ORIGINAL ARTICLE

Bali Journal of Anesthesiology (*BJOA*) 2019, Volume 3, Number 1: 19-22
E-ISSN: 2549-2276

Published by DiscoverSys

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The ultrasonic cardiac output monitor (USCOM) as a tool in evaluating fluid responsiveness in pediatric patients underwent emergency surgery

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ABSTRACT

Background: Assessment fluid adequacy in pediatric patients underwent surgery is a challenge for anesthesiologists. Hemodynamic parameters used as fluid monitoring sometimes don't accurately provide valid information. Ultrasonic Cardiac Output Monitor (USCOM) is one of the non-invasive methods that are easy to operate and may provide various hemodynamic parameters monitoring information.

Objective: Analyze the effectiveness of Stroke Volume Variation (SVV) and Stroke Volume Index (SVI) by using USCOM in assessing fluid responsiveness in preoperative pediatric patients who underwent emergency surgeries.

Method: This study was conducted on 16 pediatric patients underwent emergency surgeries. Before general anesthesia is given, blood pressure, mean arterial pressure, heart rate, cardiac index, SVV, SVI were recorded before and after administration of 10 mL/kg of fluid given within 20 minutes.

Results: 10 subjects responded with SVV and SVI changes of more than 10% compared to 6 non-responders. SVV changes between responders and non-responders were 31.5±1.58 and 7.5±1.04, respectively. SVV percentage changes between responders and non-responders were 38.04±0.47 and 5.24±4.89, respectively.

Conclusion: SVV and SVI recorded by USCOM showed significant fluid responsiveness changes in pediatric patients underwent emergency surgeries in 62.5% of the subjects.

Keywords: *fluid responsiveness, stroke volume variation, stroke volume index, USCOM*

Cite This Article: Kurniyanta, P., Utariani, A., Hanindito, E., Ryalino, C. 2019. The ultrasonic cardiac output monitor (USCOM) as a tool in evaluating fluid responsiveness in pediatric patients underwent emergency surgery. *Bali Journal of Anesthesiology* 3(1): 19-22. DOI:10.15562/bjoa.v3i1.111

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INTRODUCTION

Perioperative fluid management in pediatric patients is essential in preventing perioperative complication. Assessment of fluid adequacy in pediatric patients who undergo surgery is a challenge for anesthesiologists. Early fluids administration during the resuscitation phase increase recovery time, but excessive administration worsens the condition.[1] Previous studies in esophageal and transthoracic Doppler on variations respiration of aortic blood flow in critically ill patients found that only 40-69% responded to administration of fluids.[1,2]

Some hemodynamic parameters regularly used as fluid monitoring are blood pressure, heart rate, urine output, central venous pressure (CVP), and pulmonary artery occlusion pressure (PAOP), but they sometimes cannot accurately provide valid information.[1,3,4] Invasive monitoring such as a central venous catheter (CVC) and pulmonary artery catheter (PAC) are also associated with their own complications, hence it is less frequently used nowadays.[5,6]

Lee[6] reported that CVC provides no validity to assess fluid responsiveness in pediatric patients in cardiothoracic surgery measured non-invasive cardiac output monitoring (NICOM) compared to SVV and the velocity of aortic blood flow (V_{peak}). Conversely, dynamic hemodynamic parameters such as SVV and SVI have significance validity related to fluid adequacy in patients underwent cerebrovascular surgery.[7-11]

Non-invasive dynamic monitoring, such as echocardiography and Doppler, has become an alternative method to assess preload, contractility, and afterload. In the preoperative period, fluid adequacy is an absolute concern because pediatric patients are susceptible to both fluid depletion and excessive fluid administration, hence its monitoring has to be employed at least by various parameters.[10,12-14] This case series has been conducted to analyze the effectiveness of USCOM in assessing the fluid responsiveness of preoperative pediatric patients who underwent emergency surgery.

PATIENTS AND METHOD

This is a descriptive observational case series in pediatric patients underwent emergency surgeries in Sanglah General Hospital during June and July of 2018. The subjects of this study were selected by using a consecutive sampling method. The study was approved by the Committee of Ethical Research of Udayana University/Sanglah General Hospital. The parents or legal guardian of the subjects have provided written informed consents to be included in this study.

Inclusion criteria include pediatric patients aged 5-15 years old underwent emergency surgeries in dehydration state and ongoing hemorrhage. Hemodynamic parameters recorded were blood pressure (BP), mean arterial pressure (MAP), heart rate (HR), cardiac index (CI), stroke volume variation (SVV), and stroke volume index (SVI) by USCOM. They were recorded twice: before and after the administration of 10 mL/kg fluid loaded within 20 minutes.

Data were collected and analyzed using SPSS 16.0 software. Descriptive analysis was used to obtain the characteristics of subjects. Paired t-test and Mann-Whitney test were used in the computation. A p-value of <0.05 is considered statistically significant.

RESULTS

A total of 16 subjects were enrolled in this study. The subjects consisted of 9 males and 7 females with a mean age of 10.56±3.48. The characteristic of the subjects involved in this study is showed in table 1.

Table 2 shows the mean SVV, SVI, CI, and CO in all subjects divided into two major groups: the fluid responders and the fluid non-responders. In fluid responders, the mean SVV, SVI, CI, and CO in before vs. after the 10 mL/kg of fluid administration were 48.5±6.55 vs. 17.00±5.81, 31.7±9.35 vs. 39.20±7.11, 3.27±0.93 vs. 4.30±1.05, and 3.26±0.75 vs. 4.03±0.87, respectively. While in fluid non-responders, the respective figures of before vs. after fluid administration were 30.83±0.1 vs. 23.33±10.2, 38.33 ± 6.79 vs. 38.33±6.27, 3.55± 0.42 vs. 3.73±0.45, and 4.11±0.55 vs. 4.31±0.60.

The mean differences in hemodynamic parameter changes are showed in Table 3. The percentage changes of SVV, SVI, CI, and CO between fluid responders and non-responders were 31.5±1.58 vs. 7.5±1.04 (p <0.001), 29.07±0.29 vs. 4.36±2.27 (p=0.011), 38.04±0.47 vs. 5.24±4.89 (p=0.005), and 25.22±0.21 vs. 4.81±2.07 (p=0.014), respectively. Based on this data, there was a significant difference in every each hemodynamic parameter changes between the fluid responders and fluid non-responders.

DISCUSSION

This study showed significant changes in SVV and SVI parameters after crystalloid loading administration. This is in line with previous studies that found SVV and SVI were dynamic hemodynamic parameters with sensitive values in assessing fluid responsiveness in pediatric patients who received fluid loading administration.[15-18] Other studies

Table 1 Characteristics of the subjects involved in this study

Variables	N = 16
Sex	
-Male, n(%)	9 (56)
-Female, n(%)	7 (44)
Age (years), mean±SD	10.56±3.48
Body weight (kg), mean±SD	30.59±12.88
Body height (cm), mean±SD	136.18±19.29
Diagnosis upon admission, n(%)	
Retropharyngeal abscess + sepsis	1 (6.25)
Acute appendicitis + moderate dehydration	5 (31.25)
Severe TBI + hypovolemic Shock	1 (6.25)
Perforation of appendix + dehydration	5 (31.25)
The dead limb of upper left extremity region	1 (6.25)
Depressive fracture of the right parietal	1 (6.25)
Wound dehiscence, post-laparotomy due to abdominal blunt trauma + sepsis	1 (6.25)
Submandibular abscess + sepsis	1 (6.25)
Response to fluid administration of 10 mL/kg	
Responded, n(%)	10 (62.5)
Not responded, n(%)	6 (37.5)

SD: standard deviation; TBI: traumatic brain injury

Table 2 Mean ± SD comparisons between parameters observed in fluid responders and fluid non-responders

Parameter	Fluid responders (N=10)		Fluid non-responders (N=6)	
	Preloading	Post loading	Preloading	Post loading
SVV (mL)	48.5±6.55	17.00±5.81	30.83±0.1	23.33±10.2
SVI (mL/m^2)	31.7±9.35	39.20±7.11	38.33 ± 6.79	38.33±6.27
CI (L/min/m^2)	3.27±0.93	4.30±1.05	3.55 ± 0.42	3.73±0.45
CO (L/min)	3.26±0.75	4.03±0.87	4.11 ± 0.55	4.31±0.60

SD: standard deviation; SVV: stroke volume variations; SVI: stroke volume index; CI: cardiac index; CO: cardiac output

Table 3 Percentage of SVV, SVI, CI, and CO changes in fluid responder and non-responders (mean±SD)

Parameters observed	Fluid responders (N=10)	Fluid non-responders (N=6)	p
SVV changes (%)	31.5±1.58	7.5±1.04	<0.001[a]
SVI changes (%)	29.07±0.29	4.36±2.27	0.011[b]
CI changes (%)	38.04±0.47	5.24±4.89	0.005[b]
CO changes (%)	25.22±0.21	4.81±2.07	0.014[a]

SD: standard deviation; SVV: stroke volume variations; SVI: stroke volume index; CI: cardiac index; CO: cardiac output; [a]Paired t-test, [b]Mann-Whitney test

reported that in SVV changes for more than 30% had 72.7% sensitivity and 70% specificity in assessing vascular responsiveness after crystalloid loading.[17,19,20] Some studies showed that SVV can act as a gold standard of vascular responsiveness assessment in pediatric patients.[14,21-26] However, those studies have yet to recommend any diagnostic tools in assessing SVV value due to the heterogeneity of the data study.[25-27]

Fluid responsiveness is a condition where SV is increased by ≥10% and SVV is increased by ≥30%.[16-18] This study concluded there were 10 subjects who classified as fluid responders, and the other 6 subjects did not meet the criteria (fluid non-responder). It has been known that certain diagnosis may lead to intravascular volume depletion caused by various conditions. This study also recorded the subjects' diagnosis who were fluid responders. We found that the fluid responders patients were those with moderate or severe dehydration, and the non-responders were those with mild dehydration.

This result is consistent with our initial prediction that SVV value may act as a dynamic parameter that is more sensitive in assessing the state of the intravascular volume. A previous study in 2014 stated that Bioreactance-derived SVV and SVI were the parameters with strong correlation to intravascular volume state (r = 0.88).[11] Roux *et al.*[15] reported that both SVV and SVI provide 92% sensitivity and 83% specificity in assessing intravascular volume status. Other studies reported that SVV may be used as clinical criteria of pediatric patients suffered from intravascular volume depletion, especially in ongoing shock, dehydration, poor oral intake, diarrhea, and fever with tachycardia.[26-28]

USCOM is a non-invasive diagnostic tool that is easy to operate in assessing hemodynamic. The pitfall in USCOM includes it needs well-collaboration with the patients, which is hard to achieve in the pediatric population. Previous studies showed a significant result but they were mostly conducted in the adult population.

This study enrolled a small number of subjects and yet yielding doubtful results due to the uniqueness of pediatric cardiovascular features in infants and neonates. This study is a preliminary study and still needs a larger sample size in order to provide the results that are significantly valid in assessing fluid adequacy in pediatric patients. Further studies are needed to discover the gold standard assessment method in pediatric patients.

CONCLUSION

SVV and SVI recorded by USCOM showed significant fluid responsiveness changes in pediatric patients underwent emergency surgeries in 62.5% of the subjects.

ACKNOWLEDGMENT

The authors report no conflicts of interests.

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