Asian Journal of Medical Principles and Clinical Practice

Volume 7, Issue 2, Page 327-333, 2024; Article no.AJMPCP.118549

Investigating the Importance of Point-of-care Ultrasound for Rapid Diagnosis and Management of Critical Illness, Including Its Role in Guiding Procedures and Assessing Fluid Status at the Bedside

Ashraf AbdelAziz Elkamhawy [a*]

[a] *Sheikh Khalifa Medical City, Abu Dhabi, UAE.*

Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

Article Information

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/118549

Review Article

Received: 13/04/2024
Accepted: 14/06/2024
Published: 08/07/2024

ABSTRACT

Point of care ultrasound commonly known as POCUS is now an essential tool in managing critical illness since it is involved in diagnosing several illnesses. POCUS enables clinicians to image patients at the bedside, making diagnosis more accurate and helping to guide procedures and assessment of fluid status, all of which are fundamental in treating critically ill patients. Yet, one of the most significant advantages of POCUS is that it helps to shorten the time needed to make a diagnosis. This is because, in emergency and critical care situations, time is one of the most valuable resources that can be called into play. For instance, in the traumatized patient the POCUS can easily diagnose serious conditions like hemorrhage or pneumothorax, and then the patient can be treated. Moreover, in the realm of cardiac diseases, POCUS is also helpful in diagnosing trauma

**Corresponding author: E-mail: ashrafabdelazizelkamhawy@gmail.com;*

Cite as: *Elkamhawy, Ashraf AbdelAziz. 2024. "Investigating the Importance of Point-of-Care Ultrasound for Rapid Diagnosis and Management of Critical Illness, Including Its Role in Guiding Procedures and Assessing Fluid Status at the Bedside". Asian Journal of Medical Principles and Clinical Practice 7 (2):327-33. https://journalajmpcp.com/index.php/AJMPCP/article/view/240.*

patients. Bedside echocardiography can detect pericardial effusions, ventricular dysfunction, and fundamental valve disorders to inform appropriate treatments expeditiously. POCUS offers the advantages of rapid diagnosis, which is critical for making appropriate therapeutic decisions and warranting better outcomes of patient treatment. This paper will show that the use of POCUS in patient management has been linked with positive enhancements specifically in the critically ill populace. POCUS does influence patient care because it allows for quicker and more accurate diagnosis, safer execution of specific procedures, and an accurate evaluation of a patient's fluid status. The analysis of the existing literature revealed that the application of POCUS in the ICU is effective in shortening the length of stay, decreasing the frequency of ordering of other imaging studies, and reducing the incidence of adverse outcomes from invasive procedures.

Keywords: Point-of-care ultrasound; POCUS; critical illness; emergencies; ICU; better patient outcomes.

1. INTRODUCTION

Point-of-care ultrasound is a useful tool in the immediate evaluation and management of critical illness as is evidenced by this case report [1]. It offers the possibility of performing imaging at the patient's bedside, which changes clinical practice for the better, since it increases the diagnostic yield, decreases the risk of complications during interventions, and optimizes fluid resuscitation [2]. Considering the growth of POCUS technology as well as its availability in the future, its application in critical care will only grow creating a positive impact on the patient's survival rate and efficient clinical management of critical illnesses [3,3a,3b,3c].

Misdiagnoses in medicine, especially in intensive care, appear to be an important problem, as indicated by autopsy studies that show high rates of diagnostic mistakes [4]. POCUS has therefore found its way into the management of patients as a valuable tool in cases of diagnostic doubt in prognosis and management plans [5]. Nonetheless, they must embrace the fact that POCUS is only as effective as the operator performing it. Inadequate imaging acquisition and interpretation can also lead to missed diagnoses, and this can lead to further erroneous treatment that can either worsen the condition of patients or even cause the death of the patients involved [6]. Thus, it is essential to ensure that POCUS is performed by adequately trained individuals and that other imaging methods should be used in follow-up if needed. Furthermore, POCUS has to be a supplementary examination to the clinical assessment that remains crucial in diagnosing diseases and planning for management [7].

Intensivists and emergency physicians use POCUS in the patient's management; however, these are not radiologists or sonographers by training. POCUS offers several advantages: it is cost-effective, does not require the use of any instruments, and can be done at the patient's bedside, which is why as a skill it is very useful for nurses and other caregivers in the intensive care units [8].

However, some disadvantages are present in the application of POCUS. The time constraint especially in busy intensive care units or emergency departments may not allow for detailed scanning which may reduce the ability to interrogate any pathological finding that may have been spotted [9]. This indicates that a lot of time can be taken on image acquisition and measurements to the detriment of other essential clinical examination and management routines. Therefore, if POCUS demonstrates any pathologies or if further assessment is needed, the patient should undergo a formal transthoracic echocardiogram or computed tomography (CT) when possible [10].

Although POCUS is a versatile imaging modality that supports critical care by offering timely, point-of-care imaging, its use can be associated with diagnostic errors if not competently performed [11]. Its integration into clinical practice should not be viewed as competing with other diagnostic tests but as an addition to them to provide an all-round approach to patient management [12].

2. EXPLORING THE ROLE OF POINT-OF-CARE ULTRASOUND IN ASSESSING FLUID LEVELS AND OTHER IMPORTANT PROCEDURES

Point-of-care ultrasonography (POCUS) is slowly gaining credence as a non-invasive, imaging modality that provides objective assessment of physiological and hemodynamic parameters

pertaining to fluid status, tolerance and responsiveness at the bedside [13].

The bedside sonographic assessment provides the clinician with qualitative information regarding cardiac performance, and quantitative information about the presence of pulmonary congestion. Other detailed POCUS methods like goal-directed Doppler echocardiography give further quantitative data for the velocities of the flow and pressures across the heart structures [14].

Newer concepts in Doppler flow and its association with abdominal organs have provided further information about the hemodynamic aspects; abnormal Doppler flow patterns in abdominal organs due to elevated right atrial pressure are known to cause congestion of the organs and subsequent damage [15]. The ability to incorporate the POCUS findings into the broader clinical and lab picture helps to establish a patient's hemodynamic state, whether for the administration of crystalloids or engaging diuresis or ultrafiltration, allowing the development of individualized therapy [16].

Evaluation of volume and hemodynamics remains the foundational knowledge for nephrology and is relevant in most consults that involve hypertension, electrolyte disorders, Acute Kidney Injury, or End Stage Kidney Disease. Classically, physical exam findings like jugular venous pressure, third heart sounds, crackles, and leg swelling have defined fluid status [17].

However, although these signs can be useful in extreme conditions, in other cases they are crude to determine volume overload. Radiographic signs of volume overload, Pleural effusions and Kerley B lines are also helpful in assessing the fluid status but are not very sensitive [18]. Furthermore, other biomarkers such as natriuretic peptides and invasive diagnostic tools such as pulmonary artery catheters also have their drawbacks [19].

POCUS has now become mainstream in the last 30 years, and it is now nearly impossible to imagine medicine without it [20]. Unlike the normal method, the POCUS gives a real-time view of the internal structures of the body thus increasing the sensitivity of the routine physical assessment [20]. POCUS entails using Point of Care Ultrasound to address specific clinical queries in a bid to enhance diagnoses and management. Research works have shown that POCUS increases the sensitivity of physical assessments and gives important information that is not easily obtainable [21].

3. INCORPORATING POCUS FINDINGS INTO CLINICAL PRACTICE

As more ultrasonographic markers of fluid status are being discovered and their accuracy for assessment of volume status is being tested, some of them seem to resonate with the basic principles of physiology, while others identify hitherto unknown factors that could potentially be useful in determining the patient's volume status [22].

Nonetheless, the results derived from POCUS should not be restricted to its findings but should incorporate other clinical variables that include; patient's temperature, pulse, respiration rate, blood pressure, and weight, mucosal condition, capillary refill time, and axillary moisture. Instead of acting as a complete replacement of the traditional physical exam or conventional imaging techniques, POCUS should integrate into the approach adopted in the diagnosis and treatment of patients [23,24].

3.1 Carotid Artery Measurements

Most of the previous POCUS studies were conducted on large veins in determining patients' response to intravenous fluids, while the recent studies show that arterial measurements are also important. In particular, it has been found that the diameter of the common carotid artery rises with the augmentation of intravascular volume and is related to the changes in pulse pressure variation [25].

This makes the common carotid artery a useful tool to be used in the evaluation of fluid status by ultrasound. Furthermore, carotid systolic flow time can be assessed using POCUS which can give another parameter towards the assessment of fluid status. For example, if carotid systolic flow time increases by more than thirty milliseconds after PLR the variations in the volume status of patients after dialysis are identified [26].

Discharge time corrected for flow (FTc) of the carotid artery is another important parameter. Studies have shown that variation in FTc can be noted by Doppler ultrasound before the change in a patient's hemodynamic status or any clinical

evident sign in volume depleted patients receiving IV fluids [27].

This ability to detect these changes for such an early period showcases the effectiveness of ultrasound in evaluating the fluid response. Additionally, in healthy participants, FTc correlated well with the delivery of intravascular lower extremity volume to the heart, proving the utility of the index in volume determination [28].

3.2 Detecting Fluid Overload

It can also be useful in diagnosing conditions that result in full excess such as pulmonary edema. The accumulation of fluid in the interlobular septa in the lungs causes hyperechoic reverberation artifactual echoes off the pleura which are referred to as B-lines [29].

The number of B-lines in an ultrasound correlates with the extent of pulmonary edema and thereby can be used as a specific indicator of subclinical fluid accumulation. Recognition of pulmonary congestion using ultrasonography is more sensitive than with chest X-rays or auscultation [30].

3.3 Special Populations and Clinical Applications

It also applies in the evaluation of volume status in unique patients such as; pregnant female, intubated patients, and patients in shock or having congestive heart failure (CHF). For instance, the study on pregnant women observed that the changes in the diameter of the Inferior Vena Cava before and after an intravenous bolus could be measured using ultrasound [31].

Ultrasound measurements of IVC collapsibility index as well as the diameter can predict hypotensive episodes in mechanically ventilated patients to prevent adverse outcomes post-anesthesia [32].

In emergency care environments, ultrasound has been employed to assess volume status in acute mountain sickness patients to determine that patients retain fluid at altitude. This shows versatility of ultrasound in various and complicated scenarios as highlighted above. Furthermore, ultrasound can accurately depict volume changes after resuscitation, and therefore serves as a useful modality in emergency and intensive care medicine [33].

ADHF patients also need to be closely monitored regarding intravascular fluid management, in which POCUS is also useful. It helps in maintaining an accurate fluid balance, an aspect that is core to the treatment and healing process of these patients [34].

4. CONCLUSION

POCUS with or without PLR is an efficient, cost effective and time saving technique that enables the clinician to assess the volume status and fluid responsiveness in patients. Conventional approaches in the assessment of volume status has been through the large veins, but latest findings shows that large arteries can give similar information. It is expected that as more future research is carried out and more knowledge is gained concerning the reliability of sonographic measurements, the utilization of POCUS in critically ill patients will be the norm.

Given that POCUS has not only made significant improvements in diagnosing intravascular volume and fluid status but also provided a non-invasive, rapid and accurate method of assessment at the bedside. It has both the breadth of use, ranging from the evaluation of carotid artery dimensions and systolic flow times to the identification of pulmonary edema and the versatility of being able to track special populations.

HCAs must use POCUS results in conjunction with clinical and laboratory data to manage patients and refine their approach to fluid therapy. With the development of POCUS technology and learning, the technology is predicted to play a big role in critical care medicine to offer tailored patient diagnosis and treatment.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

CONSENT AND ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Lau YH, See KC. Point-of-care ultrasound for critically-ill patients: A mini-review of key diagnostic features and protocols. World J Crit Care Med. 2022 Mar 9;11(2): 70–84.
2. Pourmand A, Pyle M, Yamane D, Sumon K, Frasure SE. The utility of point-of-care ultrasound in the assessment of volume status in acute and critically ill patients. World J Emerg Med. 2019;10(4):232–8.
3. Fraleigh CDM, Duff E. Point-of-care ultrasound. Nurse Pract. 2022 Aug;47(8): 14–20.

3a. Mirian AO, Nneamaka OA, Angela AU. Comparing the accuracy of sonoelastographic ultrasound with biopsy in the assessment of breast masses among Nigerian Women in the lagos university teaching hospital, Lagos, Nigeria. Curr. J. Appl. Sci. Technol. 2022 Sep. 23 [cited 2024 Jun. 2];41(34):12-24. Available:https://journalcjast.com/index.php/CJAST/article/view/3952

3b. Mohamed FR, el-bahnasawy MG, Hasan El-shafey M, Samy Sharaf M. Role of point of care ultrasound in confirmation of endotracheal tube placement in children. J. Adv. Med. Med. Res. 2022 Mar. 25 [cited 2024 Jun. 2];34(5):45-51. Available:https://www.journaljammr.com/index.php/JAMMR/article/view/4411

3c. Breakey N, Osterwalder J, Mathis G, Lehmann B, Sauter TC. Point of care ultrasound for rapid assessment and treatment of palliative care patients in acute medical settings. European Journal of Internal Medicine. 2020 Nov 1;81:7-14.

4. Smallwood N, Dachsel M. Point-of-care ultrasound (POCUS): Unnecessary gadgetry or evidence-based medicine? Clin Med. 2018 Jun;18(3):219–24.
5. Chelikam N, Vyas A, Desai R, Khan N, Raol K, Kavarthapu A, et al. Past and present of point-of-care ultrasound (PoCUS): A narrative review. Cureus. 15(12):e50155.
6. Osterwalder J, Polyzogopoulou E, Hoffmann B. Point-of-care ultrasound—history, current and evolving clinical concepts in emergency medicine. Medicina (Mex). 2023 Dec 15;59(12):2179.
7. Argaiz ER, Koratala A, Reisinger N. Comprehensive assessment of fluid status by point-of-care ultrasonography. Kidney360. 2021 May 27;2(8):1326–38.
8. Balmuth EA, Luan D, Jannat-Khah D, Evans A, Wong T, Scales DA. Point-of-care ultrasound (POCUS): Assessing patient satisfaction and socioemotional benefits in the hospital setting. PloS One. 2024;19(2):e0298665.
9. Tierney DM, Rosborough TK, Sipsey LM, Hanson K, Smith CS, Boland LL, et al. Association of internal medicine point of care ultrasound (POCUS) with length of stay, hospitalization costs, and formal imaging: A prospective cohort study. POCUS J. 8(2):184–92.
10. Rice JA, Brewer J, Speaks T, Choi C, Lahsaei P, Romito BT. The POCUS consult: How point of care ultrasound helps guide medical decision making. Int J Gen Med. 2021 Dec 15;14:9789–806.
11. Mengel-Jørgensen T, Jensen MB. Variation in the use of point-of-care ultrasound in general practice in various European countries. Results of a survey among experts. Eur J Gen Pract. 2016 Dec;22(4):274–7.
12. Ahn C, Kim C, Kang BS, Choi HJ, Cho JH. Variation of availability and frequency of emergency physician-performed ultrasonography between adult and pediatric patients in the academic emergency department in Korea. Clin Exp Emerg Med. 2015 Mar 31;2(1):16–23.
13. Demi L, Wolfram F, Klersy C, De Silvestri A, Ferretti VV, Muller M, et al. New international guidelines and consensus on the use of lung ultrasound. J Ultrasound Med. 2023 Feb;42(2):309–44.
14. Prosen G, Klemen P, Strnad M, Grmec Š. Combination of lung ultrasound (a comet-tail sign) and N-terminal pro-brain natriuretic peptide in differentiating acute heart failure from chronic obstructive pulmonary disease and asthma as cause of acute dyspnea in prehospital

emergency setting. Crit Care. 2011;15 (2):R114.

15. Bustam A, Noor Azhar M, Singh Veriah R, Arumugam K, Loch A. Performance of emergency physicians in point-of-care echocardiography following limited training. Emerg Med J EMJ. 2014 May;31(5):369–73.
16. Mumoli N, Vitale J, Giorgi-Pierfranceschi M, Sabatini S, Tulino R, Cei M, et al. General practitioner-performed compression ultrasonography for diagnosis of deep vein thrombosis of the leg: A multicenter, prospective cohort study. Ann Fam Med. 2017 Nov;15(6):535–9.
17. Bustam A, Noor Azhar M, Singh Veriah R, Arumugam K, Loch A. Performance of emergency physicians in point-of-care echocardiography following limited training. Emerg Med J EMJ. 2014 May;31(5):369–73.
18. Bravo-Merino L, González-Lozano N, Maroto-Salmón R, Meijide-Santos G, Suárez-Gil P, Fañanás-Mastral A. [Validity of the abdominal ecography in primary care for detection of aorta abdominal aneurism in male between 65 and 75 years]. Aten Primaria. 2019 Jan;51(1): 11–7.
19. Lindgaard K, Riisgaard L. Validation of ultrasound examinations performed by general practitioners. Scand J Prim Health Care. 2017 Sep;35(3):256–61.
20. Stein JC, Wang R, Adler N, Boscardin J, Jacoby VL, Won G, et al. Emergency physician ultrasonography for evaluating patients at risk for ectopic pregnancy: A meta-analysis. Ann Emerg Med. 2010 Dec;56(6):674–83.
21. Andersen CA, Jensen MBB, Toftegaard BS, Vedsted P, Harris M, Group ÖR. Primary care physicians' access to in-house ultrasound examinations across Europe: A questionnaire study. BMJ Open. 2019 Sep 1;9(9):e030958.
22. Chen L, Malek T. Point-of-care ultrasonography in emergency and critical care medicine. Crit Care Nurs Q. 2018;41 (2):94–101.
23. Tanael M. Point-of-care ultrasonography, primary care, and prudence. Ann Intern Med. 2020 Oct 20;173(8):650–1.
24. Løkkegaard T, Todsen T, Nayahangan LJ, Andersen CA, Jensen MB, Konge L. Point-of-care ultrasound for general practitioners: A systematic needs assessment. Scand J Prim Health Care. 2020 Mar;38(1):3–11.
25. Gassner M, Killu K, Bauman Z, Coba V, Rosso K, Blyden D. Feasibility of common carotid artery point of care ultrasound in cardiac output measurements compared to invasive methods. J Ultrasound. 2014 Nov 12;18(2):127–33.
26. Montorfano L, Sarkissyan M, Wolfers M, Rodríguez F, Pla F, Montorfano M. POCUS and POCDUS: Essential tools for the evaluation and management of carotid artery pseudoaneurysms after a gunshot wound. Ultrasound J. 2020 Jul 22;12:35.
27. Cheong I, Bermeo M, Granberg G, Tamagnone FM. Tips for carotid ultrasound in the intensive care unit. J Ultrasound. 2022 Aug 2;26(1):277–83.
28. Chang WL, Chen PY, Hsu PJ, Lin SK. Validity and reliability of point-of-care ultrasound for detecting moderate- or high-grade carotid atherosclerosis in an outpatient department. Diagnostics. 2023 Jun 2;13(11):1952.
29. Patel S, Green A, Ashokumar S, Hoke A, Rachoin JS. Objective methods of assessing fluid status to optimize volume management in kidney disease and hypertension: The importance of ultrasound. J Clin Med. 2023 Oct 5;12(19):6368.
30. Pugliese CM, Adegbite BR, Edoa JR, Mombo-Ngoma G, Obone-Atome FA, Heuvelings CC, et al. Point-of-care ultrasound to assess volume status and pulmonary oedema in malaria patients. Infection. 2022;50(1):65–82.
31. Calderon Martinez E, Diarte E, Othon Martinez D, Rodriguez Reyes L, Aguirre Cano DA, Cantu Navarro C, et al. Point-of-care ultrasound for the diagnosis of frequent cardiovascular diseases: A review. Cureus. 15(12):e51032.
32. Shaikh F, Kenny JE, Awan O, Markovic D, Friedman O, He T, et al. Measuring the accuracy of cardiac output using POCUS: The introduction of artificial intelligence into routine care. Ultrasound J. 2022 Dec 14;14:47.
33. Abraham JR, Torline E, Fentanes E. Focus on POCUS: Carcinoid heart disease found with point-of-care ultrasound during basic physical exam. CASE Cardiovasc

Imaging Case Rep. 2021 Oct 7;5(6): 380–3.

34. Swanson JR, Shook DC, Vacanti JC, Molloy LM, Fields KG, Palmer LJ. Implementation of a self-guided focused cardiac ultrasound curriculum for anesthesiology residents. J Educ Perioper Med JEPM. 2020 Apr 1;22(2):E642.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/118549