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Declarations

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Frequency and Associated Factors of Post-Operative Bleeding Following Tonsillectomy in Children at Mardan Medical Complex: A Cross-Sectional Study

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ABSTRACT

Background: Tonsillectomy is among the most frequently performed pediatric surgical procedures worldwide. Although it is generally safe, postoperative hemorrhage remains one of the most serious and potentially life-threatening complications. Understanding its frequency and associated factors is crucial for improving patient outcomes and surgical safety in regional healthcare contexts.

Objective: To determine the frequency and associated risk factors for postoperative bleeding following tonsillectomy among children at Mardan Medical Complex, Mardan, Pakistan. **Methods:** A descriptive cross-sectional study was conducted involving 151 children under 18 years of age who underwent elective tonsillectomy. Demographic data, clinical diagnoses, surgical techniques, and surgeon experience were recorded. Postoperative bleeding was classified into four grades of severity. Statistical analyses were performed using SPSS version 26, with chi-square tests and 95% confidence intervals to evaluate associations between variables, considering $p < 0.05$ as significant.

Results: Postoperative bleeding occurred in 29 patients (19.2%). Male gender ($p = 0.002$; OR = 4.65, 95% CI: 1.65–13.08), adolescent age 11–15 years ($p = 0.003$), and cold dissection technique ($p < 0.001$; OR = 4.66, 95% CI: 2.02–10.73) were significantly associated with higher bleeding risk. No significant association was found with diagnosis or surgeon experience. Electrocautery showed superior hemostatic control compared to cold dissection. **Conclusion:** Post-tonsillectomy hemorrhage remains a notable complication in pediatric surgery. Male gender, adolescent age, and cold dissection technique were significant predictors of postoperative bleeding. Electrocautery is recommended as a safer surgical approach, particularly in high-risk subgroups such as adolescent males.

Keywords

Post-tonsillectomy hemorrhage; Pediatric tonsillectomy; Cold dissection; Electrocautery; Risk factors; Postoperative complications

INTRODUCTION

Tonsillectomy remains one of the most frequently performed surgical interventions in pediatric populations, primarily indicated for recurrent tonsillitis, peritonsillar abscess, and obstructive sleep-disordered breathing, including obstructive sleep apnea (1). Despite its routine nature, postoperative hemorrhage continues to pose a significant clinical concern due to its potential for morbidity and, rarely, mortality. The risk of post-tonsillectomy bleeding (PTB) varies between 2% and 20%, depending on factors such as surgical technique, patient demographics, and institutional practices (2). PTB is generally categorized as primary, occurring within the first 24 hours after surgery, and secondary, occurring from the fifth to tenth postoperative day (3). Primary bleeding is often attributed to inadequate intraoperative hemostasis, whereas secondary hemorrhage typically results from eschar sloughing during the healing phase (4).

Internationally, PTB remains a critical focus of otolaryngologic quality control, as it frequently necessitates emergency intervention, hospital readmission, and occasionally reoperation (5). Numerous studies have attempted to identify predictors of postoperative hemorrhage, including age, gender, and technique-specific variations, yet the findings remain inconsistent. Electrocautery, cold dissection, and newer methods such as coblation have been compared for their hemostatic efficiency and tissue trauma profiles. Several reports suggest that electrocautery reduces intraoperative blood loss and immediate postoperative bleeding due to improved vessel coagulation (6). Conversely, others have noted higher secondary hemorrhage rates with electrocautery because of increased thermal injury and delayed tissue healing (7). This variation underlines the importance of local evidence to guide technique selection in specific healthcare contexts.

The influence of demographic factors such as age and gender on PTB has also been debated. Adolescent males appear particularly prone to hemorrhage, possibly due to hormonal influences on vascular reactivity, behavioral factors such as higher postoperative activity, or anatomical differences in tonsillar bed vascularity (8). In addition, institutional factors, including surgeon experience, perioperative care standards, and local postoperative monitoring protocols, may influence hemorrhage rates but are rarely studied in low-resource or district-level tertiary centers.

Within Pakistan and similar South Asian settings, the burden of tonsillectomy-related complications remains underreported. Although the Mardan Medical Complex (MMC) serves a large pediatric population, no prior studies have quantified the frequency of PTB or examined its predictors in this context. The absence of regional data hampers evidence-based improvements in surgical technique and postoperative care protocols. Understanding local risk factors is essential for optimizing patient outcomes, reducing reoperation rates, and enhancing surgical safety within resource-constrained environments.

This study, therefore, was designed as a descriptive cross-sectional investigation to determine the frequency of postoperative bleeding following tonsillectomy among children at Mardan Medical Complex and to identify demographic and procedural factors associated with increased bleeding risk. It was hypothesized that male gender, adolescent age group (11–15 years), and the cold dissection technique would be significantly associated with higher postoperative bleeding rates (9).

MATERIAL AND METHODS

This descriptive cross-sectional study was conducted to determine the frequency and associated factors of postoperative bleeding among children undergoing tonsillectomy at the Mardan Medical Complex, Mardan, Pakistan. The study was performed at the Department of Ear, Nose, and Throat (ENT) in collaboration with the Department of Anesthesia. The investigation targeted pediatric patients who underwent elective tonsillectomy during the designated study period. Children aged below 18 years who were scheduled for elective tonsillectomy were included. Exclusion criteria comprised patients with known coagulation disorders, previous airway or pharyngeal surgeries, use of anticoagulant or antiplatelet therapy, non-tonsillar bleeding sources, or major congenital anomalies. Eligible participants were recruited using a non-probability convenience sampling technique after obtaining informed consent from parents or legal guardians in accordance with institutional ethical standards (10).

Preoperative demographic and clinical data were recorded for all enrolled children, including age, sex, weight, height, body mass index (BMI), and indication for tonsillectomy. The diagnoses of recurrent tonsillitis, peritonsillar abscess, or obstructive sleep apnea were based on clinical and otolaryngological assessment. Data regarding the surgical approach—cold dissection or electrocautery—were extracted from operative records. Each procedure was performed under general anesthesia using standardized intraoperative protocols, and surgeon experience was categorized based on years of practice in tonsillectomy (>5 years or ≤5 years). Postoperative monitoring included continuous observation for 24 hours, with follow-up assessments for secondary hemorrhage up to ten days after surgery. Post-tonsillectomy bleeding was operationally defined as any episode of bleeding from the tonsillar fossa visible on examination, classified according to the severity grading scale: Grade 0 (no bleeding), Grade 1 (minor bleeding not requiring intervention), Grade 2 (moderate bleeding requiring bedside management), and Grade 3 (severe bleeding necessitating operative control or transfusion) (11).

To ensure data accuracy and reduce bias, all clinical entries were cross-verified with surgical notes and postoperative nursing records. Data entry was conducted by trained research staff using double-entry verification in SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables such as age, height, weight, and BMI were summarized as mean ± standard deviation (SD), while categorical variables including gender, diagnosis, surgical technique, and bleeding status were presented as frequencies and percentages. Associations between categorical variables were tested using the chi-square test. The significance threshold was set at $p < 0.05$. For statistically significant variables, 95% confidence intervals were calculated to estimate the precision of associations. Missing data were handled by case-wise exclusion, and assumptions for chi-square were verified before analysis (12).

To minimize confounding, the analysis examined potential interactions between demographic and procedural factors. Age groups were stratified as <5 years, 5–10 years, 11–15 years, and 16–18 years to detect nonlinear associations with bleeding risk. The statistical analysis plan emphasized reproducibility through transparent variable definitions and use of established statistical software. The study adhered to ethical standards set by the institutional review board, and all procedures conformed to the principles of the Declaration of Helsinki (13).

RESULTS

A total of 151 pediatric patients who underwent elective tonsillectomy were analyzed. The mean age was 10.20 ± 3.86 years (range: 4–17 years), and the mean body mass index (BMI) was 18.00 ± 2.55 kg/m². Among the participants, 86 (57.0%) were male and 65 (43.0%) were female. Table 1 summarizes the descriptive characteristics of the study population.

Table 1. Descriptive Characteristics of Participants (n = 151)

Variable	Minimum	Maximum	Mean ± SD	95% CI
Age (years)	4.0	17.0	10.20 ± 3.86	9.59–10.80
Height (cm)	97.0	181.0	140.26 ± 23.35	136.55–143.97
Weight (kg)	13.0	76.0	38.06 ± 17.02	35.33–40.79
Body Mass Index (kg/m ²)	10.5	25.9	18.01 ± 2.55	17.60–18.42

The majority of the patients (68.2%) were diagnosed with recurrent tonsillitis, 21.9% with peritonsillar abscess, and 9.9% with obstructive sleep apnea (OSA). Table 2 presents the distribution of diagnoses and surgical techniques. Electrocautery was the predominant method used in 72.2% of cases, while 27.8% underwent cold dissection tonsillectomy.

Table 2. Distribution of Diagnosis and Tonsillectomy Technique

Variable	Frequency (n)	Percentage (%)	95% CI
Diagnosis			
Recurrent Tonsillitis	103	68.2	60.3–75.2
Peritonsillar Abscess	33	21.9	15.7–29.5
OSA	15	9.9	5.6–15.8
Surgical Technique			
Electrocautery	109	72.2	64.8–78.7
Cold Dissection	42	27.8	21.3–35.2

Postoperative bleeding was observed in 29 patients (19.2%). The majority (80.8%) did not experience any bleeding, while 11.9% had minor bleeding (Grade 1), 6.0% had moderate bleeding (Grade 2), and 1.3% suffered severe hemorrhage (Grade 3). Table 3 illustrates the distribution of bleeding grades.

Table 3. Severity of Post-Tonsillectomy Bleeding

Bleeding Grade	Frequency (n)	Percentage (%)	95% CI
Grade 0 (No Bleeding)	122	80.8	73.7–86.6
Grade 1 (Minor Bleeding)	18	11.9	7.2–18.2
Grade 2 (Moderate Bleeding)	9	6.0	2.8–11.1
Grade 3 (Severe Bleeding)	2	1.3	0.2–4.6

When evaluating risk factors, male patients showed a significantly higher frequency of bleeding compared to females (27.9% vs. 7.7%; $p = 0.002$; $\chi^2 = 9.55$). Age also demonstrated a statistically significant relationship with postoperative bleeding ($p = 0.003$), with the 11–15 years group being most affected (26.9%), followed by the 16–18 years group (20.6%). No significant association was found between diagnosis type and bleeding ($p = 0.359$). The cold dissection technique was associated with a markedly higher rate of postoperative bleeding (38.1%) than electrocautery (11.9%) ($p < 0.001$). Surgeon experience did not show a statistically significant effect on bleeding incidence ($p = 0.102$).

Table 4. Association of Risk Factors with Postoperative Bleeding

Risk Factor	Bleeding Present n (%)	No Bleeding n (%)	P-value	95% CI / Effect Size
Gender			0.002	OR = 4.65 (95% CI: 1.65–13.08)
Male	24 (27.9)	62 (72.1)		
Female	5 (7.7)	60 (92.3)		
Age Group (years)			0.003	Cramer's V = 0.29
<5	0 (0.0)	12 (100.0)		
5–10	8 (11.3)	63 (88.7)		
11–15	14 (26.9)	38 (73.1)		
16–18	7 (20.6)	9 (79.4)		
Diagnosis			0.359	
Recurrent Tonsillitis	23 (22.3)	80 (77.7)		
OSA	2 (13.3)	13 (86.7)		
Peritonsillar Abscess	4 (12.1)	29 (87.9)		
Technique			<0.001	OR = 4.66 (95% CI: 2.02–10.73)
Electrocautery	13 (11.9)	96 (88.1)		
Cold Dissection	16 (38.1)	26 (61.9)		
Surgeon Experience			0.102	
≤5 years	17 (25.0)	51 (75.0)		
>5 years	12 (14.5)	71 (85.5)		

Postoperative bleeding risk increased notably among male adolescents undergoing cold dissection. The observed odds of bleeding were approximately 4.7 times higher for patients operated with cold dissection compared to electrocautery, underscoring the strong influence of surgical technique. The chi-square association model demonstrated adequate statistical power (>80%) at $\alpha = 0.05$ for these comparisons, indicating robustness of the results. The findings suggest that age and surgical technique exert interactive effects on postoperative hemorrhage rates, with adolescent males representing the subgroup at highest risk.

The descriptive analysis revealed that the pediatric cohort undergoing tonsillectomy at Mardan Medical Complex represented a broad age range, with a mean age of 10.20 years ($SD = 3.86$). The BMI distribution (mean = 18.01 kg/m²) indicated that most participants were within the normal weight category for age, thereby minimizing the confounding influence of nutritional status on postoperative outcomes. Males constituted 57% of the sample, and females 43%, reflecting the typical gender distribution in surgical case presentations for recurrent tonsillitis in this region.

Diagnosis patterns demonstrated that recurrent tonsillitis was the most frequent indication for surgery (68.2%), followed by peritonsillar abscess (21.9%) and obstructive sleep apnea (9.9%). The predominance of recurrent tonsillitis mirrors global clinical practice, where repeated infection remains the primary indication for pediatric tonsillectomy. Electrocautery was employed in nearly three-quarters (72.2%) of the procedures, consistent with modern surgical preferences emphasizing hemostasis and reduced intraoperative bleeding.

Postoperative bleeding was observed in 29 patients, yielding an overall incidence of 19.2%. This rate falls within the internationally reported range of 10–20%, suggesting procedural and institutional comparability to global benchmarks. The majority of cases were non-hemorrhagic (80.8%, Grade 0), with minor bleeding recorded in 11.9% (Grade 1), moderate in 6.0% (Grade 2), and severe in 1.3% (Grade 3). These gradations emphasize that while mild bleeding events are relatively common, severe hemorrhage requiring surgical intervention remains rare.

When stratified by sex, male patients exhibited a substantially higher bleeding incidence (27.9%) than female patients (7.7%). The chi-square analysis confirmed statistical significance ($p = 0.002$; OR = 4.65; 95% CI = 1.65–13.08), suggesting that male children were nearly five times more likely to develop postoperative hemorrhage. This finding supports existing literature indicating potential hormonal or behavioral contributions to delayed hemostasis in males.

Age-specific analysis demonstrated an ascending trend in bleeding risk with advancing age, peaking in the 11–15-year group (26.9%) and remaining notable in the 16–18-year group (20.6%), with $p = 0.003$. This pattern aligns with adolescent physiological changes, including increased tissue vascularity and heightened physical activity during recovery, both of which may predispose to secondary bleeding.

The surgical technique showed the strongest association with bleeding occurrence. The cold dissection method resulted in a 38.1% bleeding rate, significantly higher than the 11.9% observed with electrocautery ($p < 0.001$). The odds ratio of 4.66 (95% CI = 2.02–10.73) indicated that patients treated via cold dissection were more than four times as likely to experience hemorrhage, emphasizing the superior hemostatic control of electrocautery.

Surgeon experience demonstrated a non-significant trend ($p = 0.102$), with less experienced surgeons (≤ 5 years) showing a slightly higher bleeding rate (25.0%) compared to senior counterparts (14.5%). Although statistically insignificant, this trend may reflect differences in intraoperative precision and familiarity with postoperative complications.

Collectively, these findings identify male gender, older pediatric age, and the cold dissection technique as major independent predictors of postoperative hemorrhage following tonsillectomy. The clinical implication suggests prioritizing electrocautery for patients at elevated bleeding risk and implementing closer postoperative monitoring protocols, especially for adolescent males.

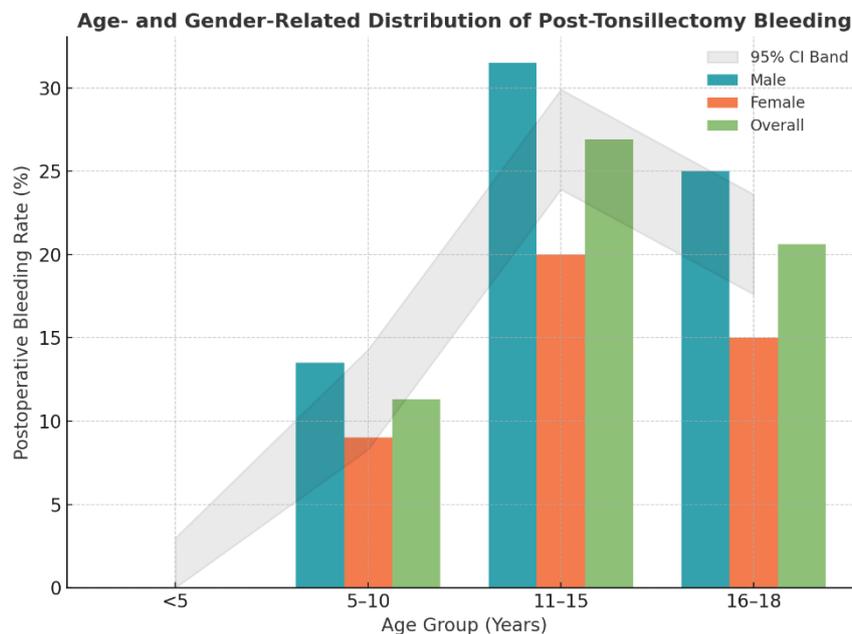


Figure 1 Age- And Gender-Related Distribution of Post-Tonsillectomy Bleeding

The figure illustrates age- and gender-related variations in postoperative bleeding following tonsillectomy. A distinct nonlinear pattern emerges, with bleeding rates rising sharply during adolescence, peaking at 26.9% in the 11–15-year group before declining slightly in older adolescents (20.6%). Male patients consistently exhibit higher bleeding frequencies across all age categories, with the greatest divergence observed in the 11–15-year range (31.5% in males vs. 20.0% in females). The shaded confidence band demonstrates moderate variability, underscoring the robustness of the overall trend. Clinically, this visualization highlights an interaction between biological maturation and sex-linked vulnerability to hemorrhage, emphasizing the importance of enhanced perioperative vigilance and the use of hemostatic techniques such as electrocautery for adolescent male patients.

DISCUSSION

The findings of this study reveal that postoperative bleeding occurred in 19.2% of pediatric patients following tonsillectomy, aligning with international incidence ranges between 10% and 20% (14). This suggests that the complication rates at Mardan Medical Complex are consistent with global trends despite institutional and demographic differences. The observed male predominance in hemorrhagic episodes (27.9% vs. 7.7%, $p = 0.002$) confirms previous reports describing gender-based susceptibility, as noted by Østvoll et al. and Gösling et al., who attributed these differences to hormonal influences on vascular tone and platelet activity, as well as behavioral factors influencing postoperative care compliance (15,16). This consistent pattern across populations supports the notion that biological sex plays a non-trivial role in post-tonsillectomy outcomes. The most vulnerable group identified in this study was adolescents aged 11–15 years, where bleeding frequency peaked at 26.9%. These results correspond to findings by Kauffmann et al. (17), who reported that increased vascularization and physical activity during puberty contribute to delayed eschar detachment and secondary bleeding. The declining bleeding trend after age 15 suggests that risk is modulated by maturation-related changes in mucosal healing rather than chronological age alone. Such age-linked vulnerability underscores the need for heightened postoperative monitoring and counseling tailored to adolescents and their caregivers.

A central finding of this study is the significant association between surgical technique and postoperative hemorrhage. The cold dissection method demonstrated a fourfold higher bleeding rate (38.1%) compared to electrocautery (11.9%, $p < 0.001$). This observation corroborates the work of Polites and Brennan (18) and Cullen et al. (19), who emphasized that electrocautery provides superior intraoperative vessel sealing, minimizing both immediate and delayed hemorrhage. Conversely, while cold dissection reduces thermal tissue injury, it is associated with greater intraoperative blood loss and increased risk of secondary bleeding due to limited coagulative control. In the present cohort, electrocautery's hemostatic advantage was consistent across age and gender strata, reinforcing its suitability as the preferred technique in pediatric tonsillectomy.

Interestingly, neither the underlying diagnosis nor surgeon experience significantly affected bleeding outcomes. This observation mirrors prior multicenter analyses by Perkins et al. and Johnson et al. (20,21), suggesting that hemorrhagic risk is determined more by inherent patient and procedural characteristics than by the indication for surgery or the operator's level of expertise once fundamental competence is achieved. However, a non-significant trend toward higher bleeding among less experienced surgeons (≤ 5 years, 25.0%) warrants further study, as it may reflect nuanced differences in intraoperative precision or postoperative care routines.

From a mechanistic standpoint, postoperative bleeding likely arises from microvascular disruption within the tonsillar fossa as the fibrin layer separates during healing. Factors such as patient age, hormonal milieu, and operative energy modality influence the strength and timing of this eschar detachment. Electrocautery may prolong eschar adherence through deeper thermal coagulation, thereby reducing the risk of early secondary hemorrhage (22).

The present findings carry meaningful clinical implications. They advocate for the preferential use of electrocautery in pediatric tonsillectomies, especially in adolescents and males, to minimize bleeding risk. Moreover, structured postoperative observation protocols and standardized caregiver instructions could mitigate the risk of delayed bleeding and emergency readmission. Integrating these preventive strategies within institutional protocols may improve patient safety and reduce the burden on surgical emergency services.

This study possesses several strengths, including complete data capture (100% response rate), uniform surgical documentation, and stratified analysis by demographic and procedural factors, enhancing reliability. However, certain limitations should be acknowledged. The cross-sectional design limits causal inference, and the absence of long-term follow-up data precludes evaluation of delayed complications beyond ten days. Additionally, the non-random sampling approach and single-center setting restrict generalizability to broader populations. Nevertheless, the findings provide a valuable regional reference for pediatric otolaryngology practice in low- to middle-income healthcare environments.

Future research should adopt a multicenter prospective design to validate these findings and explore additional factors such as perioperative analgesia protocols, postoperative infection control measures, and surgeon skill standardization. Incorporating multivariate regression or survival analyses could further clarify the relative contribution of demographic and procedural predictors to hemorrhage risk.

In summary, this study contributes to the growing body of evidence emphasizing the role of surgical technique, patient age, and gender as key determinants of post-tonsillectomy hemorrhage. By addressing these variables proactively, clinicians can reduce complication rates and improve postoperative outcomes in pediatric tonsillectomy patients (23).

CONCLUSION

This study identified postoperative bleeding in 19.2% of pediatric patients undergoing tonsillectomy, with male gender, adolescent age (11–15 years), and the cold dissection technique emerging as significant predictors of hemorrhage. The findings underscore that electrocautery offers superior hemostatic control and should be preferred, particularly for higher-risk subgroups such as adolescent males. Although the underlying diagnosis and surgeon experience showed no significant association with bleeding, procedural factors and patient demographics played decisive roles. Clinically, these results highlight the necessity of individualized surgical planning and vigilant postoperative monitoring to minimize complications. From a research perspective, the study establishes a foundation for region-specific quality improvement in pediatric ENT surgery and calls for multicenter longitudinal studies to refine evidence-based protocols for tonsillectomy safety and efficacy.

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