

## REVIEW ARTICLE

# Surgery Timing and Pre-Incision Antibiotic Prophylaxis in Emergency Cesarean Deliveries: Current Evidence and Gaps from India and Beyond

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### ABSTRACT

*Emergency cesarean deliveries (ECD) are crucial; however, they entail increased risks of maternal morbidity and negative neonatal outcomes when compared to elective procedures. Two adjustable factors—surgery timing, frequently assessed by the decision-to-delivery interval (DDI), and pre-incision antibiotic prophylaxis—are vital for enhancing outcomes. This mini-review consolidates existing evidence regarding the impact of surgical timing and the administration of prophylactic antibiotics in ECDs, focusing particularly on the Indian context and the existing research deficiencies. A review of pertinent peer-reviewed literature from 2020 to 2025, indexed in PubMed, Web of Science, and Scopus, was conducted, concentrating on maternal and neonatal outcomes linked to DDI, the timing of surgeries during day versus night shifts, and the practices surrounding pre-incision antibiotic administration. Data from Indian cohorts were given precedence to emphasise evidence specific to the region. Global data indicate that night-time surgeries and delayed antibiotics increase the risk of surgical site infection, postpartum morbidity, low Apgar scores, and NICU admissions. Indian studies reveal frequent breaches in recommended DDI and prophylaxis timing but lack integrated analyses of both factors, limiting region-specific insights. Enhancing compliance with established guidelines, minimising surgical delays, and tackling staffing challenges are essential. Our current academic initiative seeks to bridge these evidence gaps by prospectively assessing the timing of surgeries and prophylactic measures concurrently within Indian ECD cohorts to inform policy and practice.*

**Keywords:** Emergency cesarean delivery; surgery timing; decision-to-delivery interval; antibiotic prophylaxis; maternal morbidity; neonatal outcomes; India; surgical site infection; antimicrobial stewardship.

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### INTRODUCTION

Globally, the rates of caesarean section (CS) have experienced a significant increase over the last decade [1], and India is no exception to this trend. Comprehensive national surveys indicate that although the World Health Organisation advocates for CS rates between 10-15%, numerous regions in India, particularly in urban and private healthcare settings, report considerably elevated figures. This situation raises serious concerns regarding the potential overuse of CS and its implications for both maternal and neonatal health outcomes [2]. In this regard, emergency caesarean deliveries (ECD) take on a critical role: while they are essential for saving lives in urgent circumstances, they also present greater risks of maternal infections, neonatal complications, and less favourable outcomes when compared to elective CS.

Key risk factors intensify these risks. One such factor is the timing of surgery, which is frequently assessed by the decision-to-delivery interval (DDI). Research conducted in India consistently indicates that the recommended DDIs (for instance, less than 30 minutes for Category-1 emergencies) are met in only a small percentage of cases; prolonged DDIs are associated with poorer fetal outcomes, including lower Apgar scores and a higher rate of NICU admissions [3, 4]. Another often overlooked factor is the timing of prophylactic antibiotic administration in relation to the skin incision. In Indian healthcare settings, compliance with guidelines (administering antibiotics within 30 to 60 minutes before skin incision) is inconsistent; improper timing constitutes a considerable risk factor for surgical site infection (SSI) [5, 6].

Despite the strong evidence, significant gaps persist. Few investigations specifically address night-time emergency cesarean sections, during which staff levels, fatigue, or limitations in resources may exacerbate delays in surgical procedures or the administration of antibiotics [7, 8]. Furthermore, comparative data contrasting Indian practices with standards based on Western guidelines regarding both the timing of DDI and antibiotics in the context of emergency cesarean deliveries is limited. Therefore, this review seeks to consolidate existing evidence concerning the timing of surgical interventions and the use of antibiotic prophylaxis in emergency cesarean deliveries, with particular emphasis on the situation in India and the prevailing research gaps.

### **SURGERY TIMINGS AND MATERNAL/NEONATAL OUTCOMES**

Research conducted in affluent nations suggests that emergency cesarean sections carried out during non-standard hours (such as night or evening shifts) correlate with heightened maternal morbidity and suboptimal neonatal results. A comprehensive population-based investigation in Canada and the United States (MDPI) revealed that births occurring at night (including both weekdays and weekends) exhibited a markedly increased risk of severe maternal morbidity (SMM) when compared to deliveries conducted during regular daytime hours (adjusted relative risk approximately 1.4) [7]. In Japan, an examination of perinatal databases uncovered that emergency cesarean sections performed during the night exhibited a 2.3-fold higher likelihood of negative outcomes such as cerebral palsy. This increased risk may be attributed to factors such as inadequate fetal monitoring, diminished oversight from experienced personnel, and fatigue among the staff [9].

Additionally, another retrospective analysis indicated that unscheduled cesarean deliveries at night correlated with prolonged operative durations and heightened maternal morbidity. Conversely, the data on neonatal morbidity, including indicators like Apgar scores and the need for NICU admission, did not reveal as consistent an elevation [10].

In India, there is a scarcity of studies that have specifically assessed the outcomes of emergency cesarean sections (CS) conducted at night compared to those performed during the day. Nevertheless, multiple investigations into the decision-to-delivery interval (DDI) indicate that an extended DDI is linked to poorer maternal and neonatal outcomes. A cohort study conducted in Bhilai, Chhattisgarh, revealed that a prolonged DDI was associated with increased incidences of postpartum hemorrhage, postoperative fever, and the necessity for blood transfusions; furthermore, neonatal outcomes deteriorated, evidenced by lower Apgar scores at both 1 and 5 minutes, as well as elevated rates of NICU admissions when DDI intervals were longer (Category I versus Category II) and when the time taken for delivery decisions surpassed approximately 50 minutes [3]. In another investigation, merely around 30% of emergency cesarean sections in India met the <30-minute DDI benchmark for category I; not achieving this standard was linked to an increase in stillbirths, lower 5-minute Apgar scores, and a higher number of NICU admissions, particularly when the DDI surpassed 60 minutes [11].

Notwithstanding this, there are limited Indian studies that differentiate between day and night for emergency cesarean sections, which complicates the ability to determine the impact of nighttime staffing or resource limitations. The existing evidence indicates that postponing surgical procedures, whether due to extended decision-to-incision intervals or surgeries conducted during night shifts, heightens risks for both the mother (such as surgical site infections, haemorrhage, the need for transfusions, and increased operative complications) and the neonate (including low Apgar scores and admissions to the neonatal intensive care unit).

### **ANTIBIOTIC PROPHYLAXIS IN CESAREAN DELIVERIES**

Antibiotic prophylaxis continues to be a fundamental aspect of preventing infections in cesarean deliveries. Global guidelines, such as those from the World Health Organisation, the American College of Obstetricians and Gynaecologists, and the U.S. Centres for Disease Control, consistently advocate for the administration of a single dose of prophylactic antibiotics within 30 to 60 minutes before the skin incision

[12-14]. Research indicates that postponing the administration of treatment, especially when it occurs after cord clamping or after incision, almost doubles the likelihood of surgical site infection (SSI) and markedly elevates maternal morbidity, length of hospital stay, and healthcare expenses [15].

Global adherence to pre-incision prophylaxis is currently moderate, with numerous high-income regions indicating compliance rates between 70% and 80%. Conversely, research conducted in India reveals significant deficiencies. Prospective studies from Medchal and Central India indicate elevated instances of delayed or improper timing in prophylaxis administration, even with universal access to these preventive measures, and illustrate an increased incidence of surgical site infections (SSI) when antibiotics are not given within the advised timeframe [5,6].

Variations in practice, such as prolonged multi-dose treatment plans and irregular adherence to established guidelines, illustrate both deeply rooted prescribing behaviours and limitations in resources. These results highlight the dual importance of prophylaxis in India: to avert infections while reducing unnecessary exposure to antibiotics. Enhancing adherence to global standards is essential not only for the safety of mothers but also for the responsible use of antimicrobials and the formulation of public health policies.

### COMBINED INFLUENCE AND KNOWLEDGE GAPS

While there is a significant amount of research that looks at surgical timing (such as DDI) and antibiotic prophylaxis in isolation, very few investigations have examined the interaction of these two elements to better understand their collective influence on maternal and neonatal outcomes. As far as we are aware, no Indian research has assessed whether delayed surgical intervention and insufficient antibiotic timing synergistically elevate the risk associated with emergency cesarean deliveries. Existing studies on antibiotic timing (pre-incision versus post-clamping) frequently do not control for delays in the procedure, and investigations into DDI seldom take antibiotic timing into account [15, 16].

The originality of our upcoming research is rooted in addressing this disparity: by prospectively investigating both the intervals from decision to incision and the timing of pre-incision antibiotics in Indian emergency cesarean section cohorts, we seek to identify their individual and combined effects on surgical site infections, maternal morbidity, neonatal Apgar scores, and NICU admissions, all within the context of real-world limitations.

**Table 1** illustrates that while global and Indian studies have explored surgical timing or prophylactic antibiotic use independently, no Indian study has integrated both, underscoring the novelty of our project

| Study/Region                               | Surgery Timing<br>(Decision-to-Delivery Interval /<br>Night vs Day)     | Antibiotic Timing<br>Examined                                   | Combined<br>Analysis of<br>Both Factors                                 | Key Findings                                                       |
|--------------------------------------------|-------------------------------------------------------------------------|-----------------------------------------------------------------|-------------------------------------------------------------------------|--------------------------------------------------------------------|
| Yun et al, [7]                             | Yes – Off-hour/night deliveries linked with ↑ severe maternal morbidity | No                                                              | No                                                                      | Night-time births had ~1.4× higher maternal morbidity.             |
| Toyokawa et al., [9] (Japan, Perinatal DB) | Yes – Night CS ↑ risk of cerebral palsy                                 | No                                                              | No                                                                      | Night CS is associated with a 2.3-fold higher cerebral palsy risk. |
| Shishodiya et al., [3]                     | Yes – Longer DDI linked with worse Apgar, ↑ NICU admissions, PPH        | No                                                              | No                                                                      | Only ~30% met <30 min DDI benchmark; delays worsened outcomes.     |
| Singh et al., [4]                          | Yes – DDI delays common; adverse maternal & neonatal outcomes           | No                                                              | No                                                                      | Delays >60 min are associated with more stillbirths, low Apgar.    |
| Central India SSI Study, [14]              | No                                                                      | Yes – Prophylaxis timing studied                                | No                                                                      | Higher SSI with delayed/extended regimens.                         |
| Rubin et al., [15]                         | No                                                                      | Yes – pre-incision 30 vs 60 min                                 | No                                                                      | Antibiotic timing within 60 min critical to reduce SSI.            |
| Gap                                        | Very few Indian studies stratify night vs day                           | Indian studies rarely achieve universal pre-incision compliance | No study combines both timing and antibiotic prophylaxis in Indian ECDs | Highlights the novelty of our upcoming academic project.           |

Critical gaps persist. Firstly, data that is specific to regions in India and other low- and middle-income countries (LMICs) is limited, which restricts the applicability of findings from Western cohorts that operate under different staffing, infrastructural, and institutional standards. Secondly, factors related to staffing and constraints in human resources (such as the availability of senior surgeons, night shift staffing, and the readiness of operating rooms) are infrequently quantified or modelled in current research. Thirdly, barriers related to policies and guidelines, such as the lack of institutionally mandated protocols for antibiotic timing or incentives aimed at reducing drug-drug interactions (DDI), are seldom discussed in the existing literature. Additionally, there is a scarcity of studies that differentiate between time of day (day versus night shifts), which could influence both delays and adherence to prophylactic measures.

## **CONCLUSION AND FUTURE DIRECTIONS**

In summary, the current body of evidence suggests that emergency cesarean deliveries performed at night and the administration of delayed or post-incision antibiotic prophylaxis both independently lead to poorer maternal and neonatal outcomes. These outcomes include elevated rates of infection, increased haemorrhage, lower Apgar scores, and a rise in NICU admissions. The intersection of these two factors likely exacerbates the risk, especially in Indian hospital environments that are constrained by resources, where adherence to recommended practices is often inadequate. This highlights the critical necessity for comprehensive, context-specific research in India to accurately delineate the combined effects of these factors on surgical safety and neonatal health.

Future strategies should emphasise the importance of strictly following international guidelines for antibiotic timing and aim to minimise delays from decision to incision by implementing systematic process enhancements. Additionally, reforms in staffing and policy are crucial, which include ensuring the presence of skilled obstetric teams during nighttime, providing senior oversight, and conducting institutional audits of perioperative practices. Our upcoming academic project, titled “A Prospective Study on the Influence of Surgery Timing and Pre-Incision Antibiotic Administration on Maternal and Neonatal Outcomes in Emergency Cesarean Deliveries at a Tertiary Care Teaching Hospital in Andhra Pradesh” is designed to tackle these deficiencies by prospectively analysing both the timing of surgeries and the administration of antibiotic prophylaxis in Indian emergency cesarean cohorts, to produce evidence that supports targeted interventions and improves maternal and neonatal outcomes in similar low-resource settings.

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## **CONFLICTS OF INTEREST**

The authors declare that they have no conflicts of interest related to this work.

## **ETHICAL APPROVAL**

Not applicable. This article is a narrative mini-review and does not involve studies with human participants or animals performed by the authors.

## **CONSENT TO PARTICIPATE**

Not applicable.

## **CONSENT FOR PUBLICATION**

Not applicable.

## **AVAILABILITY OF DATA AND MATERIALS**

All data discussed in this review are derived from previously published studies, which are appropriately cited in the references.

## **AUTHORS' CONTRIBUTIONS**

PKY and AV conceptualised the review. SS, RK, SMP, and TSP conducted the literature search and drafted the manuscript. RRN provided academic supervision, critical review, and intellectual input. All the authors read and approved the final version of the manuscript.

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