The Egyptian Journal of Hospital Medicine (July 2018) Vol. 72 (9), Page 5227-5232

Comparative Study between Femoral Arterial Doppler and Echocardiography in fluid responsiveness assessment in Septic Shock Patients

Hany Mohamed Mohamed EL Zahaby, Ahmed Mohamed El Sayed El Henawy, Ahmed Monier Ahmed Youssef, Eslam Kandil Abd El Moaty Ghallab

Department of Anesthesiology, ICU and Pain Management- Ain Shams University

Corresponding author: Eslam Kandil Abd El Moaty Ghallab**, E-Mail:** Es_kg88@yahoo.com, Mobile: 0201007731217

ABSTRACT

Background: Fluid replacement is considered the cornerstone of resuscitation in critically ill patients especially in patients with septic shock. However, only about 50% of critically ill hemodynamically unstable patients are responsive to fluids. Furthermore, both under resuscitation and overzealous fluid administration adversely affect the outcome. Consequently, the resuscitation of critically ill patients requires an accurate assessment of the patients' intravascular volume status and their volume responsiveness.

Aim of the Study: The aim of this study is to compare between the femoral arterial doppler and Echocardiography in fluid responsiveness assessment in septic shock patients.

Methodology: The study was conducted on 30 adult male and female patients admitted to Critical Care Department in Ain shams University Hospitals with the diagnosis septic shock. All patients in this study have the Criteria of Septic shock. Echocardiographic examination and femoral Doppler were done for all included patients. Velocity time integral on left ventricle outflow tract and Velocity time integral on femoral artery were measured before and after fluid resuscitation, after infusion of 30 ml/kg over 3 hours,

Results: These results show that there were 23 patients were responded clinically to fluid resuscitation from all total number of 30 patients. From all total number of patients whom clinically responded, 22 patients responded to fluid resuscitation by transthoracic echocardiography and 23 patients responded by femoral Doppler.

Conclusion: These results showed that femoral Doppler parameters were a reliable predictor to fluid responsiveness in patients with severe sepsis and septic shock as well as transthoracic echocardiography in dynamic monitoring of the change in stroke volume after a maneuver that increases or decreases venous return (preload). However femoral Doppler seems to be easier and rapid tools to be used by junior staff.

Keywords: Femoral Arterial Doppler, Echocardiography, Septic Shock Patients

INTRODUCTION

Fluid replacement is considered the cornerstone of resuscitation in critically ill patients especially in patients with septic shock. However, only about 50% of critically ill hemodynamically unstable patients are responsive to fluids. Furthermore, both under resuscitation and overzealous fluid administration adversely affect the outcome. Consequently, the resuscitation of critically ill patients requires an accurate assessment of the patients' intravascular volume status and their volume responsiveness [(1)].

Traditional methods of determining the adequacy of volume resuscitation have relied on preload measures, there are central venous pressure (CVP), pulmonary artery wedge pressure (PAWP), right ventricular end-diastolic volume index (RVEDVI), left ventricular end-diastolic area index (LVEDVAI), and global end-diastolic volume (GEDV) also known as static parameters of volume status. However, none of these is accurate in predicting preload responsiveness [(2)].

It is important to realize that stroke volume (SV) or cardiac output (CO), or its surrogate, for example, pulse pressure (PP) or arterial blood flow velocity, is the preferred end-point because a preload responsive heart may not be recognized otherwise [(3)].

Dynamic parameters of volume status outperform the static ones in predicting preload responsiveness and should be used to optimize preload in septic shock patients [(4)].

AIM OF THE WORK

The aim of this study is to compare between the femoral arterial doppler and Echocardiography in fluid responsiveness assessment in septic shock patients.

PATIENTS AND METHODS

This study was conducted in the Intensive care unit of Ain Shams University Hospitals at 2017, to compare between femoral arterial Doppler and Echocardiography in fluid responsiveness in septic shock patients.

After the Medical Ethical Committee in Ain Shams University approval and informed consent was taken from thirty patients' relatives (1^{st} degree) were included in the study.

Inclusion criteria: Age: 18 - 60 years. Sex: both sexes. Sepsis as life-threatening organ dysfunction caused by a dysregulated host response

Received:21/6/2018
Accepted:30/6/2018

to infection which is defined as an increase of 2 points or more in the Sequential Organ Failure Assessment (SOFA) Score [(5)]. Evident source of infection. Septic shock which is defined as sepsis but despite adequate volume resuscitation there is persistent hypotension and serum lactate greater or equal to 2 mmol/l and subset of sepsis with circulatory and cellular/metabolic dysfunction associated with a higher risk of mortality.

Exclusion criteria: Lower limb amputations. Cardiac patients. Aortic insufficiency. Chemotherapy or radiotherapy. Cancer disease. Pregnancy and lactation. Patient refusal.

Study Group:

Thirty (30) patients were included in this study. All patients experienced assessment of fluid responsiveness using both Echocardiography and femoral arterial.

Technique:

Patients with septic shock will be subjected in this study to the followings: Detailed history taking including age, sex, date of ICU admission and preexisting underlying disease. Full clinical examination. Severity of illness was be assessed by Sequential Organ Failure Assessment (SOFA) Score. [(5)] Mean arterial pressure (MAP), heart rate (HR), respiratory rate (RR) and temperature. Serum lactate in mmol/l. 6) Left ventricular outflow tract (LVOT) velocity time integral measuring by Echocardiography using (Transducer Probe 2.5 MHz Phased Array) (GE Vivid 3 Machine, made in USA) by placing the pulsed wave Doppler to show five chamber view. Femoral artery Doppler measurements were made by (GE Vivid 3 Machine, made in USA) using (Transducer Probe 2.5 MHz Phased Array).

Measurements:

This study was designed to measure the following parameters after responding to fluid challenge for both groups: Mean arterial pressure (MAP). Heart rate (HR). Respiratory rate (RR). Temperature. Serum lactate in mmol/l.

RESULTS

The current study was carried on 30 adult male and female patients who were admitted to the critical care units in Ain Shams university hospital with criteria of septic shock.

Echocardiographic examination and femoral Doppler was done for all the 30 patients, both before and after fluid administration of 30 ml/kg of NaCl 0.9% over 3 hours.

Analysis of haemodynamic data showed that patients fell into two groups, responders (23 patients) and non-responders (7 patients).

Patients are then considered as two groups, responders and non-responders and data were furtherly analyzed.

Mean arterial pressure in responder patients before fluid administration was in (Mean ±SD) (47±8) and after fluid administration in (Mean ±SD) (77 ±13), with p-value (<0.001) indicating high significant difference in MAP in responder patients before and after fluid administration. Table (1)

On the contrary, Mean arterial pressure in non-responder patients before fluid administration was in (Mean ±SD) (43 ± 8) and after fluid administration in (Mean ±SD) (44 ± 7), with p-value (0.001) indicating no significant difference in MAP in responder patients before and after fluid administration. Table (1)

Table (1): Mean arterial pressure before and after fluid administration of 30 ml/kg of NaCl 0.9% in responder and non-responder patients.

MAP (mmHg)		**Groups**					
		Responder			**Non responder**		
Before	Mean ±SD	47	±	8	43	±	8
After	Mean ±SD	77	±	13	44	±	7
Differences	Mean ±SD	-30	±	15	-0.857	±	1
Paired Test	P-value	<0.001*			0.111		

The heart rate in responder patients before fluid administration was in (Mean ±SD) (133± 8) (bpm) and after fluid administration was in (Mean ±SD) (79± 11) (bpm), with p-value (<0.001) indicating high significant difference in heart rate before and after fluid administration. Table (2)

On other contrary, Heart rate in non-responder patients before fluid administration was in (Mean ±SD) (141± 5) (bpm) and after fluid administration was in (Mean ±SD) (140± 4) (bpm), with p-value (0.001) indicating no significant difference in heart rate before and after fluid administration. Table (2)

Table (2): Heart rate before and after fluid administration of 30 ml/kg of NaCl 0.9% in responder and non-responder patients.

HR (bpm)		Groups					
		Responder			Non responder		
Before	Mean ±SD	133	±	8	141	±	5.
After	Mean ±SD	79	±	11	140	±	4
Differences	Mean ±SD	53	±	14	1.000	±	1.414
Paired Test	P-value	<0.001*			0.111		

The respiratory rate was in responder patients before fluid administration was in (Mean ±SD) (25 ± 2/min) and after fluid administration was in (Mean ±SD) (25± 2/min), with p-value (<0.328) indicating no significant difference in respiratory rate in responding patients before and after fluid administration. Table (3)

In addition, Respiratory rate in non-responder patients before fluid administration was in (Mean ±SD) (25± 2/min) and after fluid administration was in (Mean ±SD) (24±1/min), with p-value (<0.094) indicating no significant difference in respiratory rate in non-responding patients before and after fluid administration. Table (3)

Table (3): Respiratory rate before and after fluid administration of 30 ml/kg of NaCl 0.9% in responder and non-responder patients.

RR/min		Groups					
		Responder			Non responder		
Before	Mean ±SD	25	±	2	25	±	2
After	Mean ±SD	25	±	2	24	±	1
Differences	Mean ±SD	0.043	±	0.209	0.714	±	0.951
Paired Test	P-value	0.328			0.094		

The temperature in responder patients before fluid administration was in (Mean ±SD) (38.822± 0.536oC) and after fluid administration was in (Mean ±SD) (37.252± 0.195 oC), with p-value (<0.001) indicating high significant difference in temperature in responder patients before and after fluid administration. Table (4)

On other contrary, Temperature in non-responder patients before fluid administration was in (Mean ±SD) (39.057± 0.632 oC) and after fluid administration was in (Mean ±SD) (39.014±0.641 oC), with p-value (<0.289) indicating no significant difference in temperature in non-responder patients before and after fluid administration. Table (4)

Table (4): Temperature before and after fluid administration of 30 ml/kg of NaCl 0.9% in responder and non-responder patients.

Temperature oC		Groups					
		Responder			Non responder		
Before	Mean ±SD	38.822	±	0.536	39.057	±	0.632
After	Mean ±SD	37.252	±	0.195	39.014	±	0.641
Differences	Mean ±SD	1.570	±	0.603	0.043	±	0.098
Paired Test	P-value	<0.001*			0.289		

The serum lactate level in responder patients before fluid administration was in (Mean ±SD) (36.6± 17mmol) and after fluid administration was in (Mean ±SD) (21.5± 11.7 mmol), with p-value (<0.001) indicating high significant difference in serum lactate in responder patients before and after fluid administration. Table (5)

However, serum lactate level in non-responder patients before fluid administration was in (Mean ±SD) (36.9± 13.7 mmol) and after fluid administration was in (Mean ±SD) (36.4±13.3 mmol), with p-value (<0.139) indicating no significant difference in serum lactate in non-responder patients before and after fluid administration. Table (5)

Table (5): Serum lactate level before and after fluid administration of 30 ml/kg of NaCl 0.9% in responder and non-responder patients.

Serum Lactate (mmol)		Groups					
		Responder			Non responder		
Before	Mean ±SD	36.6	±	17.	36.9	±	13.7
After	Mean ±SD	21.5	±	11.7	36.4	±	13.3
Differences	Mean ±SD	15	±	8.813	0.486	±	0.754
Paired Test	P-value	<0.001*			0.139		

After monitoring hemodynamics in the thirty patients, the data revel that there were 23 patients (76.67%) responding hemodynamically after fluid resuscitation and just 7 patients (23.33%) weren't responded to fluid resuscitation. Figure (1)

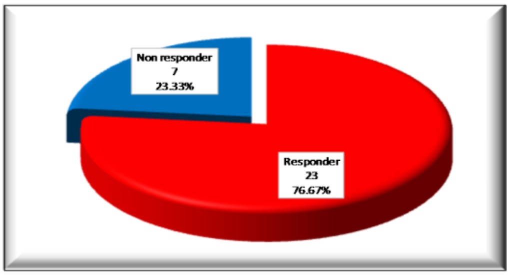

Figure (1): Percentage of patients who respond hemodynamically to fluid resuscitation and patients who didn't respond hemodynamically to fluids.

Velocity time integral – left ventricle outflow tract (VTI-LV) in responder patients before fluid administration was in (Mean ±SD) (12.4± 3.6) and after fluid administration was in (Mean ±SD) (17.8± 3.6), with p-value (<0.001) indicating high significant difference in VTI-LV in responder patients before and after fluid administration. Table (6)

On other contrary, Velocity time integral – left ventricle outflow tract (VTI-LV) in non-responder patients before fluid administration was (Mean ±SD) (13.857± 3.2) and after fluid administration in range (10-21), (Mean ±SD) (14.2±4.1), with p-value (<0.356) indicating no significant difference in VTI-LV in non-responder patients before and after fluid administration. Table (6)

Table (6): Velocity time integral – left ventricle outflow tract (VTI-LV) before and after fluid administration of 30 ml/kg of NaCl 0.9% in responder and non-responder patients.

VTI-LV		**Groups**					
		Responder			**Non responder**		
Before	Mean ±SD	12.4	±	3.6	13.8	±	3.2
After	Mean ±SD	17.8	±	3.6	14.2	±	4.1
Differences	Mean ±SD	-5.4	±	2.1	-0.4	±	1.1
Paired Test	P-value	<0.001*			0.356		

Velocity time integral –femoral artery (VTIF) in responder patients before fluid administration was in (Mean ±SD) (12.6± 3.9) and after fluid administration was in (Mean ±SD) (18.3± 3.5), with p-value (<0.001) indicating high significant difference in VTIF in responder patients before and after fluid administration. Table (7)

On other contrary, Velocity time integral – femoral artery (VTIF) in non-responder patients before fluid administration was in (Mean ±SD) (14.4± 2.2) and after fluid administration was in (Mean ±SD) (14.8±2.5), with p-value (<0.356) indicating no significant difference in VTIF in non-responder patients before and after fluid administration. Table (7)

Table (7): Velocity time integral –femoral artery (VTIF) before and after fluid administration of 30 ml/kg of NaCl 0.9% in responder and non-responder patients.

VTIF		**Groups**					
		Responder			**Non responder**		
Before	Mean ±SD	12.6	±	3.9	14.4	±	2.2
After	Mean ±SD	18.3	±	3.5	14.8	±	2.5
Differences	Mean ±SD	-5.6	±	2.1	-0.4	±	1.1
Paired Test	P-value	<0.001*			0.356		

Total number hemodynamically responder patients (23) were responder by femoral Doppler and just (22) patients from total number of responder patients were responder to ECHO. Table (8)

Table (8): Numbers of patients who responded to fluid resuscitation as diagnosed by Echo and femoral doppler.

Responders	**Groups**			
	Re ECHO		**Re F.D**	
	N	**%**	**N**	**%**
Yes	22	95.65	23	100.00
No	1	4.35	0	0.00
Total	23	100.00	23	100.00

DISCUSSION

Septic patients were considered responsive to fluid therapy when their mean arterial pressure increase, temperature and heart rate decreases significantly. The haemodynamic and biochemical parameters were used in many studies to detect these patients whom are responded to fluid resuscitation. Those patients tested by two noninvasive tools were able to detect these patients [(6)].

Both hemodynamic assessment tools were able to detect patients who responded to fluid therapy. Femoral Doppler used the increase in velocity time integral variation (%VTIf) and detected 23 patients out of 23 diagnosed as responders by hemodynamic parameters.

Echocardiography used velocity time integral variation in left ventricle outflow tract (LVOT) and detected 22 patients out of 23 diagnosed as responders by hemodynamics parameters.

Patients whom excluded from this study included amputated lower limb patients as it is interfere with femoral doppler, cardiac, aortic insufficiency patients, Chemotherapy or radiotherapy, Cancer disease, Pregnant and lactating women as these would give unaccurate measurements in ECHO and femoral doppler [(7)].

Sepsis-related organ failure assessment score (SOFA score) is used in our study, it assists health care providers in estimating the risk of morbidity and mortality due to sepsis. It was developed in 1982 and recently it has been used extensively in clinical and research practice for assessing morbidity and mortality in sepsis patients [(8)].

Tools used to detect fluid responsiveness in sepsis are gradually shifted to dynamic parameters.

Of these are systolic pressure variation (SPV), pulse pressure variation (PPV), stroke volume variation (SVV) and the plethysmographic waveform [(8)].

Unfortunately PPV, SPV and SVV were not available for each patient in ICU units and they need modern monitors ventilated patients, with a practice which is getting used less in the face of recommended gentle ventilation strategies tidal volume 8ml/kg and this against gentle ventilation strategies which recommend tidal volume not more than 6ml/kg [(8)].

This study tries to test the ability of two noninvasive haemodynamic monitoring tools femoral doppler and echocardiography as rapid, easy and accurate tools in assessment of fluid responsiveness in septic patients.

Serum lactate level is used in this study as predictive marker to assess responding the patients for fluid challenge. Serum lactate is an important indicator of the septic patient's prognosis. A level over 4 mmol/L is associated with a 27% mortality rate, with mortality dropping significantly as the lactate level decreases [(9)].

Concerning the demographic data in our results there was no significant differences between responders and non-responders as regard age or sex.

Hemodynamic changes were assessed before and after fluid challenge and found that MAP increase percentages was higher in responder group than non-responder group. Also HR decrease percentages was higher in responder group than non-responder group. These results meet results of studies of ***Vincent et al*** [(10)] and ***Muller et al.*** [(11)] which assessed Physiological changes after fluid bolus therapy in sepsis.

Respiratory rate change percentages was higher in non-responder group than responder group. This meet with ***Michard et al.*** [(12)] who investigate whether the respiratory changes in arterial pulse pressure (ΔPP) and in systolic pressure (ΔSP) could predict fluid responsiveness in spontaneously breathing (SB) patients, and found that these respiratory rate changes lack sensitivity and dependence to monitoring fluid responsiveness.

Temperature level change percentages was higher in responder group than non-responder group. This meet with studies of ***Shigeki et al.*** [(13)].

Serum lactate level change percentages was higher in responder group than non-responder group. This meet with studies of ***Houwink et al*** [(14)].

In the assessment of response to fluid challenge using femoral Doppler, our study showed that the change of VTIF% and VFMX% before and after Fluid challenge was higher in responder group than non-responder group. This meet study of ***Messina et al*** [(15)] who assess hemodynamic response to a fluid challenge using femoral Doppler in critically ill ventilated patients and stated that Variation of femoral Doppler parameters before and after Fluid challenge are mirrors for cardiac response to fluid loading and could be considered as an alternative to transthoracic echocardiography.

In the assessment of response to Fluid challenge using transthoracic echocardiography our study showed that the change of LVOT VTI and LVOT VTI% before and after Fluid challenge was higher in responder group than non-responder group. This meet the study of ***Lamia et al*** [(16)] who proved that Changes in stroke volume measured with echocardiography are an excellent method for predicting preload reserve. Stroke volume can be measured by determining the velocity-time integral (VTI) of aortic blood flow with transthoracic echocardiography. The product of VTI and aortic area equals the stroke volume; assuming that the aortic diameter is constant, multiplying the result by heart rate yields cardiac output. Also our study meet with studies of ***Maizel et al*** [(17)] and ***Manuel et al*** [(18)].

CONCLUSION

Femoral Doppler parameters were a reliable predictor to fluid responsiveness in patients with severe sepsis and septic shock as well as transthoracic echocardiography in dynamic monitoring of the change in stroke volume after a maneuver that increases or decreases venous return (preload). However femoral Doppler seems to be easier and rapid tools to be used by junior staff.

Recommendations

In light of the results of the current study, future studies may need to use large population and recommending femoral Doppler as routine easy to learn in house monitoring tool, Fluid responsiveness in other causes of shock may also be tested using femoral Doppler, Grouping of patients may include ventilated and non- ventilated to determine its effect on these hemodynamic tools and Encouraging training programs and educating staff for junior staff.

REFERENCES

1. **Brennan JM (2007):** Radial artery pulse pressure variation correlates with brachial artery peak velocity variation in ventilated subject when measured by internal medicine residents using hand carried ultrasound devices. Chest, 131(5):1301-1307.
2. **Murphy CV, Schramm GE, Doherty JA *et al.* (2009):** The importance of fluid management in acute lung injury secondary to septic shock. Chest, 136(1):102-109.
3. **Mari PE, Cavallazzi R, Vasu T, Hirani A *et al.* (2009**): Dynamic changes in arterial waveform derived variables and fluid responsiveness in mechanically ventilated patients. Critical Care Medicine, 37(9):2642-2647.
4. **Michard F, Boussat S, Chemla D *et al.* (2000):** Relation between respiratory changes in arterial pulse pressure and fluid responsiveness in septic patients with acute circulatory failure. Crit. Care Med., 162(1):134-138.
5. **Allingstrup M, Wetterslev J, Ravn FB *et al* (2016): Antithrombin III for critically ill patients.** *Cochrane Database Syst. Rev*., 2:CD005370
6. **Bourgoin A, Leone M, Delmas A *et al*. (2005):** Increasing mean arterial pressure in patients with septic shock: effects on oxygen variables and renal function. *Crit. Care Med*., 33:780–786
7. **Cannesson M and Forget P *(*2010)** Fluid Responsiveness Monitoring In Surgical and Critically Ill Patients. Cardiothorac Vasc. Anesth., 24(3):487-497
8. **Dellinger RP, Levy MM, Rhodes A *et al.* *(*2012):** Surviving Sepsis Campaign Guidelines Committee including The Pediatric Subgroup: Surviving Sepsis Campaign: international guidelines for management of severe sepsis and septic shock. *Intensive Care Med.*,39:165– 228
9. **Casserly B, Phillips GS, Schorr C *et al*. (2015):** Lactate measurements in sepsis-induced tissue hypoperfusion: results from the Surviving Sepsis Campaign database. *Crit. Care Med.*, 43:567–573
10. **Vincent JL and Weil MH (2006):** Fluid challenge revisited**.** Crit. Care Med., 34: 1333-1337.
11. **Muller L, Toumi M, Bousquet PJ *et al.* (2011):** An increase in aortic blood flow after an infusion of 100 ml colloid over 1 minute can predict fluid responsiveness: the mini-fluid challenge study. Anesthesiology, 115: 541-547.
12. **Michard F and Teboul JL (2002):** Predicting fluid responsiveness in ICU patients: a critical analysis of the evidence. Chest, 121(6):2000-2008.
13. **Shigeki K, Satoshi Y, Tomoyuki E *et al.* (2014):** Body temperature abnormalities in non-neurological critically ill patients: a review of the literature. J. Intensive Care, 2(1): 14.
14. **Houwink AP, Rijkenberg S, Bosman RJ *et al.* (2016):** The association between lactate, mean arterial pressure, central venous oxygen saturation and peripheral temperature and mortality in severe sepsis: a retrospective cohort analysis. Crit. Care, 20: 56.
15. **Messina A, Longhini F, Coppo C *et al.* (2017):** Use of the Fluid Challenge in Critically Ill Adult Patients: A Systematic Review. Anesth. Analg., 125(5):1532-1543.
16. **Lamia B, Ochagavia A, Monnet X *et al.* (2007):** Echocardiographic prediction of volume responsiveness in critically ill patients with spontaneously breathing activity. Intensive Care Med., 33(7):1125-1132.
17. **Maizel J, Airapetian N, Lorne E *et al.* (2007):** Diagnosis of Central Hypovolemia by Using Passive Leg Raising. Intensive Care Medicine, 33: 1133-1138.
18. **Manuel I, Anselmo G and Juan C (2009):** Brachial artery peak velocity variation to predict fluid responsiveness in mechanically ventilated patients. Crit. Care, 13(5): 142.