

Prevalence and Predictors of Patent Ductus Arteriosus on Day 3 and Day 7 in Preterm Neonates: A Prospective Observational Study

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ABSTRACT

Introduction: Patent Ductus Arteriosus (PDA) refers to a persistent vascular connection between the pulmonary artery and the aorta. In a healthy newborn, this foetal vessel typically undergoes functional closure shortly after birth, followed by anatomical sealing. If the shunting is substantial, it can lead to significant haemodynamic instability. PDA is a common cardiovascular condition seen in neonates, particularly in preterm infants. As preterm birth is a significant contributor to neonatal mortality in India and other low-middle-income countries, understanding how PDA contributes to this burden is essential. By limiting the study to one specific rural hospital, the findings are highly relevant for similar settings and may serve as a baseline for future larger-scale or multicentric studies.

Aim: To determine the prevalence of PDA on day 3 and day 7 of life in preterm neonates admitted to a rural neonatal intensive care unit and to assess its determinants, particularly gestational age and birth weight.

Materials and Methods: The present prospective observational study was conducted in a rural tertiary care hospital, Neonatal Intensive Care Unit (NICU), Department of Paediatrics, at JNMC

and AVBRH, Sawangi (Meghe), Wardha, Maharashtra, India from January 2023 to September 2024. A total of 100 preterm neonates with gestational age up to 34 weeks admitted to the neonatal intensive care unit were included. Echocardiographic assessment was performed on day 3 of life and repeated on day 7 in neonates with PDA. Determinants such as gestational age and birth weight were analysed. Data were analysed using statistical software, and Chi-square test was used to find association of gestational age and birth weight with PDA. A p-value less than 0.05 was considered statistically significant.

Results: On day 3 of life, PDA was detected in 76% of preterm neonates. On repeat echocardiography on day 7, persistence of PDA was observed in 27% of neonates. Lower gestational age and lower birth weight were significantly associated with persistence of PDA, indicating prematurity as a major determinant.

Conclusion: The present study highlights PDA as a prevalent condition contributing significantly to early complications and death. The most affected infants were those born before 30 weeks of gestation and those with extremely low birth weights.

Keywords: Echocardiography, Haemodynamics, Premature birth, Very low birth weight

INTRODUCTION

Persistent vascular connection between the pulmonary artery and the aorta is termed as PDA. Anatomically, the ductus arteriosus arises just distal to the origin of the left subclavian artery [1]. In a healthy newborn, this foetal vessel typically undergoes functional closure shortly after birth, followed by anatomical sealing. After birth, as the infant transitions to a circulatory system, the continued presence of such a shunt becomes abnormal [1,2]. If the shunting is substantial, it can lead to significant haemodynamic instability. PDA is a common cardiovascular condition seen in neonates, particularly in preterm infants. In most term infants, however, the ductus arteriosus closes spontaneously within the first few days of life. Normally, this vessel constricts and closes shortly after birth as a response to increased oxygenation and decreased prostaglandin levels [3]. However, in preterm infants, this physiological closure is often delayed or absent due to their immature cardiovascular and respiratory systems [4]. When the ductus arteriosus remains patent, or open, after birth, it can result in significant haemodynamic instability and a range of complications, collectively termed as PDA.

It has been reported that the incidence of PDA is inversely related to both gestational age and birth weight. Globally, PDA is seen in about 30-60% of infants born <28 weeks and in 10-20% of those born between 30 and 32 weeks [5,6]. In preterm infants with Respiratory Distress Syndrome (RDS), the prevalence of PDA varies between

15-35% in those with a birth weight under 1800 g, and rises to 50-85% in those weighing less than 1200 g [7]. Hammoud MS et al., (2003) reviewed the records of 101 ventilated preterm infants under 34 weeks of gestation. PDA diagnosis was confirmed using echocardiography. The study found that 53.4% of these infants had a significant PDA [8]. Several risk factors were significantly associated with PDA, including lower gestational age and birth weight, maternal diabetes, Antepartum Haemorrhage (APH), multiple births, and female gender. Despite advancements in neonatal care and access to pharmacological and surgical interventions, timely detection and management of PDA remains a challenge-particularly in rural and resource constrained tertiary care centres.

The present study was conducted in a rural tertiary care hospital with the objective of determining the prevalence of PDA among preterm infants, and evaluating associated risk factors like early gestational age and low birth weight and their outcomes within this specific context. As preterm birth is a significant contributor to neonatal mortality in India and other low-middle-income countries, understanding how PDA contributes to this burden is essential. By identifying local prevalence and patterns, this study aims to improve early detection, appropriate intervention, and resource planning in neonatal units that cater to rural populations.

Most existing studies on PDA in preterm neonates are from urban, well-equipped neonatal intensive care units in high-income countries

[9,10]. There is also a lack of studies that clearly relate gestational age, birth weight, and early echocardiographic findings to short-term clinical outcomes in rural populations. Factors such as differences in antenatal care, delayed referrals, and variations in postnatal management are often not adequately addressed in existing literature. The novelty of present study lies in evaluating the prevalence of PDA in preterm infants in a rural tertiary care hospital using bedside echocardiography performed at standardised postnatal days (day 3 and day 7). This approach helps in understanding early ductal closure patterns and their relationship with gestational age and birth weight in a real-world rural NICU setting. The findings will provide locally relevant data that may help in early detection, better clinical decision-making, and development of practical PDA screening and management protocols for rural neonatal units.

By limiting the study to one specific rural hospital, the findings are highly relevant for similar settings and may serve as a baseline for future larger-scale or multicentric studies. It may also help in establishing standardised protocols for early screening and management of PDA in preterm infants in rural Neonatal Intensive Care Units (NICUs).

MATERIALS AND METHODS

The present study was a prospective, observational study conducted to determine the prevalence of PDA in preterm neonates admitted to a tertiary care rural hospital. The study was conducted in the NICU, Department of Paediatrics, at JNMC & AVBRH, Sawangi (Meghe), Wardha, Maharashtra, India. Data collection was carried out from January 2023 to September 2024. Prior to initiating study, ethical clearance was obtained from Institutional Ethics Committee (IEC) of Jawahar Lal Nehru Medical College, Wardha (ref.No. DMIHER (DU)/IEC/2023/907).

Inclusion criteria: Preterm neonates with gestational age up to 34 weeks who were admitted to the NICU during the study period.

Exclusion criteria: Neonates with congenital malformations, including congenital heart diseases other than PDA were excluded..

Sample size calculation: Sample size was not formally calculated and sampling was done based on convenience. Total 100 neonates fulfilling the eligibility criteria were included.

Study Procedure

After obtaining written informed consent from the parents or legal guardians, 100 eligible neonates were enrolled in the study. The preterm status of each neonate was verified by reviewing maternal antenatal records, including the Last Menstrual Period (LMP) and early pregnancy ultrasound reports, where available. Each enrolled neonate underwent bedside echocardiographic evaluation using a GE Vivid Versana colour flow doppler ultrasound system with an 11 MHz neonatal transducer. Echocardiography was performed on day 3 of birth, and a follow-up scan was conducted on day 7 of life if PDA was detected. These assessments were carried out by a neonatal fellow trained in advanced neonatal echocardiography in a quiet setting, without administering any sedative medications.

STATISTICAL ANALYSIS

Data were entered into Microsoft Excel and analysed using International Business (IBM) Machine Statistical Packages of Social Sciences (SPSS) statistics software. Chi-square test was used to find association of gestational age and birth weight with PDA and logistic regression was done. p-value less than 0.05 was considered statistically significant.

RESULTS

The majority of neonates (90%) fell within the 30-34 weeks gestational age range, as depicted in [Table/Fig-1]. gestational age range and

Variables	n (%)
Gestational age (weeks)	
<30	10 (10 %)
30-34	90 (90%)
Birth weight (kg)	
<1	6 (6%)
1-1.5	44 (44%)
1.5-2	34 (34%)
2-2.5	16 (16%)

[Table/Fig-1]: Gestational age-wise distribution in study group (N=100).

only 10% fell within <30 weeks. A total of 53% of the neonates were males and 47% were females. A 50% of the neonates had birth weight of up to 1.5 kg only.

A significant majority, 76% of the neonates were diagnosed with PDA, while 24% did not have this condition. The prevalence of PDA among the neonates on the seventh day after birth reduced to 27%, while 73% no longer showed signs of the condition [Table/Fig-2].

Category	Day 3 Prevalence n (%)	Day 7 Prevalence n (%)
No PDA	24 (24%)	73 (73%)
PDA	76 (76%)	27 (27%)

[Table/Fig-2]: Prevalence of PDA on day 3 and day 7.

The highest proportion of PDA cases occurred in neonates born before 30 weeks (60%), followed by those born between 30-34 weeks of gestation (23.33%) has been depicted in [Table/Fig-3]. The association between lower gestational age and persistence of PDA at day 7 was statistically significant ($p=0.001$), highlighting prematurity as a major risk factor for PDA.

Gestational age (weeks)	PDA at day 7 n (%)	p-value
<30 (n = 10)	6 (60%)	0.001
30-34 (n = 90)	21 (23.33%)	

[Table/Fig-3]: Association of gestational age with PDA at day 7 (n = 27).

Test of significance: Chi-square test

The highest proportion of PDA cases was observed in neonates weighing between <1 kg (66.7%), followed by those weighing less than 1-1.5 kg (47.8%). A marked decline in PDA occurrence was seen in neonates weighing 1.5-2 kg (5.9%). This association between lower birth weight and PDA persistence at day 7 was statistically significant ($p<0.001$), indicating that low birth weight is a strong determinant of PDA [Table/Fig-4].

Birth weight (kg)	PDA at day 7 n (%)	p-value
<1 (n=6)	4 (66.7)	0.001
1-1.5 (n=44)	21 (47.8)	
1.5-2 (n=34)	2 (5.9)	
2-2.5 (n=16)	0	

[Table/Fig-4]: Association of birth weight with PDA at day 7 (n = 27).

Test of significance: Chi-square test

Out of the 100 neonates included in the study, 86 (86%) successfully survived, indicating a favourable outcome in the majority of cases. However, 14 neonates (14%) succumbed to their illness, reflecting the mortality rate within this cohort. Mortality rate was significantly associated with PDA persistence on Day 7 ($p=0.003$) [Table/Fig-5].

The higher gestational age was significantly associated with improved survival outcomes (coefficient +0.43, $p=0.028$), indicating that more mature infants had better chances of survival. Similarly lower the birth weight decreased the survival outcome (coefficient -0.39, $p=0.045$) has been depicted in [Table/Fig-6].

S. No.	Outcome	N (%)	PDA at day 7	p-value
1.	Death	14 (14%)	8 (57.1%)	0.003
2.	Survived	86 (86%)	19 (22.1%)	

[Table/Fig-5]: The outcome distribution of the study population in terms of mortality and discharge N=100.

Test of significance: Chi-square test

Variable	Coefficient	p-value	Interpretation
Gestational age	+0.43	0.028	Higher gestational age increases survival
Weight	-0.39	0.045	Lower Birth weight decrease survival

[Table/Fig-6]: Logistic regression analysis of factors for survival.

DISCUSSION

The PDA remains a critical concern in neonatology, especially among preterm and low birth weight infants. The ductus arteriosus, a normal foetal structure, should close functionally within 24 hours of birth and anatomically within a few weeks in full-term neonates. However, in preterm neonates, this closure is often delayed or fails to occur, leading to persistent left-to-right shunting, which contributes to significant haemodynamic and pulmonary complications [11].

Present study found a high prevalence of PDA at day 3, post-birth (76%) among the neonates evaluated. This rate aligns with data from Bordbar A et al., (2019), who reported a PDA prevalence of 95.9%, and Park J et al., (2021), who observed PDA affecting 45.2% of Very Low Birth Weight (VLBW) infants nationally [12,13]. By day 7, the prevalence of PDA in this study dropped significantly to 27%, suggesting that spontaneous ductal closure or effective medical management occurred in a substantial number of neonates within the first week. This is consistent with the natural history of PDA described in the literature, where spontaneous closure is often observed within days to weeks after birth, particularly in more mature neonates [14]. This decline reflects the natural progression of ductal constriction and the impact of medical therapies during the critical first week of life. Tschuppert S et al., (2008) found that early identification of PDA size is crucial, as larger ductal diameters often predict failure of medical closure and may prompt earlier surgical intervention to prevent prolonged respiratory support [15].

The occurrence of PDA showed a strong association with gestational age. In the present study, 23.33% of PDA occurring in infants born between 30-34 weeks of gestation and 60% in those born before 30 weeks. This finding is consistent with existing literature, which reports that while transient ductal patency may be observed in term infants during the first 24 hours of life, the true incidence of persistent PDA in term neonates is extremely low, estimated at approximately 57 per 100,000 live births [16]. In contrast, the significantly higher occurrence in premature neonates is primarily attributed to physiological immaturity, reduced sensitivity of the ductal smooth muscle to oxygen, and delayed functional closure of the ductus arteriosus [16]. The association between lower gestational age and persistence of PDA in present study was found to be statistically significant ($p = 0.001$), emphasising prematurity as a major risk factor for PDA [16]. This is largely attributed to physiological immaturity and delayed functional closure of the ductus arteriosus. Koch J et al., (2006) observed that while spontaneous closure can occur in up to 34% of ELBW infants between 2-6 days of life, a large proportion of VLBW neonates eventually achieve closure within the first year [14].

The present study shows that 66.7 % neonates weighing less than one kg had persistent PDA at day 7 of life, clearly establishing the predominance of PDA in low and VLBW infants. This observation aligns with Park J et al., (2021), who reported that PDA affects 45.2% of VLBW infants and highlighted a growing preference for conservative management due to its association with better outcomes and lower mortality compared to surgical intervention [13]. This study's findings further support the conclusions by Pourarian S et al., (2016), who identified low birth weight, lower gestational age, and complications like RDS and low Apgar scores

as key risk factors for PDA [17]. In present study, the highest burden was among neonates in the 1-1.5 kg range, underlining the need for early screening and risk stratification in this vulnerable group. Pourarian S et al., emphasis on the value of echocardiographic screening between days 4 and 7 is relevant for timely identification and intervention [17]. Present study concludes that low birth weight as a key predictor of PDA. The decision-making in PDA treatment must balance the risks of intervention against potential benefits, with conservative management increasingly favoured, except in selected cases where surgical ligation may still improve survival. These findings underscore the need for tailored, evidence-based PDA management protocols that integrate birth weight, gestational age, and comorbid risk factors for optimal neonatal outcomes.

Limitation(s)

The present study has few important limitations that must be considered when interpreting its findings. First, it was conducted in a single tertiary NICU serving a predominantly rural population and the convenient sampling method was used; consequently, the results may not be generalisable to urban or better-resourced centres, where patient demographics, staffing patterns, and treatment protocols differ. Second, the observational window was short; echocardiographic follow-up ended at seven days of life, meaning late PDA reopening, prolonged cardiopulmonary morbidity, and later interventions were not captured, potentially underestimating the true clinical burden.

CONCLUSION(S)

The PDA remains a major challenge in the care of preterm neonates, particularly in resource-limited settings. The present study highlights PDA as a prevalent condition contributing significantly to early complications and deaths. On day 3 of life, nearly 76% of neonates had a persistent ductus, emphasising the importance of early and routine echocardiographic screening. Although the PDA closure rate improved to 49%, that is from 76% on day 3 to 27% on day 7, many infants continued to suffer from respiratory and haemodynamic instability. The most affected infants were those born before 30 weeks of gestation and those with extremely low birth weights (<1 kg). These infants often presented with low Appearance, Pulse, Grimace, Activity, Respiration (APGAR) scores, abnormal respiration, and pulmonary hypertension-indicators of their fragile physiological status. Classic clinical signs such as bounding pulses and cardiac murmurs were also common and should prompt early echocardiographic evaluation.

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