

Epidemiological trends of fatal pediatric trauma

A single-center study

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Abstract

To evaluate the potential risk factors which increase the incidence of post-trauma complications and mortality in pediatric population.

A retrospective cohort study was conducted on patients below 18 years of age with a fatal outcome who were admitted to an Indian level-1 trauma center between January 2013 and December 2015. This cohort was analyzed to determine the demographics, injury mechanism, injury severity, microbiological profile, and cause of death.

In total, 320 pediatric patients with a fatal outcome were studied which showed male preponderance (71.56%). The median age of the patients was 11 years (range, 0.14–18 years). Median duration of stay was 1 day (range, 0–183 days). Fall and road traffic accidents were the common mechanisms of trauma while the main injury was head injury. In total, 857 clinical samples were received from 56 patients. The clinical samples from 35 (10.94%) patients were culture positive. Culture-proven infections were significantly correlated with the length of hospital stay ($P = .001$). In total, 212 organisms were isolated from 193 positive samples of which gram-negative bacteria were predominant (89.15%). The most common gram-positive bacterial isolate was *Staphylococcus aureus* (12, 52.17%), while *Acinetobacter baumannii* (66, 34.92%) was the most prevalent gram-negative bacterial isolate followed by *Pseudomonas* spp. (36, 19.05%), *Klebsiella pneumoniae* (35, 18.52%), and *Escherichia coli* (16, 8.47%). Up to 100% multidrug resistance was seen in both gram-positive and gram-negative bacterial isolates. The first 24 hours after trauma were the deadliest for our patients. Head/central nervous system injury was the primary cause of disabilities and early death whereas infection attributed to prolonged hospital stay.

From these observations we concluded that management of pediatric trauma requires expert, multidisciplinary, and timely interventions. Moreover, nosocomial infections with multidrug resistant gram-negative bacteria challenges the accepted tenets of trauma care affecting the outcome of the pediatric population. Early identification of such high-risk patients' infection may facilitate early intervention. Thus, many deaths in pediatric group are preventable.

Abbreviation: CNS = central nervous system.

Keywords: fatal, head injury, infection, trauma

1. Introduction

Trauma is one of the most common cause of mortality and morbidity in pediatric population.^[1,2] Up to 12% of the patients admitted to pediatric intensive care units develops one or more infections during their admission.^[3] The severity and type of trauma may serve as confounding factors leading to poor prognosis of such patients. Trauma has become a rapidly expanding epidemic in the world's low and middle-income countries and the pediatric trauma patients remain a less studied group.^[4–7]

The management of trauma remains a challenge, since long hospital stay is often associated with the development of local or

systemic infections. The spectrum of pathogens and their resistant pattern after traumatic injury varies and depends upon the individual center.^[8–12] Over use of antibiotics and emerging antimicrobial resistance across the genera are increasingly affecting the outcome of trauma patients. The various factors affecting the epidemiology of pediatric trauma patients may be different from that of adults, so it is important to study this unique group separately. Understanding of pattern of infections and antimicrobial spectrum may help in formulating targeted bundles of intervention. While there is no standard or definitive strategy for the management of pediatric trauma, each center needs to develop their own data to standardize treatment and surveillance of infection.

Although many reports on the risk factors, causes, and treatment of the pediatric trauma are available^[1,2,7]; but studies on fatality and infection in pediatric trauma cases are limited. Therefore, this study was undertaken to investigate the clinical characteristics of pediatric trauma, patient's demography, incidence of microbial infection, and antimicrobial resistance at an Indian level I trauma center. The aim was to achieve a better understanding on pediatric trauma cases to facilitate better management of this vulnerable patient population.

2. Materials and methods

A retrospective cohort study was conducted on all trauma patients aged 0 to 18 years who were admitted to the Jai Prakash Narayan Apex Trauma Center, All India Institute of Medical Sciences, New Delhi, India between January 2013 and December,

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2015 whose final outcome was death. This cohort was analyzed to determine the demographics, mechanism of trauma, main injury type, length of hospital stay prior to death, microbiological profile, and factors associated with mortality. Sample for microbiological culture was sent by the clinicians based on suspected infections, as per standard recommendations. The processing of samples was done by standard methods. The identification of bacterial pathogens was performed using VITEK 2 (Biomérieux, France). Antibiotic susceptibility was performed according to the Clinical Laboratory Standards Institute guidelines.^[13] The study had been approved by the appropriate local institutional ethics committee.

2.1. Statistical analysis

Data were analyzed by Stata 11.1 (Stata Corp 4905, College station, TX) and represented in mean \pm (standard deviation) or median (range, minimum–maximum), and frequency (%). Categorical variables were compared by the independent *t* test and Wilcoxon rank-sum (skewed data). A *P* value of .05 or less was considered statistically significant.

3. Results

3.1. Patient demography

During the study period, a total of 3614 pediatric patients were brought to our center with trauma. Of which, 320 (8.85%) had fatal outcome; 105 (8.90%) in 2013, 114 (9.30%) in 2014, and 101 (8.80%) in 2015, respectively. The median age of the patients was 11 years (range, 0–18 years) and 229 (71.56%) were male. Median duration of hospital stay before fatal outcome was 1 day (range, 0–183 days). A total of 125 (39.06%) patients had a length of hospital stay for <24 hours, 111 (34.68%) had stayed for more than 24 hours to 7 days and remaining 51 (15.94%) had stayed for more than 7 days, 33 (10.31%) were brought dead.

3.2. Trauma profile

The most common mechanism of trauma was fall (134, 41.86%) followed by road traffic accident (130, 40.63%), railway track accidents (12, 3.75%), assault (8, 2.50%), hanging (6, 1.88%), and others (30, 9.38%). The commonest primary trauma in these fatal patients was head/spinal injury (188, 58.75%) followed by polytrauma (44, 13.75%), abdominal (19, 5.94%), orthopedics injury (18, 5.63%), chest trauma (2, 0.63%), and others (16,

5%). High risk of trauma was seen in patients with age group of 0 to 6 years (122, 38.13%) and 12 to 18 years (143, 45.31%). History of fall was significant among 0 to 6 years (73.00%) which decreased significantly with age whereas road traffic accident was the most common type of trauma among 12 to 18 years of age (64.00%) (Fig. 1). The risk of trauma beyond 6 years of age was more in male than female (Fig. 1).

3.3. Microbiological profile

Of 320 cases studied, clinical samples were received from 56 patients of whom 10.94% (35/320) had infective complication during the hospital stay. Among 320 patients, 51 (15.94%) had a hospital stay of more than 7 days, of which 29 (56.86%) contracted nosocomial infections during the clinical course. The rate of infective complication increased significantly with the length of hospital stay ($P < .001$) (Fig. 2).

In total, 857 clinical samples were received from 56 patients, 193 were culture positive. Sample received included 336 (39.21%) blood samples, 220 (25.67%) respiratory tract samples, 111 (12.95%) urine samples, 80 (9.33%) skin/soft tissue samples, 71 (8.28%) sterile fluids, and 39 (4.55%) others. Culture positive samples (193) included blood (14.60%), respiratory tract (28.10%), urine (11.70%), skin/soft tissue (50.00%), sterile fluid (31.00%), and others (18.00%). From the culture positive samples, 212 microorganisms were identified, which included 189 (89.15%) gram-negative bacteria and 23 (10.85%) gram-positive bacteria as shown in Table 1. The most common gram-positive bacterial isolate was *Staphylococcus aureus* (12, 52.17%), while *Acinetobacter baumannii* (66, 34.92%) was the most prevalent gram-negative bacterial isolate followed by *Pseudomonas* spp. (36, 19.05%), *Klebsiella pneumoniae* (35, 18.52%), and *Escherichia coli* (16, 8.47%).

3.4. Antimicrobial sensitivity profile

Antimicrobial susceptibility was performed for all 212 bacterial isolates. Of the total gram-positive isolates ($n = 23$), 2 (8.70%) were resistant to 2 antibiotics and the rest (21, 91.30%) were resistant to more than 2 antibiotics. Among gram-positive bacteria, 78.00% *S aureus* were methicillin-resistant *S aureus* and 90.00% coagulase negative staphylococci (CONS) were methicillin resistant. Highest level resistance to gram-positive isolates was against macrolides (75.00–100.00%), clindamycin (67.00–100.00%), and fluoroquinolone (40.00–90.00%), as shown in Table 2. Among aminoglycosides, netilmicin (0–22.00% resistance) was found to be more

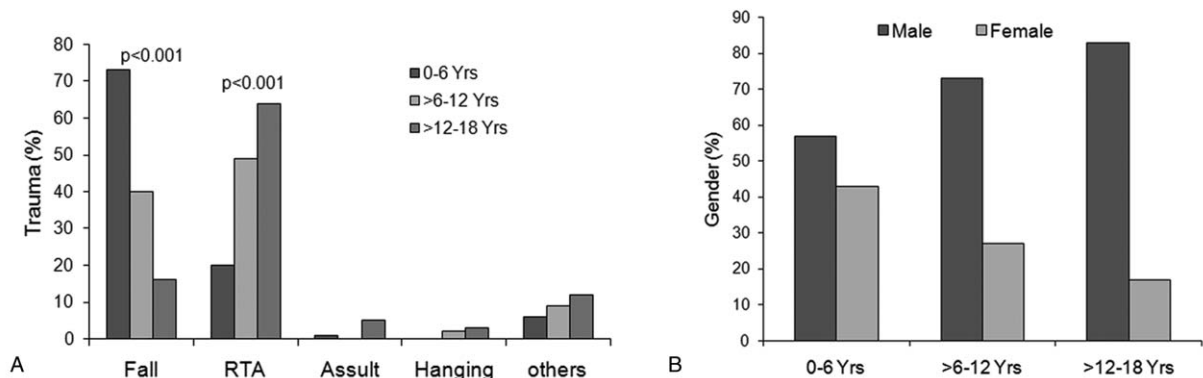


Figure 1. Correlation between the profile of trauma patients with age (A) and gender (B).

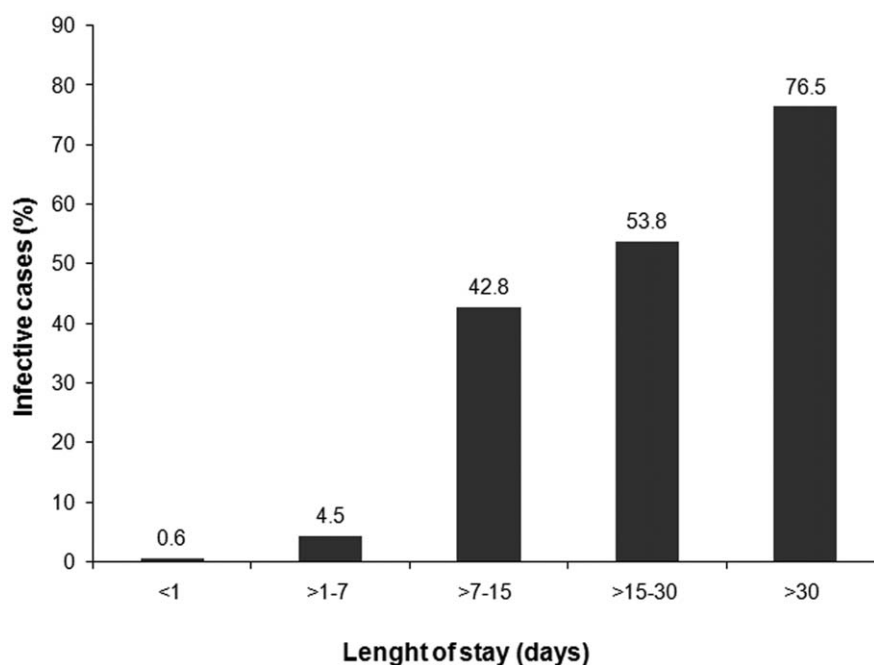


Figure 2. Correlation between the length of hospital stay and the rate of infection in trauma patients.

effective than gentamicin (67.00–83.00% resistance). No resistance was observed to vancomycin, teicoplanin, and linezolid (Table 2).

Most of the gram-negative isolates (188, 99.47%) were found to be resistant to more than 2 antibiotics. High rate of resistance to third generation of cephalosporins (67.00–100%), cefepime (43.00–98.00%), ceftazidime (88.00–100%), and aminoglycosides (69.00–100%) were observed among *Pseudomonas* spp., *A baumannii*, and *Enterobacteriaceae* including *E coli*. Colistin was most effective agent against multidrug resistant *Pseudomonas* spp., *Enterobacteriaceae*, and *A baumannii* (resistance; 3.00%, 3.00%, and 0%, respectively) (Table 3).

Table 1
Distribution of gram-positive and gram-negative bacteria.

Organism (212)	Organism name	Number (%)		
Gram positive (23, 10.85%)	<i>Staphylococcus aureus</i>	12 (52.17)		
	<i>Staphylococcus epidermidis</i>	6 (26.09)		
	<i>Staphylococcus hominis</i>	2 (8.70)		
	<i>Staphylococcus haemolyticus</i>	2 (8.70)		
	<i>Enterococcus faecium</i>	1 (4.35)		
Gram negative (189, 89.15%)	<i>Enterobacteriaceae</i> (71, 37.57%)	<i>Escherichia coli</i>	16 (8.47)	
		<i>Klebsiella pneumoniae</i>	35 (18.52)	
		<i>Proteus mirabilis</i>	2 (1.06)	
		<i>Enterobacter cloacae</i>	7 (3.70)	
		<i>Serratia marcescens</i>	7 (3.70)	
		<i>Providencia</i> spp.	3 (1.59)	
		<i>Morganella morganii</i>	1 (0.53)	
		Non-Enterobacteriaceae (102, 53.97%)	<i>Pseudomonas</i> spp.	36 (19.05)
			<i>Acinetobacter baumannii</i>	66 (34.92)
			<i>Burkholderia cepacia</i>	11 (5.82)
Others (16, 8.47%)	<i>Elizabethkingia meningoseptica</i>	2 (1.06)		
	<i>Sphingomonas paucimobilis</i>	1 (0.53)		
	<i>Stenotrophomonas maltophilia</i>	2 (1.06)		

3.5. Outcome

During study period, a total of 320 patients died. This represented 8.85% of all major pediatric trauma admissions (3614). Of the total fatalities, 33 (10.31%) were dead on arrival. Thirty-nine percent (n = 125) of the patients died within 24 hour of the admission, 34.69% (n = 111) died within 7 days, and 15.94% (n = 51) died after 7 days. Primary cause of death included head/central nervous system (CNS) injury (114, 35.63%) and multiple injuries (28, 8.75%). Children with head trauma across the age groups had the least survival period of up to 7 days. Acute inflammatory processes (multiple-organ failure, acute respiratory distress syndrome, pneumonia), septicemia and hemorrhagic shock (33, 10.31%) were common causes of death after 7 days. Death was attributed to septicemia in 16 patients (5%). Post-trauma cardiac arrest (n = 44, 13.75%) and cardio-pulmonary arrest (n = 10, 3.13%) were immediate cause of death. The cause of death for 17 patients (5.31%) remained undetermined.

4. Discussion

The present retrospective cohort study describes the profile of pediatric trauma patients with a fatal outcome. Trauma continues to account for significant morbidity and mortality annually (8.40–9.30%) in children. Various factors influence childhood injuries, including age, gender, behavioral pattern, and environment. Age and gender being the most important factors affecting the patterns of injury, we observed that male children younger than 18 years had higher injury and mortality rates, possibly because of their more aggressive behavior and exposure to contact sports than female children. This is consistent with the findings from other research where male preponderance has been observed.^[7,9] The median age at presentation was 11 years (range, 0.14–18 years). More traumatic injury was seen in

Table 2**Antibiotic-resistant pattern of gram-positive isolates (n=23).**

Antibiotics	<i>Staphylococcus aureus</i> (n=12) resistance, number; %	CONS (n=10) resistance, number; %	<i>Enterococcus faecium</i> (n=1) resistance, number; %
Ampicillin/Sulbactam	9; 75	7; 70.00	1; 100
Amoxicillin/Clavulanic acid	9; 75.00	9; 90.00	1; 100
Ampicillin	12; 100	10; 100	1; 100
Penicillin	12; 100	10; 100	1; 100
Oxacillin	9; 75.00	9; 90.00	NA
Cefoxitin	9; 75.00	9; 90.00	NA
Erythromycin	9; 75.00	10; 100	1; 100
Clindamycin	8; 66.67	10; 100	NA
Levofloxacin	10; 83.33	8; 80.00	1; 100
Ciprofloxacin	11; 91.67	4; 40.00	0
Gentamicin	10; 83.33	7; 70.00	NA
Netilmicin	0	2; 20.00	NA
Vancomycin	0	0	0
Linezolid	0	0	0
Teichoplanin	0	0	0
Tetracycline	4; 33.33	0	1; 100
Cotrimoxazole	2; 16.67	9; 90.00	0

CONS = coagulase negative staphylococci.

children falling under 0 to 6 years (38.00%) and 12 to 18 years (45.00%) age groups.

In contrast to a study from southwestern Norway where prehospital death was seen in 58.00% of the cases,^[14] we observed 10.00% prehospital deaths in our study population in the duration of 3 years. The most common mechanism of trauma in this study was fall (41.90%) and road traffic accident (40.60%). Post-trauma head injury (58.70%) was most common in our patient population. Children aged between 0 and 6 years sustained more falls and were at increased risk for head injury. Fall and head injury has also been reported as major risk factors for trauma from other parts of the world.^[15-17] This emphasizes the importance of preventive measures like use of helmets and

seatbelts, which would result in a fewer head injuries and decrease the severity of them as well. In developing countries, compliance to helmet wearing is very dismal. Assault or violence was observed in 2.50% of cases. In some studies, violence has been observed to be the major cause of trauma and associated with mortality in pediatric population.^[7] Difference in social fabric of a nation may be responsible for this.

Longer length of hospital stays (>7 days; 51 patients) was associated with more number of infective cases (29/51, 56.86%). Post-trauma infections were associated with increased duration of hospital stay and were found to be statistically significantly ($P = .001$). In this study, most pathogens were isolated from skin/soft tissue infection and most common isolates were *A baumannii*

Table 3**Antibiotic-resistant pattern of gram-negative bacteria (n=189).**

Antibiotics	<i>Pseudomonas</i> spp. (n=36) resistance, number; %	<i>Acinetobacter baumannii</i> (n=66) resistance, number; %	<i>Enterobacteriaceae</i> (n=71) resistance, number; %	Others (n=16) resistance, number; %
Amikacin	25; 69.44	61; 92.42	53; 74.65	12; 75
Gentamycin	28; 77.78	66; 100	53; 74.65	16; 100
Netilmicin	30; 83.33	57; 86.36	55; 77.46	16; 100
Cefotaxime	32; 88.89	66; 100	67; 94.37	0
Ceftazidime	32; 88.89	65; 98.48	67; 94.37	5; 31.25
Ceftriaxone	35; 97.22	66; 100	67; 94.37	16; 100
Cefoperazone/Sulbactam	28; 77.78	60; 90.91	53; 74.65	5; 31.25
Ceftriaxone/Sulbactam	31; 86.11	62; 93.94	48; 67.61	5; 31.25
Cefepime	27; 75.00	65; 98.48	63; 88.73	5; 31.25
Cefepime/Tazobactam	24; 66.67	65; 98.48	31; 43.66	0
Piperacillin/Tazobactam	26; 72.22	64; 96.97	51; 71.83	0
Ticarclillin/Clavulanic acid	33; 91.67	66; 100	69; 97.18	11; 68.75
Piperacillin	28; 77.78	65; 98.48	65; 91.55	0
Imipenem	25; 69.44	61; 92.42	30; 42.25	14; 87.50
Meropenem	29; 80.56	64; 96.97	40; 56.33	12; 75
Colistin	1; 2.78	0	2; 2.82	0
Ciprofloxacin	30; 83.33	66; 100	62; 87.32	11; 68.75
Levofloxacin	28; 77.78	53; 80.30	63; 88.73	6; 37.50
Chloramphenicol	NA	65; 98.48	52; 73.24	11; 68.75
Tigecycline	NA	0	6; 8.45	2; 12.50

NA = not available.

(31.13%) followed by *Pseudomonas* spp. (16.98%), *K pneumoniae* (16.51%), and *Staphylococcus* spp. (5.66%). Other studies have also reported gram-negative bacteria as most commonly isolated pathogen, but the distribution pattern varies.^[8,9] Similarly, other reports on adult trauma patients have also showed the predominance of gram-positive bacteria.^[11,18,19]

In the present study, a very high rate of antimicrobial resistance was observed for most microorganisms. Resistance in gram-negative bacteria was observed to be higher than those in gram-positive isolates. Gram-positive bacteria showed no resistance to glycopeptides antibiotics, which has been seen previously by us and in other studies.^[20-22] Among gram-negative bacteria, the most common multidrug resistant bacteria were *Pseudomonas* spp. and *A baumannii*. Multidrug resistant *Pseudomonas* spp. and *Acinetobacter* spp. infections are an emerging problem in critically ill cases in many parts of the world.^[12] Similar high rate of resistance was observed in *Pseudomonas* spp. isolates from trauma patients from South Asian country.^[23] Our study showed that resistance rate of *Acinetobacter* spp. (91.80%) was relatively higher as compared to *Pseudomonas* species (77.90%), which is in line with previously published data.^[12] Tigecycline was effective against most gram-negative bacteria, a finding which we had observed in a previous study too.^[24] In contrast to a study in Egypt where only 11.50% of *Burkholderia cepacia* were resistant to meropenem, all our stains were resistant to this antimicrobial.^[25] These findings reiterate the need to evaluate the epidemiology of microbial infections and antimicrobial resistance at individual centers, especially in the pediatric population.

The first 24 hours after trauma were the deadliest for our patients. Head/CNS injuries were the leading causes of death. After 24 hours of admission, other factors like acute inflammatory processes, sepsis, hemorrhagic shock, and others were the most common causes of death. This has been reported in other studies too that have found CNS injury as most common cause of early death.^[26,27] Thus, many deaths in pediatric group are preventable. The limitation of our study is its retrospective nature. No patient specific interventions could be done, especially on high-risk neurotrauma pediatric patients. Because, the patients were not prospectively followed up, they could not be isolated on early identification of infection with Multidrug resistant (MDR) bacteria. Awareness among parents and teenage children about the risk factors of trauma, early identification of trauma, timely arrival to hospital, treatment of potentially lethal injuries, and early identification of infection should remain the focus of those who treat trauma patients.

5. Conclusion

Management of pediatric trauma requires expert, multidisciplinary, and timely interventions. The characteristics and unique profile of pediatric trauma patients must be recognized. The mechanisms of childhood injuries largely affect the developmental milestones in children. Head injuries, either isolated or in association with polytrauma, are the most severe and cause the most deaths. Head injuries have been known to account for most disability or deaths in children. Moreover, such patients are at high risk of developing nosocomial infections with multidrug resistant bugs. Multidrug resistant gram-negative bacteria in particular pose higher threat accounting for mortality in this cohort. Longer duration of stay in hospital was associated with more infections. Early identification of the patients, who are at increased risk for infection may allow for early intervention.

Author contributions

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Writing – review & editing: Sanjeev Lalwani, Fahmi Hasan, Surbhi Khurana, Purva Mathur.

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