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# Awake caudal anesthesia method in inguinal hernia surgery in preterm infants

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## Abstract

**Objectives:** This study aims to evaluate the safety and efficacy of awake caudal anesthesia in inguinal hernia repair surgery in preterm infants.

**Patients and methods:** Between April 2024 and April 2025, a total of 15 preterm infants (10 males, 5 females; mean age: 10.60±3.90 weeks; range, 4 to 7 week) with a gestational age <37 weeks and a postconceptional age <46 weeks were retrospectively analyzed. The patients included in the study were those who underwent awake caudal anesthesia. The patients' demographic data, intra- and postoperative hemodynamic data, analgesia requirements, postoperative micturition time, complications, and discharge times were recorded.

**Results:** Of the patients, 40% underwent bilateral surgery. Caudal anesthesia was technically successful in all patients. No patient developed bradycardia, apnea, or required general anesthesia during the operation. No respiratory depression, urinary retention, or neurological complications were observed in the postoperative period. All patients were discharged on the first postoperative day. The mean surgical duration was 29.4±6.37 min, and the mean time to first analgesia requirement was 3.33±0.48 h.

**Conclusion:** Awake caudal anesthesia is a safe and effective regional anesthesia method for inguinal hernia repair in preterm infants. This method provides a significant advantage in low birth weight and small postconceptional age newborns by reducing the risks of respiratory and neurological complications associated with general anesthesia.

***Keywords:*** Caudal anesthesia, inguinal hernia, postoperative apnea, preterm infant, regional anesthesia.

With recent technological and medical advances in neonatal intensive care units, there has been a significant increase in the survival rates of preterm infants. As a result, anesthesiologists are increasingly administering anesthesia to preterm patients. One of the most common surgical procedures in the preterm patient group is inguinal hernia repair. The incidence of inguinal hernia in preterm infants with a birth weight between 751 and 1,000 g is approximately 38%.[1] The main reason for this is that the processus vaginalis typically closes between the 36$^{th}$ and 40$^{th}$ weeks of gestation, and in preterm infants (<36 weeks), it tends to remain open compared to term infants.[2]

General anesthesia in preterm infants increases the risk of bradycardia, postoperative apnea, and other serious cardiorespiratory complications due to immature organ systems.[3] In particular, the development of bradycardia and apnea can have adverse effects on cerebral blood flow and tissue oxygenation, thereby increasing the risk of complications such as ischemia, intracranial hemorrhage, and permanent neurological deficits.[3] Therefore, minimizing potential risks is of great importance while selecting anesthetic techniques for this patient group.

Caudal anesthesia is a frequently preferred regional anesthesia method in lower abdominal and urological surgeries in newborns and pediatric patients.[4] The literature indicates that caudal anesthesia reduces the incidence of postoperative apnea and may prevent adverse effects on

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neurodevelopmental processes by eliminating the potential risk of neurotoxicity.[5,6]

In the present study, we aimed to examine the intraoperative findings of preterm infants undergoing inguinal hernia surgery under awake caudal anesthesia and to evaluate the safety, efficacy, and advantages of the awake caudal anesthesia technique in preterm infants.

## PATIENTS AND METHODS

This single-center, retrospective study was conducted at Giresun Maternity and Child Health Training and Research Hospital, Department of Pediatric Surgery between April 2024 and April 2025. Medical files of preterm infants who underwent inguinal hernia repair under awake caudal anesthesia were reviewed. A total of 15 preterm infants (10 males, 5 females; mean age: 10.60±3.90 weeks; range, 4 to 7 week) with a gestational age <37 weeks and a postconceptional age <46 weeks were included in the study. Written informed consent was obtained from the parents and/or legal guardians of the patients. The study protocol was approved by the Giresun Training and Research Hospital Ethics Committee (Date: 11.06.2025, No: 15). The study was conducted in accordance with the principles of the Declaration of Helsinki.

### Anesthesia management

All patients were evaluated during the preoperative period. In accordance with the recommendations of the American Society of Anesthesiologists (ASA), families were informed of a preoperative fasting period of 2 h for clear liquids, 4 h for breast milk, and 6 h for formula. Patients admitted to the operating room without premedication were provided with standard monitoring, including electrocardiography, peripheral oxygen saturation, and end-tidal carbon dioxide. Oxygen was administered via mask at a flow rate of 4 L/min.

For sedation, 0.01 mg/kg atropine, 0.05 mg/kg midazolam, 1 mg/kg ketamine, and 0.5 mcg/kg fentanyl were administered intravenously. In cases deemed necessary, an additional dose of 0.5 mg/kg ketamine was administered until adequate sedation was achieved. Once loss of consciousness was achieved, the level of sedation was considered adequate only in patients who could be awakened only by severe physical stimulation.

Patients were placed in the lateral position and the sacral region was prepared under aseptic conditions. The line connecting the bilateral posterior superior iliac points (Tuffier line) was considered the lower side of the triangle, then two sacral cornu were palpated and the sacral hiatus was felt as a depression between them. A 25 G Epican Paed (Braun, Melsungen, Germany) needle was inserted at a 45-degree angle into the caudal space and, upon contact with the posterior surface of the sacrum, the angle was narrowed and directed. After aspirating to exclude the presence of blood and CSF, 2.5 mg/kg of bupivacaine at a concentration of 0.25% was injected at a volume of 1 mL/kg. The sensory block level was assessed using a pinprick test and recorded at the T5-6 level. Motor block was achieved in the lower extremities. Approximately 20 min after the caudal injection, the surgical procedure was initiated, when no motor or sensory response was obtained from the patient (motor: no leg movement, sensory: no change in heart rate or blood pressure). Patients who successfully completed the surgery were monitored in the recovery unit and then transferred to the pediatric surgery ward. Intravenous paracetamol was administered at a dose of 10 mg/kg for postoperative analgesia.

### Data collection

Demographic data (sex, gestational age, postconceptional age, body weight, and type of surgery) were recorded for all patients. Hemodynamic parameters (pulse, $SpO_2$) were measured and recorded at 5, 10, 15, and 20 min before and after the caudal block; additionally, at 5, 10, 15, 20, and 30 min after the start of surgery. Additionally, surgical duration, first postoperative analgesia requirement, time to spontaneous micturition, and discharge times were also evaluated in our study.

### Statistical analysis

In this retrospective study, descriptive statistics were used to summarize the data. Continuous variables are presented as mean ± standard deviation, while categorical variables are shown as frequencies and percentages. Due to the small sample size, no inferential statistical analyses were performed.

 

**TABLE 1**
Patient demographic and clinical data (n=15)

| | n | Mean±SD |
|---|---|---|
| Sex<br>Male<br>Female | <br>10<br>5 | |
| Type of surgery;<br>Unilateral (F/M)<br>Bilateral (F/M) | <br>0/9<br>5/1 | |
| Week of birth | | 32.13±4.10 |
| Current age (w) | | 10.60±3.90 |
| Postconceptional age (w) | | 30.48±3.59 |
| Weight (grams) | | 4254±942.65 |
| Micturition time (min) | | 145.33±17.67 |
| First postoperative analgesia time (sec) | | 3.33±0.48 |
| Surgical duration (min) | | 29.4±6.37 |

SD: Standard deviation.

## RESULTS

The demographic and clinical characteristics of the 15 preterm infants included in the study are summarized in Table 1. Bilateral inguinal hernia repair was performed in all female infants, while 90% of male patients underwent unilateral surgery and 10% underwent bilateral surgery. The mean gestational age was 32.13±4.10 weeks, the mean post-conceptional age was 30.48±3.59 weeks, and the mean body weight was 4254±942.65 g.

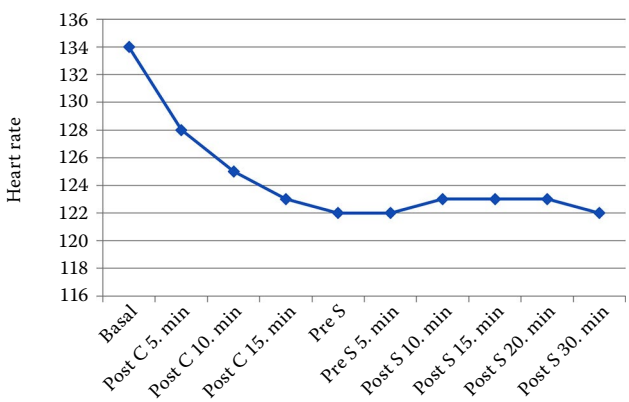


**Figure 1.** Graph showing mean heart rate at various times during the operation.

Post C: Post-caudal anesthesia; Pre S: Pre-surgery; Post S: Post-caudal anesthesia.

Following caudal block administration, successful sensory and motor block was achieved in all patients. The sensory block level was determined to be between T5 and T6 using the pinprick test. From the start of surgery, no motor response (leg movement) or hemodynamic response (change in heart rate or blood pressure) was observed in any patient.

Vital signs remained stable during the intraoperative period. Although heart rate showed a slight decrease compared to pre-caudal block values, it remained within physiological limits throughout the entire operation (Figure 1). The mean peripheral oxygen saturation ($SpO_2$) ranged between 98 and 100%, indicating no impairment in oxygenation.

No patient developed intraoperative apnea, bradycardia, or required general anesthesia. Furthermore, there was no respiratory depression, oxygen desaturation, or need for ventilatory support during the operation. After completion of the surgery, all patients were safely transferred to the recovery unit and then to the pediatric surgery ward with stable clinical findings.

No complications developed during the postoperative follow-up period. All patients achieved spontaneous micturition within the first 4 h. The mean spontaneous micturition time was 145.33±17.67 min. The mean time to postoperative

 

analgesia 3.33±0.48 h and was successfully managed with intravenous paracetamol. No temporary or permanent deficits in lower extremity motor function, urinary retention, respiratory depression, or other neurological complications were observed.

All patients were discharged on the first postoperative day with stable vital signs and full mobilization. The mean surgical duration was 29.4±6.37 min.

## DISCUSSION

One of the most serious complications in surgeries performed on preterm and postconceptional age <44 weeks infants is postoperative apnea.[7] Therefore, anesthetic practices in this patient group should be carefully planned, and methods which minimally affect the respiratory system should be preferred whenever possible. In our study, the intra- and postoperative safety of inguinal hernia repairs performed using awake caudal anesthesia in 15 preterm infants with a postconceptional age <46 weeks was evaluated.

Inguinal hernia is one of the most common congenital anomalies requiring surgery in preterm infants. While it occurs in 1 to 4.4% of term newborns, this rate rises to 30 to 40% in preterm infants, and the incidence increases further as birth weight decreases.[8,9] Similarly, in our study, bilateral hernias were detected in 40% of patients, and bilateral surgery was performed in all female infants. This finding is consistent with data in the literature indicating a higher rate of bilateral hernias in female infants.[9,10]

The development of postoperative apnea and bradycardia in preterm infants is common, particularly in surgeries performed under general anesthesia.[3] The main causes include central nervous system immaturity, weakness of the respiratory muscles, susceptibility to airway collapse, and metabolic imbalances. These physiological deficiencies can lead to reduced cerebral perfusion and potentially neurological damage.[3] The risk of apnea is inversely proportional to postconceptional age, and some studies recommend that this age be between 44 and 60 weeks for safe surgery.[7]

In our study, awake caudal anesthesia was administered to this high-risk group instead of general anesthesia, and no intraoperative or postoperative apnea, bradycardia, respiratory depression, or oxygen desaturation was observed in any patient. These findings are consistent with previous studies showing that regional anesthesia methods are a safer approach in preterm infants.[1,5,6]

In addition, recent studies have drawn attention to the neurotoxic effects of anesthetic agents. Exposure to anesthetics during early brain development has been shown to increase neuronal apoptosis, leading to long-term cognitive and behavioral disorders.[11-13] Therefore, regional anesthesia is more advantageous, particularly in infants during the critical period of neurodevelopment. In our study, a combination of low-dose ketamine and fentanyl was used for sedation, opting for a mild sedative level instead of deep sedation, thereby minimizing anesthetic exposure.

Although spinal anesthesia is an effective method for reducing the risk of postoperative apnea, caudal anesthesia is a more common and practical alternative due to technical difficulties and limited application time.[4,14] Caudal block stands out for its ease of application, high success rate, and effectiveness in postoperative pain control. In our study, technical success was achieved in all patients, and postoperative analgesia was effectively managed.

Although caudal anesthesia is considered a safe technique, some potential complications should be taken into account. One of these is local anesthetic systemic toxicity (LAST), which poses a higher risk in newborns due to low alpha-1 acid glycoprotein levels and immature liver enzyme systems.[15] Therefore, aspiration control should be performed prior to administration, and the dose should be carefully calculated. In our study, all these precautions were taken, and no toxicity developed in any patient.

In addition, caudal block may cause complications in the presence of certain congenital anomalies (e.g., tethered cord, sacral dysraphism). Careful neurological examination and, if necessary, advanced imaging are recommended for the early detection of such cases.[16] In our study, all patients underwent surgery under elective conditions and in a stable clinical condition, and no motor dysfunction or urinary retention was observed during postoperative follow-up.

 

The main limitations to this study include its single-center, retrospective design and the lack of a control group.

In conclusion, our study results demonstrate that the risk of anesthesia-related respiratory complications and neurological sequelae is quite low in preterm infants undergoing inguinal hernia repair with awake caudal anesthesia. When evaluated in conjunction with appropriate patient selection, careful application, and experienced teams, this approach stands out as a safe and effective alternative in preterm surgery.

**Data Sharing Statement:** The data that support the findings of this study are available from the corresponding author upon reasonable request.

**Author Contributions:** Study idea/concept, critical review, data collection and/or processing/materials: D.Y., M.D., A.Y.Ö.; Design and writing the article, references, literature review: D.Y., A.A.; Control/ supervision: D.Y., A.Y.Ö.

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