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Research Article

Factors Influencing Continuous Positive Airway Pressure Outcome in Neonates with Respiratory Distress in Resource-Constrained Settings: Experience from Mosul, Iraq

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Abstract

Background: Neonatal respiratory distress (RD) remains a leading cause of morbidity and mortality, particularly in low- and middle-income countries (LMICs) with limited resources. Continuous Positive Airway Pressure (CPAP) is a cornerstone of management, but its efficacy and factors influencing outcomes in such settings require further investigation. ***Objective***: To identify predictors of CPAP success or failure and subsequent survival in neonates with RD in a neonatal critical care institution in a post-conflict area like Mosul (a healthcare-constrained system). ***Methods***: This prospective observational study included 119 neonates initiated on CPAP. Data on demographics, clinical characteristics, CPAP outcomes (success/failure), and final patient outcomes (discharge/death) were collected. Univariate and multivariate logistic regression analyses were performed to identify independent predictors. ***Results***: Overall, 79(66.4%) neonates achieved CPAP success, while 40(33.6%) experienced failure. Birth weight ≤1500 g and a 5-minute APGAR score <7 were independent predictors of CPAP failure. Mortality occurred in 29.4% of cases, with 87.5% of deaths occurring among those who failed CPAP (p<0.001). In multivariate analysis, low birth weight remained the sole independent predictor of death. Kaplan-Meier survival analysis showed significantly reduced survival in neonates weighing 1500 g or less. ***Conclusions*:** Low birth weight and low APGAR are strong predictors of CPAP failure, increasing the risk of death. In resource-constrained settings, improving antenatal care, ensuring the availability of surfactants, and expanding access to mechanical ventilation may help improve outcomes for high-risk neonates requiring CPAP.

Keywords: CPAP outcome, LMICs, Neonatal respiratory distress, Neonatal mortality.

العوامل المؤثرة على نتائج ضغط مجرى الهواء الإيجابي المستمر لدى حديثي الولادة المصابين بضائقة تنفسية في ظروف محدودة الموارد: تجربة من الموصل، العراق

الخلاصة

الخلفية: لا تزال الضائقة التنفسية الوليدية سببا رئيسيا للمراضة والوفيات، خاصة في البلدان المنخفضة والمتوسطة الدخل ذات الموارد المحدودة. يعد ضغط مجرى الهواء الإيجابي المستمر (CPAP) حجر الزاوية في العلاج ، لكن فعاليته وعوامله المؤثرة على النتائج تتطلب مزيدا من التحقيق. **الهدف**: تحديد مؤشرات نجاح أو فشل CPAP والبقاء على قيد الحياة اللاحق لدى حديثي الولادة المصابين باضطراب التنفس في مؤسسة رعاية حرجة لحديثي الولادة في منطقة ما بعد النزاع مثل الموصل. **الطرائق**: تضمنت هذه الدراسة القائمة على الملاحظة المستقبلية 119 حديث الولادة بدأوا في العلاج التنفسي الإيجابي. تم جمع البيانات حول التركيبة السكانية والخصائص السريرية ونتائج CPAP (النجاح/الفشل) والنتائج النهائية للمريض (الخروج/الوفاة). تم إجراء تحليلات الانحدار اللوجستي أحادية المتغير ومتعددة المتغيرات لتحديد المتنبئين المستقلين. **النتائج**: حقق 79 (66.4٪) حديثي الولادة نجاحا في CPAP، بينما عانى 40 (33.6٪) من الفشل. كان الوزن عند الولادة ≥1500 جرام ودرجة APGAR لمدة 5 دقائق >7 تنبؤات مستقلة لفشل CPAP. حدثت الوفيات في 29.4٪ من الحالات، مع حدوث 87.5٪ من الوفيات بين أولئك الذين فشلوا في CPAP (p<0.001). في التحليل متعدد المتغيرات، ظل انخفاض الوزن عند الولادة هو المؤشر الوحيد المستقل للوفاة. أظهر تحليل البقاء على قيد الحياة في كابلان ماير انخفاضا كبيرا في البقاء على قيد الحياة لدى الأطفال حديثي الولادة الذين يزن 1500 جرام أو أقل. **الاستنتاجات**: انخفاض الوزن عند الولادة وانخفاض APGAR من المؤشرات القوية لفشل CPAP، مما يزيد من خطر الوفاة. في البيئات المحدودة الموارد، قد يساعد تحسين الرعاية السابقة للولادة، وضمان توافر المواد الخافضة للتوتر السطحي، وتوسيع نطاق الوصول إلى التهوية الميكانيكية في تحسين النتائج لحديثي الولادة المعرضين لمخاطر عالية والذين يحتاجون إلى CPAP.

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INTRODUCTION

Neonatal respiratory disorders are the most common reason for neonatal intensive care unit (NICU) admission in both preterm and term neonates [1]. Respiratory distress syndrome (RDS) is one of the initial complications that preterm infants face, which occurs due to insufficient surfactants in the lungs. The incidence of RDS is inversely related to gestational age, and its frequency declines significantly after 37 weeks of gestation [2]. RDS induces hyaline membrane formation within the lungs, leading to decreased lung

compliance and impaired gas exchange. During the initial three days of life, this condition increases respiratory effort, leading to hypoxia; if left untreated, it may progress to respiratory failure and even death [3]. Tachypnea and signs of respiratory distress are the hallmarks of transient tachypnea of the newborn (TTN), which typically manifest in the first two hours of life in late-preterm and term neonates [4]. It results from delayed fetal lung fluid absorption, leading to increased breathing to compensate for respiratory function impairment [5]. Ultimately, these respiratory disorders have a profound impact on neonatal health. Globally, neonatal mortality accounts for 46% of all under-5-year deaths [6]. In a resource-constrained setting, the case fatality rate due to neonatal respiratory distress can be as high as 20% [7]. When a newborn is having trouble breathing, CPAP is an effective, noninvasive way to help. It lowers the need for mechanical ventilation and the risk of death and bronchopulmonary dysplasia [8]. According to the 2022 European Consensus Guidelines, early initiation of CPAP is crucial for improving outcomes in neonates susceptible to respiratory distress syndrome [9]. It helps in maintaining functional residual capacity, reduces the work of breathing, and improves oxygenation, thereby preventing alveolar collapse and decreasing the need for surfactant and mechanical ventilation. However, its implementation encounters numerous challenges in resource-limited settings [10]. Clinical factors such as lower gestational age, severe respiratory distress, high fraction of inspired oxygen, and delayed CPAP initiation predict outcome [11]. However, in resource-constrained, post-conflict settings, factors like inadequate infrastructure, limited equipment, and untrained staff critically impede optimal CPAP delivery, leading to a significant gap in the literature [12]. This study aims to determine the CPAP outcomes in neonates with respiratory distress and to identify the factors associated with it, particularly in a city like Mosul, undergoing reconstruction after prolonged conflict. This knowledge will provide crucial insights to pinpoint areas for improving neonatal respiratory care.

METHODS

Study design and setting

A prospective observational study was conducted in the NICU of Al-Batool Teaching Hospital (ATH), the main neonatal critical care institution in Mosul, Nineveh Governorate, Iraq. This study aimed to identify factors associated with CPAP therapy success or failure and subsequent patient outcomes (discharge/death) in neonates admitted with respiratory distress. ATH handles approximately 19,000 annual births and 1500 NICU admissions, with capacity for 40 neonates concurrently. Care is provided by a consultant pediatrician, a general pediatrics resident, and nurses (1:5 patient ratio). The unit is equipped for concurrent CPAP therapy for up to 14 neonates using SLE1000 devices. Mechanical ventilation is limited to four neonates, and surfactant therapy was unavailable. Mosul's health system faces significant post-conflict rebuilding challenges. CPAP therapy was introduced and became a key respiratory care component in the hospital in 2022, making ATH a relevant setting to evaluate CPAP outcomes in a post-conflict, resource-limited environment.

Study population and data collection

This prospective study enrolled 119 neonates initiated on CPAP within their first 24 hours of life due to respiratory distress between December 2024 and April 2025. All neonates included in this study were inborn and admitted directly from the delivery room or operating theater within ATH. Inclusion criteria were gestational age ≥27 weeks, NICU admission within 24 hours, and clinical respiratory distress (tachypnea > 70/min, grunting, nasal flaring, retractions, or cyanosis). Neonates with major anomalies, sepsis, or those requiring intubation at birth were excluded. Pediatric residents used standardized forms for data collection. Gestational age was estimated via the New Ballard Score [13], and respiratory distress was assessed using the Silverman-Anderson Score (SAS) [14]. TTN was diagnosed based on tachypnea within the first hours of life, mild respiratory distress, and chest X-ray findings resolving within 72 hours. Variables collected included gestational age, birth weight, sex, mode of delivery, 5-minute Apgar scores, respiratory distress type, age at CPAP initiation, initial fraction of inspired oxygen (FiO_2), and maternal factors (antenatal steroid use, PROM). CPAP was initiated at a Positive End Expiratory Pressure (PEEP) of 5 cmH_2O (maximum 8 cmH_2O). FiO_2 was adjusted in 5% increments every 30 minutes (maximum 60%) to maintain peripheral oxygen saturation (SpO_2) ≥90%. Escalation to mechanical ventilation occurred (contingent on ventilator availability and clinical assessment) for ongoing hypoxia (SpO_2< 90%), SAS >6 despite maximal oxygen flow, or > 2 apnea episodes (cessation of breathing for a period of ≥ 20 sec, or a period < 20 sec that is associated with cyanosis or bradycardia) in 12 hours despite maximum PEEP at 8 cmH_2O. When no ventilator was available, patients were managed with maximal noninvasive support and continuous monitoring until a ventilator became available. Inter-facility referral was not routinely feasible due to limited neonatal ventilation capacity in the region. CPAP weaning was considered after 12-24 hours of stability on the current PEEP, with parameters including SpO_2 consistently >90%, SAS <3, and FiO_2 <27%. Following successful CPAP discontinuation, neonates were managed with nasal oxygen prongs (0.5–2 L/min) to maintain adequate oxygenation. All enrolled neonates are managed in incubators immediately upon admission and are kept euthermic and receive routine care: SpO_2,

vital signs monitoring, daily respiratory distress severity assessment, and random blood sugar testing for suspected hypoglycemia. Additionally, antibiotics were empirically initiated for all neonates as part of routine NICU protocol pending sepsis evaluation, and intravenous caffeine citrate was administered to premature neonate experiencing apnea.

Ethical considerations

The Research Ethics Committee of the College of Medicine, University of Mosul, approved the study protocol (UOM/COM/MREC/24-25/FEB10/B dated in 23/2/2025). Written informed consent was obtained from the parents.

Statistical analysis

Statistical analysis was conducted using SPSS version 23.0, with normality assessed by the Shapiro-Wilk test. Descriptive statistics summarized the study population using medians/IQRs for continuous variables and frequencies/percentages for categorical data. Univariate logistic regression examined associations between independent variables and outcomes (CPAP wean/fail, survival/death). This involved Chi-Square/Fisher's Exact Tests and Odds Ratios (OR) with 95% Confidence Intervals (CI) for categorical variables and Mann-Whitney U Tests for continuous variables. We used multivariate analysis to find independent predictors of CPAP success/failure and survival/death by looking at variables with $p<0.05$ and figuring out Adjusted Odds Ratios (AOR) with 95% CI. A p-value of < 0.05 was considered statistically significant. Kaplan-Meier survival analysis was also employed to ascertain survival time.

RESULTS

Of the 119 neonates included, 79 (66.4%) achieved CPAP success, while 40 (33.6%) experienced CPAP failure (Table 1). Gestational age, birth weight, and CPAP duration significantly deviated from normal distribution ($p< 0.05$).

Table 1: Descriptive statistics for the study population

Characteristics	Total n= 119	CPAP success (n=79)	CPAP failure (n=40)	*p*-value	Effect size (Cramer's V)
Sex					
Male	77(64.7)	56(70.9)	21(52.5)	0.067[f]	0.182
Female	42(35.3)	23(29.1)	19(47.5)		
Gestational age (median IQR)	33(30-36)	34(32-36)	29(27-32)	< 0.001[a]	
Gestational age group (week)					
≤32	54(45.4)	22(27.8)	32(80)	<0.001[f]	0.459
>32	65(54.6)	57(72.2)	8(20)		
Birth weight (median IQR)	1800 (1250-2500)	2300 (1700-2600)	1100 (907.5-1475)	<0.001[a]	
Birth weight group					
≤1500	44(37)	13(16.5)	31(77.5)	<0.001[f]	0.596
>1500	75(63)	66(83.5)	9(22.5)		
Mode of delivery					
NVD	49(41.2)	25(31.6)	24(60)	0.005[f]	0.272
C/S	70(58.8)	54(68.4)	16(40)		
Multiple birth					
Singleton	101(84.9)	74(93.7)	27(67.5)	0.002[c]	0.351
Twins	8(6.7)	2(2.5)	6(15)		
Triplets	5(4.2)	1(1.3)	4(10)		
Quadruple	5(4.2)	2(2.5)	3(7.5)		
5-minute APGAR score group					
< 7	31(26.1)	12(15.2)	19(47.5)	<0.001[f]	0.348
≥ 7	88(73.9)	67(84.8)	21(52.5)		
Type of respiratory distress					
RDS	85(71.4)	47(59.5)	38(95)	<0.001[c]	0.423
TTN	28 (23.5)	28 (35.4)	0(0.0)		
MAS	5 (4.2)	4 (5.1)	1(2.5)		
Neonatal pneumonia	1 (0.8)	0(0.0)	1(2.5)		
Duration of CPAP in days (median IQR)	3(2.0-4.0)	3(2.0-4.0)	3(2.0-4.75)	0.337[a]	
Maternal use of antenatal steroids					
Receive	23(19.3)	18(22.8)	5(12.5)	0.224[f]	0.123
Not receive	96(80.7)	61(77.2)	35(87.5)		
PROM					
Yes	10(8.4)	8(10.1)	2(5)	0.492[f]	0.087
No	109(91.6)	71(89.9)	38(95)		

Values were expressed as frequency, percentage, and median IQR. AOR: Adjusted Odds Ratio, [a] Mannwhinty U test, [c]Chi-square test, CI: Confidence Interval: C/S; Cesarian Section, FiO2: Fraction of inspired oxygen, [f]Fischer exact test, IQR: Interquartile Range, MAS: Meconium Aspiration Syndrome, NVD: Normal Vaginal Delivery, OR: Odds Ratio, PROM: Premature Rupture of Membrane, RDS: Respiratory Distress Syndrome, TTN: Transient Tachypnoea of Newborn.

The CPAP failure group exhibited notably lower median gestational age [29 weeks (IQR: 27-32) *vs*. 34 weeks (IQR: 32-36), $p< 0.001$] and median birth weight [1100 g (IQR: 907.5-1475) vs. 2300 g (IQR: 1700-2600), $p< 0.001$]. CPAP failure was strongly associated with neonates ≤32 weeks gestation (80% failure; Cramer's V: 0.459) and birth weight ≤ 1500 g (77.5% failure; Cramer's V: 0.596). Mode of delivery was significantly associated (p=0.005, Cramer's V: 0.272), with normal vaginal delivery (NVD) more prevalent in the CPAP failure group (60% *vs*. 31.6%). Multiple births are also significantly associated with failure (p= 0.002, Cramer's V 0.351). The 5-minute APGAR score significantly differed ($p< 0.001$, Cramer's V: 0.348), with scores < 7 more frequent in the failure group (47.5% *vs*. 15.2%). The respiratory distress type showed a highly significant difference ($p< 0.001$, Cramer's V 0.423). RDS was overwhelmingly common in the CPAP failure group (95% *vs*. 59.5% in success), while TTN was exclusive to the success group (35.4%). No statistically significant differences were observed for sex (p= 0.067), duration of CPAP (p= 0.337), maternal antenatal steroid use (p= 0.224), or premature rupture of membranes (p= 0.492). The overall mortality rate was 29.4%. CPAP failure was associated with 87.5% mortality (35/40), while all 79 weaned neonates survived, a statistically significant difference ($p< 0.001$). In Table 2 univariate analysis of factors influencing CPAP outcome (wean/fail) revealed several significant associations. Males had lower odds of CPAP failure (OR= 0.454, 95% CI: 0.206-0.998, p= 0.049). Gestational age ≤ 32 weeks was highly associated with CPAP failure (OR for weaning = 0.096, 95% CI: 0.039-0.242, $p< 0.001$). Similarly, birth weight ≤ 1500 g was highly linked to CPAP failure (OR for weaning = 0.057, 95% CI: 0.022-0.148, $p< 0.001$).

Table 2: Factors associated with CPAP outcome (wean/fail)

Baseline characteristic	Wean	Fail	Univariate analysis		Multivariate analysis	
			OR (95% CI)	*p*-value	AOR (95%CI)	*p*-value
Sex						
Male	56(72.7)	21(27.3)	0.454	0.049	0.572	0.300
Female	23(54.8)	19(45.2)	(0.206-0.998)		(0.199-1.646)	
Gestational age (week)						
≤32	22(40.7)	32(59.3)	0.096	<0.001	0.565	0.402
>32	57(87.7)	8(12.3)	(0.039-0.242)		(0.143-2.171)	
Birth weight (g)						
≤1500	13(29.5)	31(70.5)	0.057	<0.001	0.101	0.001
>1500	66(88)	9(12)	(0.022-0.148)		(0.026-0.387)	
Mode of delivery						
NVD	25 (51)	24 (49)	3.240	0.004	2.080	0.194
C/S	54 (77.1)	16 (22.9)	(1.470-7.143)		(0.689-6.280)	
5-minute APGAR score						
< 7	12(38.7)	19(61.3)	0.198	<0.001	0.271	0.029*
≥ 7	67(76.1)	21(23.9)	(0.083-0.474)		(0.084-0.877)	
Antenatal corticosteroids						
Receive	18(78.3)	5(21.7)	0.484	0.186	0.528	0.380
Not receive	61(63.5)	35(36.5)	(0.165-1.418)		(0.127-2.200)	
Age at initiation of CPAP (hr)						
≤ 6	69(66.3)	35 (33.7)	0.986	0.98		
> 6	10(66.7)	5(33.3)	(0.313-3.107)			
Initial FiO_2 (%)						
≤35	31(77.5)	9(22.5)	2.225	0.071		
>35	48(60.8)	31(39.2)	(0.933-5.303)			

Values were expressed as frequency and percentage. AOR: Adjusted Odds Ratio, CI: Confidence Interval, C/S; Cesarian Section, FiO_2: Fraction of inspired oxygen, IQR: Interquartile Range, NVD: Normal Vaginal Delivery, OR: Odds Ratio.

Neonates born via NVD had significantly higher odds of CPAP failure (OR= 3.240, 95% CI: 1.470-7.143, p= 0.004) compared to those born via C/S. A 5-minute APGAR score < 7 was also highly associated with CPAP failure (OR for weaning = 0.198, 95% CI: 0.083-0.474, $p< 0.001$). In multivariate analysis, birth weight ≤1500 g remained a highly significant independent predictor of CPAP failure (AOR for weaning = 0.101, 95% CI: 0.026-0.387, p= 0.001). Likewise, a 5-minute APGAR score < 7 persisted as a significant independent factor associated with CPAP failure (AOR for weaning = 0.271, 95% CI: 0.084-0.877, p= 0.029). Other factors (sex, gestational age, mode of delivery, antenatal corticosteroids, age at CPAP initiation, initial FiO_2) did not retain statistical significance. Univariate analysis of factors influencing CPAP outcome (discharge/death) revealed several significant associations (Table 3). Males had lower odds of death (OR= 0.378, 95% CI: 0.167-0.853, p= 0.019). Gestational age ≤ 32 weeks was highly associated with death (OR for discharge = 0.067, 95% CI: 0.023-0.192, $p< 0.001$). Similarly, birth weight ≤ 1500 g was highly linked to death (OR for discharge = 0.033, 95% CI: 0.011-0.101, $p< 0.001$). Neonates born via vaginal delivery had significantly higher odds of death (OR = 3.000, 95% CI: 1.329-6.773, p= 0.008) compared to those born via C/S. A 5-minute APGAR score < 7 was also significantly associated with death (OR for discharge = 0.258, 95% CI: 0.108-0.615, p=

0.002). In multivariate analysis, birth weight ≤1500 g remained a highly significant independent factor for outcome (AOR for discharge = 0.067, 95% CI: 0.016-0.280, $p< 0.001$). Other factors, including sex, gestational age, mode of delivery, 5-minute APGAR score, antenatal corticosteroids, age at CPAP initiation, and initial FiO_2, showed no statistically significant associations with CPAP outcome.

Table 3: Factors associated with CPAP outcome (discharge/death)

Baseline characteristic	Discharge	Death	Univariate analysis		Multivariate analysis	
			OR (95%CI)	*p*-value	AOR (95%CI)	*p*-value
Sex						
Male	60(77.9)	17(22.1)	0.378 (0.167-0.853)	0.019	0.464 (0.150-1.436)	0.183
Female	24(57.1)	18(42.9)				
Gestational age (wk)						
≤32	24(44.4)	30(55.6)	0.067 (0.023-0.192)	<0.001	0.471 (0.106-2.102)	0.324
>32	60(92.3)	5(7.7)				
Birth weight (g)						
≤1500	14(31.8)	30(68.2)	0.033 (0.011-0.101)	<0.001	0.067 (0.016-0.280)	<0.001
>1500	70(93.3)	5(6.7)				
Mode of delivery						
NVD	28(57.1)	2(42.9)	3.00 (1.329-6.773)	0.008	1.802 (0.520-6.246)	0.353
C/S	56(80)	14(20)				
5-minute APGAR score						
< 7	15(48.4)	16(51.6)	0.258 (0.108-0.615)	0.002	0.380 (0.101-1.425)	0.151
≥ 7	69(78.4)	19(21.6)				
Antenatal corticosteroids						
Receive	18(78.3)	5(21.7)	0.372 (0.207-1.801)	0.186	0.814 (0.179-3.695)	0.79
Not receive	66(68.75)	30(31.25)				
Age at initiation of CPAP (hr)						
≤ 6	74(71.2)	30(28.8)	1.233 (0.389-3.912)	0.722		
> 6	10(66.7)	5(33.3)				
Initial FiO_2 (%)						
≤35	32(80)	8(20)	2.077 (0.841-5.127)	0.113		
>35	52(65.8)	27(34.2)				

Values were expressed as frequency and percentage. AOR: Adjusted Odds Ratio, CI: Confidence Interval, C/S; Cesarian Section, FiO_2: Fraction of inspired oxygen, IQR: Interquartile Range, NVD: Normal Vaginal Delivery, OR: Odds Ratio.

Kaplan-Meier survival analysis for CPAP outcome (discharge/death) demonstrated a significantly higher survival ($p< 0.001$) for neonates > 1500 g (mean: 8.390 days) versus ≤ 1500 g (mean: 4.212 days). This indicates that lower birth weight is significantly associated with poorer survival outcomes from CPAP initiation (Figure 1).

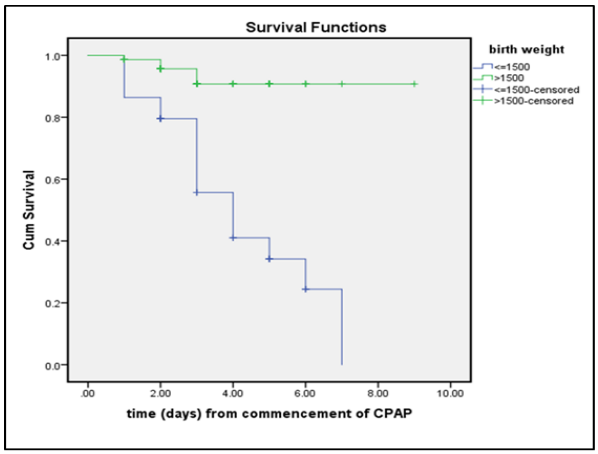

Figure 1: Kaplan–Meier survival curves showing cumulative survival probability among neonates receiving CPAP, stratified by birth weight (≤1500 g vs. >1500 g). Survival time was measured in days from initiation of CPAP until discharge or death. Neonates >1500 g had significantly higher cumulative survival and a longer estimated mean survival time (8.390 days) compared with those ≤1500 g (mean: 4.212 days). Censored observations are marked with cross (+) symbols. $p< 0.001$.

DISCUSSION

This study identified factors influencing CPAP success or failure and subsequent survival (discharge or death) in neonates with respiratory distress. The results of this study highlight critical determinants of CPAP efficacy and neonatal survival, consistent with existing literature, especially from similar settings. Our cohort's CPAP success (66.4%) and failure (33.6%) rates are comparable to recent LMIC studies [3,15], contrasting with 12% failure reported in France [16]. This underscores ongoing challenges in managing neonatal respiratory distress where advanced interventions, like surfactant therapy, are unavailable, as in our unit. Univariate analysis revealed that lower gestational age and lower birth weight were significantly associated with CPAP failure, consistent with other studies [2,17]. NVD was significantly associated with CPAP failure in the initial analysis, a finding consistent with Kamugisha *et al*. [18]. This may be due to complications like fetal distress, prolonged labor, or poor antenatal care, as only 19.3% of mothers received antenatal steroids. The lack of antenatal steroids in premature neonates can lead to severe respiratory compromise and less responsiveness to CPAP. However, this finding contrasts with Gromann *et al*. [19], who cited C/S as a respiratory morbidity risk factor. Multiple births and RDS were also significantly associated with CPAP failure, aligning with established risk factors [17]. The fact that RDS is so common (95%

of people in the CPAP failure group vs. 59.5% of people in the success group) shows how important it is as a main reason why CPAP fails, most likely because of a lack of surfactants. In the multivariate analysis, birth weight ≤1500 g independently predicted CPAP failure (AOR for weaning = 0.101, p= 0.001), consistent with Gulczyńska et al. [20], but contrasting with other studies [17,21]. This highlights the inherent vulnerability of very low birth weight infants due to immature lung development and reduced physiological reserves. Similarly, a low 5-minute APGAR score (AOR for weaning = 0.271, p= 0.029) independently predicted CPAP failure, aligning with Bopape-Chinyanga et al. [22], reflecting the initial severity of cardiorespiratory depression and potential underlying complications at birth. Interestingly, while gestational age, mode of delivery, and sex were significant in univariate analysis, they lost independent significance in the multivariate model. This suggests that their initial associations might be largely confounded by birth weight and APGAR score, which are often closely correlated with these factors. Regarding the final outcome of discharge versus death, the overall mortality was 29.4%. These results align with multiple studies conducted in LMICs [2,23], and sharply contrast with the 5.2% found by Boix et al. in Spain [24]. This study showed a significant association between CPAP failure and mortality, with 87.5% of CPAP failure cases resulting in death, compared to 0% in the weaned group (p< 0.001). This stark difference underscores the critical importance of successful CPAP management in preventing adverse outcomes. Univariate analysis of factors influencing CPAP outcome (discharge/death) revealed that females have higher odds of death (OR= 2.646, p= 0.019) compared to males. However, this finding on sex disparity in mortality contrasts with Hubbard *et al*. [23], who found no significant association. Neonates with gestational age ≤ 32 weeks were highly associated with death, showing a substantially lower likelihood of discharge (OR for discharge = 0.067, 95% CI: 0.023-0.192, p< 0.001), aligning with findings by Bulimba *et al*. [2]. Neonates with an Apgar score < 7 at 5 minutes had a higher mortality rate of 51.6% compared to 21.6% in those with an Apgar score ≥ 7 at 5 minutes (p< 0.002). Our findings are comparable to other studies [2,22,25]. Severe birth asphyxia, often reflected by a low APGAR score, can impair pulmonary surfactant production and function, increasing the risk of respiratory complications and mortality. In multivariate analysis, birth weight was the sole independent predictor of death, aligning with Bulimba et al. and Hubbard *et al*. [2,23] Neonates with birth weight ≤ 1500 g have higher mortality (68.2%) compared to neonates > 1500 g (6.7%). This could be attributed to the fact that neonates with lower birth weight were more premature and exhibited more severe illness [1].

Study limitations

A key limitation of the present study is its single-center observational design, which may limit generalizability. Furthermore, the unavailability of surfactant therapy in our NICU during the study period represents a significant contextual factor that likely influenced CPAP failure rates and survival outcomes. The severe constraint of four mechanical ventilators also significantly impacted patient outcomes following CPAP failure. Finally, blood gas analysis was not available for the assessment and ongoing monitoring of respiratory distress. Future multi-center studies incorporating varied resource settings and treatment availabilities would provide a more comprehensive understanding.

Conclusion

This study revealed low birth weight and low 5-minute APGAR scores as independent predictors of CPAP failure. Low birth weight was also established as an independent predictor of mortality in neonates with respiratory distress in a resource-constrained setting. The stark finding that 87.5% of CPAP failure cases resulted in death underscores the severe consequences of inadequate advanced respiratory support. These findings emphasize the development of targeted maternal and preterm care strategies, ensuring surfactant availability and increased mechanical ventilation capacity to improve CPAP outcomes and overall survival in similar environments.

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Conflict of interests

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Data sharing statement

Supplementary data can be shared with the corresponding author upon reasonable request.

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