

# Newborns in intensive care: Apgar score predicts in fifth minute

Emerson Rocha (✉ [emersonrochaa1@gmail.com](mailto:emersonrochaa1@gmail.com))

Universidade Federal do Pará: Universidade Federal do Para

Lucio FG Rodrigues

UFPA: Universidade Federal do Para

Luciana FC Moraes

UFPA: Universidade Federal do Para

Gabrielly Coelho

UFPA: Universidade Federal do Para

Josiel Souza

UFPA: Universidade Federal do Para

Natália Costa

UFPA: Universidade Federal do Para

Sabrina Araújo

UFPA: Universidade Federal do Para

Ana Elisa Stroppa-Marques

UNESP: Universidade Estadual Paulista Julio de Mesquita Filho

Fabiana Gomes

FAMERP: Faculdade de Medicina de Sao Jose do Rio Preto

João Melo-Neto

UFPA: Universidade Federal do Para

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# Abstract

Apgar Score (AS) < 7 is a predictor of mortality. Survival is shorter in newborns, with AS<sup>5min</sup> < 7 and the use of invasive mechanical ventilation (IMV). Thus, the objective of this study was to analyze whether maternal, obstetric, anthropometric, and postnatal variables of newborns admitted to the neonatal intensive care unit (NICU) may be associated with AS<sup>5min</sup> < 7. If this score is a predictor of morbidity and mortality, and if factors most associated with the worse AS interfere with survival. This observational, retrospective, and quantitative study used a descriptive and inferential approach to analyze the medical records of patients of both sexes treated in the NICU of a tertiary hospital which is a recognized reference center of maternal and child health, during 2017. Data were collected to verify the relationship between AS values (AS<sup>5min</sup> < 7 and AS<sup>5min</sup> ≥ 7).

AS<sup>5min</sup> < 7 was associated with hypertensive disorders of pregnancy (HDP), premature rupture of the amniotic membrane, vaginal delivery, fetal trauma at birth, abdominal perimeter, and ventilatory support. Among these, HDP and the use of IMV were predictors of lower survival.

*Conclusion:* AS<sup>5min</sup> was associated with maternal, obstetric, anthropometric, and postnatal variables of neonates admitted to the NICU. Specific maternal and postnatal variables interfered with the survival of these newborns.

## Introduction

Over 3 million children are born annually in Brazil. Approximately 16% of deaths occur per 1,000 live births. Neonatal death accounts for about 70% of deaths in the first year of life. Prematurity is one of the most significant factors contributing to this high rate of neonatal mortality (approximately 7.2% of deaths in live births). The challenge is to reduce the infant mortality rate in this country [1].

The neonatal intensive care unit (NICU) is defined as a convenient environment, focused on the care of at-risk newborns with various abnormalities, including congenital and acquired diseases, or those at risk of death. Premature newborns (defined as those with a gestation period of fewer than 30 weeks and weighing less than 1 kg), or neonates who require invasive procedures, or those with highly complex clinical presentations, are also directed to the NICU. Immediate identification of all these conditions is essential for the maintenance and recovery of neonatal health [2].

The Apgar Score (AS) was developed in 1952 by the anesthesiologist, Virginia Apgar, as a scoring system that was used to standardize the evaluation of newborns after birth. This index has five components that indicate the well-being of newborns: skin color, muscle tone, heart rate, breathing, and reflexes. AS is an essential indicator despite the subjectivity of the evaluation. This scale converts clinical analyses into quantitative data and assisting the health team in making decisions to improve perinatal care [3].

For quantification, a score of 0 to 2 points is assigned. The result is reflective of the newborn's condition and should consider the following clinical factors: apnea, bradycardia, cyanosis, and hypotonia, among

other conditions. The measurement is carried out at 1-minute, 5-minute, and 10-minute after birth. However, if the newborn has a score lower than 7 in the first minute ( $AS^{1min} < 7$ ), the evaluation will be carried out at 5-minute intervals until the 20-minute interval. This provides a convenient measure to report the life conditions of the newborn in the immediate postpartum period, as well as the potential need for resuscitation [3].

An AS score is less than 7 in the fifth minute ( $AS^{5min} < 7$ ) after birth is associated with low neurological and cognitive functions. Immediate identification of high-risk newborns may reduce perinatal morbidity and mortality [3, 4]. If the AS is low and comorbidity such as bronchopulmonary dysplasia is present, there is an increased chance of delayed neuropsychomotor development in the premature neonate weighing less than 1500 g. This shows that the scale has great relevance in the prior identification of diseases and conditions associated with the neurological system [5].

AS is used clinically as a screening tool to identify newborns who require greater attention, close observation, and/or intervention. Factors associated with  $AS^{1min}$  and  $AS^{5min} < 7$  should be analyzed in clinical research to gain a better understanding of the different aspects and also, the negative implications [6]. Information on how these scores may indicate morbidity and mortality of newborns is scarce.

A low AS on this scale ( $AS^{1min}$  and  $AS^{5min} < 7$ ) is correlated with increased mortality. This aspect has stimulated much research [7]. Therefore, understanding the clinical importance of a low AS has been stimulated and further research to analyze the possible contributing factors is needed [8].

It is important to emphasize that the influence of these factors has been rarely studied in Brazil. Pediatric health teams need more information to assist in clinical practice. Therefore, this study aimed to analyze whether maternal factors, obstetric factors, anthropometric data, and postnatal variables of neonates admitted to the NICU are associated with  $AS^{1min}$  and  $AS^{5min} < 7$ . This study also aimed to analyze whether this score is a predictor of morbidity and mortality and whether factors associated with the worst AS interfere with survival.

## **Materials And Methods**

### **Ethical Aspects**

The research was conducted after approval by the Research Ethics Committee, n. 2,442,015. The design was performed in accordance with the ethical principles provided in Resolution 466/12 of the National Health Council of Brazil and was conducted as per the Declaration of Helsinki.

### **Study Design**

This study was designed as an observational, retrospective and quantitative study. Descriptive and inferential approaches were used.

## Characterization of the place and period of study

The study collected data from the medical records of patients treated at Santa Casa de Misericórdia de Belém, PA, Brazil, during 2017. The hospital is a tertiary reference center for maternal and child health.

## Participants

For this study, the researchers had access to a total of 651 records collected in 2017 by a multidisciplinary team at Hospital Santa Casa de Misericórdia de Belém, PA. These records were all randomly organized. Each medical record was assessed to determine whether all the necessary items were correctly filled in and written legibly before inclusion for analysis. The study involved neonates of both sexes admitted to the neonatal intensive care unit (NICU).

## Sampling

Sampling was probability-based. It was a simple random sample.

## Sample

Data from 651 medical records were initially collected. Of these, 240 were selected after considering the inclusion and exclusion criteria. The minimum number of 217 medical records ( $AS^{5min} < 7$ :  $n=65$ ;  $AS^{5min} \geq 7$ :  $n= 152$ ) was needed for the analysis, based on sample size calculations and pilot data from this study. Analyses were performed using the odds ratio (OR: 2.3199). The association between the use of invasive mechanical ventilation (IMV) and the values of neonates with  $AS^{5min} < 7$  and  $AS^{5min} \geq 7$  was analyzed. For this calculation, the following parameters were established: one-tail, proportion  $p_2$ : 0.67, relation of allocation  $N_2/N_1$ : 0.43, error  $\alpha = 0.05$ , and  $\beta = 0.2$ .

## Exclusion Criteria

We excluded patients with  $AS^{1min} \geq 7$  and incomplete medical records that prevented data analysis.

## Inclusion Criteria

This study included the medical records of neonates who presented with  $AS^{1min} \leq 7$  and  $AS^{5min} < 7$  and  $\geq 7$ . The medical records included were categorized into two groups:  $AS^{5min} < 7$  and  $AS^{5min} \geq 7$ , for comparison between the factors, analyzed for the primary outcomes.

## Data Collection

For data collection, we used a form elaborated by the authors, including maternal factors, obstetric factors, and anthropometric and postnatal data of the newborn. After completing the form, all data were tabulated and compared to verify the relationship between the values, AS ( $AS^{5min} < 7$  versus  $AS^{5min} \geq 7$ ), and the different factors.

## Primary Outcomes

The maternal factors analyzed were gestation time, number of deliveries, occurrence of abortion, number of pregnancies, absent prenatal care, gestational complications (leukorrhea, hypertensive disorders of pregnancy [HDP], anemia, urinary tract infections [UTIs], premature labor, premature rupture of membranes, and sexually transmitted infections [STIs]).

The obstetric factors studied were amniotic fluid (clear with or without lumps, thick, thin, or bloody meconium), type of delivery (cesarean or vaginal), use of spinal anesthesia, fetal presentation (cephalic, pelvic, or umbilical cord around the fetal neck), fetal trauma at birth, single delivery, and amniotic membrane condition (intact or ruptured).

Anthropometric data included height, weight, cephalic perimeter, thoracic perimeter, abdominal perimeter, and capillary glycemia.

The clinical variables in the postnatal evaluation were signs of respiratory failure (apnea, cyanosis, nasal flaring, retraction [intercostal, subcostal, supracostal], wailing), resuscitation maneuvers, use of ventilatory support (continuous positive airway pressure [CPAP], invasive mechanical ventilation [IMV], and surfactant), complications (jaundice, bleeding, atelectasis, and pneumonia), length of hospital stay, and mortality.

## Statistical Analysis

After verifying the normality of the data via the Lilliefors test, they were presented as means and standard deviations (parametric data) or medians with interquartiles (first and third) (non-parametric data). To verify intergroup differences, non-paired t-tests (parametric data) and Mann-Whitney (nonparametric data) tests were used. Categorical variables were presented as absolute frequencies. The chi-squared test with Yates's correction was used to analyze the association between categorical variables. To quantify the level of association, odds ratios (OR) with 95% confidence intervals (95% CI) were used. Subsequently, the data most associated with the worst AS were submitted for survival analysis. For the analysis of life expectancy, the calculation was performed considering the life period from birth to the occurrence of the event corresponding to death. In addition, the Log-rank, Breslow, and Tarone-Ware tests were used to analyze each independent variable along with the Kaplan-Meier survival curves.

## Results

Maternal age did not differ between the two groups ( $AS^{5min} \geq 7$ : 25 [20–31] years;  $AS^{5min} < 7$ : 23.5 [19.75–29.25] years; Mann-Whitney test  $p = 0.5098$ ). The maternal and obstetric factors analyzed are presented in (Tables 1 and 2) respectively.

Table 1

Maternal factors of neonates admitted to the NICU who presented Apgar score  $\geq 7$  or  $< 7$  in the fifth minute.

	AS <sup>5min</sup> $\geq 7$ n = 168	AS <sup>5min</sup> $< 7$ n = 72	OR	95% CI	p
<b>Gestation time</b>					
$\leq 24$ weeks	24	13	1.3220	0.6309–2.7705	0.5850
25–28 weeks	35	11	0.6852	0.3262–1.4394	0.4105
29–32 weeks	52	24	1.1154	0.6188–2.0104	0.8321
33–36 weeks	41	14	0.7477	0.3782–1.4782	0.5027
37–40 weeks	13	9	1.7033	0.6932–4.1850	0.3537
NI	3	1			
<b>Number of deliveries</b>					
00	54	29	1.4238	0.8039–2.5215	0.2864
01	52	23	1.0471	0.5783–1.8959	1.0000
02	28	8	0.6250	0.2699–1.4471	0.3642
$\geq 03$	28	8	0.6250	0.2699–1.4471	0.3642
NI	6	4			
<b>Abortion</b>					
00	125	53	0.9596	0.5119–1.7986	0.9743
01	27	9	0.7460	0.3316–1.6783	0.6081
$\geq 02$	8	5	1.4925	0.4711–4.7288	0.7089
NI	8	5			
<b>Number of pregnancies</b>					
00	0	2	11.950	0.5661–252.29	0.1632
01	61	30	1.2529	0.7126–2.2029	0.5230
02	37	16	1.0116	0.5204–1.9665	0.8920
$\geq 03$	64	21	0.6691	0.3687–1.2144	0.2388
NI	6	3			

NI: not informed. HDP: hypertensive disorders of pregnancy. \* significant values.

	AS <sup>5min</sup> ≥ 7 n = 168	AS <sup>5min</sup> < 7 n = 72	OR	95% CI	p
<b>Absent prenatal</b>	28	12	1.000	0.4766–2.098	1.0000
<b>Gestational complications</b>					
Leukorrhea	116	23	0.2104	0.1162–0.3810*	0.0001*
HDP	21	19	2.5094	1.2518–5.0308*	0.0140*
Anemia	16	3	0.4130	0.1165–1.4642	0.2511
Urinary tract infection	61	31	1.3263	0.7556–2.3279	0.4008
Premature labor	35	15	1.000	0.5066–1.974	1.0000
Premature rupture of membrane	13	6	1.0839	0.3950–2.9740	0.9169
Sexually transmitted infections	4	1	0.5775	0.0634–5.2586	1.0000
NI: not informed. HDP: hypertensive disorders of pregnancy. * significant values.					

Table 2  
Obstetric factors of neonates admitted to the NICU who presented Apgar score  $\geq 7$  or  $< 7$  in the fifth minute.

	AS <sup>5min</sup> $\geq 7$ n = 168	AS <sup>5min</sup> $< 7$ n = 72	OR	95% CI	p
<b>Amniotic fluid</b>					
Clear with lumps	46	18	0.8841	0.4698–1.6634	0.8236
Clear without lumps	62	25	0.9094	0.5104–1.6203	0.8604
Thick meconium	13	10	1.9231	0.8013–4.6153	0.2134
Thin meconium	9	3	0.7681	0.2018–2.9243	0.9485
Bloody	5	4	1.9176	0.4997–7.3596	0.5531
NI	33	12			
<b>Type of delivery</b>					
Caesarean	101	25	0.3529	0.1985–0.6271*	0.0005*
Vaginal	60	46	3.1846	1.7916–5.6607*	0.0001*
NI	7	1			
<b>Spinal anesthesia</b>	91	25	0.4501	0.2540–0.7977*	0.0088*
<b>Fetal presentation</b>					
Cephalic	108	50	1.2626	0.6982–2.2834	0.5328
Pelvic	46	15	0.6979	0.3599–1.3533	0.3650
UCAFN	3	1	0.7746	0.0792–7.5753	0.7413
NI	11	9			
<b>Fetal trauma at birth</b>	46	35	2.5088	1.4142–4.4506*	0.0024*
<b>Single delivery</b>	144	66	1.8333	0.7155–4.6973	0.2870
<b>Amniotic membrane</b>					
Intact	85	27	0.5859	0.3330–1.0307	0.0850
Rupture	37	31	2.6770	1.4806–4.8402*	0.0016*
NI	46	14			
NI: not informed. UCAFN: umbilical cord around fetal neck. * significant values.					

Among the maternal factors analyzed, leukorrhea was associated with  $AS^{5min} \geq 07$  and HDP was associated with  $AS^{5min} < 7$ . For obstetric factors, vaginal delivery, fetal trauma at birth, and premature rupture of the amniotic membrane were associated with  $AS^{5min} < 7$ , while cesarean delivery and spinal anesthesia were associated with higher  $AS^{5min}$ .

Male neonates were more prevalent in both groups ( $AS^{5min} \geq 7$ :  $n = 100$ ;  $AS^{5min} < 7$ :  $n = 43$ ). Table 3 presents anthropometric data of the neonates. The abdominal perimeter of the neonates with  $AS^{5min} < 7$  was greater than that of the neonates with  $AS^{5min} \geq 7$ .

Table 3  
Anthropometric data of neonates admitted to the NICU who presented Apgar score  $\geq 07$  or  $< 07$  in the fifth minute.

	<b><math>AS^{5min} \geq 07</math></b>	<b><math>AS^{5min} &lt; 07</math></b>	<b>P</b>
	<b>n = 168</b>	<b>n = 72</b>	
<b>Height (cm)</b>	40 [35–46]	40 [33.75–46.20]	0.9264
<b>Weight (g)</b>	1407.5 [914–2111]	1625 [951–2352]	0.3177
<b>Cephalic perimeter (cm)</b>	28.5 [25–32]	29.25 [25–33.12]	0.3863
<b>Thoracic perimeter (cm)</b>	24 [21–28]	25.25 [22–29]	0.2496
<b>Abdominal perimeter (cm)</b>	23 [19–26]	24.5 [20–28]	0.0376*
<b>Capillary glycemia</b>	74 [60–100]	89.5 [58.25–111]	0.2900
* Significant values.			

The clinical variables in the postnatal period are presented in (Table 4). Neonates with  $AS^{5min} < 7$  were associated with the use of CPAP and IMV. Neonates with higher AS remained longer in the NICU ( $AS^{5min} \geq 7$ : 15 [5–29];  $AS^{5min} < 7$ : 06 [2–24.75]; Mann-Whitney test  $p = 0.0215$ ). Neonates with  $AS^{5min} < 7$  were twice as likely to die than neonates with  $AS^{5min} \geq 7$ .

Table 4

Postnatal variables of neonates admitted to the NICU with Apgar score  $\geq 7$  or  $< 7$  in the fifth minute.

	AS <sup>5min</sup> $\geq 7$ n = 168	AS <sup>5min</sup> $< 7$ n = 72	OR	95% IC	p
<b>Signs of respiratory failure</b>					
Apnea	35	23	1.7837	0.9598–3.3148	0.0933
Cyanosis	60	22	0.7920	0.4379–1.4323	0.5328
Nasal flaring	98	41	0.9447	0.5405–1.6511	0.9545
Wailing	72	24	1.529	0.3742 to 1.188	0.2163
Retraction	114	49	1.0092	0.5584–1.8238	0.9039
<b>Resuscitation</b>	150	67	1.6080	0.5730–4.5124	0.5029
<b>Ventilatory support</b>					
CPAP	22	46	11.7413	6.0842–22.6583*	0.0001*
IMV	61	41	2.3199	1.3217–4.0720*	0.0048*
Surfactant	65	33	1.3408	0.7675–2.3426	0.3743
<b>Complications</b>					
Jaundice	69	26	0.8110	0.4583–1.4351	0.5646
Bleeding	21	5	0.5224	0.1889–1.4447	0.2972
Atelectasis	3	1	0.7746	0.0792–7.5753	0.7414
Pneumonia	15	2	0.2914	0.0649–1.3091	0.1534
<b>Mortality</b>	59	39	2.1834	1.2453–3.8280*	0.0091*
* significant values.					

According to the analysis of the survival curve, we observed that differences exist between newborns admitted to the NICU of mothers who presented HDP (A) and who made use of IMV, with shorter survival in patients with AS<sup>5min</sup>  $< 07$  (Fig. 1). Lastly, the other variables did not differ between the groups.

## Discussion

The Apgar score contributes to the improvement of perinatal care by converting clinical analyses into quantitative data [3]. However, studies are needed to verify the clinical implications. In this context, this study found that neonates with AS<sup>5min</sup>  $\geq 7$  were associated with the presence of gestational leukorrhea and a longer stay in the NICU. Furthermore, AS<sup>5min</sup>  $< 7$  is associated with HDP, premature rupture of the

amniotic membrane, vaginal delivery, fetal trauma at birth, abdominal perimeter, and the use of ventilatory support. Among these, HDP and use of IMV were identified as predictors of lower survival. However, we observed that mortality was higher in neonates with  $AS^{5min} < 7$ .

$AS^{5min} \geq 7$  was associated with the maternal factor, gestational leukorrhea. Leukorrhea refers to the presence of vaginal discharge of liquid, except blood, through the vagina.<sup>9</sup> In pathological cases, the main factors are STIs, young women, non-stable marital relationships, multiple sexual partners, sexual intercourse without using a condom, and the black race [9]. The results of our study showed that STIs and age were not different findings in our study.

HDP was related to  $AS^{5min} < 7$ . HDP refers to a diastolic blood pressure of at least 90 mmHg or systolic blood pressure of at least 140 mmHg over a period of at least 6 h. [10–12]. This relationship has been observed in previous studies [10–13]. The presence of polycythemia is a determining factor for the higher incidence of birth asphyxia [10]. HDP may impair uteroplacental circulation, generate an imbalance in maternal homeostasis, facilitate pathophysiological changes in the placenta, and increase the risk of fetal hypoxia due to vascularization deficiency, [10, 14]. thereby resulting in lower survival, as observed in this study.

Premature rupture of membranes (PROM) was another maternal factor related to  $AS^{5min} < 7$ . This variable was associated with all preterm births [15, 16]. The presence of this maternal factor in premature neonates with low AS was associated with an increased mortality [17].

Vaginal delivery and fetal trauma at birth were associated with  $AS^{5min} < 7$ , as confirmed in the literature [18, 19]. Fetal trauma at birth is defined as any sign or trauma found in the newborn after birth. The presence of fetal trauma at birth may be related to obstetric and demographic factors, or maybe related to maternal anatomical characteristics [18, 19].

The abdominal perimeter was higher in neonates with  $AS^{5min} < 7$ . Anthropometric data contributed positively to a general analysis of this condition in a newborn [20]. Abdominal circumference after birth has been related to the resistance of the anterior abdominal wall, phase of breathing, and amount of fat [21]. These factors can directly influence ventilatory mechanics.

Moreover,  $AS^{5min} < 07$  was associated with the use of ventilatory support, and IMV was a predictor of lower survival in the first days of life.  $AS^{5min} < 07$  may suggest a higher probability of perinatal asphyxia [22, 23]. In this way, several maneuvers were used to reverse this condition including CPAP and IMV.

In addition, this study found that  $AS^{5min}$  in neonates with  $AS^{1min} < 7$ , is directly related to newborn mortality. Previous studies [3, 24, 25].. analyzing only  $AS^{5min}$  corroborated with the results of this research. However, the survival of the newborn seems to be directly related to immediate postnatal conditions [3, 24, 25].  $AS^{5min} \geq 7$  was associated with a longer length of stay in the NICU. Concerning the

longer length of stay in the NICU, the longer survival presented by these neonates should also be considered.

Thus, we believe that there is a need for professional follow-up during the gestational, perinatal, and postnatal periods. Prenatal care is essential because it minimizes the possibilities of complications during pregnancy, and enable clinical and laboratory findings to be added to the standard clinical evaluation [26]. The follow-up of the newborn during other developmental phases may further contribute to guiding clinical practice. The relevant factors found in this study should also be considered.

## Conclusion

$AS^{5min} \geq 7$  was associated with the presence of gestational leukorrhea and prolonged stay in the NICU. In addition, it was observed that HDP, vaginal delivery, fetal trauma at birth, and premature rupture of the amniotic membrane are predictors of  $AS^{5min} < 7$ , indicating a greater need for ventilatory support. Furthermore, lower scores at  $AS^{5min}$  were predictors of mortality. Finally, we conclude that survival is lower in newborns with  $AS^{5min} < 7$ , born to mothers with HDP, and the use of IMV.

## Abbreviations

AS - Apgar Score

CPAP - Continuous positive airway pressure

HDP - Hypertensive disorders of pregnancy

IMV - Invasive mechanical ventilation IMV

NICU - Neonatal intensive care unit

PROM - Premature rupture of membranes

STIs - Sexually transmitted infections

UTIs - Urinary tract infections

## Declarations

**Ethical approval:** The use of data was approved by the Research Ethics Committee Institutional, n° 2.442.015 in line with the ethical principles set out in the Resolution 466/12 of the National Health Council, conducted in accordance with the Helsinki Declaration.

**Consent for publication:** Not applicable

**Availability of data and material:** All data were made available by the Hospital in maternal and child health Fundação Santa Casa de Misericórdia do Pará - Brazil

**competing interest:** The authors declare that they have no conflicts of interest

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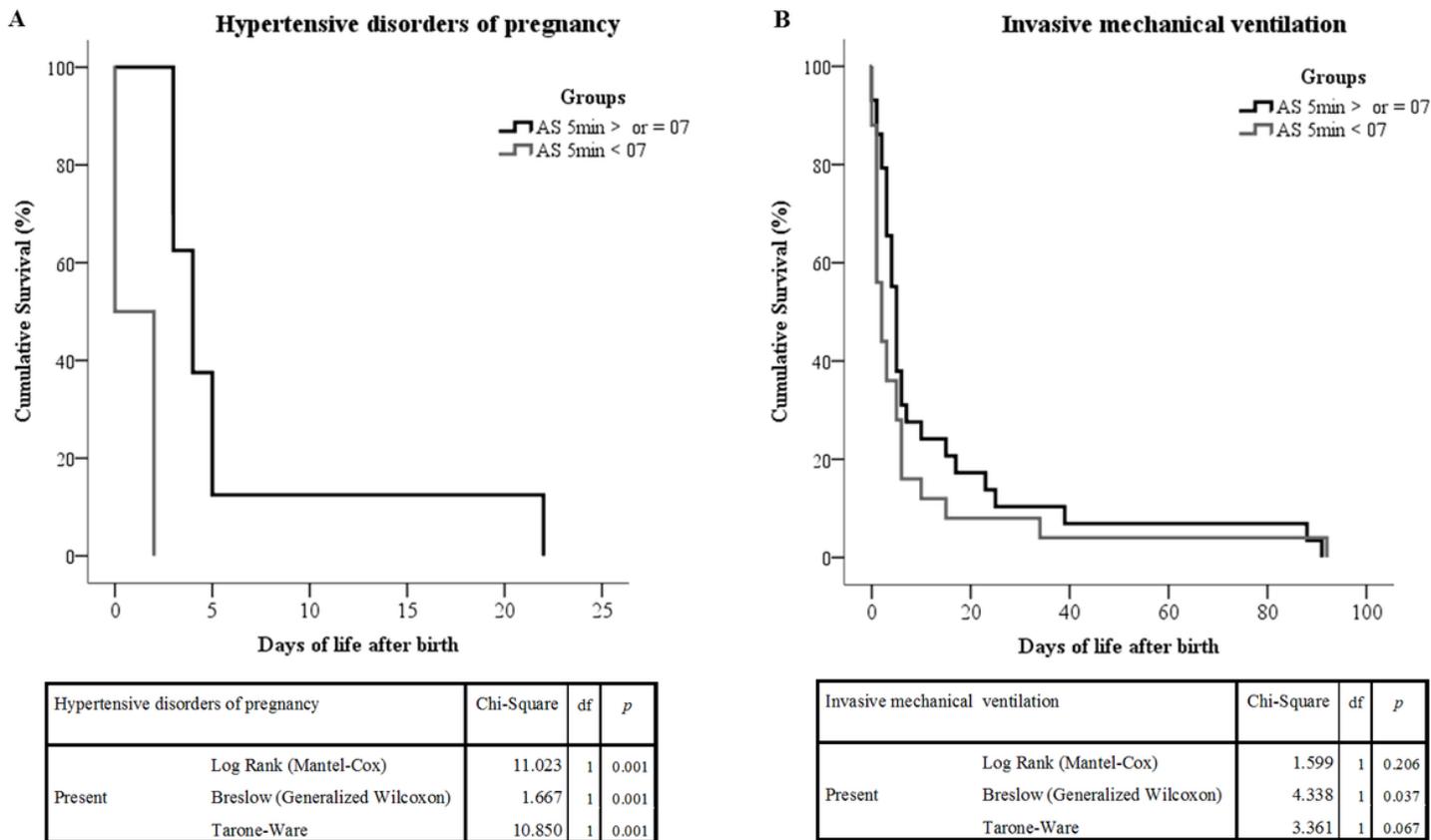
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## Figures



**Figure 1**

Kaplan-Meier survival curves for newborns admitted to the ICU of mothers who presented hypertensive disorders of pregnancy (A) and who made use of invasive mechanical ventilation (B), in accordance with Apgar score  $\geq 7$  or  $< 7$  in the fifth minute.