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Body Temperature on Admission and its Association with Neonatal Mortality and Morbidity in Neonatal Intensive Care Unit

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Abstract:

Background: This research sought to examine the relationship between hypothermia and poor newborn outcomes and death in neonates hospitalized to the intensive care units (NICU) of Benha University Hospitals. Raise awareness of the significance of keeping a normal temperature in neonates.Methods: This research was done on all newborns hospitalized to Benha University Hospital's Neonatal Intensive Care Unit (NICU) throughout the study period. At the time of admission, axillary and rectal temperatures were taken.Results: The research included 288 newborns who were further categorised based on their outcome: Survived group: included 227 neonates (78.8 percent), with a mean gestational age of 35.42.9 weeks. The average age of the infants in the group that perished was 31.93.8 weeks.Conclusion: The correlation between body temperature and gestational age, Apgar score, and weight is favourable. Hypothermia was related with mortality and sequelae such as an increase in the demand for and duration of oxygen support, pulmonary haemorrhage, sepsis, intravascular haemorrhage, and necrotizing enterocolitis. To decrease hospital admission hypothermia, more active methods are necessary.

Keywords: Hypothermia, Neonatal mortality, Neonatal Intensive Care Unit

1. Introduction

Every year, around 2.5 million babies die during the first four weeks of life. Even in warm tropical climes, neonatal hypothermia has been regarded a significant cause of death and morbidity among infants with low birth weight and normal birth weight [1]. A substantial proportion of high-risk and LBW children were hypothermic upon arrival, making it a serious global health concern, but its precise impact to neonatal death may be difficult to ascertain [2]. Hypothermia was linked to hypoglycemia, metabolic acidosis, hypoxia, respiratory distress syndrome (RDS), chronic lung disease, coagulation defects, intraventricular haemorrhage, sepsis, and increased insensible water loss resulting in dehydration, fluid and electrolyte imbalance, and hypotension [3]. The World Health Organization (WHO) suggests classifying hypothermia into mild (36.0°C-36.4°C), moderate (35.9°C-32.0°C), and severe (32.0°C) categories. Sodemann et al. argue that the existing "moderate" temperature range (32.0°C-35.9°C) is too broad since it is associated with vastly varied outcomes. Therefore, they suggested lowering the "severe" temperature category to 34.0°C. This new categorization method more accurately represents future mortality risk throughout the range of measured temperatures, raises awareness of hypothermia by extending the most severe group, and enables a more effective approach to take relevant steps [4]. As a consequence of their huge surface area-to-body mass ratio and poor thermoregulation, preterm newborns have difficulties regulating body temperature after delivery, and hypothermia may readily ensue [5]. WHO recommends maintaining newborn body temperature between 36.5°C and 37.5°C [6].

In 2012, the American Academy of Pediatrics/American College of Obstetrics and Gynecologists issued recommendations supporting a delivery room axillary temperature range of 36.5°C to 37.4°C (DR). Numerous research have proposed methods to avoid hypothermia, such as plastic wrapping without drying, head covering with a hat, and the use of radiant heaters and exothermic mattresses. Recent studies have shown that a considerable number of preterm newborns in high-resource nations are unable to maintain normothermia after birth, despite the understanding and development of novel ways to better manage body temperature [7]

2. Patients and Methods

This research included all newborns hospitalized to the Neonatal Intensive Care Unit (NICU) at Benha University Hospitals between December 2022 and July 2022. All live-born neonates born in or transferred to our hospital throughout the research period met the inclusion criteria. Exclusion criteria: infants with any congenital anomaly or chromosomal disorder, infants who did not have data on admission temperature taken within one hour of admission, infants who were sent to other

institutions, and neonates who did not provide informed consent.

All neonates were evaluated based on their personal history, gestational age, gender, and prenatal history, as well as any maternal risk factors during pregnancy, such as smoking. Chronic medical disease -infection- substance addiction - polyhydramnios - premature membrane rupture - trauma. Multiple gestation – foetal distress erythroblastosis fetalis are foetal risk factors. Antenatal steroid: dexamethasone or betamethasone administered intramuscularly (IM) (total 24 mg in divided doses). Place and method of birth, APGAR score at 1 and 5 minutes, and the primary reason for admission to the NICU. In addition to clinical evaluation, vital signs and anthropometric measures (Weight and Head circumference).

Axillary and rectal temperatures were measured using digital thermometers in degrees Celsius. The entrance temperature was defined as the infant's axillary or rectal temperature taken within one hour of admission to the NICU, in line with local protocols.

Because the WHO definition of mild hypothermia has a broad temperature range (32.0°C–35.9°C) and severe hypothermia (32.0°C) is relatively uncommon, we categorized the babies into 5 groups based on their admission temperature: Moderate hypothermia 35.0°C–35.9°C, Mild hypothermia 36.0°C–36.4°C, Normal temperature 36.5°C–37.5°C, Hyperthermia >37.5°C [8]

Each infant was monitored until discharge, and death and morbidity due to all causes were reported.

Utilization of mechanical ventilation, CPAP, HHHNFC, and length of treatment. Detection of consequences such as pulmonary haemorrhage, sepsis, necrotizing enterocolitis, and intravascular haemorrhage Hospital length of stay and death rate

Ethical considerations:

Approval of the study protocol by ethical scientific committee of Benha university hospital was obtained & informed consent was obtained from the parents before enrollment in the study.

Data Collection And Analysis:

The acquired data was reviewed, tagged, and tabulated using the 2017 release of IBM's Statistical programme for Social Science. IBM SPSS Statistics for Windows, Version 25.0 (Armonk, New York: IBM Corporation, 2005). According to the kind of data acquired for each parameter, the results were displayed and analysed accordingly. The Shapiro test was performed to examine the normality of the data distribution.

Descriptive numbers: Median and range for non-parametric numerical data. Mean, Standard deviation (SD) for parametric numerical data. Percentage and frequency of non-numerical data. Statistical analysis: Student T Test was used to determine the statistical significance of the difference between the means of the two research groups. For comparing the means of more than two groups, analysis of variance (ANOVA) was performed. The Mann Whitney Test (U test) was used to determine the statistical significance of the difference between two non-parametric research groups. The Kruskal-Wallis test was used to determine the statistical significance of the difference between non-parametric variables of more than two research groups. Using the Chi-Square test, the connection between two qualitative variables was analysed. Fisher's exact test was used to assess the link between two qualitative variables when the predicted count was less than 5 in more than 20% of the cells. Relationship analysis: To evaluate the strength of the relationship between two quantitative variables. The correlation coefficient characterises the magnitude and direction of the linear link between two variables. The ROC Curve (receiver operating characteristic) is an efficient method for assessing the sensitivity and specificity of quantitative diagnostic measures that classify patients into one of two categories. The optimal cutoff point was determined by maximising the AUC value. The area under the ROC curve (AUC) findings were deemed excellent for AUC values between 0.91 and 1, good for AUC values between 0.80 and 0.90, acceptable for AUC values between 0.70 and 0.80, bad for AUC values between 0.60 and 0.70, and failed for AUC values between 0.5 and 0.6 [9]. P values less than 0.05 were statistically significant.

3. Results

Our study was conducted on all neonates admitted to NICU in Benha University hospital during the period from December 2022 to July 2022. A total of 323 neonates were admitted to NICU during the study period, 17 cases were excluded due to having severe congenital anomalies, and 18 cases were excluded due to lack of data due to missing or late admission temperature recordings. Therefore, the study included 288 neonates who were further divided according to their outcome into 2 group: **Survived group:** included 227

neonates (78.8%) **Died group:** included 61 neonates (21.2%).

Table1 shows that survived group had statistically higher Apgar score, higher weight and higher temperature compared to died group. In survived group 8.8% of cases had sever hypothermia (<35 C), 25.1% had moderate hypothermia (35.0-35.9 C), 24.7% had mild hypothermia (36.0-36.4) and 40.1% had normal body temperature (36.5-37.5 C). While, in died group 62.3% of cases had sever hypothermia (<35 C), 21.3% had moderate hypothermia (35.0-35.9 C), 9.8% had mild hypothermia (36.0-36.4) and 6.6% had normal body temperature (36.5-37.5 C).

Table2 shows that survived group had statistically lower frequency of oxygen support compared to died group. However, there was no statistical difference between group regarding the duration of oxygen support

Table 3 shows that died group had statistically higher frequencies of pulmonary hemorrhage, sepsis, IVH and NEC compared to survived group. However, survived group had statistically longer duration of hospital stay.

Table4 shows that preterm neonates had statistically lower temperature compared to full term neonates. Neonates who were born by CS had statistically higher temperature compared to neonates born with NVD. However, there was no significant difference in body temperature as regarding to sex, order or singleton.

Table 5 shows that there was statistical difference in body temperature as regarding to cause of admission; as it was highest in hyperbilirubinemia (36.78), late onset sepsis (36.72) and TTN (36.47), and it was lowest in HIE (32.23) and in RDS (34.62).

Table 6 shows that neonates who needed oxygen support had statistically lower body temperature compared to who didn't need oxygen support, also patients who required HFMV and MV had statistically lower body temperature compared to who didn't.

Table7 shows that neonates who developed pulmonary hemorrhage had statistically lower body temperature compared to neonates who didn't. Neonates who developed sepsis had statistically lower body temperature compared to neonates who didn't. Neonates who developed IVH had statistically lower body temperature compared to neonates who didn't. Neonates who developed NEC had statistically lower body temperature compared to neonates who didn't. In addition, neonates who died had statistically lower body temperature compared to neonates who survived.

Table 8 shows that in survived group; body temperature correlates positively with gestational age, Apgar score, weight and correlates negatively with duration of oxygen support and duration of admission. In died group; body temperature correlates positively with gestational age, Apgar score, duration of oxygen support and duration of admission. While it has no statistical correlation with weight.

4. Discussion

A significant predictor of newborn morbidity and death is hypothermia. However, neonatal temperature is often omitted from clinical records despite being an essential and straightforward sign [15].

Our research comprised 288 neonates who were then separated into two groups based on their outcomes: Survived group: included 227 neonates (78.8 percent), 125 males and 102 females, with a mean gestational age of 35.4 2.9 weeks and a mean gestational age of 35.4 2.9 weeks. The deceased group included 61 neonates (21.2%), 27 males and 34 females, with a mean age of 31.93.8 weeks. Statistically, the survivor group had a greater gestational age than the deceased group, but there was no statistical difference in sex across groups.

Similarly, [10] who evaluated the cause and predictors of newborn death among neonates referred to neonatal critical care units, found that maternal smoking was a significant risk factor. During the research period, a total of 489 infants were hospitalised. Three hundred six (62.6%) of the hospitalised infants were male, 98 (20%) of the admitted newborns died, and the remaining neonates survived from admission to release from the NICU.

[11], who evaluated risk factors for newborn death in neonatal intensive care facilities in Tanta City, included 238 neonates, of whom 57.1% were males and 42.9% were girls; yet, they reported a greater mortality rate among boys (27.7 percent). The greatest fatality rate was among preterm infants less than 30 weeks (39.9 percent), followed by full term infants older than 37 weeks (25.5 percent). It was discovered that gestational age is a major predictor of newborn death.

In the current investigation, the survivors were statistically heavier than the deceased.

This was consistent with [11] .'s finding that infants weighing between 1.1 and 1.5 kilogrammes had a higher death rate than those weighing over 2.5 kilogrammes. In addition, [12] discovered that low birth weight has traditionally been related with newborn mortality. This is consistent with the findings

of [13] who discovered that the birth weight of newborns who died was much lower than that of newborns who survived.

In the current investigation, the group that survived had a greater temperature than the group that perished. The incidence of severe hypothermia (35 degrees Celsius) was 20.1%, moderate hypothermia (35.0-35.9 degrees Celsius) was 24.3%, light hypothermia (36.0-36.4 degrees Celsius) was 21.5%, and normal body temperature (36.5-37.5 degrees Celsius) was 33.1%; only 1% had fever >37 degrees Celsius. Hypothermia was statistically more prevalent in the group that perished than in the group that survived.

Our findings mirrored those of [14], The median temperature at admission for 1344 neonates was 36.3 °C (IQR 35.8–36.9 °C; minimum 32 °C, maximum 41.1 °C). 395 neonates (29.4 percent) were diagnosed with severe/moderate hypothermia, 376 (28 percent) with mild hypothermia, 436 (32 percent) with normal temperature, and 137 with overheating (10.2 percent). Using logistic regression models, the link between death rate and newborn temperature at admission was studied. 848 neonates were released alive and 488 died, while information was unavailable for eight neonates. Mortality rate observed was 58% (231 out of 395) for severe/moderate hypothermia, 33% (123 out of 372) for mild hypothermia, 24% (103 out of 432) for normal temperature range, and 23% (31 out of 137) for heat.

In low-resource settings, the prevalence of postnatal hypothermia is quite high, ranging from 32 to 85 percent, although hyperthermia upon admission has received less attention, demonstrating that the prevention of postnatal thermal losses remains an unappreciated important problem [15].

In the present investigation, there was a statistical difference between the surviving and deceased groups in terms of their admittance reason. RDS was the leading reason of admission in the deceased group (60.7%), followed by pneumonia (11.5%) and HIE (11.5 percent). TTN (26.9 percent) was the leading cause of admission in the group that survived, followed by hyperbilirubinemia (24.7 percent) and RDS (22.1 percent).

[16] showed that hyaline membrane disease 31 (66 percent), perinatal asphyxia 58 (22 percent), and congenital deformity 2 (5.3 percent) were the primary causes of mortality during admission. Our findings corroborated these findings. Similarly, [10] showed that the most prevalent causes of newborn death were complications of preterm delivery (28.58%), birth hypoxia (22.45%), and neonatal infection (18%). (18.36 percent).

In the current investigation, the frequency of oxygen support was significantly lower in the group that lived than in the group that perished. The frequency of HFMV and MV usage was statistically greater in the deceased group, but the frequency of HHFNC use was statistically higher in the surviving group. However, there was no significant difference in duration of oxygen support across groups.

[11] noted that 54/66 of the deceased utilised MV compared to 86/176 of the survivors, and it was discovered that 38.6% of neonates who got MV died compared to just 12.4% of those who did not, p0.001.

In the present investigation, the frequency of pulmonary haemorrhage, sepsis, IVH, and NEC was significantly greater in the deceased group compared to the survivors. However, survival was statistically associated with a longer hospital stay.

[10] found that length of stay was a significant predictor of neonatal mortality, as newborns hospitalised for less than 3 days were nearly four times (AOR = 3.63; 95% CI: 1.82, 7.22) more likely to die than those hospitalised for 4–7 days; this suggests that the majority of deaths occurred in the first 72 hrs. of life.

[17] reported a statistically significant difference, with more deaths with mechanical ventilation, presence of sepsis, pneumothorax, CNS problems, haemorrhage, low GA, low birth weight, low Apgar score at 5 minutes, and low days of NICU admission. Our results were also in agreement with Hany et al.

In the present research, infants with pulmonary haemorrhage had a statistically lower body temperature than those without. Statistically, neonates who got sepsis had a lower body temperature than those who did not. Statistically, neonates who had IVH had a lower body temperature than those who did not. Statistically, neonates who had NEC had a lower body temperature than those who did not. In addition, the body temperature of newborns who died was statistically lower than that of newborns who survived.

Hypothermia in newborns was substantially linked with death (OR = 1.89; 1.72–2.09), intra-ventricular haemorrhage (OR = 1.86; 1.09–3.14), and neonatal sepsis (OR = 1.47; 1.09–2.49), according to [18].

In the current research, in the group that survived, body temperature corresponds favourably with gestational age, Apgar score, and weight, and adversely with duration of oxygen support and length of hospitalisation. In the group of infants that died, body

temperature correlates positively with gestational age, Apgar score, weight, duration of oxygen support, and length of hospitalisation. While there is no statistical association between the two.

[19] found that the temperature of newborns was directly related to gestational age (p0.010), birth weight (p0.010), and Apgar score (p0.050).

In the present research, ROC analysis was performed to evaluate the efficacy of body temperature in predicting death in the examined neonates; the AUC was 0.863 (95 percent confidence interval: 0.810-0.917), p0.001. At a threshold temperature of 35.6 C, the sensitivity was 80.3% and the specificity was 74%. A ROC analysis was performed to evaluate the ability of body temperature to predict sepsis in the examined neonates; the AUC was 0.735 (95 percent confidence interval: 0.676-0.794), p0.001. At a threshold temperature of 36 C, the sensitivity was 80.9% and the specificity was 66%. A ROC analysis was performed to evaluate the ability of body temperature to predict pulmonary haemorrhage in the examined neonates; the AUC was 0.895% (95 percent confidence interval: 0.851-0.939), p0.001. At a threshold temperature of 35.6 C, the sensitivity was 86.8% and the specificity was 75.4%.

The link between fatality rate and newborn temperature at admission was analysed using logistic regression models in which temperature was represented using first order polynomials and limited cubic splines. A non-linear relationship between death rate and temperature was observed (non-linear term: p 0.0001), hence the model with cubic splines was chosen above the model with a first-order polynomial. There were recognised four knots at 34.6 °C, 36 °C, 36.6 °C, and 38.3 °C. Estimated mortality rate decreased from 84 percent at 32 degrees Celsius to 64 percent at 34.6 degrees Celsius (mean 8 percent per degree Celsius), to 41 percent at 36 degrees Celsius (mean 16 percent per degree Celsius), to 26 percent at 36.6 degrees Celsius (mean 25 percent per degree Celsius), to 22 percent at 38.3 degrees Celsius (mean 2 percent per degree Celsius), and then increased to 40 percent at 41 degrees Celsius (mean + 7 percent per degree Celsius) [14]

This study's strengths were its prospective follow-up of newborns from admission through discharge or death. In addition, no sample was performed; hence, the risk of sampling error was removed. However, the very small sample size, brief duration, and single-center design of this research may compromise its validity.

5. Conclusions

According to our findings, the incidence of severe hypothermia (35 C) was 20.1%, moderate hypothermia (35.0-35.9 C) was 24.3%, light hypothermia (36.0-36.4 C) was 21.5%, normal body temperature (36.5-37.5 C) was 33.1%, and only 1% had a fever more than 37 C. The correlation between body temperature and gestational age, Apgar score, and weight is favourable. Hypothermia was related with death and poor outcomes, including RDS, pulmonary haemorrhage, sepsis, intravascular haemorrhage, and necrotizing enterocolitis.

6. Limitation

The current research has certain limitations, such as the small number of neonates delivered in our hospital, the restriction to neonates born in our hospital, and the need for further hospital amenities.

7. Recommendations

Increase understanding of the significance of neonatal temperature. In addition to focusing on thermal stability in quality improvement efforts (i.e., warm delivery room, immediate drying, skin-to-skin contact, early breastfeeding, delayed bathing, adequate clothing, warm transport, keeping baby close to the mother). Evaluation of the impact of hypothermia on infant mortality in community settings requires more study.

Table (1) Clinical data of the studied groups

		Survived group	Died group	Total	Test	P value
		N=227 78.8%	**N=61 21.2%**	**N=288 %**		
Apgar score	**Mean±SD**	7.5±1.2	5.3±1.6	7.2±1.5	t=7.5	**<0.001***
	Range	5-10	3-8	3-10		
Weight (kg)	**Mean±SD**	2.5±0.9	1.69±0.65	2.35±0.9	t=6.8	**<0.001***
	Range	1.13-5.7	0.8-3	0.8-5.7		
Temperature (C^o)	**Mean±SD**	36.06±0.98	33.5±2.2	35.5±1.7	t=13.3	**<0.001***
	Range	32-37.6	30-36.7	30-37.6		
<35.0°C		20 8.8%	38 62.3%	58 20.1%	X^2=148	**<0.001***

35.0°C–35.9°C	57	25.1%	13	21.3%	70	24.3%
36.0°C–36.4°C	56	24.7%	6	9.8%	62	21.5%
36.5°C–37.5°C	91	40.1%	4	6.6%	95	33.1%
>37.5°C	3	1.3%	0	0.0%	3	1.0%

X^2; Chi-square test, t: Student t-test, *: Significant,

Table (2) Oxygen support in the studied groups

		Survived group		Died group		Total		Test	P value
		N=227	78.8%	N=61	21.2%	N=288	%		
Oxygen support	**No need**	**54**	**23.8%**	**5**	**8.2%**	**59**	**20.5%**	**X^2=7.2**	**0.007***
	Yes	**173**	**76.2%**	**56**	**91.8%**	**229**	**79.5%**		
Type of Oxygen support	**HFMV**	**5**	**2.2%**	**29**	**47.5%**	**34**	**11.9%**	**X^2=76.8**	**<0.001***
	MV	**65**	**28.9%**	**41**	**67.2%**	**106**	**37.1%**		
	CPAP	**84**	**37.3%**	**20**	**32.8%**	**104**	**36.4%**		
	HHFNC	**126**	**55.5%**	**3**	**4.9%**	**129**	**44.8%**		
Duration of Oxygen support (dayes)	**Median**	**3**		**5**		**3**		**U=4.9**	**0.32**
	Range	**1-31**		**1-59**		**1-59**			

X^2; Chi-square test, U: Mann-Whitney U-test, *: Significant, HFMV: High frequency mechanical vantilator, MV: mechanical ventilator, CPAP: Continuous positive airway pressure, HHFNC: Humidified High-flow nasal cannulae

Table (3) Complication of the studied group

		Survived group		Died group		Total		Test	P value
		N=227	78.8%	N=61	21.2%	N=288	%		
Pulmonary hemorrhage	**No**	224	98.7%	26	42.6%	250	86.8%	X^2=90.2	**<0.001***
	Yes	3	1.3%	35	57.4%	38	13.2%		
Sepsis	**No**	152	67.0%	26	42.6%	178	61.8%	X^2=12.1	**<0.001***
	Yes	75	33.0%	35	57.4%	110	38.2%		
IVH	**No**	224	98.7%	50	82.0%	274	95.1%	X^2=29	**<0.001***
	Yes	3	1.3%	11	18.0%	14	4.9%		
NEC	**No**	222	97.8%	53	86.9%	275	95.5%	X^2=13.2	**<0.001***
	Yes	5	2.2%	8	13.1%	13	4.5%		
Duration of hospital stay (days)	**Median**	9		6		7		U=5.1	**<0.001***
	Range	2-78		1-61		1-78			

X^2; Chi-square test, U: Mann-Whitney U-test, *: Significant, IVH: intraventricular hemorrhage, NEC: necrotizing enterocolitis

Table (4) Body temperature according to patients' data

		Body temperature				Test	P value
		Mean	±SD	Min.	Max.		
Sex	**Male**	35.68	1.67	30.00	37.60	t=1.6	0.11
	Female	35.34	1.70	30.00	37.50		
Gestational age	**<37 weeks**	34.95	1.88	30.00	37.10	t=7.65	**<0.001***
	>=37weeks	36.37	0.88	32.00	37.50		
Mode of delivery	**CS**	35.74	1.44	30.00	37.60	t=2.9	**0.008***
	NVD	35.13	2.02	30.00	37.30		
Order	**1st**	35.82	1.03	32.00	37.30	F=1.3	0.26
	2nd	35.33	2.05	30.00	37.20		
	3rd	35.48	1.71	30.00	37.40		

	4th	35.62	1.85	31.00	37.60		
	5th	35.12	1.75	32.00	37.30		
	6th	34.92	2.54	30.50	36.60		
Singleton	**Single**	35.51	1.80	30.00	37.60	F=0.32	0.91
	One of twins	35.56	1.11	33.00	37.00		
	One of triplet	35.60	0.60	35.00	36.50		

F: F value of One way-ANOVA, t: Student t-test, *: Significant, CS: cesarean section, NVD: normal vaginal delivery

Table (5) Body temperature according to patients' cause of admission

	Body temperature				**Test**	**P value**
	Mean	**±SD**	**Min.**	**Max.**		
RDS	34.62	1.84	30.00	37.00	F=15.1	**<0.001***
TTN	36.47	0.56	35.00	37.60		
Hyperbilirubinemia	36.78	0.56	35.60	37.50		
Pneumonia	36.24	0.50	35.50	37.10		
Early onset sepsis	35.79	0.51	35.00	36.60		
Late onset sepsis	36.72	0.71	36.00	37.30		
IDM	36.42	0.62	35.70	37.40		
Grower	35.70	1.37	34.20	36.70		
HIE	32.23	2.64	30.00	35.70		
MAS	34.84	1.15	34.00	36.10		
PDA	35.17	0.93	34.00	36.00		

F: F value of One way-ANOVA, *: Significant, RDS: respiratory distress syndrome, TTN: transient tachypnea of newborn, IDM: Infant of diabetic mother, HIE: hypoxic ischemic encephalopathy, MAS: meconium aspiration syndrome, PDA: patent ductus arterosus.

Table (6) Body temperature according to need of oxygen support

		Body temperature				**Test**	**P value**
		Mean	**±SD**	**Min.**	**Max.**		
Oxygen support	**No need**	36.56	0.61	35.40	37.50	t=5.5	**<0.001***
	yes	35.26	1.77	30.00	37.60		
HFMV	**No**	35.89	1.22	30.30	37.60	t=12.7	**<0.001***
	yes	32.72	2.11	30.00	36.20		
MV	**No**	35.88	1.57	30.20	37.60	t=4.9	**<0.001***
	Yes	34.89	1.73	30.00	37.00		
CPAP	**No**	35.61	1.83	30.00	37.60	t=1.2	0.19
	Yes	35.35	1.42	30.50	37.10		
HHFNC	**No**	35.08	2.02	30.00	37.50	t=5.1	**<0.001***
	Yes	36.06	0.92	33.50	37.60		

t: Student t-test, *: Significant, HFMV: High frequency mechanical vantilator, MV: mechanical ventilator, CPAP: Continuous positive airway pressure, HHFNC: Humidified High-flow nasal cannula

Table (7) Body temperature according to outcome

		Body temperature				**Test**	**P value**
		Mean	**±SD**	**Min.**	**Max.**		
Pulmonary	**No**	35.87	1.33	30.30	37.60	t=10.4	**<0.001***
hemorrhage	**Yes**	33.23	2.05	30.00	36.00		
Sepsis	**No**	35.84	1.69	30.50	37.60	t=4.1	**<0.001***
	Yes	35.03	1.58	30.00	37.30		
IVH	**No**	35.68	1.51	30.20	37.60	t=7.4	**<0.001***

	Yes	32.50	2.28	30.00	35.50		
NEC	**No**	35.60	1.62	30.00	37.60	t=3.8	**0.014***
	Yes	33.78	2.28	30.50	36.10		
Mortality	**Survived**	36.06	.98	32.00	37.60	t=13.3	**<0.001***
	Died	33.50	2.22	30.00	36.70		

t: Student t-test, *: Significant, IVH: intraventricular hemorrhage, NEC: necrotizing enterocolitis

Table (8) Correlation between body temperature and other clinical data in survived and died groups

		Body temperature	
		Survived group	**Died group**
		N=227	**N=61**
Gestational age (weeks)	**r**	0.453	0.352
	P value	**<0.001***	**0.005***
Apgar score	**r**	0.298	0.318
	P value	**<0.001***	**<0.001***
Weight (kg)	**r**	0.154	0.096
	P value	**<0.001***	0.460
Duration of oxygen support	**r**	-0.232	0.496
	P value	**0.002***	**<0.001***
Duration of admission	**r**	-0.457	0.523
	P value	**<0.001***	**<0.001***

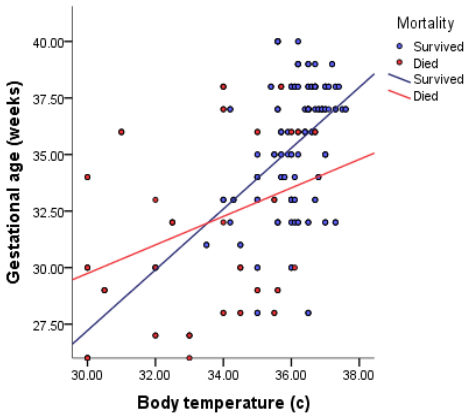

Fig. (1) Correlation between body temperature and gestational age

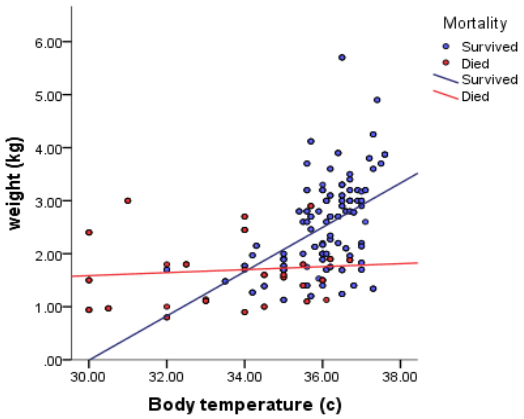

Fig. (2) Correlation between body temperature and weight

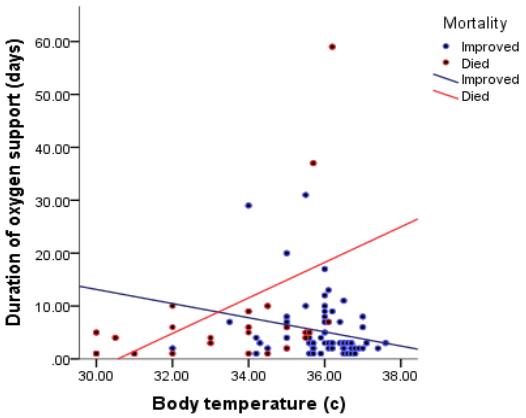

Fig. (3) Correlation between body temperature and duration of oxygen support

Table (9) Performance of body temperature to predict mortality in the studied neonates

	AUC	95% CI		Cut-off value	Sensitivity	Specificity	P value
Body temperature	0.863	0.810	0.917	<35.6	80.3%	74%	**<0.001***

ROC analysis was done to assess the performance of body temperature to predict mortality in the studied neonates; AUC was 0.863 (95% confidence interval: 0.810-0.917), p<0.001. At a cutoff point < 35.6 C, the sensitivity was 80.3% and specificity was 74%.

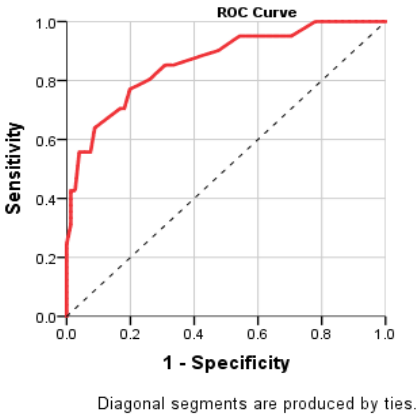

Fig (4) ROC curve of performance of body temperature to predict mortality in the studied neonates

Table (10) Performance of body temperature to predict sepsis in the studied neonates

	AUC	95% CI		Cut-off value	Sensitivity	Specificity	P value
Body temperature	0.735	0.676	0.794	<36	80.9%	65%	**<0.001***

ROC analysis was done to assess the performance of body temperature to predict sepsis in the studied neonates; AUC was 0.735 (95% confidence interval: 0.676-0.794), p<0.001. At a cutoff point < 36 C, the sensitivity was 80.9% and specificity was 65%.

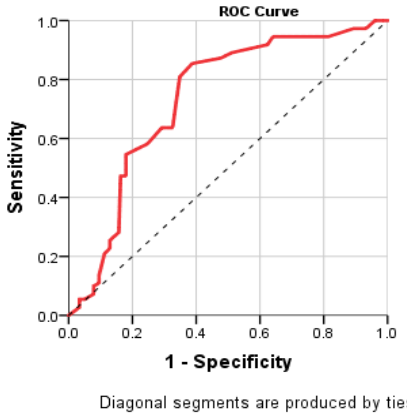

Fig. (5) ROC curve of performance of body temperature to predict sepsis in the studied neonates

Table (11) Performance of body temperature to predict pulmonary hemorrhage in the studied neonates

	AUC	95% CI		Cut-off value	Sensitivity	Specificity	P value
Body temperature	0.895	0.851	0.939	<35.6	86.8 %	75.4%	**<0.001***

ROC analysis was done to assess the performance of body temperature to predict pulmonary hemorrhage in the studied neonates; AUC was 0.895 (95% confidence interval: 0.851-0.939), p<0.001. At a cutoff point < 35.6 C, the sensitivity was 86.8% and specificity was 75.4%.

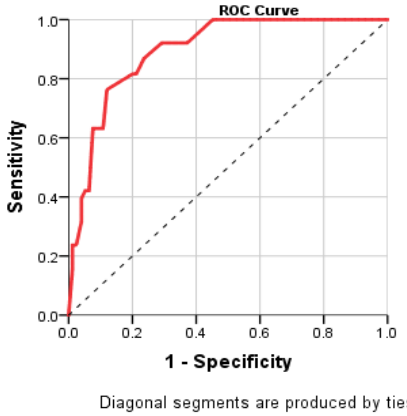

Fig. (6) ROC curve of performance of body temperature to predict pulmonary hemorrhage in the studied neonates

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