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REVIEW

Point of Care Ultrasound Shock Protocols for Patients' Bedside Assessment, Diagnosis, and Treatment of Tamponade: a Case Report and Literature Review

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Abstract

Point-of-care ultrasound reduces diagnosis uncertainty, increases diagnosis accuracy, and improves the treatment of patients presenting to the emergency department with undifferentiated hypotension secondary to a tamponade. The following narrative review describes how the literature supports the use of point-of-care ultrasound as a major adjunct of clinical examination, diagnosis, and treatment for patients presenting in shock due to cardiac tamponade using different point-of-care ultrasound protocols. When used by trained physicians, we believe that point-of-care ultrasound should be part of every protocol for the management of shocked patients in emergency departments.

Keywords Ultrasound · Tamponade · Shock · Point-of-care ultrasound · Protocol · Emergency · RUSH · SHoC · Echo

Introduction

Over the years, the use of ultrasound has been broadened to many medical specialties, including emergency medicine. Unlike ultrasounds performed in radiology, point-of-care ultrasound (PoCUS) is defined as a focused ultrasound exam performed at the bedside by the treating physician and used to answer a specific question during the clinical examination or guide an invasive procedure [1, 2]. Over the last two decades, ultrasound devices have become increasingly portable, which has proven to be a boon for their bedside use, especially in emergency medicine. Indeed, the emergency department (ED) setting is occasionally unfavorable to the use of traditional ultrasound machines for patients with acute conditions in need of continual vital sign monitoring or immediate treatment. These conditions combined with the expansion of PoCUS use stress the necessity for the development of skills and standards to promote appropriate practices, especially given the user-dependent nature of ultrasound [3]. Therefore, many curricula recently included PoCUS for trainees and residents in emergency medicine and even for medical students [4, 5]. At present, acute care societies are organizing many lectures regarding PoCUS and promoting its use [6].

PoCUS has proven its usefulness in treating patients presenting with undifferentiated hypotension, which is one of the clinical features of shock [7]. Tamponade incidence is known to be between 4 and 10 patients per 1000 admissions in ED [8]. Overall, 90% of cases of undifferentiated shock tend to be hypovolemic or cardiogenic [9]. The initial cause of shock is ascertained in only 25–50% of cases [10]. Based on our experience, any emergency physician can attest to the difficulty of managing hypotensive patients for a variety of reasons: lack of history, unsuspected cause, inadequate information given by the clinical evaluation, or rapid worsening of the patients' condition. PoCUS can contribute to reducing diagnosis uncertainty and increasing diagnosis accuracy, while it can also substantially change the treatment of patients presenting in the ED with undifferentiated hypotension, especially for tamponade [11].

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Many protocols including PoCUS are reported in the literature to help manage such patients. At present, the RUSH protocol [12] published in 2010 seems to be the most popular, which is supported by the fact that its use is taught in many courses around Europe and Northern America. A study published in 2016 even concluded that the introduction of the RUSH protocol in teaching modules allows emergency residents to improve their image acquisition, image interpretation, speed, and comfort level while using PoCUS in critically ill patients [13]. This protocol has a three-step approach (Fig. 1), which, as an analogy to the physiology of shock, draws on the vocabulary of plumbing (pump, tanks, pipes) to correlate ultrasound findings to the type of shock [14]. In 2016, an international expert consensus initiated a more comprehensive and adaptive protocol for the management of patients presenting with undifferentiated hypotension: the SHoC protocol—Hypotension [15]. Instead of a screening tool, the SHoC protocol is a diagnostic tool that orientates the ultrasound investigation according to the clinical picture of patients [15]. PoCUS is known to be a fundamental adjunct for the management of shocked patients [16].

Throughout the following common clinical case used for illustrative purposes, this narrative review describes how PoCUS shock protocols are used to assess patients for tamponade and sheds light on the utility and limitations of PoCUS for the diagnosis and treatment of this condition.

Literature Search

The following research question was considered in this review: Is PoCUS useful for tamponade management using previously published PoCUS shock protocols?

After performing a scoping literature review, an extended search was conducted in the following databases: Embase, Central (Cochrane library), Web of Science, MEDLINE, and Google Scholar. While the user guide of each database was taken into account, the search used a combination of MeSH headings and free text words (Appendix 1). The search was performed exclusively using English terms. In addition, a snowballing method screened the reference lists and citations of the relevant articles to find other articles of interest. Bibliographic management was done with ZOTERO® software. The search period was set from January 1, 1991, to March 1, 2021, and then completed a year later up to March 7, 2022, although no recently published articles were considered valuable to answer the research question. Two reviewers selected the articles. All types of study design were considered. Articles considering cardiac arrest instead of shock were excluded. Data were used if both reviewers considered the identified study to be relevant to address the research question and shed light on the illustrative case reported below.

Illustrative Case

A 58-year-old man came to the ED complaining of dizziness and dyspnea. At triage, the patient was found to be tachycardic (heart rate: 120 beats/min) and hypotensive (blood pressure: 81/33 mmHg) with an accelerated respiratory rate (30/min) and normal blood saturation (100%). Due to the unstable hemodynamic condition, the patient was admitted to the resuscitation room of the ED. The patient had a medical history of high blood pressure treated with perindopril 4 mg daily; he was also overweight and an active smoker.

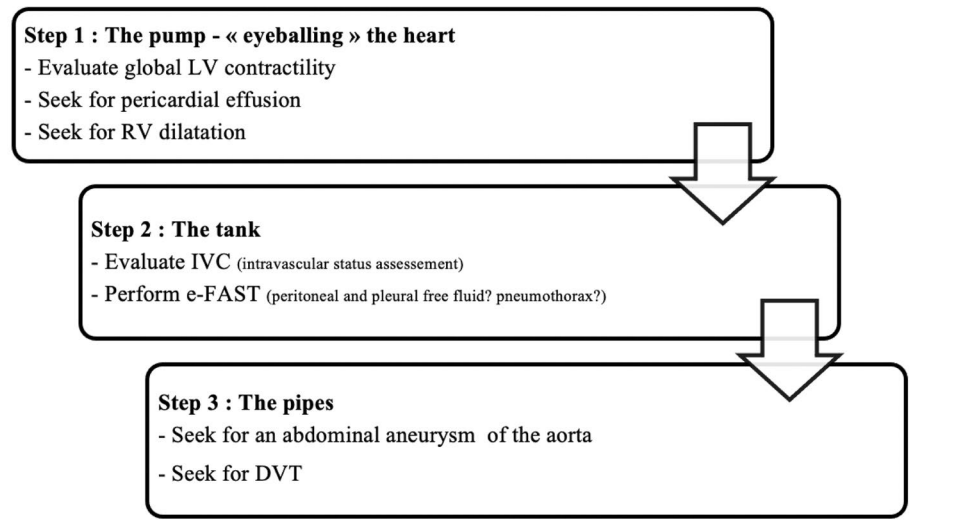


Fig. 1 The RUSH protocol. [12]

The patient reported a recent immobilization. A systematic anamnesis revealed the rapid onset of dyspnea and slight medio-thoracic pain. The clinical examination was normal. ECG showed no repolarization abnormality. An arterial blood sample showed a slightly high lactate at 2.7 mmol/l (nl ≤ 2 mmol/l), PCO2 32 mmHg, and PO2 83 mmHg. A venous blood sample with a d-Dimer dosage was taken. For the clinical examination, the emergency physician performed the RUSH protocol, which led to the diagnosis of cardiac tamponade. Pathological findings are illustrated in Table 1. Blood sample results showed abnormal d-Dimer dosage > 500 ng/ml, elevated creatinine 2.1 mg/dl (normal 0.4 mg/dl–1.2 mg/dl), and thrombocytopenia 60,000 g/l (normal 150,000–350,000 g/l). No other abnormalities were found. Secondary to the patient's unstable hemodynamic state, drainage was performed using an apical approach under ultrasound guidance. Patient outcome was good after monitoring in the intensive care unit.

This rather common clinical case illustrates the importance of PoCUS use in managing a patient presenting with undifferentiated hypotension. Indeed, using PoCUS provided a rapid response to the origin of the shock, thus allowing a rapid drainage and the prompt stabilization of the patient's hemodynamic status. The absence of ultrasound examination would probably have required the realization of computerized tomography (CT), which would have been time-consuming and exposed the patient to unnecessary radiation. Moreover, the initial hemodynamic instability and renal insufficiency of the patient did not favor the use of CT.

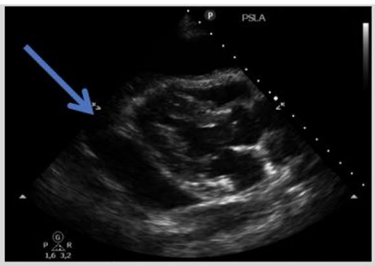
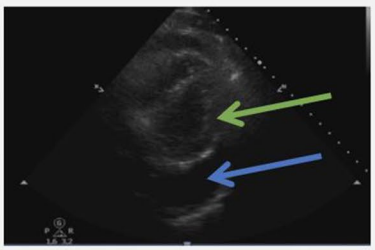
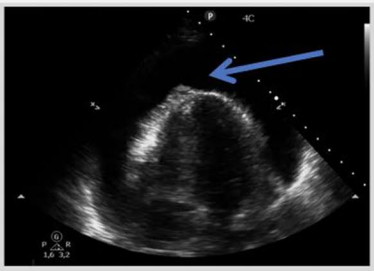
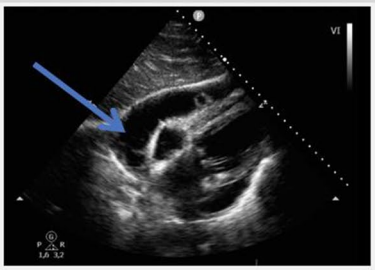
Tamponade

Tamponade is a true cardiovascular emergency [17]. Regarding the tamponade as an obstructive shock, its clinical presentation can be similar to pulmonary embolism. Tamponade occurs when fluid accumulates in the pericardium, with either rapidly rising pressure or a large amount of fluid. These two phenomena explain why the pressure in the pericardial space ends up exceeding the pressure of the right cardiac chambers [18]. Considering the pericardial compliance, even a small amount of fluid can provoke an impaired cardiac filling, leading to shock. On a transthoracic ultrasound view, the amount of fluid can be determined by measuring the separation between the parietal and visceral pericardium [18]. The amount of pericardial fluid does not indicate the presence of a tamponade. Tamponades have been reported with as little as 5-mm circumferential effusions with 80 ml of fluid [19]. By contrast, some patients presenting with a large pericardial effusion (> 3 cm) have no clinical findings to indicate shock [19]. Indeed, tamponade depends on the speed of the fluid accumulation rather than on the amount of fluid itself [19]. Pericardial effusions may occasionally be loculated and compress part of the heart, although this more commonly occurs in a post-cardiac surgery setting [20]. It is, among other ultrasound signs, the diastolic collapse of the right ventricle that sonographically points to a tamponade. This sign is known to be more specific than sensitive [18]. Another sign of high right heart chamber pressure is the dilatation and low diameter variation of the inferior vena cava, which suggests an obstructive shock that could be secondary to a tamponade. This sign is sensitive but not specific [18]. Whereas the presence of pericardial effusion is based on ultrasound diagnosis, the diagnosis of tamponade is based on the clinical picture and hemodynamic status of the patient [21]. PoCUS nevertheless contributes to the correct diagnosis.

Existing PoCUS Protocols for Undifferentiated Hypotension

Ultrasound protocols developed to manage undifferentiated hypotension are known to significantly improve diagnostic accuracy by up to 80% [22]. More than just a complementary exam, ultrasound is considered to be adjunct to clinical examination [23]. The RUSH protocol effectively orientates the physician to the correct diagnosis for patients presenting to the ED with undifferentiated shock, but it does even better if interpreted as part of a complete evaluation of the patient's clinical presentation [24]. It is therefore crucial to understand that more than strictly applying a protocol, all physicians should adapt their PoCUS practice to the clinical findings and state of the patient in order to facilitate the diagnosis and plan treatment accurately. A recent international expert consensus supports a hierarchical approach based on the incidence of a disease or its estimated likelihood [15]. According to this scientific consensus, bedside ultrasound is more than just a screening tool, as it can also be used as a diagnostic tool [15]. This group of experts developed the SHoC protocol, the first approach based on diagnosis and resuscitative care. The SHoC protocol for undifferentiated hypotension is described in Fig. 2. This protocol aims to guide the physician performing the ultrasound views according to the clinical presentation in order to improve efficacy and reduce the frequency of incidental ultrasound findings, which can be distracting [15]. A recent meta-analysis evaluating the diagnostic accuracy of different shock protocols reported a pooled sensitivity of 93% (95% CI: 69–100) and a pooled specificity of 98% (95% CI: 96–99) for obstructive shock [25]. Early recognition and appropriate treatment of shock have an impact on decreasing mortality [26]. The literature shows evidence that diagnosis accuracy and rapidity of treatment are enhanced by PoCUS use in critically ill patients [10]. It is well known that the longer the patient is hemodynamically unstable, the more secondary lesions appear with an increase in mortality [27]. Therefore, in the case described above, we are of the opinion that the patient's

Table 1 Illustration of emergency ultrasound pathological findings

PUMP	Parasternal long axis view of the heart		**Pericardial effusion**
	Parasternal short axis view of the heart		**Pericardial effusion** with **D-shaped left ventricle** due to a pressure overload on the septum secondary to the high pressure in the pericardium creating a right ventricle repercussion.
	Apical four chamber view of the heart		**Pericardial effusion**
	Sub-costal view		**Pericardial effusion**
TANK	Inferior vena cava	No good quality image could be achieved	If accessible, the IVC would have been dilated and with no variation throughout the respiratory cycle.
	E-FAST		Negative
	Lung		Normal
PIPES	Aorta		Normal
	Deep veinous thrombosis		None

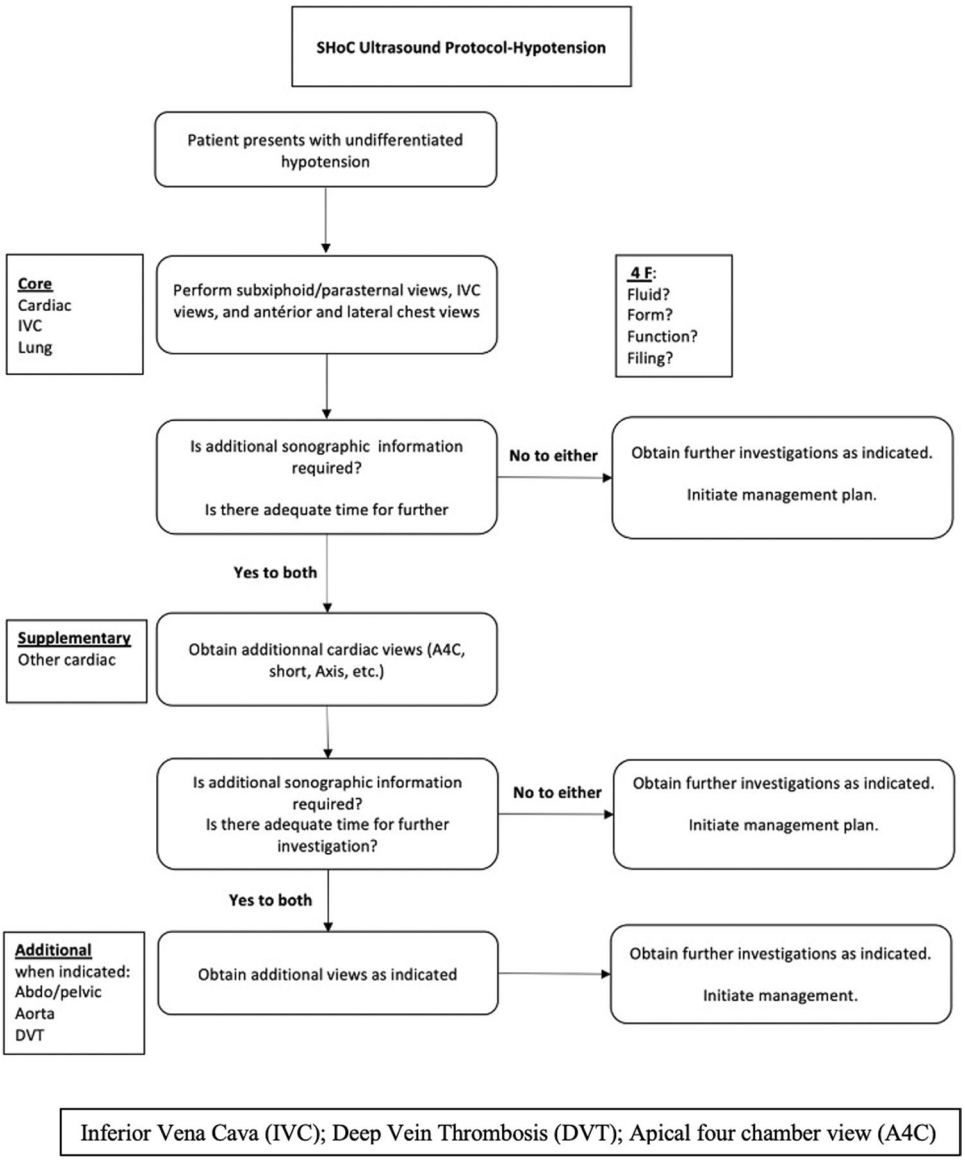


Fig. 2 The SHoC Ultrasound Protocol. [15]

outcome improved due to the prompt use of PoCUS. The use of any of the main bedside ultrasound protocols currently published for the management of undifferentiated hypotension would have led to the diagnosis of tamponade given that all these protocols include the use of a cardiac view. However, these protocols do not include any of the possible diagnoses in the case of undifferentiated shock. Table 2, initially published by Liteplo et al. in 2012 [28], was completed with recent findings to illustrate the clinical information covered by the main published ultrasound protocols.

PoCUS for Tamponade Diagnosis

Transthoracic echocardiography is a tremendous adjunct for the non-invasive assessment of the hemodynamic status of critically ill patients [18]. It is the examination of choice to diagnose the presence of pericardial effusion [17]. Four main cardiac views are described when using bedside cardiac assessment: the parasternal long and short axis, the apical four chambers, and the subxiphoid view. The SHoC protocol for undifferentiated hypotension suggests using the parasternal long axis and the subxiphoid view before considering other cardiac views [15]. As far as possible, we believe that these views should be used in all hypotensive patients if the anatomy, echogenicity, and resuscitation settings allow for their acquisition.

PoCUS for Tamponade Treatment

PoCUS use allows for real-time data analysis, which gives the physician the possibility to immediately adjust the treatment [29]. The pericardiocentesis performed under

Table 2 Components of ultrasound protocols for hypotension

Protocol	Pericardial effusion	RV dilation	LV function	IVC	Aorta	Abdominal fluid	Pleural fluid	Pulmonary oedema	Pneumothorax	DVT	Ectopic pregnancy
RUSH	●	●	●	●	●	●	●	●	●	●	
SHoC	●	●	●	●	●	●	●	●	●	●	
Jones	●	●	●	●	●	●					
UHP	●		●		●	●					
CAUSE	●	●	●	●					●		
ACES	●	●	●	●	●	●	●		(●)	(●)	
FAST and RELIABLE	●	●	●	●	●	●	●		●	●	●

Right ventricle (RV); Left ventricle (LV); Inferior vena cava (IVC); Deep venous thrombosis (DVT); Standard component of protocol = ● ; Optional component of protocol = (●)

echocardiographic guidance is known to reduce the morbidity and mortality associated with this technique. With a landmark-guided approach, morbidity reaches 50% and mortality 19% [19]. Furthermore, the ultrasound-guided procedure considerably reduces morbidity [19]. Pericardiocentesis using subcostal echocardiographic guidance is known to be relatively safe, with a 97% success rate and 1% of severe complications [17]. Different emergency ultrasound approaches are described in the literature. The commonly described landmarks are parasternal, subcostal, or apical [30]. The choice of approaches is driven by the patient's anatomy and the location of the pericardial effusion determined using ultrasound [30]. In a large prospective registry of pericardiocentesis performed under ultrasound guidance from 2002, the reported procedural success rate was 97%, with a total complication rate of 4.7%, 1.2% of which were considered major and 3.5% minor [31]. However, these procedures were performed or supervised by cardiac sonographers as opposed to emergency physicians. PoCUS is nevertheless increasingly more common in EDs [4]. In the hands of a trained operator, it is assumed that emergency physicians can achieve similar results.

Discussion

Though not a systematic review due to the absence of an "a priori" protocol, this narrative review provides a clear overview of how PoCUS should be integrated in patient care for tamponade management. PoCUS shock protocols all include valuable steps for the diagnosis of tamponade. These protocols are, however, not intended to guide tamponade treatment. Recently published articles clearly state the importance of PoCUS to guide invasive procedures such as pericardiocentesis [17, 19]. PoCUS is nevertheless known to be an operator-dependent tool. Though considered to be easy to learn and apply, these protocols should be used while taking into account the PoCUS ability of the physicians. Any physician using POCUS to orientate the diagnostic approach should be adequately trained or supervised. Despite being viewed as a pillar of clinical evaluation, PoCUS needs to be correctly performed to enhance clinical practices [32, 33].

Limitations

Though undertaken by two different reviewers, the database search and article selection were not performed independently in the strictest sense. The reviewers discussed any article that would be eligible to discuss the illustrative case as well as its pertinence to address the research question. Moreover, besides the research question and the search strings, no protocol was written prior to the literature search. Searching multiple databases and using a snowballing method can nevertheless reduce publication bias and strengthen our conviction that this narrative review identified all relevant studies.

Conclusion

Everyday emergency medicine is characterized by a great diversity of clinical presentations and diagnoses. The etiology of undifferentiated hypotension can be difficult to identify. PoCUS shock protocols help assess the cause of shock and lead to tamponade diagnoses, thus allowing for the rapid initiation of adequate treatment. PoCUS is a non-invasive approach. In the hands of a good operator, diagnostic accuracy for undifferentiated hypotension can be significantly raised. Using PoCUS to assess the presence of a tamponade gives rise to its use for the entire patient management from clinical examination and diagnosis to treatment guidance. We believe that the rapidly growing use of PoCUS in the ED will improve the care of shocked patients for tamponade management.

Appendix 1

Search strings

"Emergency"[All Fields] AND "ultrasound"[All Fields] AND "protocol"[All Fields]) OR "algorithm"[All Fields]) AND "tamponade"[All Fields] AND "shock"[All Fields]) OR "undifferentiated hypotension"[All Fields].

"Emergency"[All Fields] AND "ultrasound"[All Fields] AND "tamponade"[All Fields] AND "treatment"[All Fields].

MESH terms

Emergency medical services [MESH].
Point-of-care testing [MESH].
Ultrasonography [MESH].
Cardiac tamponade [MESH].
Pericardial effusion [MESH].

Free text words

Tamponade, pericardial effusion, emergency ultrasound, emergency patients, emergency department, point of care ultrasound, bedside ultrasound, clinical ultrasound, shock, undifferentiated hypotension, protocol, algorithm diagnosis, treatment.

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Author Contribution Valérie de Visscher: literature review and draft of the manuscript.

Gauthier Moureau: critical revision of the manuscript.

Félix Gendebien: critical revision of the manuscript.

Florence Dupriez: literature review, conception, and critical revision of the manuscript.

Data Availability Patient consent available in French. Translation can be obtained if necessary.

Code Availability Bibliographic management with ZOTERO® software.

Declarations

Ethics Approval Patient consent form for publication was obtained in French.

Consent to Participate Not applicable.

Consent for Publication Patient gave written consent in French for publication.

Conflict of Interest The authors declare no competing interests.

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