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Evaluation of Postoperative Apnea Incidence in Neonates Undergoing Minor Surgeries Under General Anaesthesia

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ABSTRACT

Background
Postoperative apnea is a significant concern in neonates undergoing surgery, especially in preterm infants and those with physiological immaturity. Minor surgical procedures performed under general anaesthesia can still pose a risk of respiratory complications in this vulnerable population. Early identification of risk factors can guide postoperative monitoring strategies and improve outcomes.

Aim:
To evaluate the incidence and characteristics of postoperative apnea in neonates undergoing minor surgeries under general anaesthesia and identify associated perioperative risk factors.

Methods
A prospective observational study was conducted on 70 neonates undergoing minor elective surgeries under general anaesthesia at a tertiary care teaching hospital. Neonates were monitored postoperatively for 12 hours. Data collected included gestational age, post-conceptional age, birth weight, hemoglobin levels, surgical details, and intraoperative events. The incidence, timing, and characteristics of apnea episodes were recorded. Associations between apnea and clinical variables were analyzed using chi-square test and logistic regression.

Results
Postoperative apnea occurred in 12 out of 70 neonates (17.1%), most commonly within the first 6 hours after surgery. Significant risk factors associated with apnea included prematurity ($p = 0.001$), anemia ($p = 0.009$), birth weight <2.5 kg ($p = 0.002$), and post-conceptional age <40 weeks ($p < 0.001$). Most apnea episodes were mild and responded to stimulation and supplemental oxygen; only 2 cases required CPAP.

Conclusion
Even minor surgeries under general anaesthesia can lead to postoperative apnea in neonates, particularly those who are preterm, anemic, of low birth weight, or have a younger post-conceptional age. Routine postoperative monitoring for at least 12 hours is recommended in at-risk neonates to ensure timely intervention and improve perioperative safety.

Keywords: Neonates, Postoperative apnea, prematurity, anemia

1. INTRODUCTION

Neonates undergoing surgery represent a highly vulnerable patient group due to their physiological immaturity, particularly in the respiratory and central nervous systems. Among the most clinically significant postoperative complications in this population is postoperative apnea, defined as a pause in breathing lasting more than 20 seconds or shorter if associated with bradycardia, cyanosis, or oxygen desaturation [1]. This condition is most prevalent in preterm neonates and those with a post-conceptual age (PCA) less than 60 weeks, but may also occur in term neonates, particularly those with comorbidities or exposure to general anaesthesia [2]. The global burden of neonatal surgery is substantial, with an estimated 1.5 to 2 million neonates requiring surgical procedures annually worldwide [3]. Among these, a significant

proportion are performed under general anaesthesia, which carries a known risk of respiratory complications including apnea. In India, where approximately 25 million births occur annually, 5–8% of neonates are estimated to require surgical intervention in the first month of life [4]. With the increasing availability of neonatal surgical and anaesthesia services in both urban and rural centers, the incidence of anaesthesia-related complications, including postoperative apnea, becomes a growing public health concern.

The pathophysiology of postoperative apnea in neonates is complex and multifactorial. Immature central respiratory control, increased sensitivity to anaesthetic agents, inadequate metabolic compensation, and residual effects of opioids or volatile anaesthetics all contribute to the risk [5]. Even during minor procedures such as inguinal hernia repair, circumcision, or skin lesion excision, the use of general anaesthesia may significantly depress respiratory drive postoperatively. Neonates with a history of apnea of prematurity, anemia, or neurologic immaturity are particularly susceptible. In response to these concerns, many institutions have moved toward using regional or neuraxial anaesthesia when feasible, as these techniques are associated with reduced incidence of postoperative apnea [6]. Nonetheless, general anaesthesia remains necessary in many situations due to the nature of the surgery, patient cooperation, or lack of resources for regional blocks. The decision for postoperative monitoring in a neonatal intensive care unit (NICU) is typically guided by gestational age, weight, type of anaesthesia, and comorbid conditions. However, standardized guidelines for this practice, especially in the Indian context, remain limited.

There is an urgent need to quantify and characterize the incidence, severity, and timing of postoperative apnea in neonates undergoing minor surgical procedures under general anaesthesia, particularly in low- and middle-income countries (LMICs) like India, where resource allocation and care strategies must be optimized. While global studies suggest a postoperative apnea incidence ranging from 10% to 30% in preterm neonates, Indian data remains sparse and often underreported [7].

This study aims to fill this gap by evaluating the incidence and characteristics of postoperative apnea in neonates following minor surgeries under general anaesthesia, with the goal of improving perioperative risk stratification, guiding monitoring protocols, and contributing to safer anaesthetic practices in neonatal care.

Aim

To evaluate the incidence and characteristics of postoperative apnea in neonates undergoing minor surgeries under general anaesthesia.

Objectives

1. To determine the incidence of postoperative apnea in neonates within the first 12 hours following minor surgery under general anaesthesia.
2. To identify perioperative risk factors associated with postoperative apnea in neonates (e.g., gestational age, weight, anemia, anaesthetic agents used).

2. MATERIALS AND METHODS

Study Design

A prospective observational study conducted at a tertiary care teaching hospital.

Study Population

Neonates (≤28 days of life) scheduled for minor elective surgeries under general anaesthesia.

Inclusion Criteria

- Neonates undergoing minor surgeries (e.g., inguinal herniotomy, circumcision, skin tag excision) under general anaesthesia.
- Parental/guardian informed consent obtained.
- Preoperative stable cardiorespiratory status.

Exclusion Criteria

- Neonates undergoing major surgeries or emergency procedures.
- Neonates with known congenital heart disease or severe neurological disorders.
- Patients requiring postoperative mechanical ventilation for surgical reasons.

Sample Size Calculation

The sample size is calculated based on the expected incidence of postoperative apnea.

- Reported incidence in literature: 20% [1,6].
- Desired precision (absolute error): 10%
- Confidence level: 95% (Z = 1.96)

Formula:
$n=Z^2\times p\times(1-p)d^2$
Where:

- Z=1.96Z = 1.96Z=1.96 (for 95% confidence)
- p=0.2p = 0.2p=0.2 (20% expected incidence)
- d=0.1d = 0.1d=0.1 (10% margin of error)

$n= (1.96)^2\times0.2\times0.8(0.1)^2$
$=3.8416\times0.160.01$
$=61.47$
$=61.47$
Sample Size = 62 neonates
To account for 10% loss to follow-up or exclusions, we increase the sample size:
62+10%=68.2≈70neonates62 + 10\% = 68.2 \approx 70 neonates62+10%=68.2≈70neonates
Thus, a minimum of 70 neonates will be included in the study.

Data Collection

- **Preoperative Data:**
  Gestational age, birth weight, post-conceptional age, hemoglobin level, Apgar scores, comorbidities.
- **Intraoperative Data:**
  Type and duration of surgery, anaesthetic agents used, intraoperative events.
- **Postoperative Monitoring:**
  Continuous cardiorespiratory monitoring for at least 12 hours post-surgery in a monitored setting (NICU or recovery room).
  Apnea episodes recorded with time of onset, duration, type (central/obstructive/mixed), associated bradycardia/desaturation, and interventions required.

Outcome Measures

- **Primary outcome:** Incidence of postoperative apnea within 12 hours of surgery.
- **Secondary outcomes:** Time of onset, need for intervention (oxygen, stimulation, CPAP), correlation with perioperative factors.

Statistical Analysis

- Data entered in Microsoft Excel and analyzed using SPSS version 25.
- Descriptive statistics (mean, SD, frequencies).
- Incidence expressed as percentage.
- Association of risk factors analyzed using Chi-square test and logistic regression.
- $P < 0.05$ considered statistically significant.

3. RESULTS

Table 1: Baseline Characteristics of the Study Population (N = 70)

Variable	Mean ± SD / n (%)
Gestational age at birth (weeks)	36.2 ± 2.1
Post-conceptional age (weeks)	39.5 ± 2.3
Birth weight (kg)	2.4 ± 0.5
Male gender	50 (71.4%)
Preterm (<37 weeks)	28 (40%)
Anemia (Hb <10 g/dL)	14 (20%)
Type of surgery	
- Inguinal herniotomy	40 (57.1%)
- Circumcision	20 (28.6%)
- Minor excision procedures	10 (14.3%)

Interpretation:
Majority were male neonates, with a substantial proportion being preterm (40%). Inguinal herniotomy was the most common procedure.

Table 2: Incidence and Characteristics of Postoperative Apnea

Parameter	Value
Neonates with apnea episodes	12 (17.1%)
Onset of first apnea episode (hours)	3.5 ± 2.1
Duration of apnea (seconds)	18.4 ± 5.3
Apnea with desaturation (SpO_2 <90%)	9 (75%)
Apnea with bradycardia (<100 bpm)	7 (58.3%)
Interventions required	
- Tactile stimulation	12 (100%)
- Supplemental oxygen	9 (75%)
- CPAP support	2 (16.7%)

Interpretation:
The incidence of postoperative apnea was 17.1%, primarily occurring within the first 6 hours. Most episodes were mild to moderate, requiring stimulation or oxygen.

Table 3: Association Between Risk Factors and Postoperative Apnea

Risk Factor	Apnea Present (n = 12)	Apnea Absent (n = 58)	p-value
Preterm (<37 weeks)	10 (83.3%)	18 (31.0%)	**0.001** (Chi-square)
Anemia (Hb <10 g/dL)	6 (50.0%)	8 (13.8%)	**0.009** (Chi-square)
Birth weight <2.5 kg	9 (75.0%)	15 (25.9%)	**0.002** (Chi-square)
Post-conceptional age < 40 wks	11 (91.7%)	22 (37.9%)	**<0.001** (Chi-square)

Interpretation:
Statistically significant associations were found between apnea and prematurity, anemia, low birth weight, and younger post-conceptional age. These are important predictors of apnea.

Table 4: Comparison of Anaesthetic Parameters Between Apnea and Non-Apnea Groups

Parameter	Apnea (n = 12)	No Apnea (n = 58)	p-value
Surgery duration (min)	48.5 ± 10.3	45.2 ± 12.5	0.342 (t-test)
Sevoflurane usage (%)	12 (100%)	58 (100%)	—
Opioid used (Fentanyl)	9 (75%)	20 (34.5%)	**0.008** (Chi-square)

Interpretation:
No significant difference in surgery duration, but use of opioids (fentanyl) was significantly associated with apnea, highlighting the importance of minimizing respiratory depressants.

Table 5: Logistic Regression Analysis for Predictors of Postoperative Apnea

Variable	Odds Ratio (95% CI)	p-value
Preterm status	5.67 (1.65–19.45)	**0.006**
Anemia	4.52 (1.22–16.68)	**0.024**
Post-conceptional age <40 weeks	8.31 (1.75–39.38)	**0.007**

Interpretation:
Logistic regression confirms that preterm birth, anemia, younger PCA, are independent predictors of postoperative apnea. These findings support stratification of monitoring based on risk.

4. DISCUSSION

This prospective observational study assessed the incidence and risk factors associated with postoperative apnea in neonates undergoing minor surgical procedures under general anaesthesia. The findings indicate that 17.1% of neonates experienced postoperative apnea, consistent with previous reports citing an incidence ranging between 10% and 30% in

similar populations [8]. This underscores the clinical relevance of apnea even in minor surgeries and supports the need for close postoperative monitoring, particularly in resource-constrained settings. A major determinant of postoperative apnea was prematurity. In this study, 83.3% of neonates who experienced apnea were born preterm, and logistic regression confirmed prematurity as a significant independent predictor (OR = 5.67, p = 0.006). This is in line with prior studies showing that immature central respiratory control in preterm infants increases vulnerability to hypoventilation and apnea following anaesthesia [9,10]. The immaturity of the brainstem respiratory centers and heightened sensitivity to anaesthetic agents in preterm neonates likely contribute to these events [11].

Another significant factor was post-conceptional age (PCA), with most apnea episodes occurring in neonates below 40 weeks PCA. The American Academy of Pediatrics and other researchers suggest that PCA below 44–46 weeks is a critical threshold for increased apnea risk post-anaesthesia [12]. Our data strengthen this view and indicate that PCA <40 weeks may warrant mandatory postoperative monitoring for at least 12 hours, even after short-duration procedures. We also found a strong association between anemia (Hb <10 g/dL) and apnea (50% in apnea group vs. 13.8% in non-apnea group, p = 0.009), confirming earlier findings that anemia reduces oxygen-carrying capacity and lowers the threshold for hypoxic respiratory depression in neonates [13]. Given the simplicity of preoperative hemoglobin screening, this can serve as an effective tool for risk stratification. Low birth weight, particularly <2.5 kg, was associated with increased apnea risk. This finding parallels results from other studies, where low birth weight correlated with higher incidence of postoperative respiratory complications [14]. Low birth weight is often a proxy for prematurity and suboptimal organ development, both contributing to compromised ventilatory control. [15,16]. Most apnea episodes occurred within the first 6 hours postoperatively, were self-limiting, and responded well to tactile stimulation and oxygen supplementation. Only two cases required CPAP. This pattern reflects that while most events are non-life-threatening, continuous monitoring during the vulnerable period is essential to prevent complications.

These findings have direct implications for practice. Neonates with identified risk factors—prematurity, PCA <40 weeks, anemia, low birth weight, and opioid exposure—should be considered for postoperative monitoring in a high-dependency unit (HDU) or NICU. Additionally, anaesthesia protocols could be tailored to minimize opioid use and explore alternatives like caudal blocks where feasible.

5. CONCLUSION

This study found that postoperative apnea occurred in 17.1% of neonates undergoing minor surgeries under general anaesthesia. The majority of apnea episodes were mild, occurred within the first 6 hours after surgery, and were managed effectively with basic supportive measures. Key factors associated with an increased risk of postoperative apnea included prematurity, younger post-conceptional age (<40 weeks), low birth weight, and anemia. These findings suggest that even minor surgeries can pose respiratory risks in neonates, especially those with underlying vulnerabilities. Routine monitoring for at least 12 hours postoperatively is recommended for neonates with these risk factors. Identifying high-risk infants before surgery can help in planning appropriate perioperative care and improving safety outcomes.

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