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Review

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An approach to identify high-risk neonatal surgical cases to optimize postoperative results

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ABSTRACT

Postoperative recovery in pediatric surgery can vary greatly, even among patients with identical anomalies. While some cases meet expectations, others may result in disappointing outcomes. To underscore the importance of identifying high-risk surgical neonates early and understanding the critical factors influencing postoperative results, a thorough literature review was undertaken to pinpoint the key elements contributing to poor outcomes in surgical neonates. It is important to recognize that each surgical neonate requires a unique approach to management, influenced by factors such as family background, preoperative condition, and the involvement of a multidisciplinary team. The elevated mortality rates observed in emergencies can be attributed to various factors, including delays in hospital arrival, the timing of surgical intervention, and the operating surgeon's level of expertise. Ultimately, the early identification of high-risk surgical neonates is essential for improving clinical outcomes. A comprehensive strategy that incorporates individualized management and fosters collaboration among multidisciplinary teams is crucial for achieving the best possible postoperative recovery.

Keywords: Determinants, emergencies, mortality, patient care, postoperative care, surgical neonates

INTRODUCTION

A surgical neonate is defined as a child who is either (i) born at >37 weeks of gestation (term neonate) and younger than 29 days at the time of surgery or (ii) born at <37 weeks of gestation (preterm neonate) and younger than 50 weeks postconception at the time of surgery.[1] The World Health Organization estimates that approximately 240.000 newborns die annually within the first 28 days of life because of congenital disorders, with 90% of affected children residing in low- and middle-income countries.[2] In developed nations, the primary contributors to mortality among surgical neonates include irreparable abnormalities of the heart, lungs, kidneys, and central nervous system; metabolic disorders; extreme prematurity; and low birth weight.[3]

Despite advances in neonatal surgery, high-risk surgical neonates continue to experience significant morbidity and mortality. Several critical gaps in knowledge must be addressed to improve clinical outcomes. First, standardized criteria are needed to identify high-risk surgical neonates, because the current lack of standardization hinders timely intervention and effective management. Second, the optimal timing of surgery for different surgical conditions in neonates remains unclear, highlighting the need for further research in this area. Third, the effectiveness of multidisciplinary team approaches in improving outcomes in high-risk surgical neonates requires further investigation. Furthermore, studies on the role of prenatal factors, such as maternal health and fetal monitoring, in predicting postoperative outcomes in surgical neonates are limited. Moreover, there is a significant knowledge gap in low- and middle-income countries, where the challenges and opportunities for improving outcomes in high-risk surgical neonates are unclear. Other critical knowledge gaps include the impact of hospital volume and surgeon experience on outcomes and the potential benefits and challenges of using technology, such as telemedicine, to improve outcomes for high-risk surgical neonates.

Although the overall infant mortality rate has decreased over time, birth defects, which affect an estimated 3–5% of pregnancies, continue to be the leading cause of infant mortality in the United States.[4] Nearly 10% of all neonatal fatalities are attributed to congenital malformations that necessitate surgical intervention.[5] Survival rates vary according to the type of defect, owing to differences in functional impact and organ systems involved. Reported neonatal surgical mortality rates exhibit geographical

disparities, with figures of 4% in the United States, 6–7% in Japan, 35–45% in India, 52.7% in Uganda, and 62.2% in Nigeria.[1,6-9] The margin of error in neonatal surgery is very low, as evidenced by a significant global variation in neonatal surgical mortality rates, which range between 4% and 80%.[10] This highlights the need for early recognition of high-risk surgical neonates to improve clinical outcomes. Furthermore, studies have shown that delayed recognition of high-risk neonates can lead to increased morbidity and mortality.[11] Therefore, it is essential to identify high-risk surgical neonates early to provide timely and appropriate interventions. Developing predictive models and scoring systems can aid in the early recognition of high-risk surgical neonates. However, further studies are required to improve the accuracy and reliability of these models (**Table 1**).

Table 1. Knowledge gaps

1. Lack of standardized criteria for identifying high-risk surgical neonates.
2. Limited understanding of the impact of surgical timing on outcomes.
3. Insufficient data on the effectiveness of multidisciplinary team approaches.
4. Limited studies on the role of prenatal factors in predicting postoperative outcomes.
5. Knowledge gap in low- and middle-income countries.
6. Limited understanding of the impact of hospital volume and surgeon experience on outcomes.
7. Insufficient data on the role of technology such as telemedicine in improving outcomes.

REVIEW

Familial Factors

Familial factors, particularly those associated with socioeconomic conditions, have been correlated with reduced access to pediatric subspecialty care and increased early mortality rates among neonates with low birth weight.[12] These factors include the family's overall literacy, economic status, preference for institutional or home deliveries, planned or unplanned pregnancies, consanguineous marriages, hereditary diseases, and maternal age. Family assessments can provide valuable insights into these factors. Families with low literacy levels and limited socioeconomic resources may lack awareness of critical health issues, including family planning, personal hygiene, the advantages of planned pregnancies, dietary adjustments during pregnancy, and the importance of regular antenatal visits. Consequently, surgical neonates from these families have lower survival rates.[13-18] One review indicated that maternal alcohol consumption is associated with an increased risk of conditions such as d-transposition of the great arteries, neural tube defects, and multiple cleft palates in infants.[19] Additionally, maternal smoking, whether before or during pregnancy, significantly increases the risk of various congenital anomalies, even with minimal exposure to 1–5 cigarettes daily.[20] Congenital anomalies linked to chromosomal defects may be more prevalent in populations where women have children after the age of 35 years and in pregnancies resulting from consanguineous unions.[21,22] Furthermore, studies have shown that maternal nutrition and micronutrient deficiencies can affect fetal development and increase the risk of congenital anomalies.[23,24] Additionally, exposure to environmental pollutants and toxins during pregnancy is associated with an increased risk of birth defects.[25,26] High-risk pregnancies and a lack of awareness of health and health policies can transform a normal newborn into a high-risk one. Therefore, the fundamentals of health and awareness should be extended to remote populations. This effort can yield some success in decreasing infant mortality in the neonatal period due to surgery for anatomical defects by facilitating either early arrival at a well-equipped center or planned delivery at a tertiary care center.

Administrative Factors

Multiple factors beyond familial considerations, including early diagnosis, prompt initiation of supportive treatment, and an effective referral policy, can contribute to successful outcomes. A robust referral system is a vital element of the healthcare framework and is essential for enhancing outcomes for mothers and newborns during childbirth.[27] Reducing maternal and neonatal mortality and morbidity rates can be achieved through prompt recognition of conditions requiring specialized treatment, which may not be available at every medical facility, coupled with an effective referral process.[28,29] **Table 2** classifies patients according to their referral urgency, while **Figure 1** outlines the suggested surgical referral protocol for critically ill newborns in need of surgical intervention.

Table 2. Category of referral with examples

1. Acute surgical referrals	Postnatally diagnosed congenital malformations like Oesophageal atresia +/- trachea-oesophageal fistula-congenital diaphragmatic hernia Suspected Hirschsprung's disease Anorectal malformations Abdominal wall defects (gastroschisis and exomphalos) sacrococcygeal teratoma Gross abdominal distension and/or bowel obstruction including duodenal, jejunoileal and colonic atresia; meconium ileus and malrotation+/- volvulus Bowel perforation associated with necrotising enterocolitis or spontaneous intestinal perforation Other visceral injury/perforation (oesophageal/gastric) Severe NEC unresponsive to medical management Testicular torsion Incarcerated inguinal hernia Emergency requirement for surgical central venous access Swallowed foreign body Pneumothorax/empyema
2. Elective surgical referrals	Inguinal hernia repair Stoma closure Removal of a tunnelled central venous catheter Vascular malformation in stable patients Tumors in stable patients Congenital hypertrophic pyloric stenosis Ruptured meningo-myelocoele Rachischisis Biliary atresia Choledochal malformation and other surgical cholestatic conditions Abscesses Posterior urethral valves/ ureteropelvic junction obstruction Bladder exstrophy
3. Outpatient transfers	Undescended testes Umbilical granuloma Ranula Haemangioma/lymphangioma Cleft lip/palate Hydrocephalus Other neural tube defects Hydrocephalus Pectus excavatum Umbilical hernia

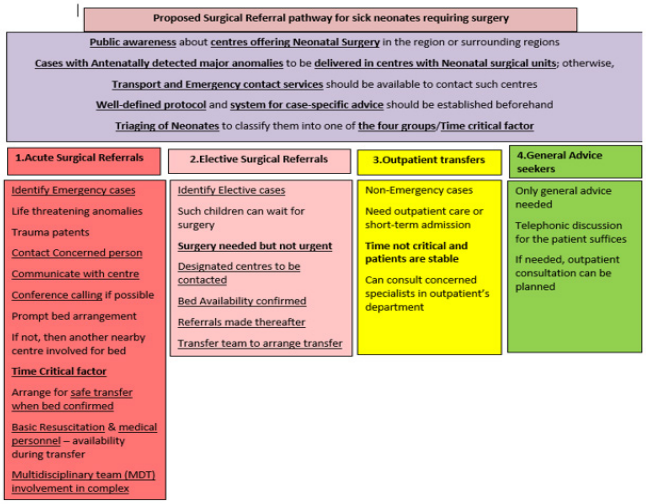

Figure 1. Proposed surgical referral pathway for sick neonates requiring surgery

The prognosis of surgical neonates may be adversely affected by uncoordinated arrival at tertiary care centers. Infants with congenital anomalies require continuous monitoring and multiple surgical procedures. The transportation of surgical neonates presents a considerable challenge that can influence their survival rates. Insufficient transportation resources can result in treatment delays, increasing the risk of morbidity and mortality.[30] Furthermore, families may face significant financial burdens that affect their economic well-being and morale. In low-income nations lacking comprehensive government health policies, delays in pursuing surgical interventions or the decision to forgo surgery can result in unfavourable outcomes. A comprehensive policy package for managing small and sick newborns underscores the importance of specialized care policies during the antepartum and immediate postpartum periods to ensure neonatal survival.[31] Studies have shown that the availability of pediatric surgical services, including emergency surgical care, can significantly affect neonatal mortality rates.[32-35] The development of pediatric surgery as a speciality has been associated with improved outcomes in neonates requiring surgery.[36] Moreover, the implementation of quality improvement initiatives, such as the American College of Surgeons National Surgical Quality Improvement Program Pediatric, can help reduce morbidity and mortality rates in surgical neonates.[37]

Patient-Related Factors

Patient-related factors were term or preterm delivery, single or twin pregnancy, birth weight, isolated anomalies or syndromic associations, timing and location of diagnosis, and general condition of the neonate at diagnosis.

Successful postoperative recovery of surgical neonates primarily depends on patient-specific factors, with other previously mentioned factors aiding in thorough assessment and preparation for surgery. Neonatal surgery requires a profound understanding of neonatal physiology/anatomy, advanced surgical expertise, and comprehensive neonatal care before and after the operation.[38] A preliminary study by Puri et al.[39] in 2019 highlighted numerous variables that must be considered when dealing with surgical neonates, including preoperative, intraoperative, and postoperative variables. Based on these variables, a severity score was generated (normal values were allocated a score of 0, and a score of 1 or 2 was allocated values moving towards abnormal) to categorize the surgical neonate as low-, moderate-, or high-risk. These variables include 20 parameters, as summarized in **Table 3**.

Table 3. Numerical grading of preoperative, intraoperative and postoperative variables

Grade	0	1	2
Preoperative variables			
Admission weight (kg)	≥3	2-3	≤2
Place of delivery (level)	III	II or III	Home
Gestational age (weeks)	≥36	32-36	≤32
Delay in seeking treatment (h)	<24	24-48	>48
Associated anomalies	None	Minor	Major
Illness severity score (ISS)	0-4	5-8	9-12
Temperature (°C)	34-36	32-34	<32
Heart rate (per minute)	140-160	160-180	<100 or >180
Respiratory rate (per minute)	30-40	40-60	>60
Urine output (mL/kg/h)	≥2	1-2	<1
Platelet counts (cells/μL)	>100.000	60.000-100.000	<60.000
Blood pH	7.3-7.45	7.2-7.3	<7.2
Intraoperative variables			
Site of surgery	Superficial	Intraabdominal	Intrathoracic
Duration of surgery (min)	<60	60-120	>120
Amount of blood loss (% blood volume)	<5	5-10	10-15
Temperature after surgery (°C)	34-36	32-34	<32
Postoperative variables			
Extubation after surgery (h)	On table	<24	≥24, reintubation
Need for vasopressor	No	D1 or D2*	D1+D2±A**
Infection	Nil	Local	Systemic
Complications	Nil	Minor	Major#
Time till resuming enteral feeding (days)	<7	7-14	>14

D1: Dopamine, D2: Dobutamine, *Dose of D1 or D2-@5 mcg/kg/min, A: Adreline (dose of 0.05-0.3 mcg/kg/min), ** Dose of D1 and D2 @ >10 mcg/kg/min, # major: Complication requiring reoperations

In their study, numerically graded scores were assigned to preoperative (0–12), intraoperative (0–8), and postoperative variables (0–10).

However, the study highlighted that preoperative variables did not significantly affect the postoperative outcome; however, intraoperative and postoperative variables were major determinants of survival.

Newborns born prematurely have an increased risk of developing sepsis before surgery, as reported by Mpody et al.[40] They highlighted the synergistic effects of sepsis and premature birth on postoperative neonatal mortality. Additionally, they found that premature newborns with preoperative sepsis have a significantly higher risk of death and complications after surgery. Hasan et al.[41] investigated neonatal surgical morbidity and mortality in a tertiary

center in low-and middle-income countries. They found that emergency surgery was a major cause of death in newborns, with approximately 67.6% of newborns who died after surgery having undergone emergency operations. Numerous other factors, such as the surgeon's and anesthetist's experience, timing of surgery (same-day vs. delayed), and timely involvement of a multidisciplinary team are also significant determinants of satisfactory postoperative outcomes, in addition to those listed by Puri et al.[39] Surgical stress to the neonate undergoing surgery varies considerably with the type of surgery, its duration, whether performed by open or minimally invasive techniques, whether done in an emergency or electively, whether adequate anaesthesia and pain control was taken care of and related to various patient-related factors like age, body weight, overall health, and psychological state. The more complex the surgery, the more profound its stress level. For example, while major cardiac surgery alters physiology due to its complexity, major abdominal surgery with prolonged exposure of the bowel leads to dehydration and fluid imbalances which need to be taken care of. An open abdominal/thoracic surgery is more stressful compared to the same surgery performed via laparoscopy or thoracoscopy. Similarly, elective surgeries done in stable and optimized neonates lead to less surgical stress compared to emergency surgeries in sick children. The longer the duration of surgery, the more stress it induces.

According to the 2020 Consensus guidelines for perioperative care in neonatal intestinal surgery: enhanced recovery after surgery society recommendations, a standardized perioperative team communication system with a structured process and protocol can lower the risk of negative patient outcomes, ensure continuity of care, and enhance communication among staff.[43]

Caring for a newborn undergoing surgery is always a team effort that includes neonatal surgeons, neonatologists, and neonatal anesthesiologists. By working together, a team can provide a higher level of care, thereby improving the overall survival rate. **Figure 2** provides a comprehensive overview of the factors to consider when managing a surgical neonate in an emergency setting. This enables the identification of high-risk cases, thereby facilitating the implementation of preventive measures to avert complications.

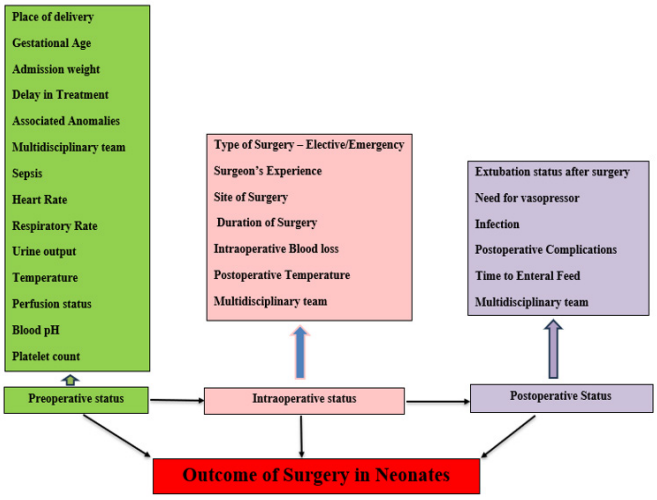

Figure 2. How to approach a surgical neonate

CONCLUSION

Timely evaluation and intervention are crucial for improving postoperative outcomes in neonates undergoing surgery. The high mortality rate in emergency cases can be attributed to various factors, including delayed hospital arrival, surgical timing, and expertise of the operating surgeon and anaesthetist. A comprehensive approach that considers the unique needs of each premature newborn is essential for achieving favourable postoperative outcomes. The growing focus on reducing infant mortality rates worldwide underscores the importance of addressing the mortality rates of surgical neonates. Early identification of high-risk surgical neonates, particularly those with multiple congenital anomalies and other risk factors, is critical for improving their chances of survival. A multidisciplinary approach incorporating the expertise of neonatologists, pediatric surgeons, and anesthesiologists is essential for providing specialized care to these vulnerable patients.

Future Scope

Future studies should focus on developing and implementing effective strategies for the early identification and management of high-risk surgical neonates. This may include the development of predictive models and scoring systems to identify neonates with the highest risk of poor outcomes. Additionally, studies examining the impact of standardized care protocols and multidisciplinary team approaches on the outcomes of neonates undergoing surgery are warranted. Furthermore, efforts to improve access to specialized care for surgical neonates in low- and middle-income countries are critical for reducing global disparities in infant mortality rates.

ETHICAL DECLARATIONS

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

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Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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