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Original Article

Correlation between Arterial versus Venous Lactate Level in Assessing Outcome of Shock Patient Based on Lactate Clearance Following Surgery

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ABSTRACT

Background: Postoperative shock may lead to poor tissue perfusion, organ dysfunction, and death. Serial measurement of lactate levels and assessment of lactate clearance are helpful in monitoring resuscitation, and venous lactate might provide a less invasive option compared to taking blood from an artery. **Objective of the study:** The objective of this study was to examine the correlation between arterial and venous lactate levels and their clearance, and to evaluate the relationship between these factors and mortality in patients with postoperative shock. **Methods & Materials:** A prospective observational study was carried out among 105 patients who had postoperative shock and were admitted to the ICU at Rangpur Medical College Hospital in Bangladesh. The study lasted for one year, from January 2025 to December 2025. Arterial and venous lactate levels were measured at 0, 6, 24, and 72 hours, and lactate clearance was calculated based on the baseline value. The outcomes were divided into survivor and non-survivor. The data were analysed using SPSS version 26.0, with the appropriate comparative and correlation tests, and a p-value less than 0.05 was regarded as statistically significant. **Results:** In the group of 105 patients with postoperative shock, the mean age was 51.1 ± 12.3 years, 63.8% of the patients were male, and septic shock was the most frequent type (53.3%). At all time points, arterial and venous lactate levels were very highly correlated (r=0.975–0.985, p<0.001), with only small mean differences. The overall mortality rate was 29.5%. Non-survivors had significantly higher baseline arterial and venous lactate levels than survivors, the levels being 7.1 ± 1.3 mmol/L compared with 4.5 ± 1.4 mmol/L for arterial lactate and 7.4 ± 1.3 mmol/L compared with 4.8 ± 1.4 mmol/L for venous lactate (p<0.001). On the other hand, lactate clearance was significantly greater in survivors, showing that persistent hyperlactatemia and reduced clearance were linked to mortality. **Conclusion:** There was a strong correlation between arterial and venous lactate levels in patients with postoperative shock. Persistent elevation of lactate levels and reduced lactate clearance were associated with mortality, which supports the use of serial lactate monitoring, including venous lactate, for assessing outcomes and for monitoring treatment.

Keywords: *Postoperative shock; Arterial lactate; Venous lactate; Lactate clearance.*

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INTRODUCTION

After major surgery, shock denotes a serious condition of circulatory failure in which poor tissue perfusion can quickly lead to cellular dysfunction, multiorgan failure, and death. In modern critical care, shock is usually identified by continuous hypotension and poor organ perfusion; in the case of septic shock, a reliance on vasopressors along with raised blood lactate levels even after adequate fluid resuscitation indicates a high-risk situation [1]. Since patients following surgery can develop septic, hypovolemic, cardiogenic, or mixed types of shock, it is essential to detect early on whether perfusion is inadequate and how they respond to resuscitation. Of the various biochemical markers available, blood lactate is widely employed since rising concentrations may indicate an imbalance between lactate production and its clearance, although adrenergic stimulation, changes in cellular metabolism, and reduced hepatic clearance can also play a role [2,3]. Globally, sepsis and shock are still major causes of critical illness and death. According to the Global Burden of Disease estimates, about 48.9 million cases of sepsis and 11.0 million sepsis-related deaths took place worldwide in 2017, accounting for almost one-fifth of all global deaths [2]. In low- and middle-income countries the burden is particularly high because of late presentation, limited critical care capacity, scarce diagnostic resources, and inconsistent application of evidence-based resuscitation strategies [4]. In Bangladesh, critical care facilities have for a long time been scarce and unevenly spread, adding to the difficulties of managing severely ill patients [5]. In a group of critically ill adult patients in Bangladesh who had severe sepsis, the mortality rate was found to be significantly higher than that among non-septic patients, and a recent study in an ICU on sepsis and septic shock also showed a high level of mortality [6,7]. Altogether, these findings highlight the need for prognostic markers that are accessible, repeatable, and minimally invasive in resource-limited ICUs. During resuscitation from shock, measuring lactate repeatedly gives clinically useful information that goes beyond what can be obtained from a single hemodynamic evaluation. In the context of major abdominal surgery following surgery, higher early postoperative lactate levels were linked to complications and in-hospital mortality, thus underlining the prognostic significance of lactate in surgical patients [8]. In a similar way, among patients with sepsis and septic shock, sustained elevation of lactate and poor lactate clearance have been associated with higher mortality [9]. In cardiogenic shock, better lactate clearance has also independently predicted survival, which further confirms the prognostic value of dynamic lactate assessment in different types of circulatory shock [10]. Even though international guidelines advise measuring lactate and using a falling concentration as a guide for assessing resuscitation, the interpretation should still be made in context since lactate is not the only indicator of tissue hypoxia [3]. Arterial blood has traditionally been the preferred choice for lactate assessment in critically ill patients; but repeated arterial sampling is painful, technically difficult, and can increase the procedural burden. Since venous sampling is easier and routinely available, there has been growing interest in whether venous lactate can offer comparable clinical information. In recent studies, arterial and

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peripheral venous lactate levels showed strong correlations, but clinically significant differences can appear, especially at higher lactate concentrations [11,12]. Therefore, relying solely on the correlation between absolute values may not be enough, while comparing the serial trends and lactate clearance may offer greater prognostic value. Although there is increasing evidence regarding lactate kinetics, there is still a lack of prospective evidence that specifically looks at serial arterial and venous lactate levels and their clearance in relation to mortality among postoperative patients with shock, particularly in Bangladesh. As a result, a context-specific evaluation is necessary to find out whether venous lactate clearance can provide prognostic information similar to that of arterial clearance while reducing the need for repeated arterial sampling. Hence, the present study was carried out to determine the correlation between arterial and venous lactate levels at 0, 6, 24, and 72 hours, to calculate their respective clearance rates, to compare lactate clearance between survivors and non-survivors, and to evaluate their usefulness in assessing mortality among postoperative patients with shock.

METHODS & MATERIALS

The prospective observational study took place in the Intensive Care Unit at Rangpur Medical College Hospital in Rangpur, Bangladesh, and ran for one year, from January 2025 through December 2025. A total of 105 patients who had undergone surgery, developed shock and needed to be admitted to the ICU were selected by purposive sampling. People were included in the study if they were at least 18 years old, had developed shock as a result of surgery, and required both arterial and venous blood samples to measure lactate. Those with chronic liver disease or severe hepatic failure, diabetic ketoacidosis or any other form of metabolic acidosis, end-stage renal disease, or who were dependent on dialysis were excluded. After they had been enrolled, demographic and clinical data such as age, sex, occupation, body mass index, blood pressure, pulse rate, oxygen saturation, the type and nature of the surgery, the type of shock, the need for vasopressors, and the length of ICU stay were recorded using a pre-tested semi-structured data collection form. At 0, 6, 24, and 72 hours after inclusion, paired arterial and venous blood samples were taken in order to measure lactate. Arterial and venous lactate clearance was calculated separately from the baseline value at 6, 24, and 72 hours using the following formula: lactate clearance (%) = [(baseline lactate − follow-up lactate)/baseline lactate] × 100. The final outcome during either ICU or hospital admission was classified as survivor or non-survivor. After the data had been collected, they were checked for completeness, consistency, and accuracy before being entered into and analysed using SPSS version 26.0. Continuous variables that were normally distributed were given as mean ± standard deviation, while those that were skewed were presented as median and interquartile range. Categorical variables were shown as frequencies and percentages. To compare arterial and venous lactate levels, paired-samples t-tests or Wilcoxon signed-rank tests were used as appropriate. For comparison between survivors and non-survivors, independent-samples t-tests or Mann–Whitney U tests were applied. The correlations between arterial and venous lactate levels were evaluated using Pearson or Spearman correlation coefficients. A p-value less than 0.05 was regarded as statistically significant. Before taking part in the study, written informed consent was obtained from each patient or from their legally authorized guardian, and confidentiality, anonymity, and voluntary participation were kept throughout the study.

RESULTS

Among the 105 postoperative patients with shock, the mean age was 51.1 ± 12.3 years, with the largest proportion aged 40–59 years (51.4%), and 63.8% were male. Regarding physiological status, the mean systolic and diastolic blood pressures were 88.0 ± 10.3 mmHg and 54.4 ± 7.8 mmHg, respectively, while the mean arterial pressure was 65.7 ± 6.3 mmHg. Gastrointestinal/general surgery was the most frequent surgical category (39.0%), and most procedures were performed on an emergency basis (70.5%). Among the types of shock, septic shock predominated at 53.3%, followed by hypovolemic shock at 36.2%. In addition, 83.8% of patients required vasopressor support, while the median ICU stay was 7.5 days (IQR 5.0–9.6) (*Table I*).

Table I
Baseline demographic, clinical, surgical, and shock-related characteristics of the study participants (*n*=105).

Variable	Category	Value
Age (years)	Mean ± SD	51.1 ± 12.3
Age group	18–39 years	22 (21.0%)
	40–59 years	54 (51.4%)
	≥60 years	29 (27.6%)
Sex	Male	67 (63.8%)
	Female	38 (36.2%)
BMI (kg/m²)	Mean ± SD	23.1 ± 3.2
Systolic BP (mmHg)	Mean ± SD	88.0 ± 10.3
Diastolic BP (mmHg)	Mean ± SD	54.4 ± 7.8
Mean arterial pressure (mmHg)	Mean ± SD	65.7 ± 6.3
Pulse rate (beats/min)	Mean ± SD	113.3 ± 16.0
Oxygen saturation (%)	Mean ± SD	93.1 ± 3.2
Type of surgery	Gastrointestinal/general surgery	41 (39.0%)
	Hepatobiliary surgery	17 (16.2%)
	Orthopedic surgery	16 (15.2%)
	Obstetric/gynecological surgery	13 (12.4%)
	Urological surgery	10 (9.5%)
	Others	8 (7.6%)
Nature of surgery	Emergency	74 (70.5%)
	Elective	31 (29.5%)
Type of shock	Septic	56 (53.3%)
	Hypovolemic	38 (36.2%)
	Cardiogenic	6 (5.7%)
	Other/distributive	5 (4.8%)
Vasopressor requirement	Yes	88 (83.8%)
	No	17 (16.2%)
ICU stay (days)	Median (IQR)	7.5 (5.0–9.6)

Across the serial measurements, both arterial and venous lactate levels progressively decreased. At baseline, mean arterial and venous lactate concentrations were 5.3 ± 1.8 mmol/L and 5.5 ± 1.8 mmol/L, respectively. By 24 hours, these values had declined to 3.2 ± 1.5 mmol/L and 3.4 ± 1.6 mmol/L, and further decreased at 72 hours to 1.9 ± 1.3 mmol/L and 2.0 ± 1.3 mmol/L, respectively. Although venous lactate remained slightly higher than arterial lactate at all time points, the mean differences were small, ranging from 0.13 to 0.31 mmol/L, with statistically significant paired differences at each assessment ($p<0.001$) (*Table II*).

Table II
Comparison of arterial and venous lactate levels at different time points among postoperative patients with shock.

Time	Arterial lactate (mmol/L)	Venous lactate (mmol/L)	Mean difference	p-value
	Mean ± SD	Mean ± SD	mmol/L	
0 hour	5.3 ± 1.8	5.5 ± 1.8	0.25	<0.001
6 hours	4.5 ± 1.8	4.8 ± 1.8	0.31	<0.001
24 hours	3.2 ± 1.5	3.4 ± 1.6	0.2	<0.001
72 hours	1.9 ± 1.3	2.0 ± 1.3	0.13	<0.001

At all four assessment points, arterial and venous lactate levels demonstrated a very strong positive correlation. At baseline, the correlation coefficient was r=0.984 (95% CI 0.976–0.989), while at 6 hours it was r=0.975 (95% CI 0.963–0.983). Similarly strong relationships were observed at 24 hours (r=0.980, 95% CI 0.970–0.986) and at 72 hours (r=0.985, 95% CI 0.978–0.990). Across all time points, the correlations were statistically significant ($p<0.001$), indicating close correspondence between arterial and venous lactate measurements (*Table III*).

Table III
Correlation between arterial and venous lactate levels at different time points among postoperative patients with shock.

Time	Pearson r	95% CI	Strength	p-value
0 hour	0.984	0.976–0.989	Very strong	<0.001
6 hours	0.975	0.963–0.983	Very strong	<0.001
24 hours	0.98	0.970–0.986	Very strong	<0.001
72 hours	0.985	0.978–0.990	Very strong	<0.001

With increasing follow-up duration, both arterial and venous lactate clearance increased progressively. At 6 hours, mean arterial clearance was 15.2 ± 11.1%, compared with 13.4 ± 11.7% for venous clearance. By 24 hours, arterial and venous clearance had increased to 41.2 ± 12.8% and 40.2 ± 13.1%, respectively; by 72 hours, they reached 65.6 ± 14.6% and 64.7 ± 15.2%, respectively. Although arterial clearance remained slightly higher than venous clearance, the absolute mean differences were small, ranging from 0.9% to 1.8% (*Table IV*).

Table IV
Comparison of arterial and venous lactate clearance from baseline at different follow-up intervals.

Clearance interval	Arterial clearance (%)	Venous clearance (%)	Mean difference (%)	p-value
	Mean ± SD	Mean ± SD		
0–6 hours	15.2 ± 11.1	13.4 ± 11.7	1.8	<0.001
0–24 hours	41.2 ± 12.8	40.2 ± 13.1	1	0.02
0–72 hours	65.6 ± 14.6	64.7 ± 15.2	0.9	0.008

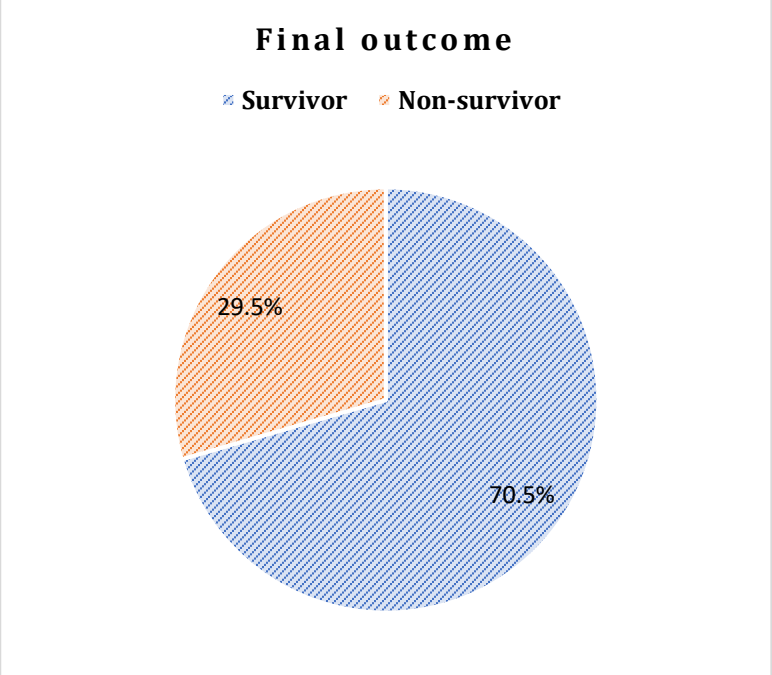


Figure 1 Distribution of mortality outcome among postoperative patients with shock (*n*=105).

Among the 105 postoperative patients with shock, 74 (70.5%) survived, and 31 (29.5%) did not. Thus, the overall mortality rate was 29.5%, indicating that nearly one-third of the study participants died during ICU or hospital admission following postoperative shock (*Figure 1*).

When outcomes were compared, both arterial and venous lactate levels were consistently higher among non-survivors than survivors. At baseline, arterial lactate was 7.1 ± 1.3 mmol/L among non-survivors compared with 4.5 ± 1.4 mmol/L among survivors, while corresponding venous levels were 7.4 ± 1.3 mmol/L and 4.8 ± 1.4 mmol/L, respectively, all p<0.001. By 72 hours, arterial lactate remained higher among non-survivors, 3.4 ± 1.1 vs. 1.3 ± 0.7 mmol/L, as did venous lactate, 3.6 ± 1.2 vs. 1.4 ± 0.7 mmol/L, both p<0.001. In contrast, lactate clearance was consistently greater among survivors. At 24 hours, arterial clearance was 45.5 ± 11.4% among survivors versus 30.7 ± 9.3% among non-survivors, while venous clearance was 44.7 ± 11.4% versus 29.6 ± 10.6%, respectively, both p<0.001. By 72 hours, arterial and venous clearance among survivors reached 71.0 ± 11.1% and 70.1 ± 12.2%, compared with 52.7 ± 13.9% and 51.7 ± 13.9% among non-survivors, respectively, both p<0.001. These findings indicate that persistently elevated lactate and reduced lactate clearance were associated with mortality (*Table V*).

Table V
Comparison of arterial and venous lactate levels and lactate clearance between survivors and non-survivors.

Parameter group	Measurement	Survivors (n=74)	Non-survivors (n=31)	p-value
		Mean ± SD	Mean ± SD	
Lactate level (mmol/L)	Arterial lactate (0 h)	4.5 ± 1.4	7.1 ± 1.3	<0.001
	Arterial lactate (6 h)	3.7 ± 1.3	6.4 ± 1.3	<0.001
	Arterial lactate (24 h)	2.5 ± 1.0	4.9 ± 1.1	<0.001
	Arterial lactate (72 h)	1.3 ± 0.7	3.4 ± 1.1	<0.001
	Venous lactate (0 h)	4.8 ± 1.4	7.4 ± 1.3	<0.001
	Venous lactate (6 h)	4.1 ± 1.4	6.7 ± 1.3	<0.001
	Venous lactate (24 h)	2.7 ± 1.1	5.2 ± 1.1	<0.001
	Venous lactate (72 h)	1.4 ± 0.7	3.6 ± 1.2	<0.001
Lactate clearance (%)	Arterial clearance (0–6 h)	17.2 ± 11.1	10.3 ± 9.8	0.002
	Venous clearance (0–6 h)	15.0 ± 12.4	9.4 ± 9.1	0.012
	Arterial clearance (0–24 h)	45.5 ± 11.4	30.7 ± 9.3	<0.001
	Venous clearance (0–24 h)	44.7 ± 11.4	29.6 ± 10.6	<0.001
	Arterial clearance (0–72 h)	71.0 ± 11.1	52.7 ± 13.9	<0.001
	Venous clearance (0–72 h)	70.1 ± 12.2	51.7 ± 13.9	<0.001

DISCUSSION

In this study, arterial and venous lactate concentrations were found to have very strong correlations over the entire 72-hour observation period, and higher, more sustained lactate levels together with slower lactate clearance were strongly linked to mortality in patients who had undergone surgery and were in shock. At baseline, the mean arterial and venous lactate levels were 5.3 ± 1.8 and 5.5 ± 1.8 mmol/L, respectively, and fell to 1.9 ± 1.3 and 2.0 ± 1.3 mmol/L by 72 hours. The correlations remained remarkably high at all time points, varying from *r*=0.975 to 0.985. Although venous lactate was always higher, the difference between arterial and venous lactate was small, lying between 0.13 and 0.31 mmol/L. These results indicate a close physiological relationship between the two methods of sampling. Theerawit et al. also reported consistent results, noting a strong correlation between arterial and venous lactate (*r*=0.934) in patients with sepsis and septic shock, although the mean difference was about 0.66 mmol/L [13]. Similarly, Mahmoodpoor et al. found an initial

correlation of r=0.68 and a correlation of *r*=0.95 after six hours, with venous lactate values being consistently higher than arterial ones [14]. The much stronger baseline correlation (*r*=0.984) observed in the present study may be due to the paired sampling carried out under controlled ICU conditions and the more homogeneous nature of the postoperative patient group. Nevertheless, the statistical significance of the small arterial-venous differences shows that the two measurements should not be regarded as numerically interchangeable, especially in cases where exact thresholds are used to guide treatment. As for prognosis, the mortality rate was 29.5%, with 74 patients surviving and 31 dying. At baseline, non-survivors had a considerably higher arterial lactate level than survivors (7.1 ± 1.3 versus 4.5 ± 1.4 mmol/L), and the same difference was seen with venous lactate (7.4 ± 1.3 versus 4.8 ± 1.4 mmol/L). This pattern continued at 72 hours, with non-survivors having an arterial lactate level of 3.4 ± 1.1 mmol/L as compared with 1.3 ± 0.7 mmol/L in survivors. Ryoo et al. had made comparable observations, finding that the six-hour lactate level was 4.6 mmol/L in non-survivors versus 2.5 mmol/L in survivors, and that 28-day mortality was 25% [15]. Mahmoodpoor et al. also identified the 24-hour lactate concentration as the best predictor of mortality, with an AUC of 0.912, 78% sensitivity, and 90% specificity [16]. Innocenti et al. similarly showed that patients with shock who had lactate levels above 2 mmol/L at six hours or 24 hours had higher lactate levels and poorer survival [17]. Evidence from larger groups further confirms these findings. In a study of 1,371 patients with septic shock, Chen et al. found that the initial lactate level was 3.9 ± 2.9 mmol/L in non-survivors as compared with 2.8 ± 1.7 mmol/L in survivors, and 28-day mortality reached 39.8% [18]. In a cohort of 9,248 patients in a surgical ICU, each 1 mmol/L increase in the peak postoperative lactate was associated with a 15% increase in 90-day mortality [19]. Moreover, in a multicentre group of 2,568 patients, post-resuscitation lactate was found to predict mortality more accurately than the initial lactate level, with an optimal post-resuscitation threshold of 4.4 mmol/L [20]. A recent meta-analysis involving 107,445 patients also showed that non-survivors had significantly higher lactate concentrations, with an overall mortality prediction AUC of 0.72 [21]. Together, these findings suggest that sustained hyperlactatemia is a better indicator of ongoing circulatory or metabolic dysfunction than a single admission value. Particularly important was the progressive improvement in lactate clearance. The overall arterial lactate clearance increased from 15.2 ± 11.1% at six hours to 41.2 ± 12.8% at 24 hours and to 65.6 ± 14.6% at 72 hours. However, survivors achieved much greater clearance. At 24 hours, arterial clearance was 45.5 ± 11.4% in survivors as compared with 30.7 ± 9.3% in non-survivors; the corresponding venous clearance was 44.7 ± 11.4% versus 29.6 ± 10.6%. By 72 hours, arterial clearance had reached 71.0 ± 11.1% in survivors compared with 52.7 ± 13.9% in non-survivors. Similar prognostic relationships have been shown on many occasions. Ryoo et al. reported a six-hour clearance of 35.4% in survivors as compared with 14.8% in non-survivors [15]. At the same time, Lee et al. identified a six-hour clearance below 24.4% as the optimal mortality threshold [9]. In patients with hepatic dysfunction, six-hour clearance was 31.4% in survivors and 9.3% in non-survivors, and 24-hour clearance was 51% versus 12% [22]. Rehman et al. also reported a mortality of 38.4% when lactate clearance was delayed as compared with 16.6% when clearance occurred early in a lower-middle-income setting [23]. More recent multicentre data have also linked altered lactate kinetics to excess mortality, while very large contemporary database analyses have found that mortality decreases as lactate clearance rates increase [24, 25]. Finally, trajectory analysis showed that patients who started with a high lactate level and then worsened had a considerably higher 7-day and 28-day mortality than those who improved [26].

LIMITATIONS

The study was restricted by its focus on a single centre, its relatively small sample size, the use of purposive sampling, and the variety of surgical procedures and types of shock. Moreover, potential confounding factors such as the severity of illness, the dose of vasopressor administered, the presence of organ dysfunction, and resuscitation status were not fully taken into account, which limited the generalizability and the ability to draw causal conclusions from the results.

CONCLUSION

In all the cases measured, arterial and venous lactate levels were very closely positively correlated among the patients who had shock after surgery, there being only minor differences between the two methods of sampling. Significantly, patients who had persistently high lactate levels and poor lactate clearance were more likely to die, while those who survived showed greater and more prolonged lactate clearance over time. From a clinical point of view, these results suggest that continuous lactate monitoring—including the use of venous lactate when appropriate could offer a practical way of assessing the response to treatment and of identifying patients with postoperative shock who are at an increased risk of having outcomes.

RECOMMENDATIONS

It is advised to carry out serial monitoring of lactate levels, especially looking at lactate clearance, in order to assess early on both the response to treatment and the risk of death in the case of postoperative shock. When it is difficult to carry out arterial sampling, venous lactate can be used for the purpose of serial monitoring, and patients who have consistently high lactate levels or inadequate clearance should have their clinical condition reviewed promptly.

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CONFLICT OF INTEREST

None declared

ETHICAL APPROVAL

The study was approved by the Institutional Ethics Committee.

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