

Clinico-Etiological Profile and Outcome of Shock in Children Admitted To A Tertiary Care Hospital

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ABSTRACT

Objective: To describe the clinical profile, etiology, and immediate outcome of shock in children admitted to the pediatric intensive care unit of a tertiary care hospital.

Methods: This hospital-based descriptive observational study was conducted over 18 months at Bharati Vidyapeeth Medical College and Hospital, Sangli, India. Ninety children aged 1 month to 18 years with shock were enrolled. Clinical features, type and etiology of shock, organ involvement, organ support, Pediatric Risk of Mortality III score, and immediate outcome were recorded.

Results: Of 90 children, 51.1% were girls and 44.4% were older than 60 months. Fever (94.4%), altered sensorium (83.3%), and breathlessness (82.2%) were the commonest symptoms; cold extremities (98.9%), hypotension (96.7%), and tachypnea (95.6%) were the commonest signs. Distributive shock was most frequent (60.0%), followed by hypovolemic (23.3%), cardiogenic (13.3%), and obstructive shock (3.3%). Septicemia was the leading etiology (64.4%); *Klebsiella pneumoniae* (11.1%) and *Acinetobacter baumannii* (10.0%) were the commonest isolates. Neurological involvement occurred in 84.4%, and 66.7% needed invasive mechanical ventilation. Overall, 53 children (58.9%) survived and 37 (41.1%) died. All deaths occurred in children with a Pediatric Risk of Mortality III score above 18 (mortality 59.7% in this group).

Conclusion: Septicemia was the leading cause of pediatric shock, and distributive shock was the commonest type. Most children needed advanced respiratory and hemodynamic support, and mortality remained high. A higher Pediatric Risk of Mortality III score identified children at greatest risk of death. Early recognition, etiology-directed treatment, timely intensive care, and risk stratification are essential to improve outcomes.

Keywords: Shock; Sepsis; Child; Intensive Care Units, Pediatric; Mortality; Severity of Illness Index.

INTRODUCTION

Shock is a life-threatening condition of acute circulatory failure as oxygen cannot be delivered to tissues in sufficient quantities to sustain them. If left untreated, cellular hypoxia leads to several organ dysfunctions and death.^{1,2} Shock continues to be an important cause for admission to pediatrics intensive care units (PICUs). This burden is highest in low and middle-income countries where late presentation, infection, malnutrition and limited resources for critical care all coexist.^{1,2} In children, shock may be hypovolemic, distributive, cardiogenic or obstructive and each type has a different hemodynamic profile and treatment. The most common type of distributive shock is septic shock, which is not early recognized, as children make up for it by developing tachycardia and peripheral vasoconstriction and may not be normotensive until late.^{3,4} Shock is caused by a variety of reasons that are location, season and infection burden dependent, so this data must be hospital specific to guide protocol and resource planning. Severity scores can be used to stratify the risk in very sick children. There are limited data on the relationship between these scores with outcome in children with shock in western Maharashtra, an area of high rural referral. We, therefore, studied the clinical profile, classification, etiology and immediate outcome of shock in children who were admitted to the PICU of a Tertiary care teaching hospital and investigated the relationship between the type of shock, age and PRISM III score with death.

Methods:

Study design and setting

It is a descriptive observational study which was conducted in the PICU of Bharati Vidyapeeth (Deemed to be University) Medical College and Hospital, Sangli, Maharashtra, India which is a tertiary care centre for both urban and rural population. The study period is 18 months, from July 2023 till January 2025. Data was gathered retrospectively (from the assessment at the first presentation) and also prospectively (via follow-up with each child on the PICU).

Participants

Children between 1 month and 18 years of age admitted to the PICU who were clinically considered to have shock (by the attending pediatric intensivist) were eligible. In accordance with accepted definitions in pediatrics, shock was defined by signs of hypoperfusion (cold extremities, delayed capillary refill time, weak pulses, oliguria) and altered mental status and hemodynamic instability; children were excluded if they were discharged against medical advice, had been in PICU less than 24 hrs or parents consent had not been obtained. Children were recruited (convenience sampling) that were consecutive eligible children.

Sample size

The sample size was calculated for a single proportion using $n = Z^2 p(1-p)/d^2$, where $Z = 1.96$ (95% confidence level), $p = 0.3$ (from previous Indian PICU audits) and $d = 0.1$ (absolute precision). This resulted in at least 81 children; 90 children were enrolled.

Data collection

A proforma (structured) was completed that recorded details of age, sex, presenting symptoms, vital signs, capillary refill time, and examination findings at admission. Complete blood count, C-reactive protein, blood gas analysis (with lactate), serum electrolytes, renal and liver function tests, blood or other cultures, cardiac enzymes, coagulation profile, and chest radiograph (where indicated) were performed. Based on the worst data during the first 24 hours, the PRISM III score was calculated, and the source of shock was classified as hypovolemic, distributive (septic, neurogenic, anaphylactic), cardiogenic, or obstructive. The etiology was categorized by the final diagnosis, septicemia was classified as having a “microbiologically proven” or “clinically proven” diagnosis. Data recorded included organ involvement, use of respiratory support (invasive ventilation, HFNC, NRB), inotrope use, length of PICU stay, and outcome.

Management

All children were managed by the PICU team following standard institutional practice – oxygen, fluid resuscitation, early empirical intravenous antibiotic treatment following cultures when septicemia was suspected, inotropes, and ventilation (as indicated). No changes of management occurred due to the study.

Outcome

The outcome was immediate: death in the PICU or discharge (transfer out) from the PICU alive.

Statistical analysis

The data were recorded on a spreadsheet and analyzed using statistical software. All categorical variables presented as numbers and percentages, and all continuous variables presented as mean $\pm$ standard deviation. The outcomes were compared between the categories by the chi-square test or Fisher exact test and were considered significant at a p value < 0.05 .

Ethics

The institutional ethics committee approved the study. Parent/guardian informed consent was obtained for all children. The study adhered to the Declaration of Helsinki, anonymity was ensured and analysis of data was not linked to the refusal of a patient to participate in the study, which would have affected the course of treatment.

Table 1. Age, sex, presenting symptoms, and clinical signs of 90 children with shock

Characteristic	n	%
Age group (months)		
1–12	27	30.0
13–60	23	25.6
>60	40	44.4
Sex		
Male	44	48.9
Female	46	51.1
Symptoms		
Fever	85	94.4
Altered sensorium	75	83.3
Breathlessness	74	82.2
Vomiting	66	73.3
Convulsions	37	41.1

Characteristic	n	%
Loose stools	25	27.8
Bleeding manifestations	5	5.6
Signs		
Cold extremities	89	98.9
Hypotension	87	96.7
Tachypnea	86	95.6
Oliguria or anuria	84	93.3
Tachycardia	81	90.0
Altered mental status	75	83.3
Delayed capillary refill time	69	76.7

Mean age 79.5 ± 64.9 months. Percentages are of 90 children; categories are not mutually exclusive for symptoms and signs.

Table 2. Type and etiology of shock

Variable	n	%
Type of shock		
Distributive	54	60.0
Septic	52	57.8
Neurogenic	2	2.2
Anaphylactic	0	0
Hypovolemic	21	23.3
Cardiogenic	12	13.3
Obstructive	3	3.3
Etiology		
Septicemia, microbiologically proven	34	37.8
Septicemia, clinically proven	24	26.7
Dengue	11	12.2
Acute cardiomyopathy	9	10.0
Congenital heart disease	6	6.7
Acute watery diarrhea	3	3.3
Multisystem inflammatory syndrome in children	2	2.2
Acute rickettsial fever	1	1.1

Percentages are of 90 children.

Table 3. Isolated organisms and organ involvement

Variable	n	%
Organisms isolated (n = 34 culture-positive children)		
Klebsiella pneumoniae	10	11.1
Acinetobacter baumannii	9	10.0
Escherichia coli	5	5.6
Streptococcus pneumoniae	5	5.6
Staphylococcus aureus (methicillin resistant)	4	4.4
Pseudomonas aeruginosa	1	1.1

Variable	n	%
Organ involvement		
Neurological	76	84.4
Cardio-respiratory	68	75.6
Hepatic	51	56.7
Renal	24	26.7
Gastrointestinal	20	22.2

Percentages are of all 90 children; organ categories are not mutually exclusive.

RESULTS

Demographic and clinical profile

Ninety children were enrolled: 44 (48.9%) boys and 46 (51.1%) girls. The mean age was 79.5 ± 64.9 months. Forty children (44.4%) were older than 60 months, 27 (30.0%) were aged 1 to 12 months, and 23 (25.6%) were aged 13 to 60 months (Table 1). Fever was the commonest presenting symptom (94.4%), followed by altered sensorium (83.3%), breathlessness (82.2%), vomiting (73.3%), convulsions (41.1%), loose stools (27.8%), and bleeding manifestations (5.6%). On examination, cold extremities (98.9%), hypotension (96.7%), tachypnea (95.6%), oliguria or anuria (93.3%), and tachycardia (90.0%) were common; altered mental status was present in 83.3% and capillary refill time was delayed in 76.7%.

Table 4. Organ support, severity of illness, and length of PICU stay

Variable	n	%
Respiratory support		
Invasive mechanical ventilation	60	66.7
High-flow nasal cannula	15	16.7
Non-rebreather mask	15	16.7
Inotropes		
Adrenaline	37	41.1
Dobutamine and milrinone	22	24.4
Dobutamine	17	18.9
Noradrenaline	10	11.1
PRISM III score		
Below 14	1	1.1
14–18	27	30.0
Above 18	62	68.9
PICU stay		
1–3 days	25	27.8
4–7 days	32	35.6
More than 7 days	33	36.7

PICU, pediatric intensive care unit; PRISM, Pediatric Risk of Mortality. Percentages are of 90 children.

Type and etiology of shock

Distributive shock accounted for 54 children (60.0%), of whom 52 (57.8%) had septic shock and 2 (2.2%) had neurogenic shock. Hypovolemic shock occurred in 21 (23.3%), cardiogenic shock in 12 (13.3%), and obstructive shock in 3 (3.3%). No child had anaphylactic shock (Table 2). Septicemia was the leading etiology in 58 children (64.4%), microbiologically proven in 34 (37.8%) and clinically proven in 24 (26.7%). Other causes were dengue (12.2%), acute cardiomyopathy (10.0%), congenital heart disease (6.7%), acute watery diarrhea (3.3%), multisystem inflammatory syndrome in children (2.2%), and acute rickettsial fever (1.1%).

A pathogen was isolated in 34 children (Table 3). Gram-negative bacilli predominated: *Klebsiella pneumoniae* (n = 10; 11.1% of all children), *Acinetobacter baumannii* (n = 9; 10.0%), *Escherichia coli* (n = 5; 5.6%), and *Pseudomonas aeruginosa* (n = 1; 1.1%). The Gram-positive isolates were *Streptococcus pneumoniae* (n = 5; 5.6%) and *Staphylococcus aureus*, all methicillin resistant (n = 4; 4.4%).

Organ involvement and organ support

Multi-organ involvement was usual (Table 3). Neurological involvement was present in 76 children (84.4%), cardio-respiratory in 68 (75.6%), hepatic in 51 (56.7%), renal in 24 (26.7%), and gastrointestinal in 20 (22.2%). Sixty children (66.7%) needed invasive mechanical ventilation, and the other 30 (33.3%) received non-invasive support by high-flow nasal cannula (n = 15) or non-rebreather mask (n = 15) (Table 4). Inotropes were used in 86 children (95.6%): adrenaline in 37 (41.1%), dobutamine with milrinone in 22 (24.4%), dobutamine alone in 17 (18.9%), and noradrenaline in 10 (11.1%).

Severity of illness and length of stay

The PRISM III score was above 18 in 62 children (68.9%), 14 to 18 in 27 (30.0%), and below 14 in 1 (1.1%). PICU stay was 1 to 3 days in 25 children (27.8%), 4 to 7 days in 32 (35.6%), and more than 7 days in 33 (36.7%) (Table 4).

Outcome

Fifty-three children (58.9%) survived and 37 (41.1%) died. Mortality by shock type was 42.3% in septic shock (22 of 52), 42.9% in hypovolemic shock (9 of 21), 33.3% in cardiogenic shock (4 of 12), 1 of 2 in neurogenic shock, and 1 of 3 in obstructive shock (Table 5). These differences were not statistically significant, and the numbers in the neurogenic and obstructive groups were too small for comparison. Age group was not significantly associated with death.

The PRISM III score was strongly associated with outcome (Table 5). All 27 children with scores of 14 to 18 and the one child with a score below 14 survived, whereas all 37 deaths occurred among the 62 children with scores above 18 (mortality 59.7%; $p < 0.01$).

Table 5. Outcome according to type of shock, age group, and PRISM III score

Variable	Survived	Died	Total	Mortality %
Overall	53	37	90	41.1
Type of shock				
Septic	30	22	52	42.3
Neurogenic	1	1	2	50.0
Cardiogenic	8	4	12	33.3
Hypovolemic	12	9	21	42.9
Obstructive	2	1	3	33.3
PRISM III score				
Below 14	1	0	1	0
14–18	27	0	27	0
Above 18	25	37	62	59.7

Mortality did not differ significantly by type of shock or by age group. All deaths occurred with a PRISM III score above 18 ($p < 0.01$, Fisher exact test, score ≤ 18 vs > 18).

DISCUSSION

The most common form of shock in this PICU population of 90 children with shock was distributive shock (mostly septic shock); the most common etiology was septicemia and approximately 2/5 died. Most children were multi-organ involved and required ventilatory and inotropic support and all children who died had a PRISM III score greater than 18.

Profile of presentation

The largest age group was older children (44.4%) followed by infants (30.0%). The age range in our hospital was comparable to other Indian and Asian series which reported peaks in 1 to 5 year age group or mean age of 6 years, and age distribution in our hospital may be explained by the referral pattern, and the burden of dengue infection, enteric infection and multi system inflammatory syndrome in older children.^{7,8} The male predominance (62.7%) reported by John and Varghese suggests that sex was not a major determinant of shock

in our population.^{7,8} The only significant features of the presentation was fever, altered sensorium and breathlessness, which emphasized the overwhelming nature of infection. Over 95% of children had cold extremities, hypotension and tachypnea. Hypotension was present in the majority of children (96.7%) when they arrived in the PICU in decompensated shock. It is logically possible that children with symptoms referred for resuscitation would have had normal blood pressure when presented to hospital and that this is one cause of the high mortality, a point made in the guidelines.^{3,4}

Type and etiology

The second most common type of shock was hypovolemic shock (23.3%), with the proportion of cases corresponding to the 25% to 30% reported by John and Varghese and by Anshori et al.^{7,8,11,12} The proportion of cases with multisystem inflammatory syndrome in children was 2.2%, which is lower than the 3.7% reported by John and Varghese.^{7,8,13} Dengue was responsible for 12.2% of cases, a proportion similar to that reported by Anshori et al. Acute cardiomyopathy and congenital heart disease made up the cardiogenic shock (13.3%), which was somewhat more common than was reported by Anshori et al.^{7,8,11,12} This may be because we are a referral centre for cardiac cases. The majority of isolates were gram-negative, *Klebsiella pneumoniae* and *Acinetobacter baumannii* being the most common, with all *Staphylococcus aureus* isolates being methicillin resistant. As is common in other hospital-acquired and referred septicemias in Indian intensive care units, only 34 of 58 children with septicemia had a blood culture positive result and were possibly diluted effect by previous antibiotic use prior to referral.^{15,16,21}

Organ dysfunction and support

Neurological dysfunction (84.4%) and cardio-respiratory involvement (75.6%) were the most frequent organ derangements, followed by hepatic (56.7%) and renal (26.7%) involvement. Respiratory failure and multi-organ dysfunction are the main drivers of mortality in pediatric septic shock.^{9,15} Two thirds of our children needed invasive ventilation, a proportion higher than the 40.5% reported by Gangawati et al. and likely a reflection of the severity of illness in a referral PICU.¹⁰ Adrenaline was the commonest inotrope, which is consistent with guideline recommendations for epinephrine in fluid-refractory cold septic shock, and the combination of dobutamine and milrinone was used for low cardiac output states.^{4,17,22}

Mortality and its determinants

The mortality of 41.1% is higher than the 20% to 33% reported by several Indian and Indonesian PICUs, and far above the 6.3% reported in a large United States sepsis database, but it is comparable to the 45% in mechanically ventilated children.^{7-10,15,18} The difference is easily explained by case mix: 68.9% of our children had PRISM III scores above 18, two thirds were ventilated, and many arrived as referrals. Akande et al. showed that children transferred from outside emergency departments had higher mortality and needed more ventilation than those admitted directly, which supports the view that delay and inter-facility transfer worsen outcome.^{18,22} The Malawi study showed that mortality depends heavily on how shock is defined (11.9% with a clinical definition against 60% with the stricter WHO definition), which underlines that mortality figures from different centers should be compared with caution.¹⁹

Mortality did not differ significantly by shock type or by age group in our series. The numbers in some subgroups were small, so these analyses had little power to detect differences. The lack of an age effect should be read with caution because infants are known to have limited physiological reserve, and a larger sample may reveal a difference.^{1,20} In contrast, the PRISM III score discriminated strongly: no child with a score of 18 or below died, whereas nearly 60% of those above 18 died. This supports the use of PRISM III for early risk stratification, identification of children who need the most intensive monitoring, and counselling of families, as shown in other series.^{5,8,10,23}

Clinical implications

We suggest that three priorities are needed: to improve the recognition of compensated shock in primary and secondary facilities; to improve resuscitation, antibiotic use and safe transfer of children with suspected sepsis; and to enhance infection control and antimicrobial stewardship in intensive care units to reduce the risk of resistant Gram-negative infection.^{4,17,24-31}

Strengths and limitations

The strengths are the prospective follow-up of each child, the uniformity of the proforma, the systematic calculation of PRISM III and the microbiological characterization. The limitations are: single centre, thus reducing generalisability; relatively low number of patients, limiting subgroup analysis; exclusion of children who did not

meet the 24 hour stay criteria or children who left against medical advice may lead to underestimation of early mortality; pre-referral treatment and length of illness were not collected and thus cannot be assessed; there was no follow-up beyond the PICU admission, meaning long term neurological and organ outcomes remain unknown. Multivariable analysis was not performed.

CONCLUSION

Septicemia was the most common cause of shock in children admitted to this tertiary PICU and distributive shock was the most common shock type. The majority of children were multi-organ involved and required invasive ventilation and inotropic support in addition, and 41.1% of children succumbed to their illness. The PRISM III score was useful for early risk stratification as all deaths occurred in children whose score was greater than 18. Better recognition of shock, quick, etiology-directed management with proper antibiotic therapy, early admission to intensive care unit and risk stratification should be stressed for better survival. More multicenter studies with longer duration of follow-up are required.

DECLARATIONS

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Ethics approval

Approved by the Institutional Ethics Committee of Bharati Vidyapeeth (Deemed to be University) Medical College and Hospital, Sangli. Written informed consent was obtained from parents or guardians.

Conflict of interest

None declared by the authors.

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Author contributions

ASB: study design, data collection, analysis, and drafting. SGK: conception, supervision, and critical revision. Both authors approved the final version.

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