ORIGINAL ARTICLE

FLUID RESUSCITATION IN CARDIOGENIC SHOCK: AN ASSESSMENT OF RESPONSIVENESS AND OUTCOME

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Background: Fluid replacement for resuscitation in cardiogenic shock (CS) patients remains a point of debate in clinical practice. The purpose of the study was to assess the frequency of fluid responsiveness and outcomes of patients with cardiogenic shock receiving fluid resuscitation at the critical care unit (ICU) of a tertiary care cardiac center. **Methods:** In this descriptive case series, in which all mechanically ventilated CS patients were evaluated who were assessed for fluid responsiveness by a fluid challenge. It was conducted at the critical care unit of a tertiary care cardiac center in Karachi, Pakistan, from January 2020 to June 2020, by including 41 consecutive patients. Fluid challenge was given as either a 250 ml crystallized bolus or a passive leg raise (PLR) manoeuvre. An increase in the velocity time integral (ΔVTI) of ≥ 10% was considered fluid responsiveness. **Results:** A total of 41 patients were evaluated: 25 (61%) were males, and the mean age was 61.9±17.0 years, and 36.6% (15) of the patients presented with non-ST elevation myocardial infarction (NSTEMI), followed by anterior wall ST elevation myocardial infarction (31.7% (13)). Fluid responsiveness was observed in 48.8% (20/41). Mean VTI change after the fluid challenge was 1.07±0.86. Survival rate was 33.3% (7/21) in fluid responders vs. 50.0% (10/20) in non-fluid responders; *p*=0.279. **Conclusion:** Almost half of patients presenting with CS from acute coronary syndrome are responsive to fluids. These findings support the routine evaluation by fluid challenge in these patients. Fluid challenge can be by either PLR or fluid bolus.

Keywords: Cardiogenic shock; Myocardial infarction; Left ventricular dysfunction; Fluid resuscitation; Right ventricle dysfunction; Passive leg raise; Velocity time integral

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INTRODUCTION

Cardiogenic shock (CS) complicating myocardial infarction (MI) is a life-threatening low-cardiac-output state with incidence ranging from 3–13%.[1,2] It is associated with increased risk of hypoxia, end-organ hypoperfusion, and mortality ranging from 40–50%.[3–5] Left ventricular (LV) dysfunction after acute MI remains the leading cause behind CS observed in around 80% of cases.[6] Other factors, such as valvular heart disease, decompensated chronic heart failure, Takotsubo syndrome, acute myocarditis, and arrhythmias, may also cause non-infarct-related cardiogenic shock.[5] Practice guidelines regarding the management of CS and treatment targets are heterogeneous depending on the understanding of pathophysiology and disease-specific statements.[5] CS is not merely a low-cardiac-output state, but it involves the whole circulatory system and is characterized as multiorgan dysfunction syndrome often complicated by systemic inflammatory response syndrome.[7]

Early fluid resuscitation is the standard of care for the management of shock.[5] Right ventricle (RV) dysfunction with inferior wall MI is a situation where the LV appears to be fluid responsive with appropriate fluid loading and is associated with improvement in in-hospital outcomes and long-term survival; however, administration of fluid in non-inferior wall MI is the subject of debate.[8–10] Therefore, before vasopressors and inotropes, judicious fluid boluses based on bedside assessment of fluid responsiveness are imperative to avoid the needless increase in left ventricular end-diastolic pressure (LVEDP), a consequence of pulmonary oedema.

The gold standard for defining fluid responsiveness is a >10% increase in cardiac output after a fluid challenge or given either by a fluid bolus or a passive leg raise (PLR) manoeuvre. Passive leg raise is a simple method to mobilize volume from the lower extremities and thereby administer a non-invasive fluid challenge. The patients' legs were elevated to 45° for approximately two minutes, and the variable of interest was measured before and after the PLR manoeuvre. Intravascular volume from the pelvic and lower extremity venous system is returned by elevation to the right heart. This effect of preload

augmentation on cardiac output can be used to define fluid responsiveness.[11] The echocardiographic assessment of velocity time integral (VTI) at LVOT can be a valuable bedside method for assessing stroke volume and responsiveness to fluid administration in these patients. The echo transducer is positioned at the left ventricle outflow tract (LVOT), just above the aortic valve in the apical five-chamber view. Using pulsed-wave Doppler, the peak velocity tracing is identified and VTI is measured.[12] The aim of this study was to assess the frequency of fluid responsiveness in cardiogenic shock after acute coronary syndrome (ACS).

MATERIAL AND METHODS

It was a descriptive case series that included patients with cardiogenic shock admitted to the critical care unit of a tertiary care cardiac center in Karachi, Pakistan, from January to June 2020. The study was approved by the ethical review committee. Inclusion criteria for the study were patients diagnosed with cardiogenic shock, sedated, mechanically ventilated, and receiving fluid challenges by the treating team. Consent for participation in the study and publication was obtained from the attendant or legal caretaker of the patient. Patients with atrial or ventricular arrhythmias or with temporary pacemakers or intra-aortic balloon pumps were excluded from the study. Forty-one patients were included through consecutive non-probability sampling technique.

Clinical characteristics, physiological variables, type of myocardial infarction, and co-morbid conditions were recorded. At baseline, ejection fraction (EF) and velocity time integral (VTI) were recorded by bedside 2D echocardiogram. Fluid challenge was given either as a 250 ml crystallized bolus or a passive leg raise (PLR) manoeuvre. Passive leg raise was performed for two minutes in which the patient's legs were raised to 45° from a recumbent position. Velocity time integral was measured pre-PLR or fluid bolus. Patients with an increase of 10% in post-fluid challenge VTI (ΔVTI > 10%) were categorized as fluid responders. All the patients were managed as per the institutional protocols. All patients were kept under observation during their ICU stay, and outcome (survival) was recorded. All the collected information was recorded on a predefined structured *pro forma*.

Collected data were entered and analysed using IBM SPSS (statistical package for the social sciences) version 21. Descriptive statistics such as frequency (%) or mean±standard deviations were calculated. Survivor and non-survivor groups of patients were compared by applying an independent sample t-test or chi-square test. $p \leq 0.05$ was considered statistically significant.

RESULTS

The total number of patients evaluated was 41, of which 25 (61%) were males and the mean age was 61.9±17.0 years. Cardiovascular risk factors found in the study were diabetes (46%), hypertension (32%), chronic obstructive pulmonary disease (COPD) (29.3%), and smoking (24%). Nearly 36.6% (15) of patients presented with non-ST elevation myocardial infarction (NSTEMI), and 31.7% (13) of patients had anterior wall myocardial infarction (AWMI). The mean acute Physiologic Assessment and Chronic Health Evaluation II (APACHE II) score was 16.93±7.63.

Patients were categorized based on intensive care unit (ICU) survival status. A comparison of demographic and clinical characteristics, fluid responsiveness, and ICU outcome patient data are presented in table-1. Demographic and clinical characteristics of the survivor and non-survivor patients were not significantly different. Fluid responsiveness was observed in 48.8% (20/41). Mean VTI change after fluid challenge was 1.19±0.87 for survivors vs. 0.97±0.85 for non-survivors; p=0.423. Around 58.8% of surviving patients were fluid-responsive, while 41.7% of non-survivors were fluid-responsive. Survival and mortality rates for fluid responders and non-responders are presented in figure-1. Survival rate was 33.3% (7/21) vs. 50.0% (10/20); p=0.279 for fluid non-responder and responder patients.

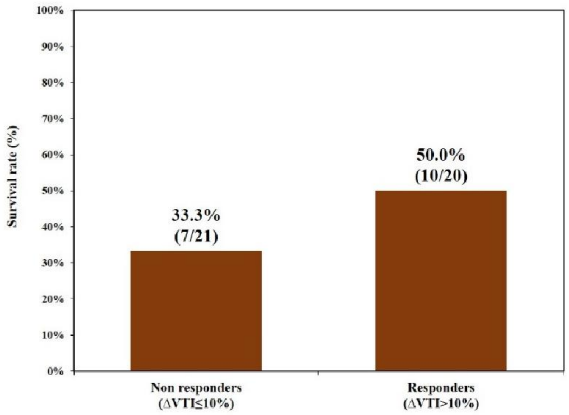

Figure-1: Intensive care unit (ICU) survival rate (%) of cardiogenic shock patients stratified by fluid responsiveness

(VTI = velocity time integral)

Table-1: Demographic and clinical characteristics of cardiogenic shock patients by survival status

Characteristics	Total	Outcome		*p*-value
		Survived	Died	
n	**41**	**17**	**24**	**-**
Gender				
Male	61% (25)	64.7% (11)	58.3% (14)	0.680
Female	39% (16)	35.3% (6)	41.7% (10)	
Age (years)	61.88±17.01	61.29±8.36	62.29±21.31	0.856
≤ 60 years	39% (16)	41.2% (7)	37.5% (9)	0.812
> 60 years	61% (25)	58.8% (10)	62.5% (15)	
Risk factors				
COPD	29.3% (12)	35.3% (6)	25% (6)	0.475
CHF	9.8% (4)	11.8% (2)	8.3% (2)	0.715
Smoking	24.4% (10)	29.4% (5)	20.8% (5)	0.529
Diabetes	46.3% (19)	52.9% (9)	41.7% (10)	0.476
Hypertension	31.7% (13)	47.1% (8)	20.8% (5)	0.075
CKD	12.2% (5)	11.8% (2)	12.5% (3)	0.943
Ejection fraction (EF)	30.24±9.22	31.18±6.74	29.58±10.73	0.592
Myocardial infarction				
Anterior Wall MI	31.7% (13)	29.4% (5)	33.3% (8)	0.418
Inferior Wall MI	9.8% (4)	17.6% (3)	4.2% (1)	
Inferior Posterior Wall MI	4.9% (2)	0% (0)	8.3% (2)	
Antero Inferior Wall MI	7.3% (3)	5.9% (1)	8.3% (2)	
High Lateral Wall MI	2.4% (1)	0% (0)	4.2% (1)	
NSTEMI	36.6% (15)	41.2% (7)	33.3% (8)	
Non ICMP	4.9% (2)	0% (0)	8.3% (2)	
Infero-Lateral Wall MI	2.4% (1)	5.9% (1)	0% (0)	
APACHE score	16.93±7.63	15.18±6.85	18.17±8.04	0.220
ΔVTI	1.07±0.86	1.19±0.87	0.97±0.85	0.423
Non responders (ΔVTI ≤10%)	51.2% (21)	41.2% (7)	58.3% (14)	0.279
Responders (ΔVTI >10%)	48.8% (20)	58.8% (10)	41.7% (10)	

CHF = congestive heart failure, COPD = chronic obstructive pulmonary disease, CKD = chronic kidney disease, MI = myocardial infarction, NSTEMI = non-ST elevation MI, ICMP = ischemic cardiomyopathy, VTI = velocity time integral, APACHE = Acute Physiology and Chronic Health Evaluation II

DISCUSSION

In our observational study of patients in cardiogenic shock, we found that almost half of patients were responsive to the fluid challenge. However, we found no difference in survival, probably because survival is dependent on many other factors.

Early fluid resuscitation in circulatory shock patients is the standard of care. The primary goal of management in these patients is to optimize the oxygen supply to hypoxic tissues by increasing preload (fluids), decreasing afterload (vasodilators), or increasing contractility (inotropes) of the ventricular as per the Frank Starling law.[13,14] Fluid in these patients can have beneficial or deleterious effects depending on the right ventricle's structural or functional status. Administration of fluids can be potentially harmful in patients with RV dysfunction secondary to structural causes, such as severe acute respiratory distress syndrome or pulmonary embolism, however, it might be beneficial in case of functional causes, such as mechanical ventilation or inferior wall MI. Volume may result in a decline in stroke volume rather than an increase and may cause an increase in left-ventricular end-diastolic volume, resulting in pulmonary oedema and worsening of shock.[15]

According to Frank Starling law "the dilated right ventricle (RV) should operate on the flat portion of systolic-function curve, therefore, a further increase in RV preload with fluid administration cannot increase the RV stroke volume". Second, the whole heart is encased by the pericardium, so a raised right ventricle volume and pressure due to fluids would push the septum to the left side and increase filling pressure on the left ventricle (left-ventricle-interdependence phenomena). Third, regarding the hyperbolic end-diastolic pressure-volume relationship, RV end-diastolic pressure increases more in dilated ventricles than non-dilated ones.[13,14,16] Holubarsch *et al*. described the filling–force mechanism (FFm), "a positive relationship between the distension of a ventricular chamber and its force of ejection".[16]

Thus, assessment of fluid responsiveness has a pivotal role in managing these patients. Invasive assessment of cardiac output in these patients can be clinically challenging; however, left ventricle out tract velocity (LVOT VTI) is well-documented as a stranded dynamic measurement. Its utility can be rectified by PLR without using fluid in a controversial state of shock like cardiogenic shock, unlike septic and hypovolemic shock, where straightforward volume replacement is directed.[5] Stroke volume assessment using Swan Ganz's

(pulmonary artery catheter) method is no longer in clinical practice due to its invasive approach, misinterpretation, requirement of highly technical staff, lethal complications, increase in chance of line related sepsis, and increase in mortality. Also, right-side estimation of cardiac output is unreliable in patients with right heart disease like severe tricuspid regurgitation secondary to a high after-load condition; therefore, the role of cather placement for hemodynamic measurement is limited to the cardiac surgery patient.[17] Hence, echocardiographic assessment of VTI can be a better surrogate of cardiac output in these patients.

In our study, we assessed ventilated CS patients for fluid responsiveness based on changes in VTI after the fluid challenge; nearly half of the patients were found to be responsive. Mean VTI change after the fluid challenge was 1.19±0.87 for survivors vs. 0.97 ± 0.85 for non-survivors. A relatively better short-term (ICU) survival rate was observed for fluid responders as compared to non-responders.

Limitations: A major limitation of this study is the small sample size; further larger studies are needed to assess the role of post-fluid challenge VTI change in clinical decision-making regarding fluid administration.

CONCLUSION

In our study, we found almost half of the patients presenting with cardiogenic shock to be responsive to fluids. Our findings support the routine assessment of fluid responsiveness in these patients. Fluid challenge can be by either PLR or fluid bolus.

AUTHORS' CONTRIBUTION

AR, JA, NS: Concept and design, data acquisition, interpretation, drafting, final approval, and agree to be accountable for all aspects of the work. MIA, SAS, MK: Data acquisition, interpretation, drafting, final approval and agree to be accountable for all aspects of the work.

Conflict of interest: Authors declared no conflict of interest.

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