Case Report

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Protocols for Point-of-Care-Ultrasound (POCUS) in a Patient with Sepsis; An Algorithmic Approach

***Joaquín Valle Alonso*[1]*, *John Turpie*[1], *Islam Farhad*[1], *Gabrielle Ruffino*[1]**

[1]*Department of Emergency Medicine, Royal Bournemouth Hospital, Bournemouth, UK, BH7 7DW*

***Corresponding author:** *Joaquin Valle Alonso*
Address: Royal Bournemouth Hospital, Bournemouth, Royal Bournemouth Hospital, Castle Lane East. Bournemouth BH7 7DW,UK.
Tel: +1-202-303626
e-mail: joa51274@hotmail.com

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ABSTRACT

Sepsis and septic shock remain a major cause of morbidity and mortality globally. In septic patient's bedside physical examination can often be unhelpful in helping to identify the source of infection and, therefore, decide upon appropriate management. Protocols for point-of-care-ultrasound (POCUS) in critically-ill patients who present with shock or trauma have been described elsewhere including rapid ultrasound in shock (RUSH), focused assessment with sonography for trauma (FAST), and focused cardiac ultrasound (FOCUS). Although the use of POCUS in sepsis has been reported in existing literature, there is not an algorithm for when POCUS is indicated in septic patients. We describe the case of a 70-year-old woman who presented to the emergency department (ED) with a 1-week history of diarrhoea and vomiting. The initial diagnosis in ED was viral gastroenteritis with prerenal acute kidney injury and she was initially referred to the medial team. However, the patient remained hypotensive and oliguric after 2 litters of IV fluids. A point-of-case-ultrasound (POCUS) showed a right kidney with moderate hydronephrosis. Urology team was immediately contacted with a CT that confirmed an obstructive stone causing moderate kidney hydronephrosis. Emergency nephrostomy was performed and the patient was discharged and has remained asymptomatic.

Keywords: Traffic accidents; Disability persons; Socioeconomic factor; Pedestrian; Disparity health status; Motor vehicles.

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Introduction

Point-of-care ultrasound (POCUS) has become a standard tool for the emergency physician in a variety of presentations in the emergency department. Several protocols are currently established including extended focused assessment with sonography in trauma (eFAST) for trauma, Bedside Lung Ultrasound in Emergency (BLUE) and Rapid Assessment of Dyspnea with Ultrasound (RADiUS) for dyspnoea, Rapid Ultrasound in Shock (RUSH) for shock and Focused Echocardiography in Emergency Life support (FEEL) for cardiac arrest. POCUS is a very useful imaging technique for the emergency medicine physician widely used in the European countries and part of the program of emergency medicine residency programs in the United States and Canada. The difference between POCUS and consultative ultrasonography is that the doctor performs all acquisitions and interpretations

of images at the point of care and uses information immediately to address specific hypotheses and guide therapy in progress. There is also a difference between POCUS and the term "bedside ultrasound", as "beside ultrasound" is an older term that describes the sonographic assessment of patients, usually in a medical facility, at the patient's bedside. The term recognizes the use of portable ultrasound so that the patient is not affected by the need to physically go to a radiology department. POCUS is a broader term that includes the many scenarios (emergency room, ambulance, helicopter, etc.) in which portable ultrasound can be used. There is no current protocol for POCUS in sepsis. The potential benefits of POCUS for sepsis include infection control, haemodynamic monitoring and treatment guidance. In this case, we will demonstrate how POCUS can assist in clinical decision making in patients with sepsis.

Case Report

A 70-year-old white British women with previous unremarkable medical history presented to the emergency department (ED) with diarrhoea and vomiting for 1 week. Lives independent in a flat, walks without aids, her two daughters visit her regularly. Non-smoker and occasional alcohol consumption, (one glass of wine on the weekend). On admission to ED, observations showed blood pressure 93/45 mmHg, pulse 75, initial lactate 5 mmol/L, temperature 37.6 °C. The patient was initially assessed and described daily episodes of nausea and vomiting with watery diarrhoea for the past 2 weeks that had become more frequent in the last 48 hours; she did not describe any other related symptoms and specifically no abdominal pain or urinary symptoms. The physical exam was unremarkable; she was started on intravenous fluids. Bloods on admission revealed WBC of 16,800 per microliter, sodium 132 mmol/L, potassium 2.6 mmol/L, urea level 13.9 mmol/L, creatinine 347 mmol/L, GFR calculated 11 (baseline 60), serum C reactive protein level 332 mg/L. The initial diagnosis was sepsis secondary to gastroenteritis (the department had seen several cases due to a norovirus outbreak that had closed one of the hospital wards) and prerenal acute kidney injury. 2 litres of fluid were administered and a urinary catheter inserted. The patient was initially referred to the medical unit. After a reassessment in ED, despite 2 litres of fluid there was no urine output in the catheter bag, blood pressure was 75/45 mmHg, lactate 2.5 mmol/L, the patient remained communicative without any other related symptoms. Multi-organ POCUS was performed in order to guide fluid management and rule out other sources of infection. The echocardiogram showed a normal contractile left ventricle with no obvious source of endocarditis, normal right ventricle and normal inferior vena cava (IVC). A passive leg-raising test was performed after measuring the initial Velocity Time Integral (VTI) with a second set of VTI measurements 2 minutes after the change in position showing an increment of 9%. Lung ultrasound showed scattered bibasal B lines, but no obvious consolidation. Abdominal ultrasound did not reveal dilated bowel and the aorta was normal. Hepato-biliary ultrasound showed a normal, non-distended gallbladder and normal common bile duct. However, renal and genitourinary ultrasound revealed a right kidney with moderate hydronephrosis (Figure 1) with an empty bladder (urinary catheter in place). Intravenous antibiotics were started and an abdomen and pelvis computed tomography (CT) was requested. The CT scan demonstrated a right proximal ureteric obstructive stone and moderate right-sided hydronephrosis (Figure 2). Despite being hypotensive, the patient remained with a heart rate between 65 and 75 during her admission in the resuscitation room. On further questioning, the patient mentioned that she was able to pass urine early in the morning but has not pass more urine since them. The urologist on-call was contacted and an emergency nephrostomy was immediately performed with pus aspirated. The patient was admitted to the intensive care unit and required vasopressor treatment over the next 24 hours. During admission, the bloods improved to WCC 13.2, CRP 74 and diarrhoea had settled. She remained apyrexial and was discharged home with a plan for an elective flexible ureterorenoscopy.

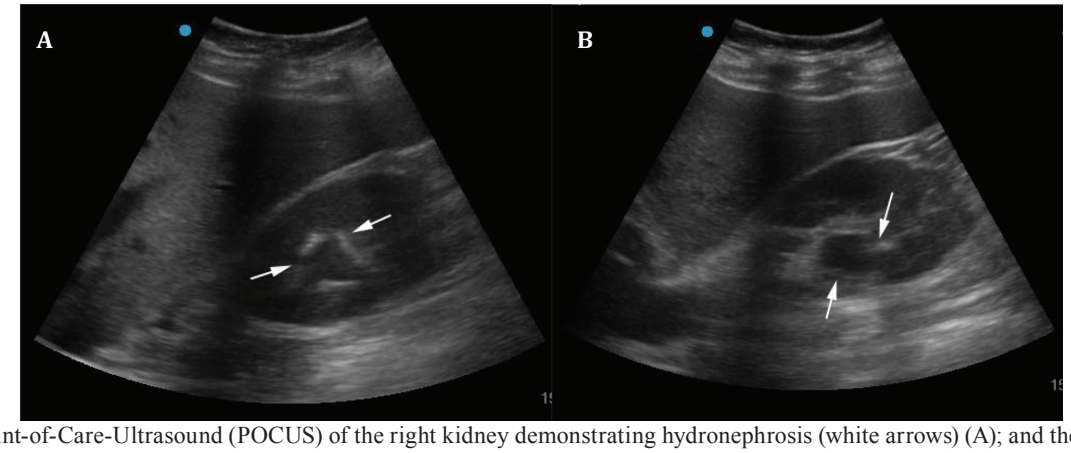

Fig. 1. Point-of-Care-Ultrasound (POCUS) of the right kidney demonstrating hydronephrosis (white arrows) (A); and the dilatation of the collecting system of the kidney (white arrows) (B).

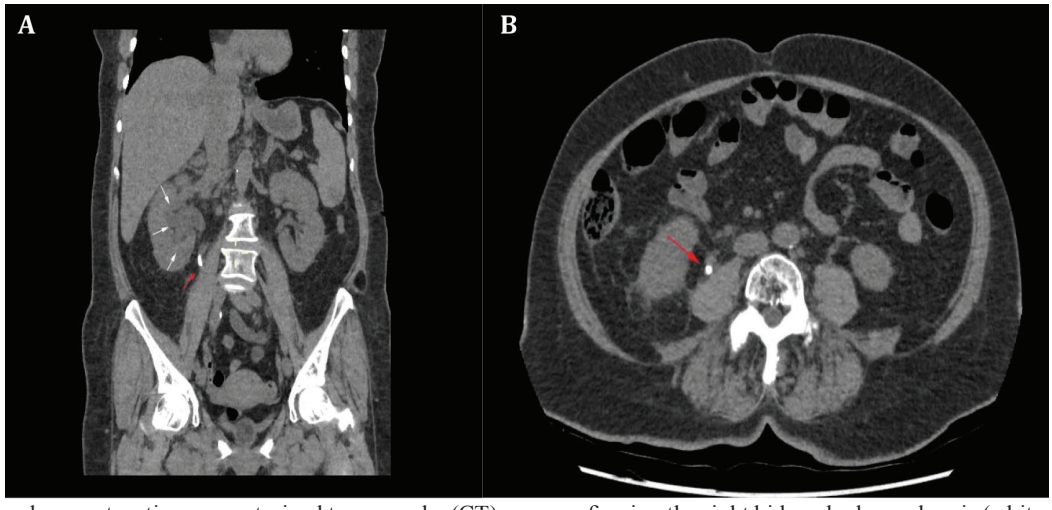

Fig. 2. Coronal reconstruction computerized tomography (CT) scan confirming the right kidney hydronephrosis (white arrows) (A); axial CT-scan demonstrating an obstructive stone (red arrows) (B).

Discussion

Sepsis is a medical emergency that requires multidisciplinary team input for better outcomes. Sepsis definition and management has been evolving and the latest guidelines have recently been published. There are clear indications for POCUS in the emergency department including cardiac, thoracic (pleura/lung), vascular, abdominal, obstetric, testicular, musculoskeletal, ocular and procedural guidance. The implementation of a systematic protocol for the use of POCUS in sepsis is yet to be described.

Rosen *et al*. first described the use of ultrasound in the emergency department for flank pain in 1997 [1]. In renal POCUS, the goal is to detect hydronephrosis. Hydronephrosis is a dilation of the area from the renal calices/pyramids to the renal pelvis and ureter and will be seen as a hypoechoic area inside the renal cortex. Pyonephrosis most commonly presents with flank pain, fever or chills. Patients are mostly symptomatic but may remain asymptomatic in 15% of cases. Urosepsis occurs most commonly as a result of a urinary tract infection with complicating factors such as urinary outflow obstruction. It has been demonstrated that, in suspected pyelonephritis, ultrasound can identify abnormalities in 61% of patients and may change the management in 34.3% of patients who go onto receive surgical interventions [2]. Pyonephrosis is a potentially life- threatening cause of urosepsis and should be considered as the only absolute indication for emergency decompression overnight [3]. POCUS for hydronephrosis has a sensitivity of 72–83.3% and a varying specificity, similar to radiology-performed ultrasonography [4].

POCUS can be extremely valuable in sepsis. We propose an algorithm for the assessment of septic patients based on POCUS (Figure 3). The first step is an echocardiogram, as POCUS will help with physiologically-guided fluid resuscitation. POCUS echo can be used to predict fluid responsiveness by assessing the right ventricle; an increase in right ventricle size with no increase in stroke volume is a definite stopping point for fluid administration. Paradoxical septal wall motion demonstrating very high right ventricle pressure may be a contraindication to intravenous fluids. Left ventricle contractility assessment that demonstrates small hyperdynamic ventricles with a small inferior vena cava (IVC) suggest significant hypovolaemia that will benefit of fluids and, conversely, patients with a reduced ejection fraction will be at risk of fluid overload. IVC size and collapsibility, although less commonly used, remains useful. A small (<10 mm) IVC suggests that IV fluid will be tolerated. For fluid responsiveness, transthoracic measurements of left ventricle outflow tract velocities can be used to estimate the stroke volume. This requires considerable expertise, as these measurements are not easily or rapidly obtainable. Therefore, this should only be considered in specific patients and provision will be dependent on provider skills. When interpreting echocardiography findings, the limitations of the technique in certain patients must be considered. POCUS can also identify endocarditis. Transthoracic echocardiography shows 84% sensitivity for vegetations of more than 10 mm in size. Recent case reports have highlighted how POCUS can identify endocarditis and facilitate rapid management of septic patients with relatively large vegetations [5].

The second step is a lung ultrasound. The presence of 'B lines' detected on lung ultrasound integrated with echo could be used to guide the volume of fluid replacement necessary in the resuscitation of the patient with sepsis. It has also been reported that POCUS can be helpful in the diagnosis of pneumonia [6]. In early pneumonia, B lines and areas of subpleural consolidation can be identified; in later stages of pneumonia, hepatisation, the shred sign, air, dynamic bronchograms as well as associated pleural effusions or empyemas can be identified. Once the lung and pleura have been visualised, hepatobiliary and gastrointestinal

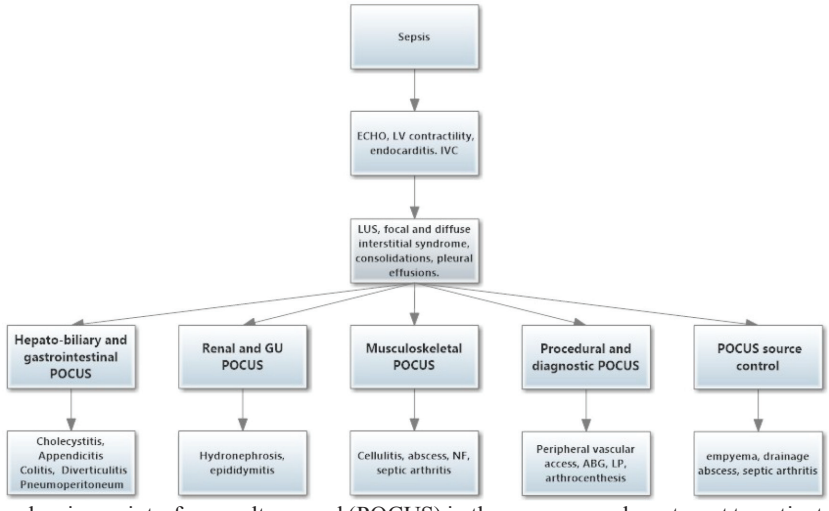

Fig. 3. Suggested approach using point-of-care-ultrasound (POCUS) in the emergency department to patients presenting with sepsis.

ultrasound evaluation are the next step. POCUS of the right upper quadrant has been demonstrated to be accurate in the hands of emergency physicians for the diagnosis of cholecystitis [7]. Cases of suspected appendicitis and diverticulitis may be more difficult as ultrasound is technically difficult and dependent on patient body habitus. When the appendix is visualised, POCUS has a sensitivity of nearly 100 % and specificity of 80–90 % [8]. In suspected appendicitis, POCUS could be especially useful in pregnant and paediatric patients. Diverticulitis can be appreciated on ultrasound by colonic oedema, sometimes producing an image called the "pseudo kidney" sign (as it resembles a kidney). There are few reports on use of POCUS for diverticulitis; however, it can be useful as a rule in test [9].

Next, a simultaneous renal and genitourinary POCUS is performed. Our case above highlights the importance of recognising hydronephrosis. The absence of hydronephrosis rules out obstructive nephropathy and obstructed urinary tract infection requiring procedural drainage for source control, however, can dramatically change management of patients if identified. Testicular POCUS performed by emergency physicians has sensitivity and specificity of 80–90 % for epididymo-orchitis [10].

Musculoskeletal POCUS is the next step, especially if no obvious source of infection has yet been identified. Cellulitis is the most common type of soft tissue infection. A cobblestone-like appearance on ultrasound, although not specific, indicates inflamed tissue and combined with the clinical examination, can be helpful in diagnosis of cellulitis. In occult abscess, POCUS has been shown to alter patient management in up to half of patients [11]. POCUS can also identify necrotising fasciitis and expedite management.

Finally, it is important to consider the multiple procedures that are performed in a critically ill patient in which POCUS can be used to increase the success rate and reduce the complication rate. One example is POCUS guided central venous access. It has been clearly demonstrated that central access central access can be achieved with POCUS and requires fewer attempts, demonstrates fewer complications and requires less time than blind attempts to insert a central line. In POCUS-guided peripheral venous access, the benefits have been demonstrated compared to the usual techniques [12]. POCUS is also able to assist lumbar punctures for patients with difficult landmarks and can also be useful in performance of arthrocentesis and airway management.

Source control is a cornerstone in the treatment of infectious diseases and it is an urgent matter in septic patients. Intraabdominal infections represent the other identifiable foci of infection where source control actions become feasible besides skin and soft tissues infection. As mentioned, POCUS is useful in the diagnosis of several intraabdominal pathologies that may require emergency surgical treatment in which diagnosis may otherwise be delayed due to atypical presentation. Soft tissue and skin infections represent the third most frequent cause of severe sepsis and septic shock after pneumonia and intra-abdominal infections. The evidence indicates that POCUS is useful in identifying abscesses in patients with sepsis. This rapid identification of the source of infection can change management, prevent invasive procedures and guide further imaging or consultation. In necrotizing fasciitis the early use of POCUS is an appropriate adjunct in those patients in whom there is a clinical suspicion, with the goal of expediting surgical treatment [13]. Pleural infection is a non-rare complication for pneumonia and almost 20% of empyema episodes will require surgical intervention as source control measure. POCUS is a safe, fast and effective tool to determine volume and accessibility in order to drain abscesses or infected pleural effusions. POCUS can diagnose empyema even in the setting of diagnostic uncertainty on computed tomographic imaging [14]. As the case report above demonstrates, in patient with urinary tract infections, it is important to detect where an

obstruction in the usual urinary flow is responsible for the infection and studies have demonstrated the advantage of POCUS in facilitating rapid bedside diagnosis and rapid intervention.

The only study of POCUS in sepsis [15] in ED compared multi-organ POCUS vs initial clinical assessment. This study showed that POCUS is more accurate than physical exam and history alone in the evaluation of sepsis with a positive likelihood ratio of 16.06 for sepsis source and was able to save time to diagnosis and alter management. Although POCUS is not likely to delay the time to antibiotics, the benefits of POCUS include elucidating the source of infection and guiding use of more targeted antibiotics, determining the need for source control procedures, assisting with hemodynamic assessment and identification of sepsis mimics. It is important to note that accurate use of POCUS for diagnostic purposes requires advance ultrasound skills. Therefore, due to differences in skillsets between clinicians and difficulty of procedure in certain patient groups, for example, those with large body habitus, any research into the benefit of POCUS in emergency departments, could be difficult to conduct and externally validate.

In conclusion, the advantage of POCUS in this case was to establish the diagnosis and guide the management plan of the patient. The patient had an immediate CT that confirmed the diagnosis and was treated in less than 2 hours by the urology team. Without POCUS, this patient would have been referred to the medical team for a suspected gastroenteritis and likely would not have had a CT scan as their abdomen was soft, non-tender, therefore, there would have been no indication. Thus, the sequence of events (and potentially patient outcome) would likely have been different for this case if POCUS were not used. This suggests POCUS can be more accurate when compared to physical examination alone in the initial evaluation of septic patients and potentially can save time to diagnosis and guide management.

Conflicts of Interest: None declared.

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