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ORIGINAL RESEARCH

SLICE: An algorithm for incorporating ultrasonography in the assessment of shocked or breathless patients

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Abstract

SLICE is an algorithm for the integration of point-of-care ultrasound in the assessment and resuscitation of the shocked or breathless patient. It aims to determine the patient's fluid status, and identify reversible causes for the patient's clinical picture. SLICE stands for 'In a patient who is Shocked/Short of breath, scan the Lungs, IVC, Cardiac and Extra regions as indicated'. Its key advantages are that it explicitly guides resuscitative fluid management, can be performed rapidly and by clinicians with a broad range of sonographic experience, and can be used in a broad range of clinical scenarios. Its use has been successfully taught and implemented in routine clinical practice at our local institution.

Key words: *fluid therapy, point-of-care ultrasound, resuscitation, shock, ultrasound.*

Introduction

The utility of point-of-care ultrasound (POCUS) in the ED is best demonstrated in the shocked and unwell patient. It provides rapid clinical information while allowing for concomitant resuscitation, without the risks and delays of moving out of the resuscitation bay. An example of this is the use of extended focused assessment with sonography in trauma (EFAST) in the shocked blunt trauma patient. There are also several POCUS protocols described for shocked or breathless patients without underlying trauma. For example, the basic lung ultrasound examination (BLUE) protocol provides a diagnostic framework to differentiate causes of respiratory failure.[1] The rapid ultrasound for shock and hypotension (RUSH) examination describes the use of ultrasound to differentiate between obstructive, cardiogenic, distributive and hypovolaemic shock.[2] A number of studies have found that RUSH improves diagnostic accuracy and alters the initial management approach.[3,4]

However, utilisation of such protocols remains low in the ED setting. The barriers to their implementation include time constraints, lack of clinician experience and the number of different protocols for different scenarios. SLICE aims to address this by being applicable to shocked, breathless and traumatised patients. It is easy to perform, guides resuscitative management early, and can be terminated when other priorities emerge.

SLICE protocol

SLICE is an approach to ultrasonography in the shocked or breathless patient. It is an acronym which stands for 'In a patient who is Shocked/Short of breath, scan the Lungs, IVC, Cardiac and Extra regions as indicated'.

Key findings

- SLICE is simple to follow, to learn and to teach.
- SLICE guides initial management as well as diagnosis.
- SLICE does not replace other diagnostic modalities, but it does augment them.

Shocked/Short of breath patient

SLICE is indicated in the shocked and/or breathless patient. It has two main objectives: to determine if intravenous fluids can be given without causing harm, and to identify a reversible cause for a patient's shock or shortness of breath (SOB). It can also assist in providing additional clinical information in diagnostically complex patients. If your objectives have been met at any point during the protocol, ultrasonography should stop in order to prioritise clinical management.

Lung

The SLICE protocol begins with ultrasonography of the lung fields. The authors follow the approach set out in the Australasian Society for Ultrasound in Medicine's Certificate in Clinician Performed Ultrasound (CCPU) requirements for lung ultrasound.[5] If symmetrical B-pattern, that is B-profile[6] is demonstrated (Fig. 1), this indicates acute pulmonary oedema or interstitial fibrosis

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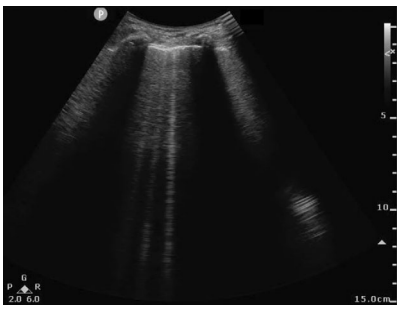

Figure 1. *'B-pattern' on ultrasound consistent with interstitial oedema or interstitial fibrosis.*

and the clinician withholds fluid resuscitation for the time being. If no B-profile is seen, then the clinician may commence fluid resuscitation while continuing with SLICE. If a tension pneumothorax is identified, then the objectives of SLICE are met and sonography can be postponed or terminated while the patient is resuscitated. Pathology such as pleural effusion or pulmonary consolidation can also be identified on lung ultrasound.

Inferior vena cava

If a cause of the patient's shock/SOB has not been identified on lung ultrasound, the inferior vena cava (IVC) is scanned next. The IVC calibre should be assessed to guide the cause of the patient's shock/SOB – is it 'distended' (Fig. 2), 'collapsing' (Fig. 3) or 'non-contributory'?

A 'distended' IVC is round and does not move with respiratory variation. It suggests a cardiogenic or an obstructive cause of shock/SOB (i.e. pericardial tamponade, massive pulmonary embolism [PE] or tension pneumothorax), noting that some of these causes may have been identified on lung ultrasound (Fig. 2). If a distended IVC is seen without a tension pneumothorax identified by the lung scan, the clinician should progress to a cardiac ultrasound.

A 'collapsing' IVC suggests a hypovolaemic or distributive cause of shock/SOB (Fig. 3). It can, however, also be seen in left ventricular failure with acute pulmonary oedema. For this reason, the presence of B-profile on lung ultrasound, rather than IVC calibre, should guide fluid resuscitation. If the IVC is collapsing and the lungs are dry, then pericardial tamponade, massive PE and significant heart failure have been excluded and the heart is not the cause of acute shock/SOB. The clinician can consider prioritising other resuscitation efforts rather than proceeding to cardiac ultrasound.

Cardiac

If the lung and IVC scans suggest an obstructive or cardiogenic picture, then proceed to a basic cardiac ultrasound to assess for pericardial tamponade, massive PE and cardiogenic shock. If any of these conditions are identified, treatment should be prioritised over further ultrasonography.

Extra views

Once the lung, IVC and/or cardiac ultrasound have been performed, SLICE reminds the clinician to consider whether any additional ultrasound would be useful. This may involve scanning of the peritoneal cavity (to complete an EFAST), abdominal aorta, proximal deep veins of the lower limbs, renal tract or biliary tree. The decision to perform extra studies, and which ones to perform, will be guided by the clinical picture.

To summarise, SLICE involves sequential scans of the lungs, IVC, cardiac, extra views, in a patient who is shocked or short of breath (Fig. 4).

Discussion

SLICE compared with other protocols

SLICE is similar to other protocols for the shocked or breathless patient in that it incorporates a mixture of lung, IVC and cardiac ultrasound. However, it has a number of differences, which we believe improve its clinical utility.

Firstly, SLICE is designed to be easier to perform than many other protocols. Most existing protocols are targeted towards either the shocked patient (e.g. RUSH), the

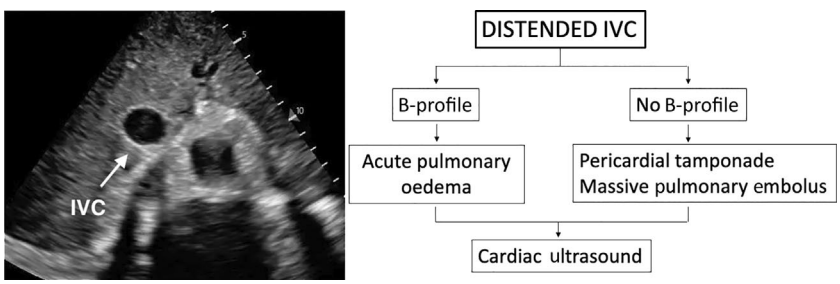

Figure 2. *Ultrasound image of a distended inferior vena cava (IVC), and clinical reasoning pathway for causes of shock/shortness of breath with a distended IVC.*

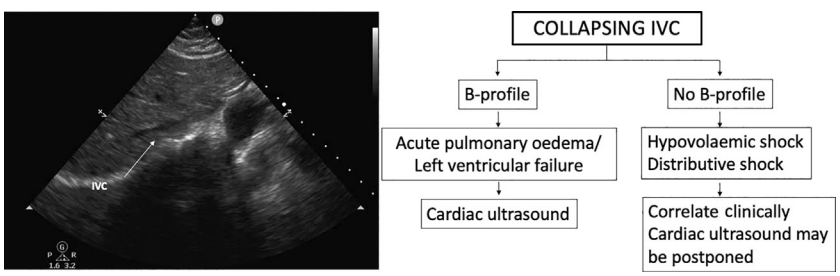

Figure 3. *Ultrasound image of a collapsing inferior vena cava (IVC), and clinical reasoning pathway for causes of shock/shortness of breath with a collapsing IVC.*

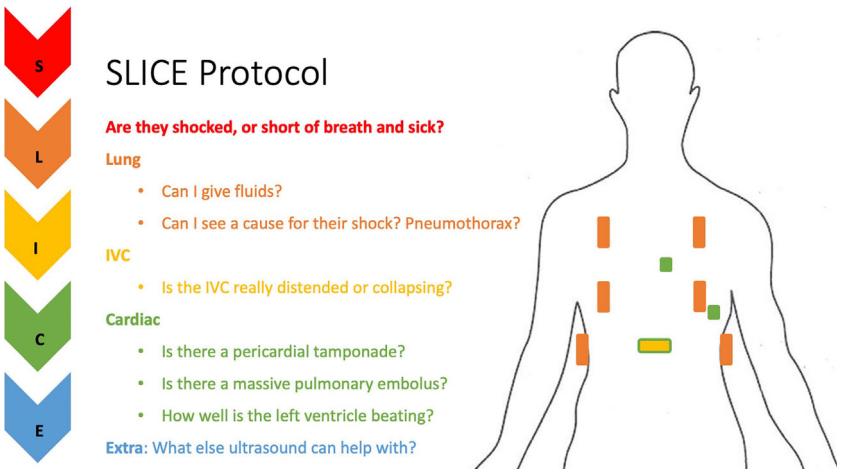

Figure 4. *Summary of the SLICE protocol. IVC, inferior vena cava.*

breathless patient (e.g. BLUE) or the traumatised patient (e.g. EFAST). SLICE can be used for all these scenarios, thereby reducing confusion about which scan to perform. SLICE also begins with the lung fields, which are easily identifiable, simple to scan and can be scanned with the patient in any position – upright, supine or even prone. The IVC is next, and the heart, as the most complex structure to scan, is placed third and can sometimes be omitted. This sequence minimises the time spent scanning, and allows even inexperienced sonologists to obtain clinically significant information.

Secondly, by starting with the lung fields, SLICE is designed to explicitly guide the next steps of resuscitative management, that is whether intravenous fluids should be commenced or withheld.

Finally, SLICE allows a significant degree of flexibility based on clinical needs. It recognises that POCUS for the shocked/SOB patient is often performed concurrently with resuscitation, and encourages the clinician to obtain the required information and then abandon ultrasound, rather than adhering to a rigid diagnostic protocol. It can be as brief or as detailed as clinically required. It is therefore useful both as a diagnostic study, and as a tool to aid initial assessment and guide investigations and intervention. The flexibility of SLICE makes it clinically applicable for a range of scenarios – for example during initial resuscitation, for progress assessments of fluid balance, or in complex undifferentiated patients.

Clinical case

The authors have been employing SLICE for several years, and have encountered many cases where SLICE has changed clinical management. A clinical case is described below.

SLICE was performed on a breathless hypotensive patient with a chest radiograph showing a large right sided pleural effusion on a background of recently diagnosed lung cancer. The lung ultrasound confirmed the pleural effusion; however, the IVC was distended so basic echocardiography was performed. A pericardial effusion with tamponade was identified, and the patient proceeded to an urgent pericardial window and operative drainage of the pleural effusion. If SLICE had not been performed, the patient would have proceeded to a thoracocentesis, but the pericardial tamponade would have been missed.

Limitations

Although SLICE can easily distinguish the different causes of obstructive and cardiogenic shock, it is less able to differentiate hypovolaemic and distributive shock. It is designed to be used as one component of clinical assessment, in conjunction with clinical correlation and other investigations.

The intention of this article is to present a perspective on how to improve the clinical utility of ultrasound in shocked/SOB patients, rather than to present a didactic way of scanning. It, therefore, does not describe the method of scanning, but assumes that the sonologist is trained at least to a basic level in lung and basic echocardiography – for example in Australia, CCPU certification in the above.[5]

SLICE describes a theoretical framework for the application of POCUS in the shocked/SOB patient. It has been applied and taught in our local ED, and the authors have found its implementation to be straightforward and clinically beneficial. However, further research is required to assess the real-world acceptability and comparative accuracy of SLICE.

Conclusion

SLICE describes an algorithmic approach for the use and interpretation of ultrasound in the shocked or short of breath patient. It involves sequential scanning of the lung, IVC, heart and extra views in order to guide intravenous fluid therapy and to identify a reversible cause of the patient's haemodynamic instability. It is easy to perform, adaptable to the clinical scenario and directly guides resuscitation. Implementation and validation studies may further investigate its applicability to clinical practice, and impact on patient outcomes.

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Competing interests

JB is a member of the Medical Advisory Board, Echonous Pty Ltd.

Data availability statement

Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

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