The transthoracic echocardiographic skills of registrars in a department of anaesthesiology

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A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg in partial fulfilment of the requirements for the degree of Master of Medicine in the branch of Anaesthesiology.

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Declaration

I, Nicholas Coetzee declare that this research report is my own unaided work. It is being submitted for the Degree of Master of Medicine in the branch of Anaesthesiology at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

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Abstract

Background

Research has shown the value of integrating point of care ultrasonography into daily practice and has highlighted the poor competency in transthoracic echocardiographic (TTE) skill in anaesthesiology registrars. The aim of this study was to determine the TTE skills of anaesthesiology registrars at Wits using an objective structured clinical examination (OSCE).

Methods

This research study employed a cross-sectional research design. Convenience sampling was used and 28 registrars were enrolled in this study. The OSCE consisted of two practical stations (Stations 1 and 2) and two clinical pathology stations (Stations 3 and 4). Adequate TTE skill was defined as competency in both the practical and clinical stations and an overall pass score of 70% was used.

Results

The overall mean (SD) score obtained for the OSCE was 46.9% (24.3%). Comparing TTE skills (Stations 1 and 2, Stations 3 and 4 and all stations combined) between those who have completed a cardiac rotation, those that have completed an accredited course and those who have not, no significant differences were found between those who obtained a pass score and those who did not. Registrars who had completed an accredited TTE course performed significantly better in Stations 3 and 4 (p=0.005). Of the registrars 33.9% obtained a pass score for practical stations and 17.9% for the clinical stations with an overall 21.4% achieving a pass score. No significant difference in pass scores was found with the different categories of registrars. There was a strong positive significant correlation between completing more TTEs and the scores obtained (r=0.540, p=0.004).

Conclusion

Findings from this study suggest that the current skill levels of registrars in performing TTEs is not sufficient to achieve clinical competency and that the training may not be initiated early enough in the registrar program.

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Whatever you do work at it with all your heart as working for the Lord not for men. (col 3:23)

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Abbreviations

A4C	Apical four chamber
ACC	American College of Cardiology
AHA	American Heart Association
ASE	American Society of Echocardiography
EACVI	The European Association of Cardiovascular Imaging
FAST	Focused assessment with sonography in trauma
FATE	Focus assessed transthoracic echo
FCU	Focused cardiac ultrasound
FEEL	Focused echocardiography in life support
FOCUS	Focused cardiac ultrasound
POCUS	Point-of-care ultrasonography
P-POCUS	Perioperative point-of-care ultrasonography
PLAX	Parasternal long axis
PSAX	Parasternal short axis
RUSH	Rapid ultrasound in shock
SC4C	Subcostal four chamber
TOE	Trans oesophageal echocardiography
TTE	Trans thoracic echocardiography

Statement

The Research Report consists of a literature review, draft article, study proposal and appendices. The study proposal is included for background reference and is not for examination.

The formatting of this Research Report complies with the University of the Witwatersrand's Style Guide for Theses, Dissertations and Research Reports. The formatting of the draft article may differ from the author guidelines of the South African Journal of Anaesthesia and Analgesia, the journal to which it is intended to be submitted, in order to comply with the university's style guide

Section 1: Review of the literature

1.1 Introduction

Ultrasound has become widely accepted as a diagnostic and procedural tool even though the application thereof has been limited to specialist radiographers (1). With the advances in technology, portable ultrasound machines have become more affordable and widely available to other medical disciplines (1,2). Over the last two decades, advances in technology have led to the more frequent incorporation of ultrasonography into clinical practice (1,2). The bedside application of ultrasound is referred to as point-of-care ultrasonography (POCUS) (1–5). Emergency medicine, cardiac anaesthesia and critical care were some of the first fields to incorporate this skill into their daily practice. As the applications of POCUS have expanded and new research has validated and emphasised benefits for the clinician, many other medical disciplines have integrated POCUS into their daily practice (4).

1.2 Point of care ultrasound

The term POCUS was first introduced in selected medical specialities and has now expanded to a wide variety of clinical disciplines (4–6) and is now widely recognised as the standard of care (6). POCUS is defined as a diagnostic or procedural guidance tool, which is performed to assist with the clinician's evaluation and management of a patient (7). The following terms have become synonymous with POCUS, emergency ultrasound, focused ultrasound and clinician performed ultrasound and for the purpose of this research review the term POCUS will be used (4). In fields such as emergency medicine anaesthesia and critical care, POCUS has become an extension of the physical examination (1). Health care providers are able to use ultrasound at the patient's bedside for either screening, diagnostic or procedural purposes (1,2,6). This, in conjunction with a thorough patient history and clinical examination, can be used to make immediate decisions regarding patient care (6). POCUS allows for easy portability, immediate access to images and continuous assessment of implemented interventions (8). An added safety benefit is the absence of ionizing radiation (8). The clinician is responsible for image acquisition, interpretation and diagnostic and therapeutic decision making (1,2). This accelerates the clinical process and avoids any delay (1,2).

Traditional ultrasound examinations are performed by trained radiologists, radiographers or echocardiographic technicians who have been accredited in their field (6). These examinations are usually performed in a separate location, requiring patient transfer, requiring more time and resources. Despite the advantages, POCUS is not intended to substitute formal ultrasound examinations and is most effective as a supplementary tool (6).

POCUS can potentially improve patient care and the delivery of health care (6). Daniels et al (6) emphasises the value POCUS adds to medicine and the advantage this tool presents to POCUS trained and competent clinicians.

The application of POCUS in anaesthesia is referred to as perioperative POCUS (1). There are a number of applications of POCUS in anaesthesia (8). The applications include trans thoracic echocardiography (TTE) of the heart, trans oesophageal echocardiography (TOE), examination of the lung, airway, heart, as well as gastric and other abdominal structures. The placement of intravascular catheters and regional nerve blocks are some of the interventional applications of POCUS. The training required for each of these applications varies according to the difficulty of each examination or procedure (8). Hence, it is essential for the modern anaesthetist to acquire and maintain adequate skills and knowledge in POCUS. Undergoing continuous training and evaluation in this skill are essential to maintain minimum standards of competency. The use of POCUS in anaesthesia is widely recognised but the accreditation and training process for anaesthetists is still limited (3).

1.3 Focused cardiac ultrasound

Echocardiography is an investigation that requires specific technical skills as well as expertise in cardiovascular pathophysiology and diseases (9). It is important to distinguish between formal echocardiography and point of care echocardiography, also known as focused cardiac ultrasound (FCU). FCU, as a concept falls within the scope of POCUS and is a focused aspect of a greater general examination or protocol (10,11).

The American Society of Echocardiography (ASE) (10) defines FCU as a specific ultrasound examination of the cardiovascular system to be performed by a qualified physician. The ASE refers to the concept of trans thoracic cardiac ultrasound as FCU (12). A wide variety of terms have been used to describe cardiac ultrasound, including FCU. Other synonyms include, point of care cardiac ultrasound, bedside ultrasound, quick look cardiac ultrasound, ultrasound stethoscope and FOCUS (Focused cardiac ultrasound) (9–11). The European Association of Cardiovascular Imaging (EACVI) (9) uses the term FOCUS and defines it as a point-of-care cardiac ultrasound examination that is performed according to standardised protocols. FCU aims to add information to the physical examination. The operator does not necessarily need to be fully trained in echocardiography but requires appropriate training in FCU. For the purpose of this literature review, the abbreviation FCU will be used (9).

EACVI (9) recognises that cardiologists are not the only medical professionals who manage cardiovascular emergencies, interpret cardiac pathophysiology and utilise information obtained through echocardiography. Clinicians from various fields have recognised the value of FCU and appreciate the many advantages in clinical practice. This has led to the more frequent incorporation of this skill into their daily practice (9). The use of FCU by non-cardiologists is fast increasing(9,13,14). Its use has been well documented and validated in emergency medicine and critical care settings (3). FCU is typically performed by non-cardiologists who often have minimal training and usually do not meet the requirements to perform formal echocardiography (9,14). The FCU aims to assist with the identification of signs that may be indicative of potential diagnoses within a specific clinical setting and acts as an adjunct to the physical examination (9,12,13). EACVI (9) encourages medical professionals to be adequately trained to use FCU. The level of competence in echocardiography must be the same for emergency and elective cases, as well as for cardiologists and non-cardiologists (9,14).

It is important to differentiate between limited or complete TTE and FCU. Complete TTE is a formal diagnostic test with a particular billing code, a standardised protocol and an advanced analytic component (11). Archiving and documentation requirements of TTE are regulated by strict acquisition and reporting accreditation standards (11). The limited TTE refers to an ultrasound examination of the cardiovascular system which is limited to a certain number of echocardiographic views (14). An accredited echocardiographer is required to perform a limited or complete TTE and can be a registered sonographer or physician (10). FCU describes a narrower scope of practice and is defined by the equipment and the expertise of the clinician performing the examination (10,14). The FCU examination is limited by the training and skill of the clinician performing the examination and is not considered a comprehensive echocardiographic examination (10). An FCU also differs from the TTE in that it allows quick serial assessments of a patient. This is an essential component of a goal-directed resuscitative strategy, as the clinician can repeatedly review a patient’s response to therapy and resuscitative measures undertaken (15).

FCU should not take the place of formal echocardiography but complement it. Any abnormalities detected on an FCU examination require the referral for complete, formal echocardiographic evaluation by an accredited echocardiographer (10,11,14). An FCU examination is not intended to make a definitive diagnosis, but guide point of care decision making (9,10). The FCU helps refine the differential diagnoses and guides clinical interventions and management strategies. (10) The differences between the limited echocardiography and FCU are listed in Table 1.

Table 1: Differences between FCU and limited TTE

Differences between limited echocardiography and FCU		
Examination	**Limited echocardiogram**	**FCU**
Patients	Any adult patient	Limited scope of practice
Location of imaging	Any location	Limited scope of practice
Image protocol	Skill to perform any view, but only selected views may be required	Limited number of views
Equipment	Full function (M-mode, 2D, colour Doppler, spectral Doppler, Tissue Doppler imaging, contrast), EKG gated	2D minimum
Transducers	Multiple	Single
Measurements	Advanced quantification	None or linear measurement
Acquisition	Sonographer or level II/III echocardiographer	Physician with FCU training
Interpretation	Echocardiographer; all pathology and normal structures within imaging view	Physician with FCU training defined, limited scope
Image storage	Digital imaging and communication format, archived for easy retrieval and review	Only for select indications
Documentation	Formal report	Documentation as brief report or as part of physical exam depending on indication
Billing	Specific billing code	None

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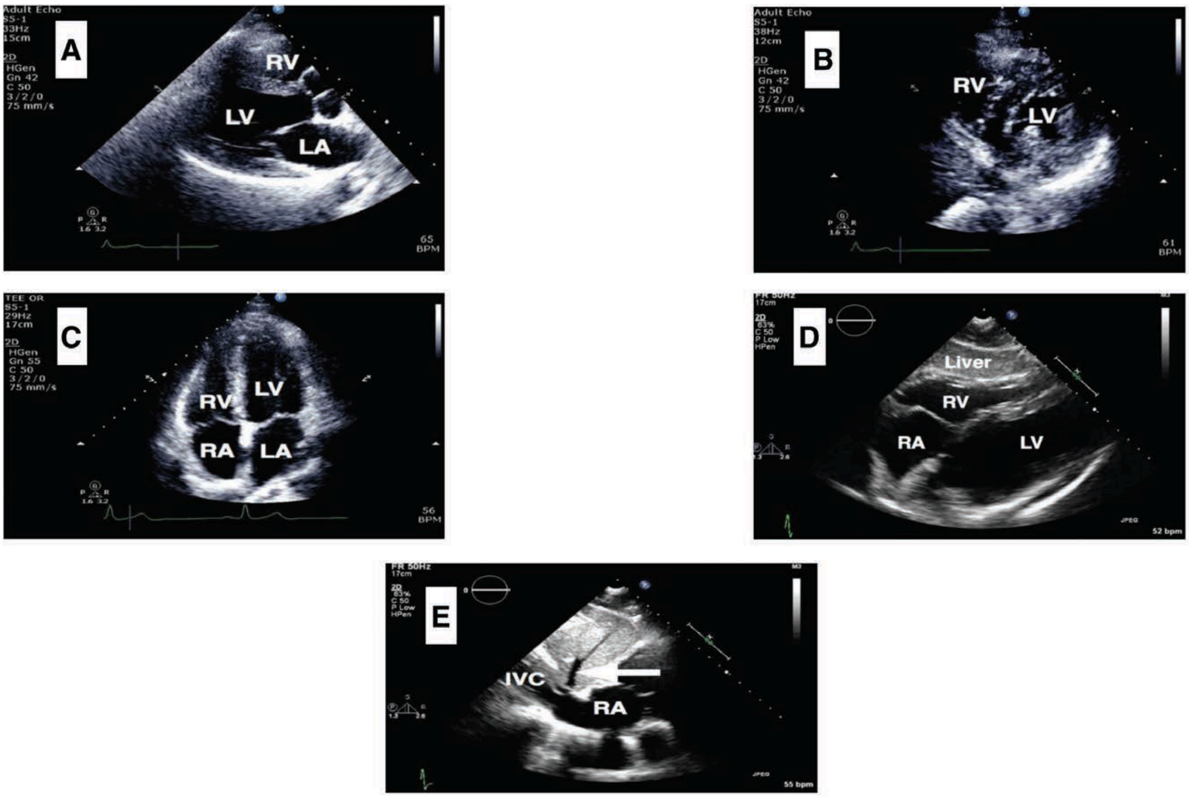
An FCU examination allows for a number of different views by which the clinician is able to assess various structural aspects of the cardiovascular system (10). Some of the more commonly used cardiac views include parasternal long axis (PLAX), parasternal short axis (PSAX), apical two-chamber, apical three-chamber, apical four-chamber, apical five-chamber, subcostal four-chamber and subcostal inferior vena cava view (10,15). FCU is a simplified examination of TTE and can be applied to point of care through different clinical protocols (10). The basic protocols focus on qualitative information and do not necessarily include methods of quantification and measurement (10). Depending on the degree of clinical skill and training of the clinician, as well as the capabilities of the ultrasound equipment, the examination may include measurements that may provide valuable information for use in the critical care and perioperative setting (15).

The FCU examination enables the clinician to measure fractional shortening (ejection fraction) and, with the addition of Doppler ultrasound examination, allows for the measurement of velocity time index. The velocity time index is effective in the quantification of valvular pathology and the measurement of cardiac output (15). Some of the FCU views are depicted in Figure 1.



(A)PLAX (B)PSAX (C)Apical 4-chamber view (D)Subcostal 4-chamber view (E)Subcostal inferior vena cava

Figure 1. FCU examination

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It is important for clinicians to recognise that FCU is not a comprehensive examination and understanding the limitations of an FCU is essential (9,10). The quality of an FCU examination depends on the skill, training and experience of the person performing the examination, as well as the equipment and its functionality (9,10). Most information obtained in an FCU examination is qualitative in nature and hence there is not typically a need to quantify the pathology detected. However, quantitative measurements can be obtained if the examiner is adequately trained and the functions of the ultrasound equipment allow it (10,16).

1.4 Transthoracic echocardiographic examination protocols

A number of training courses in TTE, FCU and POCUS protocols are offered commercially. These courses are often once off and may not incorporate follow-up accreditation (17). Moreover, these courses may be speciality specific and often require financial and time commitments from the trainee and faculty they are training in (17). These training programs do not necessarily address the extensive applications of perioperative ultrasonography and may not be adequate to ensure complete proficiency in perioperative POCUS skill (17). The varying modalities, views, scopes and disadvantages of common TTE protocols are compared in Table 2.

Table 2: Comparison of TTE protocols

TTE Protocol	Modalities	Views	Scope	Disadvantages
FAST **Focused assessment with sonography in trauma**	2-D, M-Mode	S4CH, right upper quadrant, left upper quadrant, and pelvis	Identifies intraperitoneal, pericardial, or pleural fluid	Does not evaluate any cardiac function/anatomy other than the presence or absence of pericardial fluid
FATE **Focus assessed transthoracic echo**	2-D, M-Mode	PLAX, PSAX, A4CH, S4CH, pleura	Excludes obvious pathology, evaluates ventricular size and systolic function, and visualises pleura	More extensive image acquisition, requires larger depth of knowledge in image interpretation and analysis
FEEL **Focused echocardiography in life support**	2-D	PLAX, PSAX, A4CH, and S4CH	Evaluates for reversible causes of pulseless electrical activity	No valve assessment
RUSH **Rapid ultrasound in shock**	2-D	PLAX, PSAX, A4CH, S4CH, SIVC, right and left upper quadrants, pelvis, and thorax	Evaluates for pericardial fluid, ventricular systolic function, volume status, pleural and intraperitoneal fluid, pulmonary embolism, abdominal aortic aneurysm, and deep vein thrombosis	No valve assessment
FOCUS **Focused cardiac ultrasound**	2-D, Colour Flow Doppler	PLAX, PSAX, A4CH, S4CH, and SIVC	Evaluates ventricular systolic function, volume status, pericardial effusion/tamponade, signs of chronic heart disease	No quantitative measurements obtained

Abbreviations: 2-D, two-dimensional; A2CH, apical two- chamber; A4CH, apical four-chamber; PLAX, parasternal long axis; PSAX, parasternal short axis; S4CH, subcostal four-chamber; SCSAX, subcostal short axis; SIVC, subcostal inferior vena cava

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1.5 Equipment requirements for POCUS and FCU

The ASE (14) distinguishes four different types of cardiac platforms, namely fully functional, small, handheld and pocket ultrasound platforms. Each of these platforms have different levels of functionality and performance and require due consideration by the clinician performing the POCUS examination. Fully functional platforms are those that have a full range of capabilities, including motion over time M-mode, 2D-mode, colour-Doppler, spectral Doppler and tissue Doppler. These platforms are usually utilised by accredited sonographers. In contrast, the small ultrasound platforms support standard echocardiography and usually have the following modes available: M-mode, 2D-mode, colour-Doppler, spectral-Doppler, transoesophageal echocardiography and stress echocardiography.

Handheld packages are lightweight and portable and have limited, yet standard, echocardiographic functions. Pocket platforms are compact with very basic ultrasound functionality, with a 2D-mode and may include colour-Doppler. It is essential for the clinician to select a platform that has appropriate functionality, the correct transducer with the appropriate frequency settings for the age of the patient and a suitable screen size. This will affect the ease of image acquisition and accuracy of diagnosis (14).

The ASE (14) states that training in and understanding of the limitations of each of these platforms guides the clinician in effectively choosing the most suitable platform for the purpose of obtaining the necessary information. A platform used for FCU, for example, should be able to display a 2D grey scale with the ability to adjust the depth and gain. The Doppler modes which some platforms offer may be utilised, provided the person performing the FCU is competent and trained in those modalities. This will be determined by the limitations of both the practitioner and the equipment (14).

1.6 Competency in POCUS

Adequate FCU competency is defined as competency in all the aspects of performing a TTE, which includes choosing the correct TTE view, acquiring the TTE image and identifying the correct anatomy and pathology present and interpreting the severity and possible interventions. Traditionally unstructured observational tests have been used to assess POCUS competency, but global rating scores (GRS) and checklist scores have been validated and shown to be reliable (18).

Internationally, emergency medicine has adopted the principle that core POCUS competency is a necessary skill for emergency physicians and the training thereof should be standard in an emergency medicine training program (7).Training focused on competency assessment makes use of an outcome-based examination system (19). There are a number of areas of training that all integrate to achieve overall competency in the field of POCUS and echocardiography (20). These areas include adequate knowledge of the ultrasound platforms and the physics involved, anatomical and pathophysiological knowledge, practical skill and technical competence (21). Training often requires a minimum number of procedures to ensure exposure to an adequate range of clinical conditions (21). Even though a minimum number of echocardiographic examinations are performed, this does not necessarily ensure competency and an objective assessment of proficiency and outcomes will be required (21). A number of evaluation tools can be used to assess competency, including direct observation, procedure logbooks, simulation assessments and objective structured examinations (OSCE) (21).

For echocardiography, Level I training is defined as “an introductory or early level of competency in performing and interpreting TTE” (19). The ASE (22) and Ryan et al (19) advocate for a Level I trainee to participate in a minimum of 150 echocardiographic examinations and perform 75 of these examinations under supervision. In 2018, the Portuguese Society of Cardiology (23) recommended that emergency FCU practitioners require the completion of a minimum of 50 clinically indicated echocardiographic examinations in a period of less than a year to maintain competency.

In their TTE assessment Ramsingh et al (16) found a baseline score of 48% in performing a TTE among anaesthesiology registrars. Rebel et al (5) had a 13% pass rate for their TTE practical stations and a 40% success rate for the TTE pathology station. Rebel et al (5) concluded that exposure to and clinical use of ultrasound is not sufficient for developing competency in POCUS. The authors emphasise the need for a formal curriculum that runs throughout the entire anaesthesiology registrar program to ensure adequate competency in the clinical use and interpretation of ultrasonography (5). It is, therefore, essential to ensure a minimum standard of ultrasound knowledge and skill, which can be achieved by the implementation of an ongoing training program as part of a POCUS curriculum (17). Core aspects of a curriculum in ultrasonography should ensure adequate training, continuous quality improvement and a process of credentialing (7).

1.7 POCUS training and accreditation

The interplay between a trainee and their educational environment plays a crucial role in the training of POCUS. According to Ryan et al (19) a successful training program relies on the student, the number of cases performed, the training facility and the educational culture. The ASE (19) advises that POCUS training should commence at an undergraduate level and further encourage the introduction of fundamental principles, indications, applications and limitations of POCUS as early on in training as possible. In order to maintain excellence in the practice of echocardiography, significant training and knowledge of the guidelines for acquisition, analysis and interpretation are required. The ASE (14) recommends a formal, structured program that provides education and training as well as the continuous assessment of clinician competency in echocardiography. The EAVCI (9,14) endorse a thorough evaluation of clinician competency and that the assessment thereof should be incorporated into the ongoing process of any sonographic training program. In addition, any FCU training program should collaborate with echocardiographic societies and certified expert echocardiographers (14).

The three core aspects of any training program must include didactic education, hands-on image acquisition and image interpretation (14). Ultrasound physics, as well as choice of appropriate images, anatomical identification and pathophysiological interpretation and implementation, are areas that should be covered in teaching (15). Studies have demonstrated that TTE simulation training has been more effective in training programs than traditional didactic methods and that this consequently leads to better technical skills and improved proficiency (24,25). Prior to practical training, it is crucial for the trainee to have received training in spatial awareness, which may be achieved through the use of imaging aids, phantom imaging and simulation mannequins (14). The benefits of the use of simulator training in ultrasonography is recognised by the ASE (14). Ramsingh et al (16) developed a successful POCUS curriculum for anaesthesiology registrars, which included theoretical lectures with simulation experience (10,16). A study by Matyal et al (17) supports the benefit of implementing an ultrasound training program, which improved ultrasound skills and knowledge within their department. The use of healthy, cooperative models is a good way for trainees to learn the basics, but the ASE (14) also emphasises the importance of real-time clinical training on live patients with varying pathology. Maintaining high training standards within a faculty is challenging, as the level of training depends upon the varying ultrasound proficiencies of its members and the number of accredited POCUS trainers at a given institution (17,26). A trainees' exposure to clinical ultrasound and the quality of that exposure is dependent upon the training environment in which they find themselves (17).

The Emergency Ultrasound Society of South Africa is a subgroup of the Emergency Medicine Society of South Africa and was developed in order to promote, develop and facilitate training and credentialing in the field of emergency ultrasound. Many external courses are available and aim to assist with accreditation and standardisation (15). Traditional accreditation programs make use of a minimum number of echocardiographic examinations and a minimum duration of training before the various echocardiographic societies recognise the training and approve accreditation (27). Traditional programs also make use of an in-training evaluation report performed by accredited trainers (27). The problem with these traditional methods is that they do not indicate the quality of an examination, as unstructured observations often lack objectivity and reliability (28). The EUSSA (27) plays an important role in the accreditation process for emergency medicine practitioners and base their credentialing criteria on internationally established guidelines.

An objective structured examination (OSCE) assessment in the setting of POCUS is the assessment of a technical skill with predetermined objectives as well as a debriefing session, which allows for reflection on the OSCE (29). A number of studies have used the OSCE to evaluate various aspects of POCUS and it has been shown as an effective and reliable tool (5,30–32). Nair et al (27) recommended the use of an objective assessment of technical competency. Nielsen et al (28) successfully developed and designed a structured assessment instrument of echocardiographic skills (28). The use of an objective, standardised OSCE based system with a global rating scale and a procedure specific checklist has been shown to increase the reliability and validity of a POCUS assessment (27,28). Studies support the effectiveness of an OSCE based system to accurately assess the level of competency in echocardiography (28). Heiberg et al (30) showed that medical students with no ultrasound experience had significant improvement in practical skill after e-learning and four hours of hands-on training.

The authors made use of a previously published algorithm to assess their OSCE stations (30). Jakosen et al (31) used a global rating scale algorithm with a score from one to five, with a score of one indicating no image and five a perfect image. They judged an image score greater or equal to three to be sufficient quality to be interpreted and contribute to accurate clinical evaluation (30). Frederiksen et al (32) used an OSCE assessment to look at the four basic echocardiographic views. Rebel et al (5) assessed the ability to obtain and interpret an ultrasound image using an OSCE assessment incorporating a checklist as well as a global rating scale. The checklists were developed by the participating faculty and validated (5). Debriefing has been identified as one of the most important aspects of simulation-based medical education and forms an integral part of any OSCE. Simulation offers a valuable opportunity for practicing and gaining experience in a controlled setting (29).

1.8 Summary

Ultrasound has been proven to be beneficial in saving money and time, as well as improving patient care. Ultrasound has an important role in improving procedural safety and diagnostic accuracy. In many specialties, ultrasonography has become a core competency. The use of POCUS in anaesthesia has followed suit, with proficiency in POCUS being of great value (17). The need for the development of curricula and training protocols as part of a registrar training program remains essential (7). There has been a drive to incorporate ultrasound education into accredited registrar training programs as well as the addition of ultrasound education at an undergraduate level. In today's practice, it is essential that all anaesthesiologists should have a basic level of ultrasound understanding and proficiency (17).

Becoming proficient in a skill and maintaining competency in that skill are two separate issues that need to be addressed by any training program. A skill level will decline unless it is practiced and performed regularly (14). Ongoing training and assessments are thus very important in maintaining basic standards of practice (9,14). If FCU competency is to be ensured, continued practice, exposure and staying up to date with new research and technology is required (14).

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Section 2: Author guidelines

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1. Jun BC, Song SW, Park CS, Lee DH, Cho KJ, Cho JH. The analysis of maxillary sinus aeration according to aging process: volume assessment by 3-

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11. Figure numbers: Arabic, table numbers: Roman

Section 3: Draft article

The transthoracic echocardiographic skills of registrars in a department of anaesthesiology

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Keywords: Point of care ultrasonography, echocardiography, objective structured clinical examination, transthoracic echocardiography

Abstract

Background

Research has shown the value of integrating point of care ultrasonography into daily practice and has highlighted the poor competency in transthoracic echocardiographic (TTE) skill in anaesthesiology registrars. The aim of this study was to determine the TTE skills of anaesthesiology registrars at Wits using an objective structured clinical examination (OSCE).

Methods

This research study employed a cross-sectional research design. Convenience sampling was used and 28 registrars were enrolled in this study. The OSCE consisted of two practical stations (Stations 1 and 2) and two clinical pathology stations (Stations 3 and 4). Adequate TTE skill was defined as competency in both the practical and clinical stations and an overall pass score of 70% was used.

Results

The overall mean (SD) score obtained for the OSCE was 46.9% (24.3%). When comparing TTE skills of registrars who have completed a cardiac rotation, have completed an accredited course and those who have not, no significant differences were found in obtaining a pass score. Registrars who had completed an accredited TTE course performed significantly better in Stations 3 and 4 (p=0.005). Of the registrars 33.9% obtained a pass score for practical stations and 17.9% for the clinical stations with an overall 21.4% achieving a pass score. No significant difference in pass scores was found with the different categories of registrars. There was a strong positive significant correlation between completing more TTEs and the scores obtained (r=0.540, p=0.004).

Conclusion

Findings from this study suggest that the current skill levels of registrars in performing TTEs is not sufficient to achieve clinical competency and that the training may not be initiated early enough in the registrar program.

Introduction

Ultrasound has an important role in improving procedural safety and diagnostic accuracy and has become widely accepted as a diagnostic and procedural tool, but the application thereof was previously limited to specialist radiographers (1). With the advances in technology, portable ultrasound machines have become more affordable and more widely available to other medical disciplines (1,2). Over the last two decades, advances in technology have led to the more frequent incorporation of ultrasonography into clinical practice (1,2). The bedside application of ultrasound has since become referred to as point-of-care ultrasonography (POCUS) (1–5). Emergency medicine, cardiac anaesthesia and critical care were among the first disciplines to incorporate this skill into their daily practice (2,6). As the applications of POCUS have expanded and new research has validated and emphasised benefits for the clinician, many other medical disciplines have begun to integrate POCUS into their daily practice, including anaesthesia with its perioperative applications (4). This has resulted in a greater need for clinicians to be trained and accredited in the use of POCUS (3). Consequently, a number of courses, protocols and curricula have been developed and subsequently implemented across clinical medical disciplines in registrar training and at undergraduate level (6).

In today’s practice, all anaesthetists should have a basic level of ultrasound understanding and proficiency (7). The European Association of Cardiovascular Imaging (8) states that the level of competence in echocardiography must be the same for emergency and elective cases, as well as for cardiologists and non-cardiologists. There is limited evidence for the assessment of competency in POCUS. Poor competency in transthoracic echocardiographic (TTE) skill in anaesthesiology registrars has been shown (2,5). The aim of this study was to determine the TTE skills of anaesthesiology registrars at the University of the Witwatersrand (Wits) using an objective structured clinical examination (OSCE).

Methods

Approval to conduct the study was obtained from the Human Research Ethics Committee (Medical) at Wits and other relevant authorities. This research study employed a cross-sectional research design.

The study population consisted of registrars working in the Department of Anaesthesiology at Wits. The sample size was determined in consultation with a biostatistician using EpiInfo version 6 using the mean and standard deviation values of previous studies (5,7,9,10). A sample size of 26 participants would give a power of greater than 80% with a level of confidence of 95% and a significance of 5%. Convenience sampling was used.

A draft OSCE was compiled and reviewed by three cardiothoracic anaesthesiologists and a specialist cardiologist. Their recommendations were incorporated into the final OSCE. The OSCE consisted of two practical and two clinical stations:

- Station 1 – the parasternal long axis TTE view
- Station 2 – the apical four-chamber TTE view
- Station 3 and 4 – each displaying a real-time echocardiographic sine loop, a cardiac tamponade and a hypertrophic obstructive cardiomyopathy.

Aspects of assessment for Station 1 and 2 included appropriate orientation, depth and gain, overall image quality and target anatomy in each view. The overall image quality was assessed using a global rating scale (GRS) (11). Station 3 and 4 each required the registrar to assess a TTE sine loop and identify the view used, pathology present and echocardiographic diagnosis.

The OSCE was conducted in the Faculty of Health Sciences Simulation Laboratory at Wits. Registrars signed a consent form and provided demographic data and were allocated a time slot. The study used two ultrasound platforms (Mindray M7 Premium units) with the necessary software and adult cardiac echocardiographic probes required to perform TTE examinations. Each platform was equipped with a phased array P4-2s transducer. The two echocardiographic sine loops were displayed on laptop screens. Two cardiothoracic anaesthesiologists from the department, who are Focused Assessed Transthoracic Echocardiography (FATE) trained, assessed Stations 1 and 2 respectively. Two healthy male anaesthetists from the department were used as examination subjects. The anaesthetists were assessed to exclude any underlying pathology and abnormalities prior to the OSCE. Each station took 90 seconds to complete. The assessors graded the first two stations immediately and Station 3 and 4 were graded at a later stage by a different cardiac anaesthesiologist from the department. The registrars received feedback on their results upon request.

A junior registrar in this study was defined as a registrar who had not completed the cardiac component of training and a senior registrar was defined as one who had. The cardiac component refers to the completion of the six-week cardiac anaesthesia component of the 12-week cardiac rotation. For this OSCE, adequate TTE skill was defined as competency in both the practical (Stations 1 and 2) and clinical (Stations 3 and 4) stations and an overall pass score of 70% was used. The pass score was determined in consultation with senior cardiothoracic anaesthesiologists and a cardiologist. Image quality was assessed using a GRS (11), which is a standardised and validated method of assessing performance-based examinations, with a score ranging from 1 – 5 and was as follows:

1 No image
2 Poor or unusable image quality
3 Usable image quality
4 Good image quality
5 Perfect image quality.

Data were analysed in consultation with a biostatistician using the statistical program STATA version 13.1 (StataCorp, USA). Categorical variables were described using numbers and percentages. Numerical variables were described using means and standard deviations or medians and interquartile ranges depending on the distribution of the data. An independent t-test was used to compare scores between senior and junior registrars, between those who had passed an accredited ultrasound course and those who had not and those who have performed clinical echocardiography to those who have not. A Wilcoxon rank-sum test was used for non-parametric paired data. A Pearson's correlation was done between the number of TTEs performed and the average scores for the stations. A p-value of less than or equal to 0.05 was considered statistically significant.

Results

All registrars in the departments were invited to take part in the study and a total of 28 registrars accepted the invitation and were enrolled in the study. The registrar's characteristics are shown in Table 1.

Table 2: Characteristics of participants

Characteristic	Number	Percentage
Year of registrar training		
• 1	3	10.7
• 2	6	21.4
• 3	9	32.1
• ≥4	10	35.7
Completed cardiac rotation		
• Yes	11	39.3
• No	17	60.7
Accredited TTE course completed		
• Yes	8	28.6
• No	20	71.4
Course completed within last 6 months		
• Yes	2	25.0
• No	6	75.0
TTE performed		
• At least once	15	53.6
• Never	13	46.4
Frequency of TTE performance		
• Weekly	2	13.3
• Monthly	5	33.3
• Less than monthly	8	53.3

The participants had done a median (IQR) number of TTEs of 1.5 (0 – 6.8) with a range of 0 – 200 prior to the study. Excluding the participant who had done 200 TTEs prior to the study, the median (IQR) was 1.0 (0 – 8.3), with a range of 0 – 30. Of the 14 participants who had performed TTEs previously, excluding the participant who had performed 200 TTEs, the median (IQR) number of TTEs performed was 5.0 (0 – 9.5) with a range of 1 – 30.

The overall mean (SD) score obtained for the OSCE was 46.9% (24.3%), with 6 (21.4%) participants obtaining a pass score and 13 (46.4%) obtaining a score of 50% or more. The scores obtained for the 4 stations are shown in Table 2.

Table 2: Scores obtained for the OSCE

	Maximum achievable score	Pass %	Mean	SD	Min	Max
Station 1	14	35.7	7.4	4.5	2.0	14.0
Station 2	14	32.1	7.0	4.1	2.0	14.0
Stations 1 and 2 (%)	100	39.3	51.4	27.3	14.3	100
Station 3	5	17.9	1.8	1.4	0.0	5.0
Station 4	5	14.3	1.6	1.5	0.0	5.0
Stations 3 and 4 (%)	100	17.9	33.9	24.8	0.0	90.0
All stations	38	21.4	17.8	9.2	5.0	35.0
Percentage	100		46.9	24.3	13.2	92.1

There was a significant difference between the scores obtained for Stations 1 and 2 and Stations 3 and 4 (p=0.001). The comparisons between the scores of those who have completed a cardiac rotation and those who have not, between those who have done an accredited TTE course and those who have not and those who have performed one or more TTE in clinical practice to those who have not are shown in Table 3. Comparing TTE skills for Stations 1 and 2, Stations 3 and 4 and all stations overall between those who have completed cardiac rotation and those who have not, no significant differences were found. However, those who had completed and accredited course performed significantly better in Stations 3 and 4 (p=0.005).

Table 3: Comparison of scores obtained

	Score Mean (SD) %	p-value
Completed cardiac rotation		
Station 1 and 2		
• Yes	50.1 (29.4)	
• No	52.3 (26.8)	0.839
Station 3 and 4		
• Yes	39.1 (27.7)	
• No	30.6 (23.0)	0.387
All stations		
• Yes	47.4 (24.5)	
• No	46.6 (25.0)	0.936
Completed accredited TTE course		
Station 1 and 2		
• Yes	61.4 (33.2)	
• No	47.5 (24.4)	0.230
Station 3 and 4		
• Yes	53.8 (24.5)	
• No	26.0 (20.6)	0.005
All stations		
• Yes	59.5 (26.0)	
• No	41.8 (22.3)	0.082
Performed TTE		
• Yes	56.1 (25.4)	
• No	36.2 (18.7)	0.028

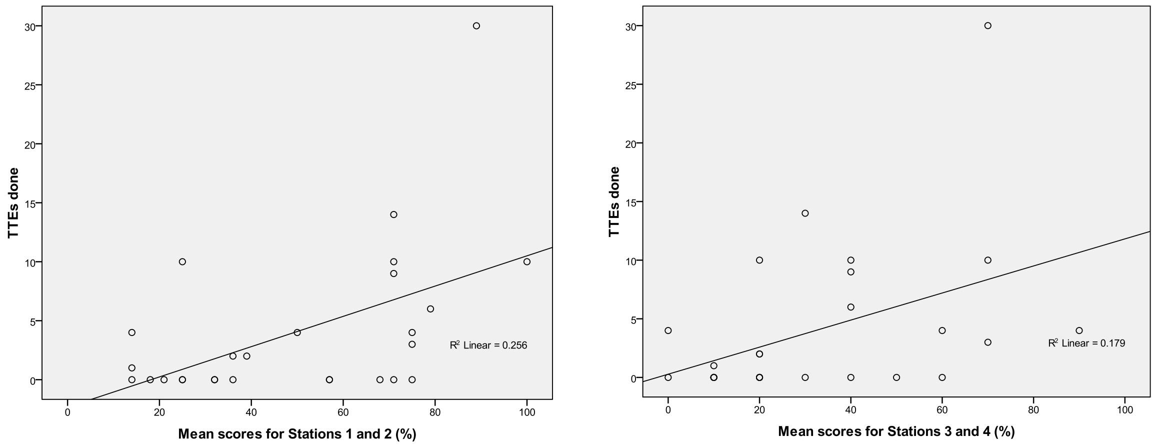
The comparisons between pass and fail of those who have completed a cardiac rotation, those who have done an accredited TTE course and those who have performed one or more TTE in clinical practice to those who have not are shown in Table 4. No significant differences were found.

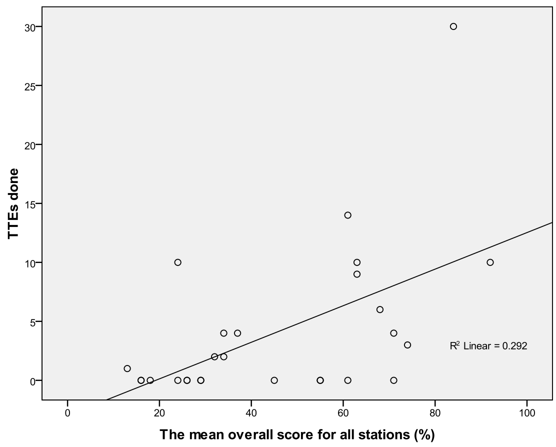
Table 4: Assessment of competency

	Pass	Fail	p-value
Completed cardiac rotation			
• Yes	2	9	
• No	4	13	0.999
Accredited TTE course done			
• Yes	3	5	
• No	3	17	0.311
Performed TTE			
• Yes	5	10	
• No	1	12	0.173

There were 3 participants who had completed a cardiac rotation, performed TTEs and completed an accredited course, however, no significant difference in their performance was found when compared to the other 25 participants (p=0.175). The overall mean (SD) for these 3 participants was 53.3 (16.7).

The correlations between the number of TTEs done and the scores obtained for Stations 1 and 2, Stations 3 and 4 and all stations and the interpretation thereof are shown in the scatter plots in Figure 1. Completing more TTEs was associated with a higher score. The participant who had performed more than 200 TTEs was excluded from this analysis.





	Stations 1 and 2	Stations 3 and 4	Stations All
Strength	Strong	Moderate	Strong
r-value	0.506	0.423	0.540
p-value	0.007	0.028	0.004

Figure 1: Correlations between the number of TTEs performed and scores obtained

Discussion

As POCUS expands and becomes part of the clinicians' daily practice, there is an increased need for the ongoing assessment, improvement of skill and maintenance of standards in this field (2). Therefore, there is a need for the development of curricula and training protocols as part of a registrar training program (6). Rebel et al (5) found that anaesthesiology registrars' exposure to and clinical use of ultrasound was not sufficient for developing competency in POCUS. The American Society of Echocardiography (ASE) (12) recommends an ongoing training, assessment and accreditation process. It is essential that all clinicians, including anaesthetists, have a basic level of ultrasound understanding and proficiency (7). There has been a drive to incorporate ultrasound education into accredited registrar training programs as well as at an undergraduate level (13).

In our study, the mean score was 46.9%, with 21.4% of participants achieving a pass score. This result is similar to Ramsingh et al (14), who found a baseline score of 48% among anaesthesiology registrars. Rebel et al (5) had a 13% pass rate for the TTE practical stations and a 40% success rate for the TTE pathology station but did not state the set pass score for the OSCE. In our study, the pass score was set at 70% and 39.3% of registrars passed the practical stations and 17.9% the clinical stations.

Ongoing training and assessments are essential in maintaining basic standards of POCUS practice and patient care (8,15). The ASE (13) recognises this and advises that POCUS training should commence at an undergraduate level and encourages the introduction of fundamental principles, indications, applications and limitations of POCUS as early on in training as possible. In our study, 40% of registrars had completed an accredited TTE course and of these, 37.5% passed the OSCE. This indicates the basic training in skill and background knowledge may not be introduced early enough in the registrar training. There was no significant difference in the overall TTE skills of those registrars who had completed an accredited course to those who had not. This suggests that a once-off accredited course in TTE may not suffice for the proficient acquisition of long term practical skill and knowledge. It has been demonstrated that when echocardiographic skills are not performed regularly, the proficiency will diminish over time. Thus a process of ongoing training and reaccreditation to ensure the maintenance of TTE standards is required (15,16).

Barber et al (4) acknowledge that the actual number of TTEs performed is less important than the overall quality of the educational experience, range of pathologies observed and the quality of supervision. The ASE (13) guidelines for TTE suggest that the number of TTEs performed or hours of training may act as surrogates for proficiency in echocardiography and recommend the performance of a minimum of 150 TTEs to ensure basic competency. In 2018, the Portuguese Society of Cardiology (17) recommended that emergency FCU practitioners require the completion of a minimum of 50 clinically indicated echocardiographic examinations in a period of less than a year to maintain competency. In our study, only one registrar had performed more than 150 TTEs in clinical practice and the remainder of the registrars had performed between 0 – 30 TTEs, which is below the recommended number. Studies with junior practitioners have found competency in performing and interpreting TTE after 20 – 30 examinations, if the examination was limited to the parasternal views (16). We found the highest scores in our practical parasternal long-axis view supporting this finding.

In our study, the registrars who had more practical experience obtained higher scores in the practical stations. Wiegers et al (13) highlight the importance of exposure to a spectrum of clinical conditions and the hands-on application of TTE in the diagnosis and management of cardiac conditions. Chisolm et al (18) found that after an initial mixed didactic and scanning training, followed by five months of independent scanning, the competency in TTE was evident. The authors further showed that acquiring the clinical ability to interpret echocardiographic images is learned more quickly than the practical skill to acquire the views. They found that there were strong trends toward increased competency with increased numbers of examinations performed (18).

There was no significant difference in TTE skills of registrars who had completed a cardiac rotation to those who had not. This may be a result of greater emphasis being placed on trans oesophageal echocardiography (TOE) during the cardiac rotation. Research has shown that competency in TOEs does not translate to the equivalent in TTEs, as the skills and learning goals are distinctly different (3,4).

Our study was done contextually and may not be generalisable to other institutions. The authors recommend a complete training program with the early completion of an accredited training course, ongoing supervised training with simulation and adequate clinical exposure and practice, recurrent objective assessment of skill and an accreditation and reaccreditation process. The results of our study could be used to motivate for a curriculum with the necessary simulation equipment to enhance the overall training and assessment process.

Conclusion

Findings from this study suggest that the current skill levels of registrars in performing TTEs is not sufficient to achieve clinical competency and that the training may not be initiated early enough in the registrar program.

Conflict of interest

The authors declare that we have no financial or personal relationships which may have inappropriately influenced us in writing this paper.

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Section 4: Proposal

The transthoracic echocardiographic skills of registrars in a department of anaesthesiology

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1810802

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Co-supervisor	Dr Juan Scribante Department of Anaesthesiology
Co-supervisor	Dr Thomas Kleyenstuber Department of Anaesthesiology

4.1 Introduction and problem statement

Ultrasound has become widely accepted as a diagnostic and procedural tool, but the application thereof was previously limited to specialist radiographers (1). With the advances in technology, portable ultrasound machines have become more affordable and more widely available to other medical disciplines (1,2). Over the last two decades, advances in technology have led to the more frequent incorporation of ultrasonography into clinical practice (1,2). The bedside application of ultrasound has since become referred to as point-of-care ultrasonography (POCUS) (1–5). Emergency medicine, cardiac anaesthesia and critical care were some of the first fields to incorporate this skill into their daily practice. As the applications of POCUS have expanded and new research has validated and emphasised benefits for the clinician, many other medical disciplines have begun integrating POCUS into their daily practice (4). This has resulted in a greater need for clinicians to be both trained effectively and accredited in the use of POCUS (3). Consequently, a number of courses, protocols and curricula have been developed and subsequently implemented across clinical medical disciplines (6).

According to Atkinson (6), emergency medicine has been at the forefront of establishing POCUS training programs and curricula. POCUS is now internationally recognised as an adjunct to the practice of emergency medicine and many other specialities are applying similar guidelines and principles to their training programs. Nielsen et al (7) successfully developed and designed a structured assessment instrument of echocardiographic skills (7). The authors argued that the use of an objective structured clinical examination (OSCE) based system with a global rating scale and a procedure specific checklist increases the reliability and validity of an assessment (7,8). Nair et al (8) supported the use of OSCEs in that their study showed that traditional measures did not accurately reflect competence in performing transthoracic echocardiography (TTE). They, therefore, recommended the use of a more objective assessment of technical competency, such as an OSCE (8). Further studies support the effectiveness of an OSCE based system to accurately assess the level of competency in echocardiography (7). In their, study Heiberg et al (9) made use of a previously published algorithm to assess their OSCE stations. This algorithm was described by Jakosen et al (10) and used a global rating scale from 1 to 5. They judged an image score greater or equal to three to be of sufficient quality to be interpreted and contribute to clinical decision-making (9). In their study, Frederiksen et al (11) used an OSCE assessment to look at the four basic focused assessed transthoracic echocardiographic (FATE) views. Images were graded according to the following five aspects: anatomical presentation, sector optimization (depth and angle), gain adjustment, image sharpness and interpretational value. Theses aspects were graded on a global rating scale and an overall global image rating score was calculated for each exam (11). Rebel et al (5) assessed the ability to obtain and interpret an ultrasound image using an OSCE assessment incorporating a check list as well as a global rating scale. The checklists were developed by the participating faculty and validated (5). A number of studies have used the OSCE to evaluate various aspects of POCUS and it has been shown as an effective and reliable tool (5,12).

In many specialties, ultrasonography has become a core competency. POCUS is a rapidly growing area in medicine especially in anaesthesia and its perioperative applications (2,6). Ultrasound has an important role in improving procedural safety and diagnostic accuracy. The need for the development of curricula and training protocols as part of a registrar training programme, remains essential (6). There has been a drive to incorporate ultrasound education into accredited registrar training programs as well as the addition of ultrasound education at an undergraduate level. In today's practice all anaesthetists should have a basic level of ultrasound understanding and proficiency (13). POCUS is continuously expanding as new diagnostic and procedural applications are established and the skills of trained clinicians evolve. It is, therefore, crucial for medical training programs to adapt to these advances and for medical professionals to be instructed and assessed accordingly (6). At present, the transthoracic echocardiographic (TTE) skills of anaesthesiology registrars at the University of the Witwatersrand (Wits) is not known.

4.2 Aim and objectives

4.2.1 Aim

The aim of this study is to determine the TTE skills of anaesthesiology registrars at Wits using an objective structured clinical examination (OSCE).

4.2.2 Objectives

The primary objective of this study is to determine the TTE skills of registrars.

The secondary objectives of this study are:

- to compare the TTE skills of senior and junior registrars
- to compare the TTE skills of registrars who have completed an accredited ultrasound course programme to those who have not
- to compare the TTE skills of registrars who perform TTE in the clinical setting to those who do not
- to correlate the number of TTEs performed and the TTE skill level.

4.3 Research assumptions

The following definitions will be used in this study.

Registrar: is a qualified doctor who is registered with the Health Professions Council of South Africa as a trainee anaesthetist.

Cardiac component: in this study will refer to the completion of the six-week cardiac anaesthesia component of the 12-week cardiac rotation.

Junior and senior registrar: a junior registrar is defined as a registrar who has not completed their cardiac component and a senior registrar is defined as one who has.

Adequate TTE skill: For this OSCE adequate TTE skill will be defined as competency in both the practical and clinical stations and a cut off of 70% will be used. This was determined in consultation with senior cardiothoracic anaesthesiologists and cardiologist.

Image quality: will be assessed using a global rating scale (GRS) (12), which is a standardised and validated method of assessing performance-based examinations like OSCEs. The following global rating scale will be used:

1 No image
2 Poor or unusable image quality
3 Usable image quality

4.4 Demarcation of study field

The study will be conducted in the Department of Anaesthesiology and the Simulation Laboratory, affiliated to the Faculty of Health Sciences of Wits. The staff complement of the department is 74 consultants, 112 registrars and 22 medical officers.

The following core hospitals are affiliated to the department's training platform.

- Charlotte Maxeke Johannesburg Academic Hospital, a 1 200-bed central hospital.
- Chris Hani Baragwanath Academic Hospital, a 2 888-bed central hospital.
- Helen Joseph Hospital, a 500-bed regional hospital.
- Rahima Moosa Mother and Child Hospital, a 338-bed regional hospital.
- Wits Donald Gordon Medical Centre, a public-private hospital with 190 beds.

The Faculty of Health Sciences Simulation Laboratory at Wits will be used to facilitate the OSCE.

4.5 Ethical considerations

Approval to conduct the study will be obtained from the Human Research Ethics Committee (Medical) and the Graduate Studies Committee of Wits. Permission from the Academic Head of the Department of Anaesthesiology (Appendix 1) as well as the Head of the Simulation Laboratory (Appendix 2) has been obtained.

An online ethics course was completed by the researcher in preparation for this study. A number of ethics presentations as part of the anaesthetic academic programme and meetings were attended.

Registrars will be invited to participate in the study and be emailed the information that will explain the purpose and the aims of the study. The researcher will provide a contact sheet that registrars can provide their contact details on and allow future correspondence with researcher. Those registrars that have indicated interest will be contacted and provided with an appointment date and time, an information letter (Appendix 3) and asked to sign a consent form (Appendix 4).

If Registrars should decide not to take part in the study, anytime during the study process, they can indicate their wish to withdraw and do so without any adverse consequence to them or their training.

Data will be collected without any identifying information and each registrar will receive a study number. A list with the registrars' names and study numbers will be compiled and kept separately. Confidentiality will be ensured as only the researcher and supervisors will have access to the raw data.

Each registrar will receive feedback on their performance on request. If a skill gap is identified this will be reported to the Academic Head of the Department of Anaesthesiology with a view to further training programs and workshops being implemented.

Data will be stored securely for six years after completion of the study in a locked cupboard. All electronic data will be stored on a password-protected database. The study will be conducted according to the principles of the Declaration of Helsinki (14) and the South African Guidelines for Good Clinical Practice (15).

4.6 Research methodology

4.6.1 Research design

This research study will employ a contextual, cross-sectional research design.

A contextual research design can be defined as a user-centred design process that was first developed by Hugh Beyer and Karin Holtzbalt (16). It incorporates the aggregation of data from participants within a certain place and applies these findings to a larger population within that field (16). This study is contextual in nature as it investigates TTE skills of anaesthesiology registrars within the context of the Department of anaesthesiology at WITS with the aim of generalising these findings to draw conclusions about the larger anaesthesiology registrar population

A cross-sectional study design is defined as a design that collects data on participants at a single point in time (17). This study will collect data through an OSCE at a single point in time on a number of registrars.

4.6.2 Study population

The study population will consist of anaesthesiology registrars working in the Department of Anaesthesiology at Wits.

4.6.3 Study sample

Sample size

Power analysis was used to calculate the minimum sample size required for this study. The sample size was determined in consultation with a biostatistician using EpiInfo version 6 based on results obtained from previous studies (5,9,11,13). In a study by Rebel et al (5), statistical significance using a one-way analysis of variance (ANOVA) with a p-value of <0.05 was considered statistically significant and had 18 participants with a p-value of 0.02. The authors compared registrars of different seniority and recorded mean values (SD) of 0.41 (0.09), 0.56 (0.12), 0.55 (0.12). Heiberg et al (9) used continuous, normally distributed data that they reported as mean (standard deviation [SD]), and the normally distributed data were compared applying ANOVA. The Wilcoxon rank-sum test was applied for paired, continuous, non-normally distributed variables. Binominal data are presented as absolute numbers and compared applying the chi-squared test. Correlations were checked applying simple linear regression analyses. They set a significance level of 95 % but adjusted appropriately for multiple comparisons by the Bonferroni correction. Therefore, only p-values < 0.01 were considered statistically significant. With a statistical power of 90 % and a level of significance of 95 %, they needed 12 students to participate in their study and used 16 students. They found baseline scores of 38.3±11% and post-training scores of 54±14% and 73.1±12% with a p-value of 0.01 in their cardiac and pleural view OSCE. In a study by Frederiksen et al (11), 21 participants achieved a mean global image rating on baseline cardiac ultrasound examinations of 70.2% (CI 68.0 – 72.4) and a mean global image rating after intervention was 75.0 (CI 72.9 – 77.0) with a p-value of 0.0002. In a study by Matyal et al (13), looking at post training ultrasound proficiency they had a mean (SD) score of 92.5 (8.56) for cardiac ultrasound OSCE station and 95 (9.66) for their pleural ultrasound OSCE station

Utilising the mean and standard deviation values of each of these studies a power analysis was performed and a sample size was determined. Twenty-six participants would give a power of greater than 80% with a level of confidence of 95% and a significance of 5%.

Sampling method

Convenience sampling will be used. Convenience sampling is a non-probability sampling method where participants being selected are based upon availability and willingness to take part in the study (18).

Inclusion and exclusion criteria

The inclusion criteria of this study are registrars who have given written informed consent.

4.6.4 Data collection

Data collection form

A draft data collection form was compiled and reviewed by three cardiothoracic anaesthesiologists. Their recommendations were incorporated into the final data collection form (Appendix 6). The data collection form consists of a demographic section and four station assessments. The four stations will assess the following:

- Station 1 – the parasternal long axis (PLAX) TTE view
- Station 2 – the apical four-chamber (A4C) TTE view
- Station 3 and 4 – each displaying a real-time echocardiographic sine loop of a common clinical pathology.

Aspects of assessment for Station 1 and 2 include appropriate orientation, depth and gain, overall image quality and target anatomy in each view. The overall image quality will be assessed using a GRS as defined in the research assumptions. Station 3 and 4 will each require the registrar to assess a TTE sine loop and identify the view used, pathology present and echocardiographic diagnosis. The two pathologies will be a cardiac tamponade and a hypertrophic obstructive cardiomyopathy.

Data collection

The OSCE will be conducted in the Faculty of Health Sciences Simulation Laboratory at Wits on a Wednesday afternoon. Each registrar will be asked to sign a consent form and provide demographic data. Each registrar will be allocated a time slot and will be asked to wait in a separate room isolated from the candidates who have already completed the OSCE.

The study will be making use of two ultrasound platforms with the necessary software and adult cardiac echocardiographic probes required to perform TTE examinations. Ascendis Medical has agreed to loan (Appendix 5) two Mindray M7 Premium units each equipped with a phased array P4-2s transducer. The transducers each have a bandwidth of 1.3 – 4.7 MHz, field-of-view of 90°, 64 elements and a footprint of 38.2 mm x 30.5 mm.

The two echocardiographic sine loops will be obtained in consultation with a cardiologist and cardiac anaesthesiologist and each will be displayed on a laptop screen.

Two cardiothoracic anaesthesiologists from the Department of Anaesthesiology, who are FATE trained, will be used to assess Stations 1 and 2 and will be blinded to results from Stations 3 and 4. Two healthy male anaesthetists from the department will be used as examination subjects. The two anaesthetists will be assessed by one of the assessors to exclude any underlying pathology and abnormalities prior to the OSCE.

Each station will take 90 seconds to complete and the assessors will grade the first two stations immediately and station 3 and 4 will be graded at a later stage by a cardiac anaesthesiologist from the Wits anaesthesiology department.

The registrars will receive feedback on their results upon request.

4.6.5 Data analysis

A Microsoft Excel spreadsheet will be used to capture data. Data will be analysed in consultation with a biostatistician using the statistical program STATA version 13.1 (StataCorp, USA). Categorical variables will be described using numbers and percentages. Numerical variables will be described using means and standard deviations or medians and interquartile ranges depending on the distribution of the data. An independent t-test will be used to compare marks received between senior and junior registrars, between those who have done an accredited ultrasound course and those who have not and those who have performed clinical echocardiography to those who have not. A Wilcoxon rank-sum test will be used for non-parametric paired data. A p-value of less than or equal to 0.05 will be considered statistically significant. A Pearson’s correlation test will be done to correlate TTEs done with the average scores for the stations.

4.7 Significance of the study

POCUS is an essential tool for the clinician and assessing the competency and training within this field is essential to maintain standards. This study may identify possible areas for improvement in the registrar training programme at Wits. This study will provide a baseline standard from which further studies or interventions can be assessed. It is essential for all medical training programs to remain up to date and continually strive for improvement and by implementing quality improvement strategies allowing for the continuity and maintenance of excellence in training and education.

4.8 Validity and reliability of the study

Botma et al (19) refer to validity as “the degree to which a measurement represents a true value” and reliability as “the consistency of the measure achieved”. In this study, the measures to ensure validity and reliability include:

- appropriate research design
- sample size was determined in consultation with a biostatistician
- a standard ultrasound platform will be used for each station
- FATE accredited assessors will be used for each station
- the same healthy male volunteer will be used for each of the two practical stations
- a standard assessment and GRS will be used
- data will be analysed in consultation with a biostatistician.

4.9 Potential limitations

The following potential limitations may occur in this study:

- volunteer bias as a result of the convenience sampling
- the results might not be generalisable due to the contextual design

4.10 Project outline

4.10.1 Time Frame

Table 1: Time frame

Activity	Oct 2019	Nov 2019	Dec 2019	Jan 2020	Feb 2020	Mar 2020	Apr 2020	May 2020	Jun 2020	Jul 2020
Proposal preparation										
Literature review										
Proposal submission										
Ethics approval										
Postgraduate approval										
Data collection										
Data analysis										
Draft article										
Submission										

4.10.2 Budget

Two assessors and two volunteers from the Department of Anaesthesiology at Wits will be used and will not require funding. Refreshments will be provided for the volunteers and the assessors at the cost of the researcher. A medical company has been approached and has agreed to supply two ultrasound machines needed for the OSCE's (Appendix 5). The Wits Department of Anaesthesiology will incur the costs of paper and printing of the proposal and postgraduate application.

Table 2: Budget

Item	Price per page	Number of pages	Copies	Total
Proposal	1	19	10	R 190
Postgraduate form	1	2	6	R 12
Information letter and consent	1	2	30	R60
Marking sheets	1	4	120	R120
Complete report	1	100	4	R 400
Refreshments				R300
Grand total				**R 1082**

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4.12 Appendices

Appendix 1 Information sheet

Study title: The transthoracic echocardiographic skills of registrars in a department of anaesthesiology

Dear colleague, my name is Nicholas Coetzee, I am a registrar in the Department of Anesthesiology and am conducting my M Med research study on transthoracic echocardiography (TTE). In this study we want to determine the transthoracic echocardiographic skills of registrars using an objective structured examination (OSCE) based assessment tool. Your participation would involve attending one Wednesday afternoon appointment in the Simulation Laboratory at the Wits Medical School during protected teaching time. This appointment would entail rotating through four OSCE stations each of which is 90 seconds in duration and two stations being assessed by an examiner from within our cardiothoracic department. You will be asked to wait in a separate room while other participants take part in the OSCE and this waiting time will be a maximum of one hour. Please do not share information pertaining to the study with other participants as this may skew results. You will receive feedback on request. Only my supervisors and I will have access to the raw data thereby ensuring confidentiality.

This study may identify possible areas for improvement in the registrar training programme at Wits. This study will provide a baseline standard from which further studies or interventions can be assessed. It is essential for all medical training programs to remain up to date and continually strive for improvement and by implementing quality improvement strategies allowing for the continuity and maintenance of excellence in training and education.

This letter is an invitation to you to partake in my M Med research study titled: The transthoracic echocardiographic skills of registrars in a department of anaesthesiology. The aim of this study is to determine the transthoracic echocardiographic skills of registrars in the Department of Anaesthesiology at Wits using an OSCE.

Participation in the study is voluntary and not taking part in the study will not prejudice you in any way. A consent form will need to be completed. The results of the OSCE will be reported anonymously as no identifying data will be requested from you.

The Human Research Ethics Committee (Medical) (HREC) (number xxx) and the Graduate Studies Committee of the University of the Witwatersrand have approved the study. If you have any questions regarding the study please contact me on 0828221953 or nick.coetzee@yahoo.com. You can also contact the chairman of the HRECM Prof Penny on (011) 7172301 or clement.penny@wits.ac.za, or any of the HREC administrators on (011) 717 1234/2656/2700 or any of the following emails: Rhulani.mkansi@wits.ac.za Charmaine.khumalo@wits.ac.za josh.ndkingumandla@wits.ac.za.

Thank you for taking the time to read this letter.

Yours sincerely

Nicholas Coetzee

Appendix 2 Informed consent form

I ____ hereby confirm that I have read and understood the Information letter regarding the study titled: The transthoracic echocardiographic skills of registrars in a department of anaesthesiology

I am aware that the information provided by me will be treated in a confidential manner, will not be used to discriminate against me, and will be used anonymously when the study is reported.

Participant

I hereby give consent to take part in this study.

____________________ ____________________ ____________________

(Participant Name) (Participant Signature) (Date)

Researcher

I____ hereby confirm that the above participant has been fully informed about the nature and benefits of this study.

Contact details:

Dr ND Coetzee, cellphone: 0828221953 or by e-mail: nick.coetzee@yahoo.com

Dr T Kleyenstuber, cellphone: 0820622516 or email: kleyenstuber@hotmail.com

Professor CB Penny, Chairperson of the Human Research Ethics Committee (Medical) at the University of Witwatersrand, on telephone:011 717 2301, or my e-mail: Clement.Penny@wits.ac.za

Ms. Z Ndlovu or Mr. Rhulani Mkansi, telephone : 011 717 2700/1234, or e-mail at: Zanele.Ndlovu@wits.ac.za or Rhulani.Mkansi@wits.ac.za or Charmaine.khumalo@wits.ac.za or josh.ndkingumandla@wits.ac.za Committee Secretariats.

Appendix 3 Approval Head of Department of Anaesthesiology

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

WITS UNIVERSITY

Department of Anaesthesia – University of the Witwatersrand

7 York Road, Parktown, 2193 South Africa • Telegrams "Witsmed" • Telephone (011) 488-4344 • Fax (011) 488-4343

Department of Anaesthesia
Area 361
Charlotte Maxeke Johannesburg Academic Hospital

Tel: 011 488-4344

8th October 2019

Subject: **Permission to conduct survey from Department of Anaesthesiology**

To whom it may concern,

This letter stands to affirm that I, Dr PMV Motshabi, grant permission for Dr Nicholas Coetzee HPCSA number MP 0762210, to conduct a study in the Department of Anaesthesiology at the University of the Witwatersrand for his study "The transthoracic echocardiographic skills of registrars in a department of anaesthesia".

The approximate period will be, but not limited to, the months of January 2020 to June 2020, until his sample size is obtained. The information obtained from the data will be used for Dr Coetzee's research study for his Masters in Medicine only, and will include information and data relevant to his study.

Yours sincerely,

WITS UNIVERSITY

Dr Palesa Motshabi
Academic Head: Department of Anaesthesia
Head of Clinical Unit: Cardiac Anaesthesia

Tel: +27 (0)11 488 4344
Cell: 083 432 1994
Email: palesa.motshabi@wits.ac.za
Website: www.wits.ac.za

WITS SCHOOL OF CLINICAL MEDICINE

FACULTY OF HEALTH SCIENCES

Charlotte Maxeke Johannesburg Academic Hospital, 6th Floor, Area 361/16, Jubilee Road, Parktown, Johannesburg

Appendix 4 Approval Simulation Laboratory Co-Ordinator

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

CHSE CENTRE FOR HEALTH SCIENCE EDUCATION

Kerry-Ann Singaram

Centre for Health Science Education

Simulation lab coordinator

University of the Witwatersrand

Kerry-ann.singaram@wits.ac.za

011 717 2548

2 October 2019

To: Dr Nicholas Coetzee

You have permission to use the Simulation Laboratory situated on fourth floor, in the Department of Health Sciences for your research purposes.

Thank you and kind regards

Kerry-Ann Singaram

Appendix 5 Approval of ultrasound platform loan

9009

Dr Nicholas Coetzee
Department of Anaesthesiology
University of the Witwatersrand

5th October 2019

Dear Dr Coetzee,

Thank you for your letter requesting assistance with two Ultrasound machines for your study.

This serves to confirm that Rca would be happy to assist you the loan of two machines.

The correct machine for the use with Anaesthetic Ultrasound Applications will be the Mindray M7 Premium unit with a Phased Array P4-2s Transducer.
The Transducer Bandwidth is 1.3- 4.7MHz, FOV 90 Degrees.
64 Elements, Footprint 38.2 x 30.5mm

I attach a copy of the brochure and the Technical Specifications sheet of the machine.

I will wait to hear from you for the exact date you require the machines.

Please contact me if you require any further assistance.

Regards

Lesley McDaniel

Product Manager, Mindray Ultrasound
C: +27 82 804 7664 T: +27 11 568 9047 F: +27 86 680 1973
E: lesleymm@ascendismedical.com W: www.rca.za.com

Stand 208 C, Paddock lane, Boundary Park, Cnr Malibongwe dr and Epsom ave, Northriding, Rand | 2162

RESPIRATORY CARE AFRICA (PTY) LTD | Reg. No. 1998/017606/07 | Vat No: 4940179676
449 Granite Drive | Kya Sands Business Park | Kya Sand | 2162
Suite 247 Postnet | Private Bag X18 | Northriding | 2162
p +27 (0)11 708 3926 | f +27 (0)11 708 3936
w www.ascendishealth.com
Directors: Dr. K Wellner, K Futter, CB Sampson, A Lowther

ASC01-02D RCA Rev02

Appendix 6 Data collection form

Demographics:

Participant number: [ ]

Fate course completed:

Yes	No

If yes when: ________________(Month/year)

Any other ultrasound accredited course completed

Yes	No

If yes what course: ____

When: ______________(Month/year)

Cardiac rotation completed:

yes	No

How often do you perform TTE in clinical settings?

Daily	Weekly	Monthly	Never

Approximate total number of TTE’s performed in clinical practice: ___________

Station 1 (PLAX)	
Appropriate orientation/depth/gain	/3
Overall image Quality	/5
Target anatomy identified (LA/RA/LV/LA/MV/AV)	/6
Total	/14

Station 2 (A4C)	
Appropriate orientation/depth/gain	/3
Overall image Quality	/5
Target anatomy identified (LA/RA/LV/LA/MV/AV)	/6
Total	/14

Station 3 (pathological sine loop)	
Identify view	/1
Identify 3 abnormalities	/3
Diagnosis	/1
Total	/5

Station 4 (pathological sine loop)	
Identify view	/1
Identify 3 abnormalities	/3
Diagnosis	/1
Total	/5

Section 5: Annexures

5.1 Ethics Approval

UNIVERSITY OF THE
WITWATERSRAND,
JOHANNESBURG

R14/49 Dr Nicholas Coetzee

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M191101

NAME: **(Principal Investigator)**	Dr Nicholas Coetzee
DEPARTMENT:	Anaesthesiology Simulation Laboratory
PROJECT TITLE:	The transthoracic echocardiographic skills of registrars in a department of anaesthesiology
DATE CONSIDERED:	29/11/2019
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Mrs H Perrie, Prof J Scribante and Dr T Kleyenstuber
APPROVED BY:	Dr CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	07/02/2020

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary on the Third Floor, Faculty of Health Sciences, Phillip Tobias Building, 29 Princess of Wales Terrace, Parktown, 2193, University of the Witwatersrand. I/we fully understand the conditions under which I am/we are authorized
to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report**. The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed in **November** and will therefore be due in the month of **November** each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature   Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

5.2 Graduate Studies Committee approval

UNIVERSITY OF THE
WITWATERSRAND,
JOHANNESBURG

Private Bag 3 Wits, 2050
Fax: 027117172119
Tel: 02711 7172076

Reference: Mrs Sandra Benn
E-mail: sandra.benn@wits.ac.za

07 February 2020
Person No: 1810802
PAG

Dr ND Coetzee
36 Elgin Willows Estate
Kings Avenue
2001
South Africa

Dear Dr Nicholas Coetzee

Master of Medicine in Anaesthesia: Approval of Title

We have pleasure in advising that your proposal entitled *The transthoracic echocardiographic skills of registras in a department of anaesthesiology* has been approved. Please note that any amendments to this title have to be endorsed by the Faculty's higher degrees committee and formally approved.

Yours sincerely

Mrs Sandra Benn
Faculty Registrar
Faculty of Health Sciences

5.3 Turnitin report

1810802:turnitin.docx

ORIGINALITY REPORT

12%	7%	10%	3%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Kirk T. Spencer, Frank A. Flachskampf. "Focused Cardiac Ultrasonography", JACC: Cardiovascular Imaging, 2019 Publication	1%
2	hdl.handle.net Internet Source	1%
3	Submitted to University of Witwatersrand Student Paper	1%
4	www.thieme-connect.com Internet Source	1%
5	www.asecho.org Internet Source	1%
6	worldwidescience.org Internet Source	1%
7	ehjcimaging.oxfordjournals.org Internet Source	1%
8	www.onlinejacc.org Internet Source	<1%

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

FACULTY OF HEALTH SCIENCES

16th October, 2020

The Chairperson
Graduate Studies Committee
Faculty of Health Sciences
University of the Witwatersrand

Dear Madam,

Re: M Med: **The transthoracic echocardiographic skills of registrars in a department of anaesthesiology**

Dr Nicholas Coetzee, student number: 1810802, has submitted his research report to Turnitin which revealed a similarity index of 12%. These similarities appear not to be plagiarism but mainly the use of common terminology and phrases specific to the topic of the research.

Yours sincerely,

H C Perrie

Helen Perrie
Supervisor