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The Association between Daily Fluid Balance and Mean Perfusion Pressure as a Critical Sign in the Intensive Care Unit of Adam Malik Central Hospital, Medan

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Abstract

BACKGROUND: The patient mortality rate in intensive care unit (ICU) is still high. However, we still lack measures to reduce this high mortality rate. Fluid balance is known as a marker for mortality in ICU. If the balance of fluid becomes more positive, the mortality rate consequently becomes higher. Positive fluid balance elevates central venous pressure (CVP), while this elevation increases the risk of renal failure and mortality. Mean perfusion pressure (MPP) is the difference between mean arterial pressure and CVP.

AIM: We propose that the MPP value can be used as an alternative indicator to monitor excessive fluid balance since its measurement is faster and more accurate than the manual 24 h record of fluid balance.

PATIENTS AND METHODS: It is expected that we can prevent excessive fluid accumulation and the subsequent mortality risk by monitoring MPP in the ICU. To investigate the association between MPP and daily fluid balance in the ICU, a prospective study was conducted from March 2016 to August 2018 in the ICU of Adam Malik Hospital, Medan. During the study period, 76 patients were admitted. Sixty-point 5% were male, with the mean age of 48.3 ± 16.5 years old.

RESULTS: The overall mortality of 76 patients was 10.5%, and there was a significant negative correlation found between MPP and fluid balance ($r = -0.204$; $p = 0.048$), where a lower MPP value was associated with a more positive fluid balance.

CONCLUSIONS: We conclude that there is a negative correlation between MPP and fluid balance, where a more positive fluid balance is associated with a lower MPP value. The positive fluid balance had been previously associated with increased mortality risk in the ICU.

Background

In patients with a critical condition, fluid balance is one of the important factors to be maintained [1], [2]. Daily fluid balance is the difference between all intakes and outputs [3], [4]. Fluid balance is a part of the process of care [3], [4], [5]. Proper management of fluid balance can treat hypotension, sepsis, heart failure, and acute kidney injury (AKI) [2], [3].

However, cumulative fluid accumulation is recognized as a potential threat that can increase morbidity and mortality [3], [6], [7]. Positive fluid balance elevates central venous pressure (CVP) and increases mortality in septic patients [6]. It also has negative impacts in critically ill patients with acute renal injury, for the positive fluid balance is known to impede renal recovery [8].

It is widely known that CVP is a traditional indicator frequently monitored in the intensive care unit (ICU). The research found that the higher value of CVP is associated with worse outcomes [9]. Meanwhile, in patients who underwent cardiac surgery, it is understood that CVP may be useful for determining mortality and risk for renal failure [10]. Central venous uptake is also often associated with renal impairment and death [11].

Meanwhile, mean perfusion pressure (MPP) is the difference between mean arterial pressure (MAP) and CVP [12]. The difference between these pressures is related to the patient's mortality rate in the ICU. Furthermore, patients with low MPP are found to have high rates of renal failure [13].

To prevent AKI and reduce mortality in treating patients with fluid therapy, it is understood that we need to maintain adequacy and to avoid excessively positive balance. We propose that the MPP value can be used as an alternative indicator to monitor excessive fluid balance since its measurement is faster and more accurate than the manual 24 h record of fluid balance. It is expected that we can prevent excessive fluid accumulation and the subsequent mortality risk by monitoring MPP. This study aims to investigate the

association between MPP, daily fluid balance, and mortality in the ICU.

Methods

This cohort study was conducted from March 2016 to August 2018 in the ICU of Adam Malik Hospital, Medan. The sampling method was consecutive sampling. Patients with age over 18 years admitted to our ICU during the study period were included in the study. Informed consent was given to confirm the willingness to participate. Patients who refuse to be involved in the study were excluded from the study.

The demographic data, MAP, CVP, MPP, and cumulative fluid balance were analyzed to investigate the association between MPP and daily fluid balance, and mortality in the ICU. MPP was measured by calculating the difference between MAP and CVP. MAP was observed using the ICU monitor, while CVP was measured manually through a central venous catheter.

Data were analyzed using SPSS version 26.0. The quantitative variable was expressed as means and standard deviations. The categorical variables were described by their absolute (n) and relative (%) frequencies. Pearson's correlation test was used to analyze for an association between daily fluid balance and MPP. $p < 0.05$ was considered statistically significant. This study was approved by the Ethics Committee of Faculty of Medicine, Universitas Sumatera Utara.

Results

During the study period, 76 patients were admitted. About 60.5% were male, and 39.5% were female. The mean age of patients admitted was 48.3 ± 16.5 years old. Eight patients died during the study with the overall mortality of 10.5%, predominantly male (Table 1).

Table 1: Patients characteristics

Variables	n (%) / Mean (SD)
Mean age (SD), years	48.3 (16.5)
Gender, n (%)	
Male	45(60.5)
Female	31 (39.5)
Mean MPP (SD), mmHg	86.9 (18.04)
Mean cumulative fluid balance (SD), cc	−10.2 (829.5)
Mortality, n (%)	
Yes	8 (10.5)
No	68 (89.5)

There was a significant negative correlation found between MPP and fluid balance ($r = −0.204$; $p = 0.048$), where a lower MPP value was associated with a more positive fluid balance (Table 2).

Table 2: Association between MPP and cumulative fluid balance

MPP	MPP	Balance
Pearson correlation (r)	1	−0.204
Sig. (two tailed)		0.048
n	76	76
Balance		
Pearson correlation (r)	−0.204	1
Sig. (two tailed)	0.048	
n	76	76

Discussion

This study found that there is a significant negative correlation between MPP and fluid balance. This finding will be useful in monitoring the ICU patients since MPP measurement is faster and more reliable than the manual record of fluid balance, which is very prone to mistakes. Our study found that a lower MPP was associated with a more positive fluid balance, which is in line with research by Patel *et al.* [12].

The higher fluid balance associated with an increase in mortality and possibly reduced renal recovery [5], [14], [15], [16]. Eight patients died during the study period which represented 10.5% of the study population, while other studies showed varied results, ranging from 15% to 58% [5], [12], [13], [14], [15], [16], [17]. Most of them had low MPP and positive fluid balance (Table 3). The mean age of patients was 43 years old. The value was different from other studies, which mostly above 60 years old [5], [12], [13], [14], [15], [16], [17]. The gender mostly admitted to ICU was male for 60.5%. Bouchard *et al.*, Patel *et al.,* and Ostermann *et al.* also had relatively the same percentage of male dominance.

Table 3: Non-survivor characteristics

Dead	MPP	Balance	Age	Sex
1	54.80	1334.00	73	Male
2	47.60	423.00	55	Male
3	52.40	646.00	22	Male
4	41.90	1391.00	27	Male
5	54.80	206.40	65	Male
6	73.00	419.00	21	Male
7	54.90	-2376.00	69	Male
8	39.10	300.00	80	Female

Increasing CVP had a more significant impact on AKI progression than MAP [12], [13], [17]. AKI was one of the main problems in ICU, and the mortality rate was high. Because of the high mortality, early detection and prevention were needed [8], [18]. Fluid balance was one of the important markers for AKI beside creatinine serum. MPP is also a potential marker for AKI [17]. By measuring CVP and MAP, we can calculate MPP (CVP-MAP). CVP represents congestion in vena, and MAP represents renal perfusion. Using these variables, we can predict AKI occurrence [13]. It is expected that we can prevent excessive fluid accumulation and the subsequent mortality risk by monitoring MPP, which will enable a prompt intervention for patients at risk in the ICU.

There were some limitations in our study. We had a relatively small sample size, and the research was conducted in a single center, which may have led to bias due to specific environmental characteristics in the population.

Conclusions

In this study, we conclude that there is a negative correlation between MPP and fluid balance, where a more positive fluid balance is associated with a lower MPP value. The positive fluid balance had been previously associated with increased mortality risk in the ICU.

Declarations

This study was approved by the Ethics Committee of the Faculty of Medicine, Universitas Sumatera Utara. Informed consent for participation was obtained before the research was conducted.

Authors' Contributions

BL, PA, and MA wrote the manuscript and designed the experiments. BL and PA performed the experiments. BL and MA performed the data analysis. BL and PA performed the statistical testing. All authors read and approved the final manuscript.

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Availability of Data and Materials

All data analyzed for this paper are available from the corresponding authors on reasonable request.

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