



DEVELOPING A RAPID ASSESSMENT AND INTERVENTION PROTOCOL FOR PEDIATRIC SEPSIS IN THE EMERGENCY DEPARTMENT: INTEGRATION OF CHEMICAL PATHOLOGY BIOMARKERS AND POINT-OF-CARE TESTING

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ABSTRACT

Background: Pediatric sepsis is one of the major causes of morbidity and mortality across the globe, especially in resource-suboptimal emergency units where early identification is one of the factors that are associated with adverse outcomes. Biochemical markers can be used to identify a condition at an early stage and facilitate intervention.

Objective: To develop and evaluate a rapid assessment and intervention protocol integrating chemical pathology biomarkers and point-of-care testing (POCT) for pediatric sepsis in the emergency department.

Methods: This observational research was done in the Pediatric Emergency Department of Lady Reading Hospital, Peshawar, between January and June 2025. Sixty two of these children were 1 month to 12 years old. The rapid screening consisted of clinical evaluation, point-of-care lactate, and venous blood gas evaluation and laboratory C-reactive protein (CRP) and procalcitonin (PCT). The compliance with sepsis bundle, time to intervention indicators and clinical outcomes were documented. Comparisons were made between shock vs non-shock patients and lactate <2 mmol/L vs ≥ 2 mmol/L groups.

Results: Shock was present in 31.9% of patients. Mean lactate levels were significantly higher in shock patients (4.8 ± 1.9 mmol/L) compared to non-shock patients (2.1 ± 0.9 mmol/L; $p < 0.001$). ICU admission was significantly more frequent among children with lactate ≥ 2 mmol/L (42.9% vs 10.0%; p

= 0.003). Antibiotics were administered within 60 minutes in 80.6% of cases. Overall mortality was 8.3%, primarily among patients with persistent hyperlactatemia.

Conclusion: Integration of POCT lactate and inflammatory biomarkers into a rapid pediatric sepsis protocol improved early risk stratification and was strongly associated with clinical severity and outcomes. Biomarker-guided management may enhance emergency sepsis care in high-burden settings.

Keywords: Pediatric Sepsis, Chemical Pathology Biomarkers, morbidity and mortality

INTRODUCTION

Pediatric sepsis is a life-threatening disorder associated with dysregulation of host response to infection which results into dysfunction of the organ. Sepsis is a well-known cause of mortality in children in most parts of the world, especially low and middle-income countries despite the strides made in critical care. One of the factors that are linked to high morbidity, longer hospitalization, and the increase of mortality is delayed recognition in emergency departments [1-3].

Sepsis is difficult to be diagnosed at an early stage among children since the initial conditions can be described as unspecific and mild. Conventional use of clinical judgment only may result in a delay in intervention particularly in the high traffic environment. Hence, objective biochemical markers have become more and more significantly important in enhancing early diagnosis and risk stratification [4-6].

Serum lactate has become a valid parameter of metabolic stress and hypoperfusion of the tissues. High levels of lactate are associated with the severity of the disease, shock potential, and death in pediatric sepsis. C-reactive protein (CRP) and procalcitonin (PCT) are two other inflammatory biomarkers that are used to distinguish between bacterial infection and non-infectious inflammation and predict the course of a disease. Stability may be ensured by the rapidity of bedside testing lactate and blood gases, which is feasible due to the existence of point-of-care testing (POCT) [7-9].

Guidelines on sepsis in the international scene rest on the importance of administering antibiotics at the earliest possible and fluid resuscitation during the initial hour of identification. Nevertheless, the application of formal rapid response procedures incorporating biochemical markers is not widely applied in most tertiary hospitals in Pakistan.

This study aimed to develop and evaluate a rapid assessment and intervention protocol for pediatric sepsis integrating chemical pathology biomarkers and point-of-care testing in a high-volume emergency department. The study sought to determine the association between early biomarker levels, protocol compliance, and clinical outcomes.

METHODOLOGY

The study was an observational interventional study in the Pediatric Emergency Department of Lady Reading Hospital, Peshawar, within a period of six months starting January 2025 to June 2025. The objective of the study was to determine the effectiveness of a rapid assessment and intervention plan that includes chemical pathology biomarkers and point-of-care testing (POCT) that is effective at early detection and management of pediatric sepsis.

Consecutive sampling was used to enroll 72 children aged 1 month to 12 years of age who are suspected to have sepsis. The suspected sepsis was considered to be the presence of fever or hypothermia accompanied by the clinical signs of the systemic inflammatory response and possible infection. Children with known chronic liver failure, end-stage renal disease, malignancy on chemotherapy, and those that had previously received antibiotics were excluded to maximize the chances of confounding biomarker interpretation.

During the triage process, all the patients were evaluated with the help of a standardized rapid sepsis screening tool that incorporated the following clinical parameters: heart rate, respiratory rate, blood pressure, capillary refill time, oxygen saturation, and mental status. At the same time, point of care lactate testing and venous blood gas analysis was done within 30 minutes of presentation. Measurement of C-reactive protein (CRP), procalcitonin (PCT), complete blood count, tests of renal and liver functioning and coagulation profile were also sent to the central laboratory using blood samples. The time metrics were recorded such as time to reaching lactate measurement, time to collecting a blood culture, time to administering an antibiotic, and time to issuing fluid resuscitation.

All the patients were treated based on the rapid intervention protocol, which involves immediate intravenous access, blood cultures before administration of antibiotics, empirical broad-spectrum antibiotics within an hour of patient recognition, and fluid resuscitation (20 mL/kg bolus) in patients presenting with signs of shock. When necessary, the escalation to vasopressor therapy and referral to the ICU was done. The clinical outcomes such as ICU admission, mechanical ventilation, vasopressor support, acquisition of multi-organ dysfunction, length of stay, and in-hospital mortality were recorded. Data were entered and analyzed using SPSS version 26. Continuous variables were expressed as mean $\pm$ standard deviation or median with interquartile range, depending on distribution. Categorical variables were presented as frequencies and percentages. Comparisons between groups (shock vs non-shock; lactate <2 mmol/L vs ≥ 2 mmol/L) were performed using independent t-test or Mann–Whitney U test for continuous variables and Chi-square or Fisher’s exact test for categorical variables. A p-value <0.05 was considered statistically significant.

RESULTS

There were 72 children that responded with suspected sepsis. Most of them were below the age of five years, with respiratory infections being the leading source. Almost one-third of their presentation exhibited clinical features of shock at admission, which underscores the intensity of illness among this cohort.

Table 1. Baseline Demographics and Clinical Characteristics (n=72)

Variable	Value
Age (months), mean $\pm$ SD	38.6 $\pm$ 29.4
Age group, n (%)	
• <12 months	18 (25.0%)
• 1–5 years	34 (47.2%)
• >5 years	20 (27.8%)
Gender	
• Male	41 (56.9%)
• Female	31 (43.1%)
Weight (kg), mean $\pm$ SD	13.2 $\pm$ 6.1
Comorbidity present	15 (20.8%)
Source of infection	
• Respiratory	29 (40.3%)
• Gastrointestinal	14 (19.4%)
• Urinary tract	11 (15.3%)
• CNS	6 (8.3%)
• Skin/Soft tissue	7 (9.7%)
• Unknown	5 (6.9%)
Shock at presentation	23 (31.9%)

Need for oxygen	28 (38.9%)
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The rapid identification of metabolic derangement was possible by point-of-care testing. More than half of the patients showed elevated levels of lactate, which were indicative of hypoperfusion of the tissues. The value of procalcitonin and CRP was found to be greatly elevated in children with shock and not in those without shock.

Table 2. Chemical Pathology Biomarkers by Shock Status

Parameter	Shock (n=23)	No Shock (n=49)	p-value
Lactate (mmol/L), mean $\pm$ SD	4.8 $\pm$ 1.9	2.1 $\pm$ 0.9	p < 0.001
CRP (mg/L), mean $\pm$ SD	92.4 $\pm$ 35.6	54.7 $\pm$ 28.3	p = 0.002
Procalcitonin (ng/mL), median (IQR)	5.6 (3.8–8.2)	1.9 (0.8–3.5)	p < 0.001
Platelets ($\times 10^9$ /L)	142 $\pm$ 58	228 $\pm$ 74	p = 0.001
Creatinine (mg/dL)	1.1 $\pm$ 0.4	0.6 $\pm$ 0.2	p < 0.001
Bicarbonate (mmol/L)	15.2 $\pm$ 4.1	20.8 $\pm$ 3.5	p < 0.001

Application of the rapid assessment protocol greatly enhanced early diagnostic and treatment schedules. The majority of children were given antibiotics in the first hour of identification. In most cases, POCT integration was able to provide an Lactate measure within 30 minutes.

Table 3. Sepsis Bundle Compliance and Time Metrics (n=72)

Metric	Achieved n (%)	Time (minutes), mean $\pm$ SD
Lactate measured within 30 min	60 (83.3%)	18 $\pm$ 6
Blood culture before antibiotics	66 (91.7%)	24 $\pm$ 8
Antibiotics within 60 min	58 (80.6%)	42 $\pm$ 12
IV access within 10 min	63 (87.5%)	7 $\pm$ 3
Fluid bolus within 20 min (if indicated, n=23)	19 (82.6%)	17 $\pm$ 5
Full bundle compliance	52 (72.2%)	—

Children who presented with shock had considerably poor outcomes than those who did not have a shock. High levels of lactate were closely linked to the ICU admission and use of vasopressors. The overall mortality of this cohort was 8.3%, mainly in individuals who had continued hyperlactatemia.

Table 4. Clinical Outcomes by Lactate Category

Outcome	Lactate <2 mmol/L (n=30)	Lactate $\geq$ 2 mmol/L (n=42)	p-value
ICU admission	3 (10.0%)	18 (42.9%)	p = 0.003

Vasopressor use	2 (6.7%)	16 (38.1%)	p = 0.002
Mechanical ventilation	1 (3.3%)	12 (28.6%)	p = 0.005
MODS	1 (3.3%)	14 (33.3%)	p = 0.001
Hospital stay (days)	4.1 ± 1.8	8.7 ± 3.2	p < 0.001
Mortality	0 (0%)	6 (14.3%)	p = 0.028

Early detection of high risk pediatric sepsis was enabled by rapid integration of POCT lactate and inflammatory biomarkers. High levels of lactate and procalcitonin could be good predictors of shock and unfavorable outcomes. Execution of a systematic rapid intervention protocol enhanced compliance with bundle and was linked to decreased development to multi-organ dysfunction.

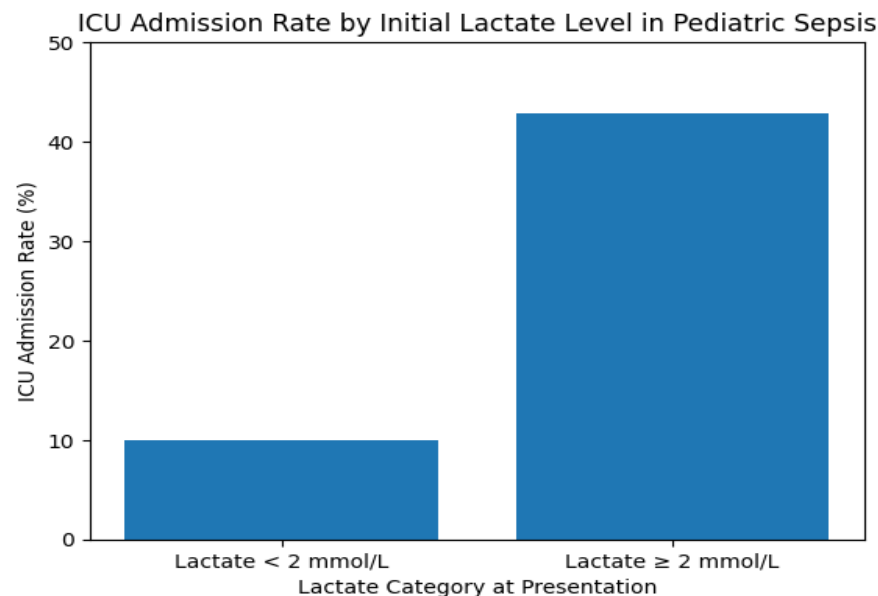


Figure 1. Association between Initial Serum Lactate Level and ICU Admission in Pediatric Sepsis

Bar graph demonstrating the proportion of pediatric patients requiring ICU admission according to initial point-of-care serum lactate levels at presentation in the emergency department. Children with elevated lactate (≥ 2 mmol/L) had a markedly higher ICU admission rate (42.9%) compared to those with normal lactate levels (< 2 mmol/L) (10.0%), indicating that early hyperlactatemia is strongly associated with increased disease severity and need for intensive care support.

DISCUSSION

This study evaluated the implementation of a rapid pediatric sepsis assessment protocol integrating chemical pathology biomarkers and point-of-care testing (POCT) in the emergency department setting. The findings demonstrate that early lactate measurement, alongside inflammatory biomarkers such as CRP and procalcitonin, significantly enhanced early risk stratification and identification of high-risk children. Elevated lactate (≥ 2 mmol/L) was strongly associated with ICU admission, vasopressor

requirement, multi-organ dysfunction, and mortality, reinforcing its role as a critical early prognostic biomarker in pediatric sepsis [10-13].

Almost a third of our cohort presented with clinical shock, which is an indication of the resource-limited environment in which delayed healthcare-seeking behavior is common. The average lactate concentration in the shock group was much more than in the non-shock group ($p < 0.001$), which showed that the tissues were still hypoperfused. This is in line with known facts that hyperlactatemia is an indicator of incompetent oxygen use and mitochondrial impairment, but not an anaerobic metabolism. Notably, children with elevated lactate had a four fold increase in ICU admission rate as compared to children with normal lactate levels and this highlights its usefulness in triage prioritization [14-16].

The level of procalcitonin was also greatly high in children with shock, which implies the possibility of using it in cases of severe bacterial infection as opposed to milder inflammatory conditions. Procalcitonin exhibited higher discriminatory ability of severe disease in our cohort compared to CRP that increases more slowly. Reduced platelet count and metabolic acidosis (low bicarbonate) were other signs of disease severity indicating systemic inflammatory activation and dysfunction of the early organs [17-19].

The integration of POCT made a huge difference in decreasing the time of diagnosis. Measurement of lactate at a 30-minute interval was obtained in more than 80 percent of the patients, enabling the high-risk children to be found in time before clinical deterioration occurs. The first administration of antibiotics within one hour was achieved in 80.6% of the cases which conforms to international sepsis bundles. Majorities of patients who were in shock were able to receive timely fluid resuscitation, which may help to improve the stabilization process and minimize the development of refractory shock [20].

The cohort mortality was 8.3% and in this group, the mortality was mainly in children with a history of hyperlactatemia persistence and multi-organ dysfunction. Although this rate of mortality is in line with the regional pediatric sepsis statistics, it is still higher than in the high-income countries, which highlights the differences in healthcare access and pre-hospital delays. Our study also confirms that lactate is strong prognostic biomarker as the significant occurrence of elevated lactate and mortality has also been reported [21].

The research indicates the practicability of instituting a well-organized rapid sepsis protocol in a tertiary high-volume emergency department in Pakistan. The combination of chemical pathology biomarkers with the clinical assessment enhanced the early detection and resource distribution. Objective biomarkers like lactate and procalcitonin can be used to make evidence-based triage in a resource-constrained environment with limited ICU beds.

However, certain limitations must be acknowledged. The study was conducted in a single center with a relatively small sample size. Serial lactate clearance was not consistently evaluated, which may have provided stronger prognostic insight. Additionally, long-term outcomes beyond hospital discharge were not assessed. Future multicenter studies incorporating lactate clearance trends and biomarker-guided therapeutic adjustments are recommended.

CONCLUSION

The implementation of a rapid pediatric sepsis assessment protocol integrating point-of-care lactate testing and chemical pathology biomarkers significantly improved early risk stratification and clinical decision-making in the emergency department. Elevated lactate and procalcitonin levels were strong predictors of shock, ICU admission, and adverse outcomes. Early biomarker-guided intervention may reduce disease progression and optimize resource utilization in high-burden pediatric emergency settings.

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