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A longitudinal population analysis of cumulative risks of circumcision

Ya-Ching Hung, MD, MPH,[a,b] David C. Chang, PhD, MPH, MBA,[a,b] Maggie L. Westfal, MD, MPH,[a,b] Isobel H. Marks, MBBS, MA (Cantab),[a,b,c] Peter T. Masiakos, MD, MS,[b,d] and Cassandra M. Kelleher, MD[b,d,*]

[a] Department of Surgery, Massachusetts General Hospital, Boston, Massachusetts
[b] Harvard Medical School, Boston, Massachusetts
[c] Northwick Park Hospital, London
[d] Department of Pediatric Surgery, MassGeneral Hospital for Children, Boston, Massachusetts

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ABSTRACT

Background: Circumcision is widely accepted for newborns in the United States. However, circumcision carries a risk of complications, the rates of which are not well described in the contemporary era.

Methods: We performed a longitudinal population analysis of the California Office of Statewide Health Planning and Development database between 2005 and 2010. Using International Classification of Procedures, Ninth Revision, Clinical Modification and Current Procedural Terminology codes, we calculated early and late complication rates by Kaplan–Meier survival estimates. Late complications were defined as those that occurred between 30 d and 5 y after circumcision. Descriptive analysis of complications was obtained by analysis of variance, chi-square test, or log-rank test. On adjusted analysis, a Cox proportional hazard model was performed to determine the risk of early and late complications, adjusting for patient demographics.

Results: A total of 24,432 circumcised children under age 5 y were analyzed. Overall, cumulative complication rates over 5 y were 1.5% in neonates, 0.5% of which were early, and 2.9% in non-neonates, 2.2% of which were early. On adjusted analysis, non-neonates had a higher risk of early complications (OR 18.5). In both neonates and non-neonates, the majority of patients with late complications underwent circumcision revision.

Conclusions: Circumcision has a complication rate higher than previously recognized. Most patients with late complications after circumcision received an operative circumcision revision. Clinicians should weigh the surgical risks against the reported medical benefits of circumcision when counseling parents about circumcision.

Introduction

Circumcision is the most common surgical procedure in children, with more than one million performed each year in the United States (US).[1] Although it is reported that only 38% of males are circumcised globally, at least 60% of male children born in the US are electively circumcised.[2,3]

* *Corresponding author.* Pediatric Surgery, Massachusetts General Hospital, 55 Fruit Street, WRN-11, Boston, MA 02114. Tel.: +1 617 724 1602; fax: +1 617 726 2167.
E-mail address: ckelleher3@partners.org (C.M. Kelleher).
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In 2012, the American Academy of Pediatrics released a policy statement on circumcision, which states that the benefits of elective circumcision outweigh the risks of the procedure.[4] Many studies have reported medical benefits of circumcision, including decreased risk of urinary tract infection (UTI), human immunodeficiency virus (HIV), and other sexually transmitted infections, penile cancer, and human papillomavirus (HPV)-related cervical cancer.[5-13] However, fewer contemporary studies have reported the complication rates, and those that do, focus on short-term outcomes.[14,15] The most recent large population study in the US used data from a collection of private insurance databases and reported a 0.4% complication rate when babies were circumcised in the first year of life, whereas the risk of complication increased by 10- to 20-fold when the procedure was performed later in life. The emphasis of this study was on complications that occurred within 30 d, and the reported late complications had variable follow-up times, with a few up to 3 y. In addition, their reported complications included conditions unlikely related to circumcision, for example, pneumothorax and meningitis.[14] Other, older US studies report complication rates ranging between 0% and 30%,[16,17] and international studies report complication rates ranging between 2% and 14%.[15,18,19]

Given the widely variable study designs and outcome data on circumcision, it is understandably difficult for providers to compare the surgical risks with the reported medical benefits of circumcision when counseling parents. Therefore, the goal of this study is to analyze patient demographics and characterize clinically meaningful early and late complication rates after circumcision in a large heterogeneous population.

Methods

A retrospective longitudinal analysis of the California Office of Statewide Health Planning and Development database was performed for the years 2005 to 2010. This database contains all inpatient admissions in public and private hospitals in the state of California, excluding US military and Veterans Affairs hospitals ($n = 350$). We also searched the ambulatory and emergency department databases. Ambulatory surgeries are defined as day surgeries that do not require an overnight stay but does not include clinic procedures that are done in physician offices or clinics. All data are deidentified with a unique record linkage ID (encrypted social security number (SSN)) that allows patients to be tracked over time in all hospitals and years.

The inclusion criteria were male patients under age 5 y, with a circumcision defined by International Classification of Procedures, Ninth Revision, Clinical Modification (ICD-9) procedural code 64.0, or Current Procedural Terminology (CPT) codes 54150 (circumcision, using clamp), 54160 (circumcision, surgical excision other than clamp, 28 d of age or less), 54161 (circumcision, surgical excision other than clamp, patient older than 28 d), and with a linkage ID at the time of initial circumcision. We were not able to differentiate the methods of circumcision, clamp or nonclamp, for neonates as these patients were coded with ICD-9 procedural codes. We defined neonates as babies under 3 mo old because some infants, such as those born prematurely, may have a nonoperative circumcision within the first few months of life, rather than at birth.

Preoperative indications for circumcision were grouped into five categories: redundant prepuce or phimosis, infection or vesicoureteral reflux (VUR), non-VUR hydronephrosis, neurogenic bladder, and posterior urethral valves. Redundant prepuce or phimosis was defined by ICD-9 code 605. Infection or VUR was defined by the following ICD-9 codes: balanoposthitis (607.1), balanitis xerotica obliterans (607.81), UTI, site not specified (599.0), VUR, unspecified or without reflux nephropathy (593.70), VUR with reflux nephropathy, unilateral (593.71), VUR with reflux nephropathy, bilateral (593.72), VUR with reflux nephropathy, not otherwise specified (593.73). Non-VUR hydronephrosis included ICD-9 diagnosis codes of 593.70 (VUR, unspecified or without reflex nephropathy) and 593.5 (hydroureter). Neurogenic bladder was defined by ICD-9 codes of 596.51 (hypertonicity of the bladder), 596.52 (low bladder compliance), 596.53 (paralysis of the bladder), 596.54 (neurogenic bladder, not otherwise specified), 596.55 (detrusor sphincter dyssynergia), and 596.59 (other functional disorder of the bladder). Posterior urethral valve was defined by ICD-9 codes of 753.6 (atresia and stenosis of the urethra and bladder neck) and 753.8 (other specified anomalies of the bladder and urethra). Patients were defined as having a preoperative indication for circumcision when these codes were captured within a year before circumcision.

Complications included accidental puncture or laceration during a procedure (ICD-9 998.2), hemorrhage complicating a procedure (ICD-9 998.11), hematoma complicating a procedure (ICD-9 998.12), seroma complicating a procedure (ICD-9 998.13), infection, nonhealing wound, and complications requiring surgical revisions after initial circumcision. Infection was defined by the following ICD-9 codes: postoperative infection (998.5), infected postoperative seroma (998.51), or other postoperative infection (998.59). Nonhealing wounds included ICD-9 codes of disruption of wound (998.3), disruption of wound unspecified (998.30), disruption of internal operation (surgical) wound (998.31), disruption of external operation (surgical) wound (998.32), nonhealing surgical wound (998.83), open wound of penis without mention of complications (878.0), or open wound of penis, complicated (878.1).

Complications requiring surgical revisions were defined as the presence of the following procedural codes at a subsequent event after the initial circumcision: urethral meatoplasty (ICD-9 58.47), release of urethral stricture (ICD-9 58.5), suture of penile of laceration (ICD-9 64.41), release of chordee (ICD-9 64.42), construction of penis (ICD-9 64.43), reconstruction of penis (ICD-9 64.44), replantation of penis (ICD-9 64.45), other repair of penis (ICD-9 64.49), amputation of penis (ICD-9 64.3), partial amputation of penis (CPT 54120), complete amputation of penis (CPT 54125), partial division of penile adhesions (ICD-9 64.93), suture of unspecified blood vessel (ICD-9 39.30), suture of artery (ICD-9 39.31), suture of vein (ICD-9 39.32), hemorrhage control (ICD-9 39.98), incision and drainage of penis (CPT 54015), incomplete circumcision (CPT 54163), lysis of post circumcision adhesion (CPT 54162), complex revision (CPT 54300), lysis of skin bridges and suture tracts (CPT 11420), removal of inclusion cyst (CPT 54060), or a second encounter with one of the circumcision codes. We included the aforementioned ICD-9 procedure codes 39.30, 39.31, 39.32, 39.98, and diagnosis codes 998.11, 998.12 into the category of hemorrhage.

Complications requiring a second operation were categorized as circumcision revision (revision) or complication repair (repair). Revisions were defined by CPT codes of incomplete circumcision (54163), complex revision (54300), or a second encounter with one of the circumcision codes. Repairs were defined as complications requiring surgical operations, excluding revisions.

Outcomes of interest were early and late complication rates. The risk window for early complications was within 30 d and was 1 mo to 5 y for late complications. There was no way to accurately calculate loss to follow-up rates; however, we expect this number to be insignificant. This statewide database captures visits from all hospitals and emergency rooms. Therefore, unless a patient moved out of state, they were unlikely to be lost to follow-up. In addition, we have no reason to believe there are differences in emigration rates between those children with and without complications; therefore, emigration of a small number of patients should not affect our complication rates. Complication rates were calculated by the Kaplan–Meier failure function. Descriptive analysis of patient demographics was obtained using chi-square test or analysis of variance. Unadjusted comparisons were performed by log-rank test. On adjusted analysis, Cox proportional hazards regression was utilized to predict early and late complications, while adjusting for age, race, operative setting, and insurance types. Statistical analysis was performed with Stata SE statistical software, version 13.1 (StataCorp LP, College Station, TX). IRB approval was granted for this work from the state of California (IRB identifying number: 16-05-2558).

Results

A total of 24,432 patients from 350 hospitals were analyzed. Most neonates who underwent circumcision were white (44.7%), whereas the majority of non-neonates were Hispanic (47%). None of the neonates received an ambulatory circumcision. In non-neonates, nearly all of the patients had either private insurance (48.4%) or Medicaid (42.3%). A significantly higher proportion of non-neonates than neonates had a documented preoperative diagnosis of redundant prepuce or phimosis (93.9% *versus* 0.9%, P value < 0.001). Non-neonates also had a significantly higher preoperative diagnosis rate of infection or VUR (18.6% *versus* 0.09%), non-VUR hydronephrosis (1.2% *versus* 0.04%), neurogenic bladder (0.17% *versus* 0.01%), and posterior urethral valve (0.42% *versus* 0.07%), when compared to neonates (all P value < 0.001) (Table 1). Overall, cumulative complication rates were 1.5% in neonates and 2.9% in non-neonates. Most of the complications occurred within approximately 2 y of the initial circumcision, after which the rates rose more slowly (Fig. 1).

Only 36.0% of patients had a documented preoperative diagnosis. For neonates who were circumcised due to redundant prepuce and phimosis, the majority of them were white (44.8%) and had private insurance (67.2%). Most of the circumcised non-neonates with a documented redundant prepuce and phimosis were Hispanic (47.3%) and had private insurance (48.0%) or Medicaid (42.9%) (Table 2). A similar distribution was seen in circumcised non-neonates with a

Table 1 – Demographics of the study population.

	Neonates (%) (n = 15,425)	Non-neonates (%) (n = 7859)	P value
Race			<0.001
White	6288 (44.7%)	1909 (27.6%)	
African-American	2126 (15.1%)	1134 (16.4%)	
Hispanic	3760 (26.7%)	3252 (47.0%)	
Asian	1857 (13.2%)	627 (9.1%)	
Operative setting			<0.001
Inpatient	15,223 (99.2%)	118 (2.7%)	
Ambulatory	0 (0%)	4314 (97.3%)	
Insurance			<0.001
Private	12,370 (80.2%)	3801 (48.4%)	
Medicaid	2640 (17.1%)	3321 (42.3%)	
Self-pay	401 (2.6%)	679 (8.6%)	
Preoperative diagnosis[‡]			
Redundant prepuce or phimosis[*]	134 (0.9%)	7377 (93.9%)	<0.001
Infection or VUR[†]	14 (0.09%)	1458 (18.6%)	<0.001
Non-VUR hydronephrosis	6 (0.04%)	91 (1.2%)	<0.001
Neurogenic bladder	1 (0.01%)	13 (0.17%)	<0.001
Posterior urethral valve	11 (0.07%)	33 (0.42%)	<0.001

[*] Include paraphimosis.
[†] Include UTI, balanitis, balanoposthitis, VUR.
[‡] Total number does not equal to n because not all patients had a preoperative diagnosis.

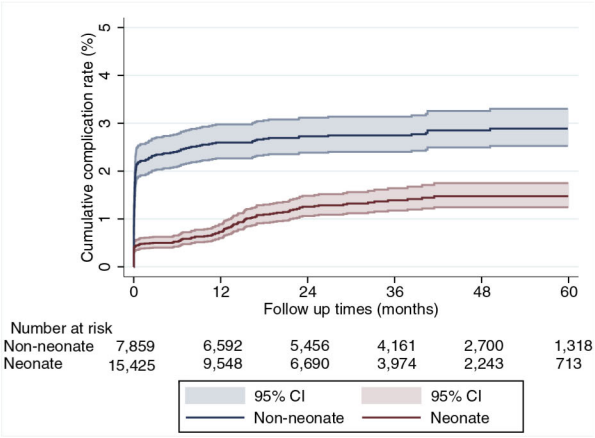

Fig. 1 – Complication rates for neonatal and non-neonatal circumcisions. (Color version of figure is available online.)

documented indication of infection or VUR. Most of those non-neonates were Hispanic (54.4%) and had private insurance (43.7%) or Medicaid (45.3%) (Table 3).

The rates of early complications were 0.5% in neonates and 2.2% in non-neonates, whereas the rates of late complications were 1.0% in neonates and 0.7% in non-neonates (Tables 4 and 5). There was no difference in the complication rates between methods of circumcision in non-neonates (clamp 2.5% *versus* nonclamp 2.5%, $P = 0.96$, data not shown in the table). Although this comparison in neonates would be of interest to clinicians, these data are not available because neonatal circumcisions are coded with a single ICD-9 procedural code that does not differentiate between circumcision methods. Furthermore, for early complications, rates of hemorrhage, nonhealing wound, and complication repair were significantly lower in neonates (0.32%, 0.08%, and 0.08%, respectively) than non-neonates (1.55%, 0.13%, and 0.22%, respectively) (all P value ≤ 0.01). There were no differences in late complication rates of circumcision revision or complication repair between neonates and non-neonates (P value > 0.05). Most early complications for both neonates and non-neonates were hemorrhage, while the need for circumcision revision presented later in convalescence (>30 d) (Tables 4 and 5).

On adjusted analysis, non-neonates had an 18.5 times higher risk of early complications ($P < 0.001$) than neonates. Patients who had circumcisions performed in the ambulatory setting had a significantly reduced risk of early complications (OR 0.12, P value < 0.001). After adjustment for patient demographics, including age, race, operative settings and insurance, there were no significant factors associated with late complications (Table 6).

Discussion

This study reports a large, multi-institutional population review of complications after circumcision. Overall, we found that the complications of circumcision vary between neonatal and non-neonatal populations as well as between inpatient and ambulatory procedures. In our population, 1.5% of neonates and 2.9% of non-neonates experienced a complication from circumcision within 5 y. The majority of complications (76.8%) in non-neonates occurred within 30 d after circumcision, whereas complications for neonates occurred after 30 d. As our study utilized a large, diverse statewide database that allowed for tracking of patients over time and across hospitals, we believe our study is more representative of the true rates of complications for this procedure than most articles in the current literature.

Although circumcision and circumcision revisions may be considered by some to be cosmetic in nature, this is a subject of intense debate in both the literature and in the general public. Nevertheless, these procedures pose surgical risks, inconvenience to the patients, and cost to our health care system, whether or not circumcisions or revisions are cosmetic or elective. Therefore, understanding the true risks of the procedures is necessary to appropriately calculate their risk-benefit ratios.

Reported complication rates for circumcision in the US range between 0% and 30%.[16,17] Most of these studies have relatively small sample sizes, are from single institutions or small groups of specialty hospitals, and have varying definitions of complication and follow-up times, which make their findings less generalizable.[14-17,20] To date, the only multi-

Table 2 – Breakdown of patients with documented preoperative indication of redundant prepuce and phimosis* for circumcision.

	Neonate (%) ($n = 134$)	Non-neonates (%) ($n = 7347$)	P value	P value comparing Tables 2 and 3: neonate	P value comparing Tables 2 and 3: non-neonate
Race			<0.001	0.92	<0.001
White	52 (44.8%)	1739 (26.8%)			
African-American	19 (16.4%)	1078 (16.6%)			
Hispanic	34 (29.3%)	3071 (47.3%)			
Asian	11 (9.5%)	600 (9.3%)			
Insurance			<0.001	0.003	0.01
Private	90 (67.2%)	3541 (48.0%)			
Medicaid	34 (25.4%)	3164 (42.9%)			
Self-pay	10 (7.5%)	617 (8.4%)			

*Include paraphimosis.

Table 3 – Breakdown of patients with documented preoperative indication of infection and VUR* for circumcision.

	Neonate (%) ($n = 14$)	Non-neonates (%) ($n = 1458$)	P value
Race			0.69
White	5 (38.5%)	344 (26.1%)	
African-American	2 (15.4%)	159 (12.1%)	
Hispanic	5 (38.5%)	716 (54.4%)	
Asian	1 (7.7%)	98 (7.4%)	
Insurance			0.25
Private	3 (21.4%)	637 (43.7%)	
Medicaid	8 (57.1%)	660 (45.3%)	
Self-pay	3 (21.4%)	142 (9.7%)	

* Include UTI, balanitis, balanoposthitis, VUR.

institutional population analysis of circumcision complications in the US is from El Bcheraoui *et al.*, who reported similar early complication rates as our study (0.5% *versus* 0.4%).[14] Interestingly, our 30-d complication rate is also similar to the 7-d complication rate found by Roth *et al.* (0.12% *versus* 0.1%) suggesting that most early complications happen in the immediate postoperative period.[21]

Our study is unique in reporting late complication rates, whereas existing literature reports only cumulative complication rates. Our cumulative complication rates differ from prior literature for several possible reasons. For example, El Bcheraoui *et al.* grouped newborns with all children under age 1 y despite known differences in circumcision techniques between these groups. Neonates and infants up to 3 mo of age are more likely to have clamp style circumcisions, whereas older babies and children most often have operative circumcisions. To account for these differences in operative technique, we defined neonates as infants 3 mo or younger, and all others as non-neonates. In addition, we reported on early, late, and cumulative complications, as the types of complications that occur immediately are different than those identified months to years after the initial procedure. This differentiation allowed us to delineate between complications requiring immediate operative repair such as hemorrhage and those complications requiring repair or revision months to years later such as meatal stenosis or foreskin redundancy. Furthermore, we reviewed outcomes up to 5 y after circumcision while previous literature applied variable and often shorter follow-up periods for complications.[14-21]

Using this refined methodology, we made several notable findings. Although the rates of early reoperation did not differ between the age groups, the indication for reoperation did. Although 0.22% of neonates required an operative repair for complications, 0.09% of neonates required an operative revision for excess foreskin within 30 d. The low rate of recorded surgical indications in neonates is likely because foreskin and congenital phimosis are not considered pathologic in this age group. Our data suggest that most early complications of circumcision are treated nonoperatively. Opposite of this trend, all of the late complications required an operation. Notably, most of the late operations were circumcision revisions (88% neonate and 76% non-neonates), and this significant long-term data have been under-represented in the literature (Tables 4 and 5). Although the absolute risk seems low, extrapolation of these data to the US circumcision data suggest that approximately 10,000 circumcision revisions may be performed annually in the US.[1]

We also found that the percentage of boys who are circumcised after the non-neonatal period differs significantly by ethnicity. Hispanic boys were circumcised as non-neonates nearly half of the time, whereas the majority of Caucasian, Asian, and African-American boys were circumcised in the newborn period (77%, 76%, and 65%, respectively). Understanding the reasons why Hispanics deferred circumcision until later in childhood is beyond the scope of this study. Circumcision as a non-neonate also occurred more frequently in children with Medicaid or who were self-pay than in those patients with private insurance. We anticipated that this may be due to differing indications for surgery in non-neonates. Examination of the indication for initial circumcision showed that the number of patients with a documented infection (i.e., UTI or balanitis) or VUR was increased in patients who were circumcised as non-neonates, but that these accounted for less than 20% of the circumcisions performed. The remainder was done for redundant prepuce or phimosis, neither of which denotes an absolute medical indication for circumcision, with redundant prepuce indicating the presence of foreskin and phimosis treatable with application of topical steroid cream (Table 1).[22] Together, these results suggest that the majority of higher risk non-neonatal circumcisions were being performed for reasons similar to neonates,

Table 4 – Breakdown of early complication rates.

	Neonate (%)		Non-neonate (%)		P value
	Rate	95% CI	Rate	95% CI	
Total	0.48	0.38-0.60	2.22	1.91-2.57	0.03
Hemorrhage	0.32	0.24-0.42	1.55	1.30-1.85	<0.001
Infection	0.07	0.04-0.12	0.50	0.36-0.68	0.45
Nonhealing wound	0.08	0.04-0.14	0.13	0.07-0.24	0.01
Reoperation rate	0.12	0.08-0.19	0.31	0.20-0.46	0.16
Circumcision revision	0.05	0.02-0.10	0.09	0.04-0.19	0.2
Complication repair	0.08	0.04-0.14	0.22	0.13-0.35	0.005

Table 5 – Breakdown of late complication rates.

	Neonate (%)		Non-neonate (%)		P value
	Rate	95% CI	Rate	95% CI	
Total	1.02	0.81-1.27	0.67	0.49-0.92	0.63
Circumcision revision	0.90	0.71-1.14	0.51	0.36-0.72	0.15
Complication repair	0.12	0.06-0.24	0.18	0.09-0.35	0.24

such as cultural practice, or concern for medical complications later in life and not for absolute medical indications, such as documented infections or VUR.

Among these higher risk non-neonate circumcisions, higher rates of nonhealing wounds were found (0.13% *versus* 0.08%). They were also found to experience hemorrhage in the immediate postoperative setting more often than neonates (0.32% *versus* 1.55%). We found that ambulatory circumcision is independently associated with lower risk of complications. Some may be surprised by this finding because older children with increased penile vascularity and increased risk of bleeding are circumcised in the ambulatory setting. Our adjusted analysis separated the effect of age from the effect of the operative setting. Therefore, our finding that the ambulatory setting confers lower risk is likely explained by the controlled environment of an operative circumcision, after the effect of age is removed.

The use of large population datasets for research introduces certain limitations, and these hold true for this study as well. We suspect that nonsurgical complication rates may be underestimated in our study as many ICD-9 codes for nonsurgical complications may not be routinely recorded by the providers. In addition, our analysis time, 2005-2010, was before the American Academy of Pediatrics circumcision policy statement revision, released in 2012, which detailed changes from a prior neutral stance to recommending consideration of circumcision for all males.[4] Theoretically this may have increased the rate of circumcision after 2012 but is unlikely to change procedure outcomes. Finally, as only a subset of newborns are issued an SSN at birth, only these patients can be tracked longitudinally. Hence, this analysis was only possible for a portion of the patients in California and biased toward older children and those circumcised in the ambulatory setting. As we have no reason to suspect outcomes of the newborns who were issued an SSN differ from those that did not, we expect the trackable cohort to be a valid representation of the whole.

Our study also has several strengths. First, we report early and late complication rates that have not previously been differentiated and reported in the literature. Furthermore, our late complication rate is also a long-term complication rate as we tracked patients for 5 y and across care settings by using unique identifiers, a method unique to this type of data set. Our study is also generalizable and less biased than single institution studies because we include a heterogeneous population across multiple socioeconomic, ethnic, and geographic domains. In addition, we believe a large population database is less likely to be biased than chart reviews as it is collected by different people from multiple institutions. As such, any inaccuracy introduced by any single reviewer during chart reviews will be mitigated.

Table 6 – Adjusted analysis: outcomes of circumcision in California.

	Early complications: Hazard ratio	95% Cl	P value	Late complications: Hazard ratio	95% CI	P value
Age						
Neonate	Reference			Reference		
Non-neonate	18.51	9.27-36.97	<0.001	1.41	0.19-10.22	0.74
Race						
White	Reference			Reference		
African-American	1.22	0.67-2.21	0.51	1.61	0.91-2.85	0.11
Hispanic	1.49	0.94-2.34	0.09	0.57	0.30-1.08	0.08
Asian	1.32	0.71-2.46	0.38	1.58	0.84-2.97	0.15
Operative setting						
Inpatient	Reference			Reference		
Ambulatory	0.12	0.06-0.24	<0.001	0.53	0.07-4.02	0.54
Insurance						
Private	Reference			Reference		
Medicaid	1.25	0.80-1.96	0.33	1.22	0.73-2.04	0.44
Self-pay	2.36	1.27-4.38	0.01	0.57	0.14-2.36	0.44

In summary, this study offers clinically relevant complication rates for physicians to better inform families considering circumcision. Specifically, for families considering deferment of circumcision in the neonatal period, they should be made aware that the risk of early complications in non-neonates is 19 times higher than neonates, after adjusting for patient demographics. This study also provides important insight into the rate of reoperation and late complications of circumcision at the population level. Parents should be aware that 1% of boys may require additional surgery within 5 y including the need for a late circumcision revision.

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Authors' contributions: C.M.K. conceptualized the study, critically reviewed the data and drafted the initial article, and reviewed and revised the final article. D.C.C. conceptualized the study, collected the data and carried out the initial data analysis, critically reviewed the data and drafted the initial article, and reviewed and revised the final article. M.L.W. critically reviewed the data, reviewed and revised the final article. I.H.M. and Y-C.H. collected the data and carried out the initial data analysis, critically reviewed the data, and drafted the initial article. P.T.M. conceptualized the study, and reviewed and revised the final article. All authors approved the final article as submitted and agree to be accountable for all aspects of the work.

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