

Comparison of anesthesia onset and duration between needle and needle-free methods in pediatric circumcision

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ABSTRACT

Introduction: Various anesthesia methods are utilized during circumcision, including needle anesthesia (NA) and needle-free anesthesia (NFA). However, research on differences in the total duration of anesthetic action between these methods remains limited. Therefore, this study aimed to evaluate the effectiveness of NA and NFA techniques in circumcision.

Methods: This observational study employed a prospective cohort design and an independent *t*-test. A total of 56 participants were included, with 28 patients assigned to each technique. Data collection was conducted using an observation sheet. Consecutive sampling was applied, and the primary variables measured were the onset of anesthetic drug, duration of anesthetic effect, and total duration of anesthetic action.

Results: The onset of anesthetic drug, measured as the time from administration to numbness, averaged 4.53 minutes and 3.14 minutes using the NA and NFA methods, respectively ($p < 0.001$). The average duration of anesthetic effect, measured as the time from the onset of numbness to anesthesia dissipation, was 95.39 minutes and 79.00 minutes in the NA and NFA methods, respectively ($p < 0.001$). Finally, the total duration of anesthetic action was 100.46 minutes and 82.54 minutes using the NA and NFA methods, respectively ($p < 0.001$).

Conclusions: The NFA method facilitates a faster onset, while the NA method provides a longer duration of anesthetic effect. These findings may assist clinicians in selecting anesthesia techniques based on procedural duration and patient comfort in pediatric circumcision. Further studies are suggested to explore other influencing factors.

Keywords: anesthesia, circumcision, duration of anesthetic action, needle anesthesia, needle-free anesthesia

Introduction

Circumcision is a common medical, cultural, or religious practice. However, there is still a lack of data and comparative research on the use and effectiveness of needle anesthesia (NA) versus the needle-free anesthesia (NFA) method in clinical circumcision services. While some modern clinics have adopted NFA devices, most still rely on conventional NA techniques, often due to cost, familiarity, or limited access to alternative technology (Akyüz & Ergün, 2020).

Male circumcision is a surgical procedure whereby a part of the prepuce is excised or removed to uncover the glans penis. Circumcision is generally recommended for religious and health reasons (Santoso *et al.*, 2022; Redho *et al.*, 2023; Welan, 2023). The skin covering the glans penis is removed during the procedure to enhance cleanliness and prevent infection (Ganeswari *et al.*, 2020; Rahayuningrum *et al.*, 2020). The American Academy of Pediatrics recognized that urinary tract infections in children can be prevented through circumcision (Eisenberg *et al.*, 2018). Furthermore, circumcision also

inhibits the accumulation of smegma, which is suspected to have carcinogenic properties, further reducing the risk of cancer (Mehta *et al.*, 2021; Thumma *et al.*, 2024). Circumcision, again, is known to be a highly recommended procedure in certain circumstances related to diseases and congenital abnormalities of the genitals (Alifariki *et al.*, 2022).

The increasing demand for safer and more comfortable circumcision procedures has led to a growing comparison between NA and NFA methods. Each technique presents specific advantages and limitations, yet their real-world application and outcomes remain debated. Despite its benefits, circumcision is often associated with the creation of a wound, leading to the perception that it is inherently painful (Perrot *et al.*, 2022; Selomo, 2022). The pain experienced during the administration of anesthetic injections is hypothesized to be comparable to the pain of the circumcision itself (Sari *et al.*, 2022). The success of circumcision is closely linked to the efficacy of the anesthesia used, as effective anesthetic administration contributes to patient comfort and enhances the overall quality of the procedure (Altaş *et al.*, 2017; Münevveroglu & Gunduz, 2019; Saputro & Efendy, 2021; Samsugito *et al.*, 2022; Sundari, 2022).

Various anesthesia techniques are utilized during circumcision, including the NA and NFA methods. In the NA method, nerve block techniques are used to inhibit sensory nerve transmission (Carreira De Oliveira *et al.*, 2025). On the other hand, NFA uses a device with three main parts: a spray device, an injector, and an injector pump. This method uses the power of high-speed air pressure to inject the anesthetic through the skin, without the need for needles (Saputro & Efendy, 2021).

NA has the advantage of targeting specific regions to relieve pain without causing loss of consciousness (Budiono *et al.*, 2022). However, it is not without risks, including incomplete block, bleeding, and hematoma (Carreira De Oliveira *et al.*, 2025). In contrast, NFA has several advantages, including the elimination of needle-related fear or phobia, prevention of puncture injuries, and reduced risk of infection. These features enhance patient safety and comfort during the procedure (Barolet & Benohanian, 2018; Alameeri *et al.*, 2022).

Although several studies have compared the effectiveness of NA and NFA methods in various medical procedures, our literature review found that most studies focused on dental procedures (Amorim *et al.*, 2020; Yıldırım *et al.*, 2020; Altan *et al.*, 2021; Jaju *et al.*, 2024; Nogueira *et al.*, 2024; Vishwanathaiah *et al.*, 2024; Altan & Almas, 2025; Qian *et al.*, 2025). Meanwhile, in the context of circumcision, only one study was found (Akyüz & Ergün, 2020). Still, the study found that NFA by spraying 0.1 mL (2 mg) of lidocaine was no more effective than the conventional technique or NA, as well as one other study (Saputro & Efendy, 2021); however, this study used

hypnotherapy as an additional intervention in the NFA group with no NA as a comparison. Based on the literature review, we found that the topic of circumcision in Indonesia has not been extensively evaluated comparatively. Furthermore, the use of 3 mL of lidocaine in this study differs from previous research. A prospective approach, with direct measurement of the onset and duration of anesthetic drugs, provides more accurate empirical data. Therefore, the objective of this study was to determine whether there is a difference in the duration of anesthetic action between the needle and needle-free methods in circumcision.

Materials and Methods

Study design

This study utilized an observational research design with a prospective cohort approach. This study was conducted at one of the circumcision clinics in Yogyakarta in June 2024, with the study population being all male patients who underwent circumcision in Yogyakarta.

Participants

The sample size in this study was determined using the analytical formula for comparing two independent numerical groups with a single measurement (Dahlan, 2016). The calculated minimum sample requirement was then increased by 10% to account for potential dropouts, resulting in a final target of 28 participants per group. The study population, therefore, comprised two groups: one group undergoing the NA method and the other utilizing the NFA method, with a total of 56 respondents. The sampling technique used was non-probability, specifically, consecutive sampling. Participants were selected based on the following inclusion criteria: willingness to participate, age range of 6–12 years, normal penile anatomy, and cooperative behavior. Participant consent was obtained from the participant's parent or guardian, while parents or guardians of patients who refused to participate were excluded from the study.

All samples that met the criteria were collected during the research period until the desired number was reached. In this study, there were two groups: the NA method group and the NFA method group. The sampling method was done alternately, where the first respondent was circumcised using the needle method. The second respondent used the needle-free method, and the third patient used the needle method again, and so on. This process continued throughout the study period until the required sample size was reached, with all participants meeting the inclusion criteria. Although participants were not offered a choice of anesthesia method, parents or guardians were clearly informed that the procedure would follow the standard protocol of the clinic, which includes the use of either NA or NFA. They were told that both methods were routinely used and considered safe.

Table 1. Operational definition of each research variable

Variable	Operational definition	Measurement	Measurement Method	Scale
Needle anesthesia (NA) method	The anesthesia procedure was carried out using a syringe injected directly around the target nerve, using lidocaine at a dose of 3 cc	Using observation sheet	Observation	Nominal
Needle-free anesthesia (NFA) method	Anesthesia procedure carried out without using a syringe consisting of three main components (a sprayer, an injector, and an injector pump as a jet injector), using lidocaine with a dose of 3 cc	Using observation sheet	Observation	Nominal
Onset of anesthetic drugs	Time (hours, minutes, and seconds) when the operator administered the anesthesia	Count the time from injection to numbness, using a stopwatch.	Using a needle or NA method and without a needle or NFA method. After anesthesia was administered, the operator gently pinched the tip of the foreskin using tweezers to determine the onset of numbness. Participants were asked whether they still felt pain. The onset was defined as the time point when the child verbally reported no pain in response to the pinch stimulus.	Ratio
Duration of anesthetic effect	Time (hours, minutes, and seconds) from when the anesthetic effect starts to be felt until the effect ends	Count the time from numbness to pain (normal), using a stopwatch.	Using tweezers by pinching the tip of the foreskin or prepuce. Participants were verbally asked to report whether the pinch felt painful again. The duration was defined as the time from the onset of numbness until the participants verbally confirmed the return of pain.	Ratio
Total duration of anesthetic drug action	Time (minutes and seconds) from the patient being administered anesthetic drug until numbness occurs, and until the patient feels pain (normal)	Count the time from injection until the patient feels pain, using a stopwatch.	-	Ratio

Written informed consent was obtained before the procedure. One author (Y.S.K.) filled out the research observation sheet during this procedure.

Instruments and data collection

The independent variable in this study is the type of anesthesia used in circumcision, using the needle and needle-free injection methods. In contrast, the dependent variable is the duration of action of the anesthetic drug. [Table 1](#) explains the operational definition of each variable.

Data collection was conducted using an observation sheet as the primary instrument, which included patient identity, method used, time of anesthesia, anesthetic effect, loss of anesthetic effect, and duration of anesthetic effect. In the NA method, anesthetic drugs were injected into specific nerve regions, including the pudendal, dorsal penile, and perineal nerves, to block sensory signals responsible for pain transmission to the brain. Conversely, the NFA method employed a technology referred to as free needle injection. This method used a device comprising three main components: a spray device, an injector, and an injector pump. The device used a high-speed spring mechanism to deliver anesthetic agents through the skin without a syringe. All anesthesia and circumcision procedures were carried out by a well-trained operator (medical doctor) who has circumcision expertise and is responsible for all procedures.

Data analysis

In univariate analysis, variables were described using frequency distributions and percentages within each group to characterize the research subjects, which were presented in tables and narratives. This description included age, the presence of a companion during circumcision, body weight, and the average anesthetic effect.

Meanwhile, in bivariate analysis, normality and homogeneity tests were performed using the Kolmogorov-Smirnov test. The independent *t*-test was subsequently used to perform bivariate analysis based on the results of the normality test. If the data were found not to be normally distributed, a non-parametric alternative, the Mann-Whitney U test, would be considered for comparing the two groups. Interpretation of significant results for the onset and duration of anesthetic drugs was reported when *p*-values were <0.05 .

The independent *t*-test was chosen to compare the mean onset of anesthetic drugs, duration of anesthetic effects, and total duration of anesthetic drug action between the two groups (NA and NFA), because these variables were measured on a ratio scale and the data were normally distributed. This test allows evaluation of whether the observed differences in mean values between the groups are statistically significant, thus identifying actual discrepancies rather than those due to random variation. A *p*-value <0.05 indicates that the difference is unlikely to be due to chance, suggesting a

Table 2. Characteristics of respondents of circumcision patients in Yogyakarta.

Variables	Group (n= 56)		p-value
	Needle anesthesia method	Needle-free anesthesia method	
Age (Mean ± SD)	9.68±1.46	10.75±1.23	0.005 ^a
Body Weight (Mean ± SD)	28.86±2.24	28.43±3.28	0.571 ^a
Companion (n, %)			
Father and Mother	15 (53.57%)	14 (50%)	1.00 ^b
Father	8 (28.57%)	7 (25%)	
Mother	5 (17.85%)	7 (25%)	

^a independent *t*-test^b One-way ANOVA

real effect of the anesthesia method on the measured outcome.

Ethical consideration

Ethical approval for this study was obtained from the Medical and Health Research Ethics Committee (MHREC) of the Faculty of Medicine, Public Health, and Nursing, Universitas Gadjah Mada, in collaboration with Dr. Sardjito General Hospital. The study was conducted under approval number KE/FK/0757/EC/2024. Given the involvement of underage participants aged 6-12 years, specific ethical considerations were addressed. Written informed consent was obtained from each participant's parent or legal guardian after receiving a full explanation of the study objectives, procedures, potential benefits, and possible discomfort. All procedures, including the administration of NA and NFA during circumcision, were part of routine clinical practice and did not introduce additional risks beyond standard care. Sensory assessment (e.g., evaluating numbness and the return of pain) was performed using gentle, minimally invasive stimuli and followed safety protocols suitable for pediatric patients. Confidentiality was strictly maintained, with all data anonymized and stored securely. The study adhered to the principles of the Declaration of Helsinki and complied with guidelines for research involving human subjects.

Results

Characteristics of respondents

This study involved 56 respondents, with 28 per group. The mean age of respondents in the NA group was 9.68±1.46 years, while the mean age in the NFA group was 10.75±1.23 years, with a statistically significant difference ($p=0.005$). The mean body weight of respondents in the NA group was 28.86±2.24 kg, compared to 28.43±3.28 kg in the NFA group, with no statistically significant difference ($p=0.571$).

According to the parental assistance during the procedure, both parents assisted in 15 cases (53.57%) in the NA group and 14 cases (50%) in the NFA group, only the father assisted in 8 cases (28.57%) in the NA group and 7 cases (25%) in the NFA group, and only the mother assisted in 5 cases (17.85%) in the NA group and 7 cases

(25%) in the NFA group. The differences in parental assistance between the two groups were not statistically significant ($p=1.00$). The characteristics of respondents in this study are detailed in [Table 2](#).

The normality test was then carried out using the Kolmogorov-Smirnov test, with the provision that if the *p*-value is >0.05, the research data are normally distributed (see [Table 3](#)). Based on the results of the normality test, the *p*-value was >0.05 for all data in both the needle method and the needle-free method, indicating that all data were normally distributed.

Onset of anesthetic drugs using the needle anesthesia and the needle-free anesthesia method in circumcision procedures

The independent *t*-test revealed that the onset of anesthetic action was significantly different between the two methods. The mean onset of anesthetic drug for the NA method was 4.53 minutes, while for the NFA method it was 3.14 minutes, with $p<0.001$. These findings indicated that the NFA method achieved a faster onset of anesthetic action compared to the NA method (see [Table 4](#)).

Duration of anesthetic effect using the needle anesthesia and the needle-free anesthesia method in circumcision procedures

The duration of the anesthetic effect was significantly different between the two methods. The mean duration of anesthetic effect for the NA method was 95.39 minutes, while for the NFA method, it was 79.00 minutes, with $p<0.001$. These results indicated that the NA method provides a longer duration of anesthetic effect compared to the NFA method (see [Table 5](#)).

Differences in the total duration of anesthetic drug action using the needle anesthesia and needle-free anesthesia methods in circumcision procedures

The total duration of anesthetic drug action differed significantly between the two methods. The average total duration of anesthetic drug action for the NA method was 100.46 minutes, while for the NFA method, it was 82.54 minutes, with $p<0.001$. These findings confirmed that there was a statistically significant difference in the total duration of anesthetic drug action between the NA and NFA methods (see [Table 6](#)).

Table 3. Normality test using Kolmogorov-Smirnov.

Variable	Group (n=56)	
	Needle anesthesia method	Needle-free anesthesia method
Companion	0.060	0.055
Body weight	0.071	0.080
Age	0.069	0.077
Onset	0.063	0.062
Duration	0.200	0.200

Discussions

The present study indicated that the onset of an anesthetic drug, measured from the time of administration to the achievement of numbness, was 4.53 minutes in the NA group compared to 3.14 minutes in the NFA group. Additionally, the time from the onset of numbness to the dissipation of the anesthetic effect was 95.39 minutes in the NA group and 79.00 minutes in the NFA group. The total time from anesthetic drug administration to the return of sensation was 100.46 minutes in the NA group and 82.54 minutes in the NFA group. Statistical analysis using the independent *t*-test revealed a statistically significant difference. However, a significant age difference was observed between the two groups. Older children may have a greater ability to articulate pain or numbness verbally, while younger children may provide less consistent responses.

Furthermore, it was difficult to determine whether the children's responses of pain or numbness were genuine or influenced by anxiety and fear of the circumcision procedure (Jalali *et al.*, 2020). This difference may influence measurements that relied on verbal confirmation, such as the onset and return of pain, thereby functioning as a potential confounding factor. Although the primary comparative trends remained consistent, age should be considered when interpreting sensory response-based outcomes.

The findings of this study suggest that the NFA method achieves a faster onset of anesthesia than the NA method. This study also confirms that the duration of anesthetic effect and total duration of anesthetic drug action were significantly longer in the NA method group. The findings are in line with pharmacological theory, which holds that the deeper, more localized distribution of anesthetic agents in needle methods contributes to prolonged nerve blockade. Conversely, the NFA method offers rapid drug delivery but shallower diffusion,

Table 5. Duration of anesthesia drugs using the needle and the needle-free anesthesia method.

Methods	n	Duration of effect of anesthetic drugs (minutes)			p-value
		Mean ± SD	Min	Max	
Needle anesthesia method	28	95.39±16.50	65.00	134.00	<0.001
Needle-free anesthesia method	28	79.00±11.13	53.00	102.00	

Independent *t*-test

Table 4. Onset of anesthesia drugs using needle and needle-free anesthesia methods.

Methods	n	Onset of anesthetic drugs (minutes)			p-value
		Mean ± SD	Min	Max	
Needle anesthesia method	28	4.53±0.63	3.22	6.00	<0.001
Needle-free anesthesia method	28	3.14±0.46	2.30	4.10	

Independent *t*-test

resulting in a shorter total anesthetic duration. These results, furthermore, are in accordance with previous studies that have established that NA is generally slower to achieve the desired anesthetic level and usually takes more than 15 minutes (Wang *et al.*, 2019). On the other hand, the NFA method can produce the anesthetic effect in less than 45 seconds (Soegiharto & Isrok, 2023).

The NFA method does not use needles to deliver anesthetic agents; instead, it uses high-pressure spray technology. The technology consists of using a stream of air to the area to be annotated, in this case, the penis, where the anesthetic is applied on the skin pores, then injected into the dorsal nerve. This approach offers a different way for medical professionals to deliver anesthesia, tailored to clinical needs. As with previous work, this research also establishes that the NFA approach cuts down the time to reach the optimal anesthetic effect to a great extent (Khoa *et al.*, 2019). However, the findings of this study contradict the research conducted by Akyüz and Ergün (Akyüz & Ergün, 2020) which found that the duration of action of anesthetic drugs using the syringe method was faster than the NFA method. This is thought to be due to the different characteristics of the respondents in the study, with an average age of 3.99 years, as well as differences in the dose of anesthetic drugs used, namely 0.1 mL.

The NFA method applies a high-speed spray mechanism. This technology allows the anesthetic drug, in this case lidocaine at a dose of 3 mL, to penetrate the skin quickly and directly through the pores to the target nerve tissue. This mechanism allows the time required to reach the target nerve to be shorter. In contrast, the longer anesthetic effect of the NA method is due to the wider, deeper distribution of the anesthetic around the blocked nerve, resulting from direct injection into the tissue via physical penetration. Thus, this ultimately prolongs the duration of the nerve blockade because the

Table 6. Differences in the total duration of anesthesia using the needle and the needle-free anesthesia method in Yogyakarta.

Methods	n	Total duration of anesthesia (minutes)			p-value
		Mean ± SD	Min	Max	
Needle anesthesia method	28	100.46±16.63	70	140	<0.001
Needle-free anesthesia method	28	82.54±11.24	56	105	

Independent *t*-test

anesthetic spreads gradually, providing a longer-lasting effect.

The method of anesthesia used in circumcision can be selected and adjusted based on the needs of the procedure and patient preferences. NA is more suitable for procedures that require a longer duration of anesthesia. At the same time, the NFA method is more ideal for short procedures or when rapid anesthesia onset is needed. NFA methods are generally more comfortable for patients with needle phobia, but the effects tend to be less long-lasting due to the more diffuse distribution of the drug (Akyüz & Ergün, 2020). This can help medical personnel make a flexible choice of the appropriate approach based on the complexity of the intervention and the patient's comfort.

This study has several strengths. It used a prospective design with a standardized sensory assessment method, reducing operator-dependent variation. Moreover, the study was conducted in a real clinical environment using commonly applied circumcision anesthesia techniques, which enhances external validity. The involvement of trained operators also contributed to methodological consistency. Nevertheless, several limitations exist in this study. The significant age difference between groups may influence sensory reporting and represent a potential confounder. Sensory assessment relied on children's verbal communication, introducing subjectivity that cannot be eliminated. Although the sample size met the minimum calculated requirement, a larger sample would allow for more robust subgroup analysis. The alternating sampling technique, while operationally practical, did not represent proper randomization and may introduce selection bias. Furthermore, the study did not utilize objective, validated pain-assessment tools. Future studies should include randomized allocation, larger samples, age stratification, and a more objective pain measurement method to enhance accuracy and generalizability.

Conclusion

The findings suggest that using an NFA method, also referred to as free needle injection, results in a faster onset of anesthetic effect than the NA technique. These results offer valuable insights, particularly for healthcare professionals specializing in circumcision, in selecting a more efficient and effective anesthesia technique for the procedure. In clinical settings, the NFA method may be considered for patients who require a rapid onset of anesthesia and have concerns related to needle use, such as anxiety or needle phobia. Conversely, the NA method may be preferable when a longer duration of anesthesia is required. While this study did not directly assess the influence of age or body weight on anesthetic effectiveness, these patient characteristics, along with procedure duration and expected comfort, should be considered in selecting the appropriate anesthetic

approach. In addition, the findings of this study require further research to determine differences between NA and NFA methods, considering factors such as age, body weight, anesthetic drugs used, and other factors that can affect the onset and duration of anesthetic medications.

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Availability of data and materials

The "Availability of Data and Materials" section in a scientific publication is crucial for ensuring transparency, reproducibility, and credibility of research findings. It refers to the accessibility of the raw data, datasets, or materials used in the study, allowing other researchers to verify results, replicate experiments, or build upon the research.

Authors' contributions

Conceptualization: YSK; Methodology: YSK and KA; Software: YSK; Validation: KA and AAPP; Formal analysis: YSK; Investigation: YSK, KA, and AAPP; Data curation: YSK; Project administration: YSK; Supervision: KA and AAPP; Writing – Original draft: YSK; Writing – Review & editing: YSK, KA, and AAPP. All authors have read and agreed to the published version of the manuscript.

Conflict of Interest

The authors declare no conflicts of interest.

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