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Rule of RUSH protocol in management of shocked patients

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Abstract

Background: Clinical assessment and classification of shock is extremely difficult to conduct on critically ill patients. Rapid Ultrasound in Shock (RUSH) is an easily learned and quickly performed shock ultrasound protocol, it allows for rapid evaluation of reversible causes of shock and improves accurate diagnosis in undifferentiated hypotension.

Objectives: to evaluate the accuracy of early RUSH protocol performed by chest physicians to predict type of shock and its guide of resuscitation in critically ill patients. **Patients and Methods:** Study was conducted on 68 patients with shock state in Respiratory Intensive Care Unit (RICU) of Chest Department at Assuit University Hospital and evaluated for the cause of shock by performing early RUSH protocol for patients. Patients received all needed standard therapeutic and diagnostic interventions without delay and were followed to document their final clinical diagnosis. The agreement between the initial impression provided by RUSH and the final diagnosis was investigated by calculating the Kappa index. Sensitivity, Specificity, positive predictive value (PPV) and negative predictive value (NPV) of RUSH for diagnosis of each case.

Results: We performed RUSH examination on 68 shocked patients. 39 were males (58%) and 29 were females (41%), with mean age 58 years. Kappa index was 0.85 (P= 0.0001), reflecting acceptable general agreement between initial impression and final diagnosis. For hypovolemic, cardiogenic and obstructive shock, the protocol had an NPV above 97%, but it had low sensitivity. For shock with distributive or mixed etiology, RUSH showed a PPV of {97% & 100%} respectively, with high sensitivity. The agreement of protocol for final diagnosis was highest in distributive and obstructive shock followed by cardiogenic and hypovolemic shock [(94% & 93%), P < 0.001 & (84% & 73%), P < 0.001,] respectively. There was a statistically significant relationship between IVCe, IVCi & IVC index and different types of shock ($P < 0.0001$).Also There was a statistically significance relationship between CVP and different types of shock (P= 0.0001). There was a statistically significance correlation between CVP and IVC index ($P < 0.0001$), IVCe diameter ($P < 0.0001$), and IVCi diameter ($P < 0.0002$).

Conclusion: We highlight the role of integrating focused ultrasound techniques, such as the RUSH examination, in the physician resuscitation pathways to diagnose shock etiology, augment their clinical evaluation and guide resuscitation.

Clinical Implications: Early identification of causes of shock in critically ill patients allow good clinical evaluation and guide resuscitation and help physician to used correct treatment.

Keywords: cardiogenic shock, hypovolemic shock, obstructive shock, rapid ultrasound in shock, RUSH exam., Shock.

Introduction:

Assessment of hemodynamic status in a shock state remains a challenging issue in Emergency Medicine and Critical Care (1). Shock includes conditions that threatens life and is divided into four categories including cardiogenic, hypovolemic, distributive and Obstructive (2). Good outcomes rely on rapid diagnosis and definitive treatment. All physicians should possess the skills to recognize the critically ill patient and investigate appropriate initial management (3). Ultrasound protocol use for diagnosis and management of shock has become commonplace and is emerging as the standard of care in emergency departments and intensive care settings worldwide (4). The RUSH is a novel emergency ultrasound protocol that uses pulmonary assessment with cardiac, abdominal, and venous evaluation. (1,5). The RUSH protocol is consisted from three stages (categories) with different factors including the pump (investigates Pump's anatomy of the heart cavity, mechanical stresses on it and the cardiac contractile power, right ventricular: left ventricular ratio as a surrogate marker for massive pulmonary embolism and the obstructive condition of cardiac output like cardiac tamponed and Massive pulmonary emboli); the tank (inferior vena cava for volume status, peritoneal and pleural cavities for free fluid); and the pipes (thoracic aorta for evidence of dissection, abdominal aorta for abdominal aortic aneurysm (AAA), and the lower extremity veins for deep venous thrombosis) (6, 7). RUSH technique is one of protocols used for early diagnosis and continuous monitoring of patients in critical care units and emergency departments (1, 8). This study was thus conducted to evaluated the accuracy of early RUSH protocol performed by chest physicians to predict type of shock and its guide of resuscitation in critically ill patients.

Patients and Methods:

The present prospective study was conducted on 68 patients with shock 39 males (58%) and 29 females (41%) their age ranged from 20 to 85years with mean age 58 years. All patients were admitted to the medical emergency room, Respiratory Intensive Care Unit (RICU) of Chest Department at Assuit University Hospital and were evaluated for the cause of shock. The approval of the study obtained from the faculty research ethics committee in Faculty of Medicine of Sohag University.

Inclusion criteria:

The patient who was shocked with:

1. Hypotension (systolic BP <90 mm Hg) or a 30-mm Hg fall in baseline BP, mean arterial pressure (MAP) <60 mmHg.
2. Tachycardia (heart rate > 100).
3. Tachypnea (respiratory rate >22).

Exclusion criteria:

1. Patients who were not shocked.
2. Patients with trauma history.
3. Children.

Methods:

Bedside ultrasound examination on the basis of the RUSH protocol was performed within 1 hour of admission to the ICU. The RUSH protocol is evaluated at three important steps: the pump (heart), the tank (IVC), and the pipes (aorta), (1). These patients were also evaluated clinically and biochemically to confirm the type of shock. All patients immediately received standard diagnostic emergent interventions including physical examination, intravenous access for whole blood assays, arterial gas analysis, electrocardiography, continuous cardiac monitoring, supplemental oxygen, chest radiograph and additional investigations were performed wherever required and followed to document their final clinical diagnosis. IVC parameters [IVC diameter during inspiration (IVCi) and expiration (IVCe), and collapsibility index] were measured. The IVC collapsibility index (IVC-CI), which is a widely used parameter in IVC assessment of intravascular volume, was determined as the percentage of the difference between eIVCD and iIVCD divided by the eIVCD as expressed by the following equation: $IVC\text{-}CI = [(eIVCD-iIVCD)/eIVCD] \times 100$. The CVP was also measured in the supine position and was measured manually using a manometer at midaxillary level with patient lying supine. The IVC diameter assessment and CVP measurements were recorded concomitantly. In the current study shock was classified into 4 groups: hypovolemic, cardiogenic, distributive (septic or neurogenic) and obstructive (due to pneumothorax, tamponade, pulmonary thromboembolic disease). Some patients showed a combination of shocks and grouped as mixed type. Patients received all needed standard therapeutic interventions without delay. The agreement between the initial impression provided by RUSH and the final diagnosis was investigated by calculating the Kappa index, Sensitivity, specificity, PPV and NPV of RUSH for diagnosis of each case.

Statistical analysis: Data was analyzed using STATA intercooled version 14.2. Quantitative data was represented as mean, standard deviation, median and range. Data was analyzed using ANOVA for comparison of the means of different groups or more. When the data was not normally distributed Kruskal Wallis test was used. Qualitative data was presented as number and percentage and compared using either Chi square test. Pearson correlation analysis was used to find correlation between different diameters. Graphs were produced by using Excel or STATA program. P value was considered significant if it was less than 0.05. In addition, we assessed the Kappa agreement and reliability indices (sensitivity, specificity, positive (PPV) and negative predictive values (NPV) of this protocol for diagnosis of each type of shock, separately. For this analysis, we excluded patients with unknown final diagnoses.

Results:

Table 1: Demographic characteristics of the studied population

Variable	Number	Percent
Age (year)		
Mean ± SD	57.8±18.2	
Median (range)	63 (20-92)	
Gender		
Females	29	(42.7%)
Males	39	(57.3%)
Occupation		
Housewife	27	(39.6%)
Farmer	16	(23.5%)
Worker	14	(20.6%)
Teacher	5	(7.4%)
Employer	4	(5.9%)
Lawyer	1	(1.5%)
Policeman	1	(1.5%)
Smoking status		
Currant	13	(19.1%)
Ex-smoker	20	(28.4%)
Non-smoker	35	(52.5%)
Smoking index		
Mild	2	(6 %)
Moderate	13	(39%)
Severe	18	(54%)

Table (1): shows; the mean age for the studied population was 57.8 years with the age ranged from 20 to 92 years. 29 cases (44.7%) were females, and 39 cases (57.3%) were males. 35 cases (52.5%) were non-smokers, 13 cases (19.1%) were smokers, and 14 cases (28.4%) were ex-smokers**.** 13 cases (39%) were moderate smokers,18cases (41.5%) were heavy smokers and 2cases (1.89%) were mild smoker.

Table (2): Diagnosis and types of shock based on RUSH criteria.

Type of shock based on RUSH criteria	Number	%
Cardiogenic	11	16.2%
Distributive	30	44.1%
Obstructive	19	27.9%
Hypovolemic	4	5.8%
Mixed	2	2.9%
Not defined	2	2.9%

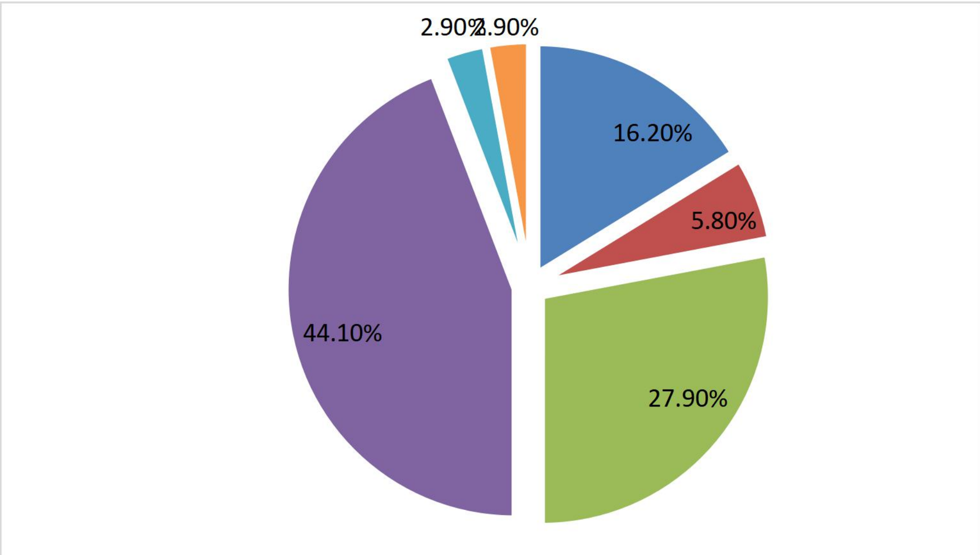

Fig. (1): Diagnosis and type of shock based on RUSH criteria.

Table 2 and fig.(1): show that the most frequent types of shock were distributive (30 patients, 44.1%) and obstructive shock (19 cases, 27.9%). followed by cardiogenic shock eleven patients (16.2%), hypovolemic type of shock four patients (5.8%) and shock due to multiple etiologies two patients (2.9%). Two cases (2.9%) died before we could clinically confirm the exact cause of shock state and were classified as “not defined”.

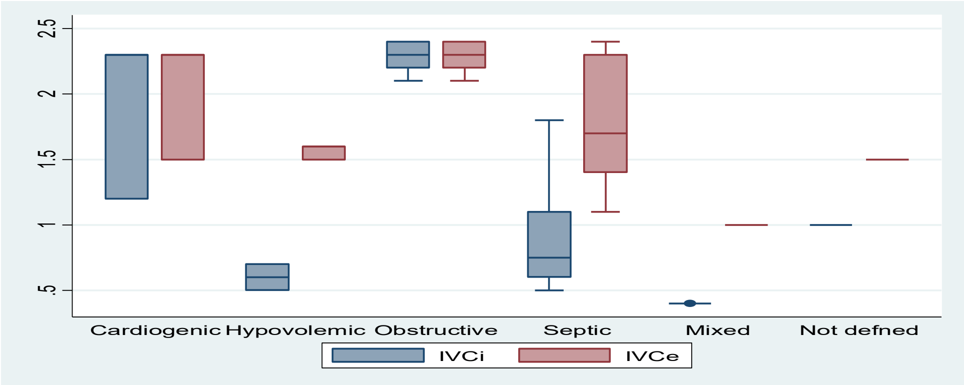

Fig. (2): Relation among different types of shock based on RUSH criteria according to IVC INSP & IVC EXP in patient breathing spontaneously (23).

The mean ± SD IVC expiratory diameter, inspiratory diameter, and collapsibility index were 1.93±0.46, 1.52±0.80 and <50 (15 patients, 65.2%), ≥50 (8 patients, 34.8%), respectively in spontaneously breathing patients. There was a statistically significance relation between IVC inspiratory & IVC expiratory diameter in spontaneously ventilated patients and different types of shock (P= 0.004, 0.01 respectively). (Fig.2).

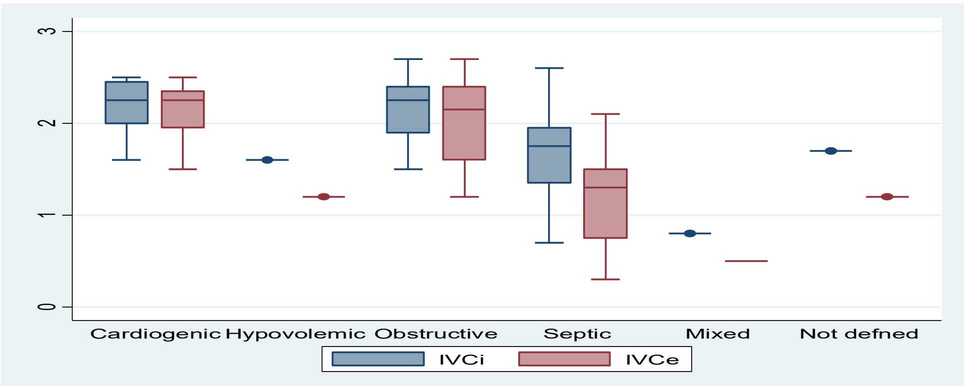

Fig. (3): Relation among different types of shock based on RUSH criteria according to IVC INSP & IVC EXP in mechanically ventilated patient (45).

The mean ± SD IVC expiratory diameter, inspiratory diameter, and collapsibility index were 1.55±0.62, 1.84±0.51 and <12 (15 patients, 33.3%), ≥12 (30 patients, 66.7%), respectively in mechanically ventilated patients. There was a statistically significant relationship between IVC inspiratory & IVC expiratory diameter and different types of shock in mechanically ventilated patients (P=0.02, 0.0003 respectively). (Fig.3)

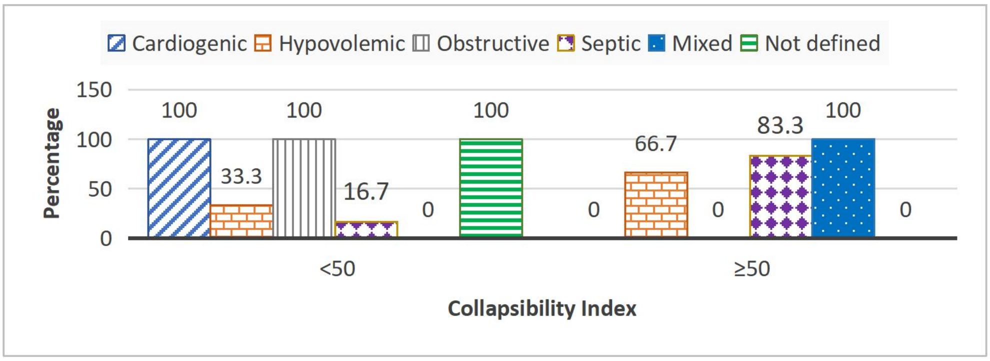

Figure (4): Relation among different types of shock based on RUSH criteria according to collapsibility Index in patient breathing spontaneously (23).

There was a statistically significant relationship between IVC index and different types of shock in spontaneous ventilated patients (P= 0.005). (Fig. 4)

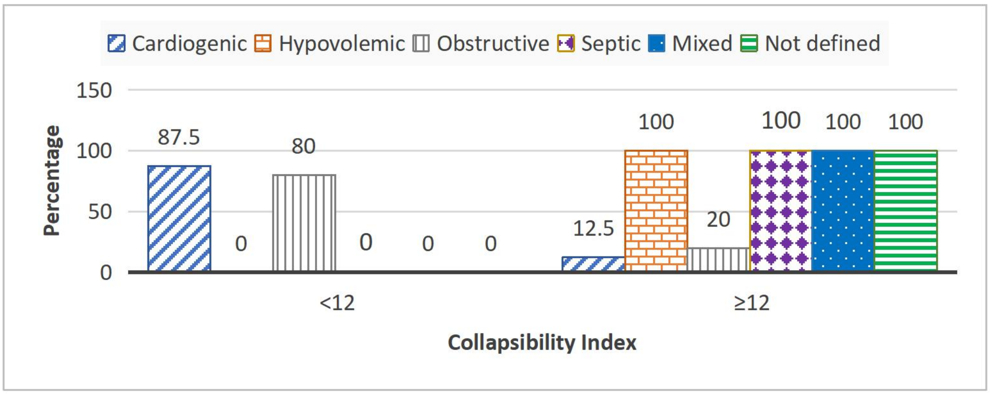

Fig. (5): Relation among different types of shock based on RUSH criteria according to collapsibility Index in mechanically ventilated patient (45).

Fig. (5): Revealed that there was a statistically significant relationship between IVC index and different types of shock in mechanically ventilated patients (P= 0.0001).

Table (3): Relationship between different types of shock based on RUSH criteria and CVP.

Variable	Cardiogenic N=11	Hypovolemic N=4	Obstructive N=19	Distributive N=30	Mixed N=2	Not defined N=2	P value
CVP No Yes	4 (36.4%) 7 (63.6%)	3 (75.50%) 1 (25%)	10 (52.6%) 9 (47.4%)	7 (23.3%) 23 (76.7%)	1 (50%) 1 (50%)	0 2 (100%)	0.15
CVP reading Mean ± SD Median (range)	20.9±3.5 20 (15-26)	6	23.1±4.0 25 (17-27)	10.21±4.1 10 (4-22)	8	17.5±7.8 17.5 (12-23)	0.0001

Table 3: shows that there was a statistically significance relationship between CVP and different types of shock (P= 0.0001).

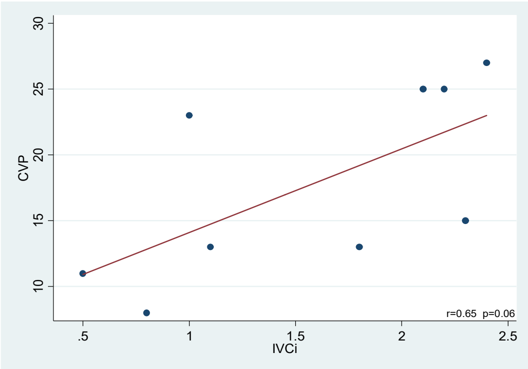

Fig. (6): Correlation between IVCi and CVP in patient breathing spontaneously (23).

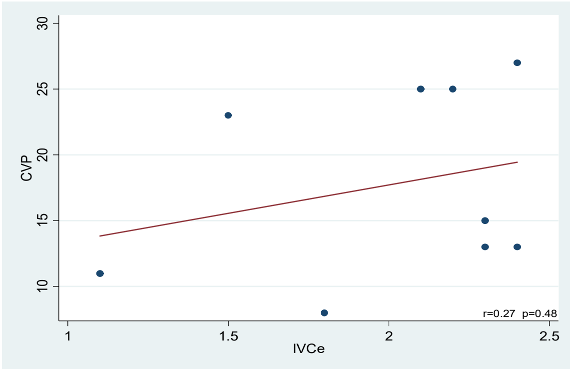

Fig. (7): Correlation between IVCe and CVP in patient breathing spontaneously

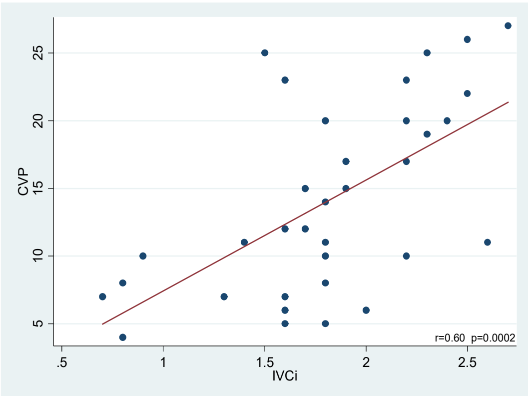

Fig. (8): Correlation between IVCi and CVP in mechanically ventilated patient.

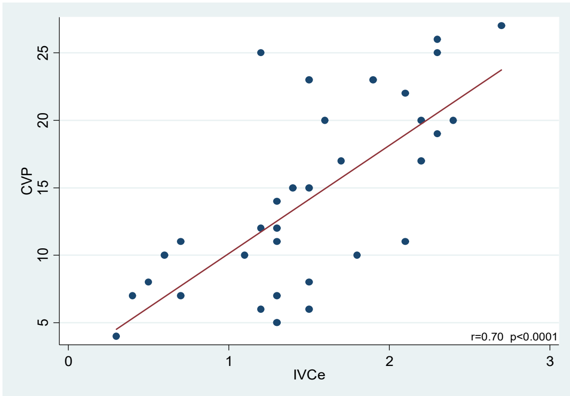

Fig. (9): Correlation between IVCe and CVP in mechanically ventilated patient.

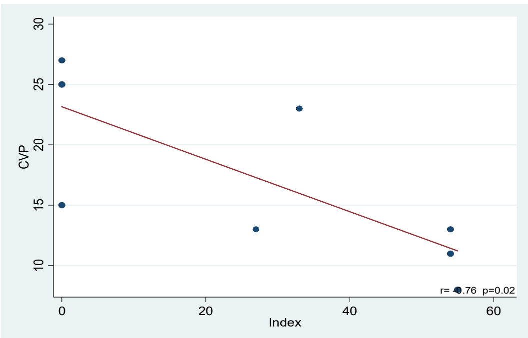

Fig. (10): Correlation between index and CVP in patient breathing spontaneously.

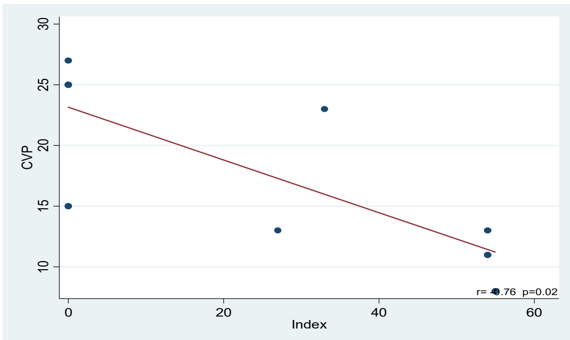

Fig. (11): Correlation between index and CVP in mechanically ventilated patient.

There was a statistically significant correlation between CVP and IVC expiratory diameter, inspiratory diameter, and collapsibility index, with P< 0.0001 in mechanically ventilated patient (Fig. 8, 9 &11). Moreover, there was no significant correlation between the CVP and

IVC expiratory diameter, inspiratory diameter, in patient breathing spontaneously but there was significant correlation between the CVP and collapsibility index with P< 0.02 (Fig. 6,7&10).

Table (4): Relation between different types of shock based on RUSH criteria and hospital stay and outcome:

Variable	Cardiogenic N=11	Hypovolemic N=4	Obstructive N=19	Septic N=30	Mixed N=2	Not defined N=2	P value
LOS in ICU/days Mean ± SD Median (range)	2.1±1.3 2 (1-5)	1.5±0.6 1.5 (1-2)	2.6±1.6 2 (1-6)	3.3±1.4 3 (1-7)	1.5±0.7 1.5 (1-2)	2.5±2.1 2.5 (1-4)	0.046
P3= 0.02, P7= 0.0.01,							
Fate Death Discharge	6 (54.5%) 5 (45.5%)	3 (75%) 1 (25%)	12 (63.2%) 7 (36.8%)	25 (83.3%) 5 (16.7%)	2 (100%) 0	1 (50%) 1 (50%)	0.35

P3 compared Cardiogenic & Septic, P7 compared Hypovolemic & Septic,

Table (4): shows that there was a statistically significance relation between length of stay in ICU and different types of shock. The patients with septic shock stayed in ICU more than other types of shock**.**

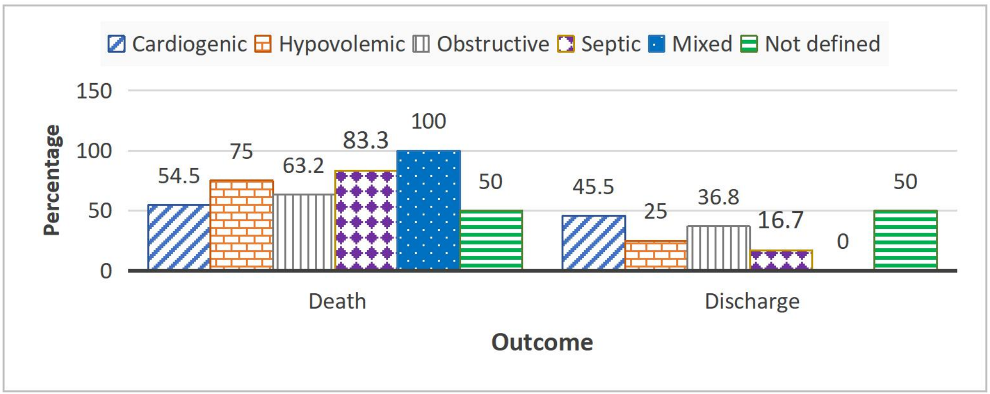

Figure (6): Comparison among different types of shock based on RUSH criteria according to outcome.

Figure (6): show that death rate was higher among patients with septic & mixed shock (83.3% & 100% respectively) in comparison with cardiogenic, hypovolemic & obstructive shock (54.5%, 75% & 63.2% respectively). Of the 68 patients, 72% patients died, 28% discharged after complete recovery

Table (5): Individual results and prevalence of each shock type based on final diagnosis.

Shock type based on RUSH criteria	Shock type based on clinical diagnosis						Total
	Cardiogenic	Hypovolemic	Obstructive[a]	Distributive[b]	Mixed	Not Defined c	
Cardiogenic	10	1	0	0	0	0	11
Hypovolemic	1	3	0	0	0	0	4
Obstructive	0	0	18	1	0	0	19
Distributive	1	0	0	27	0	2	30
Mixed	0	0	0	0	2	0	2
Not defined	0	0	1	0	0	1	2
Total[d]	12	4	19	28	2	3	68
Percent agreement =89.7, kappa=0.85, p<0.0001							

a. Due to pneumothorax, pulmonary thromboemboli, tamponed.

b. Including septic shock, neurogenic shock.

c. Due to early death of patients, before definite clinical diagnosis

d. Data are presented as No. (%)

Table (5): shows that on the clinical diagnosis 12 cases were diagnosed cardiogenic shock while RUSH protocol diagnosed 11 cases, on the clinical diagnosis 28 cases were diagnosed distributive shock while RUSH protocol diagnosed 30 cases with distributive shock. Two cases (2.9%) died before we could clinically confirm the precise cause of shock state and were classified as “not defined etiology”.

Table (6): Reliability indices of RUSH criteria in diagnosis of each shock type

Reliability Index	**Shock type based on final diagnosis (number of cases)**				
	Cardiogenic N=12	**Hypovolemic N=4**	**Obstructive N=19**	**Distributive N=28**	**Mixed N=2**
Sensitivity	83.3	75.0	94.7	96.4	100
Specificity	98.1	98.4	97.8	97.3	100
PPV	90.9	705.0	94.7	96.4	100

NPV	96.3	98.4	97.8	97.3	100
Agreement	95.4	96.9	96.9	96.9	100
Kappa	0.84	0.73	0.93	0.94	100
P value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

NB. Patients with final diagnosis of “not defined” etiology was excluded for calculation of reliability indices. PPV: Positive predictive value NPV: Negative predictive value Kappa: Index of agreement between diagnosis of shock type based on RUSH criteria and final diagnosis.

Table (6): shows that RUSH protocol had a statistical significance in diagnosing different types of shock (P <0.0001). It shows that it had high sensitivity with obstructive and septic shock (94.7%, 96.4% respectively), while low sensitivity with cardiogenic and hypovolemic shock (83.3%, 75% respectively).

Discussion:

Rapid Ultrasound in Shock (RUSH) is a recent emergency ultrasound protocol that integrates pulmonary evaluation with cardiac, abdominal and venous examination. It involves evaluation of heart (to assess tamponade, ejection fraction and strain of right ventricle), inferior vena cava (to estimate central venous pressure), thoracic and abdominal compartments (to assess pneumothorax, pulmonary edema, pleural effusion and peritoneal free fluid) and large arteries or veins (to assess aortic dissection or aneurysm and deep vein thrombosis) (9). The RUSH protocol has advantages including learning doing, the simple equipment needed, simplicity and a possible direct vision of volume.

In this study we tried to determine the type of shock of patients in respiratory intensive care unit (RICU) according to RUSH protocol aiming to decide accurate management and improve the outcome and hence save time and cost. We enrolled 68 patients consisting of 39 males and 29 females with mean age of 58 years (age range 20-92years) .

Our study shows that there was a significant relationship between different types of shock and chest ultrasound finding (P= 0.04). 14 cases (46.7%) with septic shock had consolidation, 14 cases (46.7%) with septic shock had pleural effusion and it was Parapneumonic. This result agreed with Vignon et al (10) who found that chest ultrasonographic findings of patients sustaining severe pneumonia associated with septic shock show lung consolidation and pleural effusion. This result supported by Nermeen et al (3) who found that sensitivity, specificity and diagnostic accuracy of lung ultrasound in diagnosing pleural effusion were 95.4%, 97.1% and 96% respectively and also show that Sensitivity and specificity of ultrasound was higher in diagnosing pneumonia (89.3% and 97.7%) respectively. Moreover Our results were similar to the results obtained by El Mahalawy et al (11), including 130 mechanically ventilated and non-mechanically ventilated patients with thoracic ultrasound sensitivity of 94% and a specificity of 96% and Regarding pneumonia diagnosis, US showed a sensitivity of 93%, specificity of 95%, PPV of 98%and NPV of 87% and we found 5 cases (45.5%) with cardiogenic shock had B –lines. This result agreed with Volpicelli et al (12) who found that bedside chest ultrasound of acute decompensated heart failure patients show B-line pattern

The present study found that there was a statistically significant relationship between IVC inspiratory diameter and IVC expiratory diameter in spontaneously and mechanically ventilated patients and different types of shock (P= 0.004, 0.02 & 0.01, 0.0003 respectively). This result agreed with Mohammad et al (13) who found significant correlation between IVC expiratory diameter, inspiratory diameter, and collapsibility index, and the type of shock, with P value less than 0.001. Sefidbakht et al (14) found that measurement of IVC diameter can be a very useful way to evaluate the patient's hemodynamic status, that the measurement of IVC diameter is a reliable indicator of shock in trauma patients and may even predict it in patients who still have normal blood pressure due to sympathetic over activity. We found positive correlation between IVCe and IVCi and blood pressure in spontaneous breathing. This agreed with Lyon et al (15) who found that the measurement of the IVC diameter is a reliable indicator of blood loss specially the measurement of the IVCe may be an important addition to the ultrasonographic evaluation of trauma and other potentially volume-depleted patients. Youssif et al (16) show significant correlation between IVCi, IVCe and both systolic and diastolic blood pressures, but there was no significant correlation between IVC index and both systolic and diastolic blood pressures, also Youssif, et al (16) found that values of IVC diameter during inspiration and during expiration and IVC index were statistically significant different before and after resuscitation (>0.01). Moreover, found that both IVCi and IVCe diameters were half their values before resuscitation; in contrast, IVC index was high. Yanagawa and colleagues (17) found that there is an increase in IVC e diameter after resuscitation from 7.7 to 13.5 mm, (P=0.001). Caplan et al (18) demonastrate that the measurement of cIVC is a fast, non-invasive and easy-to-implement tool which could improve clinical management of the acute phase of sepsis in SB patient & interaction between cIVC and FR is dependent on the way in which IVC diameter is measured: the best diagnostic accuracy for predicting FR is at 4 cm caudal to the cavo-atrial junction

Our study found that there was a positive significant correlation between sonographic measurements of IVC diameter (expiratory and inspiratory) and CVP. This result agreed with Khalil et al. (19) who found that CVP correlated well with expiratory IVC diameter and with inspiratory IVC diameter, and Ilyas et al. (20) who found a strong positive correlation between the CVP and the expiratory IVC diameter and the inspiratory IVC diameter. Ciozda et al (21) who found that sonographic measurement of IVC diameter is a valid method of estimating CVP. However, Wiryana et al. (22) found that there was a weak correlation between CVP and maximum IVC diameter and minimum IVC diameter. Also Mohammed et al (13) showed a statistically significant correlation between CVP and IVC expiratory diameter, and inspiratory diameter, with P value less than 0.001. Thanakitcharu et al. (23) and Mohammed et al (13) also found a significant correlation between the CVP and IVC- CI. This result is also in accordance with study performed by Stawicki et al (24), as they found that measurements of IVC- CI best correlated with CVP in the setting of low (≤20%) and high (≥60%) collapsibility ranges. On the contrary, Govender et al. (25) found that there is no association between CVP and IVC- CI, and there was a weak negative correlation between CVP and IVC- CI. Also we found statistically significant correlation between the CVP and the type of shock, with P value less than 0.001. Findings of Mohammed and colleagues (13) are in agreement with our claims that there is a positive correlation between the CVP and the type of shock. _So assessment of intravascular volume by measuring the IVC- CI and Diameter (IVC expiratory diameter & inspiratory diameter), using bedside ultrasonography has many advantages, as it is safe, noninvasive, portable, and faster assessment than inserting CVC in measuring fluid status (26).

The current study showed that there is no significance relation between outcome of shocked patients and RUSH protocol (P=0.35). This result agreed with Bagheri-Hariri, (27) who found that there was not a significant relationship between mortality and the protocol used for diagnosis (P=0.52), although the mortality rate was 64 %. Also, Elbaih et al. (28) revealed overall mortality rate of 43%. This can be explained that patients were in severe shock state.

Our study clearly delineates that in the setting of patients in shock state and under the care of chest physician with expertise in ultrasonography, initial impression provided by performing

RUSH protocol early after admission was notably congruent with the final clinical diagnosis reached at the course of hospitalization (Kappa index =0.85 and P<0.0001).This agreed with Tabibzadeh Dezfuli et al (29) who reported an appropriate Kappa correlation coefficient by (Kappa=0.85) for comparison of RUSH technique and final diagnosis that show efficiency of the protocol. Bagheri Hariri et al. (27) reported Kappa correlation coefficient for comparison of the RUSH technique and the final diagnosis by (0.84%, p value=0.0001) that shows a high compliance rate of the protocol with sensitivity and specificity of (88% & 96%). Another study reported Kappa's correlation coefficient for comparison of the RUSH by 0.85 Mohammed et al (13). Javali et al (30) found that the overall kappa correlation of the combined evaluation with PoCUS was 0.89, which shows an almost perfect agreement with the final diagnosis. Rahumalkur et al (31) found that Kappa index was 0.860. Kappa reflects acceptable general agreement between point-of-care Ultrasound (RUSH protocol) and medical diagnosis.

Also, this result agreed with the study of Ghane et al (9) who applied RUSH Protocol by emergency physicians to predict the shock type in critically ill patients and reported the index of agreement (Kappa index = 0.71 and P= 0.000) between shock type diagnosed based on a similar protocol and final clinical diagnosis of patients. Also, Volpicelli et al (12) have reported the same index of agreement (Kappa index = 0.71) between shock type diagnosed based on a similar protocol and final clinical diagnosis of patients. Moreover Elbaih et al (28) reported that The sensitivity, specificity, PPV and NPV of RUSH in different types of shock is 94.2%, 96.2%, 87.8% and 96.1% respectively, and thus the accuracy of RUSH was 95.2%. In addition, Stawicki et al (24) noted that the sensitivity, specificity, PPV and PNV for US were 86.2%, 97.2%, 89.3%, 96.3%.

We found that the most frequent types of shock were distributive (30 patients, 44.1%) and obstructive shock (19 cases, 27.9%), followed by cardiogenic shock eleven patients (16.2%), hypovolemic shock four patients (5.8%), and shock due to multiple etiologies two patients (2.9%). This is in agree with Seif et al.'s report in 2012 (1). But not in agreement with Ghane et al 2015 (9) who found that the most frequent types of shock were cardiogenic shock (12 patients, 23.1%) and shock due to multiple etiologies (10 patients, 19.2%), Eight patients had hypovolemic, eight distributive, and seven obstructive type of shock. Also not match the work by Rahumalkur et al (31) who reported that the most frequent type of shock observed by point-of-care ultrasound (RUSH protocol) was cardiogenic shock (29/97 patients, 29.9%) followed by hypovolemic shock (21 patients, 21.6%), mixed-type shock (18 patients, 18.6%), obstructive shock (16 patients,16.5%), and distributive shock (13 patients,13.4%). Moreover Elbih et al (28) found that the major cause of unstability in polytrauma patients diagnosed by RUSH is hypovolemic shock (64%), followed by obstructive shock (14%), distributive shock (12%) and then cardiogenic shock (10%). Also Bagheri-Hariri et al (27) reported that according to the expert ICU panel and the medical charts, the final diagnosis of the patients showed that hypovolemic shock was the most common type of shock in this study (68 %), followed by cardiogenic shock (12 %), distributive shock (12 %), and an overlap of hypovolemic and distributive shock (8 %).

Our study shows that the protocol had largest agreement with final diagnosis 93% ($P<0.001$) in group of obstructive shocked patients. Sensitivity and NPV were both 94.7 %, 97.8%; specificity and PPV were 97.8%, 94.7 respectively. This result agreed with the study of Ghane et al (9) who found that the criteria had largest agreement with final diagnosis 92%, ($P < 0.001$) in this group of patients. Sensitivity and NPV were both 100%; specificity and PPV were 97.4% and 87.5%, respectively. This study also agreed with Tabibzadeh Dezfuli et al (29) who showed 88.9%, 97.7%, 96.2%, 88.9%, 97.7% and 0.77% for sensitivity, specificity, accuracy, PPV, NPV and agreement, respectively in diagnosis of obstructive shock. Elbaih et al (28) demonstrated Sensitivity 92.9% Specificity 97.7% PPV 86.7% NPV 98.8% for obstructive Shock. Javali et al (30) reported that in patients with obstructive shock, combined clinical evaluation with PoCUS was in perfect agreement with Cohen's kappa coefficient (κ) = 1 and sensitivity 100%, specificity 100%, PPV 100%, and NPV 100%. Also, Rahumalkur et al (31) found 100%, 98.8%, 93.7% and 100%, sensitivity, specificity, PPV, and NPV in patients with Obstructive shock.

The present study shows that the protocol had an acceptable agreement with final diagnosis in distributive shocked patients as well 94% ($P < 0.0001$). It was shown that the specificity of the protocol to diagnose distributive shock and its PPV, NPV were 97.3%, & 96.4%, 97.3% but the sensitivity was considerably lower (96.4%), compared to other types of shock. This result agreed with Tabibzadeh Dezfuli et al (29) who showed 90%, 97.7%, 96.2%, 90%, 97.7% and 0.47% for sensitivity, specificity, accuracy, PPV, NPV and agreement, respectively. This result also agreed with the study of Ghane et al (9) who found that the specificity of the protocol to diagnose distributive shock and its PPV were 100% NPV 94.9%, agreement 0.83%,and p value < 0.001 but the sensitivity was considerably lower (75%) compared to other types. This difference in percentage of specificity is due to our patients had chest diseases and most of them were pneumonia. Elbaih et al (28) reported sensitivity 91.7%, specificity 96.6%, PPV 78.6%, and NPV 98.8% for RUSH protocol in diagnosis of Distributive shock. Also Bagheri-Hariri et al (27) reported a sensitivity 75% , specificity 100%, positive predictive value (PPV) 100%, negative predictive value (NPV) 95.5%, p value<0.002, and kappa correlation 0.83%. Javali et al (30) found that those with distributive shock were in substantial agreement with Cohen's kappa coefficient (κ) = 072% with sensitivity 73.7%, specificity 100%, PPV 100%, and NPV 86.1%. Rahumalkur et al (31) found 75%, 98.8%, 92.3% and 95.2% sensitivity, specificity, PPV, and NPV, in patients with Distributive shock.

Our study shows that there was agreement of this protocol for diagnosis of patients with cardiogenic shock (84%). These criteria had quite good indices for diagnosis of shocks with cardiac etiology, especially to rule out cardiogenic state (NPV = 96.3 %). This result agreed with Ghane et al (9) who found that the RUSH protocol had an acceptable agreement with final the diagnosis of patients with cardiogenic shock (89%, *P* value < 0.001), which was the most frequent type of shock (23.1%) in their study with the sensitivity, specificity, PPV, and NPV of 91.7%, 97.0%, 91.7%, and 97.0%, respectively. Also this result agreed with Tabibzadeh Dezfuli et al (29) who reported 87.5%, 97.3%, 94.2%, 93.3%, 97.3% and 0.62% for sensitivity, specificity, accuracy, PPV, NPV and agreement respectively for RUSH protocol in diagnosis of this shock type, and in agree with Seif and their collage's study (1). Moreover Elbaih et al (28) demonstrate that RUSH is most accurate in detecting cardiogenic shock (sensitivity 100.0%, specificity 98.9%, PPV 90.9%, and NPV 100.0%). Bagheri-Hariri et al (27) reported a sensitivity 60% , specificity 100%, positive predictive value (PPV) 100%, negative predictive value (NPV) 90.9%, p value<0.004, and kappa correlation 0.71% for RUSH protocol in diagnosis of cardiogenic shock. Rahumalkur et al (31) Cardiogenic shock 96.3%, 95.7%, 89.6% and 98.5% sensitivity, specificity, PPV, and NPV. Javali et al (30) reported that in patients with cardiogenic shock, combined clinical evaluation with PoCUS had sensitivity 100%, specificity 98.7%, PPV 95.2%, NPV 100% and kappa coefficient (κ) = 0.95%.

In our study, we found acceptable efficacy for RUSH protocol to define hypovolemic shock type (73% agreement, 75% sensitivity, and 98.4% specificity) this result was not in agreement with Ghane et al (9) who found that the acceptable efficacy for RUSH protocol to define hypovolemic shock type was (86% agreement, 100% sensitivity, 94.6% specificity, NPV 100%, PPV 80%% and *P* value < 0.001). This disagreement may be due to the difference in type of patients & place of study our study conducted in chest ICU & included patients with medical problems but their study of Ghane et al (9) was conducted in emergency department and include trauma patients or patients with GIT bleeding. Bagheri-Hariri et al (27) found highest agreement of RUSH protocol with hypovolemic shock in polytrauma patient with a sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and kappa correlation and p value, of (100%, 72.7%, 82.4%,100%, 0.75% & <0.0001, respectively).Moreover Tabibzadeh Dezfuli et al (29) reported results of 88.20%, 100%, 96.20%, 100%, 94.6% and 0.98% for sensitivity, specificity, accuracy, PPV, NPV and agreement, respectively for RUSH protocol in hypovolemic shock. Also Elbaih et al (28) reported sensitivity 92.2%, specificity 91.7%, PPV 95.2%, and NPV 86.6% for RUSH protocol in diagnosis of hypovolemic shock. Rahumalkur et al (31) found 94.4%, 94.9%, 80.9% and 98.7%, sensitivity, specificity, PPV, and NPV in patients with hypovolemic shock. Javali et al (30) reported that in patients with hypovolemic shock, RUSH protocol had sensitivity 100%, specificity 98%, PPV 85.7%, NPV 100% and kappa coefficient (κ) = 0.86%.

In addition, when there is more than one underlying mechanism for shock (mixed type), the protocol showed the sensitivity (100%) and had the agreement (100%) and this result was not in agreement with Ghane et al (9) who found that this protocol had lowest agreement (74%) with final diagnosis, the sensitivity, specificity, PPV, NPV agreement and p value of protocol were (70%,100%,100%,92.1%,74% & p value< 0.001 respectively). This can be explained by the number of patients was 2 cases while in study of Ghane et al (9) was 10 patients. Bagheri-Hariri et al (27) reported a sensitivity 100% , specificity 100%, positive predictive value (PPV) 100%, negative predictive value (NPV) 100%, p value<0.003, and kappa correlation 1.0 for RUSH protocol in diagnosis of mixed type of shock. Rahumalkur et al (31) found 80.9%, 98.7%, 4.4% and 94.9% sensitivity, specificity, PPV, and NPV, in patients with Mixed-type shock. Moreover, Javali et al (30) demonstrate sensitivity 92%, specificity 90.4%, PPV 76.5%, NPV 97% and Cohen’s kappa coefficient (κ)= 0.76%.

Conclusions:

We highlight the role of integrating focused ultrasound techniques, such as the RUSH examination, in the physician resuscitation pathways to diagnose shock etiology, augment their clinical evaluation and guide resuscitation.

Clinical Implications:

Early identification of causes of shock in critically ill patients allow good clinical evaluation and guide resuscitation and help physician to used correct treatment.

Authors' contributions

All authors contributed toward data analysis, drafting and revising the paper and agreed to be responsible for all the aspects of this work.

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