SANAMED
Online First: July 2026
ISSN-1452-662X

DOI: 10.5937/sanamed0-66289
Original article

ASSOCIATION BETWEEN CESAREAN DELIVERY AND TRANSITION DISORDERS IN TERM AND LATE PRETERM NEWBORNS: A PROSPECTIVE OBSERVATIONAL STUDY

Hadžimuratović Emina,[1] Dizdar Selma,[2] Hadžimuratović Admir[3]

[1] University Clinical Center Sarajevo, Pediatric Clinic, Department of Neonatology and Neonatal Intensive Care, Sarajevo, Bosnia and Herzegovina
[2] University Clinical Center Sarajevo, Pediatric Clinic, Department of Cardiology, Sarajevo, Bosnia and Herzegovina
[3] University Clinical Center Sarajevo, Pediatric Clinic, Department of Nephrology, Sarajevo, Bosnia and Herzegovina

Primljen/Received: 06. 04. 2026. Prihvaćen/Accepted: 27. 06. 2026. Online First: July 2026

Abstract: **Introduction:** Cesarean delivery (CS) has been associated with altered neonatal physiological transition due to the absence of labor-related hormonal and mechanical stimuli, which are essential for effective cardiopulmonary and metabolic adaptation after birth.

Aim: To evaluate the association between cesarean delivery and early neonatal transition disorders in term and late preterm newborns.

Methods: This prospective observational study included 230 newborns ≥ 35 weeks of gestation over a 12-month period. Infants were divided into CS (n = 100) and vaginal delivery (VD) groups (n = 130). Outcomes included respiratory disorders (TTN, RDS), need for respiratory support (CPAP/HFNC, oxygen therapy), NICU admission, as well as metabolic disturbances such as hypoglycemia.

Results: Cesarean delivery was associated with significantly higher rates of TTN (28% vs 9%, $p < 0.001$) and RDS (12% vs 4%, $p = 0.02$). Infants in the CS group more frequently required CPAP/HFNC (22% vs 7%, $p < 0.001$), oxygen therapy (34% vs 12%, $p < 0.001$), and NICU admission (26% vs 10%, $p < 0.001$). Hypoglycemia was also more common following CS (18% vs 7%, $p = 0.01$).

Conclusion: Cesarean delivery is associated with an increased risk of early neonatal transition disorders, particularly respiratory and metabolic complications. Optimizing the timing and indications for CS, along with structured postnatal monitoring, may reduce neonatal morbidity.

Keywords: cesarean delivery, neonatal transition, TTN, respiratory morbidity, hypoglycemia.

INTRODUCTION

The transition from intrauterine to extrauterine life involves rapid cardiopulmonary, metabolic, and thermal adaptation. Vaginal delivery facilitates this process through catecholamine surge, thoracic compression, and enhanced lung fluid clearance (1, 2).

Cesarean delivery (CS) has been associated with impaired neonatal physiological transition due to the absence of labor-related hormonal and mechanical stimuli, which are essential for effective cardiopulmonary adaptation after birth (1–4). Vaginal delivery triggers a catecholamine surge and thoracic compression that facilitate lung fluid clearance and metabolic adaptation (3, 5).

Previous studies have consistently shown higher rates of transient tachypnea of the newborn (TTN), respiratory distress syndrome (RDS), hypoglycemia, and NICU admission among infants born by CS (5–8).

PATIENTS AND METHODS

Study Design and Setting

This prospective observational study was conducted over a 12-month period at a tertiary-level perinatal center with approximately 5,500 deliveries per year. The study aimed to assess early neonatal outcomes related to the mode of delivery in a real-world clinical setting.

Study Population

A total of 230 newborns with gestational age ≥35 weeks were consecutively enrolled and stratified according to mode of delivery into: cesarean section (CS) group (n = 100) and vaginal delivery (VD) group (n = 130)

Inclusion Criteria: Gestational age ≥ 35 weeks, Liveborn infants, Delivery by CS or VD**,** Availability of complete perinatal and early neonatal data, Immediate postnatal assessment in the study center .

Exclusion Criteria: Major congenital anomalies, Congenital heart disease, Proven or suspected congenital infection, Severe perinatal trauma, Need for immediate surgical intervention after birth

Data Collection

Maternal and neonatal data were collected prospectively from delivery records and neonatal charts using a standardized data collection form.

The following variables were recorded:

• Maternal data: age, parity, pregnancy complications (e.g., diabetes, hypertension), indication for cesarean delivery

• Perinatal data: gestational age, birth weight, sex, mode of delivery, Apgar scores

• Neonatal outcomes within the first 72 hours of life

Definition of Outcomes

• **Transient tachypnea of the newborn (TTN):** diagnosed based on clinical signs of respiratory distress (tachypnea > 60/min, retractions) and compatible chest X-ray findings

• **Respiratory distress syndrome (RDS):** defined by clinical respiratory distress with radiographic confirmation and/or need for surfactant therapy

• **Respiratory support:** requirement for CPAP or high-flow nasal cannula (HFNC)

• **Oxygen supplementation:** need for supplemental oxygen to maintain adequate saturation

• **NICU admission:** transfer to neonatal intensive care unit for monitoring or treatment

• **Hypoglycemia:** blood glucose < 2.6 mmol/L

• **Hypothermia:** body temperature < 36.5 °C

• **Delayed feeding initiation:** initiation of enteral feeding later than 2 hours after birth

• **Low Apgar score:** Apgar < 7 at 1 and/or 5 minutes

• **Persistent pulmonary hypertension of the newborn (PPHN):** confirmed by echocardiography

Statistical Analysis

Statistical analysis was performed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD) and compared using Student's t-test. Categorical variables were presented as frequencies and percentages and analyzed using the χ^2 test or Fisher's exact test when appropriate. A p-value < 0.05 was considered statistically significant.

Ethical Considerations

The study was conducted in accordance with the Declaration of Helsinki. Approval was obtained from the institutional Ethics Committee. Given the observational nature of the study and use of anonymized data, informed consent was not needed.

RESULTS

The baseline characteristics of the study population were comparable between the cesarean delivery (CS) and vaginal delivery (VD) groups, with no statistically significant differences observed in gestational age, birth weight, sex distribution, or proportion of late preterm infants (Table 1).

Respiratory morbidity was significantly higher in the CS group (Table 2). Infants delivered by cesarean section had a markedly increased risk of transient tachypnea of the newborn (TTN) (28% vs 9%; OR 3.83, 95% CI 1.83–7.99; p < 0.001) and respiratory distress syndrome (RDS) (12% vs 4%; OR 3.41, 95% CI 1.16–10.03; p = 0.02). The need for respiratory support was also significantly higher among CS infants, including CPAP/HFNC therapy (22% vs 7%; OR 3.79, 95% CI 1.66–8.67; p < 0.001), oxygen supplementation (34% vs 12%; OR 3.67, 95% CI 1.89–7.16; p < 0.001), and NICU admission (26% vs 10%; OR 3.16, 95% CI 1.53–6.54; p < 0.001), indicating both increased incidence and clinical severity of respiratory transition disorders (Table 3).

Metabolic and thermal adaptation were also significantly affected by mode of delivery. Hypoglycemia was more frequent in the CS group (18% vs 7%; OR 2.95, 95% CI 1.26–6.88; p = 0.01), while hypothermia showed a trend toward higher incidence (21% vs 12%; OR 1.89, 95% CI 0.93–3.85; p = 0.05). Delayed initiation of feeding occurred significantly more often after cesarean delivery (39% vs 19%; OR 2.69, 95% CI 1.48–4.87; p < 0.001), reflecting impaired early postnatal adaptation (Table 3).

Evaluation of immediate neonatal condition demonstrated that low Apgar score (< 7 at 1 minute) was significantly more frequent in the CS group (11% vs 4%; OR 3.09, 95% CI 1.04–9.21; p = 0.03). However, no significant difference was observed at 5 minutes (3% vs 2%; OR 1.31, 95% CI 0.26–6.62; p = 0.67), suggesting effective stabilization with early postnatal support (Table 3).

Table 1. *Baseline characteristics of the study population*

Variable	CS (n = 100)	VD (n = 130)	p-value
Gestational age (weeks)	38.1 ± 1.0	38.4 ± 1.1	0.09
Birthweight (g)	3220 ± 430	3255 ± 410	0.47
Male sex (%)	53%	51%	0.78
Late preterm (%)	16%	14%	0.64

Table 2. *Respiratory outcomes*

Outcome	CS (%)	VD (%)	p-value
TTN	28	9	< 0.001
RDS	12	4	0.02
CPAP/HFNC	22	7	< 0.001
Oxygen therapy	34	12	< 0.001
NICU admission	26	10	< 0.001

Table 3. *Odds ratios for neonatal outcomes associated with cesarean delivery (CS vs VD)*

Outcome	CS (n = 100)	VD (n = 130)	OR	95% CI	p-value
TTN	28%	9%	3.83	1.83–7.99	< 0.001
RDS	12%	4%	3.41	1.16–10.03	0.02
CPAP/HFNC requirement	22%	7%	3.79	1.66–8.67	< 0.001
Oxygen therapy	34%	12%	3.67	1.89–7.16	< 0.001
NICU admission	26%	10%	3.16	1.53–6.54	< 0.001
Hypoglycemia	18%	7%	2.95	1.26–6.88	0.01
Hypothermia	21%	12%	1.89	0.93–3.85	0.05
Feeding delay	39%	19%	2.69	1.48–4.87	< 0.001
Apgar < 7 (1 min)	11%	4%	3.09	1.04–9.21	0.03
Apgar < 7 (5 min)	3%	2%	1.31	0.26–6.62	0.67
PPHN	1%	1%	1.30	0.08-21.05	1.00

Persistent pulmonary hypertension of the newborn (PPHN) was rare, with no significant difference between groups (one case in each group; OR 1.00, p = 0.98), indicating that mode of delivery did not influence its occurrence in this cohort.

DISCUSSION

This study demonstrates a strong and clinically meaningful association between cesarean delivery and impaired neonatal transition, affecting respiratory, metabolic, and thermal adaptation in term and late preterm infants. These findings support the concept that physiological processes triggered during vaginal delivery play a critical role in preparing the newborn for extrauterine life.

The increased respiratory morbidity observed in our study is consistent with previous reports demonstrating impaired lung fluid clearance in the absence of labor (3, 5, 9, 10). Vaginal delivery is characterized by a surge in catecholamines, which promotes lung fluid absorption, enhances surfactant release, and facilitates the transition from fluid-filled to air-filled lungs. In cesarean delivery, particularly when performed electively without labor, this hormonal cascade is attenuated or absent. Additionally, the lack of thoracic compression during passage through the birth canal further contributes to retained lung fluid. Together, these mechanisms provide a plausible explanation for the significantly higher rates of TTN and RDS observed in our cohort. In this context, global trends showing increasing cesarean delivery rates further emphasize the clinical relevance of these findings (8, 9).

Importantly, our results extend beyond respiratory outcomes and highlight a broader disruption of neonatal adaptation. Higher rates of hypoglycemia may be explained by altered hormonal adaptation and delayed feeding initiation, as described in earlier studies (10,

11). The absence of stress-induced hormonal responses, including catecholamine-mediated glycogenolysis and gluconeogenesis, may predispose these infants to impaired glucose homeostasis. Furthermore, delayed initiation of feeding—likely influenced by maternal postoperative recovery and reduced early skin-to-skin contact—may further contribute to metabolic instability.

Thermal adaptation also appeared to be compromised, as evidenced by higher rates of hypothermia in the CS group. This may reflect a combination of environmental factors in the operating room setting and delays in maternal–infant contact. Together with feeding delays, these findings underscore the importance of optimizing immediate postnatal care practices following cesarean delivery.

Although differences in Apgar scores at 1 minute suggest a slower initial transition in CS-delivered infants, the lack of difference at 5 minutes is reassuring and indicates that most infants respond well to early supportive care. Nevertheless, the need for such interventions remains clinically relevant, as it places additional demands on neonatal services and may impact early mother–infant bonding.

The absence of a difference in persistent pulmonary hypertension of the newborn (PPHN) between groups is noteworthy. Unlike transient respiratory disorders, PPHN is a multifactorial condition often associated with severe perinatal stress, infection, or underlying pulmonary pathology. Therefore, mode of delivery alone may not be a sufficient determinant of its occurrence.

Although our findings demonstrate a robust association between cesarean delivery and impaired early neonatal transition, several potential confounding factors should be considered when interpreting these results. First, the indication for cesarean section was not stratified in detail (elective vs. emergency CS), which may have influenced neonatal outcomes. Emergency cesarean deliveries are often preceded by fetal distress, labor complications, or maternal comorbidities, all of which independently increase the risk of respiratory and metabolic disturbances in the newborn. Therefore, part of the observed effect may be attributable to underlying obstetric or fetal conditions rather than the mode of delivery itself.

Second, maternal factors such as diabetes, hypertensive disorders, obesity, and antenatal steroid exposure were not analyzed separately in multivariable models. These conditions are known to influence neonatal respiratory adaptation, glucose homeostasis, and thermoregulation, and may partially confound the observed associations. Although baseline characteristics were comparable between groups, residual confounding cannot be excluded due to the observational study design.

Third, gestational age within the near-term spectrum (35–38 weeks) represents a biologically heterogeneous group, in which even small differences in maturity may influence respiratory outcomes. While our cohort included both term and late preterm infants, more granular stratification could further clarify the interaction between gestational maturity and mode of delivery.

From an organizational and health system perspective, the increased incidence of transition disorders in infants delivered by cesarean section has important implications for perinatal care planning. The higher need for respiratory support (CPAP/HFNC), oxygen therapy, and NICU admission observed in our study indicates increased utilization of neonatal intensive care resources among CS-delivered infants. This may contribute to higher healthcare costs, increased workload for neonatal staff, and potential strain on NICU capacity, particularly in centers with high cesarean section rates.

Furthermore, the increased frequency of hypoglycemia monitoring, thermal instability management, and delayed feeding highlights the need for structured post-cesarean newborn care pathways. Implementation of standardized protocols—including early glucose screening, proactive thermoregulation, and early skin-to-skin contact—may reduce variability in care and improve early neonatal stabilization.

At a broader system level, our findings support the importance of multidisciplinary strategies aimed at reducing non-medically indicated cesarean sections and optimizing timing of elective procedures, particularly avoiding deliveries before 39 weeks of gestation when possible. Additionally, strengthening delivery room preparedness for respiratory support in CS-born infants may improve outcomes and reduce NICU admissions.

Overall, while cesarean delivery remains a safe and often life-saving intervention, our data suggest that it is associated with increased neonatal resource utilization and requires targeted organizational planning to mitigate its short-term physiological consequences.

CONCLUSION

Cesarean delivery is associated with a significantly increased risk of early neonatal transition disorders in term and late preterm infants. In our study, infants born via cesarean section demonstrated higher rates of respiratory morbidity, including transient tachypnea of the newborn and respiratory distress syndrome, as well as a greater need for respiratory support and NICU admission. In addition to respiratory complications, cesarean delivery was also linked to impaired metabolic and ther-

mal adaptation, reflected by higher incidences of hypoglycemia, hypothermia, and delayed initiation of feeding.

These findings emphasize that cesarean delivery is not a neutral intervention from the neonatal perspective, but rather a factor that can influence multiple physiological systems during the critical period of postnatal adaptation. Although most of the observed complications are transient and manageable, their frequency and the associated need for medical interventions highlight a substantial impact on neonatal care, resource utilization, and early mother–infant interaction.

From a clinical standpoint, our results support a more cautious and individualized approach to the indication and timing of cesarean delivery. Whenever clinically feasible, delaying elective cesarean sections until at least 39 weeks of gestation and allowing the onset of labor may help promote more optimal neonatal adaptation. Furthermore, the implementation of structured postnatal care protocols for infants delivered by cesarean section—including early respiratory assessment, proactive thermal management, glucose monitoring, and timely initiation of feeding—may mitigate the risks identified in this study.

Future research should focus on differentiating elective and emergency cesarean deliveries, as well as exploring targeted interventions that could replicate the beneficial physiological effects of labor. In addition, larger multicenter studies are needed to confirm these findings and to further define strategies that optimize neonatal outcomes in the context of rising global cesarean section rates.

In conclusion, optimizing both obstetric decision-making and immediate neonatal care is essential to reduce the burden of transition disorders associated with cesarean delivery and to improve early neonatal outcomes.

Abbreviations

CPAP – Continuous Positive Airway Pressure
CS – Cesarean Section
HFNC – High-Flow Nasal Cannula
NICU – Neonatal Intensive Care Unit
RDS – Respiratory Distress Syndrome
TTN – Transient Tachypnea of the Newborn
VD – Vaginal Delivery

Acknowledgments: The authors would like to thank the medical and nursing staff of the Department of Neonatology for their support in data collection and patient care.

Funding: This research received no external funding or sponsorship.

Conflict of Interest Statement: The authors declare that there is no conflict of interest related to this paper.

Author Contribution & Responsibilities: Conceptualisation: EH, SD; Methodology: EH, SD; Validation: EH, AH; Formal analysis: EH, AH; Investigation: EH, SD; Data curation: EH, SD;Writing – original: EH; Writing – review and editing: EH, SD, AH; Supervision: EH, AH.

The authors take full responsibility for the accuracy and integrity of the content, as well as the validity of institutional affiliations. The publisher remains neutral regarding jurisdictional claims in institutional affiliations. All authors have read and agreed to the published version of the manuscript.

Note: Artificial intelligence was not used in this study.

Sažetak

POVEZANOST IZMEĐU POROĐAJA CARSKIM REZOM I POREMEĆAJA NEONATALNE TRANZICIJE KOD TERMINSKE I KASNO PRETERMINSKE NOVOROĐENČADI: PROSPEKTIVNA OPSERVACIONA STUDIJA

Hadžimuratović Emina,[1] Dizdar Selma,[2] Hadžimuratović Admir[3]

[1] Univerzitetski klinički centar Sarajevo, Pedijatrijska klinika, Odeljenje za neonatologiju i neonatalnu intenzivnu negu, Sarajevo, Bosna i Hercegovina
[2] Univerzitetski klinički centar Sarajevo, Pedijatrijska klinika, Odeljenje za kardiologiju, Sarajevo, Bosna i Hercegovina
[3] Univerzitetski klinički centar Sarajevo, Pedijatrijska klinika, Odeljenje za nefrologiju, Sarajevo, Bosna i Hercegovina

Uvod: Porođaj carskim rezom povezuje se sa izmenjenom neonatalnom fiziološkom tranzicijom usled odsustva hormonalnih i mehaničkih stimulusa karakterističnih za porođaj, a koji su ključni za efikasnu kardiopulmonalnu i metaboličku adaptaciju nakon rođenja.

Cilj: Procena povezanosti između porođaja carskim rezom i ranih poremećaja neonatalne tranzicije kod terminske i kasno preterminske novorođenčadi.

Metode: Ova prospektivna opservaciona studija obuhvatila je 230 novorođenčadi gestacijske starosti ≥

35 nedelja tokom perioda od 12 meseci. Deca su podeljena u grupu rođenih carskim rezom (CS, n = 100) i grupu rođenih vaginalnim putem (VD, n = 130). Ishodi su uključivali respiratorne poremećaje (prolazna tahipneja novorođenčeta – TTN, respiratorni distres sindrom – RDS), potrebu za respiratornom potporom (CPAP/HFNC, kiseonička terapija), prijem u neonatalnu intenzivnu negu (NICU), kao i metaboličke poremećaje poput hipoglikemije.

Rezultati: Porođaj carskim rezom bio je povezan sa značajno višom učestalošću TTN-a (28% naspram 9%, p < 0,001) i RDS-a (12% naspram 4%, p = 0,02). Novorođenčad u CS grupi češće su zahtevala CPAP/HFNC (22% naspram 7%, p < 0,001), kiseoničku terapiju (34% naspram 12%, p < 0,001) i prijem u neonatalnu intenzivnu negu (26% naspram 10%, p < 0,001). Hipoglikemija je takođe bila učestalija nakon carskog reza (18% naspram 7%, p = 0,01).

Zaključak: Porođaj carskim rezom povezuje se sa povećanim rizikom od ranih poremećaja neonatalne tranzicije, naročito respiratornih i metaboličkih komplikacija. Optimizacija vremena izvođenja i indikacija za carski rez, uz strukturisano postnatalno praćenje, može smanjiti neonatalni morbiditet.

Ključne reči: porođaj carskim rezom, neonatalna tranzicija, TTN, respiratorni morbiditet, hipoglikemija.

REFERENCES

1. Tefera M, Assefa N, Mengistie B, Abrham A, Teji K, Worku T. Elective cesarean section on term pregnancies and neonatal respiratory morbidity: a systematic review and meta-analysis. Front Pediatr. 2020; 8:286. doi: 10.3389/fped.2020.00286.

2. Horiuchi S, Shinohara R, Otawa S, Kushima M, Akiyama Y, Ooka T, et al. Elective cesarean delivery at term and neonatal respiratory outcomes: the Japan Environment and Children's Study. Health Sci Rep. 2021; 4(4): e421. doi: 10.1002/hsr2.421.

3. Thomas J, Olukade TO, Naz A, Salama H, Al-Qubaisi M, Al Rifai H, et al. The neonatal respiratory morbidity associated with early-term cesarean section. J Perinat Med. 2021; 49(7): 767-72. doi: 10.1515/jpm-2021-0123.

4. Hamidovic Dostovic L, Skokic F, Muratovic S, Terzic A. Impact of maternal anaemia on neonatal outcomes: a single-centre experience. Sanamed. 2025; 20(2): 139-45. doi: 10.5937/sanamed0-58886.

5. Kureshi A, Khalak R, Gifford J, Munshi U. Maternal obesity-associated neonatal morbidity in early newborn period. Front Pediatr. 2022; 10: 867171. doi: 10.3389/fped.2022.867171.

6. Bham SQ, Khan KMA. Impact of rising elective cesarean section rates on early neonatal outcomes. Pak J Med Dent. 2024; 13(3): 38-46.

7. Jain L, Eaton DC. Physiology of fetal lung fluid clearance and the effect of labor. Semin Perinatol. 2006; 30(1): 34-43. doi: 10.1053/j.semperi.2006.01.006.

8. Sandall J, Tribe RM, Avery L, Mola G, Visser GHA, Homer CSE, et al. Short-term and long-term effects of cesarean section on the health of women and children. Lancet. 2018; 392(10115): 1349-57. doi: 10.1016/S0140-6736(18)31930-5.

9. Tita ATN, Landon MB, Spong CY, Lai Y, Leveno KJ, Varner MW, et al. Timing of elective repeat cesarean delivery at term and neonatal outcomes. N Engl J Med. 2009; 360(2): 111-20. doi: 10.1056/NEJMoa0803267.

10. Hansen AK, Wisborg K, Uldbjerg N, Henriksen TB. Elective caesarean section and respiratory morbidity in the term and near-term neonate. Acta Obstet Gynecol Scand. 2007; 86(4): 389-94. doi: 10.1080/00016340601159256.

11. Ohuma EO, Moller AB, Bradley E, Chakwera S, Hussain-Alkhateeb L, Lewin A, et al. National, regional, and global estimates of preterm birth in 2020, with trends from 2010: a systematic analysis. Lancet. 2023; 402(10409): 1261–71. doi: 10.1016/S0140-6736(23)00878-4.

*Accepted papers are articles in press that have gone through due peer review process and have been accepted for publication by the Editorial Board of Sanamed. The final text of the article may be changed before the final publication. Accepted papers can already be cited using the year of online publication and the DOI, as follows: the author's last name and initial of the first name, article title, journal title, online first publication month and year, and the DOI. When the final article is assigned to volumes/issues of the journal, the Article in Press version will be removed and the final version will appear in the associated published volumes/issues of the journal. The date the article was made available online first will be carried over.

***How to cite this article**:* **Hadzimuratović E**, Dizdar S, Hadzimuratović A. Association Between Cesarean Delivery and Transition Disorders in Term and Late Preterm Newborns: A Prospective Observational Study. Sanamed. Online First, July. 2026. doi: 10.5937/sanamed0-66289,

Correspondence to/Autor za korespondenciju
Prof dr Emina Hadžimuratović, MD, PhD
Department of Neonatology and Neonatal Intensive Care
University Clinical Center Sarajevo
Bolnička 25
71000 Sarajevo
Bosnia and Herzegovina
Tel: +387 61478802
Email: eminahadzimuratovic@yahoo.com

ORCID:
Emina Hadžimuratović: 0000-0002-3745-6832
Admir Hadžimuratović: 0000-0001-5352-3401
Selma Dizdar: 0000-0002-1307-8558