THE DIAGNOSTIC ACCURACY OF THE RAPID ULTRASOUND IN SHOCK (RUSH) EXAM FOR SHOCK ETIOLOGY: A SYSTEMATIC REVIEW AND META-ANALYSIS

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Background

Shock is a state of metabolic and circulatory dysfunction with a high risk of mortality without appropriate treatment. When the etiology of shock is unknown, the term "undifferentiated shock" may be used to denote a shock state of unclear source (1). Hypotension alone, with or without evidence of shock, carries with it a high mortality rate as well, with a recent estimation of in-hospital mortality as high as 52% (2). The Rapid Ultrasound in Shock (RUSH) exam is a multi-organ ultrasound protocol suggested to be able to diagnose the category of shock, and therefore guide further directed treatment decisions.

	Heart	IVC	Peritoneum	Aorta	Lungs	DVT
Hypovolemic	Hyperdynamic	Slit-like, fully compressible	Peritoneal fluid (eg. from trauma, ruptured ectopic)	Aneurysm, dissection	Normal	Normal
Cardiogenic	Hypodynamic, dilated	Distended	Normal, possible peritoneal fluid	Normal	Pleural effusion, interstitial fluid	Normal
Obstructive	Pericardial effusion, dilated ventricle(s) with strain	Distended	Normal	Normal	Absent lung sliding (eg. pneumothorax)	Thrombosis
Distributive	Hyperdynamic (early) or hypodynamic (late)	Normal or slit-like	Normal, possible peritoneal fluid	Normal	Pleural effusion, interstitial fluid	Normal

IVC, inferior vena cava

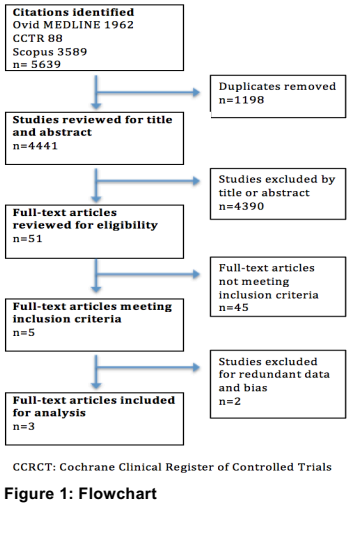
TABLE 1. RUSH findings in shock states.

Objective

The objective was to perform a diagnostic accuracy systematic review and meta-analysis of the ability of the RUSH to diagnose the etiology of undifferentiated shock in patients presenting to the Emergency Department (ED) in undifferentiated shock.

Methods

Ovid MEDLINE, Scopus, and Cochrane Central Register of Controlled Trials, and research meeting abstracts were searched up to February 2017 for studies of ED patients presenting with undifferentiated shock whom had a RUSH exam completed for diagnosis of shock etiology. QUADAS-2 was used to assess study quality and meta-analysis was conducted to pool results of individual categories of shock for assessment of sensitivity, specificity, positive likelihood ratio (+LR), and negative likelihood ratio (-LR). (3)

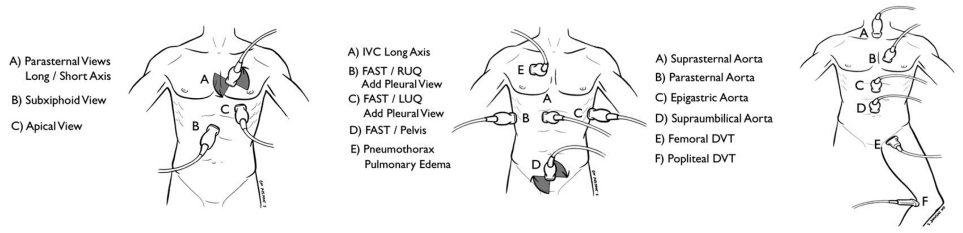


CCRCT: Cochrane Clinical Register of Controlled Trials

Figure 1: Flowchart

	Enrollment	Inclusion criteria	Exclusion criteria	Operators and Equipment	Protocol	"Gold" standard for RUSH diagnosis	Reference standard
Bagheri-Hairi, et al	Prospective convenience sample of 25 patients	Patients presenting in shock (SBP <90 mmHg or shock index >1 with hypoperfusion symptoms)	IV fluids administered prior to hospital admission; presence of known ascites or pleural effusion due to documented chronic disease; severe obesity (BMI > 40); Age <18 years; pregnancy; patients with a known or obvious type of shock; patients already under "standard treatment and management" for shock prior to the RUSH; patients with penetrating or multiple blunt trauma	*Operator*: Emergency Physicians (attendings) *Equipment*: SonoScape S6 system with 7.5 MHz linear array and 4 MHz phased array transducers	RUSH including leg veins	Pre-determined checklist	Expert ICU panel and medical chart review
Ghane, et al	Prospective convenience sample of 77 patients	Patients presenting in shock (SBP <100 mmHg or shock index > 1)	None stated	*Operator*: Emergency Physician and Radiologist familiar with RUSH exam *Equipment*: Sonoscape system with 2.5-5 MHz curvilinear and 5-12 MHz linear transducers	RUSH including leg veins	Pre-determined checklist	Medical chart review/secondary physician determination
Shokoohi, et al	Prospective convenience sample of 118 patients	SBP < 90 mm Hg after an initial fluid resuscitation; no obvious source of hypotension	Age <18 years; Obvious source; trauma-related hypotension; Pre-existing DNR order	*Operator*: Ultrasound-trained Emergency Physician (attendings and fellows) *Equipment*: Sonosite M-Turbo system with 5-1 MHz phased array transducer and Zonare z.One Ultra system with 4-1 MHz phased array transducer	*Heart*: contractility, effusion, dilatation *Lung*: lung sliding, effusion *IVC*: size *Abdomen*: free fluid, aorta (no leg vein imaging reported)	Pre-determined checklist	Consensus of two blinded intensivists after medical chart review

TABLE 2. Included studies characteristics.



Illustrations: Ultrasound probe positions for RUSH (8)

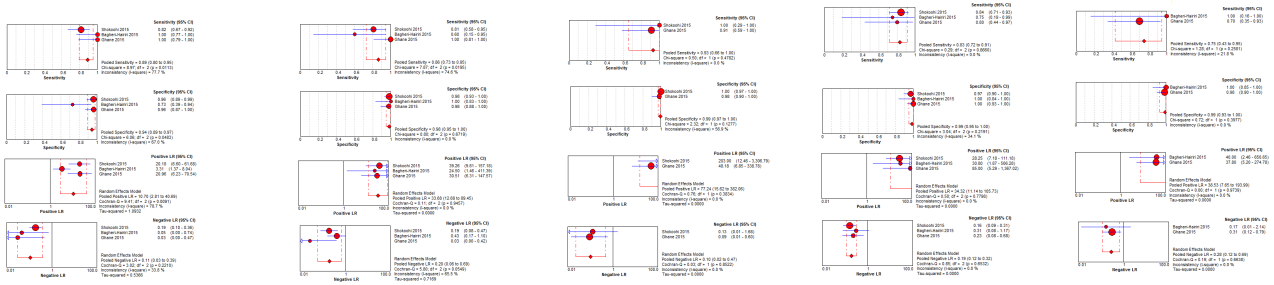


Figure 2: Meta-analysis results

Results

A total of 4441 non-duplicated studies were identified, of which 51 underwent full text review; 3 were included for analysis. Study quality by QUADAS-2 was considered overall low risk of bias. Pooled +LR values ranged from 10.7 (95% CI 2.81 to 40.69) for hypovolemic shock to 77.24 (95% CI 15.62 to 382.06) for obstructive shock. Pooled –LR values ranged from 0.10 (95% CI 0.02 to 0.47) for obstructive shock to 0.28 (95% CI 0.12 to 0.69) for mixed-etiology shock. (4,5)

Discussion

Multi-organ POCUS is an increasingly available resource that provides immediate information related to the pathology of shock states. These findings can affect management decisions, narrow differential diagnoses, and determine appropriate treatment. (6-8) Our search found only a handful of studies that have directly evaluated the diagnostic accuracy of the RUSH. The pooled positive likelihood ratios for the RUSH were strong across all etiologies range from 10.7 (95% CI 2.81-40.69) for hypovolemic to 57.5 (95% CI 11.41-292.25) for obstructive. Further, the RUSH's performance for the diagnosis of obstructive shock was nearly perfect, but this observation needs to be tempered by the fact that there were very few cases of obstructive shock overall, and no cases of cardiac tamponade in the included studies. The RUSH was least accurate for the diagnosis of mixed-etiology shock, with sensitivity of 75 (95% CI 43-95) and negative likelihood ratio of 0.28 (95% CI 0.12-0.69), limiting its value as the sole determinant for shock etiology.

Conclusion

The RUSH performs generally well to diagnose the category of shock in patients presenting with undifferentiated shock to the ED. However, given modest –LR values for several categories (notably distributive and mixed-etiology), it is likely best employed as one component to a complete evaluation of a patient with undifferentiated shock, rather than be relied upon solely.

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