Research Article

Developing a New Scoring System for Diagnosing Shock in Critically-Ill Neonates Admitted in NICU in a Resource Poor Country

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ABSTRACT

Objective: To determine the clinical predictors of shock in critically ill neonates and design a shock score to diagnose neonatal shock.

Materials and methods: This was a cross-sectional study conducted from Dec 2015-July 2017 in Sick Newborn Care Unit, GSVM medical college, Kanpur. All sick neonates requiring intensive hemodynamic monitoring having umbilical venous catheter in-situ were enrolled in the study. Central Venous Pressure (CVP) was measured through the umbilical venous catheter. Clinical parameters including gestational age, birth weight, cyanosis, pallor, core to peripheral temperature difference, heart rate, capillary refill time, blood pressure and lactate levels were recorded. Shock was defined as central venous pressure less than 5 cm H_2O or more than 8 cm H_2O.

Results: 122 neonates were included in the study, 76 of which had shock. Core to peripheral temperature difference (sensitivity-96%) and prolonged capillary refill time (sensitivity-75%) were observed to be the most sensitive indicators of neonatal shock while the best predictors were tachycardia (positive predictive value-87%) and hypotension (positive predictive value-82%). A new shock score (0-23) was developed based on clinical parameters to diagnose shock. Shock score more than 17 predicted neonatal shock with 58% sensitivity, 86% specificity and 88% positive predictive value.

Conclusion: This study established that core to peripheral temperature difference was the most sensitive indicator and tachycardia was the best predictor of neonatal shock. A new shock scoring system has been designed to diagnose neonatal shock in a resource poor country like India where facilities for invasive procedures like central venous pressure monitoring are not available at grassroot level.

Kewords: Neonates; Shock; Shock score; Clinical parameters

INTRODUCTION

Shock is an acute, complex state of circulatory dysfunction resulting in insufficient oxygen and nutrient delivery to the tissues relative to their metabolic demand leading to cellular dysfunction. Initially, shock may be compensated with reduction in blood supply to the skin, muscle, and splanchnic vessels and adequate blood flow to the vital organs. This may be followed by an uncompensated phase when signs of poor perfusion are accompanied by hypotension. Untreated shock causes irreversible tissue and organ damage and ultimately, death. In the immediate postnatal period, abnormal regulation of peripheral vascular resistance with or without myocardial dysfunction is the most frequent cause of hypotension underlying shock, especially in preterm infants. Hypovolemia must also be considered as an underlying cause of shock in the setting of fluid loss (blood, plasma, excessive urine output or transepidermal water losses) [1]. The clinical signs may be very similar, more so in the later stages of shock irrespective of the cause of shock. There is no agreement regarding what constitutes the gold standard in diagnosing circulatory compromise. The commonly used clinical signs of circulatory compromise like

hypotension, tachycardia, slow skin capillary refill time, low urine output, increased core-peripheral temperature difference and acidosis due to increased lactate production, aid in diagnosis of circulatory compromise in the preterm and term neonates but have significant limitations individually.

Central Venous Pressure (CVP) monitoring has been used most commonly by intensivists to measure intravascular volume status but it's an invasive procedure with many complications like bleeding, sepsis and venous thrombosis. It also requires sterile facilities for umbilical venous cannulation which are not available in most of the primary health care settings, even in some secondary and tertiary health care systems. This poses a challenge for health care providers to detect neonatal shock timely and manage them promptly. Most of the clinicians have to rely on the clinical parameters to identify shock. Therefore, this study was conducted with the aim to identify the clinical signs and symptoms that could predict neonatal shock.

MATERIALS AND METHODS

This cross sectional study was carried out in Sick Newborn care unit, department of pediatrics, Ganesh Shankar Vidyarthi memorial medical college, Kanpur from Dec 2015 to July 2017. Written and informed consent was taken from parents/ guardians [2]. The study protocol was reviewed and approved by ethics committee of GSVM medical college, Kanpur.

Selection of cases

122 critically ill newborns with umbilical venous catheter *in situ* for various medical reasons were selected. Clinical parameters including gestational age, birth weight, cyanosis, pallor, core to peripheral temperature difference, heart rate, capillary refill time, blood pressure and lactate levels were recorded. 37 weeks was taken as the cut-off to define low gestational age and below 2.5 kg was taken as low birth weight. Cyanosis was recorded as bluish discoloration of the tongue, buccal mucosa, ear lobes, palpebral conjunctiva, tip of nose and finger tips. Axillary temperature was considered core/central and sole temperature was taken as peripheral temperature. The thermal probes were fixed with a piece of tape in axilla and sole. The warmer's

temperature was kept between 36.5°C-37.5°C. Core-peripheral temperature difference more than 1.5°C was taken as significant. Tachycardia was taken as heart rate more than 160 per minute. Capillary refilling time was measured by pressing thumb over sternum for five seconds and the time taken for the colour to return to it's previous colour was recorded [3]. Normal Capillary Refill Time (CRT) was defined as ≤ 2 seconds, and prolonged refill as >2 seconds. Blood pressure were recorded using NIBP (Non-Invasive Blood Pressure) cuffs. Hypotension was defined as per Zubrow's charts when systolic and/or diastolic BP was <5th centile for the particular age, weight and postnatal age. Lactate levels were measured in arterial blood gas. High lactate levels were taken as plasma lactate concentration more than 4 mmol/ L. Umbilical venous catheter was used to measure central venous pressure and shock was defined as central venous pressure less than 5 cm H_2O or more than 8 cm H_2O.

Data was analysed using Microsoft Excel 2010. Results were presented as sensitivity, specificity, Positive Predictive Value (PPV) or Negative Predictive Value (NPV).

RESULTS

In the present study, 122 critically ill newborns having shock were studies. Of these, 66 (54%) were males and 56 (46%) were females with following diagnosis: 51 (41.8%) preterms, 36 (29.5%) hypoxic ischemic encephalopathy, 30 (24.5%) early onset neonatal sepsis and 5 (4.2%) post-surgical patients (Table 1) [4]. Out of 122 neonates, 76 had shock. Incidence of shock was highest in preterm (78.4%) followed by hypoxic ischemic encephalopathy (50%), post-surgical patients (40%) and early onset neonatal sepsis (24.5%) as shown in Table 2. The sensitivity, specificity and predictive value of individual predictors of shock is shown in Table 3. Core to peripheral temperature difference was the most sensitive indicator of shock (sensitivity-96%), followed by prolonged capillary refill time (sensitivity-75%) and hypotension (sensitivity-73%), while the best predictors were tachycardia (Positive Predictive Value-87%) and hypotension (PPV-82%) [5].

Table 1: Diagnosis of the study population.

Diagnosis	Number of patients	Percentage (%)
Preterm	51	41.8
Hypoxic ischemic encephalopathy	36	29.5
Early onset neonatal sepsis	30	24.5
Post-surgical cases	5	4.2

Table 2: Prevalence of shock with respect to diagnosis.

Diagnosis	Number of patients	Number and percentage (%) of patients with shock
Preterm	51	40 (78.4%)

Hypoxic ischemic encephalopathy	36	18 (50%)
Early onset neonatal sepsis	30	16 (53.3%)
Post-surgical cases	5	2 (40%)

Table 3: Predictive value of clinical parameters for diagnosing shock.

Parameters	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Negative predictive value (%)
Gestational age	33	62	24	33
Birth weight	46	56	40	27
Cyanosis	15	66	44	21
Pallor	22	62	48	22
Core-periphery temperature difference	96	60	53	50
Heart rate	67	62	87	76
CRT	75	51	53	56
BP	73	56	82	43
Lactate	43	53	47	78

Based on our findings of Positive Predictive Value (PPV) for individual clinical parameter predictive of neonatal shock, we developed a shock score assigning weightage to each of the symptoms and signs depending on its PPV. Parameters with PPV between 75% and 100% like tachycardia and hypotension were assigned a score value of 4 each.

Parameters with PPV between 50% and 74% like core-peripheral temperature difference and prolonged capillary refill time were assigned a score of 3 each. Parameters with PPV between 25% and 49% like birth weight, cyanosis and pallor were assigned a score of 2 each [6]. Parameter with PPV less than

24% like gestational age was assigned a score of 1. Adding up the individual score value for each parameter in every case, each neonate was given a shock score. This score was analysed for sensitivity, specificity and PPV at different ranges (Table 4). Out of 76 cases who had shock, 15 (19.7%) patients expired. Of 15 patients who died because of shock, 11 (73.3%) had a shock score of 17-23 and 4 (26.6%) had a shock score between 10-16. Shock score above 17 predicted neonatal shock with 58% sensitivity, 86% specificity and 88%positive predictive value [7].

Table 4: Predictive value of neonatal shock score.

Score	With shock (n=76)	Without shock (n=46)	Sensitivity (%)	Specificity (%)	Positive predictive value (%)
17-23	44	6	58	86	88
10-16	28	10	36	78	73
0-9	4	30	5.2	34	11

DISCUSSION

Neonatal shock is a very prevalent clinical challenge in front of doctors working in NICU. Shock can be of following types:

Distributive: Secondary to abnormal pheripheral vasoregulation, sepsis-related, or rarely anaphylactic in origin.

Hypovolemic: Due to placental hemorrhage, fetal to maternal hemorrhage, excessive insensible water loss or disseminated intravascular coagulation.

Cardiogenic: Due to myocardial dysfunction.

Obstructive shock: Early recognition and management of neonatal shock is desirable to prevent irreversible damage to vital organs and its progression to several life threatening disorders in newborns, *viz.* acute renal failure, disseminated intravascular coagulation, necrotising enterocolitis, and intra-ventricular hemorrhage.

Shock can be identified by various clinical symptoms and signs. Infants look pale, lethargic and hypotonic. Tachycardia, tachypnea, circumoral grayish discoloration and prolonged capillary refilling time may be present [8]. Extremeties are cold while the trunk is relatively warm. Central venous pressure is elevated in cardiogenic and septic shock whereas it is low in infants with hypovolemia.

However, there are many factors which limit the utility of these clinical parameters in diagnosing shock independently. Blood pressure measurement requires invasive intra-arterial access and the accuracy of non-invasive oscillometric method is less certain, especially when severe hypotension develops. Moreover, gestational age and postanatal age are the dominant influences on BP as studied. The state of peripheral perfusion is different (vasodilation *vs.* vasoconstriction) in different types of shock (warm *vs.* cold shock). Because many factors other than those regulating cardiovascular system affect heart rate, it has a limited yet widely utilised role in diagnosis of circulatory shock. A study by Osborn documented that only when CRT was >5 seconds did it have any clinically relevant degree of specificity in diagnosing shock [9]. According to a study, CRT ≤ 2 seconds had little predictive value and was considered too conservative in diagnosing septic shock. Central venous pressure measurement is considered as the gold standard and is widely used to measure intravascular volume status. It is an invasive procedure requiring strict asepsis which is difficult to maintain in small hospitals like primary health care centres in India. Moreover, it is associated with many side effects immediately like sepsis, bleeding, venous thrombosis as well as in future (portal venous hypertension). Individually these clinical parameters may not be optimal but combinations of these parameters are better in detecting neonatal shock. Interestingly, combining a capillary refill time >4 seconds with elevated serum lactate >4 mmol/L has a specificity of 97% for detecting low superior vena flow state in VLBW neonates during first postnatal day [10-12]. Similarly, CRT>3 seconds had sensitivity of 55% and specificity 81%, mean BP<30 mm Hg had sensitivity of 59% and specificity of 77% but combining a mean BP<30 mm Hg and/or central CRT>3 seconds increased the sensitivity for detecting low SVC flow to 78%.

The specific management of shock is related to the underlying pathological mechanism and etiological factors contributing to shock. Dopamine and dobutamine are the most common initial inotropes to be used in neonatal shock after adequate volume resuscitation [13-15]. However, overzealous fluid administeration is associated with adverse outcomes and should be avoided in the absence of obvious fluid losses. Therefore, a shock score has been designed to diagnose shock promptly and manage accordingly.

CONCLUSION

The study concluded that core to peripheral temperature difference was the most sensitive and tachycardia was the best predictor of neonatal shock. A new shock score has been developed using several clinical parameters which had adequate sensitivity and specificity as a predictor of neonatal shock. This score can be used reliably in hospitals where facilities to measure central venous pressure are not available.

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