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Original Article

Low Apgar Score and the Risk of Neonatal Acute Kidney Injury: Evidence from a Matched Retrospective Cohort Study

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ABSTRACT

Background: The Apgar score is a widely used indicator for assessing newborn health immediately after birth. However, its predictive value for specific organ dysfunctions such as acute kidney injury (AKI) remains uncertain. This study aimed to evaluate the association between low 5-minute Apgar scores and the risk of AKI in neonates admitted to the neonatal intensive care unit (NICU).

Methods: In this retrospective matched cohort study conducted between 2022 and 2024 at Amir Al-Momenin Hospital, 80 neonates (40 with Apgar <7 and 40 with Apgar ≥7) were enrolled. Neonates were matched 1:1 for gestational age and admission time. Serum creatinine was measured on days 1, 3, 5, and 7, and urine output was assessed on day 3 to diagnose AKI based on modified neonatal KDIGO criteria. Statistical analyses included the Chi-square test for categorical variables, Mann–Whitney U test for non-normally distributed continuous variables, and logistic regression analysis.

Results: Low 5-minute Apgar scores were associated with a significantly higher incidence of AKI (20% vs. 5%, P = 0.043), with a 6.3-fold increased risk (OR = 6.29, 95% CI: 1.04–37.90, P = 0.045). Gestational age between 28–32 weeks independently increased the risk of AKI (OR = 13.84, P = 0.027). Although day 1 serum creatinine was higher in the normal Apgar group (P = 0.002), no differences were observed afterward. Male sex and vaginal delivery were more common in the low Apgar group but were not associated with AKI in multivariable analysis.

Conclusion: A 5-minute Apgar score <7 and gestational age between 28–32 weeks are significant risk factors for AKI in NICU neonates. These findings highlight the potential of using Apgar score and gestational age for early risk stratification and targeted monitoring.

Keywords: Acute kidney injury, Apgar score, Neonatal intensive care unit, Neonates, Renal function

Introduction

The Apgar score, introduced by Dr. Virginia Apgar in 1952, remains a widely used tool for assessing neonatal viability in the first minutes after birth. This scoring system evaluates five critical parameters—appearance, pulse, grimace, activity, and respiration—providing a rapid assessment of a newborn's transition to extrauterine life. While a low Apgar score (typically defined as <7 at 5 minutes) is associated with increased risks of neonatal morbidity and

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mortality, its correlation with specific organ dysfunction, particularly renal impairment, remains understudied (1).

AKI is a significant complication in critically ill neonates, with reported incidence rates ranging from 8% to 24% in NICU settings (2). The immature renal system of newborns, especially preterm infants, makes them highly vulnerable to hypoxic-ischemic insults, which can lead to AKI (3). Hypoxia and perinatal asphyxia—common contributors to low Apgar scores—can reduce renal perfusion, triggering tubular injury and impaired glomerular filtration (4). However, the exact relationship between Apgar scores and early renal dysfunction remains unclear, with conflicting evidence on whether low Apgar scores independently predict AKI or merely reflect broader systemic compromise (5). Several studies have explored the association between low Apgar scores and AKI in neonates, but the findings are inconsistent. For instance, a study by Bansal et al. (2017) demonstrated a significant correlation between low Apgar scores (<7) and elevated serum creatinine levels in neonates, suggesting a potential link to renal impairment (6). In contrast, Jayashree et al. (1991) found no significant association between Apgar scores and the development of AKI (7). This inconsistency underscores the need for further research to clarify whether low Apgar scores are an independent risk factor for renal impairment or a surrogate marker for other pathologies.

This study investigated whether neonates with low Apgar scores have a higher incidence of AKI compared to those with normal scores.

This study examined neonates admitted to the NICU of Amir Al-Momenin Hospital in Zabol between 2022 and 2024, comparing the occurrence of AKI in infants with 5-minute Apgar scores below 7 versus those with scores of 7 or above. Additional factors such as neonatal gender and mode of delivery were also explored as potential modifiers of this association.

Methods

Study Design and Setting

This retrospective cohort study was conducted between 2022 and 2024 at the NICU of Amir Al-Momenin Hospital, affiliated with Zabol University of Medical Sciences, Iran. The study aimed to assess the association between low 5-minute Apgar scores and the occurrence of AKI in neonates.

Study Population and Eligibility Criteria

All neonates admitted to the NICU during the study period were considered for inclusion. Eligibility was determined based on specific inclusion and exclusion criteria, as summarized in Table 1, to minimize potential confounding factors (8-13).

Table 1. Inclusion and Exclusion Criteria of the Study

Category	Criteria
Inclusion Criteria	- Admission to the NICU within the first 24 hours after birth - Hospitalization for at least 7 days - Availability of complete medical records, including: • 5-minute Apgar score • Mode of delivery • Gestational age • Sex • Urine output • Serum renal function parameters (creatinine and BUN) - Gestational age ≥ 28 weeks
Exclusion Criteria	- Congenital kidney disease - Congenital heart disease - Major congenital anomalies - Chromosomal abnormalities - Administration of known nephrotoxic medications during the first week of life, including: • Aminoglycosides (e.g., gentamicin, amikacin) • Vancomycin • Acyclovir • Amphotericin B • NSAIDs (e.g., indomethacin, ibuprofen) • Furosemide • Piperacillin-tazobactam - Incomplete or missing medical records - Any other known conditions potentially affecting renal function

*A minimum hospitalization duration of 7 days was required, based on the need to evaluate renal function over at least 7 days and the 48-hour interval defined in the KDIGO criteria.

Sampling and Grouping

This was a retrospective cohort study. All neonates admitted to the NICU with a 5-minute Apgar score <7 and complete medical records during the study period were included as the exposed group. For each case, an unexposed neonate (5-minute Apgar score ≥7), born immediately after the case and matched for gestational age (±1 week) and same admission date, was selected to minimize temporal and maturity-related confounding.

Matching was done in a 1:1 ratio to control for key confounders, including postnatal care conditions and gestational maturity.

A total of 80 neonates (40 in each group) were enrolled based on available eligible records.

Sample Size Justification

The final sample size (n = 80) was based on complete enumeration of all eligible cases (Apgar <7) during the study period. For each, one matched control was selected as described above.

Due to the retrospective nature of the study and matching method, randomization was not applicable, and the sample size was determined by available records meeting the inclusion/exclusion criteria.

Data Collection and Variables

Data were collected retrospectively from medical records using a checklist specifically designed by the researchers. The following variables were extracted:

Perinatal Characteristics

- 5-minute Apgar score
- Mode of delivery (vaginal or cesarean)
- Gestational age
- Birth weight
- Neonatal sex
- Maternal age

Renal Function and Biochemical Parameters

Serum creatinine levels were evaluated on the 1st, 3rd, 5th, and 7th days of life, and urine output was recorded on day 3. Creatinine level on day 3 was considered the baseline, and these parameters were used to define AKI according to KDIGO criteria.

Apgar Score Assessment

The 5-minute Apgar scores were evaluated by trained neonatal nurses according to the hospital's standardized neonatal assessment protocol. In most cases, the same nurse on duty performed the scoring to ensure consistency. All nurses involved had completed relevant neonatal care training and had at least two years of clinical experience in the NICU.

Definition of AKI

AKI was diagnosed according to the modified neonatal Kidney Disease: Improving Global Outcomes (KDIGO) criteria (14, 15). A neonate was considered to have AKI if at least one of the following criteria was met:

- Urine output < 0.5 mL/kg/h for ≥6 hours, urine output < 0.3 mL/kg/h for ≥24 hours, or anuria (no urine output) for ≥12 hours.
- Urine output was measured on day 3 of hospitalization using standard urinary collection bags (urobags) under sterile conditions.
- Increase in serum creatinine ≥ 0.3 mg/dL within 48 hours or ≥1.5–1.9 times the baseline (i.e., the lowest previous creatinine level).

Statistical Analysis

Quantitative variables were reported as mean ± standard deviation (SD), and categorical variables as frequencies and percentages. The Chi-square test was used to compare categorical variables (e.g., gender, delivery mode, renal complications) between the low and normal Apgar groups. A P-value < 0.05 was considered statistically significant. All analyses were performed using SPSS software version 22.

Ethical approval

The study was approved by the Ethics Committee of Zabol University of Medical Sciences (IR.ZBMU.REC.1403.050). Written informed consent was obtained from the neonates' mothers. All collected data were anonymized to ensure patient confidentiality and privacy.

Results

Demographic and Perinatal Characteristics

A total of 80 neonates (mean gestational age of 34 weeks and 2 days) were included in this study, divided equally into two groups: 40 neonates with low Apgar scores at birth and 40 with normal Apgar scores. Among all participants, 49 (61%) were male, and 45 (56%) were delivered via normal vaginal delivery. Most of the neonates were term infants (≥37 weeks). (Table 2)

The distribution of sex and mode of delivery

Table 2. Demographic and Perinatal Characteristics of the Study Population

Variable		Low Apgar (n = 40)	Normal Apgar (n = 40)	P-value[1]
Sex	Male	29 (72.5%)	20 (50%)	0.033
	Female	11 (27.5%)	20 (50%)	
Mode of Delivery	NVD	27 (67.5%)	18 (45%)	0.035
	C/S	13 (32.5%)	22 (55%)	
Gestational Age	≤28 to <32	9 (22.5%)	9 (22.5%)	0.852
	≥32 to <34	6 (15.0%)	6 (15.0%)	
	≥34 to <37	10 (25.0%)	8 (20.0%)	
	≥37	15 (37.5%)	17 (42.5%)	

[1]Statistically significant (P < 0.05).

Table 3. Comparison of Mean Serum Creatinine Levels Between Groups

Day	Low Apgar (mean ± SD)	Normal Apgar (mean ± SD)	P-value*	Significant
1	1.20 ± 0.39	1.26 ± 0.53	0.002	Yes
3	1.09 ± 0.37	1.19 ± 0.53	0.946	No
5	0.95 ± 0.34	0.98 ± 0.43	0.707	No
7	0.83 ± 0.53	0.76 ± 0.23	0.709	No

*P-values were calculated using the Mann–Whitney U test.

was significantly different between the two groups, with male sex and vaginal delivery more common in the low Apgar group.

Renal Function and Biochemical Parameters

Serum creatinine levels were measured on days 1, 3, 5, and 7 after birth in both groups. As shown in Table 3, the only statistically significant difference between groups was observed on day 1 (P = 0.002), with higher levels in the control group. No significant differences were found on subsequent days (P > 0.05).

A total of 10 patients were diagnosed with AKI according to the KDIGO criteria. Specifically, 4 patients met the criteria based on elevated serum creatinine levels, 3 patients based on decreased urine output relative to body weight, and 3 patients met both diagnostic criteria.

The renal outcomes and biochemical parameters of neonates in both groups are summarized in Table 4.

Neonates with low Apgar scores had a significantly higher incidence of AKI. Although elevated serum creatinine and abnormal urine output were more frequent in this group, the differences were not statistically significant.

Association Between Low Apgar Score and AKI

The analysis showed that low Apgar score at birth was a significant predictor of AKI in neonates, with affected infants having about 6.3 times higher odds of AKI compared to those with normal scores. Additionally, gestational age between 28 and 32 weeks was associated with a significantly increased risk, showing nearly 13.8 times higher odds of AKI. Sex and type of delivery were not significant predictors.

Table 4. Comparison of Renal Outcomes Between Groups

Variable		Low Apgar (n = 40)	Normal Apgar (n = 40)	P-value
Serum Creatinine Abnormality	Abnormal	6 (15%)	1 (2.5%)	0.048*
	Normal	34 (85%)	39 (97.5%)	
Urinary Output	Abnormal	5 (12.5%)	1 (2.5%)	0.090
	Normal	35 (87.5%)	39 (97.5%)	
Renal Function (AKI diagnosis)	AKI	8 (20%)	2 (5%)	0.043
	Normal	32 (80%)	38 (95%)	

*AKI was defined according to neonatal KDIGO criteria.

Table 5. Results of Logistic Regression for AKI

Variable	Reference Category	Comparison Category	OR (Odds Ratio)	95% Confidence Interval	P-value
Apgar Score	Normal	Low	6.29	1.04–37.90	0.045
Gestational Age	≥37 weeks (term)	28–32 weeks	13.84	1.35–142.18	0.027
Sex	Female	Male	1.13	0.21–6.19	0.886
Type of Delivery	Cesarean Section	Vaginal Delivery	0.39	0.08–1.91	0.240

Discussion

Our findings indicate that a low Apgar score at birth is a significant independent predictor of acute kidney injury (AKI) in neonates, increasing the odds of AKI by over six-fold. Additionally, prematurity—specifically gestational age between 28 and 32 weeks—was associated with a markedly higher risk of AKI, while sex and mode of delivery showed no significant association.

Demographic and Perinatal Characteristics

In the present study, a statistically significant difference was observed between the two groups in terms of sex distribution, with a higher proportion of males in the low Apgar score group (P = 0.033). This finding aligns with the study by Nagy et al. (2009), which demonstrated that male newborns—particularly those with very low birth weight or prematurity—are more likely to have lower Apgar scores compared to females (16). Similarly, Katugume et al. (2025) reported that male neonates have a higher risk of developing complications such as neonatal sepsis, which may contribute to lower Apgar scores (17). Supporting this, a systematic review by Lidya et al. (2021) emphasized the role of male sex as a potential risk factor for neonatal morbidity, though it noted that the relationship between sex and Apgar scores is complex and context-dependent (18). Therefore, our findings are consistent with previous evidence suggesting that male neonates may be inherently more vulnerable during the perinatal period, which could partly explain their lower Apgar scores.

A statistically significant difference was observed between the groups regarding the mode of delivery, with vaginal delivery being more common among neonates with low Apgar scores (67.5%) compared to those delivered by cesarean section (P = 0.035). This finding may reflect the emergency nature or suboptimal conditions under which some vaginal deliveries occur, potentially affecting neonatal outcomes. Supporting this, a study by Fajar et al. (2017) conducted at Dr. Zainoel Abidin General Hospital reported that cesarean section, especially in breech presentations or complicated labor scenarios, was associated with higher Apgar scores at both 1 and 5 minutes (19). These results align with the notion that cesarean delivery may offer neonatal benefits in specific high-risk cases.

However, in contrast to our findings, Paudyal et al. (2020) found no significant difference in Apgar scores between delivery modes (P > 0.05), with both vaginal and cesarean deliveries showing mean scores above 7 (20). This inconsistency may be due to differences in obstetric care quality, case selection for cesarean section, or labor management protocols across settings. Overall, while our study highlights a notable association between delivery mode and Apgar scores, it also underscores the need to consider the broader perinatal context, including indications for cesarean section and the clinical conditions surrounding labor and birth.

In the regression model, AKI was significantly associated with prematurity, particularly in neonates with a gestational age between 28 and 32 weeks (P = 0.027). These infants had a 13.8-fold higher risk of developing AKI compared to term neonates. This finding aligns with the results of Gupta et al. (2023), who reported that 72.9% of preterm neonates with AKI were born between 28 and 32 weeks, a proportion significantly higher than that observed in the non-AKI group (21). Other studies have similarly identified a gestational age of less than 32 weeks as a major independent risk factor for AKI (22, 23). This increased susceptibility is likely due to the immature renal development in extremely preterm neonates, as well as their higher exposure to risk factors such as sepsis, hypotension, and the need for intensive supportive care (23).

Renal Function and Biochemical Parameters

Serum creatinine levels measured on the first day after birth showed a statistically significant difference between the two groups (P = 0.002), with higher levels observed in the normal Apgar group. This early difference may reflect placental function and maternal renal status, as creatinine levels during the first 24 hours of life are primarily influenced by the transplacental transfer of creatinine and urea from the fetal circulation to the mother, before the neonate's kidneys fully assume independent function (24, 25). Therefore, the serum creatinine level on day 3 after birth was considered the baseline value, and measurements taken on subsequent days (days 5 and 7) were compared to this baseline to assess changes and to define AKI according to the KDIGO criteria (15, 26).

Analysis of serum creatinine level changes revealed that elevated serum creatinine was significantly more common among neonates with low Apgar scores (15%) compared to those with normal Apgar scores (2.5%) (P = 0.048), suggesting a possible association between

perinatal asphyxia and early renal dysfunction. This finding contrasts with previous studies, such as that by Go et al. (2018), which reported no significant association between neonatal serum creatinine levels and Apgar scores in the early postnatal period (27). Additionally, studies by Ahn et al. (2020) and Hanna et al. (2016) also found no significant differences in creatinine levels and demonstrated that urinary biomarkers such as neutrophil gelatinase-associated lipocalin (NGAL) and epidermal growth factor (EGF) outperform serum creatinine in predicting AKI (28, 29). These discrepancies may be attributed to the inherent limitations of serum creatinine, including its delayed rise following kidney injury and its dependence on maternal clearance mechanisms, particularly during the first 72 hours of life (30, 31).

Urinary output analysis indicated that although abnormal urine output was more frequently observed in neonates with low Apgar scores (12.5% vs. 2.5%), this difference did not reach statistical significance (P = 0.090). This observation aligns with the findings of Gupta et al. (2005), who reported no significant association between Apgar scores and urine output in neonates with perinatal asphyxia (32).

Finally, the incidence of AKI was significantly higher among neonates with low Apgar scores, with a 6.3-fold increased odds of developing AKI compared to those with normal scores. This finding indicates a strong association between perinatal asphyxia and early renal dysfunction in neonates, aligning with previous studies. Alaro et al. (2014) reported that neonates with stage III hypoxic-ischemic encephalopathy (HIE) had a 15-fold increased risk of developing AKI compared to those with stage I HIE, and the mortality rate among neonates with AKI related to perinatal asphyxia reached 71.4% (8). These results underscore the critical importance of early diagnosis and prevention of AKI in neonates affected by HIE and support our findings regarding the elevated risk of AKI in neonates with low Apgar scores.

Moreover, the study by Gedefaw et al. (2024) identified several predictors of AKI development in neonates, including cesarean delivery, prolonged labor, low birth weight, inadequate antenatal care, neonatal hyperkalemia, and stage III HIE (33). These multifactorial risk factors reflect the complex pathogenesis of AKI in neonates and emphasize the need for targeted monitoring and management of high-risk infants.

Limitations

While the matched design, use of standardized KDIGO criteria, and careful patient selection strengthen this study, its retrospective and single-center nature limit causal inference and generalizability. Nonetheless, it highlights the potential value of the Apgar score as a simple tool for early AKI risk assessment in the NICU.

Conclusion

This study revealed a significantly increased risk of AKI among neonates with low Apgar scores and those born at 28–32 weeks of gestation, indicating that both factors may serve as early clinical markers for identifying high-risk infants. Considering the known limitations of serum creatinine in early AKI detection, a multimodal diagnostic approach—including novel biomarkers— may enhance early diagnosis and management. Future prospective, multicenter studies with larger cohorts are needed to validate these findings and investigate other potential risk modifiers.

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None.

Conflicts of interest

The authors declare that they have no competing interests.

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