Review Article

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Diagnostic Accuracy of Rapid Ultrasound in Shock (RUSH) Exam; A Systematic Review and Meta-A nalysis

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ABSTRACT

Objective: To perform a diagnostic accuracy of the rapid ultrasound in shock (RUSH) to diagnose the etiology of undifferentiated shock in patients presenting to the emergency department (ED).
Methods: We searched the Medline via PubMed, Scopus, and ISI Web of Knowledge till July 2017. Two independent reviewers screened studies for eligibility. Our study analysis is planned in accordance with the guidelines for meta–analysis of diagnostic studies. In the systematic search, of 397 references, 295 were excluded on the basis of the title and abstract. For the remaining 102 articles, the full text was retrieved and critically reviewed. After the selection process, five papers were included.
Results: The pooled estimate of all data showed that the RUSH protocol exhibited high sensitivity (0.87, 95% Confidence Interval (CI): 0.80-0.92, I^2=46.7%) and specificity (0.98, 95% C. I.: 0.96-0.99, I^2=30.8%). The AUC for SROC, a global measure of the RUSH protocol performance, was 0.98±0.01, indicates the high accuracy of the test. Positive and negative likelihood ratios reported from the studies ranged from 9.83 to 51.32 and 0.04 to 0.33, respectively. The pooled estimate of all data showed that the RUSH protocol exhibited high positive likelihood ratio (19.19, 95% C. I.: 11.49-32.06, I^2=14.1%) and low negative likelihood ratio (0.23, 95% C. I.: 0.15-0.34, I^2=18.4%).
Conclusion: This meta-analysis suggests that RUSH protocol has generally good role to distinguish the states of shock in patients with undifferentiated shock referred to the emergency department.

Keywords: Ultrasonography; RUSH exam; Rapid ultrasound; Shock examination; Shock.

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Introduction

Shock is a life-threatening condition which is typically divided into four categories: cardiogenic, hypovolemic, distributive, obstructive [1]. There is an increasing trend in the number of cases of shock following the increase in accidents leading to traumatic shocks [2]. Since each type of shock requires a special treatment, we need quick-detection techniques for all kinds of shock in the emergency room and critical care units [2]. Considering the diagnosis of the cause of shock is usually based on the history of the patients or his/her relatives, along with the results of some laboratory tests, there is a possibility of an error, especially in the results of emergency tests [3]. According to this, over the last decade, multi-system shock detection techniques have been used, all based on ultrasound technology [4]. These methods include: Undifferentiated hypotensive patient, focused echocardiographic evaluation in life support, focused echocardiographic evaluation in resuscitation, abdominal and cardiac evaluation in life support, rapid ultrasound in shock (RUSH), critical care ultrasonography (CCUS), echocardiography guided life support [5]. A lot of studies have shown that use of ultrasound in the bedside management of the patients with shock provides an accurate assessment that is associated with improved patient care. One of the newest diagnostic methods used in recent years to detect all types of shock and its causes is the RUSH protocol, which not only has great success in rapid diagnosis at the patient's bedside, but is easily learned and implemented at the moment of the patient's arrival in the emergency room and this training is now included in education programs for emergency medicine residents in United States [5].

The RUSH protocol consists of three steps, in which all three categories of factors (Tank, Pipe, and Pump), which ultimately lead to the occurrence of different types of shock, are examined [5]. The RUSH protocol examines the Pump's anatomy of the heart cavity, the possible mechanical stresses on the heart and the cardiac contractile power and the obstructive situation of cardiac output like cardiac tamponade and Massive pulmonary emboli. In the Tank section, the IVC and jugular venous vein status is evaluated either in collapse or dilation, as well as retention or loss of fluids. In the Pipe section, abdominal arteries and aorta are examined for the presence of aneurysms and Lower Extremities venous system for DVT [5]. In a study by Shahram Bagheri Hariri *et al*. in 2015, the Kappa correlation coefficient for comparing the RUSH protocol and the final diagnosis was 0.84 percent, indicating a high compliance rate of the protocol. In this study, the overall sensitivity of this method (for detection of shock type) is 88% and its overall specificity is 96%. Also, in this study, the type of shock 81% of patients were correctly diagnosed using the RUSH protocol, but 19% of patients were diagnosed as being mistaken [6]. In another study in 2013, Kappa's correlation coefficient for comparison of the RUSH 0.7 protocol has been calculated [7].

Although few studies have been conducted to illustrate the effect of the Rush protocol on the diagnosis and treatment of shock patients, a systematic study has not been done so far. The purpose of this review was to review the effectiveness of the RUSH protocol in determining the exact types of shock in patients referred to the emergency department.

Materials and Methods

Literature Search

Search Strategy: We searched the Medline via PubMed, Scopus, and ISI Web of Knowledge till July, 2017. Following search strategy was used for this study: ["rapid ultrasound in shock" OR "rapid ultrasound in shock protocol" OR "RUSH protocol" OR "rush protocol"]. Flow diagram of literature search and selection of primary study process was shown in Figure 1. For increasing the sensitivity of our search we also searched Google Scholar. Ethical approval was not required as this was a secondary study. Limitations were applied to exclude conference papers, editorials, letters, commentary, short survey, and note. The search was refined to the English language and we did not consider any time limitation. Also we limited our search in human studies, but we didn't any limitation in "title/abstract", due to this logic that our desired results or outcomes might have been considered a secondary aim of the studies.

Hand Searching

To increase the sensitivity and to select more studies, the reference list of the related studies was checked as well.

Selection Criteria

Studies identified from the literature search were selected on the basis of the predefined selection criteria presented below:

Inclusion criteria:

1. All observational studies (cross-sectional studies, case–control studies, cohort studies)
2. Studies investigating the accuracy of RUSH protocol in diagnosis or classification of any type of shock.
3. Studies that investigate the RUSH protocol before doing any treatment procedures for patients.

Exclusion Criteria

1. Conference papers, editorials, letters, commentary, short survey, and note
2. Animal studies
3. Laboratory studies

Data Extraction and Abstraction

EndNote software (Version 6) was used for

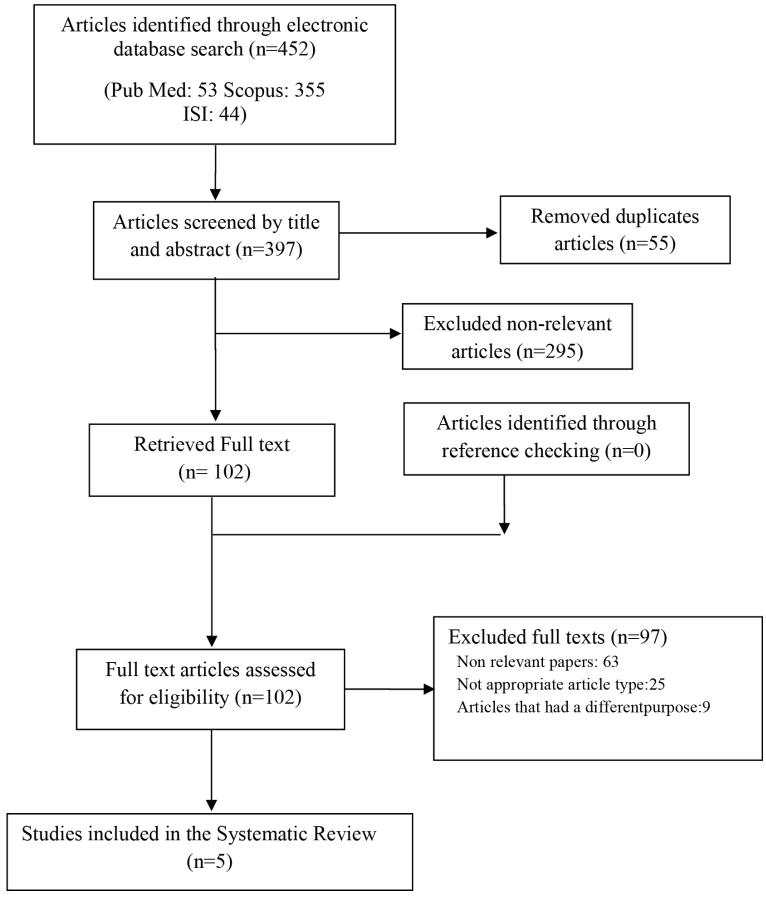

Fig. 1. Literature search and flowchart for selection of primary study.

managing and handling extracted references that were searched from databases. After include all retrieved article into *EndNote*, Duplicates were removed and entered into a duplicate library.Titles and abstracts of papers were screened, and relevant papers were selected. Then, full texts of relevant papers were read, and findings were rescreened. Two independent reviewers (RSN and MK) screened the titles and abstracts of papers, which were identified by the literature search, for their potential relevance or assessed the full text for inclusion in the review. In the case of disagreement, the discrepancy was resolved in consultation with an expert investigator (MM).Two reviewers (MK and RS) abstracted the data independently. The required information that were extracted from all eligible papers was as follows: data on first author name, publish year, location, title of study, characteristics of participants/ sample size, type of study, aim, cure before RUSH, type of shock, result of RUSH compare with final diagnosis, main findings of studies and effect size (i.e.; RR, OR).

Study Selection Strategy

In the systematic search, 397 unique references were identified (Figure 1). Of them, 295 were excluded on the basis of the title and abstract. For the remaining 102 articles, the full text was retrieved and critically reviewed. After the selection process, the review included 5 studies published from 2014 to 2015.

Statistical Analysis

Our study analysis is planned in accordance with the guidelines for meta–analysis of diagnostic studies [6]. We combined the sensitivity, specificity, likelihood ratios, and diagnostic odds ratio to estimate the usefulness of the RUSH protocol in the diagnosis or classification of any type of shock. To provide a global diagnostic performance measure, area under curve (AUC) for the summary receiver operating characteristic (SROC) curves is reported [7]. The AUC values for SROC curves, ≥0.97, 0.93-0.96, and 0.75-0.92 indicate excellent, very good, and good diagnostic accuracy, respectively. I-square statistic was used to assess the observed heterogeneity. The I-square value greater than 50% was considered as the indication of heterogeneous studies [8]. A Deeks' funnel plot was employed to investigate publication bias [9, 10]. Meta-Disk 1.4 [11] and the Midas module [12] in Stata software (Version 13.0; Stata Corp., College Station, TX) were used for meta-analysis.

Results

The summary of characteristic of included studies is presented in Table 1. In addition, we have included information of two case report study that have been report usefulness of RUSH protocol to diagnosis of shock.Sensitivities and specificities reported from

Table 1. Summary of characteristic of included studies.

First Author name, Publish Year	Location/ Type of Study	Characteristics of Participants/sample size	Aim	Result of RUSH Compare with final diagnosis	Main Findings
Ghane, M. R, 2015	Iran/ Cross sectional	All patients in shock state in the working shift of our emergency physician in ED were enrolled in this study from April 2013 to October 2013. A clear cause of shock at patients' arrival mandating prompt life-saving treatment, such as external bleeding or active gastrointestinal bleeding, was our exclusion criteria.	Evaluate the accuracy of early RUSH protocol performed by emergency physicians to predict the shock type in critically ill patients	Hypovolemic shock excellent sensitivity, good Specificity Cardiogenic shock: Good sensitivity and specificity Obstructive shock: Excellent sensitivity, and good specificity Distributive shock: Excellent specificity but low sensitivity Mixed etiology shock: Excellent The final diagnosis was usually established by a second physician in charge (other than emergency physician) whom the patient was transferred to his service (internal medicine, cardiology, or surgery). They were all board-certified specialists with acceptable expertise in their fields of interest. They should declare that these physicians were not blind relative to the information obtained from ultrasonographic Specificity but low sensitivity examination.	Hypovolemic shock excellent sensitivity, good specificity. In hypovolemic patients, RUSH protocol showed 86% agreement with final diagnosis (P value < 0.001). For hypovolemic shock, the protocol had a high sensitivity and NPV (both 100%) but a lower specificity (94.6%) which resulted in substantial low PPV (80%). Cardiogenic shock: Good sensitivity and specificity RUSH showed 89% agreement (P value < 0.001) with final diagnosis. They correctly diagnosed 11 of our 12 patients with cardiogenic shock representing 91.7% sensitivity The specificity, PPV, and NPV of RUSH protocol for diagnosis of this shock type were 97.0%, 91.7%, and 97.0%, respectively. Obstructive shock: Excellent sensitivity, and good specificity. The criteria had largest agreement with final diagnosis (92%, P value < 0.001) in this group of patients Sensitivity and NPV were both 100%; Specificity and PPV were 97.4% and 87.5%, respectively. Distributive shock: Excellent specificity but low sensitivity. The protocol had an acceptable agreement with final diagnosis in these patients as well (83%, P value < 0.001) It was shown that the specificity of the protocol to diagnose distributive shock and its PPV were 100% but the sensitivity was considerably lower (75%) compared to other types. Mixed etiology shock: Excellent specificity but low sensitivity. This protocol had lowest agreement (74%, P value < 0.001) with final diagnosis when patients had mixed etiologies as the cause for their shock state. The protocol had specificity and PPV of 100% and NPV of 92.1% in this group.
Ghane, M. R, , 2015.	Iran/ prospective	Consisting of 38 men and 29 women with mean age of 61.5 years (range of 36 to 82 years) from April 2013 to May 2014. Mean duration time of the exam (from patient's arrival till sonography) was about 20 minutes (range of 10 to 25 minutes	Study purpose was to evaluate the reliability of this protocol to accurately diagnose the type of shock patients. In addition they tried to compare the agreement index between emergency physicians (EP) and radiologists when they used this protocol at EDS.	Excellent sensitivity, good specificity and highest agreement with final diagnoses were seen in hypovolemic shock. *Cardiogenic Shock* Good sensitivity, specificity and good agreement were seen in cardiogenic shock. *Obstructive Shock* Notable reliability indices and agreement were seen in obstructive shock. *Distributive Shock* Good agreement, excellent specificity, but low sensitivity was seen in distributive shock. *Mixed Etiology Shock:* Acceptable agreement, good specificity, while low sensitivity was seen in mixed types of shock All patients were followed during their hospitalization in order to document their final diagnosis. Patients were transferred to other medical units (internal medicine, cardiology, or surgery) and the final clinical diagnosis was established by the second physician in charge. The second physicians were board certified specialists with acceptable expertise in their fields.	Excellent sensitivity, good specificity and highest agreement with final diagnoses were seen in hypovolemic shock. They had 16 cases finally diagnosed as having hypovolemic shocks who were all found based on RUSH findings (100% sensitivity, and 100% NPV)(96.2% specificity and 88.9% PPV). The criteria had the largest agreement with the final diagnosis (92%, P < 0.001) in this group of patients. *Cardiogenic Shock* Good sensitivity, specificity and good agreement were seen in cardiogenic shock. The cardiac etiology of the other two patients with heart failure could not be outlined by the initial RUSH exam (97% NPV). (98% specificity and 94.7% PPV). Agreement of sonography findings with final diagnosis was 89% (P < 0.001) for this shock type. *Obstructive Shock* Notable reliability indices and agreement were seen in obstructive shock among 11 patients with obstructive shocks, they only missed one case, which was due to traumatic rupture of the left hemidiaphragm (90.9% sensitivity and 98.3% NPV).One patient was labeled as having an obstructive shock but was found to have a mixed etiology (98.2% specificity and 90.9% PPV). Agreement of sonography findings with final diagnosis was 89% (P < 0.001) for this type of shock. *Distributive Shock* Good agreement, excellent (72.7% sensitivity and 95.1% NPV). The protocol demonstrated good agreement with final diagnosis in these patients (0.81, P < 0.001). Specificity, but low sensitivity was seen in distributive shock. *Mixed Etiology Shock:* Acceptable agreement, good specificity, while low sensitivity was seen in mixed types of shock (sensitivity of 63.6%), This protocol had the lowest agreement (0.70, P < 0.001) with the final diagnosis when patients had mixed etiologies as the cause for their shock status.

Blanco, P., 2015	Iran/ single-center prospective pilot study	148 patients were enrolled. According to the exclusion criteria, 123 patients were excluded due to the following reasons: 67 patients (45.2 %) had received intravenous fluid therapy or vasoactive/ inotropic medication prior to the RUSH exam. Forty-two patients (28.3 %) had a known type of shock (hypovolemic shock with external bleeding), and 14 patients (9.5 %) had known pleural effusion or ascites Only 25 patients were eligible to participate in the study. Fourteen patients (56 %) were male and 11 (44 %) were female. The mean age±SD was 58.2±5.31 years.	The RUSH exam could be used in emergency wards to detect types of shock.	The overall agreement for type of shock estimated by the RUSH protocol and final diagnosis of the patient was perfect (kappa=0.84, p value=0.0001 with 88 % sensitivity and 96 % specificity). The RUSH exam was performed blindly on the patient by an emergency medicine staff who was not part of the patient's care giving team. The results of the RUSH exam were then compared to the final diagnosis of the patients and the 48-h outcome.	The mortality rate in this study was 64 %. Based on the final diagnosis and ICU expert, 13 patients (81 %) had a correct diagnosis based on the RUSH protocol; however, 3 patients (19 %) were misdiagnosed by the RUSH protocol. There was not a significant relationship between mortality and the protocol used for diagnosis (p=0.52). However, there was a significant relation between APACHE II score and mortality (p<0.0001) the overall kappa correlation of the RUSH exam compared with the final diagnosis of the patients was 0.84 which is an almost perfect agreement. The overall sensitivity of the RUSH exam was 88 % and the specificity was 96 %. The highest kappa correlation was for hypovolemic and distributive shock. Although the mortality rate was 64 %, there was not a significant relationship between mortality and the protocol used for diagnosis. The high mortality rate could be due to the fact that these patients were in a severe shock state and had a high APACHE II score. With regard to the almost perfect agreement between RUSH and final diagnosis in this study, the RUSH protocol has been incorporated as one of the standard points of care in patients in critical condition. The RUSH exam compared with the final diagnosis was 0.84 which is an almost perfect agreement. The overall sensitivity of the RUSH exam was 88 % and the specificity was 96 %. Although the mortality rate was 64 %, there was not a significant relationship between mortality and the protocol used for diagnosis. As patients were receiving standard management, further evaluations for detecting the cause of shock, which were done by the care giving team, were recorded for comparison.
Jawaid, S., 2014	UK/case report				Patients with undifferentiated shock can be a real challenge for the Emergency Physician. To diagnose the underlying cause in a shocked patient in a timely manner is vital as the treatment options may be completely different and are also time critical. A patient with low GCS, shortness of breath and type-2 respiratory failure may have wide differentials like life-threatening asthma, tension pneumothorax, acute cardiac events or massive pulmonary embolism. Treatment of each is quite different and time critical. An early shock scan using ultrasound helped us narrow their differential towards a cardiac pathology. The presence of silent chest is a possible presentation in early stages of cardiogenic shock and has mortality of about 70% due to the difficulty in diagnosis. Although their patient was presented atypically with very little history available as a result of low GCS and non-specific ECG, a quick bedside echo which showed a globally hypokinetic left ventricle proved to be a life saver as the right diagnosis was made and critical minutes were saved by not making other unnecessary investigations such as CT of the head. Bedside ultrasound is widely used by most physicians during the management of trauma patients but its use in the assessment of sick medical patients is still not considered an important diagnostic tool. There is enough evidence to suggest that the use of ultrasound during the initial assessment of sick medical patients.

Jain, S. 2014	India/case report	Pump: Grossly enlarged right atrium and right ventricle with D shaped left ventricle. McConnell's sign was present. Pulmonary artery was dilated with pulmonary artery systolic pressure 80 mm of Hg. Left ventricular contractility was adequate. There was no evidence of pericardial effusion or valvular dysfunction. Tank: Inferior vena cava was full and non collapsing with respiration. Pipes: Deep venous thrombosis screening was done (femoral vein in the femoral canal, popliteal vein in popliteal fossa) which was normal. Screening of the aorta was also normal. With this information, diagnosis of pulmonary thromboembolism (PTE) causing obstructive shock was considered. By focusing on both the anatomy and the physiology, points of care ultrasound by intensivists may help in differentiating between various etiologies of hypotension in the unstable patient. The relatively poor sensitivity of ultrasound findings necessitates other investigations to rule out the diagnosis of PTE in critically ill patients.

the studies ranged from 0.70 to 1.00 and 0.94 to 1.00, respectively. The pooled estimate of all data showed that the RUSH protocol exhibited high sensitivity (0.87, 95% C. I.: 0.80-0.92, I^2=46.7%) and specificity (0.98, 95% C. I.: 0.96-0.99, I^2=30.8%). The AUC for SROC, a global measure of the RUSH protocol performance, was 0.98±0.01, indicates the high accuracy of the test. Also, a graph of SROC is shown in Figure 2. Positive and negative likelihood ratios reported from the studies ranged from 9.83 to 51.32 and 0.04 to 0.33, respectively. The pooled estimate of all data showed that the RUSH protocol exhibited high positive likelihood ratio (19.19, 95% C. I.: 11.49-32.06, I^2=14.1%) and low negative likelihood ratio (0.23, 95% C. I.: 0.15-0.34, I^2=18.4%). The pooled estimate of the diagnostic odds ratio was 210.49 (95% C. I.: 94.83-467.23, I^2=0.00%). The detailed report of accuracy measures of RUSH protocol among the several types of shock is shown in the Table 2. Furthermore, we include all validity criteria (diagnostic odds ratio, sensitivities, specificities, positive and negative likelihood ratios and SROC) for any types of shocks, separately, into a supplementary file. The Deeks' funnel plot, Figure 3, revealed a potential publication bias in our study (p=0.03). Also, sensitivity analysis by omitting each study from meta-analysis yielded similar accuracy measures as the meta-analysis of all studies.

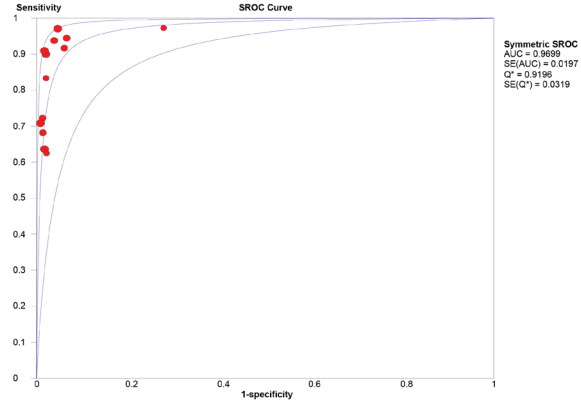

Fig. 2. Summary receiver operating characteristic (SROC) curves for accuracy of rapid ultrasound in shock.

Discussion

Several rapid protocols are increasingly available in bedsides to provide related information to the pathology and management of shocks states. The advantages of the RUSH-protocol are its rapid learning doing, the simple equipment required and the possibility to be performed at the bedside, its simplicity and a possible direct vision of volume. In a study by Shahram Bagheri Hariri *et al*. in 2015, the Kappa correlation coefficient for comparing the RUSH protocol and the final diagnosis was 0.84 percent, indicating a high compliance rate of the protocol. In this study, the overall sensitivity of this

Table 2. accuracy measures of RUSH protocol among the several types of shock

	Sensitivity	Specificity	Positive LR	Negative LR	DOR	AUC
All shock	0.87 (0.80-0.92)	0.98 (0.96-0.99)	19.19 (11.49-32.06)	0.23 (0.15-0.34)	210.49 (94.83-467.23)	0.98±0.01
	I^2=46.7%	I^2=30.8%	I^2=14.1%	I^2=18.4%	I^2=0.00%	
Hypovolemic Shock	1.00 (0.91-1.00)	0.94 (0.87-0.98)	9.83 (3.24-29.78)	0.04 (0.01-0.20)	250.54 (41.21-1523.4)	0.99±0.01
	I^2=0.00%	I^2=43.7%	I^2=63.7%	I^2=0.00%	I^2=0.00%	
Cardiogenic Shock	0.89 (0.73-0.97)	0.97 (0.92-0.99)	22.29 (7.92-62.77)	0.17(0.06-0.46)	209.77 (43.94-1001.5)	0.98±0.02
	I^2=0.00%	I^2=14.3%	I^2=0.00%	I^2=32.7%	0.00%	
Obstructive Shock	0.94 (0.73-1.00)	0.98(0.93-1.00)	33.07 (9.69-112.92)	0.08(0.02-.38)	476.42 (55.13-4114.8)	NC
	I^2=2.20%	I^2=0.00%	I^2=0.00%	I^2=0.00%	I^2=0.00%	
Distributive Shock	0.73 (0.50-0.89)	1.00 (0.97-1.00)	51.32 (10.17-258.96)	0.31 (0.17-0.56)	170.36 (26.77-1083.7)	0.97±0.02
	I^2=0.00%	I^2=0.00%	I^2=0.00%	I^2=0.00%	I^2=0.00%	
Mixed Shock	0.70 (0.47-0.87)	0.99 (0.95-1.00)	40.49 (9.97-164.39)	0.33 (0.19-0.59)	130.95 (24.12-710.68)	0.99±0.03
	I^2=0.00%	I^2=0.00%	I^2=0.00%	I^2=0.00%	I^2=0.00%	

NC: Not computable

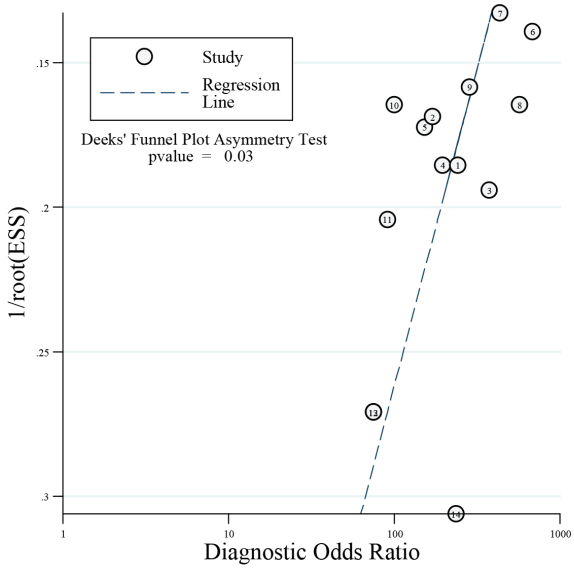

Fig. 3. Deeks' funnel plot for detecting publication bias.

method (for detection of shock type) is 88% and its overall specificity is 96%. Also, in this study, the type of shock 81% of patients were correctly diagnosed using the RUSH protocol, but 19% of patients were diagnosed as being mistaken [13]. In another study in 2013, Kappa's correlation coefficient for comparison of the RUSH 0.7 protocol has been calculated [14].

In this meta-analysis, 3 original researches and 2 case reports were analyzed to show overall efficacy of RUSH protocol. Although the efficacy of RUSH come from few studies, it has been rapidly integrated into clinical practice as a form of the pathology evaluation and management of shocks states. Regarding the effectiveness of this protocol, the meta-analysis or systematic reviews has not yet been published.In our study, RUSH showed efficacy when analyzing RCTs only, however, with the inclusion of case reports, the same results were observed. This finding is striking, as heterogeneous results from RCTs and observational studies could be the reason for detecting inconsistent effects of RUSH on shock state patients. As we observed in the present analysis, the RUSH protocol is able to identify and distinguish all types of shock with a high sensitivity and specificity. Subgroup analysis according to the type of shock state was performed.

Hypovolemic Shock

This condition is commonly occurs as a result of bleeding or severe fluid loss. The RUSH protocol is based on the hyper contractile and small chamber size for hypovolemic shock detection. Pooled sensitivity for the RUSH, 1.00 (0.91-1.00), was the stronger across the hypovolemic etiology of shock compared to other causes of shock. The pooled specificity 0.94 (0.87-0.98), actually was strong and quite homogeneous among studies. The pooled positive likelihood ratio of 9.83 (3.24-29.78), however, indicated that the test result is almost associated with a great likelihood of hypovolemic shock. Pooled negative likelihood ratio for RUSH, [0.04 (0.01-0.20)], actually were just good among studies and there is much accuracy. Overall, the evidence is strong enough on the use of diagnostic RUSH protocol in hypovolemic shock management.

Cardiogenic Shock

Cardiogenic shock is due to the pump failure and the inability of the heart to propel the needed oxygenated blood forward to vital organs. All studies included in this meta-analysis indicate that pooled sensitivity [0.89 (0.73-0.97)] and pooled specificity [0.97 (0.92-0.99)] of RUSH for cardiogenic shock are relatively high. The pooled positive likelihood ratio of 22.29 (7.92-62.77), indicated that the test result is associated with a great likelihood of cardiogenic shock, however, the pooled–LR [0.17(0.06-0.46)] support modestly in cardiogenic shock diagnosis.

Obstructive Shock

This type of shock is most commonly caused by cardiac tamponade, tension pneumothorax, or large pulmonary embolus. The pooled sensitivity [0.94 (0.73-1.00)] and pooled specificity [0.98(0.93-1.00)] of RUSH for obstructive shock are dramatically high.

The pooled positive likelihood ratio of 33.07 (9.69-112.92) and pooled – LR [0.08(0.02-.38)] indicated that the test result is associated with a great likelihood of obstructive shock. Overall, the evidence is too strong enough on the use of diagnostic RUSH protocol in obstructive shock management.

Distributive Shock

Pathology of this condition is vascular system vasodilation which to the point that the core vascular blood volume is insufficient to maintained organ perfusion. Examples of distributive shock include sepsis, neurogenic shock, caused by a spinal cord injury, and anaphylactic shock, a severe form of allergic response. Pooled specificity [1.00 (0.97-1.00)] and pooled +LR [51.32 (10.17-258.96)], in distributive shock diagnosis were shown potent, however, this potency was limited by pooled sensitivity [0.73 (0.50-0.89)] and – LR 90.31 (0.17-0.56)].

Mixed Shock

This condition is commonly occurs when shock happened due to more than one pathology. Although pooled specificity of RUSH protocol in mixed shock was obtained high [0.99 (0.95-1.00)],and high pooled positive likelihood ratio [40.49 (9.97-164.39)], indicated that the RUSH test result is accompanied with a great likelihood of mixed shock, however, pooled sensitivity [0.70 (0.47-0.87)], was observed at least in all of shock type which was studied and negative pooled likelihood ratio [0.33 (0.19-0.59)], are not support of RUSH tendency in accurate diagnosis of mixed shock.Because of lack of relevant study, 3 studies were included for meta-analysis and this may not be able to show a comprehensive estimate by 3 papers. This is a limitation for this study.

In summary, this meta-analysis suggests that RUSH protocol has generally good role to distinguish the states of shock in patients with undifferentiated shock referred to the emergency department. Although, obtained modest sensitivity and –LR values for two shock categories (distributive and mixed-etiology), it is likely most important limitation of RUSH protocol to diagnose of undifferentiated shock applying solely.

Conflicts of Interest: None declared.

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