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Original Article

The Relationship Between Lactate Level and Fluid Management After Hepatectomy

Mustafa Çolak, İlhan Ocak

Başakşehir Çam and Sakura City Hospital, İstanbul, Türkiye

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Correspondence: Mustafa Çolak, Başakşehir Çam and Sakura City Hospital, İstanbul, Türkiye
E-mail: colakk@hotmail.com.tr

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ABSTRACT

Objective: After surgeries such as hepatectomy, careful monitoring of various physiological measurements is crucial for successful outcomes. Among these measurements are lactate levels, which are significant indicators of tissue perfusion and oxygenation. Particularly in the postoperative period, arterial blood lactate (ABL) levels are important for monitoring tissue perfusion. Maintaining an optimal fluid balance is critical for sustaining tissue perfusion and preventing potential complications. The aim of this study is to examine the relationship between patients' ABL levels and fluid therapy in the postoperative period.

Methods: This study was designed as a retrospective analysis to examine the outcomes of patients treated in the intensive care unit following hepatectomy. To assess the impact of fluid therapy on patients' clinical outcomes, the amounts of fluids administered were calculated. Initial arterial blood lactate levels, peak lactate levels, the rate of lactate clearance, acidosis status, and base deficit values in arterial blood gas analyses were recorded. The Pearson Correlation Test was used to determine the relationship between arterial blood gas parameters, ABL trend parameters, and fluid therapy, considering $p<0.05$ as statistically significant.

Results: In this study, 108 patients who underwent hepatectomy were examined. Patients were administered 42.3 cc/kg of fluid until their ABL levels returned to the normal range. Additionally, a significant correlation was found between the highest ABL levels and the total amount of fluid administered ($r=0.385$, $p<0.01$).

Conclusion: The study identified a relationship between ABL levels and fluid intake. We believe that high lactate levels indicate a sepsis-like condition requiring intensive fluid therapy. These results suggest that monitoring ABL levels in patients who have undergone hepatectomy can be an important tool for predicting the need for fluid therapy and the duration of close monitoring. Arterial blood lactate monitoring can play a critical role in the postoperative management and monitoring of patients.

INTRODUCTION

Hepatectomy is a major surgical procedure that requires careful monitoring of various physiological parameters to ensure successful outcomes.[1] One of the important parameters closely monitored in the postoperative period is the lactate levels in the blood, which can serve as indicators of tissue perfusion and oxygenation.[2]

During hepatectomy, there is a significant risk of blood loss, which can lead to hypovolemia and impaired tissue perfusion.[3,4] This can result in the accumulation of lactate in the blood, which can lead to metabolic acidosis and impaired organ function. Therefore, close monitoring of lactate levels is essential to detect and address any abnormalities in tissue perfusion.[5,6]

Fluid management is also a critical aspect of postoperative care after hepatectomy. Proper fluid balance is crucial to maintaining adequate tissue perfusion and preventing complications.[7,8]

After hepatectomy, the patient may be under metabolic stress, which can cause an increase in blood lactate levels. However, fluid therapy can increase blood volume and carry more oxygen to the tissues, thereby reducing lactate levels. Therefore, this study aims to investigate the effect of fluid therapy on improving the metabolic status of the patient during the postoperative period after hepatectomy. The results of this study may impact clinical practices in fluid management after liver and biliary tract tumor surgery and improve patient outcomes.

MATERIALS AND METHODS

This study utilized a retrospective cohort study design and was conducted by examining the medical records of pa-

tients between January 2021 and April 2023. A total of 108 patients who underwent surgery due to liver and biliary tract tumors were included in the study. In this study, parameters such as initial arterial blood lactate (ABL) levels, peak lactate levels, lactate clearance, presence of acidosis, and base deficit in arterial blood gas analysis were retrospectively evaluated concerning the amount of fluid administered to the patients. The study was performed in a tertiary intensive care unit specific to hepatobiliary surgery and liver transplantation. All data were obtained from the hospital's records system and intensive care unit observation notes.

Intensive Care Follow-Up Protocol and Definitions

In the postoperative period following hepatectomy, patients require close monitoring and fluid therapy. Upon admission to the intensive care unit, arterial blood gas, hemogram, and blood biochemistry tests are conducted within the first 15 minutes. Arterial blood gas examination is then repeated at regular intervals, initially every two hours and later at wider intervals. The amount of fluid given per hour as 0.9% saline and 10% dextrose is determined until stability is achieved, as assessed by the attending physician. The first day after the operation is defined as the time from the patient's arrival in the intensive care unit until 07:00 AM the next day.

Arterial blood gas values were determined through samples taken from the radial artery cannula or femoral artery cannula. The highest ABL level recorded during the follow-up period in the intensive care unit was documented, and the time to this value was defined as the maximum ABL value time. A normal ABL concentration was defined as 2 mmol/L or less, and the time to reach this level was also noted. The amount of fluid given to patients was calculated as mL/kg, and the amount of fluid administered until the ABL level returned to normal was recorded. These protocols and definitions are crucial for the accurate assessment and management of critically ill patients in the postoperative period following hepatectomy.

Statistical Analysis

Statistical analysis was performed using SPSS Statistics version 20 (IBM, Armonk, NY). The normality of the study data was assessed using the Kolmogorov-Smirnov analysis. Vital signs of patients upon admission to the intensive care unit and laboratory values were reported as median (Q1)

Table 1. Characteristics of patients

Age*	58.5 (41-66)
Gender (%)	
Male	69 (%64)
Female	39 (%36)
Etiology (%)	
Metastasis	35 (%19.4)
Cholangiocarcinoma	24 (%17.4)
Adenoma/adenocarcinoma	21 (%17.4)
Hepatocellular carcinoma	19 (%11.6)
Gallbladder tumor	7 (%6.7)
Hemangioendothelioma	2 (%1.9)
Vital signs at admission*	
Heart beat/minute	106 (92-121)
Respiratory rate/minute	18 (16-20)
Oxygen saturation (%)	98 (97-100)
Systolic blood pressure (mmHg)	114 (105-122)
Diastolic blood pressure (mmHg)	68 (60-76)
Long of stay ICU*	1 (1-13)
Number of Inotropic / vasopressor support (%)	7 (%6.7)
Number of invasive mechanical ventilation support (%)	6 (%5.8)
Laboratory values at admission*	
Hemoglobin (g/dL)	12 (10.5-14,5)
Platelets (10^9/L)	224 (181-279)
INR	1.1 (1.04-1.18)
AST(U/L)	334 (203-508)
ALT(U/L)	254 (146-433)
Total bilirubin (mg/dL)	1.03 (0,56-1.76)

*Median (Q1-Q3); ALT: Alanine transaminase; AST: Aspartate aminotransferase ICU: Intensive care unit; INR: International normalised ratio.

Table 2. Patients arterial blood gas values and arterial lactate trend

	Adult*
ABG pH	7.38 (7.37-7.40)
ABG BE	-2.9{(-4.3)-(-1.5)}
A.lactate at admisson (mmol/L)	3.7 (2-4.5)
A.lactate maximum value (mmol/L)	6 (4.1-7.8)
A.lactate maximum value time (hours)	7.4(5.6-9.2)
A.lactate value under 2 time (hours)	11(7.2-14.6)

*Mean (%95 Confidence interval). ABG: Arterial blood gas; A. Lactate: Arterial blood lactate; BE: Base excess.

and third (Q3) quartiles. Arterial blood gas values and ABL trend parameters were reported as mean and 95% Confidence Interval (CI). The Pearson Correlation test was used to determine the correlation between arterial blood gas parameters, ABL trend parameters, and fluid therapy, with a significance level of $p<0.05$. These findings have implications for the management of critically ill patients in the intensive care unit.

Ethical Statement

The study was approved by the Başakşehir Çam and Sakura City Hospital's ethics committee with number 2022-389.

RESULTS

A total of 108 patients were included, all over 18 years old. Among the participants, 69 were male and 39 were female. Table 1 provides an overview of the characteristics of the patients upon admission to the intensive care unit. An analysis of blood gas values at admission and ABL trend parameters was performed, as shown in Table 2. The mean amount of fluid required to return the ABL level to normal was found to be 42.3 cc/kg (95% CI, 38.5-45.9). The study also examined the correlation between arterial blood gas parameters, ABL trend, and the amount of fluid administered, which is presented in Table 3. The results showed that only one patient died, and one patient required re-operation. The 30-day survival rate was 99%, indicating favorable outcomes for the majority of patients.

DISCUSSION

Our research aimed to scrutinize the influence of fluid therapy on the postoperative metabolic status of patients undergoing hepatectomy. We assessed various factors, including initial and peak lactate levels, lactate clearance, the presence of acidosis, and base deficit from arterial blood gas analysis, in relation to the volume of fluid administered to patients.

Table 3. Correlation arterial blood gas parametres, lactate trend and fluid

	pH	BE	Lactate at admisson	Max lactate	Max lactate time	Lactate<2 time	Fluid
pH							
r	-	0.17	0.09	0.05	0.36	0.05	0.06
p	-	0.15	0.46	0.68	0.02	0.68	0.64
BE							
r	0.17		0.31	0.39	0.01	0.32	0.04
p	0.15		0.01	<0.01	0.93	0.01	0.73
Lactate at admisson							
r	0.09	0.31		0.68	0.15	0.5	0.11
p	0.46	0.01		<0.01	0.34	<0.01	0.41
Max lactate							
r	0.05	0.39	0.68		0.16	0.65	0.38
p	0.68	<0.01	<0.01		0.32	<0.01	<0.01
Max lactate time							
r	0.36	0.01	0.15	0.16		0.18	0.19
p	0.02	0.93	0.34	0.32		0.31	0.29
Lactate<2 time							
r	0.05	0.32	0.50	0.65	0.18		0.484
p	0.68	0.01	0<.01	<0.01	0.31		<0.01
Fluid							
r	0.06	0.04	0.11	0.385	0.19	0.48	
p	0.68	0,73	0.41	<0.01	0.29	<0.01	

p: p value (significant the 0.05); r: Pearson correlation; BE: ABG base excess at admission; Fluid: Amount of fluid given on the first day (ml/kg); Lactate<2 time: Time until arterial lactate value<2 mmol/L; Lactate at admisson: Arterial lactate at admission; Max lactate: Maximum value of arterial lactate; Max lactate time: Time until maximum value of arterial lactate; pH: ABG pH at admission.

Our findings indicated that arterial lactate levels exhibited an uptrend post-hepatectomy, with a significant correlation between the ABL values and the volume of fluid intake. The surge in lactate levels could be attributed to tissue hypoperfusion, diminished activity of the pyruvate dehydrogenase enzyme, and reduced lactate clearance owing to hepatic dysfunction.[9] Although there are no direct studies in the existing literature drawing a correlation between increased lactate levels post-hepatectomy and fluid therapy, we propose that this correlation may indicate a sepsis-like metabolic state following hepatectomy. Tissue hypoperfusion can potentially occur during hepatectomy, contributing to lactate elevation, similar to sepsis.[10,11] Increased levels of proinflammatory cytokines have been noted post-hepatectomy, akin to sepsis.[12-14] Another commonality between hepatectomy and sepsis is the perception of low lactate clearance as an unfavorable prognostic marker.[10-15] Thus, we surmise that patients with elevated lactate levels post-hepatectomy are possibly in a sepsis-like state, necessitating higher volumes of fluid therapy.

Remarkably, we observed that the elevation in lactate levels persisted for an additional 7.4 hours in patients, and a return to normal levels was evident after approximately 11 hours. These insights underscore the necessity for vigilant monitoring of patients post-hepatectomy as the metabolic stress process persists in the postoperative period. Timely detection and management of potential complications are thereby crucial.

Our study stands as one of the pioneering pieces of research elucidating the relationship between fluid therapy and arterial lactate levels following liver surgery. Moreover, it demonstrates the trend of ABL levels post-hepatectomy. However, certain limitations warrant mention. Primarily, the retrospective nature of the study and the reliance on data from medical records can potentially influence the outcomes. Additionally, the absence of data on intraoperative variables and the long-term follow-up of patients in a surgical ward, as opposed to an intensive care unit, constitute other notable limitations.

Conclusion

This research investigated the trend of ABL levels in patients following hepatectomy and their relationship with administered fluid therapy. The findings indicate a significant correlation between ABL levels and the volume of fluid administered to patients. Our study reveals that elevated lactate levels may indicate a sepsis-like metabolic state arising post-hepatectomy and an associated increase in the need for fluid therapy. These results emphasize that close monitoring of ABL levels after hepatectomy can be a critical indicator for effectively determining patients' fluid therapy requirements and monitoring duration. Therefore, regular tracking of arterial blood lactate levels can be important in managing and monitoring patients in the postoperative period.

Ethics Committee Approval

This study approved by the Çam ve Sakura City Hospital's Ethics Committee (Date: 14.12.2022, Decision No: 2022.12.389).

Informed Consent

Retrospective study.

Peer-review

Externally peer-reviewed.

Authorship Contributions

Concept: M.Ç.; Design: M.Ç.; Supervision: M.Ç.; Fundings: M.Ç.; Materials: İ.O.; Data: İ.O.; Analysis: M.Ç.; Literature search: İ.O.; Writing: M.Ç.; Critical revision: M.Ç.

Conflict of Interest

None declared.

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Hepatektomi Sonrası Laktat Seviyesi ile Sıvı Yönetimi Arasındaki İlişki

Amaç: Hepatektomi gibi cerrahi işlemlerin ardından başarılı sonuçlar elde edebilmek için çeşitli fizyolojik ölçümlerin dikkatlice izlenmesi gerekmektedir. Bu ölçümler arasında, doku perfüzyonu ve oksijenasyonunun önemli bir göstergesi olan laktat seviyeleri de yer almaktadır. Özellikle postoperatif dönemde, arteriyel kan laktat (ABL) düzeyleri, doku perfüzyonunun izlenmesi açısından öenmli bir yere sahiptir. Optimal bir sıvı dengesinin korunması ise, doku perfüzyonunun sürdürülmesi ve potansiyel komplikasyonların önlenmesi için kritik öneme sahiptir. Bu çalışmanın amacı, postoperatif dönemde hastaların ABL düzeyleri ile sıvı tedavisi arasındaki ilişkiyi incelemektir.

Gereç ve Yöntem: Bu çalışma, hepatektomi sonrası yoğun bakım ünitesinde tedavi gören hastaların sonuçlarını incelemek için retrospektif bir çalışma olarak tasarlandı. Sıvı tedavisinin hastaların klinik sonuçları üzerindeki etkisini değerlendirmek için hastaların aldığı sıvı miktarları hesaplandı. Başlangıç arteriyel kan laktat seviyeleri, en yüksek laktat seviyeleri, laktatın vücuttan atılma hızı, asidoz durumu ve arteriyel kan gazı analizlerindeki baz açığı değerleri kaydedildi. Arteriyel kan gazı parametreleri, ABL trend parametreleri ve sıvı tedavisi arasındaki ilişkiyi belirlemek için Pearson Korelasyon Testi kullanıldı ve $p<0.05$ anlamlı olarak olarak kabul edildi.

Bulgular: Bu çalışmada, hepatektomi operasyonu geçirmiş toplam 108 hasta incelenmiştir. Hastaların ABL seviyelerini normal aralığa düşene kadar ortalama olarak 42.3cc/kg sıvı verilmiştir. Ayrıca, izlem süresince gözlemlenen en yüksek ABL değerleri ile verilen toplam sıvı miktarı arasında anlamlı bir korelasyon saptanmıştır (r: 0.385, $p<0.01$).

Sonuç: Çalışmada, ABL düzeyleri ve sıvı alımı arasında bir ilişki olduğunu tespit edilmiştir. Yüksek laktat seviyelerinin, sepsis benzeri bir durumu ve yoğun sıvı tedavisi gerektiren bir metabolik durumu işaret ettiği düşünülmektedir. Bu sonuçlar, hepatektomi geçiren hastalarda ABL seviyelerinin takibinin, sıvı tedavisi ihtiyacını ve hastanın yakın izlem süresini tahmin etmede kullanılabilecek önemli bir araç olduğuna işaret etmektedir. Arteriyel kan laktat takibi, hastaların postoperatif dönemdeki yönetimi ve takibinde kritik bir rol oynayabilir.

Anahtar Sözcükler: Hepatektomi; laktat; postoperatif yönetim; sıvı tedavisi.