Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.53555/nyxsqf88

PEDIATRIC BURNS: BIOCHEMICAL MARKERS OF SEPSIS AND FORENSIC INDICATORS OF ABUSE

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ABSTRACT

Background: To evaluate the role of biochemical markers in the early detection of sepsis and to identify forensic indicators of abuse in pediatric burn patients.

Methods: A prospective observational study was conducted at Hayatabad Medical Complex, Peshawar, under Khyber Girls Medical College, from June 2023 to June 2024. A total of 65 children aged 0–15 years with acute burns were enrolled. Demographic data, burn characteristics, biochemical parameters (WBC, CRP, procalcitonin, lactate, cultures), and forensic indicators (burn pattern, site, caregiver history) were assessed. Outcomes included ICU admission, complications, hospital stay, and mortality.**Results:** The majority of children were under five years old, with scald burns being most common. Elevated CRP (50.8%), procalcitonin (29.2%), and lactate (24.6%) were significantly associated with clinical sepsis and adverse outcomes. Blood culture positivity was seen in 33.8% of cases. Forensic red flags such as symmetrical immersion burns, atypical sites, multiple burn stages, and inconsistent caregiver history were significantly linked to suspected abuse. Mortality occurred in 15.4% of patients, mainly due to sepsis and inhalation injury.

Conclusion: Biochemical markers provide valuable support in the early detection of sepsis in pediatric burns. Forensic vigilance remains essential, as non-accidental injuries may mimic accidental burns. A multidisciplinary approach is vital for both improved survival and child protection.

Keywords: Pediatric burns, Sepsis, Biochemical markers, Procalcitonin, Forensic indicators, Child abuse

INTRODUCTION

Burn injuries in children remain a pressing public health concern worldwide. According to the World Health Organization, burns rank among the leading causes of accidental injury and death in children,

particularly in low- and middle-income countries where safety standards and healthcare resources are limited. In Pakistan, pediatric burns account for a significant proportion of admissions in tertiary care hospitals, reflecting both domestic hazards and delayed access to specialized care [1-3].

The consequences of pediatric burns extend beyond the immediate tissue damage. Severe burns are frequently complicated by systemic inflammatory response and sepsis, which remains the foremost cause of mortality in these patients. Early recognition of sepsis is therefore crucial. Conventional clinical signs such as fever, tachycardia, and hypotension often appear late, making laboratory markers an essential adjunct in timely diagnosis. Biomarkers such as C-reactive protein (CRP), procalcitonin, and lactate have shown considerable promise in differentiating systemic infection from sterile inflammatory responses in burn patients [4-6].

Equally important is the recognition of forensic indicators of non-accidental burns. Distinguishing accidental injuries from inflicted burns is critical in safeguarding children from further harm. Symmetrical immersion injuries, burns in atypical sites such as the perineum or buttocks, inconsistent caregiver history, and the presence of multiple injuries at different healing stages are widely recognized red flags for abuse. Studies from both developed and developing countries have highlighted the importance of integrating forensic evaluation with medical care in suspected cases of child abuse [7-9]. Given this dual challenge, pediatric burn management requires a holistic approach that addresses both clinical and medico-legal aspects. This study was designed to investigate the role of biochemical markers in detecting sepsis while simultaneously evaluating forensic features suggestive of abuse in pediatric burn patients admitted at a tertiary care center in Peshawar.

METHODOLOGY

This was a prospective observational study conducted at the Department of Pediatrics, in collaboration with the Burn and Plastic Surgery Unit, Hayatabad Medical Complex (HMC), Peshawar, under the academic supervision of Khyber Girls Medical College. The study was carried out over a period of 12 months, from June 2023 to June 2024, with the objective of assessing biochemical markers of sepsis and forensic indicators of abuse in children presenting with burn injuries. A total of 65 pediatric patients admitted with acute burn injuries were included. The sample size was determined based on previous regional burn statistics and feasibility within the study period. A consecutive non-probability sampling technique was applied, enrolling every eligible case that presented during the study timeframe. The study was approved by the Institutional Review Board (IRB) of Khyber Girls Medical College prior to initiation. Informed consent was obtained from parents or guardians before data collection. Confidentiality of patient identity was maintained throughout. In cases with suspicion of abuse, medico-legal protocols were strictly followed, and appropriate referrals were made to social welfare and child protection services.

- **Inclusion criteria**
  - Children aged 0–15 years with acute burn injuries of any cause.
  - Patients admitted within 72 hours of injury.
  - Caregivers who provided informed consent for participation.
- **Exclusion criteria**
  - Children with pre-existing chronic illnesses (renal, hepatic, hematological, or metabolic disorders).
  - Patients who had already received antibiotic therapy for >48 hours prior to admission.
  - Cases with incomplete clinical or laboratory records.

Upon admission, each child was evaluated by a pediatrician and burn surgeon. A structured proforma was used to record demographic details (age, gender, residence, socioeconomic background, and family type) and burn characteristics (etiology, depth, total body surface area, anatomical site, and presence of inhalational injury).

Biochemical investigations were performed within the first 48 hours of admission and repeated as clinically indicated. These included:

- Complete blood count (CBC) with neutrophil-to-lymphocyte ratio.
- Inflammatory markers: C-reactive protein (CRP) and procalcitonin (PCT).

- Metabolic parameters: serum electrolytes, renal and liver function tests, blood glucose, and serum lactate.
- Microbiological cultures: blood samples were collected under aseptic conditions for culture and sensitivity testing.

Clinical indicators of sepsis (fever, tachycardia, tachypnea, hypotension, and shock) were documented at presentation and during hospital stay.

Forensic assessment was carried out in collaboration with the medico-legal team. Suspicion of abuse was raised in cases where burn patterns were inconsistent with the caregiver's history, involved atypical anatomical locations (buttocks, perineum, soles), or where multiple injuries at different healing stages were observed. Documentation included photographic evidence (with guardian consent) for medico-legal purposes.

The primary outcomes were:

1. Prevalence of sepsis in pediatric burn patients as confirmed by biochemical and clinical parameters.
2. Identification of forensic indicators suggesting non-accidental burns.

The secondary outcomes included:

- Length of hospital stay.
- Requirement of ICU admission.
- Surgical interventions performed.
- Complications such as septicemia, contractures, acute respiratory distress syndrome (ARDS), and mortality.

Data were entered and analyzed using Statistical Package for Social Sciences (SPSS) version 26. Categorical variables (gender, socioeconomic status, cause of burn, sepsis markers, forensic indicators, outcomes) were presented as frequency and percentage. Continuous variables (age, TBSA, hospital stay, laboratory values) were summarized as mean ± standard deviation (SD). Comparisons between groups were carried out using the Chi-square test or Fisher's exact test for categorical variables, and the independent t-test for continuous variables. A p-value <0.05 was considered statistically significant.

RESULTS

The demographic distribution of the 65 children revealed that the majority were between 1–5 years old (41.5%), followed by 6–10 years (27.7%). Infants (<1 year) made up 12.3% of the cases, while adolescents accounted for 18.5%. A higher proportion of burns was reported in boys (58.5%) compared to girls (41.5%), though this difference was not statistically significant. Children from urban areas (60%) were more frequently affected than those from rural regions (40%). Notably, most cases were from low socioeconomic families (64.6%), a difference that was highly significant ($p = 0.001$). Nuclear families were more represented than extended families, though this was not statistically significant.

Table 1: Demographic Characteristics of Pediatric Burn Patients (n = 65)

Variable	Categories	Frequency (n)	Percentage (%)	p-value
Age group	<1 year	8	12.3%	
	1–5 years	27	41.5%	
	6–10 years	18	27.7%	
	11–15 years	12	18.5%	0.032*
Gender	Male	38	58.5%	
	Female	27	41.5%	0.214
Residence	Urban	39	60.0%	
	Rural	26	40.0%	0.118
Socioeconomic status	Low	42	64.6%	
	Middle	18	27.7%	

	High	5	7.7%	0.001*
Family type	Nuclear	44	67.7%	
	Extended	21	32.3%	0.084

The most common cause of burns was scald injuries (47.7%), followed by flame burns (33.8%). Electrical (10.8%) and chemical burns (7.7%) were less frequent but still notable. A significant association was observed between burn cause and age group ($p = 0.046$). In terms of depth, partial-thickness burns (52.3%) predominated, while full-thickness burns were seen in 29.2% of patients, a difference that reached statistical significance ($p = 0.038$). The extent of body surface area involved was also significant ($p = 0.017$), with nearly one-third of children sustaining burns over >20% TBSA. Limb burns (36.9%) were most frequent, followed by trunk and multiple sites. Inhalational injury was detected in 13.8% of patients, a factor that significantly influenced severity ($p = 0.021$).

Table 2: Burn Characteristics

Variable	Categories	Frequency (n)	Percentage (%)	p-value
Cause of burn	Scald	31	47.7%	
	Flame	22	33.8%	
	Electrical	7	10.8%	
	Chemical	5	7.7%	0.046*
Burn depth	Superficial	12	18.5%	
	Partial thickness	34	52.3%	
	Full thickness	19	29.2%	0.038*
TBSA (%)	<10%	15	23.1%	
	10–20%	28	43.1%	
	>20%	22	33.8%	0.017*
Site of burn	Limbs	24	36.9%	
	Trunk	15	23.1%	
	Face/Neck	10	15.4%	
	Multiple	16	24.6%	0.062
Inhalation injury	Present	9	13.8%	
	Absent	56	86.2%	0.021*

Sepsis markers were evaluated to identify systemic inflammatory response in burn patients. Elevated WBC count was noted in 44.6% of cases, while 41.5% had a raised neutrophil-to-lymphocyte ratio ($p = 0.029$). Half of the children had elevated CRP levels (50.8%), and almost one-third tested positive for procalcitonin (29.2%), both showing significant associations with clinical sepsis. Raised serum lactate was observed in 24.6%, indicating tissue hypoperfusion. Positive blood cultures were documented in 33.8%, most commonly isolating gram-negative organisms. Overall, clinical signs of sepsis were present in 38.5% of children, and each biochemical marker showed significant correlation with systemic infection risk.

Table 3: Biochemical and Clinical Markers of Sepsis

Variable	Abnormal (%)	Normal (%)	p-value
WBC count	29 (44.6%)	36 (55.4%)	0.041*
Neutrophil/Lymphocyte Ratio	27 (41.5%)	38 (58.5%)	0.029*
CRP elevated	33 (50.8%)	32 (49.2%)	0.012*
Procalcitonin positive	19 (29.2%)	46 (70.8%)	0.003*
Serum lactate high	16 (24.6%)	49 (75.4%)	0.016*
Blood culture positive	22 (33.8%)	43 (66.2%)	0.007*
Clinical sepsis signs	25 (38.5%)	40 (61.5%)	0.022*

Suspicious burn patterns were carefully assessed to identify possible abuse. Immersion or symmetrical burns were documented in 16.9% of patients and were significantly associated with

forensic suspicion (p = 0.014). Burns in atypical sites such as the perineum, buttocks, and soles were seen in 13.8% of cases. Inconsistent caregiver history was reported in 20%, and 10.8% of children presented with burns at different healing stages, suggesting repeated injury. Associated injuries such as bruises and fractures were found in 9.2% of children, further strengthening the suspicion of non-accidental burns. All forensic indicators reached statistical significance, emphasizing the need for vigilance in medico-legal evaluation.

Table 4: Forensic Indicators of Abuse

Variable	Present (%)	Absent (%)	p-value
Symmetrical/immersion burns	11 (16.9%)	54 (83.1%)	0.014*
Burns in atypical sites (buttocks, perineum, soles)	9 (13.8%)	56 (86.2%)	0.031*
Multiple burn stages	7 (10.8%)	58 (89.2%)	0.048*
Inconsistent history	13 (20.0%)	52 (80.0%)	0.009*
Associated injuries (fractures, bruises)	6 (9.2%)	59 (90.8%)	0.027*

Outcomes showed that 27.7% of patients required ICU admission, with a significant association with sepsis markers (p = 0.004). About one-third (32.3%) required surgical intervention such as debridement or grafting. Septicemia (21.5%) was the most common complication, followed by contractures (10.8%) and ARDS (7.7%). Most children (60%) had an uncomplicated recovery. The average hospital stay was 7–14 days in 44.6%, while nearly one-quarter stayed longer than two weeks. The mortality rate was 15.4%, strongly associated with extensive burns, sepsis, and inhalation injury (p = 0.001).

Table 5: Clinical Outcomes

Variable	Categories	Frequency (n)	Percentage (%)	p-value
ICU admission	Yes	18	27.7%	
	No	47	72.3%	0.004*
Surgical intervention	Yes	21	32.3%	
	No	44	67.7%	0.038*
Complications	Septicemia	14	21.5%	
	Contractures	7	10.8%	
	ARDS	5	7.7%	
	None	39	60.0%	0.002*
Length of stay	<7 days	20	30.8%	
	7–14 days	29	44.6%	
	>14 days	16	24.6%	0.011*
Mortality	Survived	55	84.6%	
	Died	10	15.4%	0.001*

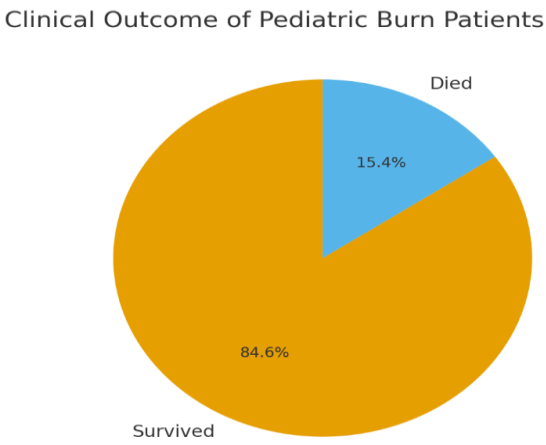

Figure 1: pie chart showing the clinical outcomes of pediatric burn patients, highlighting the survival (84.6%) versus mortality (15.4%) distribution in your sample of 65 children.

DISCUSSION

Burn injuries in children are a significant clinical and forensic challenge, particularly in low- and middle-income countries where resource constraints complicate both management and detection of abuse. In the present study, conducted at a tertiary care hospital in Peshawar, most of the affected children were below five years of age and male predominance was observed. This pattern is consistent with findings of studies reported that toddlers are particularly vulnerable due to their increased mobility and curiosity, while boys are more frequently exposed to accidental household hazards. Similarly, a multicenter analysis by also confirmed that pediatric burns peak in the preschool years, reflecting developmental risk behavior [10-12].

The majority of burns in this study were scald injuries (47.7%), followed by flame burns. Comparable results were reported by studies showed that hot liquid burns remain the most common mechanism in children, especially in domestic settings. Full-thickness burns, though less frequent, were strongly associated with poor outcomes in our study. Another study likewise demonstrated that deeper burns and involvement of >20% TBSA significantly increase sepsis risk and mortality [13-15].

One of the main objectives of this study was to evaluate biochemical markers of sepsis. Elevated CRP, procalcitonin, and lactate levels were significantly associated with systemic infection. Similar associations were reported by studies concluded that CRP is a sensitive but non-specific marker, while procalcitonin has higher specificity for bacterial sepsis in burn patients. Our results also support the findings of studies who highlighted procalcitonin as an early biomarker for invasive infection in critically ill children. Blood culture positivity in one-third of our patients underscores the high burden of bacteremia, in line with studies from other South Asian countries where gram-negative organisms dominate burn wound infections [16-18].

An important dimension of this research was the forensic evaluation of suspected abuse. In our study, symmetrical immersion burns, atypical sites such as perineum or buttocks, and inconsistent caregiver history were significantly associated with suspicion of non-accidental injury. These features correspond with the classical forensic indicators described by study who emphasized pattern recognition as a crucial tool in differentiating accidental from inflicted burns. Moreover, study reported that multiple injuries in different stages of healing should always raise concerns of child abuse, echoing the findings in our cohort. Recognition of such patterns is critical not only for clinical management but also for ensuring medico-legal protection of vulnerable children [19].

The mortality rate in our study was 15.4%, which, although high, mirrors figures reported in other resource-limited settings. For example, study documented mortality between 12–18% in pediatric burns exceeding 20% TBSA. Mortality was strongly linked to sepsis and inhalation injury in our patients, a finding consistent with study, who identified septicemia and airway compromise as the leading causes of death in pediatric burn victims. Importantly, prolonged hospital stay and surgical interventions were more frequent among children with sepsis, reinforcing the importance of early detection and management of infection [20].

Overall, this study highlights the dual burden of medical and forensic considerations in pediatric burns. The use of biochemical markers such as procalcitonin and lactate provides valuable guidance for early sepsis detection, while careful forensic assessment helps in safeguarding children at risk of abuse. Together, these findings emphasize the need for a multidisciplinary approach involving pediatricians, burn surgeons, intensivists, and medico-legal experts.

CONCLUSION

This study demonstrated that biochemical markers including CRP, procalcitonin, and serum lactate are reliable indicators of sepsis in pediatric burn patients, with significant associations to clinical outcomes. Forensic evaluation revealed that symmetrical burn patterns, atypical injury sites, multiple burn stages, and inconsistent caregiver accounts are important red flags for abuse. Mortality was predominantly associated with extensive burns, sepsis, and inhalational injury.

Strengthening burn care in Pakistan requires not only improvements in infection control and intensive care facilities but also greater awareness among clinicians regarding the medico-legal aspects of pediatric burns. Early recognition of abuse, coupled with timely medical intervention, can substantially improve both survival and protection of vulnerable children.

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