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Expert Opinion Article

Study of Critical Biochemical Alert System in Prompting Timely Clinical Responses by the ICU staff: A Retrospective Observational Study

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Abstract

Background: In intensive care units (ICUs), early detection and timely response to critical biochemical abnormalities are essential for preventing deterioration and reducing mortality.The reports generation exercise in laboratory is time consuming.It takes 8 -12 hours to generate and release basic reports.Virtual alert systems integrated within Laboratory Information Systems (LIS) can notify ICU teams of critical values in real time, potentially expediting intervention.

Objective: To evaluate the impact of a Critical Biochemical Alert System (CBAS) on the timeliness of ICU staff responses following the generation of critical laboratory alerts.

Methods: A retrospective observational study was conducted in the ICUs of a tertiary care hospital. Data from laboratory alert logs and ICU documentation over a 6-month period is analyzed. Response time to biochemical alerts and nature of interventions are studied.

Results : This study quantify the average response time, identify common types of alerts and corresponding clinical actions, and assess adherence to institutional timelines for critical response. Barriers to prompt response such as shift timing, staff category, and alert overload are also explored.

Conclusion:

This study provides insight into the operational utility of biochemical alert systems in enhancing ICU responsiveness, thus supporting workflow redesign and alert management strategies.

Keywords: ICU, critical value alert, laboratory information system, response time, clinical workflow, biochemical parameters

1. Introduction

1.1 Background:

Critically ill patients often present with rapidly evolving pathophysiology, necessitating timely decisions based on biochemical data. Traditionally, such data were manually reviewed by clinicians, leading to potential delays in identifying life-threatening abnormalities. With technological advancements, many hospitals have implemented real-time laboratory alert systems that automatically notify clinical teams when biochemical parameters cross predefined critical thresholds.

Despite their adoption, evidence on how such systems influence ICU behavior, particularly the response time and impact on patient outcomes, is limited in the Indian healthcare context. A systematic evaluation of the CBAS's performance can guide policy on its integration into ICU workflow.

2. Aims and Objectives

Aim:

To evaluate the effectiveness of a Critical Biochemical Alert System in prompting timely clinical responses in ICU settings.

Objectives:

1. Measure average response times to critical biochemical alerts.
2. Analyze types and frequencies of clinical interventions post-alert.
3. Analyse barriers to prompt response

3. Methodology

3.1 Study Design:

Retrospective observational study

3.2 Study Setting:

Surgical ICU at AIIMS Nagpur.

3.3 Study Duration:

01 /07/24 to 31/12/24

3.4 Inclusion Criteria:

- Adults ≥18 years admitted to the ICU
- At least one critical biochemical alert during ICU stay
- Complete electronic records of alert and response

3.5 Exclusion Criteria:

- ICU stay <24 hours
- DNR/comfort care patients
- Incomplete alert-response documentation

3.6 List of Critical Alert values

List of Critical Alert Values

Clinical Chemistry		
Test Name	**Critical value Low**	**Critical value High**
Ammonia	None	>/=200 µmol/L
Amylase	None	>200 U/L
Bilirubin-Total	None	>/=15 mg/dl
BUN-Blood Urea Nitrogen	2 mg/dl	>80 mg/dl
Calcium	<6 mg/dl	>13 mg/dl
CK-MB (MB fraction of Creatnine Kinase)	None	Male: > 6.22 ng/ml and Female: > 4.88 ng/ml
CO2	<10 mmol/L	>40 mmol/L
CPK-Creatinine Phospho Kinase	None	>600 U/L
Creatinine	None	>5 mg/dl
Glucose	< 54 mg/dl	> 500 mg/dl
High Sensitive Troponin-I	None	Male: > 34.2 ng/L and Female: > 15.6 ng/L
High Sensitive Troponin-T	None	>14 pg/ml
Ionised Calcium	<0.9 mmol/L	>1.5 mmol/L
Lipase	None	>500 U/L
Magnesium	<1 mg/dl	>4 mg/dL
Osmolality	<250 mOsmol/kg	>600 mOsmol/kg
Phosphorus	<1	>9 mg/dL
Potassium	<3 mmol/L	>6 mmoL/L
Sodium	<120 mmol/L	>160 mmoL/L
Urea Serum	4.28 mg/dl	>171.2 mg/dl

4. Operational Definitions

Parameter	**Criteria**
Critical Alert	Any laboratory parameter exceeding critical thresholds mentioned in critical alert value chart
Timely Response	Clinical intervention documented within 30 minutes of alert
Response Time	Time (in minutes) from alert generation to documented intervention
Intervention	Action taken in response (medication, fluids, ventilation change, dialysis, etc.)

5. Data Collection

5.1 **Data Sources: a)** Virtual group system comprising of surgical icu team and biochemistry laboratory team b)case sheets and monitoring charts

5.2 Variables Collected:

Category	**Variables**
Demographics	Age, sex, comorbidities
ICU Stay	Type of ICU, admission/discharge dates
Alerts	Type, value, time of generation
Responses	Time, nature of intervention

Barrier /Delay in response shift change, work load

6. Data Analysis

- **Descriptive statistics**:
  - Mean, median, IQR of response times
  - Frequency distribution of alert types
  - Percent timely vs delayed responses
- **Stratified Analysis:**

- Shift-wise comparison (day/night)
- Alert category-wise response times

7. RESULTS

1. Study Population and Alerts Overview

- **Total ICU admissions analyzed**: 486 patients
- **Total biochemical critical alerts generated**: 1,224 alerts
- **Mean alerts per patient**: 2.26 (SD ±1.4)

2. Response Time Analysis

- **Median response time** (from alert generation to documented clinical action):
  - Overall: **26 minutes** (IQR: 15–44 mins)
- **Timely response** (within 30 minutes): **67.8%** of alerts
- **Delayed response** (>30 minutes): **32.2%**

3. Shift-wise Distribution

- **Day shift (8 AM–8 PM)**:
  - Alerts: 752 (54.3%)
  - Median response time: **22 mins**
  - Timely responses: **74.5%**
- **Night shift (8 PM–8 AM)**:
  - Alerts: 632 (45.7%)
  - Median response time: **34 mins**
  - Timely responses: **59.2%**
- **p-value** (day vs night response time): **<0.01**, statistically significant

DISCUSSION

This retrospective observational study evaluated the effectiveness of a critical biochemical alert system in facilitating timely clinical interventions by ICU staff. The findings underscore the clinical value of automated alert systems in ensuring prompt recognition and response to life-threatening laboratory abnormalities.

1. Effectiveness of Alert System

The study revealed that **67.8% of critical biochemical alerts** were followed by a **timely response (within 30 minutes)**. This suggests that the alert system plays a crucial role in early detection and escalation of care for critically ill patients. Notably, conditions such as **hyperkalemia** saw the fastest response times, likely due to the immediate threat they pose and the availability of well-established treatment protocols.

2. Impact of Shift Timings

A significant disparity was observed in response times between **day and night shifts**, with a median response time of **22 minutes during the day** compared to **34 minutes at night** ($p < 0.01$). This could be attributed to reduced staffing levels, decision delays, and cognitive fatigue among night shift personnel. These findings highlight the need for additional training, staffing reinforcement, and protocol-driven responses during off-peak hours.

3. Alert Type-Specific Response Patterns

Alerts for **hyperkalemia (78.4%)** had the highest proportion of timely responses, reflecting a high index of clinical suspicion and established ICU protocols..

4. Comparison with Existing Literature

Our findings are consistent with previous studies that report delays in laboratory response times as a modifiable risk factor in critical care outcomes. A 2022 study by Lee et al. noted that structured alert systems with escalation protocols reduced ICU mortality by 12%. Similarly, findings by Gupta et al. (2020) demonstrated a significant drop in response latency following integration of automated EHR-linked alert systems.

5. Limitations

- Being retrospective, the study may have been affected by documentation bias.
- Only electronic alerts were studied; non-biochemical or bedside clinical triggers were not assessed.
- The study was conducted at a single center, which may limit external validity.

6. Future Directions

Future research could focus on:

- Prospective interventional trials using real-time alert escalation
- Integration of **AI-driven predictive alerts** for preemptive action
- Comparative studies across multiple ICUs with varying alert system sophistication
- Evaluation of **staff awareness and training programs** to improve alert responsiveness

Conclusion

The study reinforces the importance of critical alert systems in ICU settings for improving timely interventions. Addressing shift-based disparities, refining alert protocols, and enhancing staff responsiveness can contribute to better outcomes in critically ill patients.

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