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Original Article

Predictors of Early Postoperative Complications Following Pediatric Circumcision: A Multicenter Retrospective Cohort Study

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Abstract

Background: Circumcision is one of the most common procedures performed in male children. Although it is generally considered safe, some children develop complications soon after the procedure. The factors that contribute to these complications are still not fully understood, particularly across the different techniques and medical or non-medical reasons for circumcision.

Objective: To determine independent predictors of early postoperative complications following pediatric circumcision, and to derive an internally validated four-item complication risk score.

Methods: We reviewed the records of 850 male children aged 0–12 years who underwent circumcision at five centres over a period of 36 months. The study focused on complications that occurred within 30 days after the procedure, including bleeding, infection, wound dehiscence, injury to the glans or meatus, poor cosmetic results, and urinary retention. The factors that remained significant in the multivariable logistic regression were each given one point. These points were then combined to create a simple risk score, which was validated using bootstrap resampling.

Results: Of 850 procedures, 48 (5.6%, 95% CI 4.3–7.4%) had an early postoperative complication, rising sharply with age from 0.0% in neonates to 6.8% in older children (p=0.018). Age>1 year (aOR 4.2), trainee operator (aOR 3.8), surgical technique (aOR 3.0), and medical indication (aOR 2.5) independently predicted complications (all p≤0.014); general anaesthesia did not (p=0.312) and was excluded. The four-item score achieved an apparent AUC of 0.73 (0.65–0.81), optimism-corrected to 0.68. At the Youden-optimal cut-off (≥3), sensitivity was 79.2% and specificity 56.1%; a higher cut-off (≥4) raised specificity to 91.5% and positive predictive value to 20.0%, with sensitivity 35.4%.

Conclusion: In our study, early complications after circumcision were more common among older children, those undergoing the procedure for medical reasons, those treated with a surgical rather than device-assisted technique, and those operated on by trainees. We developed a four-item risk score based on these factors, but it needs to be tested in other groups of children before it can be used in routine clinical practice.

Keywords: Circumcision; Pediatric surgery; Postoperative complications; Surgical site infection; Prognostic accuracy; Cohort study

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Introduction

Circumcision is one of the most commonly performed procedures in male children worldwide. It may be done for religious, cultural, or medical reasons, and is estimated to have been performed in about one-third of males globally.[1] According to the American Academy of Pediatrics, newborn circumcision can provide more health benefits than risks when it is carried out by a trained healthcare professional, with adequate pain relief and proper sterile precautions.[2] Different studies have reported quite different rates of complications, ranging from less than 1% to more than 5%. This may be because the studies included children of different ages, used different circumcision techniques, had different indications for the procedure, and varied in how thoroughly patients were followed after surgery.[3] A large study using data from more than 1.4 million circumcisions in the United States found that bleeding and infection were the most common complications. These problems were seen more often in older males and in those who underwent circumcision for medical reasons.[4] A multicenter study from Southwest Asia found similar rates of complications. Previous studies have reported a range of problems after circumcision, with bleeding and infection being among the more common ones, while injuries to the glans or urethra were reported less often but could be more serious.[5,6,7,8] Reports from Bangladesh have described some serious complications related to poor hygiene and inadequate training of circumcisers. Although these complications are uncommon, such reports show the importance of having local data to better understand the risks in the Bangladeshi setting.[9]

The age at which circumcision is performed can affect the risk of complications. Older male children tend to have more bleeding and infections after the procedure than newborns. This has also been seen in large-scale circumcision programmes involving older children.[10] A review of more than 100,000 US Army hospital records found that complications were relatively uncommon in newborns. This supports performing circumcision during the neonatal period when it is chosen for religious or cultural reasons rather than for a medical problem.[11,12]

The technique used for circumcision also differs from one setting to another. Some centres use devices such as clamps or rings, which hold the foreskin in place before it is removed. Others use conventional surgical methods, such as sleeve resection or the dorsal-slit technique. The World Health Organization recommends the dorsal-slit method in settings where trained surgical staff and proper sterile conditions are available.[13] Early studies comparing the two commonly used clamp devices found that the types and rates of complications were not the same. This shows that device-assisted circumcision does not carry the same level of risk with every device.[14] Surgical site infection is most consistently defined using standard national surveillance criteria for superficial incisional infection.[15]

Adequate analgesia is not only an ethical imperative but may influence procedural conditions and complication risk: inadequately controlled pain alters infant stress responses to subsequent painful procedures, and randomised comparisons of local anaesthetic techniques show substantial differences in efficacy.[16,17] Points-based composite risk scores derived from regression coefficients are well established for translating statistical models into pragmatic tools, provided their derivation and validation are explicit.[18] Few studies, however, have simultaneously examined age, technique, indication, anaesthesia, and operator experience within a single multicenter cohort. This study determines independent predictors of early postoperative complications among 850 boys across five centres and derives and internally validates a composite four-item risk score.

Methods

This multicenter retrospective cohort study reviewed records from the pediatric surgery and urology departments of five tertiary care centres in Sylhet, Bangladesh over 36 months, from January 2023 to December 2025; ethical approval was obtained from the Institutional Ethical Review Board, with a waiver of individual consent granted for this retrospective, de-identified review.

All male children aged 0–12 years undergoing circumcision, under local or general anaesthesia, at any participating centre were eligible. Exclusion criteria were a concurrent major procedure (e.g., hypospadias repair), a pre-existing penile or urethral anomaly requiring staged reconstruction, a bleeding disorder requiring factor replacement, and incomplete operative or 30-day follow-up records (affecting <2% of records, excluded complete-case). Centres contributed unequal numbers of procedures, reflecting differing patient volumes and referral patterns.

A standardised abstraction form captured demographic and clinical characteristics (age; indication—elective/ routine versus medical, comprising phimosis, balanitis xerotica obliterans, recurrent balanoposthitis, or recurrent urinary tract infection), procedural characteristics (technique, anaesthesia type, operator grade), relevant comorbidity (coagulation disorder history), and outcome. No child had a documented coagulation disorder, as circumcision was routinely deferred pending haematology assessment in any child with a suggestive bleeding history.

The primary outcome was any early postoperative

complication within 30 days, defined as bleeding requiring intervention beyond simple pressure dressing, surgical site infection meeting standard national surveillance criteria for superficial incisional infection, wound dehiscence, glans or meatal injury, unsatisfactory cosmesis requiring revision, or urinary retention requiring catheterisation; some children experienced more than one complication type, so category-specific counts do not sum to the total with a complication.[15]

Data were analysed using SPSS (Statistical Package for the Social Sciences) version 26.0. Normality was assessed with the Shapiro-Wilk test; normally distributed variables are expressed as mean ± standard deviation (SD) and compared using the independent-samples t-test, and non-normally distributed variables as median (interquartile range) compared using the Mann-Whitney U test. Categorical variables are expressed as frequencies and percentages, with 95% confidence intervals (CI) for the primary outcome calculated using the Wilson method, and compared using the chi-square (χ^2) test, with a test for linear trend across ordered categories where appropriate.

Multivariable binary logistic regression assessed independent predictors of complications, expressed as adjusted odds ratios (aOR) with 95% CI. Multicollinearity was assessed using the variance inflation factor (VIF), and calibration using the Hosmer-Lemeshow goodness-of-fit test. Heterogeneity in complication rates across the five centres was assessed using the chi-square test.

Variables retaining independent significance ($p<0.05$) on multivariable logistic regression were used to derive a composite four-item score, with each variable assigned an equal integer weight of one point given the similar magnitude of the qualifying odds ratios, consistent with established methods for simplifying regression-derived risk scores.18 ROC analysis determined the optimal cut-off using the Youden index, yielding sensitivity, specificity, and apparent AUC with 95% CI; a second, higher cut-off prioritising specificity was also examined.19 Internal validation used bootstrap resampling (1000 iterations), from which an optimism-corrected AUC was derived by subtracting mean bootstrap optimism from the apparent AUC. A p-value <0.05 was considered significant.

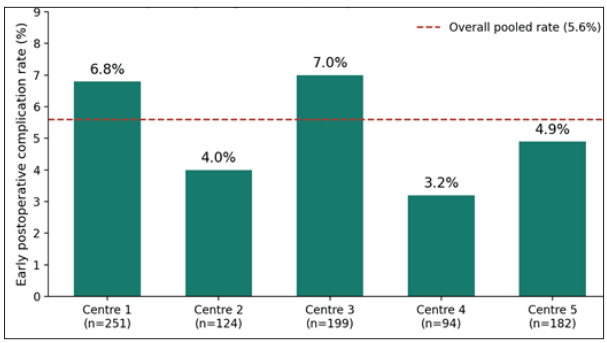
Results

Of 850 circumcisions across the five centres, 48 (5.6%, 95% CI 4.3–7.4%) had at least one early postoperative complication; 802 (94.4%) had an uncomplicated course. Enrolment varied by site (94–251 procedures), and complication rates likewise varied (3.2–7.0%) without reaching significance ($\chi^2=2.98$, $p=0.562$) (Table-I, Figure 1).

Table-I: Distribution of procedures and early postoperative complications across the five participating centres

Centre	n	Complications, n (%)
Centre 1	251	17 (6.8)
Centre 2	124	5 (4.0)
Centre 3	199	14 (7.0)
Centre 4	94	3 (3.2)
Centre 5	182	9 (4.9)
Total	850	48 (5.6)

Figure 1. Early postoperative complication rate across the five participating centres (unequal enrolment, n=94–251).



Baseline characteristics are summarised in Table-II: four-fifths of procedures were in children older than one year, trainees performed just under three-fifths, and no child had a documented coagulation disorder.

Table-II: Demographic and procedural characteristics of the study population (N=850)

Characteristic	n (%)
Age: Neonatal (<1 month)	26 (3.1)
Age: Infant (1–12 months)	144 (16.9)
Age: Older child (>1–12 years)	680 (80.0)
Technique: Device-assisted	128 (15.1)
Technique: Surgical (sleeve/dorsal-slit)	722 (84.9)
Indication: Elective/routine	748 (88.0)
Indication: Medical	102 (12.0)
Anaesthesia: Local	179 (21.1)
Anaesthesia: General	671 (78.9)
Operator: Consultant/attending	360 (42.4)
Operator: Trainee under supervision	490 (57.6)
Known coagulation disorder	0 (0.0)

Bleeding requiring intervention and surgical site infection were the most frequent complication types (Table-III, Figure 2); since some children had more than one type, the 52 category-specific events exceed the 48 children with at least one complication.

Table-III: Types of early postoperative complications (N=850)

Complication Type	n (%)
Bleeding requiring intervention	21 (2.5)
Surgical site infection	14 (1.6)
Wound dehiscence	7 (0.8)
Urinary retention	5 (0.6)
Unsatisfactory cosmesis requiring revision	3 (0.4)
Glans or meatal injury	2 (0.2)
Any complication (primary outcome)	48 (5.6)

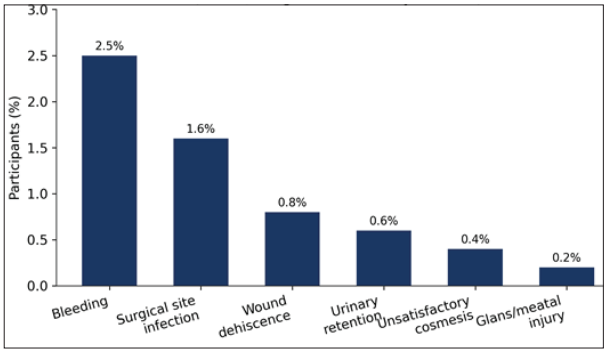


Figure 2. Types of early postoperative complications (N=850; categories not mutually exclusive).

On bivariate comparison, age, indication, and operator grade were each significantly associated with complications; technique was of borderline significance and anaesthesia was not (Table-IV). Rates rose sharply with age, from 0.0% in neonates to 1.4% in infants and 6.8% in older children (Figure 3).

Table-IV: Bivariate predictors of early postoperative complications

Variable	n	Complications, n (%)	p-value
Age: Neonatal	26	0 (0.0)	
Age: Infant	144	2 (1.4)	0.018*
Age: Older child	680	46 (6.8)	
Technique: Device-assisted	128	2 (1.6)	0.050
Technique: Surgical	722	46 (6.4)	
Indication: Elective/routine	748	36 (4.8)	0.009
Indication: Medical	102	12 (11.8)	
Anaesthesia: Local	179	7 (3.9)	0.342
Anaesthesia: General	671	41 (6.1)	
Operator: Consultant/attending	360	9 (2.5)	0.001
Operator: Trainee	490	39 (8.0)	

**Overall chi-square across the three age categories.*

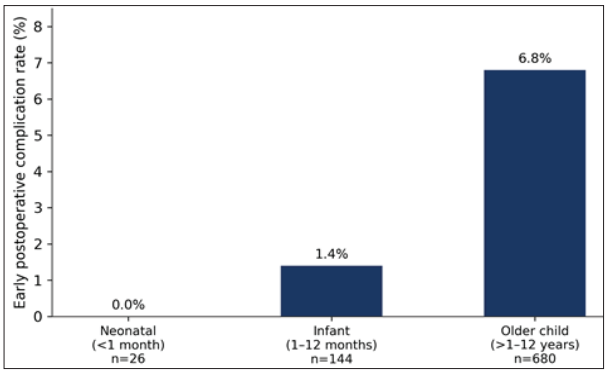


Figure 3. Early postoperative complication rate by age at circumcision.

Variance inflation factors (1.1–1.9) indicated no important multicollinearity, and the Hosmer-Lemeshow test showed no evidence of poor fit (χ^2=6.42, p=0.60). Age>1 year, trainee operator, surgical technique, and medical indication remained independently associated with complications; general anaesthesia did not and was excluded from the score (Table-V).

Table-V: Independent predictors of early postoperative complications — multivariable logistic regression

Predictor	Adjusted OR	95% CI	p-value
Age>1 year	4.2	1.9–9.3	<0.001
Trainee (vs consultant) operator	3.8	1.8–8.0	<0.001
Surgical (vs device-assisted) technique	3.0	1.3–6.9	0.009
Medical (vs elective) indication	2.5	1.2–5.2	0.014
General (vs local) anaesthesia	1.4	0.7–2.6	0.312

The composite score combined the four independently significant variables—age>1 year, trainee operator, surgical technique, and medical indication—each worth one point (range 0–4). Complication rates rose steeply with score, from 0.0% at 0 to 20.0% at 4 (p for trend<0.001) (Figure 4).

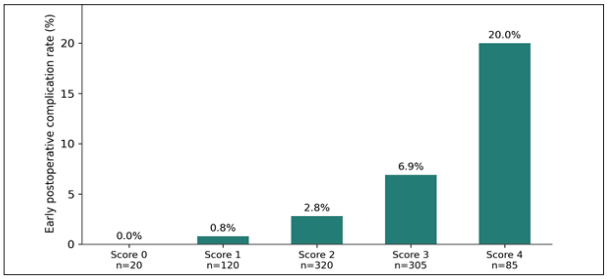


Figure 4. Risk gradient across the four-item composite risk score and early postoperative complications.

On ROC analysis, the score discriminated complications with an apparent AUC of 0.73 (95% CI 0.65–0.81) (Figure 5), optimism-corrected to 0.68 on bootstrap validation. At the Youden-optimal cut-off (≥3), sensitivity was 79.2% and specificity 56.1%; at a higher cut-off (≥4), specificity rose to 91.5% and positive predictive value to 20.0%, with sensitivity 35.4% (Table-VI).

Table-VI: Apparent and internally validated prognostic accuracy of the composite risk score for early postoperative complications

Index	Score ≥3 (Youden-optimal)	Score ≥4 (high-precision)
Sensitivity	79.2%	35.4%
Specificity	56.1%	91.5%
Positive predictive value	9.7%	20.0%
Negative predictive value	97.8%	95.9%
Overall accuracy	57.4%	88.4%
Positive likelihood ratio	1.80	4.18
Negative likelihood ratio	0.37	0.71
Apparent AUC (95% CI)	0.73 (0.65–0.81)	
Optimism-corrected AUC (bootstrap, 1000 iterations)	0.68	

Figure 5. ROC curve of the four-item composite risk score for prediction of early postoperative complications.

Discussion

The principal finding of this study is that early postoperative complications following pediatric circumcision are independently associated with four readily identifiable preoperative and procedural characteristics—older age, trainee involvement, surgical rather than device-assisted technique, and medical indication—allowing modest, internally validated discrimination of complication risk (optimism-corrected AUC 0.68). This finding was broadly consistent across the five participating centres, and the steep risk gradient across increasing score categories, rising from 0.0% at a score of 0 to 20.0% at a score of 4, strengthens the inference of a cumulative relationship between these characteristics and postoperative risk.

There are also some clear differences between newborns and older children that may help explain why complications are more common with increasing age. In newborns, the foreskin is thinner and usually easier to separate from the glans, making the procedure quicker and less traumatic. In older children, the foreskin is generally thicker and has a richer blood supply. They are also more active after the procedure, which may increase the chances of bleeding or disturbing the healing area.[10] Device-assisted techniques may make the procedure more consistent, particularly in terms of tissue removal and control of bleeding. This could be one reason why they are sometimes associated with fewer complications than conventional surgical methods. However, the risk is not the same for all devices, and different device-based techniques have been reported to have different complication rates.[13,14]

Our findings are similar to what has been reported in earlier studies on circumcision complications. However, most of those studies were conducted in Western countries or in healthcare settings with more resources than are typically available in our setting. El Bcheraoui et al., in a large study from the United States, also found that older age and having a non-neonatal indication were associated with a higher risk of complications. These findings are similar to what we observed in our study.[4] A multicenter study from Southwest Asia reported similar findings. Other reviews have also described bleeding and infection as the main complications following circumcision.[5,6,7] Reports from Bangladesh have also described some serious complications, particularly when circumcision is performed outside formal healthcare settings by people without adequate training. These findings highlight the need for larger studies from Bangladesh and other South Asian countries to better understand the risks.9 This study adds to the previous research by examining all five potential risk factors together in a multicenter cohort. We then used the findings to develop a four-item score for identifying children at higher risk of complications. The score showed modest performance in our study, but it will need to be tested in other patient groups before it can be used more widely.[8]

The higher risk seen with medical indications may be related more to the condition being treated than to the circumcision procedure itself. Conditions such as phimosis and balanitis xerotica obliterans can cause long-standing inflammation and make the foreskin less flexible. This may make the operation more difficult and affect healing, even when the procedure is performed properly.[3] General anaesthesia was not independently linked to complications after taking age, indication, and surgical technique into account. This may be because children who received general anaesthesia were more likely to be older or to have more complex medical reasons for circumcision. For this reason, general anaesthesia was not included in the final score.[16,17]

These findings may be useful when discussing the procedure and its possible risks with families before surgery. They may also help with planning the procedure.

However, the cut-off used should depend on what the score is intended to be used for. A cut-off of ≥3 gave the best balance between sensitivity and specificity. This may be useful when the main goal is to identify as many children at higher risk as possible. The higher cut-off of ≥ 4 identifies a smaller group of children who have about a one-in-five chance of developing a complication. This is more than three times the overall rate in our study. In practice, this cut-off may be useful when resources are limited and closer attention is needed for children who appear to be at higher risk, such as arranging senior supervision or planned observation after the procedure.[2] All four factors are available before the procedure starts or can be decided during the planning stage. So, the score does not require any additional tests. Having clear and consistent definitions for postoperative complications also helps ensure that complications are identified and recorded in the same way.[15]

This study has certain limitations. Because this was a retrospective study, we had to rely on what was recorded in the medical records. Some complications may have been missed if they were treated at a primary care facility and the child did not return to the study centres. As a result, the actual complication rate may be slightly higher than what we found. The choice of anaesthesia, surgical technique, and operator grade was based on clinical circumstances rather than random assignment. In some cases, children who were expected to have a more difficult procedure may have been more likely to receive a particular type of anaesthesia, technique, or a more experienced operator. Although we accounted for these factors in our analysis, we cannot completely rule out the effect of this confounding. There were only 48 complication events for the five predictors included in the analysis, giving about 9.6 events per predictor. This is slightly below the commonly used minimum of 10 events per predictor. Therefore, the results and the risk score should be interpreted with some caution and confirmed in larger prospective studies. We did not find any child with a documented coagulation disorder in our study. This may be because children with known bleeding problems were identified before circumcision and were not included for the procedure. Therefore, the absence of such cases in our data does not necessarily mean that coagulation disorders were completely absent. This may also limit how well our score can be applied in settings where similar screening and deferral practices are not routinely followed. To keep the score simple and easy to use, all four factors were given one point each. However, this means that the score does not fully reflect the differences in the strength of association between the individual factors.18 The score has not yet been tested in an independent group of patients, and its internally validated AUC of 0.68 suggests only modest accuracy. Therefore, it should not be used as a standalone tool. For now, it is better considered as an additional aid alongside clinical judgement rather than as a replacement for it. Finally, comparative literature remains predominantly Western, with only case-level South Asian data available; larger regional cohorts and prospective external validation are needed before routine clinical use.[9]

Conclusion

We reviewed 850 male children who underwent circumcision at five different centres. Early postoperative complications occurred in 5.6% of the cases. Complications were more common in older children, in those operated on by trainee doctors, and when a surgical technique was used instead of a device-assisted technique. They were also more frequent when circumcision was performed for a medical reason. General anaesthesia, on the other hand, was not found to be an independent risk factor and was not included in the final risk score. The four-item score showed a modest ability to distinguish children at higher risk of complications, with an optimism-corrected AUC of 0.68. A higher cut-off identified a smaller group of children who had a noticeably higher risk. However, the score still needs to be tested in an independent cohort, preferably from South Asia, before it can be used in routine practice. Further validation would be needed before using the score to help with operator selection, counselling, or follow-up planning.

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