

ORIGINAL ARTICLE

Admission Lactate-to-Albumin Ratio as a Predictor of Severe Maternal Outcomes in Postpartum Haemorrhage

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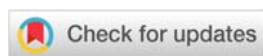
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ABSTRACT

Background: Postpartum haemorrhage is an obstetric emergency which may quickly escalate to shock, coagulopathy, organ failure and death. Conventional vital signs and haemoglobin may underestimate the severity of blood-loss early on, and the identification of women at risk is difficult.

Objectives: To assess the predictive value of admission lactate/albumin ratio (LAR) in women with postpartum haemorrhage (PPH) on severe maternal outcomes.

Methods: This prospective observational cohort study involved 70 women at Lady Willingdon Hospital, who had primary postpartum haemorrhage from April 2025 to January 2026. Venous lactate and serum albumin were obtained within 30 minutes of recognition of haemorrhage and lactate to albumin ratio (L:ALB) was calculated. Severe maternal outcome defined as either maternal death, peripartum hysterectomy, transfusion of ≥ 5 PRBC units, vasopressor support, disseminated intravascular coagulation, invasive mechanical ventilation, cardiac arrest or renal replacement therapy. ROC and logistic regression analyses were used.

Results: There were 18 women (25.7%) with severe maternal outcomes. The median lactate-to-albumin ratio was significantly higher in women with severe outcome than in women without severe outcome (1.72 versus 0.66; $p < 0.001$). The ratio demonstrated good discriminatory ability with an area under the curve of 0.88. With a threshold value of 0.95, 83.3% sensitivity, 78.8% specificity, 57.7% PPV and 93.2% NPV were obtained. The ratio, after taking into account estimated blood loss, was independently associated with severe maternal outcomes at a ratio of 0.95 or less (adjusted odds ratio 6.74; 95% confidence interval 1.72 – 26.46, $p = 0.006$).

Conclusions: Admission lactate/albumin ratio could be a tool to identify women at risk of complications after PPH.

Keywords: Postpartum haemorrhage; lactate-to-albumin ratio; maternal outcomes; haemorrhagic shock; massive transfusion; risk prediction

INTRODUCTION

Postpartum haemorrhage is one of the most severe obstetric emergencies, and is an important cause of preventable maternal morbidity and mortality¹. Despite timely treatment with uterotonics, tranexamic acid, blood products, and surgery, rapid deterioration can happen if

continuous blood loss is not detected at an early stage. Due to the physiological adaptations of pregnancy, women with postpartum haemorrhage may appear to have apparently normal blood pressure initially, therefore making severity assessment difficult².

Traditional parameters like estimated blood loss, heart rate, blood pressure, haemoglobin level and shock

index are used for guiding the management³. But estimating blood loss visually can be quite unreliable, haemoglobin does not necessarily correlate with acute blood loss and traditional vital signs may remain normal until there is significant circulatory failure. Such restrictions have spurred interest in biochemical markers that could detect tissue hypoperfusion before it progresses to irreversible organ dysfunction and that are readily available⁴.

Lactate is a serum marker of inadequate tissue oxygen delivery, altered cellular metabolism and of physiological stress⁵. High lactate levels have been associated with transfusion requirements, organ dysfunction and poor outcome in critically ill patients and could indicate significant circulatory compromise. However, a number of factors are known to affect lactate levels, such as adrenergic stimulation, muscular activity during labour, liver function, intravenous fluid given, and time of blood sampling. This may consequently give an incomplete picture of the physiological reserve of the mother as lactate alone⁶.

An important plasma protein, serum albumin is responsible for maintaining the oncotic pressure, transporting both endogenous and exogenous substances and regulating vascular permeability along with antioxidant activity⁷. Hypoalbuminaemia can be indicative of haemodilution, systemic inflammation, endothelial leakage, nutritional status or a decreased physiological reserve. The use of albumin alone is not necessarily sensitive enough to detect acute haemorrhagic deterioration, but may have a wider prognostic value when combined with lactate⁸.

The lactate to albumin ratio combines a measure of tissue hypoperfusion with a measure of systemic reserve and integrity of the vascular system⁹. The ratio can therefore be an indicator of both the immediate metabolic effects of blood loss, and the patient's decreased tolerance to physiologic stress. This composite marker has been found to be prognostic in a number of serious illnesses, with limited exploration of its clinical utility in postpartum haemorrhage¹⁰.

The current study aimed to assess the relationship between admission LAR and severe maternal outcome in women with postpartum haemorrhage (PPH)¹¹. It also set out to establish an optimum predictive threshold, and to compare the discriminative ability of the ratio with that of lactate, albumin, shock index and estimated blood loss¹².

MATERIALS AND METHODS

A prospective observational cohort study was carried out in the Obstetrics and Gynaecology Department of Lady Willingdon Hospital over a period of 10 months from April

2025 to January 2026. This study assessed the lactate-to-albumin (LA:Alb) ratio as a predictor of severe maternal outcomes in women with primary postpartum haemorrhage (PPH) on presentation.

Study Population: The number of respondents was 70 women who were enrolled by consecutive non-probability sampling. Primary postpartum haemorrhage was defined as blood loss $\geq 500\text{mL}$ after a vaginal delivery, $\geq 1,000\text{mL}$ after a cesarean delivery, or postpartum bleeding in association with haemodynamic instability within 24 hours of childbirth.

Women 18 years and older who had primary postpartum haemorrhage and had available lactate and albumin levels at admission were included. Patients with secondary postpartum haemorrhage, active sepsis, chronic liver disease, nephrotic syndrome, dialysis dependent renal disease, protein losing diseases and known severe hypoalbuminaemia were excluded. Patients who had blood transfusion, albumin or extensive fluids resuscitation prior to blood sampling were also excluded.

Sample Size: An expected severe maternal outcome rate of 25%, an anticipated area under the receiver-operating-characteristic curve of 0.75, 80% power, a 5% significance level and a 95% confidence interval were used in sample size calculations. The minimum calculated sample was 66; the sample was raised to 70 to cover for some incomplete observations.

Data Collection: Maternal age, parity, gestational age, antenatal haemoglobin, mode of delivery, history of postpartum haemorrhage, multiple pregnancy and cause of bleeding, estimated blood loss, vital signs, laboratory results, transfusion requirement, intervention performed and hospital outcome were documented on a structured form.

Postpartum haemorrhage was categorized as uterine atony, retained placental tissue/placenta accreta spectrum, genital-tract trauma, uterine rupture, and coagulation abnormality. Whenever possible, blood loss was recorded through calibrated collection devices, suction volume and weighed surgical tools.

Heart rate (HR) and blood pressure (BP) were taken at the time of haemorrhage recognition. A shock index (SI) was calculated as heart rate/systolic blood pressure. Significant haemodynamic compromise was deemed to be a shock index ≥ 1.0 .

Laboratory Measurements: Venous blood samples were taken within 30 minutes of recognition of PPH and prior to blood transfusion or prior to receiving albumin. Lactate was measured with a blood-gas analyser (mmol/L) while serum

albumin was measured by an automated chemistry analyser (g/dL).

Lactate to albumin ratio (LAR) was computed as lactate (mmol/L) divided by albumin (g/dL). The first set of lactate and albumin were analysed. Where clinically indicated further tests were performed which included haemoglobin, platelet count, fibrinogen, international normalised ratio, serum creatinine and blood-gas measurements.

Clinical Management: All of the women were treated using the institutional postpartum haemorrhage (PPH) protocol. Uterine massage, uterotonic drugs, intravenous tranexamic acid, oxygen, intravenous fluids and blood-component therapy were the methods of treatment. Manual removal of placenta, correction of genital tract trauma, uterine balloon tamponade, compression sutures, arterial ligation, embolisation, laparotomy or hysterectomy was performed where indicated.

The treating obstetric, anaesthetic and critical-care teams determined the necessity for transfusion, vasopressor support, mechanical ventilation, surgery and admission to intensive-care. In this study, lactate to albumin ratio was not utilized for guiding the treatment.

Outcome Measures: The primary outcome was a composite severe maternal outcome before hospital discharge. This comprised maternal death, peripartum hysterectomy, transfusion of five units or more of packed red blood cells, continuous vasopressor therapy, disseminated intravascular coagulation with blood-component replacement, invasive mechanical ventilation not for routine anaesthetic purposes, cardiac arrest or renal replacement therapy.

Secondary outcomes were intensive-care admission, total blood transfusion, surgical haemorrhage-control procedures, acute kidney injury, and length of hospital stay. In order to avoid incorporation bias, lactate and arterial pH were not included in the primary outcome definition.

Statistical Analysis: IBM SPSS Statistics (version [insert version]) was used for data analysis. Continuous variables were expressed as mean $\pm$ standard deviation (SD) or median (IQR), depending on the distribution. The categorical variables were presented as frequencies and percentages.

Independent-samples t test, Mann–Whitney U test, chi-square test, or Fisher's exact test was used to compare women with severe maternal outcomes with women without severe maternal outcomes, as appropriate. Receiver-operating-characteristic analysis was used to assess the predictive performance of the lactate-to-albumin ratio. The best cut-off value was established by the

use of Youden index and sensitivity, specificity, positive predictive value and negative predictive value were derived.

Univariable logistic regression was used initially. The multivariable model was limited to lactate-to-albumin ratio and estimated blood loss due to the limited number of severe-outcome events in the study (18). Odds ratios with 95% confidence intervals were reported and a p value of <0.05 was deemed statistically significant.

Ethical Considerations: The study was approved by the Institutional Review Board. All participants (or their legally authorised representative) provided written informed consent. All patients had their privacy protected during the study.

RESULTS

Participant Characteristics: A total of 76 women with primary postpartum haemorrhage were assessed for eligibility. Six women were excluded – two had blood transfusion prior to laboratory sampling, two had missing serum albumin data, one had concurrent sepsis, and the sixth, chronic liver disease. 70 participants were included in the final analysis. 18 women had a severe maternal outcome (25.7%) and 52 women did not have a severe maternal outcome.

The average age of the participants was 28.9 ± 5.1 years, with 26 women (37.1%) being primiparous. Twenty seven women (38.6%) had caesarean sections and 43 (61.4%) gave birth vaginally. The most common cause of post partum haemorrhage was uterine atony which was observed in 49 women (70.0%).

The rates of cesarean delivery were higher in women with severe maternal outcome than in women without severe outcome (61.1% vs. 30.8%, $p=0.028$). There was also a higher prevalence of antenatal haemoglobin less than 10 g/dL in the severe-outcome group (72.2% vs 38.5%, $p=0.016$). A placenta accreta spectrum disorder or placental tissue was found in 33.3% of women with severe outcome and 9.6% of women without severe outcome ($p=0.027$). The estimated blood loss was significantly greater in women with severe outcome (2180 ± 550 mL versus 1305 ± 330 mL; $P<0.001$). Table 1 shows maternal and obstetric characteristics were similar between the two groups.

Admission Haemodynamic and Laboratory Findings: Women who developed severe maternal outcomes showed greater haemodynamic instability at the initial assessment. Mean systolic blood pressure was lower in the severe-outcome group than in the non-severe-outcome group (90 ± 15 mmHg versus 108 ± 13 mmHg; $p<0.001$), whereas

mean heart rate was higher (115 ± 18 beats/min versus 95 ± 15 beats/min; $p < 0.001$). Mean shock index was also significantly higher among women with severe outcomes (1.29 ± 0.31 versus 0.89 ± 0.19 ; $p < 0.001$).

Admission haemoglobin, platelet count, and fibrinogen concentration were significantly lower among women with severe maternal outcomes. Median serum lactate was 4.5 mmol/L in the severe-outcome group compared with 2.0 mmol/L in the non-severe-outcome group ($p < 0.001$). Mean serum albumin was also lower among women with severe outcomes (2.65 ± 0.42 g/dL versus 3.15 ± 0.39 g/dL; $p < 0.001$).

The median admission lactate-to-albumin ratio was 1.72 among women who developed severe maternal outcomes compared with 0.66 among women without severe outcomes ($p < 0.001$). Complete admission haemodynamic and laboratory findings are presented in Table 2.

Clinical Interventions and Maternal Outcomes: Among the 18 women who developed a severe maternal outcome, 12 required transfusion of at least five units of packed red blood cells, 10 required continuous vasopressor support, seven developed disseminated intravascular coagulation, five required invasive mechanical ventilation, and four underwent peripartum hysterectomy. Two women required renal replacement therapy, one experienced cardiac arrest, and one maternal death occurred. Some participants experienced more than one severe complication.

Overall, 19 women were admitted to the intensive care unit. Intensive-care admission occurred in 16 women with severe outcomes and three women without severe outcomes (88.9% versus 5.8%; $p < 0.001$). Women with severe outcomes received a greater number of packed red-cell units and experienced longer hospital stays. Surgical haemorrhage-control procedures were required in 55.6% of women with severe outcomes compared with 7.7% of women without severe outcomes ($p < 0.001$), as shown in Table 3.

Predictive Performance of the Lactate-to-Albumin Ratio: ROC analysis showed a good discriminatory ability for the lactate-to-albumin ratio at admission for severe maternal outcomes. The area under the curve was 0.88 with 95% CI (0.79-0.96). A Youden index of 0.95 was used to find the best cutoff point for the prediction.

When the threshold was set at a LAC of 0.95, 15/18 (83%) of the women who had a severe outcome were classified correctly, and 41/52 (80%) of the women without a severe outcome were classified correctly. The threshold provided a sensitivity of 83.3%, specificity of 78.8%, positive predictive value of 57.7%, and negative predictive value of 93.2%.

The lactate-to-albumin ratio numerically showed better discrimination than lactate alone, albumin alone, shock index, and estimated blood loss. Comparative predictive performance of markers investigated are presented in Table 4.

Logistic Regression Analysis: The univariable analysis showed that lactate-to-albumin ratio ≥ 0.95 was strongly associated with severe maternal outcomes with an unadjusted OR of 18.64. Severe maternal outcomes were also associated with shock index (SI) ≥ 1.0 , antenatal haemoglobin (ANTHB) < 10 g/dL, caesarean delivery, placental tissue disorder, and placenta accreta spectrum disorder and increasing estimated blood loss.

Due to the limited number of severe maternal outcome events, the multivariable model was limited to two predictors to prevent overfitting. In the final model, admission lactate-to-albumin ratio and estimated blood loss were included.

Estimated blood loss was used to adjust the lactate and albumin levels, and a lactate-to-albumin ratio of 0.95 or higher was still independently associated with severe maternal outcomes with an adjusted odds ratio of 6.74. In addition, there was an independent association between higher estimated blood loss (eB) (500mL increments) and increased risk of severe outcome. The results of the regression are given in Table 5.

Table 1: Maternal and obstetric characteristics according to severe maternal outcome

Variable	Overall (n=70)	No severe outcome (n=52)	Severe outcome (n=18)	p value
Maternal age, years	28.9 ± 5.1	28.2 ± 4.9	30.8 ± 5.1	0.070
Primiparity	26 (37.1%)	18 (34.6%)	8 (44.4%)	0.573
Gestational age, weeks	38.0 ± 1.6	38.1 ± 1.5	37.6 ± 1.8	0.300
Caesarean delivery	27 (38.6%)	16 (30.8%)	11 (61.1%)	0.028
Antenatal haemoglobin below 10 g/dL	33 (47.1%)	20 (38.5%)	13 (72.2%)	0.016
Multiple pregnancy	6 (8.6%)	4 (7.7%)	2 (11.1%)	0.644
Previous postpartum haemorrhage	9 (12.9%)	5 (9.6%)	4 (22.2%)	0.220
Uterine atony	49 (70.0%)	38 (73.1%)	11 (61.1%)	0.380
Placental tissue or placenta accreta spectrum disorder	11 (15.7%)	5 (9.6%)	6 (33.3%)	0.027
Genital-tract trauma	7 (10.0%)	6 (11.5%)	1 (5.6%)	0.668
Coagulation abnormality	3 (4.3%)	3 (5.8%)	0 (0.0%)	0.565
Estimated blood loss, mL	$1,530 \pm 550$	$1,305 \pm 330$	$2,180 \pm 550$	< 0.001
Time from haemorrhage recognition to sampling, minutes	24 (18–31)	25 (18–32)	22 (17–29)	0.382

Table 2: Admission haemodynamic and laboratory measurements

Variable	Overall (n=70)	No severe outcome (n=52)	Severe outcome (n=18)	p value
Systolic blood pressure, mmHg	103 ± 16	108 ± 13	90 ± 15	<0.001
Heart rate, beats/min	100 ± 18	95 ± 15	115 ± 18	<0.001
Shock index	0.99 ± 0.28	0.89 ± 0.19	1.29 ± 0.31	<0.001
Admission haemoglobin, g/dL	9.3 ± 1.5	9.7 ± 1.3	8.2 ± 1.4	<0.001
Platelet count, ×10 ⁹ /L	188 ± 64	201 ± 58	151 ± 64	0.007
Fibrinogen, g/L	2.6 ± 0.8	2.9 ± 0.7	1.8 ± 0.6	<0.001
Lactate, mmol/L	2.4 (1.6–3.7)	2.0 (1.5–2.8)	4.5 (3.3–6.0)	<0.001
Albumin, g/dL	3.02 ± 0.46	3.15 ± 0.39	2.65 ± 0.42	<0.001
Lactate-to-albumin ratio	0.78 (0.52–1.27)	0.66 (0.47–0.90)	1.72 (1.19–2.34)	<0.001
International normalised ratio	1.16 (1.03–1.39)	1.08 (1.00–1.22)	1.51 (1.25–1.87)	<0.001
Serum creatinine, mg/dL	0.78 (0.65–0.98)	0.73 (0.63–0.86)	1.02 (0.77–1.34)	0.002

Table 3: Clinical interventions and hospital outcomes

Variable	Overall (n=70)	No severe outcome (n=52)	Severe outcome (n=18)	p value
Intensive-care-unit admission	19 (27.1%)	3 (5.8%)	16 (88.9%)	<0.001
Packed red-cell units transfused	2 (1–5)	2 (1–3)	7 (5–10)	<0.001
Transfusion of at least five packed red-cell units	12 (17.1%)	0 (0.0%)	12 (66.7%)	Not tested
Vasopressor requirement	10 (14.3%)	0 (0.0%)	10 (55.6%)	Not tested
Disseminated intravascular coagulation	7 (10.0%)	0 (0.0%)	7 (38.9%)	Not tested
Invasive mechanical ventilation	5 (7.1%)	0 (0.0%)	5 (27.8%)	Not tested
Peripartum hysterectomy	4 (5.7%)	0 (0.0%)	4 (22.2%)	Not tested
Renal replacement therapy	2 (2.9%)	0 (0.0%)	2 (11.1%)	Not tested
Cardiac arrest	1 (1.4%)	0 (0.0%)	1 (5.6%)	Not tested
Maternal death	1 (1.4%)	0 (0.0%)	1 (5.6%)	Not tested
Uterine balloon tamponade	20 (28.6%)	12 (23.1%)	8 (44.4%)	0.087
Surgical haemorrhage control	14 (20.0%)	4 (7.7%)	10 (55.6%)	<0.001
Hospital stay, days	4 (3–6)	3 (2–4)	7 (5–11)	<0.001

Table 4: Receiver-operating-characteristic analysis for severe maternal outcomes

Predictor	Area under the curve with 95% confidence interval	Optimal threshold	Sensitivity	Specificity	Positive predictive value	Negative predictive value
Lactate-to-albumin ratio	0.88 (0.79–0.96)	0.95	83.3%	78.8%	57.7%	93.2%
Lactate	0.83 (0.73–0.92)	3.2 mmol/L	77.8%	73.1%	50.0%	90.5%
Albumin	0.76 (0.64–0.87)	2.85 g/dL	72.2%	69.2%	44.8%	87.8%
Shock index	0.81 (0.70–0.91)	1.00	77.8%	76.9%	53.8%	90.9%
Estimated blood loss	0.85 (0.76–0.94)	1,600 mL	83.3%	73.1%	51.7%	92.7%

Table 5: Logistic regression analysis of predictors of severe maternal outcomes

Predictor	Unadjusted odds ratio with 95% confidence interval	p value	Adjusted odds ratio with 95% confidence interval	p value
Lactate-to-albumin ratio of at least 0.95	18.64 (4.56–76.10)	<0.001	6.74 (1.72–26.46)	0.006
Estimated blood loss per 500-mL increase	2.74 (1.75–4.29)	<0.001	1.84 (1.11–3.05)	0.018
Shock index of at least 1.0	11.67 (3.23–42.17)	<0.001	Not included	Not applicable
Antenatal haemoglobin below 10 g/dL	4.16 (1.29–13.44)	0.017	Not included	Not applicable
Caesarean delivery	3.54 (1.16–10.79)	0.027	Not included	Not applicable
Placental tissue or placenta accreta spectrum disorder	4.70 (1.22–18.05)	0.025	Not included	Not applicable

DISCUSSION

The current study aimed at assessing the value of admission LAR as an early predictor of adverse maternal outcomes in women with PPH¹. The main result was that women with severe complications had significantly higher lactate to albumin ratio when first evaluated than women who did not have severe outcomes. The median ratio in the severe-outcome group was 1.72 whereas the median ratio in the non-severe-outcome group was 0.66. The ratio was also able to distinguish well with an area under the receiver-operating-characteristic curve of 0.88².

Postpartum haemorrhage has the potential to quickly deteriorate from "compensated" blood loss into circulatory collapse, coagulopathy, organ dysfunction and death³. Blood pressure and haemoglobin concentration may not be good indicators of acute haemorrhage. Physiological changes during pregnancy allow a significant decrease in blood volume without impairing maternal blood pressure. A biochemical marker for early tissue hypoperfusion might therefore be useful to allow earlier identification of women at risk of deterioration⁴.

Lactate is produced in the serum when the amount of oxygen delivered to the tissues is less than what is needed⁵. During postpartum haemorrhage (PPH), increases in lactate can be a sign of diminished circulating volume, low tissue perfusion, increased adrenergic activity and increased metabolic stress. The median lactate in this study was over 2x higher in women who had severe outcomes. Labour, muscular activity, liver clearance, use of medication and the time of specimen collection, however, may all affect lactate concentration. Its interpretation as a stand-alone indicator is thus restricted⁶.

Albumin is used to give more information about the maternal physiological reserve⁷. Low levels of albumin can be caused by haemodilution, systemic inflammation, endothelial leakage, low rates of synthesis or poor nutritional status. The level of albumin at admission was significantly lower among women with severe maternal outcome compared with women without severe maternal outcome. The combined value of albumin and lactate yielded better discrimination but the predictive ability of albumin alone was moderate⁸.

Therefore, the lactate-to-albumin ratio might provide a more complete evaluation than either of these measurements alone⁹. Lactate has been associated with immediate metabolic impact of decreased perfusion and albumin with systemic resilience and vascular integrity. A high value can indicate women who have both high circulatory strain and/or lower tolerance to ongoing bleeding. The biological interaction may be a reason for the superiority of the ratio over lactate, albumin and shock index if they are used alone¹⁰.

The threshold of the lactate to albumin ratio was 0.95 with sensitivity 83.3% and specificity 78.8%¹¹. The negative predictive value is 93.2% meaning that women with a ratio below this value were unlikely to suffer severe maternal outcome within the population studied. This feature can be of clinical interest if considered together with controlled bleeding, stable haemodynamic parameters, sufficient urine production and reassuring coagulation labs. But the relatively moderate positive predictive value suggests that the ratio should not be used to make decisions about invasive intervention or intensive-care admission¹².

The association of the ratio with severe maternal outcomes was independent of estimated blood loss¹³. Women with a ratio above 0.95 had >6 times adjusted odds of severe outcome compared to women <0.95. The implication of this association is that the ratio may carry prognostic significance other than the amount of blood loss that one can see¹⁴.

Blood loss was also independently associated with adverse outcomes, but only estimated¹⁵. The adjusted risk of severe complications rose by 1% for every 500 mL of blood loss. However, blood loss can be hard to detect in

emergency delivery with blood mixed with amniotic fluid, irrigation fluid or surgical materials or intra-abdominal collections. This lactate to albumin ratio might then augment, rather than replace, objective assessment of blood loss¹⁶.

Shock index was significantly elevated in women who had severe outcomes and had good discriminatory power¹⁷. It has the advantage of being rapidly available without laboratory testing. Heart rate and blood pressure can, however, be influenced by pain, anxiety, anaesthetic, hypertensive disorders, drugs and cardiovascular adaptation to pregnancy. The combination of shock index and lactate-to-albumin ratio might be a better assessment than either alone¹⁸.

Those women who had severe outcomes had lower haemoglobin, platelet count and fibrinogen concentrations, as well as higher international normalised ratios¹⁹. These results show that consumption and dilution of coagulation factors and progressive anaemia occurred in conjunction with worsening haemostatic disturbance in severe PPH. Low fibrinogen levels were especially observed at the severe end of complications and continue to be an important parameter to consider in the assessment of haemorrhage and transfusion²⁰.

In univariable analysis severe outcomes were associated with Caesarean delivery, antenatal anaemia, and placental abnormalities⁴. C-section can result in higher blood loss during surgery or be done if the pregnancy is complicated. Persistent haemorrhage, not controlled by uterotonic treatment alone may be associated with placenta accreta spectrum and retained placental tissue. Antenatal anaemia can lead to decreased tolerance to blood loss and rapid onset of symptomatic tissue hypoxia. These factors were not included in the restricted multivariable model, perhaps due to the immediate severity of the haemorrhage having a more significant impact on outcomes¹³.

Women with severe outcomes were significantly more likely to have received intensive care, massive transfusion, vasopressors, mechanical ventilation and surgery for haemorrhage control⁷. They were also found to have longer hospital stays. These results further validate the composite outcome and indicate that the high lactate-albumin ratio was linked to significant morbidity in mothers, not just laboratory abnormalities alone¹⁶.

The ratio has a number of potential practical advantages². Lactate and albumin are readily available in tertiary-care hospitals, and the calculation is simple. Lactate can frequently be quantified within minutes using a blood-gas analyser and albumin is commonly obtainable from clinical chemistry laboratories. This ratio can therefore be used in the early assessment of postpartum

haemorrhage, without the need of special equipment or complicated scoring software¹¹.

Do not wait for the ratio before taking clinical management⁵. Postpartum haemorrhage treatment should be rapid uterotonic treatment, tranexamic acid, resuscitation with fluids and blood components, identifying the source of bleeding problems, and escalation to mechanical or surgical control as necessary. This ratio should be used as an additional risk-stratification tool, not a substitute for clinical judgement¹⁸.

An elevated admission ratio might be a clue to the clinical team that there might be occult or continuing hypoperfusion despite a seemingly preserved blood pressure⁸. In such patients, close haemodynamic monitoring, frequent laboratory testing, prompt activation of a massive-transfusion protocol, early call for senior obstetric and anaesthetic teams and preparation for definitive haemorrhage-control procedures might be beneficial¹⁵.

A big advantage of the study was the measurement of lactate and albumin at the beginning assessment and prior to blood transfusion or albumin³. This decreased the ability of the treatment to affect the primary predictor. Clinically meaningful outcomes such as massive transfusion, hysterectomy, vasopressor support, mechanical ventilation, renal replacement therapy, cardiac arrest and maternal death were also used¹⁹.

The outcome definition did not include lactate or arterial pH criteria⁶. This prevented incorporation bias, as lactate was a component of the study predictor. However, the use of a parsimonious multivariable model was also appropriate as only 18 severe-outcome events occurred¹⁴.

There are a number of limitations that should be taken into account¹⁰. The study was performed at a single institution and involved only 70 women, so the results would have been more precise and generalizable with more women in the study. There were a limited number of severe outcomes, limiting the variables to be included in multivariable analysis. Thus, residual confounding because of cause of haemorrhage, timing of resuscitation, antenatal nutritional status, treatment differences, and hypertensive disorders may exist¹⁷.

Even though calibrated containers and weighed materials were used there may have been a measurement error with regards to the estimated blood loss¹². Liver function, inflammatory diseases, intravenous fluids, pre-existing nutritional status and haemodilution due to pregnancy may have also contributed to the level of albumin. The ratio and lactate clearance were not analysed, only the first lactate and albumin value was analysed and may be useful as additional prognostic factors²⁰.

The threshold value 0.95 was based on the same population that it was tested on¹. Therefore, its sensitivity

and specificity might be lower when used in an external population. Larger SMC studies would be needed to confirm the threshold and to determine if the ratio, in conjunction with established clinical parameters, would enhance prediction to a level that would affect management⁹.

CONCLUSION

Admission lactate to albumin ratio was strongly related to poor maternal outcomes in women with primary postpartum haemorrhage. The ratios were significantly greater for women who developed severe complications, and a cut-off of 0.95 had good sensitivity, specificity and negative predictive value.

An elevated ratio was an independent predictor after adjustment for estimated blood loss, which may indicate other information about tissue hypoperfusion and maternal physiological reserve. The ratio is easily accessible, inexpensive and may be helpful in addition to clinical evaluation, blood-loss assessment and coagulation testing.

The lactate to albumin ratio should not be used as an alternative to good immediate postpartum haemorrhage management or clinical judgement. There is a need for additional prospective multicentre studies with larger sample size to validate the proposed threshold, evaluate serial measurements and study if ratio guided risk stratification is associated with better maternal outcomes.

DECLARATION

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REFERENCES

1. Yunas I, Islam MA, Sindhu KN, Devall AJ, Podsek M, et al. Causes of and risk factors for postpartum haemorrhage: a systematic review and meta-analysis. *Lancet*. 2025;405(10488):1468-1480. doi:10.1016/S0140-6736(25)00448-9.
2. Vogel JP, Nguyen PY, Ramson J, De Silva MS, Pham MD, Sultana S, et al. Effectiveness of care bundles for prevention and treatment of postpartum hemorrhage: a systematic review. *Am J Obstet Gynecol*. 2024;231(1):67-91. doi:10.1016/j.ajog.2024.01.012.

3. Anti-fibrinolytics Trialists Collaborators Obstetric Group. Tranexamic acid for postpartum bleeding: a systematic review and individual patient data meta-analysis of randomised controlled trials. *Lancet*. 2024;404(10463):1657-1667. doi:10.1016/S0140-6736(24)02102-0.
4. Gallos I, Devall A, Martin J, Middleton L, Beeson L, Galadanci H, et al. Randomized trial of early detection and treatment of postpartum hemorrhage. *N Engl J Med*. 2023;389(1):11-21. doi:10.1056/NEJMoa2303966.
5. Williams EV, Goranitis I, Oppong R, et al. A cost-effectiveness analysis of early detection and bundled treatment of postpartum hemorrhage alongside the E-MOTIVE trial. *Nat Med*. 2024;30(8):2343-2348. doi:10.1038/s41591-024-03069-5.
6. Hofer S, Blaha J, Collins PW, Ducloy-Bouthors AS, Guasch E, Labate F, et al. Haemostatic support in postpartum haemorrhage: a review of the literature and expert opinion. *Eur J Anaesthesiol*. 2023;40(1):29-38. doi:10.1097/EJA.0000000000001744.
7. Escobar MF, Nassar AH, Theron G, Barnea ER, Nicholson W, Ramasauskaite D, et al. FIGO recommendations on the management of postpartum hemorrhage 2022. *Int J Gynaecol Obstet*. 2022;157 Suppl 1:3-50. doi:10.1002/ijgo.14116.
8. Aimagambetova G, Bapayeva G, Sakhipova G, Terzic M. Management of postpartum hemorrhage in low- and middle-income countries: emergency need for updated approach due to specific circumstances, resources, and availabilities. *J Clin Med*. 2024;13(23):7387. doi:10.3390/jcm13237387.
9. Basil-Kway V, Castillo-Reyther RA, Domínguez-Salgado LA, Espinosa-Tanguma R, Gordillo-Moscato AA. Early prognostic capacity of serum lactate for severe postpartum hemorrhage. *Int J Gynaecol Obstet*. 2021;153(3):483-488. doi:10.1002/ijgo.13446.
10. Okada A, Okada Y, Inoue M, Narumiya H, Nakamoto O. Lactate and fibrinogen as good predictors of massive transfusion in postpartum hemorrhage. *Acute Med Surg*. 2020;7(1):e453. doi:10.1002/ams2.453.
11. Kong T, Lee HS, Jeon SY, You JS, Lee JW, Chung HS, et al. Delta neutrophil index and shock index can stratify risk for the requirement for massive transfusion in patients with primary postpartum hemorrhage in the emergency department. *PLoS One*. 2021;16(10):e0258619. doi:10.1371/journal.pone.0258619.
12. Sohn CH, Kim YJ, Seo DW, Won HS, Shim JY, Lim KS, et al. Blood lactate concentration and shock index associated with massive transfusion in emergency department patients with primary postpartum haemorrhage. *Br J Anaesth*. 2018;121(2):378-383. doi:10.1016/j.bja.2018.04.039.
13. Yoon SH, Choi B, Eun S, Bae GE, Koo CM, Kim MK. Using the lactate-to-albumin ratio to predict mortality in patients with sepsis or septic shock: a systematic review and meta-analysis. *Eur Rev Med Pharmacol Sci*. 2022;26(5):1743-1752. doi:10.26355/eurrev_202203_28244.
14. Suzuki Y, Aoki Y, Shimizu M, Nakajima M, Imai R, Okada Y, et al. Predictive accuracy of lactate albumin ratio for mortality in intensive care units: a nationwide cohort study. *BMJ Open*. 2024;14(12):e088926. doi:10.1136/bmjopen-2024-088926.
15. Shi X, Zhong L, Lu J, Hu B, Shen Q, Gao P. Clinical significance of the lactate-to-albumin ratio on prognosis in critically ill patients with acute kidney injury. *Ren Fail*. 2024;46(1):2350238. doi:10.1080/0886022X.2024.2350238.
16. Ray CC, Pollack MM, Gai J, Patel AK. The association of the lactate-albumin ratio with mortality and multiple organ dysfunction in PICU patients. *Pediatr Crit Care Med*. 2023;24(9):760-766. doi:10.1097/PCC.0000000000003272.
17. Yi X, Jin D, Huang S, Xie Z, Zheng M, Zhou F, et al. Association between lactate-to-albumin ratio and 28-days all-cause mortality in patients with sepsis-associated liver injury: a retrospective cohort study. *BMC Infect Dis*. 2024;24(1):65. doi:10.1186/s12879-024-08978-x.
18. Liu Q, Zheng HL, Wu MM, Wang QZ, Yan SJ, Wang M, et al. Association between lactate-to-albumin ratio and 28-days all-cause mortality in patients with acute pancreatitis: a retrospective analysis of the MIMIC-IV database. *Front Immunol*. 2022;13:1076121. doi:10.3389/fimmu.2022.1076121.
19. Zhu X, Xue J, Liu Z, Dai W, Xu H, Zhou Q, et al. The lactate/albumin ratio predicts mortality in critically ill patients with acute kidney injury: an observational multicenter study on the eICU database. *Int J Gen Med*. 2021;14:10511-10525. doi:10.2147/IJGM.S339767.
20. Rabinowitz JD, Enerbäck S. Lactate: the ugly duckling of energy metabolism. *Nat Metab*. 2020;2(7):566-571. doi:10.1038/s42255-020-0243-4.

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