Journal of
Cardiology & Cardiovascular Therapy
ISSN: 2474-7580

Juniper Publishers
key to the Researchers

Mini Review
Volume 19 Issue 1 - January 2024
DOI: 10.19080/JOCCT.2024.19.556005

J Cardiol & Cardiovasc Ther

Setting up and Maintaining a Critical Care Point of Care Ultrasound Service

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Submission: January 12, 2024; **Published:** January 25, 2024

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MeSH terms: Ultrasonography, Echocardiography, Point-of-care systems, point-of-care testing, Critical care

Abstract

Critical Care Point of Care Ultrasound (POCUS) is a rapidly growing field with a large array of benefits to patient care alongside some challenges. Its delivery can come in several different forms from being technician and cardiologist delivered, to being led by POCUS teams and intensive care clinicians. In this paper we explain the different models currently available and discuss the logistics of setting up and maintaining a Critical Care POCUS service. We'll use St. George's Hospital as a case study and also discuss results of a survey of the other major university hospitals in London to assess their current POCUS set up. It is our hope that this will assist with services being set up and improved upon. This article will be most relevant to critical care services in the UK; however, we envisage that many elements will be extendable to other specialties and healthcare systems.

Keywords: POCUS; Point-of-Care Ultrasound; Echocardiography; Critical care

Abbreviations: POCUS: Point of care Ultrasound; PA: Critical care Physician Associate; ANP: Advanced Nurse Practitioner; FUSIC: Focussed Ultrasound in Intensive Care; FUSIC HD: Focussed Ultrasound in Intensive Care Hemodynamics; ICS: Intensive Care Society; ACCE: Adult Critical Care Echocardiography; BSE: British Society of Echocardiography; ESC: European Society of Cardiology; EDEC: European Diploma in Intensive Care Echocardiography; ESICM: European Society of Intensive Care Medicine

Background

In 1942, Karl Theodore Dussik published the first work on medical ultrasound, after successfully imaging some of the structures of the brain . By the 1980's, after breaking down many of the initial technological barriers, real-time ultrasound had been developed, and over the next 30 years its use spread across many different specialties. Critical care doctors began using ultrasound in the early 1990's as a method to assist with the insertion of central venous catheters . However, over the past 10 years its value as a diagnostic tool in critical care has begun to be recognized and we are now entering a new and exciting era of Point of Care Ultrasound (POCUS) [1,2].

Critical Care POCUS may be defined as the acquisition, interpretation, and immediate clinical integration of ultrasonographic imaging during treatment of critically ill patients. This imaging has traditionally been provided by specialists such as cardiologists for echocardiography and radiologists for abdominal scanning. However, attending clinicians who have the appropriate training are able to use focused imaging to infer immediate clinical decision-making in a number of clinical settings such as the emergency department, critical care and obstetrics & gynecology.

Critical care POCUS is recognized as a valuable tool to aid clinical decision-making during resuscitation and subsequent management of critically ill patients . In contrast to the traditional model of 'ordering a scan' at a single point in time, it can be performed without delay at the bedside and can easily be repeated to assess effect of an intervention and therefore titrate dose of a treatment [3]. A critical care doctor can integrate their POCUS findings with specific clinical understanding to create an overall picture, which is more difficult to do when scans are performed by non-intensive care trained staff. Several studies report significant changes in management with POCUS and some report reduction in mortality . Its benefits go further with less tangible suggestions that it may help to reduce burnout of clinicians.

POCUS is recognized as a core intensivist skill by both the European and British Intensive Care Societies, who have recommended that training in this competency should be part of

the ICU curriculum . It is also increasingly being taught in medical school [4].

The indications for echocardiography are increasing. The European Society of Intensive Care (ESICM) have produced consensus guidelines advising echocardiography as the preferred modality for the differentiation of type of shock and the sequential evaluation of response to therapy [5,6]. Similarly, the National Institute for Clinical Excellence advise performing echocardiography within 48 hours of a new presentation of suspected acute heart failure . This quantity of initial and repeated scans is unlikely to be able to be performed by already stretched technician and cardiology services.

Critics of POCUS may point out that scans are likely to be performed by less experienced clinicians and that there are a legion of other education, safety, governance, and financial barriers to it being an effective tool in the critical care environment. However, we believe these are issues that can be successfully managed – namely by ensuring that people of appropriate competency perform the scans and manage the team. It must be recognized that patients who require basic level scanning have different needs to those with more complex pathology. In particular, patients with complex hemodynamic problems may require a senior ICU doctor with expert echocardiography knowledge to perform and/or make decisions based on the information gathered. There are also many situations where specialist ultrasound skills are beneficial and, in these cases, the advanced skills of cardiologists, technicians, radiologists, radiographers, gynecologists and others should be requested [7-10].

Although not directly extendable, we hope this information will be helpful for other specialties setting up POCUS services, such as acute medicine and countries with different healthcare systems. There will also be a focus on echocardiography as this is the most commonly used modality. Our aim is that this article will assist units in starting their own POCUS service and help more established ones develop and improve. The appendix contains the St. George's POCUS guideline, a cleaning protocol and reporting template [11,12].

Main Text

Methods of delivery of a critical care POCUS service

An ideal critical care POCUS service would enable immediate, high-quality imaging of all body systems by clinicians with the ability to integrate findings with the clinical picture to produce a comprehensive plan that can be adapted as required by repeat imaging whenever necessary. Quality would be assessed and maintained with an effective governance structure and there would be a well-organized formal and informal educational programmed for trainees at all skill levels [13]. Below, we outline the main models of providing ultrasound to critical care patients and discuss their benefits and limitations.

Echocardiography technician delivery

In this model, echocardiograms are requested by the critical care team and then performed by a technician. Technicians have the ability to perform comprehensive scans, with detailed analysis of heart valves, regional wall motion abnormalities and other advanced details that require many years of training to perform accurately. Due to high demand for this service, there will usually be a delay in getting the scan and subsequent report – which can be detrimental in acute situations. This model lacks the benefit of integration of clinical understanding such as titration of vasoactive drugs and heart-lung interactions. Echo technicians are not doctors and are mainly trained to look for structural changes. The service is also not designed to track intervention, nor it is designed to respond to acute clinical needs [14,15].

Cardiology delivery

This model is similar to the technician delivered one above. Cardiologist training can help to provide clinical context. In particular, their advanced knowledge of cardiac function and high-level structural echo knowledge can be advantageous – for example in the assessment of complex valvular disease. However, this training does not include critical care specific pathology and treatment [16]. The workload of cardiologists is also often high, and they are unlikely to be able to provide exclusive critical care echocardiography services while also managing their own patients and emergency cardiac services. Much like echocardiography technicians, cardiology services are not designed to support ICU clinical decision making 24/7.

Radiologist delivery

Abdominal and vascular ultrasound has traditionally been the remit of radiologists and radiographers. Similar to the technician delivery of echocardiograms, this model has the advantage of advanced technical skill but disadvantages of single point in time assessment, lack of out of hours service, delay in gaining results and potential lack of clinical integration by the person performing the scan [17].

Critical care POCUS team delivery

In this model, critical care physicians work as POCUS doctors for a critical care department each day. Here, a clinician can triage scans and direct them to the most appropriate team member, take time to perform advanced scans, integrate findings with clinical understanding, repeat scans after interventions and perform immediate scans if workload allows. Having a specific POCUS clinician each day can also help foster an environment where teaching, safety, governance, and research are promoted.

It is essential that there is a senior intensivist with advanced POCUS skills available for support and oversight. This should ideally be in the form of dedicated work time. A 24/7 POCUS team would be optimal; however, this is unlikely to be feasible

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- especially in smaller hospitals. A 9-5 weekday service is likely to be more practical. As hospitals have varying Rota setups, the logistics here need to be individually tailored. In the UK, an increasing number of intensive care doctors are pursuing a Special Study Year in echocardiography and this model fits well with the guidance that these doctors should spend at least 1 day per week performing scans and continue their clinical duties [18].

Other health professional delivery

Critical care Physician Associates (PA's) or Advanced Nurse Practitioners (ANP's) trained in advanced POCUS skills work on the unit and liaise with other clinical staff for scans. Fewer staff may be needed to fill Rota as their exclusive job would be to provide POCUS services or there could be a method of combining them with a service for other procedures such as line insertion and transfers. However, advanced critical care knowledge may be limited, negating some of the major benefits of critical care clinician delivered POCUS. To our knowledge this model is not currently in use, but it is an interesting field and could be an avenue for future exploration.

Critical care clinical team delivery

POCUS scans are performed by physicians working clinically on their unit. Scans may be naturally integrated into daily examinations and clinical details are most likely to be understood and integrated with findings on ultrasound. However, this model requires that there be appropriately trained physicians available each day. With increasing interest in POCUS this is likely to become a more common scenario, but currently it is not feasible due to the low numbers of clinicians that are able to perform POCUS at an advanced level. In addition, other clinical duties may impede the physician's ability to perform and repeat more time-consuming scans. However, as scanning prowess improves, it can be performed in a more focused manner – New Jersey Medical School report that their fully trained clinicians can perform a POCUS echocardiogram, lung, abdominal and DVT scan within 8 minutes while on ward rounds [19,20].

Overall

It is unlikely to be feasible to maintain a full critical care POCUS team in smaller units due to lower numbers of staff and likely insufficient workload. Therefore, clinical team delivered POCUS may be preferable. Training and general interest in POCUS can be promoted in these situations by linking hospitals together for education and governance. For example, in London there is a monthly online critical care echocardiography meeting with case presentations and there are plans afoot for monthly pan-London POCUS fellow meetings.

There are many different models for providing ultrasound to patients in critical care, each with their own benefits and limitations, summarised in Table 1. We believe that an effective POCUS service is one that is flexible and combines the above methods – gaining each of the benefits and limiting the downsides. It is therefore likely that many large hospitals would benefit from the foundation of a critical care POCUS team if they don't have one already. Fostering a positive educational environment between all parties involved in ultrasound is likely to lead to best care.

Table 1: Comparison of different models for providing ultrasound services to patients in intensive care

	Clinical context	Continuity and ongoing responsibility	Primary responsibility to perform scans	Understands ICU interventions, effects and consequences	Able to repeat scan regularly and monitor	Able to perform expert scan	No specific service set up cost	Reliable, timely service
Attending senior ICU Physician	☑	☑		☑	☑	☑	☑	
Non-attending senior ICU physician	☑		☑	☑	☑	☑		☑
Attending junior ICU physician	☑	☑			☑		☑	
Non-attending junior ICU physician			☑		☑			☑

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Non-ICU senior physician e.g. cardiology on call				(☑)		☑	☑	
Non-ICU junior physician e.g. cardiology on call							☑	☑
Imaging physician (expert scanner)			☑			☑		
Imaging technician (expert scanner)			☑			☑		

Clinical Governance

It is essential that a POCUS service is well governed. We will discuss training & staff management, information & IT, clinical effectiveness, audit, and risk management in detail.

Training and staff management

Training in POCUS can take an informal route – where clinicians are taught 'on-the-job' by more experienced clinicians. This is similar to how many critical care skills are gained, for example with central line insertion. However, it is increasingly common for POCUS education to take a more structured form. Scan results can drastically change management, so there are considerable safety and medicolegal considerations. It is therefore generally considered that scan reports should be supported by a qualification. The Intensive care society support POCUS scan reports if the reporter is qualified [21].

Courses as short as 3 days are effective at teaching the basics of POCUS . Beyond these, there are a number of more advanced critical care specific qualifications available to clinicians. Most focus on echocardiography, but lung, abdominal and vascular ultrasound qualifications are increasingly being considered. Options in the UK include the Focussed Ultrasound in Intensive Care (FUSIC and FUSIC HD) qualifications, managed by the Intensive Care Society (ICS). The Adult Critical Care Echocardiography (ACCE) accreditation, managed by the British Society of Echocardiography (BSE). The European Society of Cardiology (ESC) transthoracic echocardiography certification and the European Diploma in Intensive Care Echocardiography (EDEC), managed by the European Society of Intensive Care Medicine (ESICM). Each has a slightly different focus and required amount of theoretical and practical work, but all are completed with a structured assessment in order to gain the qualification. The future is likely to result in standardisation of these programmes.

We suggest that an effective POCUS service should focus on education. It should be set up to encourage informal teaching, provide mentorship opportunities for the above accreditations and have regular educational meetings. It would also be beneficial to share educational opportunities with cardiologists and technicians to encourage interdisciplinary cooperation and breadth of learning [22].

It may be helpful to establish a tiered education system to ensure teaching is given at the appropriate level. In our establishment, there is a weekly basic level echocardiography teaching session for those working towards their first POCUS

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qualification and a more advanced monthly half day session, which explores advanced techniques and new literature on the subject. In smaller establishments, sufficient interest and attendance could be maintained by linking educational opportunities with other hospitals in a hub and spoke model.

Information & IT

POCUS relies heavily on effective IT. This includes the software on ultrasound machines, POCUS reporting software, image storage solutions and IT systems for teaching and training. In most hospitals, there is likely to already be a central data storage system in place for cardiologists and technicians to upload images.

The software used to assist with writing reports is highly variable. In its simplest form, reports can be handwritten or typed in a freehand format. It is generally more advisable to use a proforma such as those available from FUSIC, EDEC or the BSE. The BSE has a minimum data set guideline, which may be helpful in producing a local proforma.

It is also possible to have data automatically populated into reports. This is highly desirable as it can reduce reporting time, improve accuracy and enable effective audit & research.

Clinical effectiveness, audit and risk management

Effectiveness should be measured and maintained by regular audit and ensuring that staff are adequately trained and supervised. These activities can be linked with other departments such as A&E, acute medicine and cardiology to streamline the systems and enhance learning.

In an ICU POCUS team led service, time can be dedicated to governance, and it may be easier to maintain high standards than with the other models discussed. High quality software can also enable rapid assimilation of large data sets for audit and research.

Audit projects will vary among hospitals but may include data collection on the adherence to local POCUS protocols, the usage of the POCUS service and the number of trainees achieving POCUS qualifications.

Financial considerations

Set up of a POCUS service is likely to require purchase of new equipment. Although units are likely to already have machines, their quality and quantity may need to be increased. Advanced ultrasound machines capable of comprehensive advanced echocardiography cost approximately £40,000 per unit. Less advanced machines able to perform most functions cost approximately £10,000 each. There are a plethora of handheld devices available, and their quality is rapidly improving . They currently cost £3000 - £7000 per unit, in some cases requiring a subscription. It is likely their use will increase in time. Machine maintenance and reporting software must also be factored into costs. Although not directly applicable to the NHS model in the UK, appropriate billing of POCUS is important and has several barriers [23].

There may be a need to hire more clinicians if a proportion of their time is assigned to POCUS activity. This may apply to juniors spending time on a POCUS team or consultants having dedicated time assigned to POCUS activity. In our experience, this is not common, and clinicians may use unpaid time to advance their skills and provide POCUS services, which is unlikely to be a popular or sustainable model. Although there are likely to be significant upfront costs, it is likely that the establishment of a POCUS service would be a cost-effective one overall.

An example of a Critical Care POCUS Service

St. George's hospital is a large center with three intensive care units. It is a regional Heart Attack, Hyper-acute Stroke and Major Trauma Centre. It also runs cardiothoracic services. Consequently, there is high acuity within the critical care service and high demand for POCUS. It was recognized during the COVID-19 pandemic that a specific POCUS service would be beneficial. Over several years the service has developed and it currently runs a formal POCUS team 9-5 on weekdays, with ad-hoc on-call scanning provision out of hours. Four POCUS fellows manage the day to day service, weekly basic teaching, monthly advanced training days and regular governance meetings with oversight and support from three Intensive Care Consultants. It is recognized as a valuable clinical service. The most recent audit data demonstrated that over a period of 955 days, 1478 advanced critical care echoes were performed and documented.

St. George's has also developed a reputation as an excellent center for POCUS training. A recent internal survey demonstrated that 30% of newly recruited junior doctors marked POCUS teaching as the main reason for choosing St. George's over other trusts. Ambitions for the future include the establishment of a commissioned service and to contribute to the field of POCUS research. The George's experience is summarised in Table 2.

Conclusion

The case for POCUS improving outcomes in critical care is compelling, if not yet definitive. Many of the barriers to effective POCUS are falling, such as lack of suitable mentors, unwieldy machines, and poor software. With more universal training, it is likely that POCUS will become more of a routine extension of the clinical examination. We believe that it is likely to be beneficial to set up and maintain a POCUS service in many critical care units and have presented the different models available and suggestions on how to overcome some of the logistical hurdles.

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Table 2: St. George's Hospital POCUS Service.

Size	3 units (general, cardiothoracic, neuro) with 69 Total beds
Model	ICU trained POCUS team weekday service
Staffing	3-5 POCUS fellows, work on call rota, spend 30% of their duties on the POCUS team. consultants with advanced qualifications provide oversight
Machines	3 advanced echo machines, 3 general use ultrasound machines
Software	Proforma integrated to computerised medical notes
Teaching	weekly seminar style 1 hour programme at basic basic to intermediate level run by fellows. options for junior members to join POCUS team on their 'flexi-days' and work towards accreditation under supervision. 2x manne-quin models for TTE & TOE training. annual FUSIC heart, lung, abdo and vascular training days. annual advanced critical care echocardiography 3-day course
Governance	monthly governance meeting. fellows encouraged and supported to run audit and research projects
Successes	Strong training credentials, ability for juniors to gain supervision easily and regularly participate in teaching. High quality equipment
Issues	Not currently a full weekday service due to staff limitations

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