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Research Article

Prognostic Value of Serum Lactate Levels in Predicting Outcomes in Perforated Duodenal Ulcer: A Retrospective Observational Cohort Study

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Abstract

Background. Perforated duodenal ulcer (PDU) carries a mortality of up to 30%. Serum lactate is a rapid, inexpensive marker of tissue hypoperfusion. We assessed its value in predicting outcome after PDU repair.

Methods. We retrospectively reviewed the records of 64 consecutive adults who underwent operative repair of PDU. Arterial lactate measured at admission and at 24 hours was retrieved from the case records; 24-hour clearance was calculated. The primary outcome was 30-day mortality; secondary outcomes were major morbidity (Clavien–Dindo ≥ III), ICU admission and length of stay. Groups were compared with the t-test, Mann–Whitney U test or chi-square/Fisher's exact test as appropriate. Diagnostic accuracy of admission lactate was assessed by ROC analysis.

Results. Thirty-day mortality was 10.9% (7/64). Admission lactate was higher in non-survivors than survivors (4.09 ± 1.27 vs 1.87 ± 0.89 mmol/L, $p < 0.001$), as was 24-hour lactate (4.26 ± 1.87 vs 1.48 ± 0.88 mmol/L, $p < 0.001$); 24-hour clearance was lower in non-survivors (−1.2 ± 18.5% vs 21.6 ± 16.6%, $p = 0.001$). At a cut-off of 3.3 mmol/L, admission lactate predicted death with 85.7% sensitivity, 96.5% specificity and 98.2% negative predictive value (AUC 0.932). Mortality rose stepwise across lactate strata: 2.9% (< 2.0 mmol/L), 8.7% (2.0–3.4 mmol/L) and 66.7% (≥ 3.5 mmol/L; $p < 0.001$).

Conclusions. Admission serum lactate is a simple, readily available predictor of mortality and morbidity after perforated duodenal ulcer. A level below 2.0 mmol/L identifies a low-risk group, while ≥ 3.5 mmol/L marks a small subgroup at very high risk who should be prioritised for expedited surgery and critical-care support.

Keywords: perforated duodenal ulcer; serum lactate; lactate clearance; mortality; risk stratification.

1. Introduction

Perforated duodenal ulcer (PDU) is a common and lethal surgical emergency, with reported 30-day mortality ranging from 5% to 30% and morbidity affecting up to half of patients [1–5]. Many bedside scoring systems exist — the Boey score, the Mannheim Peritonitis Index (MPI), the PULP score and ASA grade — but each has practical drawbacks: some rely on intraoperative findings, others on variables that are not always available on admission, and reported accuracy varies widely between populations [6–10].

Serum lactate is a simple, inexpensive, point-of-care measurement that rises when tissue oxygen delivery fails to meet demand, as occurs in intra-abdominal sepsis [11–16]. In critically ill and septic patients, admission lactate and its subsequent trend are consistently associated with mortality [17–19]. Data specific to perforated duodenal ulcer, rather than mixed perforation-peritonitis cohorts, remain limited [20,21].

We conducted a retrospective cohort study to determine whether admission and 24-hour serum lactate, and 24-hour lactate clearance, predict 30-day mortality and morbidity after operative repair of PDU, using simple, easily reproducible bedside statistics.

2. Materials and Methods

2.1 Study design and setting

This was a single-centre retrospective observational cohort study based on review of the case records of patients treated in the Department of Minimal Access & General Surgery of a tertiary teaching hospital over 24 consecutive months, reported in line with the STROBE statement [25].

2.2 Participants

Consecutive adults (≥ 18 years) with an operatively confirmed perforated duodenal ulcer were included. Patients with perforation at other sites, non-operative management, malignant perforation, chronic liver or kidney disease, recent metformin use, or incomplete lactate or outcome data in the case records were excluded. Of 79 records screened, 15 were excluded, leaving 64 patients for analysis.

2.3 Lactate measurement

Arterial lactate had been measured as part of routine clinical care on a point-of-care blood gas analyser at admission (before fluid resuscitation) and again 24 hours after operation; both values were retrieved from the case records. Twenty-four-hour lactate clearance (%) was calculated as [(admission lactate − 24-hour lactate) / admission lactate] × 100. Hyperlactataemia was defined as lactate > 2.0 mmol/L [13].

2.4 Outcomes

The primary outcome was 30-day mortality, ascertained from the hospital record and the routine 30-day follow-up entry. Secondary outcomes were major morbidity (Clavien–Dindo grade ≥ III) [24], ICU admission, and length of hospital stay.

2.5 Statistical analysis

Normally distributed continuous variables are presented as mean ± SD and compared with the t-test; skewed variables as median (interquartile range) and compared with the Mann–Whitney U test. Categorical variables are presented as n (%) and compared with the chi-square or Fisher's exact test. Diagnostic accuracy of admission lactate for 30-day mortality was assessed by receiver operating characteristic (ROC) curve analysis, reporting the area under the curve (AUC) with 95% confidence interval, and sensitivity, specificity, positive and negative predictive values, and accuracy at the Youden-optimal cut-off [26]. Outcomes were compared across three pre-defined lactate strata (< 2.0, 2.0–3.4, ≥ 3.5 mmol/L) using the chi-square test. A two-sided $p < 0.05$ was considered significant. Analyses were performed in Python 3.11.

3. Results

3.1 Cohort characteristics

64 patients underwent operative repair of a perforated duodenal ulcer (mean age 46.9 ± 14.5 years; 87.5% male). Thirty-day mortality was 10.9% (7/64), major morbidity 23.4% (15/64), and 27 patients (42.2%) required ICU admission. Median hospital stay was 12 days (IQR 10–16).

Non-survivors were more likely to have a major comorbidity, a longer symptom-to-surgery interval, shock on admission, higher creatinine, lower albumin, and higher Boey and MPI scores than survivors (Table 1).

Table 1. Baseline demographic, clinical and biochemical characteristics, stratified by 30-day survival status.

Variable	All patients (n = 64)	Survivors (n = 57)	Non-survivors (n = 7)	p value
Age, years	46.85 ± 14.48	45.90 ± 14.20	54.60 ± 15.50	0.135
Male sex	56 (87.5)	50 (87.7)	6 (85.7)	1.000
Current smoker	35 (54.7)	31 (54.4)	4 (57.1)	1.000
NSAID use	15 (23.4)	13 (22.8)	2 (28.6)	0.662
Major medical comorbidity	17 (26.6)	12 (21.1)	5 (71.4)	0.012
Symptom-to-surgery interval, h	12.9 (10.2–19.5)	12.3 (9.7–18.3)	25.0 (13.7–37.1)	0.025
Perforation size, cm	0.84 ± 0.46	0.85 ± 0.46	0.78 ± 0.40	0.712
Systolic BP on admission, mmHg	115.33 ± 15.24	117.10 ± 14.30	100.91 ± 16.08	0.007
Heart rate, /min	98.86 ± 14.00	97.20 ± 13.60	112.40 ± 9.60	0.006
Shock on admission (SBP <90 mmHg)	4 (6.2)	1 (1.8)	3 (42.9)	0.003
Serum creatinine, mg/dL	1.0 (0.8–1.2)	1.0 (0.8–1.1)	1.6 (1.3–1.7)	0.001
Serum albumin, g/dL	3.56 ± 0.47	3.62 ± 0.43	3.05 ± 0.50	0.002
Total leucocyte count, $\times 10^9$/L	13.69 ± 4.43	13.30 ± 4.30	16.90 ± 4.50	0.042
ASA grade III–IV	12 (18.8)	9 (15.8)	3 (42.9)	0.115
Boey score	0.0 (0.0–1.0)	0.0 (0.0–1.0)	1.0 (1.0–1.5)	<0.001
Mannheim Peritonitis Index	10.0 (6.0–13.0)	9.0 (5.0–12.0)	21.0 (15.0–21.5)	<0.001

Values are mean ± SD, median (interquartile range) or n (%). ASA, American Society of Anesthesiologists; NSAID, non-steroidal anti-inflammatory drug; SBP, systolic blood pressure.

3.2 Lactate and outcome

Admission lactate, 24-hour lactate, and 24-hour lactate clearance all differed significantly between survivors and non-survivors (Table 2, Figure 1).

Table 2. Lactate parameters according to 30-day survival status.

Lactate parameter	Survivors	Non-survivors	p value
Admission serum lactate, mmol/L	1.87 ± 0.89	4.09 ± 1.27	<0.001
24-hour serum lactate, mmol/L	1.48 ± 0.88	4.26 ± 1.87	<0.001
24-hour lactate clearance, %	21.63 ± 16.60	-1.17 ± 18.52	0.001

Values are mean ± SD, compared with the t-test.

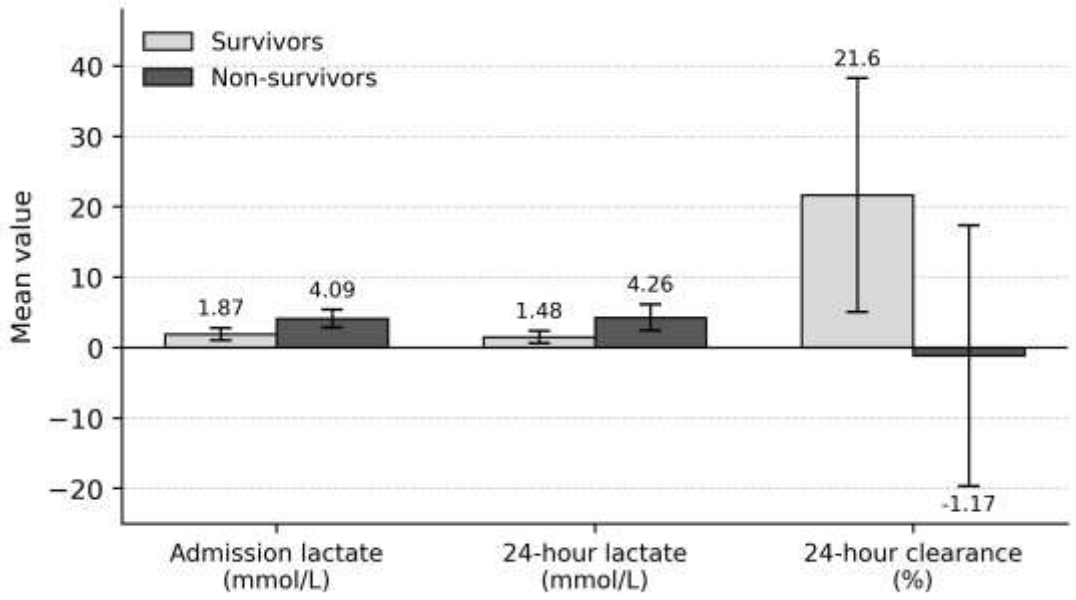

Figure 1. Admission lactate, 24-hour lactate and 24-hour lactate clearance in survivors versus non-survivors (mean ± SD).

3.3 Diagnostic accuracy

Admission lactate predicted 30-day mortality with an AUC of 0.932 (95% CI 0.801–1.000). At the Youden-optimal cut-off of 3.3 mmol/L, sensitivity was 85.7%, specificity 96.5%, positive predictive value 75.0%, negative predictive value 98.2% and overall accuracy 95.3% (Table 3).

Table 3. Diagnostic accuracy of admission serum lactate for predicting 30-day mortality.

Measure	Value
Cut-off (Youden-optimal)	≥ 3.3 mmol/L
Sensitivity	85.7 %
Specificity	96.5 %
Positive predictive value	75.0 %
Negative predictive value	98.2 %
Overall accuracy	95.3 %
Area under the ROC curve (95% CI)	0.932 (0.801–1.000)

3.4 Outcome by lactate stratum

Mortality, major morbidity and ICU admission all rose stepwise with increasing admission lactate (Table 4, Figure 2). Patients with lactate ≥ 3.5 mmol/L had substantially higher mortality (66.7%) than those below 2.0 mmol/L (2.9%; $p < 0.001$).

Table 4. Clinical outcomes by admission lactate stratum.

Admission lactate	n	30-day mortality, n (%)	Major morbidity, n (%)	ICU admission, n (%)	Hospital stay (days)
<2.0 mmol/L	35	1 (2.9)	4 (11.4)	9 (25.7)	10.4 ± 3.1
2.0–3.4 mmol/L	23	2 (8.7)	6 (26.1)	13 (56.5)	14.4 ± 2.9
≥3.5 mmol/L	6	4 (66.7)	5 (83.3)	5 (83.3)	19.6 ± 4.4

Major morbidity defined as Clavien–Dindo grade ≥ III. Hospital stay presented as mean ± SD. Across strata, $p < 0.001$ (chi-square) for mortality and major morbidity, and $p = 0.007$ for ICU admission.

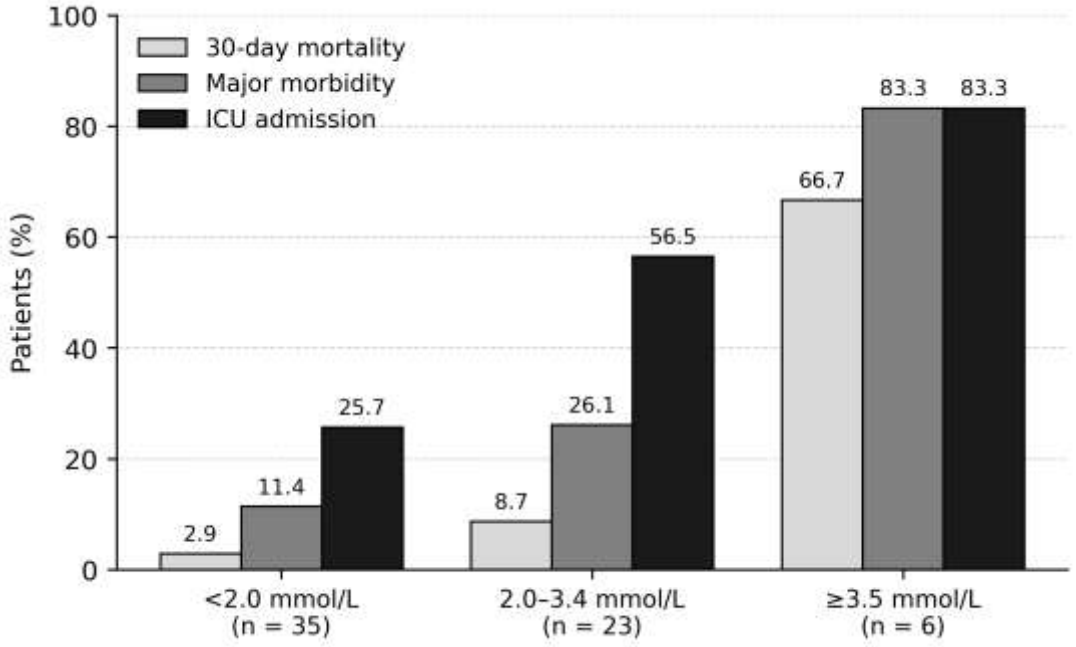

Figure 2. 30-day mortality, major morbidity and ICU admission across admission lactate strata.

4. Discussion

In this retrospective cohort of perforated duodenal ulcer, a single admission serum lactate measurement was strongly associated with 30-day mortality, major morbidity and ICU requirement, and this association strengthened rather than weakened over the first 24 postoperative hours. The gradient of risk across simple, clinically memorable thresholds — under 2.0, 2.0–3.4, and 3.5 mmol/L and above — was steep: mortality rose from under 3% to two in three patients.

These findings are consistent with the wider critical care literature, in which admission lactate and its subsequent clearance are among the most reproducible predictors of death in sepsis and septic shock [17–19]. In mixed perforation-peritonitis cohorts, similar cut-offs (around 2.5–3.0 mmol/L) have been reported to

predict 28-day mortality [20–22]. Our data suggest the same simple bedside test performs well when restricted specifically to duodenal perforation.

Lactate has practical advantages over existing clinical scores: it is measured within minutes on a point-of-care analyser, requires no subjective assessment, and — unlike the Mannheim Peritonitis Index — is available before the abdomen is opened. Patients with a value below 2.0 mmol/L can be reassured of a low probability of death; those at or above 3.5 mmol/L should be treated as a high-risk group warranting expedited surgery, invasive monitoring and early critical-care involvement, since surgical delay is itself an independent determinant of survival in perforated peptic ulcer [23].

Persistently elevated lactate at 24 hours, or failure to clear, should prompt reassessment for inadequate source control, an intra-abdominal collection, or ongoing sepsis, rather than being treated only as a prognostic label.

4.1 Limitations

This was a single-centre retrospective study of 64 patients with a small number of deaths, so the cut-off of 3.3 mmol/L is derived from, and therefore optimistic for, this dataset; external validation is needed before its adoption as a firm decision threshold. Because the data were extracted from existing case records, variables were recorded for clinical rather than research purposes and patients with incomplete records had to be excluded, which may have introduced selection and information bias. Lactate was measured at only two time points, and the cohort was young with few comorbidities, which may limit generalisability to older or more comorbid populations. As this analysis used simple bivariate comparisons in a small sample, it cannot establish that lactate predicts outcome independently of other clinical variables; a multivariable analysis in a larger sample would be needed to address this question.

5. Conclusion

Admission serum lactate is a simple, rapid and inexpensive predictor of mortality and morbidity in perforated duodenal ulcer. Routine measurement at first contact, and again at 24 hours, could help identify patients who need the most urgent surgical and critical-care attention.

Declarations

Consent for publication. Not applicable.

Competing interests. The authors declare no competing interests.

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