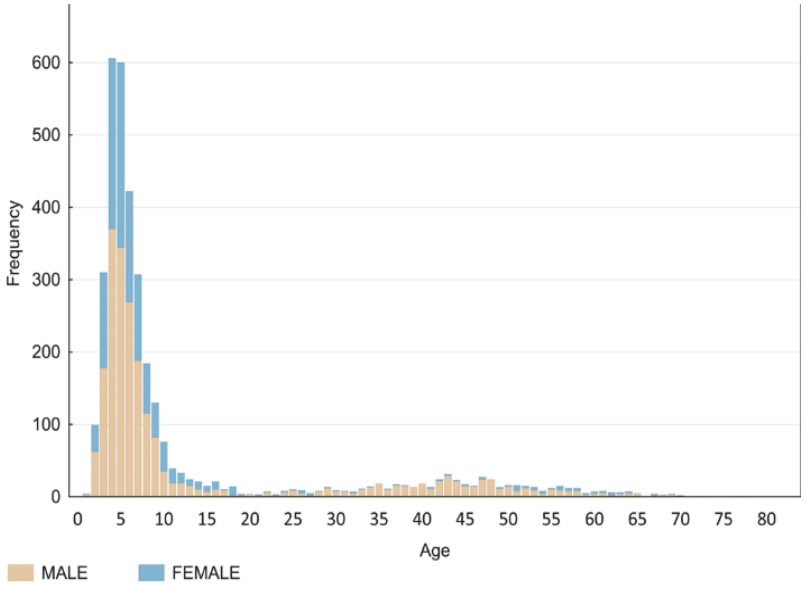


Fig. 2. Age and gender distribution of the final study cohort

Exclusion criteria included: unilateral TE or TT, surgeries (TT, TE, UPPP) performed for non-OSA indications; emergency ("à chaud") TE, oncologic or deep neck abscess surgery, history of peritonsillar incision in outpatient settings, and incomplete or missing documentation. None of the patients in the cohort had received positive airway pressure (PAP) therapy prior to surgery.

The final study sample comprised 3,498 patients: 2,221 males (63.49%) and 1277 females (36.51%). Of these, 2,808 patients (80.27%) underwent TT, 226 (6.46%) underwent extracapsular TE, and 464 (13.26%) underwent UPPP.

All participating hospitals were either secondary or tertiary care centers. Since tonsil-related surgeries (TT, TE, UPPP) represent basic otorhinolaryngological procedures routinely performed in both, no stratification according to hospital level was undertaken.

Methods

Studied variables

In this study, we examined the occurrence and severity of postoperative bleeding and their relationship to patient age and gender, surgeon experience, used surgical technique, use of anticoagulant and antiplatelet drugs, timing of surgery (day and year), and hospital type in the TT, TE, and UPPP groups. Age was analysed using five-year patient cohorts, ten-year patient cohorts, and by comparing paediatric (<17.9 years) and adult patients.

Classification of postoperative haemorrhage

The haemorrhage severity classification used in this work is similar to the staging presented by Sarny et al. (2011), Inuzuka et al. (2020), Dharmawardana et al. (2018), and Negm et al. (2017).

Late postoperative bleeding events were categorised into five severity stages:

- Stage A – Anamnestic Bleeding: Reported bleeding without clinical evidence of active haemorrhage at examination. Patients were managed with rest, cold compresses to the neck, and hemostatic therapy (e.g., Etamsylate).
- Stage B – Bleeding Controlled by Compression: Bleeding resolved by tampon compression alone. Subsequent care was identical to Stage A.
- Stage C – Active Bleeding Requiring Local Hemostasis: This is ongoing bleeding that requires electrocoagulation under local or general anaesthesia. Post-procedural management includes observation, cold compresses, intravenous hemostatics, and blood volume support as needed.
- Stage D – Severe or Life-Threatening Bleeding: Bleeding with risk of irreversible harm or fatality. Management included intervention under general anaesthesia with electrocoagulation, suturing of the tonsillar bed or palatal arches, or hypopharyngeal tamponade. Postoperative care followed standard haemorrhage control protocols and "Stage C – treatment".
- Stage E – Fatal Haemorrhage: Any postoperative bleeding resulting in patient death.

Surgical procedures, anaesthesia, and postoperative care

Patients underwent one of three surgical interventions for OSA indications under general anaesthesia: bilateral TT, bilateral extracapsular TE, or UPPP. Procedures were not combined.

The surgical instruments used included monopolar and bipolar diathermy, laser, ultrasonic scalpel, coblation devices, cold dissection with scissors, and radiofrequency devices, depending on the hospital's standard practice. Suction diathermy and cold steel techniques were applied for haemostasis. The variability of instruments was recorded under the variable "surgical technique".

All 18 hospitals were located in the same country. According to the recommendations of the national Society of Otorhinolaryngology and Head and Neck Surgery, outpatient tonsil surgery is not recommended. Therefore, no same-day discharges occurred. Patients were typically hospitalised between 4 and 8 days after surgery, depending on local protocols. Any postoperative bleeding episode was immediately evaluated by an ENT specialist.

Anticoagulants and antiplatelet drugs

The anticoagulants used were warfarin, NOACs, and low-molecular-weight heparin. The antiplatelet drugs used were acetylsalicylic acid, clopidogrel, and ticlopidine.

Surgeon experience classification

Surgeon experience was stratified into three levels:

- Level 1 (L1): Procedures performed entirely by a supervised trainee, where supervision was limited to non-hands-on, advisory involvement.
- Level 2 (L2): Certified surgeons performing procedures independently.
- Level 3 (L3): Senior, fully certified surgeons with extensive experience.

For surgeon experience classification purposes, each surgery was categorised based on the most experienced surgeon participating in the procedure.

Definition and timing of late postoperative haemorrhage

LPOH was defined as bleeding occurring more than 24 hours after surgery, up to 30 days postoperatively.

Timing of postoperative days

For the first postoperative bleeding, postoperative day 1 was defined as the day after the surgery. For the second bleeding episode, postoperative day 1 was defined as the day following the revision procedure.

Statistical methods

All statistical analyses were performed using SAS software (SAS Institute Inc., Cary, NC, USA), and graphical outputs were generated using STATISTICA (StatSoft, Inc., Tulsa, OK, USA).

Descriptive statistics – including frequencies, means, standard deviations, variances, medians, minima, and maxima – were calculated to summarise the characteristics of the studied variables. Data visualisation included box plots, pie charts, and histograms.

Nonparametric tests, specifically the Wilcoxon rank-sum test and the Kruskal–Wallis test, were used to compare age and the number of bleeding episodes between study groups. Categorical variables were compared using the Chi-square test or Fisher's exact test, as appropriate.

Spearman's rank correlation coefficient was used to assess relationships between continuous or ordinal variables.

Time to bleeding after surgery was analysed using Kaplan–Meier survival curves, with group comparisons assessed by the log-rank test. Daily bleeding risk was estimated using risk functions. The clinical impact of selected factors on bleeding risk was evaluated using hazard ratios derived from Cox proportional hazards regression models.

Classification and regression tree (C&RT) analysis was employed as a multivariate approach to identify protective and risk profiles for postoperative bleeding. The Cox regression model served as the basis for C&RT splitting criteria, with a minimum node size of 50 patients required for group analyses.

Prognostic factors for a second bleeding event were assessed using the Chi-square test or Fisher's exact test, and clinical impact was quantified using odds ratios. Statistical significance was determined at 5%. Additionally, multivariate regression analyses were performed. These did not yield clinically meaningful or statistically robust results and are therefore not presented in detail.

Results

Occurrence of bleeding

LPOH occurred in 27 patients (0.96%) in the TT group, 32 patients (14.16%) in the TE group, and 95 patients (20.47%) in the UPPP group (Fig. 3).

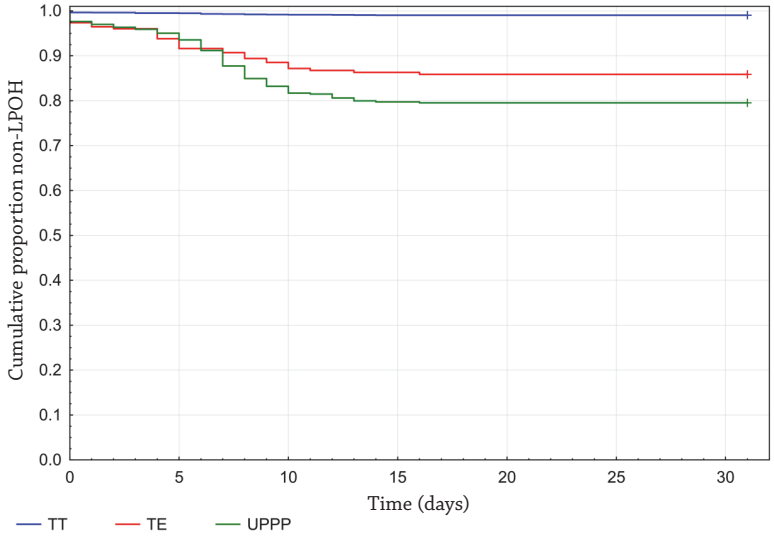
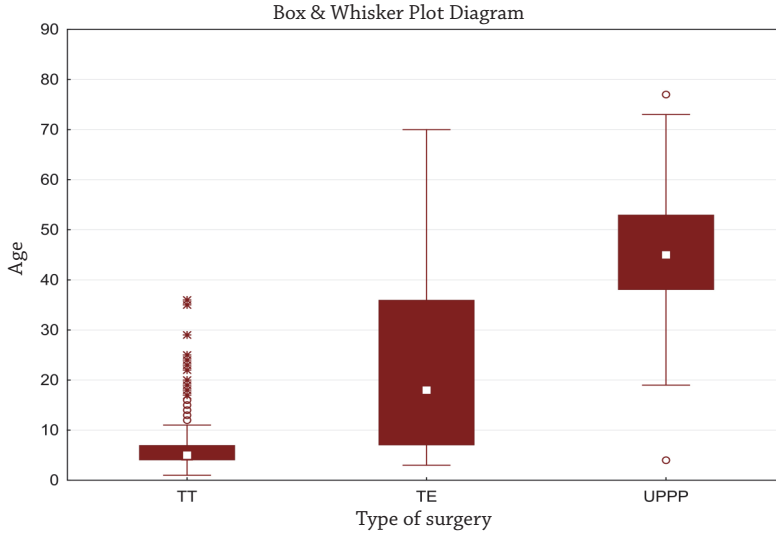


Fig. 3. Occurrence of bleeding in the TT, TE, UPPP groups

Gender distribution varied across groups. In the TT group (N = 2808), there were 1,972 men (59.54%) and 1,136 women (40.46%). In the TE group, 155 were men (68.58%) and 71 were women (31.42%). In the UPPP group, 394 were men (84.91%) and 70 were women (15.09%). However, gender was not statistically associated with bleeding in any group (p = 0.1225 for TT, p = 0.9869 for TE, p = 0.1652 for UPPP).

Age distribution differed significantly across groups (Fig. 4). When analysing bleeding occurrence by five-year age cohorts, statistically significant associations were found in the TT (p = 0.0003) and TE (p = 0.0136) groups, but not in the UPPP group (p = 0.2760). Similar results were observed for ten-year age cohorts (TT: p = 0.0013, TE: p = 0.0163; UPPP: p = 0.0604). Neither anticoagulant or antiplatelet use, nor surgeon experience or surgical technique, was significantly associated with bleeding in any group. The day of the week on which surgery was performed showed a significant association with bleeding in the TT group (p = 0.0410), but not in the TE or UPPP groups



Note: TT – tonsillotomy, TE – tonsillectomy, UPPP – uvulopalatopharyngoplasty

Fig. 4. Age distribution in the TT, TE, UPPP groups

(p = 0.5231 and p = 0.6160, respectively). Hospital choice was also significantly associated with bleeding in all three groups (TT: p = 0.0068, TE: p = 0.0413, UPPP: p = 0.0409). No association was observed between the year of surgery and bleeding occurrence in any group. For details see Table 1.

Table 1. Occurrence of LPOH in groups according to the studied variables

		TT (N = 2808)			TE (N = 226)			UPPP (N = 464)		
		N	N (of bleed)	% (of bleed from N)	N	N (of bleed)	% (of bleed from N)	N	N (of bleed)	% (of bleed from N)
Bleeding		2808	27	0.96	226	32	14.16	464	95	20.47
Gender	Male	1672	20	1.20	155	22	14.19	394	85	21.57
	Female	1136	7	0.62	71	10	14.08	70	10	14.29
	p-value		0.1225			0.9869			0.1652	
Age	Group characteristic	Range 1–36; mean 5.8; median 5			Range 3–70; mean 23.17; median 18			Range 18–77; mean 45.58; median 45		
	p-value 5 years groups		**0.0003**			**0.0136**			0.2760	
	p-value 10 years groups		**0.0013**			**0.0163**			0.0604	
	Patients (<17.9)	2789	26	0.93	111	12	10.81	1	0	0
	Patients (>18)	19	1	5.26	115	20	17.39	463	95	20.52
	p-value (young vs adl.)		0.0531			0.1633			0.6303	
Anticoagulants	p-value		0.8440			0.7635			0.0616	
Antiplatelets	p-value		0.9217			0.6947			0.7338	
Surgeon	p-value		0.4201			0.2890			0.9150	
Surg.technique	p-value		0.0764			0.7231			0.5453	
Day of the week	p-value		**0.0410**			0.5231			0.616	
Hospital choice	p-value		**0.0068**			**0.0413**			**0.0409**	
Surgery year	p-value		0.9774			0.2776			0.3896	

Note: TT – tonsillotomy, TE – tonsillectomy, UPPP – uvulopalatopharyngoplasty

Occurrence of bleeding by hospital

Significant inter-hospital variability in LPOH incidence was observed across the 18 participating centers (p < 0.0001). Rates ranged from 0% to 33.3%, irrespective of hospital designation. Detailed data are summarised in Table 2.

Severity of bleeding

Severity level B was the most common in all three groups. Two cases in the TT group and one in the UPPP group were classified as severity level D. No cases of severity level E were observed.

Only anticoagulant use in the UPPP group was significantly associated with bleeding severity (p = 0.0166). Detailed distributions are shown in Table 3.

First and second bleeding episodes

All patients in the TT group who experienced a first LPOH (n = 27) were treated in a hospital setting. Three patients (9.38%) in the TE group and 16 patients (16.84%) in the UPPP group were managed at home. All patients who experienced a second LPOH (n = 26) required hospitalisation. No third bleeding episodes were recorded in the sample. Details on care modalities and interventions are shown in Table 4.

Table 2. Occurrence of bleeding by hospital and group (TT, TE, UPPP)

TT				TE				UPPP			
Anonymised hospitals	Total (*n* = 2808)	LPOH (*n* = 27)	%	Anonymised hospitals	Total (*n* = 226)	LPOH (*n* = 32)	%	Anonymised hospitals	Total (*n* = 464)	LPOH (*n* = 95)	%
A	6	0	0.00	C	1	0	0.00	C	1	0	0.00
B	10	0	0.00	D	4	0	0.00	J	6	0	0.00
C	12	0	0.00	O	7	0	0.00	P	9	0	0.00
D	19	0	0.00	K	7	0	0.00	R	66	4	6.06
E	56	0	0.00	Q	7	0	0.00	D	14	1	7.14
F	127	0	0.00	P	8	0	0.00	L	19	2	10.53
G	563	1	0.18	H	14	0	0.00	O	9	1	11.11
H	437	2	0.46	A	13	1	7.69	I	17	3	17.65
I	291	2	0.69	N	18	2	11.11	Q	46	10	21.74
J	112	1	0.89	G	33	5	15.15	M	150	38	25.33
K	104	1	0.96	F	13	2	15.38	K	19	5	26.32
L	392	5	1.28	M	12	2	16.67	N	30	8	26.67
M	76	1	1.32	L	23	4	17.39	B	32	9	28.13
N	129	2	1.55	I	37	7	18.92	A	20	6	30.00
O	289	5	1.73	B	4	1	25.00	E	23	7	30.43
P	100	2	2.00	R	16	5	31.25	F	3	1	33.33
Q	85	5	5.88	J	9	3	33.33	G	–	–	–
R	–	–	–	E	–	–	–	H	–	–	–
p-value	**0.0068**			**0.0413**				**0.0409**			
***p* < 0.0001**											

Note: TT – tonsillotomy, TE – tonsillectomy, UPPP – uvulopalatopharyngoplasty, LPOH – late postoperative hemorrhage. Hospitals are anonymised into A, B, C, D… In the columns TT, TE and UPPP, they are ranked by % of surgeries with LPOH.

Table 3. Severity of bleeding in all three groups

Severity of bleeding	TT		TE		UPPP	
	N	%	*N*	%	*N*	%
A	7	25.93	5	15.63	29	30.53
B	12	44.44	15	46.88	34	35.79
C	6	22.22	12	37.50	31	32.63
D	2	7.41	0	0	1	1.05
E	0	0	0	0	0	0
Total	27	100	32	100	95	100
p			0.621			
Age (*p*-value)	0.8890		0.5087		0.5802	
Gender (*p*-value)	0.6351		0.1255		0.9383	
Anticoagulants (*p*-value)	–		0.5866		**0.0166**	
Antiplatelets (*p*-value)	–		–		0.7541	

Note: TT – tonsillotomy, TE – tonsillectomy, UPPP – uvulopalatopharyngoplasty

Table 4. First and second LPOH and type of care

Number of LPOH	Care	TT (*N* = 27)			TE (*N* = 32)			UPPP (*N* = 95)		
		N	%	*p*	*N*	%	*p*	*N*	%	*p*
1.	Hospitalisation	27	100	–	29	90.62	0.4758	79	83.16	0.1803
	Without hosp.	0	0		3	9.38		16	16.84	
	Observation	18	66.67	1.000	16	55.17	0.3432	39	49.37	0.4225
	Revision	9	33.33		13	44.83		40	50.63	
	Gen. anest.	8	88.89	–	11	84.62	1.0000	32	80.00	1.000
	Loc. anest.	1	11.11		2	16.38		8	20.00	
2.	Care	TT (*N* = 1; 3.70% of 1. LPOH)			TE (*N* = 6; 18.75% of 1. LPOH)			Total (*N* = 19; 20% of 1. LPOH)		
		N	%		*N*	%		*N*	%	
	Hospitalisation	1	100	–	6	100	–	19	100	–
	Observation	0	0	–	2	33.33	–	11	57.89	–
	Revision	1	100		4	66.67		8	42.11	
	Gen. anest.	1	100	–	3	75	–	8	100	–
	Loc. anest.	0	0		1	25		0	0	

Note: TT – tonsillotomy, TE – tonsillectomy, UPPP – uvulopalatopharyngoplasty

Discussion

Surgery of the palatine tonsils is a fundamental procedure in the surgical treatment of OSA (Kandasamy et al., 2013; Sundman et al., 2022; Zhang et al., 2017). In childhood, palatine tonsil surgery more often involves TT rather than TE, and it is frequently performed in combination with adenotomy (Chrobok et al., 2010; Odhagen et al., 2019; Ryczer et al., 2015). In adults, however, the trend is reversed, with TEs more common than TT (Acevedo et al., 2012; Asulin et al., 2024), and UPPP is typically performed only in adults (Aksoy et al., 2014; Haavisto and Suonpää, 1994). Although all these operations fall under the category of "palatine tonsils in OSA treatment", they have significant differences in terms of invasiveness, typical age or gender of patients, and common complications, which makes them three heterogeneous groups of surgeries. Furthermore, when indicating these operations, it is important to remember the different principles for treating paediatric and adult patients with OSA (Ersu et al., 2023; Reiter, 2025). In the studied sample, the median age differed between groups (Fig. 4). The TT and UPPP groups had medians typical for these procedures (5 years and 45 years, respectively). The TE group had a lower median age (18 years) compared with samples including all TE indications (Dharmawardana et al., 2018; Inuzuka et al., 2020).

Occurrence of bleeding

The literature contains numerous variations in reports on postoperative haemorrhage following tonsil surgery. A major reason for this diversity is the lack of a clear consensus on what constitutes significant postoperative haemorrhage in this context. Some studies describe patients who need to return to the operating theatre (Clark and Waddell, 2004; Hopkins et al., 2003; Windfuhr et al., 2005) while others include any bleeding episodes (Francis et al., 2017; Spektor et al., 2016), or those that require intervention, including outpatient care (Carmody et al., 1982; Liu et al., 2001). This lack of consensus leads to a broad range of reported LPOH rates, from 2.0% to 18% (Alexander et al., 2004; Bhattacharyya, 2001; Demars et al., 2008; Evans et al., 2003; Klimák et al., 2000; McKeon et al., 2019; Školoudík et al., 2005).

In our sample, we detected LPOH in 0.96% of the TT group, 14.16% in the TE group, and 20.47% in the UPPP group ($p < 0.0001$). Rates of bleeding after TT and TE have been studied more extensively than haemorrhage after UPPP. Most studies report LPOH after TT in the range of 0.2% to 3.9% (Asulin et al., 2024; Zhang et al., 2017) in TE as mentioned above, and in UPPP in 0.6–14.0% (Haavisto and Suonpää, 1994; Kim et al., 2005; Mickelson and Hakim, 1998; Slouka et al., 2021). Historically, some criteria have been suggested to stratify the severity of bleeding (Handler et al., 1986; Windfuhr and Seehafer, 2001). The haemorrhage severity classification used in this work is similar to the staging presented by Inuzuka et al. (2020), Dharmawardana et al. (2018), and Negm et al. (2017). For details, see Methods.

Another important consideration in the scientific literature is the lack of consensus in otolaryngology regarding the indications for TT and TE. Most institutions primarily recommend TT in paediatric patients where tonsillar hypertrophy causes difficulties with speech development, swallowing, snoring, or apnea pauses (Odhagen et al., 2019; Ryczer et al., 2015). The demographic distribution in our work aligns with these principles (Fig. 4). Extracapsular TE is typically indicated when the tonsil tissue is suspected of having a chronic or recurrent infection. However, some studies have investigated the results of TT for indications such as chronic or recurrent tonsillitis with promising results (Chung et al., 2018; Foki et al., 2017; Guntinas-Lichius et al., 2021; Wu et al., 2023). We agree with the opinion of Çetin and Düzenli (2019) and Asulin et al. (2024) that further research is needed.

The OSA indication group is large and an OSA indication is aimed at addressing a mechanical problem caused by hypertrophy of the lymphoid tissue of the tonsils. Therefore, the residual tissue in the tonsillar bed is not considered as risky as in inflammatory indications, and the reduction in the risk of postoperative bleeding (Fig. 3) is a strong argument in favour of performing TT in OSA treatment. Our view aligns with that

of Zhang et al. (2017) in their systematic review of 32 studies comparing TT and TE. Regarding secondary haemorrhage, they emphasise the higher vulnerability of younger children to a decrease in circulating blood volume (Wood et al., 2011), with occasional cases leading to death (Capobianco et al., 2014; Windfuhr, 2003; Windfuhr et al., 2009).

In our study, we examined various variables across all three groups to see if they influenced the occurrence of late postoperative bleeding. Details of the procedures are provided in the Methods section.

The occurrence of LPOH differed significantly between hospitals ($p < 0$ .0001). Also, when comparing individual hospitals and surgery groups (in TT: $p = 0.0068$, in TE: $p = 0.0413$, in UPPP: $p = 0.0409$). We found that the occurrence of LPOH ranged from 0 to 5.88% in the TT sample, from 0 to 33.33% in the TE group, and from 0 to 33.33% in the UPPP group. However, it must be noted that the number of operations performed at the individual participating hospitals varies significantly (from a few to hundreds). For details, see Table 2.

Influence of age, gender, anticoagulants, and other factors on LPOH occurrence and severity

Patient age, when grouped into 5-year intervals, significantly influenced the occurrence of LPOH in the TT and TE groups ($p = 0.0003$ and $p = 0.0136$, respectively), but not in the UPPP group ($p = 0.2760$). Similar results were observed when using 10-year age intervals ($p = 0.0013$ for TT; $p = 0.0163$ for TE; $p = 0.0604$ for UPPP). When dividing the cohort into younger patients (<18 years) and adults, no statistically significant differences were found in any of the surgical groups (Table 1). Likewise, we found no influence of age on the severity of bleeding in any group (see Table 3). Asulin et al. (2024) compared paediatric TT and TE in a large cohort ($n = 1984$), with 78.3% ($n = 1553$) of patients indicated for OSA. They found age to be a significant risk factor ($p < 0.001$), with higher LPOH occurrence in the TE group. These findings were supported by McKeon et al. (2019) in a cohort of 11,140 patients. In contrast, Ryczer et al. (2015) reported no statistically significant relationship between age and LPOH. Regarding UPPP, our results align with those of Kim et al. (2005) who also found no age-related influence on LPOH occurrence. However, Hsu et al. (2019) reported contrary findings in a larger report.

We also found that gender was not a significant risk factor for LPOH occurrence or for bleeding severity across all groups (see Table 1). This corresponds with findings from Ryczer et al. (2015), McKeon et al. (2019), and Asulin et al. (2024) for the TT group. In our TE group, the small sample size ($n = 226$) and diagnostic selection (predominantly OSA patients) may limit generalisability. Although we did not find a significant relationship in our TE group, other studies, such as those by Coordes et al. (2016), Hsueh et al. (2019), and Ikoma et al. (2014), suggest a possible gender-based risk. In the UPPP group, Kandasamy et al. (2013) found no association between gender and LPOH in 345 consecutive patients. However, Hsu et al. (2019) and Demars et al. (2008) reported a higher risk of LPOH in male patients.

The management of patients on blood thinners is an increasingly important topic due to the rising number of individuals receiving such therapy. Our findings show no significant relationship between the use of blood thinners and the occurrence of LPOH in any surgical group. However, in the UPPP group, anticoagulant use was significantly associated with increased bleeding severity ($p = 0.0166$; see Table 3). In the TT group, the number of patients on blood thinners was too low ($n = 5$) to draw reliable conclusions. Similarly, antiplatelet therapy was underrepresented in the TE group. In anticoagulants and the TE ($n = 52$) and the UPPP for both groups (anticoagulants $n = 111$; antiplatelets $n = 8$), our findings diverged from those of Seshamani et al. (2014) who reported a significant influence of blood thinners on surgical outcomes. Our results align more closely with Hazkani et al. (2023) who found no increased LPOH risk or bleeding severity associated with anticoagulants.

In line with Asulin et al. (2024), we investigated the influence of the year of surgery and found no significant association with LPOH occurrence or severity in any group. Similarly, no significant relationship was found with the day of the week on which surgery was performed – except in the TT group ($p = 0.0410$), which likely reflects scheduling practices rather than a true clinical factor (Table 1).

Surgeon experience is often considered a variable factor in LPOH risk, but our analysis did not reveal a significant relationship in any of the groups ($p = 0.4201$ for TT, $p = 0.2890$ for TE, $p = 0.9150$ for UPPP). These results are consistent with Muratori et al. (2013), but contrast with Sarny et al. (2012), Hinton-Bayre et al. (2017), and Xu et al. (2021), who all reported a higher LPOH incidence in TE cases performed by junior surgeons. Sarny et al. (2012) also investigated TT, but found the LPOH incidence too low for meaningful analysis. Capobianco et al. (2014) found that for OSA-related surgeries, both surgeon and hospital volume were associated with higher LPOH risk and severity ($p = 0.002$ and $p = 0.019$, respectively), a conclusion also supported by Hsu et al. (2020). However, interestingly, no statistically significant differences were found in bleeding severity ($p = 0.1621$). Many previous studies have compared LPOH occurrence between TT and TE (Asulin et al., 2024; Ryczer et al., 2015) or TE and UPPP (Aksoy et al., 2014; Demars et al., 2008), but few have addressed all three procedures together regarding both occurrence and severity. In our cohort, surgical technique did not have a significant relationship with the occurrence or severity of LPOH in any studied groups. This finding is in line with several previous reports showing that technique-related factors play a minor role compared with patient- and hospital-related variables (Haavisto and Suonpää, 1994; Kim et al., 2005; Sundman et al., 2022).

No deaths occurred within 30 days postoperatively, which is consistent with recent systematic reviews on tonsil surgery complications (Francis et al., 2017; Odhagen et al., 2019). In the TT group, there were 27 cases of LPOH, all requiring hospital re-admission; 33% underwent surgical revision, with only one case managed under local anaesthesia. A second bleeding episode occurred in only one case, and management was repeated. Management strategies varied between hospitals (inpatient vs. outpatient care) in the TE and UPPP groups. In the TE group, 91% were readmitted, and 45% required revision (85% under general anaesthesia). In the UPPP group, 83% were readmitted, and 51% underwent revision (80% under general anaesthesia). Management decisions – such as readmission vs. outpatient care, observation vs. revision, and general vs. local anaesthesia – had no significant impact on treatment outcomes (Table 4). The predominance of severity level B in our cohort is consistent with previous reports, where minor bleeding episodes manageable with compression are more frequent than severe cases (Inuzuka et al., 2020; Sarny et al., 2011).

Management strategies in our cohort were characterised by uniform inpatient care, as outpatient tonsil surgery is not recommended by the national Society of Otorhinolaryngology and Head and Neck Surgery. Consequently, no same-day discharges were performed among all 18 participating hospitals, and patients were hospitalised for 4–8 days postoperatively.

This approach likely reduced the risk of delayed recognition of LPOH where the time between bleeding onset and proper intervention may be critical (Sarny et al., 2012) and this may explain the relatively low rate of complications requiring urgent readmission compared with reports from countries where outpatient surgery is common (Kandasamy et al., 2013; Sarny et al., 2012). While these findings support the safety of hospital-based management, they may not be directly generalisable to health systems with different postoperative care protocols.

Limits and strengths of the study

We consider the multicentric nature of the study and the high number of operations performed to be this study's strengths. These aspects directly increase external validity and improve the generalisability of our findings across different clinical settings. However, the retrospective design of the study must be acknowledged as a limitation, as it precludes causal inference and may introduce biases related to documentation quality or reporting accuracy. Another limitation of this study design lies in the heterogeneity of work procedures (e.g., hospitalisation vs. home observation for grade "A" bleeding) and, as a poorly estimated variable, the underdiagnosis of late postoperative haemorrhage (LPOH). In such a large group, it is likely that some patients did not return to the hospital for a follow-up after a one-time grade "A" bleeding episode, opting instead for self-treatment at home.

Conclusion

In our study involving 18 independent hospitals, the factors statistically significantly associated with the probability of late postoperative bleeding in OSA-related tonsil surgery were the choice of hospital and the type of surgery. The treatment strategies for managing bleeding (readmission vs. outpatient care, observation vs. revision surgery, general vs. local anaesthesia) had no significant impact on treatment outcomes. No deaths were recorded, but three cases of severe postoperative bleeding occurred within thirty days after surgery. In any tonsil-related procedure, we must be prepared for the possibility of unpredictable situations requiring prompt and adequate care by skilled medical personnel. Late postoperative haemorrhage remains a serious complication with a potentially fatal outcome. Although our cohort was restricted to OSA patients, recent evidence suggests that TT may also hold promise in cases of recurrent tonsillitis. Further research is warranted to explore this potential role.

Authors' contributions

Conceptualisation: *DS* and *TK*; methodology: *DS* and *JV*; investigation: *DS, JV* and *TK*; writing – original draft preparation: *DS* and *TK*; writing – review and editing: *VCh* and *JV*; data collection: *MCh, MU, BG, RK, PSk, VG, AS, ZKn, JK, HD, LS, PB, LJ, SB, PSt* and *JH*.

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Ethical aspects and conflict of interest

The authors have no conflict of interest to declare.

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