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Evaluation of role of chest sonography in assessment of patients presenting with shock to emergency department

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ABSTRACT

Assessment of hemodynamic status in a shock state remains a challenging issue in Emergency Medicine and Critical Care. As the use of invasive hemodynamic monitoring declines, bedside-focused ultrasound has become a valuable tool in the evaluation and management of patients in shock. No longer a means to simply evaluate organ anatomy, ultrasound has expanded to become a rapid and non-invasive method for the assessment of patient physiology. Clinicians caring for critical patients should strongly consider integrating ultrasound into their resuscitation pathways the use of ultrasound in the hypotensive patient is not one unique application, but rather a combination of different point of care ultra sound techniques involving the heart, abdomen, chest and vessels. Several protocols have been described. Each involves a slightly different scanning protocol and evaluates for different pathologies. This study aimed to assess the efficacy of ultrasound chest for differentiation of different types of shock presented to emergency department, Study has been conducted on 55 patients diagnosed as shock by emergency physicians.

Key words: Chest Sonography

INTRODUCTION

The definition of shock has continued to change considerably over the years. It can no longer be based on blood pressure alone. Assessment of perfusion independent of arterial pressure has clearly demonstrated that adequate blood pressure does not equal adequate cardiac output or tissue perfusion. Seemingly adequate oxygen delivery (DO2) also does not guarantee oxygen or substrate utilization at a cellular level. (1)

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Classification

Shock has traditionally been classified into four categories: hypovolemic, distributive, cardiogenic, and obstructive shock. (2)

(i) Hypovolemic Shock

It is characterized by a loss in circulatory volume, which results in decreased venous return, decreased filling of the cardiac chambers, and hence a decreased cardiac output which leads to increase in the systemic vascular resistance (SVR). The hemodynamic profile on monitoring of flow pressure variables shows low central venous pressure (CVP), a low pulmonary capillary wedge pressure (PCWP), low cardiac output (CO) and cardiac index (CI), and high SVR. The arterial blood pressure may be normal or low. [3]

(ii) Cardiogenic Shock

This is primarily dependent on poor pump function. Cardiogenic shock due to acute catastrophic failure of left ventricular pump function is characterized by high PCWP, low CO and CI, and generally a high SVR. [3]

(iii) Distributive or vasogenic shock

This type of shock is associated with not only poor vascular tone in the peripheral circulation but maldistribution of blood flow to organs within the body also. The CO varies, but is usually raised. A common hemodynamic profile is a low or normal PCWP, a high CO, a low arterial blood pressure, and a low SVR. [3]

(iv) Obstructive shock

It is associated with a physical impairment to adequate forward circulatory flow involving mechanisms different than primary myocardial or valvular dysfunction. Several hemodynamic patterns may be observed, depending on the cause, from frank decrease in filling pressures (as in mediastinal compressions of great veins); to trends towards equalization of pressures in the case of cardiac tamponade; or to markedly increased right ventricular filling pressures with low PCWP in the case of pulmonary embolism. Cardiac output is usually decreased with increased SVR. [3]

Material and Methods

Diagnosis

The use of ultrasound in the hypotensive patient is not one unique application, but rather a combination of different point of care ultra sound techniques involving the heart, abdomen, chest and vessels. Several protocols have been described. [4]

Major resuscitation ultrasound protocols for use in critically ill medical and trauma patients include: ACES [32], BEAT [6], BLEEP [7], Boyd Echo [8], EGLS [9], FALLS[10], FAST [11], FATE [12], FREE [13], POCUS-Fast and Reliable [14], RUSH-HIMAP [15], and RUSH-Pump/Tank/Pipes [16]

Each involves a slightly different scanning protocol and evaluates for different pathologies. [4]

Inferior vena cava (IVC):

A sagittal or transverse view in the subxyphoid area allows for visualization of the IVC as it crosses the diaphragm and enters the right atrium. The IVC can be used to assess intravascular volume status. Normally, as a person inspires, the negative intrathoracic pressure that is generated facilitates return of blood to the heart, and the IVC collapses (Figures 2-5).

The degree of collapse is related to the central venous pressure, as is the absolute diameter of the IVC. In general, when the IVC is narrow (,1.5 cm) and collapses a large amount (.50%), the central venous pressure is low, a hypovolemic (dehydration, hemorrhage) or distributive (sepsis, anaphylaxis) cause is likely, and volume resuscitation should be initiated.[17]

When the IVC is dilated and non-collapsing, volume depletion is unlikely. A dilated IVC can also be seen in tension pneumothorax, cardiac tamponade, RV infarction, right-sided congestive heart failure or a pulmonary embolism.[17]

Right ventricular (RV) assessment:

Best seen on an apical four chamber view, the ventricular sizes can be compared. When there is an acute pressure overload on the RV as seen with a pulmonary embolism, the RV will dilate and appear larger than the left ventricle. In the unstable patient, thrombolysis (or thrombectomy if there are contraindications) should be considered.[17]

Left ventricular (LV) function:

Best assessed on the parasternal long or short-axis view, but any cardiac view may suffice. Determining how strongly the LV is beating is one of the most important uses of ultrasound in the hypotensive patient. No mathematical measurements or calculations are necessary – simple visual estimation has been shown to be as accurate. This is especially true when it is considered that an exact ejection fraction is not needed, but rather stratification into normal (50%), decreased (30–50%), or severely decreased (30%) groups. Severely decreased LV function may prompt the need for cardiac inotropes, whereas normal function means that cardiogenic shock can be ruled out. [18]

Pericardial Effusion:

Best seen on the subxyphoid or apical four-chamber views (though any cardiac view may suffice); circumferential fluid around the heart raises concern for possible tamponade (Figures 6,7).

As more fluid accumulates in the pericardial space, the pressure rises and the right side of the heart has difficulty filling completely during diastole. The RV free wall is unable to expand completely and can appear inverted with downward concavity. This is sometimes referred to as 'scalloping.' In the setting of persistent hypotension and cardiovascular collapse, emergent pericardiocentesis or a surgical pericardial window is indicated.[17]

Lung ultrasound:

Ultrasound is already in common use within critical care, typically to guide central venous access. Other applications such as echocardiography and abdominal scanning in trauma are also finding their way into everyday practice.[19]

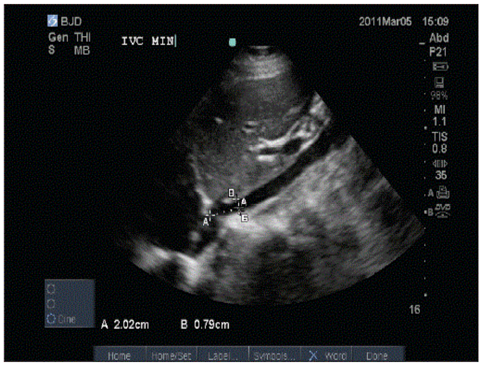

Figure-1: Inspiratory (minimal) diameter of IVC[25]

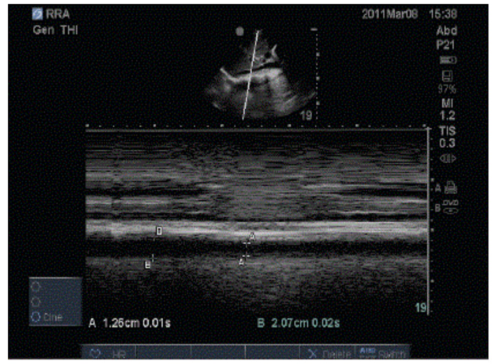

Figure-2: Inspiratory diameter of IVC in M Mode measured at smallest location[25]

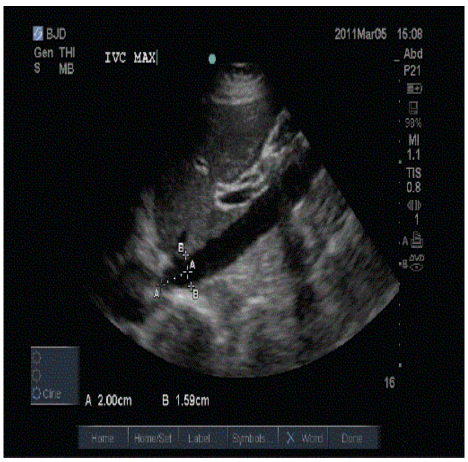

Figure-3. Expiratory (Maximal) diameter of IVC[25]

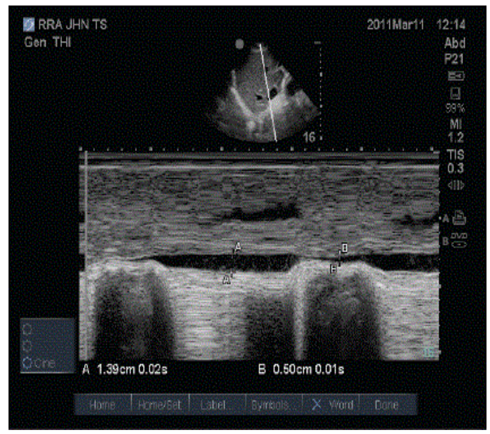

Figure-4: Expiratory diameter of IVC in M Mode measured at Largest location[25]

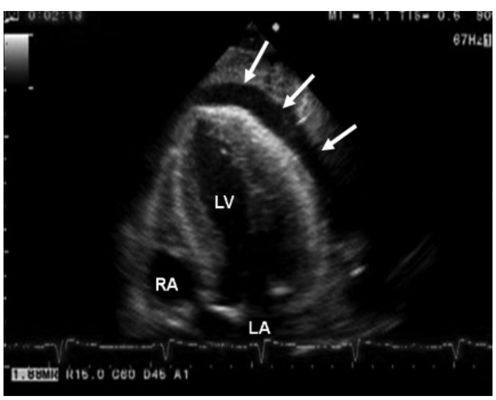

Figure-5. Pericardial effusion (white arrows) [26]

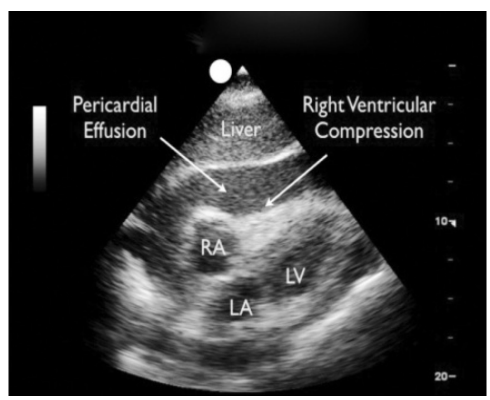

Figure-6. Cardiac tamponade causing compression of RV[26]

Advocates of thoracic ultrasound suggest that the majority of important pathology can be detected with relative ease, speed, and greater reliability when compared with plain radiography. It also spares ionizing radiation exposure and, in the case of CT, potentially hazardous transfer of the patient to the radiology suite. There is also the potential for a considerable cost saving. Despite these factors, thoracic ultrasound is not currently in widespread use within the critical care setting except in the detection of pleural effusion.[20]

Table-1. Comparison between the different studied groups according to demographic data

	Group A (n = 22)		Group B (n = 15)		Group C (n = 9)		Group D (n = 9)		Total (n = 55)		Test of Sig.	P
	No.	%	No.	%	No.	%	No.	%	No.	%		
Sex												
Male	13	59.1	6	40.0	6	66.7	5	55.6	30	54.5	χ^2=2.000	0.617
Female	9	40.9	9	60.0	3	33.3	4	44.4	25	45.5		
Age (years)												
Min. – Max.	44.0 – 77.0		40.0 – 71.0		22.0 – 62.0		18.0 – 77.0		18.0 – 77.0			
Mean ± SD.	61.0^{CD} ± 9.50		56.27 ± 10.69		45.11^{A}± 13.53		42.67^{A}± 21.94		54.11 ± 14.80		F= 5.831^{*}	0.002^{*}
Median	62.0		57.0		45.0		35.0		57.0			

Group A: Cardiogenic shock Group B: Septic shock
Group C: Obstructive shock Group D: Hypovolemic shock
χ^2: Chi square test
F: F test (ANOVA), sig bet groups was done using Post Hoc test (Tukey HSD)
Super scripts are significant with groups *: Statistically significant at p ≤ 0.05

Table (2): Comparison between the different studied groups according to history

	Group A (n = 22)		Group B (n = 15)		Group C (n = 9)		Group D (n = 9)		Total (n = 55)		χ^2	^{MC}p
	No.	%	No.	%	No.	%	No.	%	No.	%		
Ischemic Heart Disease	16	72.7^{CD}	7	46.7	2	22.2^{A}	2	22.2^{A}	27	49.1	9.907^{*}	0.016^{*}
Diabetes	15	68.2	12	80.0^{CD}	3	33.3^{B}	3	33.3^{C}	33	60.0	8.128^{*}	0.042^{*}
Hypertension	16	72.7	9	60.0	5	55.6	3	33.3	33	60.0	4.174	0.243
Valvular Lesions	3	13.6	1	6.7	1	11.1	0	0.0	5	9.1	1.415	0.800
Congestive Heart Failure	11	50.0	3	20.0	1	11.1	1	11.1	16	29.1	7.121	0.057
Recent Chest Infections	3	13.6^{B}	11	73.3^{ACD}	1	11.1^{B}	1	11.1^{B}	16	29.1	17.178^{*}	$<0.001^{*}$
Recent Blood Transfusion	3	13.6	2	13.3	1	11.1	0	0.0	6	10.9	1.277	0.871
Palpitation	5	22.7	4	26.7	1	11.1	0	0.0	10	18.2	3.025	0.419
Major Trauma	0	0.0^{CD}	0	0.0^{CD}	4	44.4^{AB}	5	55.6^{AB}	9	16.4	20.068^{*}	$<0.001^{*}$

Group A: Cardiogenic shock Group B: Septic shock
Group C: Obstructive shock Group D: Hypovolemic shock
χ^2: Value for Chi square FE: Fisher Exact test
Super scripts are significant with groups
*: Statistically significant at p ≤ 0.05

Pleural effusion (The sinusoid sign)

This is the typical indication for thoracic ultrasonography and has the potential ability to identify, as well as characterize, quantify, and guide the drainage of fluid. Studies have focused either on the ability to detect effusions or the ability to quantify the fluid volume.[21]

Several well-conducted studies have compared the ability of CCUS to detect effusions against that of CXR, using CT as a reference standard. All demonstrated high sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy (DA) for CCUS whereas CXR was notably weaker, particularly in terms of sensitivity, NPV and DA. [22]

Effusion is characterized by an echo-free space between the visceral and parietal pleura. This space may change in shape with respiration. The effusion can be free or encapsulated. The compressive atelectasis of the lungs in a large effusion can be seen as a tongue like structure within the effusion. US is helpful in determining the nature of pleural opacity, identifying minimal or loculated effusion, and discriminating between sub-pulmonary and subphrenic effusions. If an abnormal elevation of a hemidiaphragm is noted on the chest radiograph, subpulmonary effusion can be differentiated from subphrenic fluid collection and diaphragm paralysis by defining the position of the diaphragm and by the real-time visualization of diaphragmatic motion. In the presence of hemithorax opacification on chest radiograph, US is also helpful in distinguishing between fluid-filled and solid lesions.[23]

Several studies have been performed to measure the volume of pleural effusion by means of US. We arbitrarily classify the volume of effusion as minimal if the echo-free space is seen within the costophrenic angle; small, if the space is greater than the costophrenic angle but still within a one-probe range; moderate, if the space is greater than a one-probe range but within a two-probe range; and large or massive, if the space is bigger than a two-probe range.(24)

In summary, CCUS can reliably identify simple effusions and should be the method of choice over CXR. There is also compelling evidence that accurate and clinically useful estimations of effusion volume may also be derived by CCUS.(22)

Results

In our study 55 cases were enrolled, resulting data was tabulated and analyzed as follows:

Demographic data:

Among cases enrolled 30 cases were males (54.5%) while 25 cases were females (45.5%). There was statistical significance for age distribution between studied groups. mean age of patients with cardiogenic shock was significantly higher than other groups (61±9.5 years) followed by patients with septic shock (56.27±10.67 years) then patients with obstructive shock (45.11±13.53 years) while least mean age found in patients hypovolemic shock (42.67±21.94 years), however median age represents age variation much better, being highest (62 years) in cardiogenic shock and lowest (35 years) in hypovolemic shock.

Medical history:

Previous history of ischemic heart disease was significantly related to patients diagnosed with cardiogenic shock (72.7% of patients) followed by patients diagnosed as septic shock (46.7%) and was significantly lower in other groups. while previous diagnosis of diabetes was significantly higher in patients with septic shock (80%), followed by patients with cardiogenic shock (68.2 %) and was significantly lower in other groups.

Previous history of hypertension was significantly higher in patients with cardiogenic shock (72.7%) followed by patients with septic shock (60%) and was significantly lower in other groups

History of congestive heart failure was found in (50%) of patients with cardiogenic shock

Recent chest infection showed high significance in patients diagnosed as septic shock (73.3%) and was significantly lower in other groups

History of major trauma was significantly found in patients with hypovolemic shock (55.6%) followed by obstructive shock (44.4%) of patients

Other history items where non-significant in relation to study groups

Aortic valve abnormalities diagnosed by echo. Were only found in patients with cardiogenic shock (18.2% of patients), while mitral valve abnormalities were found in both cardiogenic shock (18.2% of patients and one patient with obstructive shock (11.1% of patients, pericardial effusion diagnosed by echo in 3 patients diagnosed with cardiogenic shock (13.6% of patients) and one patient diagnosed as cardiac tamponade (obstructive shock) (11.1% of patients), all three findings were statistically non-significant.

Mean Left ventricular end diastolic diameter (LVEDD) measured by Echocardiography showed highly significant elevation in patients with cardiogenic shock (62.73^{BCD} ± 8.64mm), (55.20^{A} ± 5.10mm) in septic shock patients, while it was within normal values in both obstructive shock (51.89^{A} ± 3.37 mm), and hypovolemic shock (53.22^{A} ± 5.09 mm) patients.

Statistical significance found in mean Ejection fraction measured by echo in different groups of patients, mean EF was found very significantly low in patients with cardiogenic shock (36.68^{BCD} ± 9.02%), higher (53.73^{A}± 11.52 %) in patients with septic shock, then (56.78^{A} ± 6.51 %) in obstructive shock patients, while it was (60.89^{A} ± 4.37 %) in patients diagnosed as hypovolemic shock.

Most of x-ray finding on admission were found to have a significant relationship to each group of patients

Bilateral opacities or picture of pulmonary edema was found in (90.9%) in patients diagnosed as cardiogenic shock, and only in two patients diagnosed as septic shock(20%) of patients, while kurley B lines were found exclusively in patients with cardiogenic shock in (54.5%) of patients

Consolidation was found in 6 patients diagnosed as septic shock (40% of patients), while it was found in one patient in each obstructive and hypovolemic shock patients counting (11.1% of patients in each group. In group of cardiogenic shock, consolidation in x-ray was only found in one patient, counting (4.5%) of the total count

Pneumothorax in chest x-ray was found in (55%) of patients diagnosed as obstructive shock and only in (11.1%) in patients diagnosed as hypovolemic shock

Pleural effusion in chest x-ray showed low significance in relation to study groups.

Left ventricular contractility as examined by chest sonography (eyeballing of left ventricle) found to have high significance in different group of patients

Among 22 patients diagnosed as cardiogenic shock, 20 patients found to have low LV contractility (90%), while the remaining two patients considered to have a normal contractility

Among 15 patients diagnosed as septic shock 8 patients had a normal contractility (54.3%), two

Table-3. Comparison between the different studied groups according to echocardiography findings

	Group A (n = 22)		Group B (n = 15)		Group C (n = 9)		Group D (n = 9)		Total (n = 55)		Test of sig.	p
	No.	%	No.	%	No.	%	No.	%	No.	%		
Aortic valve disease	4	18.2	0	0.0	0	0.0	0	0.0	4	7.4	χ^2=3.972	^{MC}p= 0.183
Mitral valve disease	4	18.2	0	0.0	1	11.1	0	0.0	5	9.1	χ^2=3.714	0.203
Cardiomegaly in chest x.ray	16	72.7^{BCD}	3	20.0^{A}	2	22.2^{A}	2	22.2^{A}	23	41.8	χ^2= 13.851^*	^{MC}p= 0.003^*
Pericardial Effusion	3	13.6	0	0.0	1	11.1	0	0.0	4	7.3	χ^2=2.796	^{MC}p= 0.426
Left ventricular end diastolic diameter (LVEDD)												
Min. – Max.	41.0 – 79.0		49.0 – 64.0		48.0 – 59.0		45.0 – 61.0		41.0 – 79.0		$^{KW}\chi^2$= 8.401^*	0.004^*
Mean ± STD.	62.73^{BCD} ± 8.64		55.20^{A} ± 5.10		51.89^{A} ± 3.37		53.22^{A} ± 5.09		57.35 ± 7.89			
Median	62.50		54.0		51.0		54.0		56.0			
Ejection fraction												
Min. – Max.	18.0 – 49.0		35.0 – 66.0		42.0 – 63.0		54.0 – 68.0		18.0 – 68.0		F= 22.950^*	$<0.001^*$
Mean ± STD.	36.68^{BCD} ± 9.02		53.73^{A}± 11.52		56.78^{A} ± 6.51		60.89^{A} ± 4.37		48.58 ± 13.29			
Median	39.50		59.0		58.0		61.0		49.0			

Group A: Cardiogenic shock
Group B: Septic shock
Group C: Obstructive shock
Group D: Hypovolemic shock
χ^2: Chi square test
F: F test (ANOVA+), sig bet groups was done using Post Hoc test (Tukey HSD)
KW: Kruskal Wallis test), sig bet groups was done using Mann Whitney test
Super scripts are significant with groups
*: Statistically significant at $p \le 0.05$

patients found to have hyper contractile LV (13.3%), while 5 patients found to have low contractility (33.3%).

Patients with obstructive shock where nine in total, 8 patients of them had a normal contractility(88.9%), while only one patients found to have a low LV contractility

Among 9 patients diagnosed as hypovolemic shock, 7 patients (77.8%) had a hyper contractile, and remaining two patients found to have a normal contractility.

Sonographic examination of Right Ventricular size showed to have high significance, (100%) of patients diagnosed as cardiogenic, septic and obstructive shock had a normal RV size, while in nine patients with obstructive shock, 5 patients (55.6%) found to have normal RV size, 3 patients (33.3%)had a dilated RV in relation to LV(in all patients who had a confirmed diagnosis of a pulmonary embolism), while only one patient(11.1%) had a noticeable diastolic collapse of RV(which was considered as a sign of a pericardial tamponade.

Inferior vena cava size was of the highest significant signs in these study, all patients who had a diagnosis with cardiogenic or obstructive shock were found to have high IVC diameter, among 15 patients diagnosed as septic shock, 8 patients(53.3%) had a low IVC size while remaining 7 patients (46.7%) had an IVC size more than 2.1 cm,

In patients with hypovolemic shock, 7 patients out of 9 (77.8%) had an IVC size less than 2.1 cm, and only 2 patients (22.2%) had an IVC diameter more than 2.1 cm

Inspiratory collapse index of IVC had a high statistical significance, all patients of both cardiogenic and obstructive shock had an IVC collapsing less than 50%, while 100% of patients diagnosed as hypovolemic shock had a collapse index more than 50%,

Among 15 Patients with septic shock, 8 patients (53.3%) had a collapsing IVC more than 50% while the other 7 patients (46.7%) had an IVC collapsing less than 50%.

Presence of A lines in sonographic examination was found to have a high statistically significance.

Table-4. Comparison between the different studied groups according to chest X.RAY

Chest X.RAY	Group A (n = 22)		Group B (n = 15)		Group C (n = 9)		Group D (n = 9)		Total (n = 55)		χ^2	^{MC}p
	No.	%	No.	%	No.	%	No.	%	No.	%		
Consolidation	1	4.5^{B}	6	40.0^{A}	1	11.1	1	11.1	9	16.4	7.405^{*}	0.033^{*}
Pleural Effusion	5	22.7	3	20.0	0	0.0	2	22.2	10	18.2	2.450	0.548
Bilateral Opacities	20	90.9^{BCD}	2	13.3^{A}	0	0.0^{A}	0	0.0^{A}	22	40.0	41.992^{*}	$<0.001^{*}$
Kurley B Lines	12	54.5^{BCD}	0	0.0^{A}	0	0.0^{A}	0	0.0^{A}	12	21.8	20.461^{*}	$<0.001^{*}$
Pneumothorax in Chest X-ray	0	0.0^{C}	0	0.0^{C}	5	55.6^{AB}	1	11.1	6	10.9	15.591^{*}	$<0.001^{*}$

Group A: Cardiogenic shock Group B: Septic shock
Group C: Obstructive shock Group D: Hypovolemic shock
χ^2: Value for Chi square MC: Monte Carlo test
FE: Fisher Exact test Super scripts are significant with groups
*: Statistically significant at $p \le 0.05$

Table-5. Comparison between the different studied groups according to chest ultrasound finding

Ultrasound Chest	Group A (n = 22)		Group B (n = 15)		Group C (n = 9)		Group D (n = 9)		Total (n = 55)		χ^2	^{MC}p
	No.	%	No.	%	No.	%	No.	%	No.	%		
Pericardial Effusion	2	9.1	1	6.7	1	11.1	0	0.0	4	7.3	1.174	1.000
Lung Point	0	0.0^{C}	0	0.0^{C}	5	55.6^{AC}	1	11.1	6	10.9	15.591^{*}	$<0.001^{*}$
Cardiac Tamponade	0	0.0	0	0.0	1	11.1	0	0.0	1	1.8	3.997	0.326
Left Ventricular Contractility		BCD		AD		AD		ABC				
Normal	2	9.1	8	53.3	8	88.9	2	22.2	20	36.4		
Low	20	90.9	5	33.3	1	11.1	0	0.0	26	47.3	45.095^{*}	$<0.001^{*}$
Hyperkinetic	0	0.0	2	13.3	0	0.0	7	77.8	9	16.4		
Right Ventricular Size												
Normal	22	100.0	15	100.0	5	55.6	9	100.0	51	92.7		
Low	0	0.0	0	0.0	1	11.1	0	0.0	1	1.8	13.382^{*}	0.001^{*}
High	0	0.0	0	0.0	3	33.3	0	0.0	3	5.5		
Inferior Vena Cava Size		BD		AC		BD		AC				
>2.1	22	100.0	7	46.7	9	100.0	2	22.2	40	72.7	28.662^{*}	$<0.001^{*}$
<2.1	0	0.0	8	53.3	0	0.0	7	77.8	15	27.3		
Inferior Vena Cava Collapsing Index		BD		ACD		BD		ABC				
>50%	0	0.0	8	53.3	0	0.0	9	100.0	17	30.9	39.101^{*}	$<0.001^{*}$
<50%	22	100.0	7	46.7	9	100.0	0	0.0	38	69.1		
A. lines in ultrasound chest	2	9.1^{BCD}	13	86.7^{A}	8	88.9^{A}	9	100.0^{A}	32	58.2	38.279^{*}	$<0.001^{*}$
Lung Sliding	22	100.0^{C}	15	100.0^{C}	4	44.4^{AB}	7	77.8	48	87.3	16.310^{*}	$<0.001^{*}$
M. Mode Finding in Ultrasound Chest		C		C		AB						
Sea Shore	22	100.0	15	100.0	4	44.4	7	77.8	48	87.3	16.310^{*}	$<0.001^{*}$
Barcode	0	0.0	0	0.0	5	55.6	2	22.2	7	12.7		
B. Lines	21	95.5^{BCD}	2	13.3^{A}	1	11.1^{A}	0	0.0^{A}	24	43.6	43.525^{*}	$<0.001^{*}$
Consolidation	2	9.1^{B}	7	46.7^{AD}	1	11.1	0	0.0^{B}	10	18.2	9.396^{*}	0.013^{*}
Pleural Effusion	8	36.4	5	33.3	0	0.0	2	22.2	15	27.3	4.836	0.173

Group A: Cardiogenic shock Group B: Septic shock
Group C: Obstructive shock Group D: Hypovolemic shock
χ^2: Value for Chi square
MC: Monte Carlo test
FE: Fisher Exact test
Super scripts are significant with groups
*: Statistically significant at $p \le 0.05$

Table-6. Relation between ejection fraction in echo and left ventricular contractility in chest ultrasound for total cases (n=55)

	Ejection fraction in echo				χ^2	^{FE}p
	Impaired LV contractility "<50 %" (n =28)		Preserved LV contractility "≥50 %" (n=27)			
	No.	%	No.	%		
Left Ventricular Contractility in chest ultrasound						
Low	26	92.9	0	0.0	47.549*	<0.001*
Normal	2	7.1	27	100.0		

χ^2: Value for Chi square
FE: Fisher Exact test
*: Statistically significant at p ≤ 0.05

Table-7. Comparison between the two studied groups according to different parameters

	Group B (n = 15)		Group D (n = 9)		Total (n = 24)		Test of sig.	p
	No.	%	No.	%	No.	%		
A. lines in ultrasound chest	13	86.7	9	100.0	22	91.7	χ^2= 1.309	^{FE}p= 0.511
Inferior Vena Cava Size								
>2.1	7	46.7	2	22.2	9	37.5	χ^2= 1.434	^{FE}p= 0.389
<2.1	8	53.3	7	77.8	15	62.5		
Inferior Vena Cava Collapsing Index								
>50%	8	53.3	9	100.0	17	70.8	χ^2= 5.929*	^{FE}p= 0.022*
<50%	7	46.7	0	0.0	7	29.2		
Left Ventricular Contractility								
Normal	8	53.3	2	22.2	10	41.7	χ^2= 9.682*	^{FE}p= 0.008*
Low	5	33.3	0	0.0	5	20.8		
Hyperkinetic	2	13.3	7	77.8	9	37.5		
Mean Arterial Pressure								
Min. – Max.	45.0 – 63.0		55.0 – 63.0		45.0 – 63.0		t= 0.270	0.789
Mean ± SD.	57.73 ± 4.88		58.22 ± 2.99		57.92 ± 4.20			
Median	58.0		58.0		58.0			
Central Venous Pressure								
Min. – Max.	1.0 – 10.0		0.0 – 12.0		0.0 – 12.0		t= 1.510	0.145
Mean ± SD.	5.47 ± 2.29		3.67± 3.57		4.79 ± 2.90			
Median	5.0		3.0		5.0			

χ^2: Chi square test
FE: Fisher Exact test
t: Student t-test
*: Statistically significant at p ≤ 0.05

Although all patients with hypovolemic shock had a clear A lines in chest sonography, only in (9.1%) of patients with cardiogenic shock A lines could be traced, Obstructive and septic shock patients showed very near percentage of A lines presence, (88.9%), (86.7%) respectively.

M. Mode finding in chest US was found to have a significant relationship with each group of patients. Normal lung sonographic view (sea shore appearance) was found in 100% of patients presented with cardiogenic and septic shock, Among 9 patients presented with obstructive shock, 5 patients had a tension pneumothorax (55.6%) of the group, these 5 patients had m. mode finding of a barcode which is a specific sign for pneumothorax

Among patients with hypovolemic shock, two patients (22.2%) had a barcode appearance in m. mode Among all patients included in the study, ultrasound chest showed high statistical significance in detection of impaired ventricular contractility, 28 patients out of 55 patients enrolled in the study was diagnosed as impaired systolic function of left ventricle, 26 of them were initially detected as low contractility by chest sonography on admission with

(92.2%) sensitivity and (100%) specificity in relation to echocardiogram.

On comparing septic and hypovolemic shock groups separately according to chest sonography, statistical significance was found in these findings as IVC size, as (77.8%) of patients with hypovolemic shock had an IVC <2.1 cm, while (53.3%) of diagnosed as septic shock had same finding, also a significant difference found in IVC collapse index in each group, as (100%) of patients with hypovolemic shock ha a collapsing IVC >50% with inspiration, while (53.3%)of septic shock patients had same finding.

Left ventricular contractility had the highest significance, in hypovolemic shock patients, (77.8%) showed hyperkinetic left ventricle on admission, and only (22.2%) showed normal contractility, while in septic shock patients (13.3%) showed hyperkinetic LV, (53.3%) showed normal LV contractility and the remaining (33.3%) had low LV contractility,

Mean central venous pressure on admission was non-significantly low in both groups of patients, also mean arterial pressure was non-significantly low in both groups of patients,

Although A line presence was detected in all patients with hypovolemic shock and in (86.7%) of patients with septic shock but it was statistically non-significant in differentiation between the two groups.

DISCUSSION

Shock remains a major cause of mortality in any setting in which it appears and without the appropriate diagnostic and therapeutic approach it is almost invariably lethal. Despite significant technological advances in critical care medicine, the combination of delay in diagnosis and incomplete understanding of its intricate pathophysiology results in high mortality rates. Optimal management requires a multidisciplinary team, in a hospital setting with appropriate diagnostic and management capabilities.[2-3]

The aim of this study was to evaluate the use of chest sonography in assessment of different types of shock presenting to emergency department.

In this study 55 patients were enrolled among them 22 patients had cardiogenic shock (40%). septic shock was diagnosed in 15 patients (27.27%). obstructive shock was the diagnosis of 9 patients (16.36%). Hypovolemic shock was seen in 9 cases (16.36%)

One patient with confirmed diagnosis of cardiac tamponade was enrolled in whom ultrasound findings were: compressed right ventricle, hyper contractile left ventricle, IVC diameter > 2.1 cm and it was compressible less than 50%, and B profile predominance in lung fields

Three patients have been enrolled in this study with diagnosis of massive pulmonary embolism. Diagnosis was confirmed by Ct pulmonary angio (taken as the gold standard for diagnosis). Sonongraphic detection of A profile predominance in lung fields, dilated ivc more than 2.1 cm with poor collapse index less than 50%, dilated right ventricle along with presence of a DVT were 100 % specific to those patients.

This is agreement with meta-analysis of several studies suggesting that lung ultrasound may be a useful diagnostic tool in the management of patients with suspected PE. However, several methodological drawbacks of the primary studies limit any definite conclusion. Further well-designed accuracy studies are necessary before planning diagnostic management studies, in particular in those with a contraindication for CTPA. [59]

Among 9 patients diagnosed as hypovolemic shock, 77% was found to have hyper contractile left ventricle, ivc showed low diameter(< 2.1cm) in 77% of patients but 100% of patients presented collapsible ivc >50%, all patients presented a. profile predominance and three patients were found to have signs of pneumothorax. (absent lung sliding, barcode view in M mode, and lung point were found only in one patient).

This is in agreement with Mohammad Reza Ghane et al. who found acceptable efficacy for RUSH protocol to define hypovolemic shock type (86% agreement, 100% sensitivity, and 94.6% specificity).[60]

Eye balling of left ventricular contractility had detected poorly contractile LV in 20 patients diagnosed as cardiogenic shock weighing 90.9% sensitivity in relation to formal echocardiogram as a gold standard,

Sensitivity was even more (92.9%) when calculated for whole study. This finding was agreed with Mohammed Reza et al 2015 in which sensitivity of us in detection of cardiac impairment was 91.7%[60]

B. profile predominance in patients diagnosed as cardiogenic shock was found in 95.5% of patients exceeding sensitivity of x.ray which showed bilateral opacities in 90.9% in patients confirmed to have cardiogenic shock.

Detection of pleural effusion In 36.4% of patients with cardiogenic shock was not of a statistical significance rather than detection of engorged IVC (diameter >2.1cm) and collapsing index <50% in all patients weighing 100 % sensitivity.

Chest sonogram in patients with septic shock revealed consolidation patches in lung fields in 7 patients 46.7% of patients, 5 of them (33.3%) found to have pleural effusion.

LV contractility remained in normal range in 8 patients (53.3%), 5 patients presented with poorly contractile LV, While two patients showed hyper contractile LV. ivc size and collapse index were non significantly related to this type of shock. Based on previous findings, sonographic finding in septic shock showed low specificity and that could be attributed to different presentations and causes of sepsis in our study.

Previous studies (Mohammed Riaz et al 2015) presented high specificity (100%) but low sensitivity (75%) of us in diagnosis of distributive shock[60]

This may be attributed to the different types of distributive shock cases enrolled in each study. In our study cases included MVO, diabetic foot an pneumonia while Riaz et al enrolled only pneumonia cases in this category.[60]

CONCLUSION

1) In a field where everything must be fast and accurate, lung ultrasound plays a first-line role in the diagnosis of acute circulatory failure.
2) Thoracic ultrasound adds significant value in diagnosing patients with shock with its different categories. Therefore, it should be implemented into emergency diagnostic procedures of patients presenting with shock symptoms.
3) Other benefits such as the potential for cost, time, and radiation are extra advantages. With the correct training and accreditation process established, thoracic ultrasound will likely hold great promise, but as yet remains in its infancy.
4) As with many techniques in medicine, it has had to go through an experimental phase to prove the technology. The challenge now is to take a promising tool from the clinical research setting and develop it into a new skill for the practicing clinician to adopt.
5) This study highlight the role of resuscitative ultrasound and the RUSH protocol in guiding the care of the patient in shock. Due to the noninvasive nature of ultrasound and its ability to provide repeated assessment of physiology during resuscitation, this modality has moved to the front line of emergency care and is considered among the new and important uses of ultrasound by the American College of Emergency Physicians and Critical Care Societies.

RECOMMENDATIONS

1. Physicians caring for critical patients should strongly consider integrating focused ultrasound techniques, such as the RUSH exam, into their resuscitation pathways to augment their clinical evaluation and guide resuscitation.
2. In conclusion, the RUSH exam provides a sequenced approach to ultrasound in the medical shock patient. Using the HI-MAP components, we can evaluate for the causes and potential responses to treatments of hypotension and tissue malperfusion. Hopefully, it will inspire the same alactrity to perform ultrasound in sick non-trauma patients as the FAST exam has in traumatic instability.
3. The name of the exam, **RUSH**, ought to inspire the same alacrity to perform ultrasound in the sick medical patients as the ubiquitous FAST has in trauma.
4. For educational videos covering all RUSH applications, please go to http://www.sound-bytes.tv. This site contains a series of free access videos to further teach the clinician how to perform the RUSH exam.

Conflict of Interests:

The authors declare that there is no conflict of interests regarding the publication of this paper.

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