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Invasive hemodynamic monitoring for fluid management in septic shock patients

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ABSTRACT

Aim: Sepsis is still one of the most common causes of death, despite advances in treatment and technologies. Invasive monitoring in sepsis can improve survival. In this study, we aimed to compare the efficacy of hemodynamic monitoring in the fluid treatment of patients with septic shock.

Material and Method: Forty septic shock patients were divided into two groups. Group I (n=20) was monitored with central venous pressure, and Group II (n=20) with a cardiac output device (EV1000). Arterial blood gases were analyzed four times daily for the groups, and lactate values, diuresis status, need for dialysis, and inotrope need was recorded. For Group I, the central venous pressure and mean arterial pressure values were recorded for group II, cardiac output, cardiac index, stroke volume, stroke volume index, and mean arterial pressure values.

Results: There was a significant difference between the mean arterial pressures of the groups on the 1st and 2nd days (p=0.034 and p=0.026, respectively). In Group II, mean arterial pressures were higher on days 1 and 2. There was no significant difference between the other data recorded.

Conclusion: We observed no significant difference between central venous pressure monitoring and invasive monitoring in septic shock patient follow-up.

Keywords: Stroke volume index, stroke volume, cardiac index, cardiac output, fluid therapy, septic shock

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INTRODUCTION

Sepsis is a dysregulated host immune response to infection leading to organ failure. Septic shock is a state of sepsis-induced hypotension that persists despite adequate fluid resuscitation. Sepsis and septic shock is a significant health problem that is increasing in frequency worldwide, affecting millions of people and causing the death of one in four errors. Rapid treatment in the first hours is essential in sepsis, as in multiple trauma, myocardial infarction, or stroke (1-4). Shock is organ damage caused by the inability of blood to reach organs due to impaired tissue perfusion. If not diagnosed early and shock management is not done immediately, organ damage can be irreversible. The leading cause of shock is insufficient cardiac output and, consequently, the inability of blood to reach the organ (5).

A relative or complete fluid deficit often accompanies septic shock. Fluid deficiency may be due to vomiting, sweating or peritonitis, vasodilation, and peripheral ponding. Low filling pressures and cardiac output characterize the early stages of experimental and clinical septic shock. The hyperdynamic picture becomes evident only after fluid replacement. Therefore, it should be aimed to increase the cardiac output by increasing the blood and plasma volume at the first stage of septic shock treatment. Despite myocardial depression due to sepsis, fluid resuscitation can increase cardiac output by 25-40% (6).

Supportive therapy in sepsis and septic shock is among the indisputables of treatment like antibiotherapy. The most crucial point is to perform adequate fluid resuscitation under appropriate monitoring and correct hypovolemia (7). A clinically accurate evaluation of the circulatory situation in the intensive care unit is essential. Continuous cardiac output monitoring provides valuable information about the follow-up of the rapid changes in the patient's hemodynamic status and the treatment to be selected in accordance with these rapid changes. In this study, we aimed to compare the efficacy of hemodynamic monitoring of cardiac output, cardiac index, stroke volume, and stroke volume index in fluid management of patients with septic shock.

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MATERIAL AND METHOD

Ethics committee approval was received for the study from Kocaeli University Clinical Research Ethics Committee (KOÜ KAEK 2015/251). Forty patients diagnosed with sepsis/septic shock according to the criteria determined by the American Society of Chest Physicians and Intensive Care (ACCP/) SCCM (8) were included in the study in Kocaeli Health Sciences University Derince Training and Research Hospital Intensive Care Unit. Verbal and written consent was obtained from the relatives of the patients.

The inclusion criteria of the patients were defined as being older than 18 years of age being admitted to the intensive care unit and being diagnosed with severe sepsis/septic shock during the intensive care follow-up, and being treated in the intensive care unit for at least 72 hours. Patients with burns, kidney failure, heart disease and failure, and those with a history of malignity were excluded from the study.

Forty patients hospitalized with the diagnosis of septic shock or diagnosed with septic shock after admission were randomly divided into two groups. Patients with right vena jugular interna or right subclavian vein central venous catheter and right radial artery cannula were named Group I, and patients with jugular central vein catheter and suitable femoral catheter were called Group II. For adequate fluid resuscitation: Mean arterial pressure (MAP) ≥ 65 mmHg, urine output > 0.5 ml/kg/hr, central venous pressure (CVB) 8-12 mmHg, and central venous (superior vena cava) or mixed venous oxygen Saturation > 65%-70% were set as target and treated. When the target was not achieved, supportive treatment was started. For supportive therapy, noradrenaline was the first choice, and when insufficient, dopamine was the second agent.

Mean arterial pressure and central venous pressure were recorded in group I. Cardiac output (CO), cardiac index (CI), stroke volume (SV), stroke volume index (SVI), and mean arterial pressure (MAP) measurements with FloTrac_EV1000 (Edwards Lifesciences, Irvine, CA) device, group II' was also recorded. . Arterial blood gas (ABG) was analyzed four times a day from both patient groups. Lactate values, diuresis status, dialysis need, and inotrope need were recorded. According to the "Surviving Sepsis Campaign 2012" guideline for both patient groups, it was aimed to have CVP values between 8-12 mmHg, urine output ≥ 0.5 mL/kg/h, and mean arterial pressure 65 mmHg and above. Considering the recorded values, fluid replacement, vasopressor, or inotropic agent (noradrenaline or dopamine) support was provided.

Statistical Analysis

Statistical evaluation was done with IBM SPSS 20.0 (SPSS Inc., Chicago, IL, USA) package program. The standard distribution test was evaluated with the Kolmogorov-Smirnov Test. Customarily distributed numerical variables were given as mean +/- standard deviation, non-normally distributed numerical variables were presented as median (25th percentile-75th percentile), and categorical variables were shown as frequency (percentage). Differences between groups were determined by the Student-t test for normally distributed numerical variables and the Mann-Whitney U test for non-normally distributed numerical variables. Chi-square analysis was used to determine the relationships between categorical variables. $p<0.05$ was considered sufficient for statistical significance.

RESULTS

When the patients' demographic data were compared, 55% (n=22) of all patients were male, and 45% (n=18) were female. The mean age was 70.60±14.10 years for Group I (n=20) and 68.35±15.87 years for Group II (n=20). There was no statistically significant difference between the groups regarding age and gender (p=0.638, p=1.000).

Simultaneous arterial blood gas (ABG) samples were taken from both patient groups four times a day (6th, 12th, 18th and 24th hours), and lactate values were recorded each day separately. When the lactate values of the groups recorded for three days were compared separately for each day and each hour, no statistically significant difference was observed (p> 0.05, **Table 1**).

Table 1: Lactate values of the groups

	Group I (Mean±SD)	Group II (Mean±SD)	p
Lactate 1.day			
6.h	2.297±1.269	4.462±4.499	0.149
12.h	3.042±1.322	4.917±4.645	0.620
18.h	3.703±1.573	5.038±4.616	0.925
24.h	4.042±1.532	5.141±4.868	0.678
Lactate 2.day			
6.h	4.538±1.644	5.478±5.021	0.565
12.h	5.061±1.748	5.668±5.197	0.625
18.h	5.550±1.697	6.044±5.206	0.690
24.h	6.060±1.945	6.351±5.160	0.815
Lactate 3.day			
6.h	6.210±2.307	6.411±5.181	0.875
12.h	6.910±2.473	7.068±5.320	0.355
18.h	8.042±3.031	7.618±5.217	0.755
24.h	9.342±3.716	8.264±5.446	0.469

In our study, mean arterial pressure (MAP) measurements; On the first day, Group I was 68,050±14.655 mmHg; Group II was 77,250±11,638 mmHg; On the second day, Group I was 67,800±14.670 mmHg, Group II was 79.351±16.727 mmHg. A statistically significant difference was found between the two groups on days 1 and 2 (p=0.034 and p=0.026, respectively). In Group II, mean arterial pressure (MAP) was significantly higher on the 1st and 2nd days. Day 3 measurements were 70.500±19.107 mmHg and 72.850±19.268 mmHg, respectively, and no statistically significant difference was observed (**Table 2**).

Table 2: Mean Arterial Pressures (MAP) of the Groups

	Group I (Mean±SD)	Group II (Mean±SD)	p
MAP			
1.day	68.050±14.655	77.250±11.638	0.034
2.day	67.800±14.670	79.351±16.727	0.026
3.day	70.500±19.107	72.850±19.268	0.253

MAP: Mean Arterial Pressure

There was no significant difference between the 1st, 2nd, and 3rd days between the groups in terms of the need for supportive treatment. Despite fluid and supportive therapy, it was noted that there was no diuresis if the urinary output was <0.5 ml/kg/hour, and if the urine output was >0.5 ml/kg/hour, there was diuresis. When the diuresis and dialysis needs of the patients were compared, no statistically significant difference was found (**Table 3**).

Table 3: Supportive treatment needs and diuresis and dialysis conditions of the groups			
	Group I n(%)	Group II n(%)	p
Supportive treatment			
1.day			
No supportive treatment	1 (5%)	4 (20%)	0.307
Noradrenaline	16 (80%)	12 (60%)	
Noradrenaline + Dopamine	3 (15%)	4 (20%)	
2.day			
No supportive treatment	0	2 (10%)	0.580
Noradrenaline	17 (85%)	15 (75%)	
Noradrenaline + Dopamine	3 (15%)	3 (15%)	
3.day			
No supportive treatment	3 (15%)	4 (20%)	0.381
Noradrenaline	3 (15%)	3 (15%)	
Noradrenaline + Dopamine	3 (15%)	4(20%)	
Diuresis and Dialysis			
1.day			
Diuresis (-)	8 (40%)	7 (35%)	1.00
Diuresis (+)	12 (60%)	13 (65%)	
Dialysis	8 (%40)	7 (35%)	1.00
2.day			
Diuresis (-)	9 (45%)	7 (35%)	0.744
Diuresis (+)	11 (55%)	13 (65%)	
Dialysis	9 (45%)	8 (40%)	1.00
3.day			
Diuresis (-)	9 (45%)	7 (35%)	0.744
Diuresis (+)	11 (55%)	13 (65%)	
Dialysis	10 (50%)	7 (35%)	0.522

Cardiac output (CO), cardiac index, stroke recorded for 3 days for Group II. Volume and stroke volume index values are given in Table 4.

Table 4: CO, CI, SV and SVI Values				
	CO	CI	SV	SVI
Day	6.187±2.511	3.378±1.201	54.337±22.089	50.075±17.276
Day	5.878±2.356	3.351±1.403	55.500±22.071	50.462±18.281
Day	5.710±2.096	3.197±1.191	56.162±22.341	51.912±19.064
CO: cardiac output, CI: cardiac index, LV: stroke volume, SVI: stroke volume index				

DISCUSSION

The main principle in treating sepsis and septic shock is to recognize the clinical picture as early as possible and to initiate measures and supportive treatment as soon as possible. Since the development of shock in sepsis is a factor that increases mortality, it should be prevented as early as possible (9).

Supportive therapy in sepsis and septic shock is among the indisputables of treatment like antibiotherapy. The most crucial point is to perform adequate fluid resuscitation under appropriate monitoring and correct hypovolemia (7,10-12).

Blood lactate level measurement can be used in the follow-up of sepsis treatment and estimation of mortality. The increase in lactate levels is accepted as an indicator of organ perfusion disorder (13). Our study found no significant difference between the groups regarding lactate levels. Animal experiments showed that a decrease in mean arterial blood pressure below 60 mmHg disrupts the autoregulation of organs (14). The minimum mean arterial blood pressure recommended in the guidelines is 65 mmHg. Studies by LeDoux et al. have shown that maintaining mean arterial blood pressure at 65, 75, and 85 mmHg in septic shock patients does not make any difference in terms of systemic oxygen metabolism, skin microcirculation flow, and splanchnic perfusion (15). However, it should be considered that optimum blood pressure may vary from patient to patient, and the blood pressure target should be interpreted together with other parameters. In our study, no statistically significant difference was found when the mean arterial pressures were compared between the two groups.

The main goal in treating sepsis is to restore the blood volume to ensure adequate tissue perfusion and oxygen demand of the tissues (7). In the treatment of septic shock, if the mean arterial pressure cannot be increased to sufficient levels (>65 mmHg) despite adequate fluid administration, vasopressor therapy is recommended (16). Requires vasopressor therapy during the treatment of the patients, we evaluated for the presence of septic shock; There was no significant difference between the groups in terms of daily average vasopressor requirement and 2-vasopressor requirement. It is common knowledge that optimizing intravascular volume and systemic hemodynamic parameters prevents the occurrence of ARF. However, it is not clear what the optimal hemodynamic parameters mean. In a multicenter randomized study, using volume expansion and vasopressors, achieving supranormal cardiac index and normal mixed venous oxygen saturation, mortality, and frequency and severity of ARF. It has been shown that it has no effect (17). In our study, when both groups were compared in terms of the diuresis-giving need for replacement, there was no statistically significant difference not found. To maintain adequate perfusion of vital organs in critically ill patients, simultaneous and effective monitoring of the variability of hemodynamic parameters is aimed at managing fluid therapy and vasoactive drugs. Hemodynamic monitoring (HDM) can even indicate its own admission to the intensive care unit. It is often used more than once to determine the hemodynamic variability of the patients. The method is used and evaluated together. The results obtained provide information about the severity and prognosis of the disease and are also helpful in understanding which type of shock is present at the diagnosis stage and in observing the response to the treatment applied (9). We attributed the lack of difference in the parameters evaluated between the two groups in our study to the low number of patients. In our study, no significant difference was found between the two methods used for targeted fluid therapy.

CONCLUSION

Central venous catheterization and invasive arterial pressure monitoring have become routine procedures in the follow-up of patients with sepsis and septic shock. The patients' existing artery cannulation and central venous catheterization are used for hemodynamic monitoring methods such as cardiac output, cardiac index, stroke volume, and stroke volume index. No extra invasive procedure is performed; therefore, no additional complications develop in patients. Thus, the application can be made quickly and safely. In conclusion, we think that this method will become a frequently used monitoring method in the follow-up and treatment of fluid management in patients with a diagnosis of sepsis and septic shock, with clinical studies to be conducted with larger patient. groups.

ETHICAL DECLARATIONS

Ethics Committee Approval: Approval for our study was obtained from Kocaeli University Clinical Research Ethics Committee with the protocol number KOÜ KAEK 2015/251.

Informed Consent: All patients signed the free and informed consent form.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

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Author Contributions: All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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