Diagnostic Nurse-led Ultrasound in Tertiary Care:

Training and Implementation Strategies

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Destination: Nepean Hospital, Sydney, Australia

ABOUT THE AUTHOR

I trained in adult nursing in 2011, specialising in critical care before moving into critical care research and then leading the emergency medicine and trauma nursing research team at King's College Hospital. Through close collaboration with the critical care research lead at KCH, Dr Phil Hopkins, I developed an interest in nurse-led Point-of-Care Ultrasound (PoCUS). With the help of Dr Hopkins, I trained in PoCUS of the whole-body, and specialised in cardiac and lung PoCUS through the Focused Intensive Care Echocardiography course (FICE) and Core Ultrasound for Intensive Care course (CUSIC). I have since begun the design of a series of research projects to evaluate a bespoke PoCUS training programme for critical care nurses and advanced critical care practitioners (ACCPs), and a feasibility study to evaluate the potential of progressing to a subsequent large-scale randomised controlled trial. The aim of these studies is to determine whether routine nurse and ACCP-led PoCUS can positively impact patient outcomes and reduce treatment costs to the National Health Service.

I was successful in securing a Pre-doctoral Clinical Academic Fellowship with the National Institute of Health Research full-time over 1 year to complete my MSc, prepare me for a doctoral fellowship application to conduct my research project, and to undertake preparatory work in my research area. This commenced upon return from my expedition with the WCMT.

TABLE OF CONTENTS

SECTION 1

BACKGROUND

Ultrasound is a medical test that produces live pictures of the inside of the body using sound waves. It involves placing a small probe on the surface of the skin and can be used at the patient's bedside to diagnose problems rapidly and guide treatments. Use at the bedside is known as point-of-care ultrasound (PoCUS) and is as accurate as other forms of imaging such as X-ray and CT scans. Routine use of PoCUS in the intensive care unit (ICU) reduces the need for other imaging, therefore reducing patient exposure to radiation and overall treatment costs. Training in PoCUS is designed for use by doctors, yet there are not enough doctors in ICU to perform PoCUS routinely. Advanced critical care practitioners (ACCPs) and ICU nurses are able to perform PoCUS scans as accurately as doctors. ACCPs are highly specialised healthcare professionals from nursing, paramedic, or physiotherapy backgrounds. Along with ICU nurses, ACCPs carry out advanced assessments and skilled procedures on patients in the ICU and are best placed to recognise any sudden deterioration in their patient's condition. Providing ACCPs and ICU nurses with PoCUS skills increases the number of trained staff to perform routine PoCUS in the ICU. However, no studies have researched whether routine ACCP/ICU nurse led ultrasound can positively benefit ICU patients or reduce healthcare costs.

POTENTIAL IMPACT ON PATIENTS AND ANTICIPATED VALUE

PoCUS minimises patient risk through reducing radiation exposure and has superior diagnostic capabilities compared to the stethoscope (1, 2). When performed by ICU physicians, PoCUS could provide more accurate and improved management of life-threatening conditions such as undifferentiated hypotension, respiratory failure and multi-organ failure compared to standard care alone (3, 4). Routine whole-body PoCUS may aid earlier recognition of physiological abnormalities, enabling more informed and timely clinical decision-making regarding lifesaving interventions such as patient positioning (proning), ventilatory support, and fluid balance optimisation (5). ACCPs and ICU nurses can learn and utilise PoCUS with comparable accuracy (6, 7). Increased PoCUS use has the potential to positively impact more patients, with less disruption to patient care. ACCPs and ICU nurses are sensitive towards patient privacy and other daily care priorities compared to other ICU team members. Therefore, they would take a more patient-centred approach to PoCUS i.e. when convenient to the patient or when they are correctly positioned.

IMPACT ON NHS STAFF AND SERVICES AND ANTICIPATED VALUE

By introducing a training and competency programme that aims to achieve competency based on individual progress as opposed to a fixed number of scans, time invested in training may be reduced. Furthermore, designing a training programme specifically for ACCPs/ICU nurses addresses the increased demand for advanced assessment skills in non-medical professionals in ICU. PoCUS may reduce service costs by limiting the need for other imaging (8). PoCUS may therefore also minimise time spent in diagnostic testing outside the ICU, allowing for uninterrupted ICU care. The economic value of reduced training time for the trainee and supervisor, fewer diagnostic tests and the potential for improved patient outcomes could be significant.

PURPOSE OF THE WCMT TRAVEL FELLOWSHIP

I want to develop a training and competency programme for ICU nurses and ACCPs. I will evaluate whether competency can be achieved for a specific sequence of PoCUS scans of the whole-body (called the INSIGHT scan). The aim is to achieve competency in the fewest scans possible to reduce the burden on the trainee and the supervisor whilst meeting a set of pre-defined competency criteria. This will be the first study in a series of research projects. Following demonstration that the proposed training programme (the INSIGHT Training and Competency Programme) can achieve competency in a sufficient proportion of ICU nurses and ACCPs undertaking training, I would like to establish whether introducing the INSIGHT scan into routine patient assessment is feasible (Study 2), and if its adoption into clinical practice can positively impact patient outcomes and healthcare costs (Study 3).

To run this series of research projects, I needed to become sufficiently competent in performing ultrasound. Proficiency in PoCUS will facilitate the robust design of my research project and enable me to provide reliable and comprehensive supervision for the ICU nurses and ACCPs who participate in the INSIGHT Training and Competency Programme. Dr Phil Hopkins established a relationship with a unique, world-renowned nurse-led echocardiography department worldwide in Nepean Hospital, Sydney, Australia. He asked if I could spend some time learning from them and I was fortunate to be invited there to train in echocardiography over a two-month period. Through this vital placement, I was not only able to advance my sonography skills, but I was able to build on my awareness of evidence-based research in PoCUS and my existing theoretical knowledge. I investigated the key strategies to implementing a nurse-led ultrasound service within an acute tertiary setting, the barriers and facilitators to successful integration of the service and useful training approaches that would ensure my training programme design would result in a high rate of competency to a consistent standard. Specific areas of focus included:

- Establishment and scope of the Nepean Hospital sonography service
- Training approaches in advanced echocardiography and PoCUS at Nepean
- How the sonography service functions for their ICU/ward patients and out-patients
- The culture shift around doctors' acceptance of nurse sonographers
- The level of training expected for a nurse to be deemed competent

ICU consultant Dr Philip Hopkins is an Honorary Senior Lecturer in Intensive Care Medicine at King's College London and the research and development lead for the Anaesthetic, Critical Care, Emergency & Trauma (ACET) research team at King's College Hospital. He holds the position of NIHR Clinical Research Network Research Lead for Critical Care in South London. As a result of his extensive experience in intensive care medicine and working closely with ICU nurses, he identified an opportunity to research a unique concept that has not yet been approached in nursing practice in the United Kingdom (UK).

Preliminary research was carried out by nurses at King's College Hospital (KCH) to look at the acceptability of nurse-led ultrasound in ICU. Over 250 cardiologists, intensivists, physiotherapists and ICU nurses were asked if they thought nurses could perform PoCUS, whether they would be able to accurately interpret and report what they scanned, and whether reports would be utilised by ICU physicians. Findings were encouraging, indicating that there was overarching acceptability of nurse-led PoCUS in the ICU, and a belief that nurses were capable of performing simple PoCUS providing they had the appropriate training which was strictly governed to ensure safe practice.

A second survey was completed by the same cohort of staff to ascertain which windows should be included in a whole-body PoCUS scan. Below is a list of the survey questions:

- Which windows would provide the most useful information to guide treatment?
- How many training scans are required to achieve competence?
- How long should it take to complete each ultrasound window?
- What binary questions should be asked when reporting each window?

The answers of the survey guided the choice of windows for the whole-body INSIGHT scan (Appendix 1) and the development of the standardised INSIGHT scan reporting form that is completed for each INSIGHT scan. The closed yes or no questions limit the possibility of any subjectivity or diagnosis beyond the capability of the INSIGHT protocol. I presented these findings at the International Symposium for Intensive Care and Emergency Medicine which are summarised in Appendix 2.

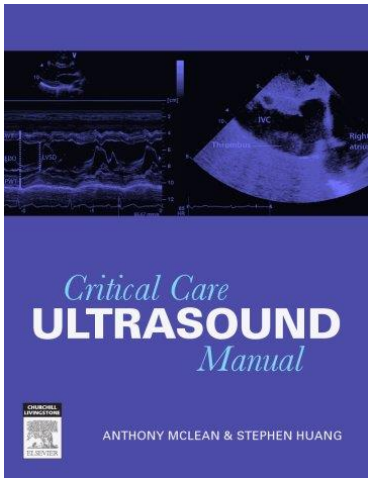
The research conducted at KCH highlighted that a study to evaluate the effectiveness of a PoCUS training programme and routine PoCUS scanning protocol would be widely accepted.

SECTION 2

ESTABLISHMENT AND SCOPE OF THE NEPEAN HOSPITAL SONOGRAPHY SERVICE

Australia is renowned for being progressive in their approach to nursing development and has an advanced healthcare system. Nepean Hospital sonography department is the brainchild of Professor Anthony McLean whose career as a cardiologist and then intensivist led him to create a sonography service of unique design. At the time of formation, no permanent sonography department existed at Nepean and ultrasound scans were generally performed by locum physicians trained in echocardiography. He therefore recognised a demand for a more cost-effective and consistently available workforce that could attend to the ever-changing condition of the ICU patient and the needs of the 24-hour critical care service. Prof McLean created the only healthcare centre world-wide that trains ICU nurses to be the principal sonographers for a trust sonography service. To work in Nepean sonography department, ICU nurses undertake a 2-year diploma, performing and reporting a minimum of 2000 scans in either cardiac or vascular sonography. ICU nurses must work at least 24 hours per week in the ultrasound laboratory during their post-graduate training and every nurse must undertake a supernumerary period prior to applying for training to ascertain whether there is genuine intent to undergo training and whether they possess the potential to reach competency. This is due to the substantial cost of training and time invested by the supervising sonographer during the 2-year period to achieve accreditation.

For the past 20 years, advanced nurse sonographers have performed ultrasound scans for ICU, ward, and out-patients. The team regularly runs international basic (rapid assessment of cardiac echo (RACE)) and advanced ultrasound training courses, live webinars for the American Society of Echocardiography and has a high research output. The echocardiography team also put together the *Critical Care Ultrasound Manual* (9) whose multiple choice questions have helped inform the knowledge questionnaire I will incorporate into the INSIGHT training day (see page 17 for further details). The sonography department facilitates regular training for doctors and clinical fellows throughout the year but had not trained an external nurse prior to my visit.



Chief nurse sonographer, Iris Ting was the first ICU nurse to be trained up when Professor Mclean created the service at Nepean hospital 20 years ago. She has worked in the department since its creation, performing more than 40,000 echocardiograms. I shadowed Ms Ting for a total of 7 weeks. The department comprises 6 ICU nurses who carry out transthoracic echocardiography (TTE), transoesophageal echocardiography (TOE) with ICU consultants, stress echocardiography tests and vascular ultrasound. The department is located in between Nepean's' two adult ICUs. It offers immediate patient scans to ICU patients during work hours and runs an on-call service for time-critical cases. The five sonography rooms receive scheduled outpatients in the morning and ward patients throughout the day.

Many benefits were visible from utilising nurses in this capacity. Examples include:

- reduced waiting times for investigations
- faster treatment
- increased efficiency of overall healthcare provision by having dedicated ICU sonographers
- increased staff retention as a result of the sonography training programme encouraging career progression

The patient population at Nepean is mostly of low socio-economic status. Many with significant co-morbidities that increase the complexity of patient cases. Several patients also had a high Body Mass Index (BMI), affecting image acquisition due to the ergonomics of probe positioning and deep tissue penetration. For each patient, the designated sonographer would receive a request form with the indication for TTE which we were asked to investigate. Each patient would require a unique set of scans to answer the issue in question. All scans would be recorded and formally reported. An ICU consultant trained in advanced echocardiography and part of the sonography department would oversee reviewing of scans and corresponding reports for one week and would be responsible for providing the formal diagnosis.

SONOGRAPHY TRAINING

My sonography training at Nepean involved TTE only. I completed on average 5 scans per day over the 7-week period. Each scan would follow a protocolised format to include a standard set of images of the heart including structure, systolic and diastolic function and set measurements to calculate valuable information (for example, cardiac output or degree of aortic valve stenosis). If any abnormalities were spotted, further images and measurements were taken to aid the reporting consultant to make an accurate diagnosis. I have included the proforma for the basic scanning sequence in Appendix 3. This scanning sequence closely resembles the UK national recommendations for an advanced TTE scan. Scans took me approximately 1 hour to complete with constant supervision at the start of training. Towards the end of the 7 weeks, I could complete the sequence in 25-30 minutes unaided (depending on the patient's body habitus) with additional time allocated to write scan reports under supervision. This opportunity for dedicated practice significantly enhanced my skill in probe positioning, image optimisation, image interpretation and reporting and facilitated continued learning of normal and abnormal pathologies. Ms Ting also set me case studies and specific revision focuses to complement the progression in my practical sonography.

During my doctorate, I will be working towards accreditation in advanced echocardiography in critical care with the British Society of Echocardiography. This is with the intention of becoming the first dedicated ICU nurse sonographer in the UK. My role would involve performing a comprehensive TTE scan on any ICU patient with a clinical question to be answered – taking over the role of out-of-department sonographers who are already stretched. By undertaking TTE's that normally require formal requesting, it reduces the burden on the radiology department, freeing up time for other patients and reduces the waiting time for the ICU patient which means scans could be acted on in a more timely fashion. This may have a significant impact on patient outcome and overall healthcare costs by reducing the need for other forms of imaging and potentially intervening earlier in the clinical deterioration of the patient. Becoming an experienced sonographer will enhance the integrity of my research, my suitability as a supervisor throughout the research programme, and assist in identifying other gaps in PoCUS ICU practice in need of research. My role will involve taking on the responsibility for physician, nurse, ACCP and allied health professional training (including PoCUS governance and standardisation of competence) in PoCUS which I hope to expand to a national scale. My training at Nepean was therefore the first step in preparing me for a nationally unrivalled clinical academic career in nurse sonography.

Ms Ting discussed her vision to train ICU nurses in PoCUS for regular clinical assessment of their patients. Along with the sonography faculty, Ms Ting recognised the potential benefits nurse-led PoCUS had for increasing nurse autonomy, sense of importance and responsibility, career progression and staff retention. She also saw its future in routine clinical assessment of the ICU patient and how that had the potential to improve patient outcomes and healthcare costs. In recent years, the sonography faculty developed a bespoke training programme in PoCUS for ICU nurses. However, despite a great deal of initial interest from the nurses, Ms Ting struggled to rally enough numbers to form regular PoCUS training and the programme was abandoned. When nurses were asked why they did not sign up or persevere with the training programme, their reasons included lack of time to attend training or perform scans alongside routine clinical care, and a belief that their scans would not be utilised by treating physicians and therefore made no difference to patient care.

This finding raised a vital issue in the possible barriers in the implementation of nurse-led PoCUS. Specifically:

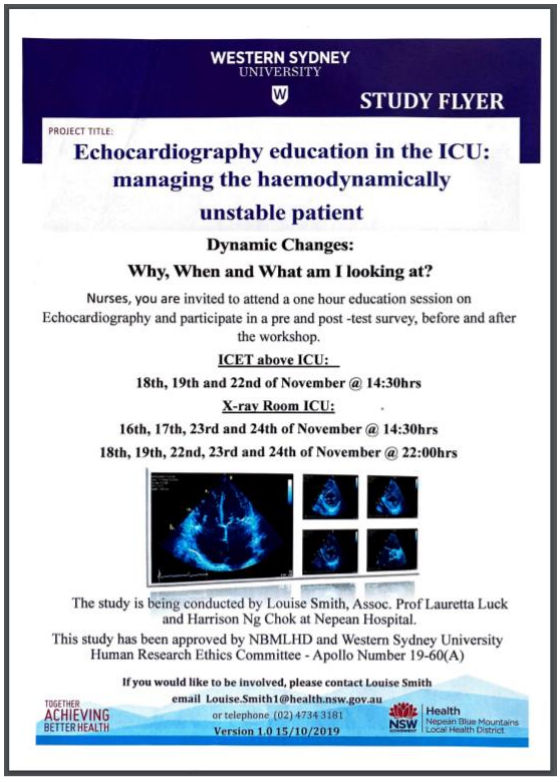
(1) The feasibility of training an already stretched workforce in another skill
(2) Nurse perception that PoCUS would be deemed time consuming to practice routinely
(3) The culture shift needed for ICU nurses to confidently perform and report PoCUS scans and for ICU physicians to actively utilise findings to inform their clinical assessment of the patient.

Although the preliminary research we conducted at KCH identified theoretical acceptance of integrating nurse-led ultrasound into clinical practice, the reality of integrating a nurse-led PoCUS service in ICU may be much more problematic. As a result, I spent considerable time researching training approaches to minimise training burden on the trainee sonographer and supervisor, training methods that enabled competency to be achieved in the least amount of training time and research into PoCUS used as part of routine clinical practice in ICU.

RESEARCH INTO POCUS EDUCATION AND GOVERNANCE FOR NURSES AT NEPEAN

Ms Louise Smith is a clinical nurse specialist in echocardiography. She has been researching prevalence and quality of nurse education of ultrasound in ICU. Her research was in response the failed attempts to engage nurses in PoCUS, and due to her continued observation of PoCUS practice among physicians. She conducted a literature review looking at (1) prevalence of nurses learning ultrasound as a clinical skill and (2) availability and quality of ultrasound education and theory for nurses. Although a small amount of literature exists in the former, there is almost no research in the latter. This is despite Ms Smith's experience that nurses receive less training than doctors in anatomy and physiology and are therefore already at a disadvantage. Her belief is that without adequate theoretical knowledge to support clinical competency, performing ultrasound can present considerable risk to the patient. She found that nurses had the potential to struggle with image acquisition, interpretation and underdiagnosing or misdiagnosing pathologies. We discussed the steep learning curve often experienced by nurses; that it can play a part in commitment to training programmes and affects overall confidence levels in the ability to practice PoCUS competently.

Ms Smith investigated ways of improving knowledge acquisition and retention. She conducted a small study to investigate whether a 1-hour theoretical training session improved nurses' knowledge and confidence in PoCUS, particularly image interpretation. The purpose was not to prepare nurses for clinical ultrasound training, but to ascertain their level of comprehension and overall confidence in knowledge acquired. She designed a knowledge questionnaire which she administered before and after the training session and 6 weeks later to compare baseline knowledge to knowledge gained, and retention of knowledge, respectively. She used previously validated multiple-choice questions.


WESTERN SYDNEY UNIVERSITY

STUDY FLYER

PROJECT TITLE:

Echocardiography education in the ICU: managing the haemodynamically unstable patient

Dynamic Changes:

Why, When and What am I looking at?

Nurses, you are invited to attend a one hour education session on Echocardiography and participate in a pre and post -test survey, before and after the workshop.

ICET above ICU:

18th, 19th and 22nd of November @ 14:30hrs

X-ray Room ICU:

16th, 17th, 23rd and 24th of November @ 14:30hrs

18th, 19th, 22nd, 23rd and 24th of November @ 22:00hrs

The study is being conducted by Louise Smith, Assoc. Prof Lauretta Luck and Harrison Ng Chok at Nepean Hospital.

This study has been approved by NBMLHD and Western Sydney University Human Research Ethics Committee - Apollo Number 19-60(A)

If you would like to be involved, please contact Louise Smith

email Louise.Smith1@health.nsw.gov.au

or telephone (02) 4734 3181

Version 1.0 15/10/2019

TOGETHER ACHIEVING BETTER HEALTH

NSW Health Nepean Blue Mountains Local Health District

I was able to attend one of Ms Smith's training sessions. In the session she covered the following:

- The 4 main windows scanned in a TTE
- Normal and abnormal cardiac function
- Abnormal pathologies
- Haemodynamic instability including static and dynamic assessments

Experiencing Ms Smith's approach to the training session helped me understand the teaching style and level of complexity required for training content when teaching to nurses. Ms Smith provided valuable recommendations for the contents of the INSIGHT Training and Competency Programme through sharing her research findings to date and relevant publications to my area of study. Her involvement has informed my review of existing evidence that forms the justification and need for the INSIGHT Training and Competency Programme and the subsequent feasibility study. As a result of Ms Smith's research, I have decided to incorporate a knowledge questionnaire for ACCPs and ICU nurses undertaking the INSIGHT Training and Competency Programme. The questionnaire will be distributed before and after the initial face-to-face training day to assess baseline knowledge of PoCUS, and level of comprehension and quality of the training day. Her guidance also led to the inclusion of a self-evaluation report as part of the trainee scan logbook which trainee ACCP and nurse sonographers must complete every time they perform and report a new INSIGHT scan. The report will measure their level of confidence and self-perception of capability in performing and reporting each PoCUS scan during their training.

At KCH, PoCUS training has historically only been available to ICU doctors. However, more recently, a handful of nurses have begun basic PoCUS training. It raises an important question as to the place nurse-led POCUS has in the future of ICU clinical practice. If nurses are reaching the same level of competence in PoCUS as ICU doctors, can they report their findings in the same way? Should reports be standardised to minimise risk of misdiagnosis? Does there need to be formal recognition of ultrasound as a nursing skill?

The INSIGHT study will incorporate a standardised reporting form which asks binary (yes/no) questions and allows for free text to document anything not covered by the checkbox system. The complexity of scanning will not be as advanced as PoCUS basic level 1 training (e.g. FICE) and there will be no expectation to recognise specific pathologies. The protocol asks for the sonographer to report whether an image is normal or abnormal, whether artefacts such as a-lines or b-lines are present and whether fluid can be seen. It is then up to the doctor to decide whether findings warrant further investigation.

I want to ensure appropriate governance is adhered to in the INSIGHT Training and Competency Programme. Ms Smith commented that an ultrasound protocol carried out as part of routine assessment by nurses could be of huge benefit to the patient provided it is closely monitored and appropriately governed. Restricting interpretation to binary questions, for a limited number of windows and using a standardised proforma, subjectivity will be greatly reduced, and scans can be quantitively assessed. This will maximise safe practice and will ensure ACCP and ICU nurse interpretation of scans is not going being their level of PoCUS competency. The INSIGHT Training and Competency Programme incorporates a reporting form that must be completed for every training scan performed with this design in mind.

My educational approach to the training day design will bear the learning needs of ACCPs and ICU nurses in mind. I will work closely with ICU echocardiography consultants to establish the best method and content of teaching bearing in mind the teaching style and content that Ms Smith adopted for her training session. Based on Ms Smith's recommendations I have also decided to work develop a partnership with the radiology department at KCH to assist in the INSIGHT Training and Competency Programme by providing overarching supervision of complex or ambiguous INSIGHT scans and to form a governance policy framework for ACCP and nurse-led PoCUS training, practice and competency maintenance in the ICU.

RESEARCH INTO ALTERNATIVE TRAINING STYLES AT NEPEAN

Further exploration into PoCUS training style and duration was guided by Dr Arvind Rajamani's research. Dr Rajamani is an ICU consultant and specialist in ICU ultrasound at Nepean. He has spent 4 years researching various approaches to PoCUS training for ICU doctors and the barriers and facilitators to achieving competency. Dr Rajamani conducted a systematic review to identify methods of assessing competency in PoCUS. The national approach to achieving competency in PoCUS is to attend a 1-day training day and complete a minimum number of training scans (commonly 50). However, he found a growing body of research in alternative approaches to achieving competency in shorter timeframes. Dr Rajamani discovered that doctors struggle to complete the minimum number of training scans required to achieve competency. Reasons include that they find them too time consuming and need to prioritise clinical duties. His research found on average that less than 10% of doctors achieve competency compared to the number trained.

In response to this, Dr Rajamani designed a basic PoCUS training programme for heart and lung ultrasound. His programme required a minimum of 30 scans but no upper limit to achieve competency. He researched which training method produced the highest proportion of competent doctors compared to number trained. His research involved 3 distinct phases:

1. A 1-day face-to face training session with no supervision. Anyone could register on the course. The training programme had a poor completion rate.
2. Face-to-face training with direct and indirect supervision. The level of commitment required was made clear at the start of the programme, ensuring ICU doctors understood the commitment. This reduced the number of doctors that registered or later dropped out. However, the proportion of doctors achieving competency compared to the number initially enrolled remained small.
3. Self-directed learning using online materials instead of face-to-face training. The programme included training videos filmed by Dr Rajamani, reading materials, a multiple-choice test, and an online self-evaluation form. He remotely reviewed the doctor's scans after 10 were performed independently. Thereafter, 10 scans were completed every 15 days for indirect supervision.

Dr Rajamani and I worked closely together to refine the reporting proforma that ACCPs and ICU nurses will use to report each INSIGHT scan. I plan to use this report form for the INSIGHT Training and Competency Programme, the future feasibility randomised controlled trial and subsequent large-scale trial. Dr Rajamani had already spent considerable time designing one of his own for the training scans he used in his study and as such, had a clear and justified format. His reporting domains were grounded in current evidence describing the most useful images and questions to answer for management of the ICU patient. Dr Rajamani's guidance was invaluable at this stage of research design due to my lack of experience in this specialty area. Understanding what information will contribute significantly to the clinical picture has the potential to have a greater impact on important clinical outcome for patients involved in the future randomised controlled trial.

Dr Rajamani also suggested creating some nursing training videos for the INSIGHT Training and Competency Programme to allow for remote self-learning. His reasoning for using training videos instead of face-to-face teaching alluded to several potential benefits:

- Reducing the burden on supervisors (there is a national shortage in the UK)
- Reducing the potentially wasted time if trainees fail to complete the minimum number of training scans required to achieve competency
- Reducing the time taken to train up nurses and ACCPs could assist the INSIGHT Training and Competency Programme (and future INSIGHT studies) in expanding to a multi-site research project.

Dr Rajamani and I filmed 3 training videos during my placement and are working together to create a full set of training videos targeted to the appropriate level of understanding for complete novices in PoCUS. I have included snapshots of two of these videos.

For the first video, he focused on the anatomy of the heart. Dr Rajamani recommended a relaxed conversational approach with anatomical visualisation as the most user-friendly. To demonstrate, he moulded a heart out of plasticine on a white background. He used this method to describe:

(1) the anatomical structures of the cardiovascular system

(2) the heart's position in relation to other intrathoracic structures. Figure 1 displays chronological freezeframes of this video.

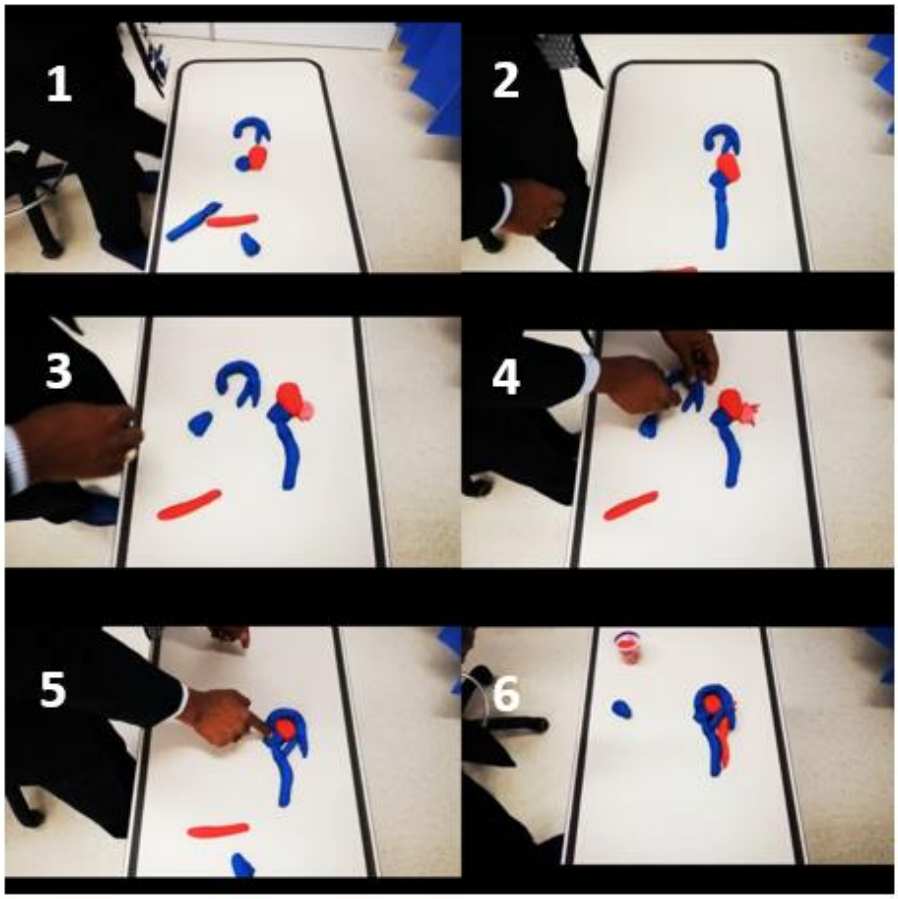


Figure 1: the anatomical structures of the cardiovascular system

Dr Rajamani thought that by constructing the heart on video rather than watching an already formed image, it would help the viewer to gain a better understanding of anatomical placement of each structure. Although content of training videos in PoCUS has been researched in depth, there lacks substantial research into training video format. Understanding the most effective training style to aid the trainee sonographer's learning is paramount in creating an efficient and successful training programme.

Figure 2 shows some freezeframes from the second video which visualised the different planes of the heart viewed using ultrasound. In this video, Dr Rajamani describes:

- how the image displayed on the ultrasound monitor reflects the angle of the ultrasound beam through the heart
- how to position the probe to achieve the desired image on screen
- the structures seen when cutting through the various planes used in a TTE scan

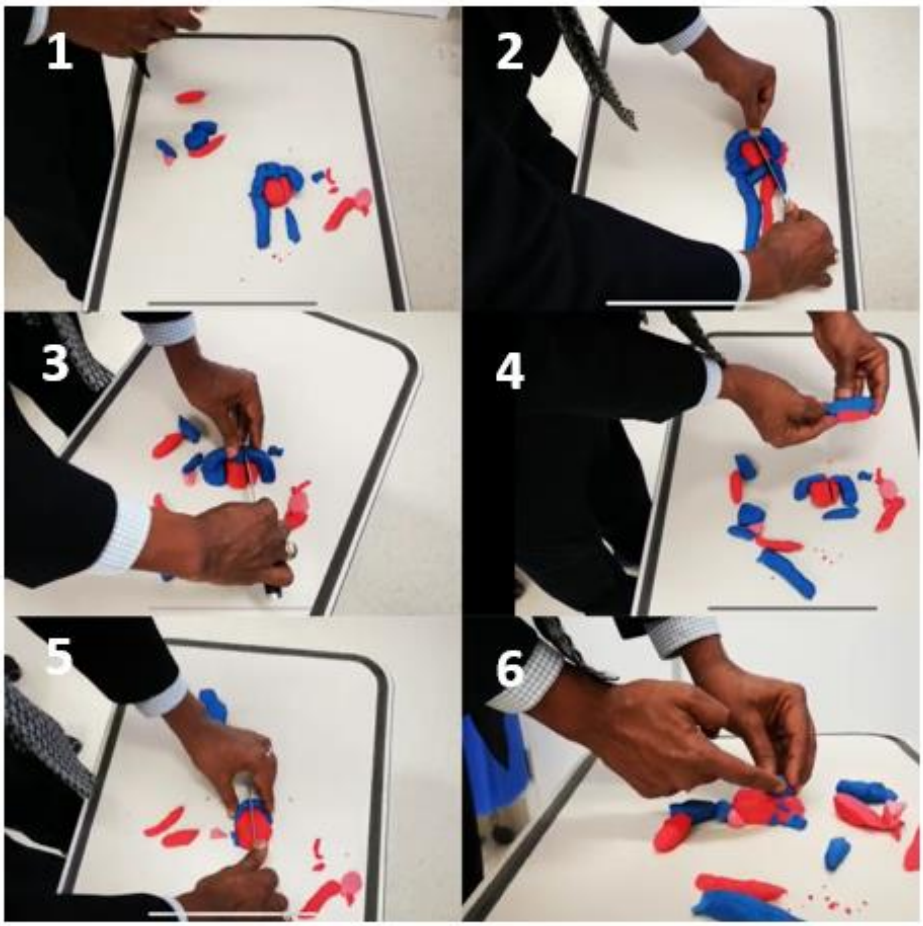


Figure 2: the different planes of view in a TTE and their relationship to the anatomical structures of the heart

Dr Rajamani's research challenged the nationally accepted training approach for PoCUS and provided valuable guidance on the most effective methods for training nurses and ACCPs for the INSIGHT Training and Competency Programme Protocol. Our collaboration has contributed considerably to the design of the training day, assessment of knowledge learnt from the training day, the INSIGHT Training Programme's requirements for achieving competency and my approach to supervision at a local level for the protocol, and national level for application in my future research. Although the videos we recorded together will not be used for the INSIGHT Training and Competency Programme, I intend to research the effect of modified versions for remote training of staff nationwide in PoCUS for the subsequent planned multi-site randomised controlled trial.

FINDINGS AND RECOMMENDATIONS

ESTABLISHMENT OF A SONOGRAPHY SERVICE

The sonography department at Nepean Hospital demonstrates that nurse-led ultrasound can be successfully integrated into the healthcare system with significant benefit to patients and healthcare costs. Establishment of the service was dependent on the vision and driving force of an extremely experienced and senior ICU consultant, and the buy-in from both intensivists and ICU nurses. Implementation and integration of a new service requires momentum in training, awareness, peer support, effective governance, and proof of health economic value and patient benefit.

In response to these findings, I have chosen a team of supervisors and mentors, ICU consultants specialised in critical care sonography, radiologists, ACCPs and ICU nurses to support the progression of my sequence of research projects which identify:

- the most appropriate training format to ensure a high proportion of trainees reach competency whilst providing the lowest burden possible on the trainee and trainer
- governance strategies to maintain competence levels following completion of training
- health economic value of the INSIGHT Training Programme and Scanning Protocol through conducting a full cost benefit analysis
- the impact of the INSIGHT Scanning Protocol on important patient outcomes

As part of my doctoral fellowship, I have enrolled on implementation science and leadership courses to ensure I have the best chance of integration nurse-led PoCUS into routine clinical practice.

SONOGRAPHY TRAINING

Training in advanced echocardiography highlighted the complexity of ultrasound and the risk of over speculation at novice level. The role of the sonographer is to scan and report objectively. Findings should never be used in the isolated assessment of the patient but to inform the wider clinical picture.

POCUS TRAINING FOR NURSES

Previous attempts to train nurses in PoCUS has identified likely barriers nurses may experience during the INSIGHT Training and Competency Programme including:

- Time required to complete training scans
- The steep learning curve affecting confidence in scanning ability
- The time to perform scans
- Reports being undervalued by physicians

I have carefully considered ways of minimising these barriers and have incorporated specific approaches in the design of the INSIGHT Protocol. Future research that involves introducing a new skill on an already stretched workforce must take the level of burden into consideration and the resulting ethical implications.

POCUS EDUCATION AND GOVERNANCE

PoCUS training content must be adapted to suit the educational needs of nurses. The INSIGHT Training and Competency Programme has been designed to reflect this and has based its design on a previously validated training format and competency assessment tool created specifically for nurses. Knowledge attainment is paramount in ascertaining the quality of training and level of comprehension. A knowledge questionnaire using validated questions is a useful addition to assess baseline and post-training day PoCUS knowledge.

Ensuring nurse sonographers do not interpret beyond their scope of understanding must be governed through objective, standardised reporting platform. Using a yes/no binary checkbox format will minimise the possibility of over or underdiagnosing pathologies.

ALTERNATIVE POCUS TRAINING STYLES

Dr Rajamani's work highlights the importance of finding a more manageable training format to encourage course completion and competent PoCUS practice.

To cater for the paucity of PoCUS supervisors nationwide, online training and supervision must be considered. If designed appropriately, an online format could expand the interdisciplinary workforce trained in PoCUS nationwide. In light of the COVID-19 pandemic, the refinement of good quality virtual platforms for continued training of healthcare professionals requires urgent prioritisation. I will focus on this as part of my PhD and hope to produce a comprehensive and easily navigable PoCUS training package that can be used both nationally and internationally.

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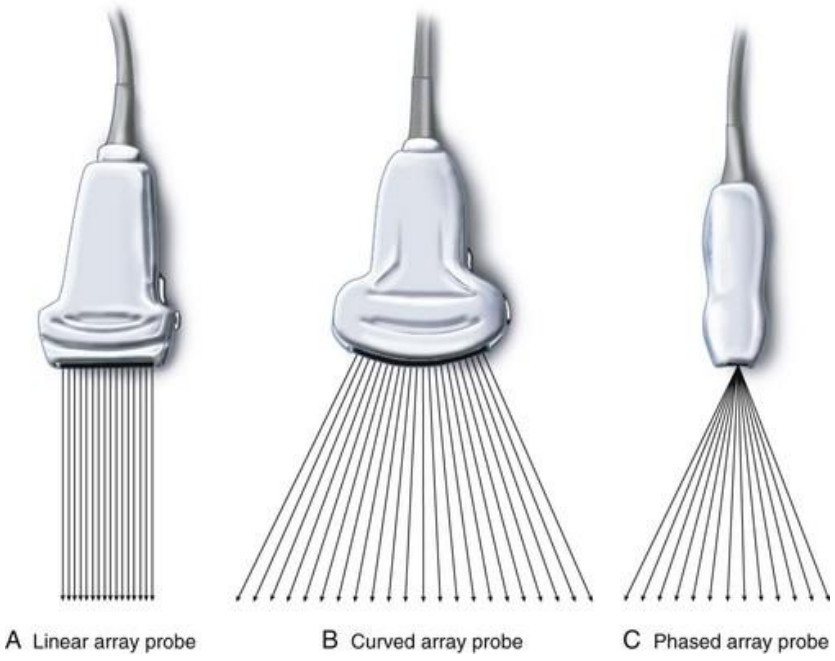
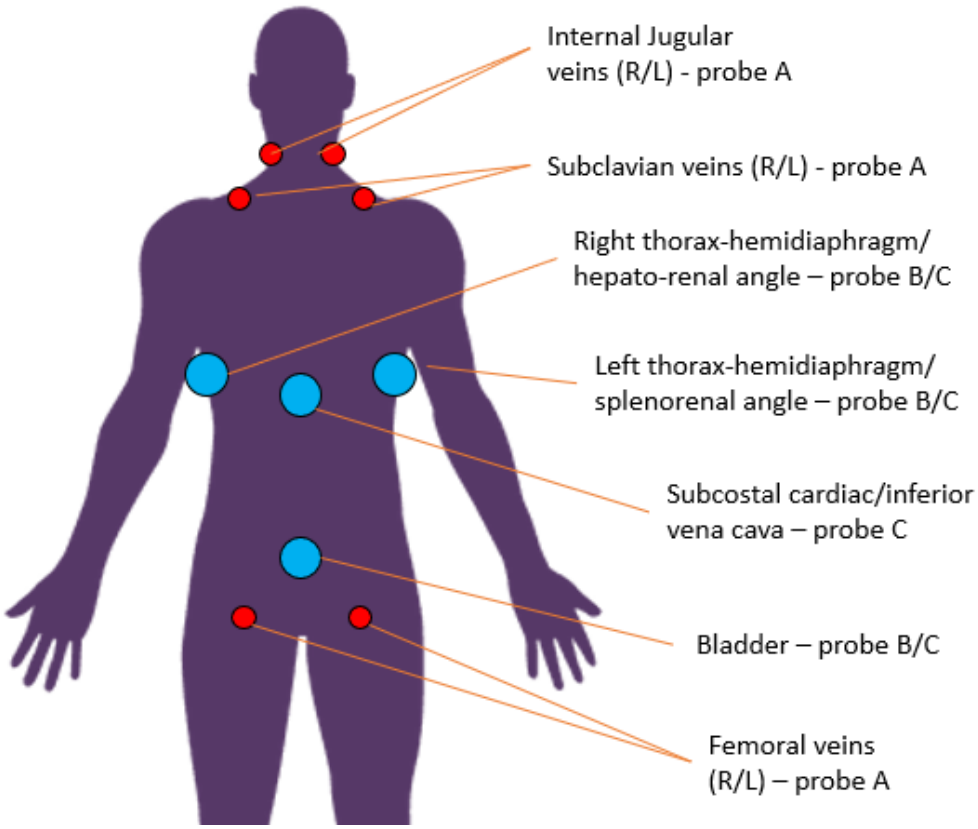
APPENDIX 1. THE INSIGHT SCANNING PROTOCOL





APPENDIX 2. SUMMARY OF PRELIMINARY SCOPING FOR THE INSIGHT PROTOCOL

INSIGHT: A modified Delphi process to develop an integrated scheduled inter-professional assessment of critically ill patients with ultrasound

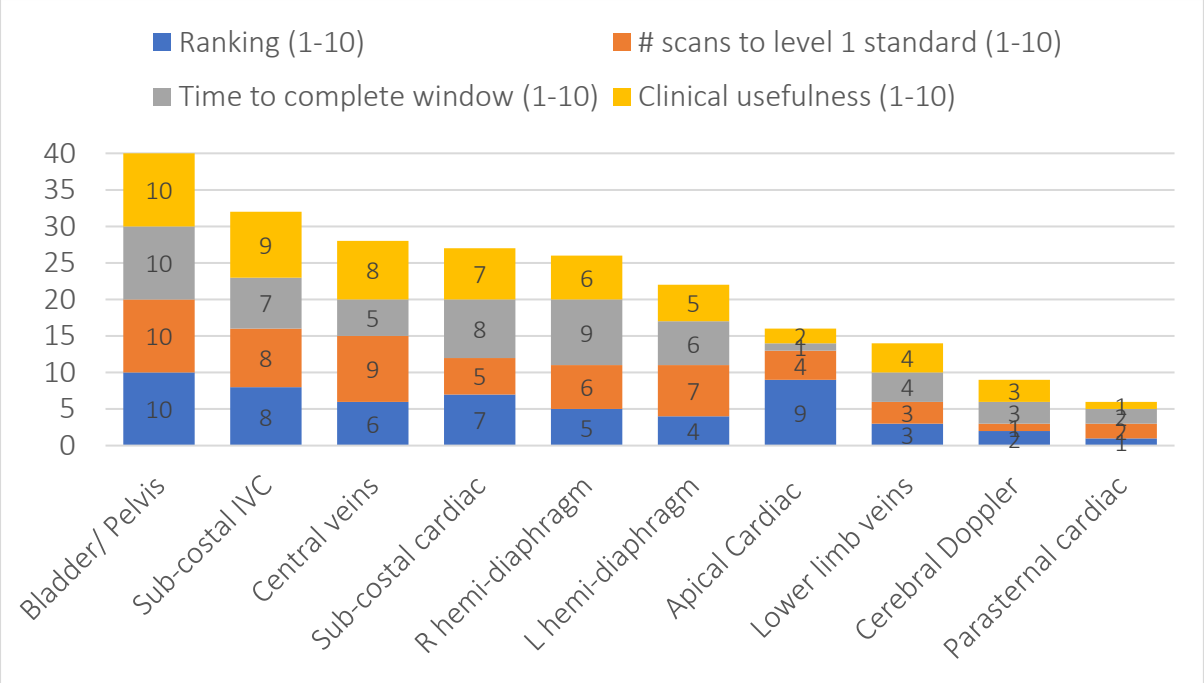
N Hare; D Hadfield; S Helyar; P Hopkins; E Corcoran - Kings College Hospital, London, UK (2019)

Introduction

Point of care, focused ultrasound offers a safe and non-invasive imaging modality for the immediate evaluation, resuscitation, and guidance of therapeutic procedures in the critically ill patient (1). We have previously reported that, despite limited evidence, all critical care professions within our institution support a trial of clinical effectiveness of nurse-led scheduled whole-body ultrasound (2). Here we describe the development and refinement of the INSIGHT ultrasound intervention, ahead of conducting a randomized controlled trial to test feasibility and clinical effectiveness.

Methods 1

We obtained institutional approval and research permissions to conduct a modified Delphi exercise to select the ultrasound windows most likely to be beneficial in the defined setting of scheduled inter-professional ultrasound and the imaging questions that should be asked with each window. 260 nurses, 46 doctors and 6 physiotherapists were involved (all part of the critical care service) and were given the same information regarding potential utility of each window.



Methods 2

10 windows across the whole body were found to be useful. These were ranked in order of perceived importance, and subsequently by (1) ease of adoption (number of scans required to achieve level one training standard), (2) time taken to scan each window and (3), clinical usefulness of each window. All criteria were ranked on a 1 to 10 scale (1=least, 10=most). Totalled scores were used to identify 5 key windows for use in a subsequent trial.

Figure 2: Final INSIGHT schedule

Ultrasound Window	Questions
Sub-costal cardiac and IVC	Can you see the heart? Is there an effusion? Is the RV bigger or smaller than LV? Is the IVC visible? Is it wide open with little resp variation, visible but dynamic with respiration or collapsed?
R hemi-diaphragm, R LL and subphrenic assessment	Can you see the diaphragm/lung RLL/liver? Is there an effusion? Is there consolidation? Is there free fluid? Is the diaphragm moving?
Abdominal ultrasound using bladder as acoustic window.	Can you see the bladder? Is there urine in it? Is the catheter in the bladder? Is there free fluid outside bladder?
L hemi-diaphargm, LLL and subphrenic assessment	Can you see the diaphragm/lung RLL/liver? Is there an effusion? Is there consolidation? Is there free fluid below diaphragm? Is the diaphragm moving?
Major central veins (L/R IJV/SCV	Can you see the vein? Depth? AP diameter?

Conclusions

We have developed a research intervention that will allow us to test the effectiveness of inter-professional scheduled whole-body assessment of critically ill patients by ultrasound. We now plan to conduct a clinical effectiveness trial with an internal pilot to confirm feasibility.

APPENDIX 3. NEPEAN ICU ECHO PROTOCOL

Parasternal long axis (PLax)	2D	RV, IVS, LV, AV, Ascending Aorta, MV, LA *check for pericardial and pleural effusion*
		Zoom AV > measure the LVOT diameter in systole (for CO)
		Zoom MV
	CD	AV, MV
	M-Mode	Aortic root (Onset of QRS) *leading edge to leading edge* LA (end-systole) *inner edge to inner edge*
		LV (tip of MV): IVS, LVD, LVPW (onset of QRS); LVDs (end systole) *leading edge to leading edge
	2D & CD	RVIT – TV (tilt transducer inferiorly), RVOT-PV (tilt transducer superiorly)
Parasternal short axis (PSax)	2D	LV (3 levels): Basal MV, Mid-papillary muscles, Apex
		Aortic valve level: AV, LA, LAS, RA, TV, RVOT, PV, MPA & bifurcation
	CD	AV,PV, TV, IAS
	CW	If TR present – measure the TR Vmax
Apical 4 chamber (A4C)	2D	LA, MV, LV, RA, TV, RV
		Zoom LV – assess LV systolic motion (inferoseptal & anterolateral & apex)
	CD	MV
	PW	Tip of the MV leaflets (mitral inflow: E & A ratio)
	TDI	PW septal and lateral mitral annulus (E' & A') – to estimate LAP = E/E' ratio <8 (normal) > 15 (LAP > 12mmHg)
A5C	CD	LVOT, AV
	CW	AV (aortic flow)
	PW	LVOT (for CO)
A4C	2D	RA, TV, RV
	CD	TV
	CW	If TR present – measure the TR Vmax
	M-mode	TAPSE to assess RV systolic function, normal >1.6
A2C/A3C	A2C 2D	LA, MV, LV (anterior and inferior)
	A3C 2D	LV (anteroseptal and inferolateral)
	CD	MV, AV
Subcostal 4 chamber	2D	LA, LV, RA, RV
	CD	IAS, IVS
Subcostal short axis	2D	IVC
	M-mode	IVC (to estimate RAP)
	2D	Short axis: AV level and LV
Suprasternal	2D	Ascending aorta, aortic arch, thoracic descending aorta, right pulmonary artery
	CD & CW	Thoracic descending aorta

Key: R=right, V=ventricle, IVS=interventricular septum, L=left, AV=aortic valve, MV=mitral valve, LA=left atrium, LVD=left ventricle diameter, LVPW=left ventricular posterior wall, RVIT=right ventricular inflow tract, TV=tricuspid valve, IAS=interatrial septum, RA= right atrium, OT=outflow tract, P=pulmonary, MPA=main pulmonary artery, AP=atrial pressure, TAPSE=Tricuspid annular plane systolic excursion, IVC-inferior vena cava