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Pediatric Septic Shock: Early Recognition and Aggressive Fluid Therapy Improves Outcome

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Authors' contributions

This work was carried out in collaboration among all authors. Author SN Collect the data, wrote the manuscript. Authors SS and RU managed the analyses of the study and participation in manuscript writing. Author Asfandyar managed the literature searches. Authors KS, CD, TA and IK read and approved the final manuscript.

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ABSTRACT

Objective: To establish the effect of aggressive fluid resuscitation in reversing the pediatric septic shock at 1 hour in children younger than 5 years of age presenting in the emergency unit of the hospital.
Methods: This was a descriptive, case series study, done for six months, from December 2015 to May 2016, at Pediatric Department of Ayub Medical College Abbottabad. Patients with age range of 1 month to 5 years, presenting in the emergency department with the diagnosis of septic shock having clinical features of tachycardia, tachypnea or hyperthermia along with hypotension and poor capillary refill time were included. All patients received aggressive fluid management. Clinical

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examination was repeated at the end of one hour for assessment of reversal of shock. Data was collected by self-made Performa.
Results: Mean age of study participants was 22.4 ± 17.6 months. Majority of participants 42(57%) were male. Mean weight was 10.3±4.3 kilograms. Mean heart rate was 173.9±17.8 beats per minutes. 67.6% were treated with a third-generation cephalosporin. At the end of one hour of treatment 51 (68.9%) showed the reversal of shock.
Conclusion: Majority of childrens who presented with septic shock showed the reversal of shock at one hour of management with weight-based fluid bolus therapy.

Keywords: Sepsis; shock; antibiotic.

1. INTRODUCTION

Sepsis is one of the common problems in the pediatric age group. Even with recent advances in management, it is fatal when not recognized and treated timely [1]. It is the most common cause of death in children worldwide. World Health Organization (WHO) defines severe sepsis as sepsis with acidosis, hypotension or both. Mortality rates in pediatric patients from severe sepsis and septic shock are significantly lower than the rates in adults [2]. Clinically septic shock is defined as the presence of tachycardia and poor perfusion with or without hypotension, the latter being a marker of decompensated shock and not required to make the diagnosis of septic shock as in adults. The mortality has been dramatically reduced from 97% in the 1960s to 9% in 1999 due to the latest and advanced critical care management [3]. According to WHO, the leading cause of death in pediatric age groups are still diarrhoea, malaria and sepsis. In all these conditions fluid resuscitation has decreased the mortality tenfold. Now, a worldwide initiative exists on the importance of improving access to this type of acute therapy [4]. The true incidence data of pediatric septic shock is lacking due to lack of uniform definition, however, a study from the US documented 42,364 annual cases of pediatric severe sepsis, i.e. 0.56 cases per 1000 population per year with 10.3% mortality rate in the hospital [5].

Most of the local and developing world studies, especially from India showed higher mortality rates in patients with septicemia due to late diagnosis, improper fluid resuscitation and lack of intensive care facilities. Indian study from Delhi showed 50% mortality, while from Ludhiana and Chandigarh reported 47% and 54.6% mortality rate respectively [6]. Persistent septic shock without adequate management will not only prolong the length of stay at the hospital and increase mortality by several folds but also burden the health system. In most of the recent studies, aggressive fluid resuscitation has reversed the shock and increased the survival dramatically up to 96% [7].

There should be early recognition of signs of sepsis at the triage and aggressive management with fluids i.e. up to 40 to 60 ml/kg (in contrast to the previous treatment protocol of 20 ml/kg) of crystalloid progressing towards inotropic support within the first hour if clinical improvement does not occur [8]. At St Mary's Hospital, mortality from meningococcal shock reduced up to 5% when 5% albumin was used with intubation of the patient and 40 mL/kg fluid was infused rapidly [9]. Aggressive fluid resuscitation of children with dengue septic shock showed 100% survival with four different solutions in the recent randomized control study. Crystalloid fluids were used as the initial fluid for resuscitation followed by colloid if no improvement was observed. In patients with hypoglycemia, dextrose fluid was preferred to prevent neurological complications [10]. For the reduction of mortality and morbidity, timely diagnosis and aggressive fluid management of sepsis are very important in children. Fluid resuscitation, vasopressor when needed, correction of hypoxia and acidosis, electrolytes and ventilatory support are the key steps in management. Response to initial fluid boluses by assessing mean blood pressure, central venous pressure, capillary refill and oxygen saturation are mandatory for further decisions of repeated boluses of fluids. As a large number of population is visiting public sector hospitals and there are limited numbers of Pediatric intensive care units (PICU) and trained pediatric intensivists, so this study aimed at improving the treatment protocols and its outcome in patients with septic shock requiring fluid resuscitation and hence reduce morbidity and mortality.

2. MATERIALS AND METHODS

This descriptive, case series study was conducted in the Emergency Department over

six months after ethical approval of the hospital ethical committee. Patients aged from 1 month to 5 years, presenting in the emergency department with the diagnosis of septic shock, having clinical features of tachycardia, tachypnea or hyperthermia along with hypotension and poor capillary refill time were included. Children those were contraindicated with a large amount of fluid due to underlying condition like congenital heart diseases, cardiomyopathy, chronic arrhythmia, severe malnutrition or the patient had already received fluids were excluded. All patients received aggressive fluid management. After each fluid bolus of 20 ml/kg following variables were checked: chest auscultation for rales, liver palpation to check for signs of cardiac failure, respiratory rate and heart rate. At time 1 (1 hour after time zero) additional variables were checked: temperature, capillary refill time, change in mental status and urine output. Blood pressure was measured weekly/daily according to Hospital policy. Clinical examination was repeated at the end of one hour for assessment of reversal of shock. After aggressive fluid resuscitation, the appropriate inotropic support and antibiotics were started according to patient's condition and the standard case management policy. All the data was recorded in the Performa. The data were analyzed at SPSS version 20.

3. RESULTS

Total of 74 patients were studied; their mean age was 22.4±17.6 months. Males were in majority 42 (56.7%). Most of the patients (54.1%) were under 20 months of age (Table 1).

Patient's mean weight was 10.3±4.3 kilograms, mean heart rate was 173.9±17.8 beats per minutes, and mean respiratory rate was 40.82±10.5 per minutes, mean systolic blood pressure was 71.7±6.3 mm of Hg and temperature mean was 38.7±0.8ºc at time zero. All these parameters improved at time one (Table 2).

Chest auscultation was normal in 86% at presentation. Majority of children's were either irritable (52.4%) or lethargic (24.3%) at time zero. The majority became comfortable at time one. (Table 3).

67.6% were treated with a third-generation cephalosporin. 43% needs inotropic support. At the end of one hour of treatment 51 (68.9%) showed the reversal of shock evidenced by improvement in systolic blood pressure, mental status and peripheral perfusion (Table 4). Small age and lower weight had a significant impact on the reversal of shock p-value 0.001 (Table 4).

Table 1. Demographic variables (N=74)

Demographic variables	N (%)
Age (months)	
1 – 20	40 (54.1)
21 – 39	22 (29.7)
40 - 60	12(16.2)
Gender	
Male	42 (56.7)
Female	32 (43.3)
Weight (kg)	
4 – 8	33(44.5)
9 – 14	27(36.5)
≥14.5	14(18.9)
Received ceftriaxone only	50 (67.6)
Received ceftriaxone Combination	5 (6.8)
Received Oxygen	32 (43.2)
Received ionotropic support	32(43.2)
Comorbid	
Asthma	2(2.7)
Febrile fits	2(2.7)
Infantile Spasm	1(1.4)
Reversal of shock in 1 hour	51 (68.9)

Age (mean+sd)= 8.4 ±5.9 months
Weight mean+sd)= 6.3±1.7 months

4. DISCUSSION

Children with sepsis require frequent monitoring and management in an intensive care unit. The most important step in initial management should be stabilization and correction of metabolic, circulatory, and respiratory derangements. Appropriate antibiotic therapy should be started as early as possible after evaluation. Monitoring and intensive care should be provided in moderate-to-critically ill cases [4].

In a previous study of Carcillo JA, et al. [11], mean age of the subjects was slightly more 112.5 vs 22.4 months. Our study also showed a significant improvement, where 69% of the patients showed a reversal of septic shock which is much better than the previous study.

Table 2. Baseline clinical parameters and response to fluid boluses (N=74)

	Time zero Mean ± SD	After fluid boluses of 20 ml/kg each			Time one Mean ± SD
		1st bolus Mean ± SD	2nd bolus Mean ± SD	3rd bolus Mean ± SD	
HR	173.9 ± 17.8	166.3±17.9	157.6±18.3	155.2±15.3	141.2±16.9
RR	40.82±10.5	39.5±10.6	33.3±10.6	38.6±11.3	32.7±9.8
SBP	71.7±6.3	73.9±7.2	76.4±8.1	75.8±7.3	82.0±7.3
CRT*(Seconds)*	4.2±0.9	4.1 ±0.9	3.7±0.9	3.4±0.7	3.0±0.7
Temp	38.7±0.8	38.5±0.7	38.1±0.7	37.9±0.7	37.4±0.5
Chest auscultation					
Clear	65 (87.8%)	65 (87.8%)	66 (89.1%)	46 (62.2%)	68 (91.8%)
Not clear	9(12.2%)	9(12.2%)	8(10.9%)	28(37.8%)	6(8.2%)
Liver palpation					
Palpable	2 (2.7%)	2 (2.7%)	2 (2.7%)	27 (36.5%)	2 (2.7%)
Not palpable	72 (97.3%)	72 (97.3%)	72 (97.3%)	47 (63.5%)	72 (97.2%)
Mental status					
Irritable	39 (52.7%)	1 (1.3%)	0(0%)	0(0%)	0(0%)
Lethargic	18 (24.3%)	0(0%)	1 (1.3%)	1 (1.3%)	0(0%)
Aborted	0(0%)	1 (1.3)	0(0%)	0(0%)	0(0%)
Drowsy	0(0%)	2 (2.7%)	3 (4.1%)	3 (4.1%)	0(0%)
Alert	0(0%)	0(0%)	0(0%)	0(0%)	21 (28.3%)
Sleep	0(0%)	0(0%)	0(0%)	0(0%)	20 (27.0%)
Asleep	0(0%)	0(0%)	0(0%)	0(0%)	10 (13.5%)
Other	18 (24.3%)	0(0%)	0(0%)	0(0%)	24 (32.4%)
Urine output					
Normal	0(0%)	0(0%)	0(0%)	0(0%)	49 (66.2%)
Not normal	72 (97.3%)	0(0%)	0(0%)	0(0%)	25 (33.8%)

Table 3. Distribution of antibiotics, oxygen, Comorbid and reversal shock (N=74)

Antibiotics	N	(%)
Ceftriaxone	50	67.6
Ceftriaxone+Amikacin	4	5.4
Ceftriaxone+Vancomycin	1	1.4
Clafron+Amikacin	3	4.1
Meroperem	1	1.4
Meroperem+Vancomycin	12	16.2
Tazocin+Amikacin	3	4.05
Inotropes		
Dopamine	32	43.2
Oxygen	32	43.2
Reversal of Shock at1 hour		
Yes	51	68.9
No	23	32.0

Our study showed no death due to hypovolemia but in a previous study, 8 patients died due to hypovolemia. In both studies, the rapid fluid resuscitation over 40 mL/kg in the first hour was associated with improved survival and minimal persistence of hypovolemia. Similarly both studies neither showed an increased risk of cardiogenic pulmonary edema nor adult respiratory distress syndrome in patients with septic shock after aggressive fluid therapy. Han YY, et al. [7] studied 91 patients and showed 29% mortality. The patients who achieved the Our study with a comparable sample size of 74 children found significant improvement and reversal of shock after 1 hour of fluid therapy were 26%, out of these patients 96% survived reversal of septic shock in 69% cases. This difference may be related to the severity of the septic shock, the onset of treatment, fluid bolus and other quality standards.

Table 4. Distribution of age, weight and Comorbid by reversal shock in an hour (N=74)

Age (months)	Reversal shock in 1 hour		
	Yes	No	p-value
1-20	22	18	
21 -39	17	5	0.001
40+	12	0	
Weight (kg)			
3.6 – 9.0	15	18	
9.1 – 14.4	23	4	0.001
14.5+	13	1	
Comorbid			
Asthma	2	0	
Febrile fits	2	0	0.001
Infantile spasm	1	0	

Ceneviva G, et al. [12] recruited fifty consecutive patients. The results found that after fluid resuscitation, 36% of the children still had a persistent shock in spite of vasopressor, and/or vasodilator therapy [12]. Our study with 74 purposefully selected patients found a very similar rate where shock persisted in 32% of the patients.

Brierley J, et al. [13] reviewed the updated 2007 guidelines and showed a reduction in mortality of children with septic shock as compared with adults due to aggressive fluid therapy in addition to the early use of inotropic and vasodilator therapies. Similarly, Kirby A, et al. [14] reported that early aggressive fluid resuscitation in children with septic shock results in improved survival. These results are consistent with our study because there was no increase in the frequency of adverse side effects like pulmonary oedema and acute respiratory distress syndrome or noncardiogenic pulmonary oedema due to aggressive fluid administration in both studies.

In contrast to our study, a prospective study from India demonstrated that rapid fluid administration by 3-way stop-cock push method increased the incidence of hepatomegaly and pulmonary oedema which later on needed endotracheal intubation [15]. This difference was most probably due to strict monitoring of patients' vitals and timely evaluation of the patients in our setup.

5. CONCLUSION

It was concluded that there was a significant role of fluid resuscitation in pediatric patients with septic shock. However, considering the nature of our study with a small sample and weak study design, it is recommend that the future studies to be conducted with a large sample size to reach the firm conclusion.

CONSENT

Informed written Consents were obtained from every parent/surrogate of patients.

ETHICAL APPROVAL

This descriptive, case series study was conducted in the Emergency Department over six months after ethical approval of the hospital ethical committee.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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