UNIVERSITY OF NAIROBI, FACULTY OF HEALTH SCIENCES

DEPARTMENT OF CLINICAL MEDICINE AND THERAPEUTICS

FOCUSED CARDIAC ULTRASOUND:

COMPETENCY AMONG PRE-INTERNSHIP MEDICAL OFFICERS IN DIAGNOSING CARDIAC CAUSES OF DYSPNOEA

BY

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LIST OF ABBREVIATIONS AND ACRONYMS

ACEP™-	American College of Emergency Physicians
ASE™-	American Society of Echocardiography
ATS™-	American Thoracic Society
APCA™-	Association of Physician Certification and Accreditation (USA)
ARDMS™-	American Registry for Diagnostic Medical Sonography
COVID-19-	Corona Virus Disease of 2019
CPoCUS-	Canadian Point of Care Ultrasound Society
CURLS-	Cardiac Ultrasound for Resource-limited Settings
CVD-	Cardiovascular Disease
EACVI™-	European Association of Cardiovascular Imaging
ESC™-	European Society of Cardiology
FATE™-	Focused Assessment using Trans-Thoracic Echocardiography
FoCUS-	Focused Cardiac Ultrasound
KNH-	Kenyatta National Hospital
LMICS-	Low and Middle-Income Countries
NYHA-	New York Heart Association
BNP-	Brain Natriuretic Peptide
OSCE-	Objective Structured Clinical Examination
PI-	Principal Investigator
PoCUS-	Point of Care Ultrasound
PLAX-	Parasternal Long Axis View
TTE-	Transthoracic Echo
UoN-CHS-	University of Nairobi-College of Health Sciences
S4C-	Sub-costal Four (4) Chamber View
SIVC-	Sub-costal Inferior Vena Cava View
SSA-	Sub-Saharan Africa

DEFINITION OF TERMS

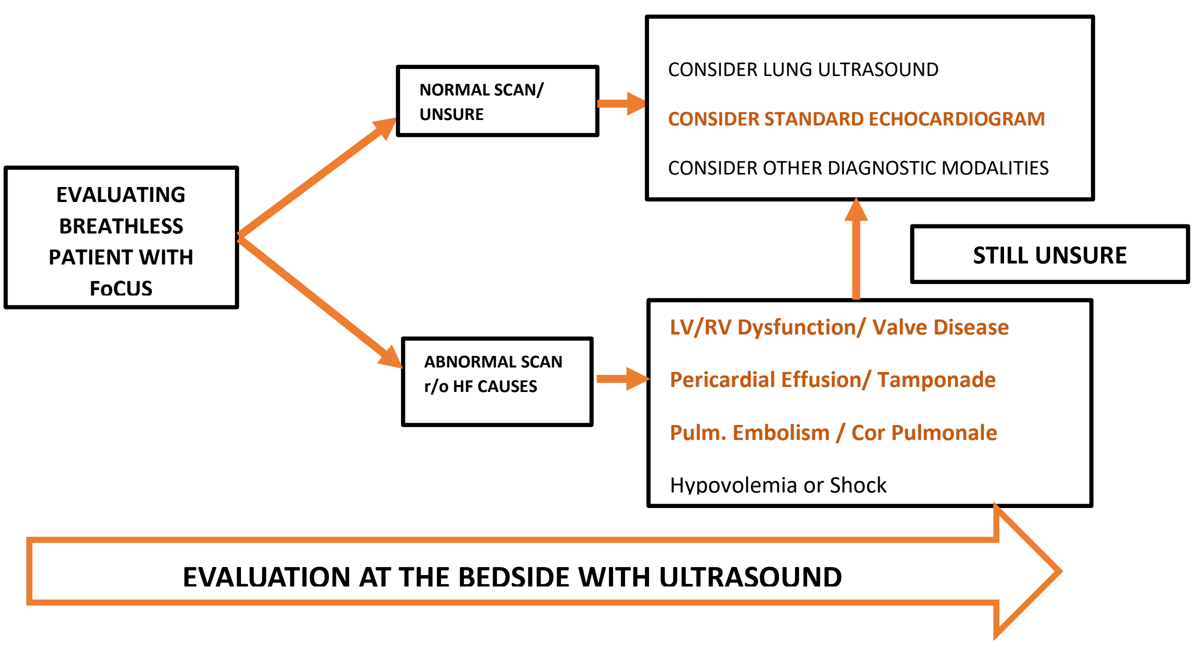
2.1 Point of Care Ultrasound (PoCUS)

PoCUS is a rapid, targeted clinical assessment of a patient using ultrasound technology performed at the bedside by the attending clinician. PoCUS is performed to answer binary questions such as the presence or absence of certain key clinical targets that may aid in evaluating and managing the patient(1). The patient's clinical presentation guides the clinician on which PoCUS protocol to use. For example, a patient presenting with breathlessness would benefit from a rapid sonographic assessment using lung ultrasound (LUS) and focused cardiac ultrasound (FoCUS).

2.2 Focused Cardiac Ultrasound (FoCUS)

FoCUS is a rapid point-of-care limited echocardiogram that can be performed by a non-expert. A non-expert is a non-cardiologist or non-cardiac sonographer. It is done at the bed-side to identify specific targets in the evaluation of cardiac disease as follows: global ventricular size and function, pericardial effusion and tamponade, gross cardiac disease or gross valvular abnormalities or the assessment of volume status(2). It provides real-time information for timely intervention e.g. to plan a pericardiocentesis for a pericardial effusion with tamponade. It utilizes basic ultrasound applications and devices including hand-held ultrasound devices.

FoCUS does not replace Standard Echocardiography which is performed by an expert, usually after the initial stabilization of the patient. Standard echocardiography, ideally performed in an echocardiography lab, is technically involving, takes longer to perform, and provides in-depth diagnostic information about the patient's cardiac function.



2.3 Expert vs Non-expert

An expert is a sonographer, radiologist, cardiologist, or cardiac technician who has been trained and certified in diagnostic ultrasound and/ or diagnostic echocardiography(2). A non-expert is a qualified clinician who has received minimal training in ultrasound applications to enable ultrasound use at the point of care.

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ABSTRACT

Background: Differentiating cardiovascular causes of dyspnea in resource-limited healthcare settings can be challenging. The use of accessible, rapid point-of-care Focused Cardiac Ultrasound (FoCUS) protocols may potentially alleviate these challenges. The Cardiac Ultrasound for Resource-limited Settings (CURLS) protocol is a non-validated, context specific, easy to train, easy to use Sub-Xiphoid Single Window FoCUS tool. We sought to assess trainee competence in evaluating cardiovascular causes of dyspnea using CURLS after a brief training.

Methods: This was a quasi-experimental study conducted at the Kenyatta National Hospital over 3 weeks. We enrolled 45 graduate medical pre-interns, novices in echocardiography. Trainees received simulated didactic and hands-on FoCUS skills training using the CURLS protocol and 2018 EACVI FoCUS training and competence assessment recommendations. Competency was assessed in three domains: image interpretation, image acquisition, and image quality. Image interpretation was assessed using a multiple-choice test. Image acquisition skills were assessed using an OSCE checklist that measured their ability to obtain a Sub-xiphoid image on two healthy living models. Image quality grading was graded by two FoCUS experts using the 2018 ACEP 5-point image quality assurance grading scale. Data analysis involved computing trainee scores using ranges, medians and 95% confidence intervals. Proportions of trainees who attained competence were expressed in percentages.

Results: Aggregate image interpretation competency was attained by n=38 (84 %) of trainees with a median score of 80%. The proportion of trainees attaining category-specific image interpretation competency was as follows: pericardial effusion n=44 (98%), left atrial enlargement n= 40 (89%), cardiomyopathy n=38 (84%), left ventricular hypertrophy n=37 (82%), and right ventricular enlargement n=29 (64%). Image acquisition skills competency was attained by n=36 (80%) of trainees with a median image acquisition skills test performance score of 82 %. Three-quarters of trainee-obtained images were of good quality.

Conclusion: The majority of trainees in our study attained competency in FoCUS skills after training with the CURLS protocol. The training conditions and participant selection bias limit results generalizability.

INTRODUCTION

Dyspnea, also known as breathlessness, is a common symptom among medical patients(3). Targeted assessment to differentiate causes of dyspnea in the acute setting allows for timely intervention and/or referral. Causes of dyspnea can be broadly classified as cardiovascular and non-cardiovascular. Non-cardiovascular causes of dyspnea include respiratory disease and other non-respiratory disorders(4). Breathlessness of cardiovascular origin arises from different causes of heart failure as a result of insidious or acute cardiovascular disease(3).

The prevalence of cardiovascular disease in low and middle-income countries such as Kenya is on the rise(5). Patients often present with breathlessness as the cardinal symptom. Differentiating cardiovascular causes of breathlessness informs its acute management. According to the 2021 European Society of Cardiology Heart Failure guidelines, cardiac biomarkers namely Brain Natriuretic Peptide (BNP) and N-terminal Pro-Brain Natriuretic Peptide (NT-Pro BNP) are pivotal in distinguishing cardiac from non-cardiac causes of dyspnea(6). Access to these biomarkers is limited in resource-limited settings. Echocardiography is the next available diagnostic modality. Echocardiography is used to further guide diagnosis and management. Echocardiography equipment and expertise are not always available in resource-limited settings(6).

Timely, relevant information regarding the heart and circulation in acutely ill patients can however be obtained by non-experts using rapid Focused Cardiac Ultrasound (FoCUS) scanning protocols(2). The impact of Focused Cardiac Ultrasound among non-experts in low and middle-income countries to improve the accuracy of diagnosing cardiovascular causes of dyspnea has been established(7–9). The use of FoCUS in resource-limited settings is limited by a lack of equipment, a lack of trainers or training opportunities, and a lack of contextualized training protocols(10). Non-experts can achieve Competence after a brief training in FoCUS protocols(11). Cardiac Ultrasound for Limited Settings (CURLS) is a proposed, simple training protocol that may be particularly suited for resource-limited settings where standard echocardiography or other imaging modalities may be unavailable or impossible due to costs, logistics, and scarcity of experts.

This study sought to establish whether novice trainees can achieve Competence in Focused Cardiac Ultrasound after a short training using the Cardiac Ultrasound for Resource-limited Settings Protocol(12).

2. LITERATURE REVIEW

2.4 Causes of Dyspnea

Dyspnea can be broadly classified as non-cardiovascular and cardiovascular in origin(3,4). Non-cardiovascular dyspnea is caused by respiratory disease and other non-respiratory disorders. Different cardiac or vascular structural or functional abnormalities due to insidious or acute cardiovascular disease may cause breathlessness of cardiovascular origin.

2.5 Epidemiology of Heart Failure

Heart Failure is a major cause of morbidity and mortality among African adults driven mainly by poorly controlled hypertension and diabetes(12). Cardiomyopathy, Valvular Heart Disease, Cor Pulmonale, Ischemic Heart Disease and Pericardial Effusion are other causes of decompensated heart failure(13–16). Decompensated heart failure is a common presentation of cardiorespiratory disease with majority of studied patients presenting in NYHA III and IV stages(14,16).

2.6 Causes of Heart Failure in Sub-Saharan Africa

In 2018, Huson et al conducted an extensive literature review on publications on etiology of heart failure in different African countries in SSA. Their search was limited to research published in the last 5 years and whose cited references were published within the last 10 years. Studies done on pediatric populations, ECG findings, surgery, cardiovascular risk or stroke, studies outside SSA, case reports and studies focusing on clinical characteristics of specific groups, such as HIV patients or patients with congenital heart disease were excluded. Hypertension and Dilated Cardiomyopathy were the most common causes. Other causes in decreasing prevalence were ischemic heart disease, valvular heart disease, right heart failure, pericardial disease and congenital heart disease. See Figure 1 and 2 below (12).

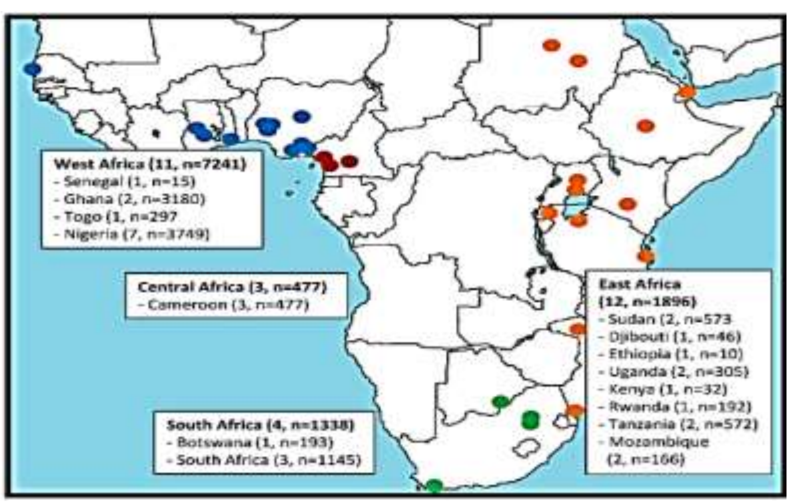


Figure 1: Geographic area of 18 included studies on Meta-analysis of causes of heart failure in Sub Saharan

Courtesy: Michela A. M. Huson et al, The Ultrasound Journal 2019 (12)

Figure 2: Etiology of heart failure in SSA, A meta-analysis. Courtesy: Michela A. M. Huson et al, The Ultrasound Journal 2019 (12)

First author, year	Patients with HF (*n*)	Hypertension (%)	Dilated cardiomyopathy (%)[a]	Ischemic (%)	Valvular (%)	Right-sided HF/cor pulmonale (%)	Effusion (%)	Endomyocardial fibrosis (%)	Congenital (%)
Ansa, 2016	339	48.6	35.4		1.4				
Appiah, 2017	1916	52.3	19.8	4	7.6				0.4
Bonsu, 2017	1488	61.2	19.9	12.9					
Boombhi, 2017	148	30.2	28.6	6.4	11.9	8.7	4		
Damasceno, 2012	1006	45.4	18.8	7.7	14.3		6.8	1.3	
Dokainish, 2017	1294	35	14.2	20	11				0.1
Kingery, 2017	588	42.8	19.3	6.2	16.6	7.6			
Kwan, 2013	192	8	54		25		1.4	0.7	5
Makubi, 2014	427	45	22.4	9	12				
Massoure, 2013	45	13	7	62					
Mwita, 2017	193	40.4	19.6	5.7	9.3		6.2		
Nkoke, 2017	529	43.2	17.6	9.6	11.7	8.8	3.8		2.1
Ogah, 2013	452	78.5	7.5	0.4	2.4	4.4	3.3	0.9	0.4
Ojji, 2013	1515	60.6	12	0.4	9.4				
Onwuchekwa, 2009	423	56.3	7.3	0.2	4.3	2.1			
Pio, 2014	297	43.1	5.9	19.2	11.8	2.7	1.7		2.7
Stewart, 2008	844	33	28	9	8	27			

2.7 Causes of Heart Failure in Kenya

Parma et al in 2010 studied 261 adult patients with acute decompensated heart failure in the Kenyatta National Hospital. Hypertensive heart disease (47%), dilated cardiomyopathy (33%), valvular heart disease (22%), ischemic heart disease (19%), cor-pulmonale (15.2%), and pericardial disease (4 %) were the major causes of heart failure(16).

In 2012, Mburu et al studied 274 adult patients at the Muranga District Hospital with acute decompensated heart failure(14). They observed that hypertension and diabetes (36 %), and dilated cardiomyopathy (25%) were key drivers of heart failure.

2.8 Breathlessness of Cardiovascular Origin in Kenya

For the two studies mentioned in section 2.4 above, majority of the patients presented in acute decompensation with breathlessness and easy fatigability being ubiquitous symptoms (100%). The prevalence of dyspnea (breathlessness) class NYHA III to IV was over 90%(14,16).

2.9 Diagnosing of heart failure in resource-limited settings

Diagnosing various etiologies of heart failure in patients with acute cardiorespiratory distress based on history and clinical examination findings alone can be challenging even to experts(17).

Further, authoritative clinical guidelines such as the European Society of Cardiology (ESC) Guidelines in the Management of Heart Failure and the Kenya Guidelines for Cardiovascular Disease Management recommend supportive laboratory studies and diagnostic imaging such as comprehensive echocardiography and chest radiography to aid in diagnosis(18,19). Brain Natriuretic Peptide (BNP) is an important biochemical marker that can be used to distinguish dyspnea due to structural or functional cardiac abnormalities from dyspnea of other causes. The use of BNP and NT-pro BNP is recommended by international heart failure guidelines(19). Access to these biomarkers in resource-limited settings is limited. The next available diagnostic modality of choice is echocardiography.

Echocardiography is important in delineating particular etiologies of heart failure and/or causes of decompensation(18,19). It is useful in planning and monitoring treatment. In resource-limited settings, late presentation, limited availability of trained cardiac sonographers and cardiologists and limited availability of equipment leads to delays in diagnosis and initiation of management(6). Standard echocardiography cannot be done at the point of care.

The learning curve of standard echocardiography is variable(20). The American Society of Echocardiography (ASE) and the European Association of Cardiovascular Imaging (EACVI) recommends a minimum of level I training under expert (Level III) guidance for cardiologists and non-cardiologists to safely perform and interpret an echocardiogram. This involves 100 to 150 performed and interpreted echocardiograms to attain expertise(21). The standard comprehensive echocardiogram takes 20 to 40 minutes to perform in an echocardiography suite(22). In the public sector, comprehensive echocardiography is only available in tertiary referral facilities and is thus inaccessible(6,10).

2.10 Focused Cardiac Ultrasound (FoCUS)

FoCUS is a limited echocardiography examination. It is an adjunct to the physical examination, and a point of care ultrasound tool used in the rapid diagnosis and management of heart failure. It differs from standard echocardiography by being focused on the absence or presence of specific critical findings or diagnosis which can impact clinical care in the acute setting. It takes a short duration to perform(2,23). FoCUS use is also recommended in sonographic lung assessment and during cardiopulmonary resuscitation (CPR). Both stand-alone machines and hand-held ultrasound devices with basic or limited sonographic imaging applications can be used(24). Formal cardiology or echocardiography training is not needed to perform it. However, competency in FoCUS requires a brief, structured training(1,23). A FoCUS trainee requires standard didactic training with 20-50 examinations logged under supervision to attain competence. This is according to the Focused Assessment by Trans-Thoracic Echocardiogram protocol (FATE), American Society of Echocardiography (ASE) and European Association of Cardiovascular Imaging (EACVI) recommendations (2,11).

In an acute setting, Focused Cardiac Ultrasound can take 5 minutes or less in evaluating causes of an acute cardiorespiratory presentation. Focused Cardiac Ultrasound in the hands of trained non-cardiologists can have equivalent sensitivity and specificity as a comprehensive echocardiogram for various etiologies of heart failure (see Table 1 below). Lucas et al showed sensitivity and specificity of FoCUS being highest for pericardial effusion (100% and 95%), left atrial enlargement (90% and 74%), severe mitral valve disease (100% and 83%), left ventricular dysfunction (85 and 88%) and left ventricular hypertrophy (70 and 73%)(25). Razi et al showed a sensitivity of 94 %, specificity of 94 % (NPV- 88%, PPV- 97%) among 3 novice internal medicine residents in assessing left ventricular systolic dysfunction and pericardial effusion(26). The 2017 AFRICA trial done in a tertiary public facility in Kumasi Ghana on Focused Cardiopulmonary Ultrasound showed enhanced diagnostic accuracy for cardiac causes of breathlessness namely Cardiogenic Shock, Congestive Heart Failure and Acute Valve Pathologies compared to physical examination alone (94.7% vs 40%)(7).

Trained medical students using FoCUS yielded a greater sensitivity and specificity (79% vs 49%, $p < 0.001$) for diagnosing cardiac pathologies in breathless patients compared to clinical examination done by board certified cardiologists(17). Accuracy was determined by standard echocardiography. First year Internal Medicine residents, after a brief FoCUS training, were able to obtain images in 94 % of 72 cases and arrive at a diagnosis 93% of the time in a study by Croft et al. 92 % of the major standard echo findings and 78 % of the minor findings were correctly identified. Management decisions were reinforced in 76% and changed in 40% of cases in this study(27).

Table 1:Selected Studies Reporting FoCUS Training for novices and Outcomes

Study	Sample (size)	Prior TTE training	Training	Imaging Goals	Accuracy
Longjohn et al(28)	Pediatric emergency Physicians (n=2)	Minimal	2 hrs didactic training 15 POC TTEs	LV Function (normal or diminished); IVC collapsibility, Pericardial Effusion	Agreement with cardiologist: LV function k=0.87, IVC collapsibility k=0.73, pericardial effusion k=0.77
Razi et al(26)	Internal medicine residents (n=3)	None	Image review (DVD with 50 sample TTEs); 20 practice POC TTEs	LV Systolic Dysfunction	Sensitivity 94% Specificity 94%
Lucas et al(25)	Internal Medicine Hospitalists (n=8)	None	27 hrs didactic & hands-on training; 34 practice POC TTEs	LV Systolic Dysfunction; Severe mitral regurgitation; Moderate/Severe Left Atrial Enlargement; Moderate/Severe LVH; Pericardial Effusion; IVC Dilatation	LV Systolic Dysfunction: Sensitivity- 84%, Specificity- 87%; Pericardial Effusion: Sensitivity- 100%, Specificity- 95%
Croft et al(27)	Internal Medicine Residents (n=9)	None	15 hrs didactic training (including image reviews); 15 hours hands on training	LV Size; Global/regional LV Systolic Function; Valvular abnormalities; LVH; Pericardial Effusion	Diagnostic images obtained: 94%; Images interpreted correctly: 93%; Correct identification of major TTE findings: 92%, and minor findings: 78%
Wangari et al(6)	Novices from all cadre (n=12)	None	Online didactic training; a skills practice session of up to 6 supervised examinations and up to 20 Unsupervised examinations	Probe skills; reduced ejection fraction; hyper-dynamic contractility; right ventricular dilatation; pericardial effusion; left sided pleural	Knowledge gain: 37.7%; Agreement with expert: Reduced EF- 83.3%, k-0.73; Hyper-dynamic contractility- 98.2%, k-0.96; RV Dilatation- 85.2%, k-

				Effusion; right-sided pleural effusion or a normal scan	0.75; Pleural Effusion- 9.62%, k-0.06; Pericardial Effusion- 87.0%, k-0.77; Normal Scan-81.5%, k-0.7

Mantuani et al showed that overall physician diagnostic accuracy in dyspneic patients increased from 53% to 77% (p–0.003) after a limited echocardiography and lung ultrasound(8). Umuhire et al in Kigali Rwanda showed that the diagnostic accuracy for Acute Decompensated Heart Failure as a cause of breathlessness increased from 38.5% to 100% using limited echocardiography (p-0.0005)(9). This shows that Focused Cardiac Ultrasound is a potentially useful preliminary diagnostic tool. A 2020 meta-analysis demonstrates that brief FoCUS training programs of up to 6 hours can enable non experts to diagnose left ventricular dysfunction and pericardial effusion to a near perfect agreement with experts (k > 0.8)(11).

The accuracy of Focused Cardiac Ultrasound in diagnosing left ventricular dysfunction, pericardial effusion and gross valvular disease is comparable to comprehensive echocardiography in most studies(11). Comprehensive echocardiography, unlike FoCUS, allows for detailed diagnostic measurements to further characterize these findings. Determinants of diagnostic accuracy using FoCUS include user training and experience, type of device (hand held with limited applications vs stand-alone) and patient factors. Patient factors include positioning, body habitus and co-morbidities(2). Patients with morbid obesity or COPD, for example, may be difficult to image.

2.11 FoCUS compared to Conventional Echocardiography in the clinical setting

FoCUS does not replace conventional comprehensive echocardiography done by experts. Standard echocardiography is useful in detailed hemodynamic, color flow, and tissue doppler assessment(2). These specialized assessments can be done while the patient is in the ward or at a tertiary center after initial stabilization. More advanced modalities such as stress, contrast enhanced echo and strain imaging may be relevant in a minority of patients with difficult windows and less common cardiac conditions. These specialized modalities are useful in assessment of ischemic heart disease, infiltrative, and other restrictive cardiomyopathies(20). These modalities are also useful in planning definitive management.

2.12 Evidence of Effectiveness and Impact of Training FoCUS Skills

A study done in 2013 in Rwanda assessed the impact of a simplified echo training strategy for Heart Failure diagnosis and management within an integrated Non-Communicable Disease clinic at 2 District Hospitals. Four registered nurses were trained over a duration of 16 days. The training included didactics of heart failure diagnosis using simple clinical signs and a basic echo diagnostic protocol, and protocol directed treatment/ intervention of diagnoses. The training curriculum was informed by the local epidemiology of heart failure based on literature review and clinical experience. Trainers conducted problem based learning discussions and supervised hands on instruction sessions in cardiology clinics. Trainees were expected to master simple echo image acquisition using the parasternal long axis (PLAX) and the sub-xiphoid views (SCV). After training, the nurses were taken to NCD clinics in two district hospitals. They then performed simple clinical assessment and basic qualitative diagnostic echo using two views (PLAX & SCV) on 237 patients presenting with breathlessness and suspected to have heart failure. The nurses would then treat and follow up, or refer diagnosed patients for advanced care based on the diagnosis and as directed by the protocol. A follow up clinical evaluation and comprehensive echocardiogram was performed on the patients by a visiting cardiologist (expert). Among 81% of the patients assessed, the nurses were in agreement with the visiting cardiologist in diagnosing Left Ventricular Systolic Dysfunction (due to Hypertension or Cardiomyopathy), Rheumatic Mitral Valve Disease, Large Pericardial Effusion, Right Ventricular Enlargement or Dysfunction. This resulted in decentralizing the initial diagnosis and medical management of heart failure patients from specialists in tertiary facilities to less specialized healthcare practitioners in lower level facilities. Only a few cases requiring complex interventions or surgery were referred to tertiary facilities. This mitigated against the shortage of experts while availing accessible and affordable care to patients in resource-limited settings(29).

A 2020 meta-analysis by Gibson et al examined existing training strategies in Focused Cardiac Ultrasound to describe the optimal quantity and type of training required for basic competence. Data was obtained from 23 studies with 292 learners. Learners ranged from 5 to 30 per study. Learner cadres ranged from medical students to attending consultants (mainly in internal medicine) with varied years of experience. The meta-analysis showed that short FoCUS training programs of up to 6 hours can equip novices with FoCUS skills in detecting left ventricular dysfunction and pericardial effusion to a near perfect level of agreement with experts ($K > 0.8$). Substantial level of agreement (K > 0.6) was achievable in half the time. In addition, trainees gained image acquisition competency after 4 to 10 practice scans. There however was no direct correlation between the number of practice scans performed by the trainees and the level of image acquisition competency.

Gibson et al concluded that more training and supervision is required to ensure skill retention, improve efficiency of image acquisition, and the detection of other less apparent abnormalities. The finding that reasonable proficiency can be obtained after only brief formal training should encourage trainers in FoCUS and physicians at any career level to acquire FoCUS skills(11).

Focused Cardiac Ultrasound training curriculum development and implementation has been taken up by cardiology, emergency, respiratory, critical care and other specialized societies in developed countries. Curricula such as Focused Assessment by Transthoracic Echo (FATE), Canadian Point of Care Ultrasound Society (CPoCUS) course and American Thoracic Society Focused Cardiac Ultrasound (ATS-FCU) exist for such trainings. Access to these training resources, supervision and accreditation is limited in less developed countries.

2.13 Challenges facing Focused Cardiac Ultrasound adoption in Developing Countries

Despite development of multiple training protocols and increasing advocacy for FoCUS and Point of Care Ultrasound (PoCUS) use in Lower- and Middle-Income Countries, the impact of these protocols in training and use remains to be seen(12). This is mainly due to lack of expert trainers and mentorship which hampers supervised learning. Most protocols require paid access to proprietary learning material which makes them inaccessible to prospective trainees(6). Ultrasound equipment are also inaccessible to students in most public training facilities. Most developed FoCUS protocols involve learning the 3 standard imaging windows (parasternal, apical and sub-xiphoid) which may prolong skills acquisition time in a low resource setting(12). A high volume of cases and supervised practice is also required to expedite skills acquisition(6,11).

2.14 Opportunities for FoCUS training and Research in Resource-limited Settings.

Despite these challenges, there is proliferation of ultrasound devices in developing countries courtesy of cheaper technologies, private healthcare entities, public-private partnerships, and government projects. In Kenya for example, at least 2 public facilities per county are equipped with a modern ultrasound machine under the Managed Medical Equipment Services Project(30,31). Eighty-four level V and level IV hospitals countrywide have benefited from ultrasound equipment. However, the human resource to utilize these equipment has been a perennial challenge.

The number of graduating medical officers has increased from 287 in 2006, to 501 in 2015 and to 757 in 2021(32). Medical interns in Kenya form a crucial skilled front line work force in tertiary hospitals. They handle acute patients including those that present with cardiovascular causes of breathlessness. Equipping junior medical officers with Point of Care Ultrasound Skills during medical training or internship builds exposure and experience. It also allows for senior supervision, peer to peer learning, and mentorship during training(10). This may expedite skills gain. Medical institutions can engage in research to build training capacity. Such research may involve development and refinement Point of Care Ultrasound and Focused Cardiac Ultrasound Curricula. The Cardiac Ultrasound for Resource-limited Settings (CURLS) Protocol was developed through similar research efforts (12).

2.15 The Cardiac Ultrasound for Resource-limited Settings (CURLS) Protocol

With the increasing burden of cardiovascular disease in Sub-Saharan Africa, Focused Cardiac Ultrasound training tools tailored to the needs and available resources are needed. The Cardiac Ultrasound for Resource-limited Settings (CURLS) is one such a tool. The CURLS protocol 2019 is a FoCUS training protocol developed in Africa for differentiating cardiovascular causes of dyspnea. It proposes a sub-xiphoid window limited Focused Cardiac Ultrasound exam performed by non-experts in resource-limited settings. CURLS requires basic ultrasound applications such as the brightness imaging mode (B-mode).

The following criteria was considered in developing the CURLS protocol: disease prevalence, difficulty of performing cardiac ultrasound and diagnostic or therapeutic impact. A multi-factorial weighting method proposed by Van Hoving et al was adopted(33). Using the weighting method, a Likert scale of 1 - 3 was used to weigh prevalence, difficulty and impact as follows.

First, a literature review was done to establish the prevalence of different causes of heart failure in Africa (See section 2.3 and figure 2 above). A prevalence of > 15% was considered frequent and given a weight of 3. A prevalence of less than 5 % was considered rare and given a weight of 1. Second, 5 experts with experience in training ultrasound techniques in resource-limited settings in Africa analyzed the difficulty of using cardiac ultrasound applications for the different causes of heart failure. A weight of 1 was given for conditions with the highest technical difficulty. A weight of 3 was given for conditions with the lowest technical difficulty.

Lastly, the diagnostic or therapeutic impact of ultrasound was established by 3 experts experienced in managing heart failure patients in resource-limited settings. Conditions where early diagnosis would highly likely change interventions and/or outcome were weighted 3. Conditions where a diagnosis had the lowest likelihood of changing intervention/ outcome were weighted at 1 (See Figure 3 below).

Figure 3: Weighting of Prevalence, Difficulty of FoCUS use and Diagnostic Impact of FoCUS in Resource Limited Settings Courtesy: Michela A. M. Huson et al, The Ultrasound Journal 2019 (12)

Weight	Disease prevalence	Diagnostic impact of US	US difficulty and technical requirements
1	Rare (< 5%)	Minor or no management change	Technically advanced, often requiring special equipment like TEE probe, cw-Doppler, cardiac software
2	Relatively common (5–15%)	Management change	Moderate, may require color-Doppler
3	Very common (> 15%)	Urgent management change (possibly life threatening)	Technically easy, only basic b/w US

For prevalence and impact the numbers indicate the following levels: 1 = low, 2 = medium, 3 = high. For difficulty, scoring is reversed with numbers indicating the following levels: 1 = high, 2 = medium, and 3 = low. This allows for a composite score where the higher numbers correspond to increasing relevance and applicability of POCUS

US ultrasound, *TEE* transesophageal echocardiography, *cw* continuous wave, *b/w* black and white

A composite weighting score of the product of prevalence, diagnostic or therapeutic impact, and technical difficulty of cardiac ultrasound was then calculated. The top 5 conditions with the highest prevalence, highest diagnostic/therapeutic impact of cardiac ultrasound, and lowest technical difficulty of cardiac ultrasound were included in the CURLS protocol (See highlight on figure 4 below)

Figure 4: Echocardiographic applications ranked based on condition prevalence in Sub-Saharan Africa, Impact of Echo and Technical Difficulty/ Requirements. Courtesy: Michela A. M. Huson et al, The Ultrasound Journal 2019 (12)

Echocardiographic finding	Prevalence (P)	Impact (I)	Difficulty (D)	PxIxD	Rank
LV hypertrophy	3	2	2	12	1
Rheumatic mitral disease (stenosis suggested by large LA)	2	2	3	12	1
Cardiomyopathy, severe	3	2	2	12	1
Cor pulmonale	2	2	3	12	1
Pericardial effusion	1	3	3	9	2
Regurgitation (MV, AV, TV by color Doppler)	2	2	2	8	3
Rheumatic mitral stenosis (valve morphology only)	2	2	1	4	4
Rheumatic aortic stenosis (valve morphology only)	2	2	1	2	4
Endocarditis (large vegetations seen on TTE)	1	2	2	4	4
RV function grading (e.g., TAPSE)	2	2	1	4	4
Mitral stenosis grading (PHT)	2	2	1	4	4
Aortic stenosis grading (continuation equation)	2	2	1	4	4
Regional hypokinesia	2	2	1	4	4
LV function grading (e.g., ejection fraction)	3	1	1	3	5
Endocarditis (TEE)	1	2	1	2	6
Endomyocardial fibrosis	1	1	2	2	6
Congenital heart diseases	1	2	1	2	6
Pulmonary artery pressure (dTR)	2	1	1	2	6

For prevalence and impact the numbers indicate the following levels: 1 = low, 2 = medium, 3 = high. For difficulty, scoring is reversed with numbers indicating the following levels: 1 = high, 2 = medium, and 3 = low. For prevalence and impact the numbers indicate the following levels: 1 = low, 2 = medium, 3 = high. For difficulty scoring is reversed with numbers indicating the following levels: 1 = high, 2 = medium, and 3 = low. This allows for a composite score where the higher numbers correspond to increasing relevance and applicability of POCUS

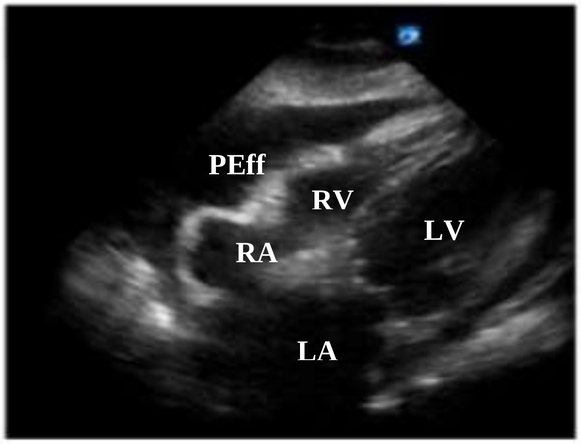
LV left ventricular, *LA* left atrium, *MV* mitral valve, *AV* aortic valve, *TV* tricuspid valve, *TEE* transesophageal echocardiogram, *RV* right ventricle, *TAPSE* tricuspid annular plane systolic excursion, *PHT* pressure half-time, *dTR* pressure gradient measured in tricuspid regurgitation

The CURLs protocol seeks to qualitatively answer 5 key questions from a sub-xiphoid Focused Cardiac Ultrasound (FoCUS) examination during evaluation of cardiovascular causes of breathlessness.

a. Is there a Pericardial Effusion present?
b. Is the Left Ventricular Function Reduced?
c. Is the Right Ventricle larger than the Left Ventricle?
d. Is the Left Atrium larger than the Left Ventricle?
e. Is there Left Ventricle wall (septum) thicker than 12 mm?

A. Is there a pericardial effusion?

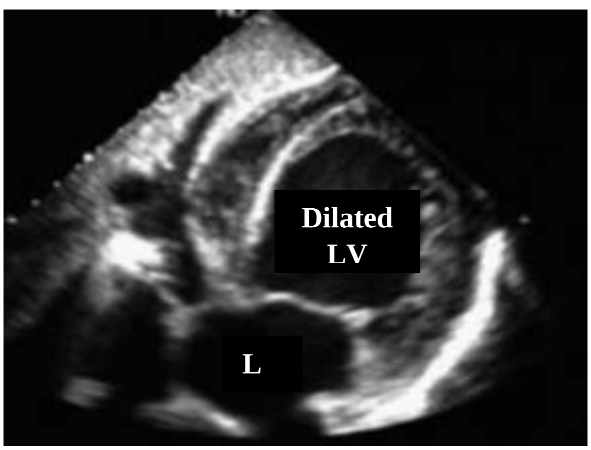
A pericardial effusion can be diagnosed by ultrasound as an echo-lucent rim surrounding the heart from the sub-xiphoid view with nearly 100% accuracy. A significant or rapid accumulation may result in tamponade physiology. Tamponade physiology can be elicited from images obtained from the sub-xiphoid view(12). (See Figure 5 below).



PEff- Pericardial Effusion, RA- Right Atrium, RV- Right Ventricle, LA- Left Atrium, LV- Left Ventricle. Courtesy Sabath et al

Figure 5: Still image of a Sub-Xiphoid 4 chamber view showing a circumferential large pericardial effusion with tamponade physiology (Right Atrium systolic collapse).

B. Is the left ventricular function reduced?



LV- Left Ventricle, LA- Left Atrium

Courtesy, Moore, C., & Hwang, J. (n.d.). Cardiac Ultrasound Journal

Figure 6: Left Ventricular Dilatation with Reduced Systolic Excursion suggestive of Cardiomyopathy as seen from Sub-Xiphoid FoCUS

Left Ventricular Dysfunction is best assessed quantitatively in the para-sternal and apical views. CURLS protocol, however, offers qualitative assessment of Left Ventricular function from sub-xiphoid view (See Figure 6 above). Ultrasound features that point towards LV dysfunction include- gross dilatation, global hypo-kinesia, regional hypo-kinesia or dyskinesia and spontaneous echo contrast suggesting sluggish blood flow. Observing symmetry of contractility and myocardial thickening during contraction can aid in broadly classifying contractility as hyper-dynamic, normal, moderately or severely impaired(12).

C. Is the right ventricle larger than the left ventricle?

The right ventricle is normally two thirds the size of the left ventricle. A right ventricle the same size as the left ventricle suggests RV enlargement. A left ventricle that is smaller than the right ventricle suggests severe RV dilatation. Ultrasound features suggestive of increased RV volume or pressure including movement of the interventricular septum towards the left ventricle, or a D-shaped LV, can be visualized from an optional parasternal short axis view(12) (See Figure 7

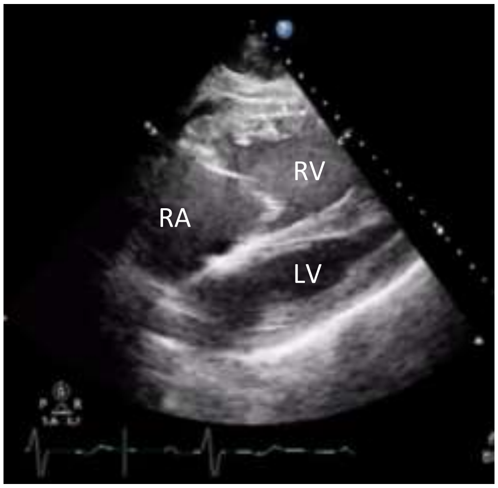


Figure 7: Still image subcostal four-chamber with right ventricular dilation and hypertrophy.

The free wall of the RV appears as thick as the left ventricle. The RV appears larger than the LV, suggesting significant enlargement.

RA: Right Atrium, RV: Right Ventricle, LV: Left Ventricle

Courtesy: Zimmerman J. et Al, Anesthesia & Analgesia

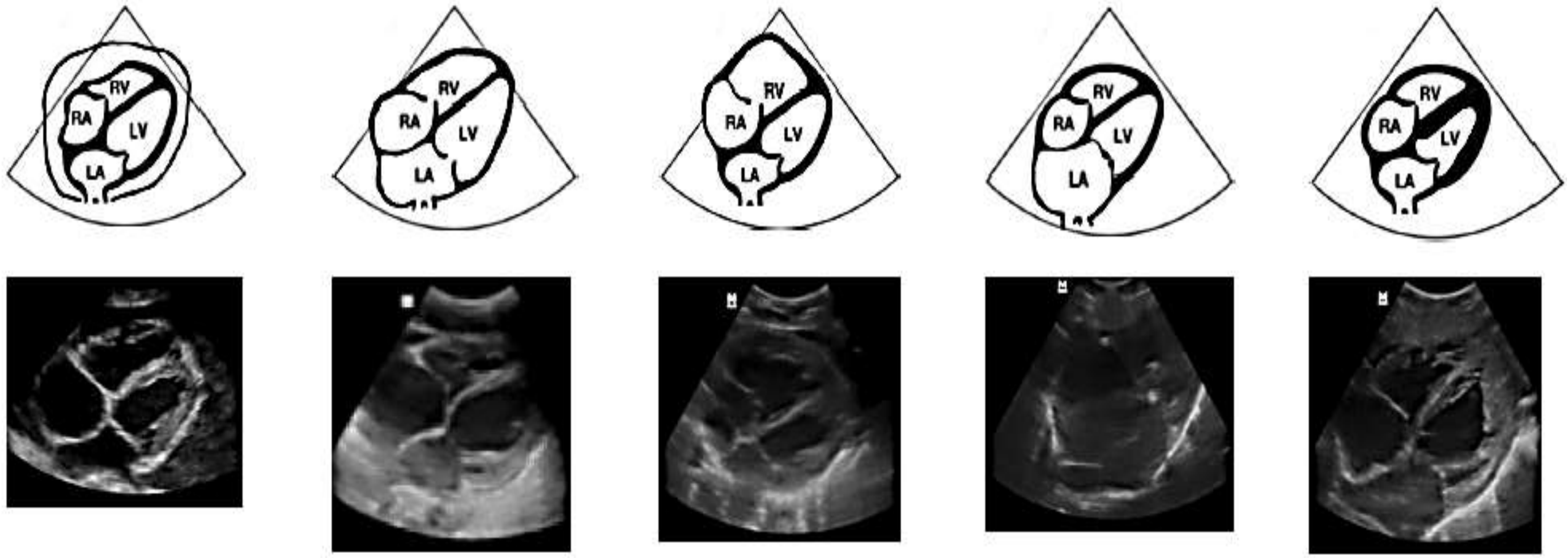
D. Is the left atrium larger than the left ventricle?

When the left atrium appears larger than the normal sized left ventricle from a sub-xiphoid view, left atrial enlargement is suspected. An enlarged left atrium may suggest mitral valve disease (mitral stenosis or regurgitation), commonly caused by rheumatic heart disease. Other clues to mitral valve disease include diastolic doming of the mitral valve leaflets, thickening of the leaflet tips and mitral valve apparatus, and reduced leaflet mobility. More detailed assessment of the mitral valve needs to be done with comprehensive echocardiography(12).

E. Is the left ventricle wall (septum) thicker than 12 mm?

The interventricular septum (IVS) can be visualized in the sub-xiphoid view and measured at the level of the mitral valve leaflet tips. An IVS more than 12 mm may suggest Left Ventricular Hypertrophy due to hypertension, aortic valve disease or other hypertrophic cardiomyopathies (12). See Summary in Figure 8 Below.

Figure 8: Still Echocardiographic Images of Sub-xiphoid views in Prevalent Etiologies of Heart Failure and Key Ultrasound Features. Courtesy: Michela A. M. Huson et al, The Ultrasound Journal 2019 (12)



Ultrasound Image	Effusion	Dilated CMP	Right-sided heart failure	Valvular (mitral)	LV Hypertrophy
Scanning method	Subxiphoid view Optional: 4-chamber view	Subxiphoid view Optional: 4-chamber view	Subxiphoid view Optional: 4-chamber view, parasternal short	Subxiphoid view Optional: 4-chamber view, parasternal long	Subxiphoid view Optional: parasternal long
Key US features	Anechoic fluid surrounding the heart[a] In severe cases collapse of RV (tamponade)	Reduced inward movement of the LV wall Generalized dilatation of both atria and ventricles	Dilated RV in comparison to the left (ratio > 0.7) D-shaped LV in the parasternal short axis	Dilated LA Thickened mitral valve Mitral regurgitation on Doppler	Thickened LV (septum > 12 mm) Dilated LA Possibly secondary dilated right heart
Differential diagnosis	TB Malignancy Uremia Massive fluid overload Viral Auto-immune	HIV CMP Idiopathic dilated CMP (post-infectious) Peripartum CMP Alcoholic CMP Ischemic heart disease (severe)	Pulmonary embolism Pulmonary hypertension of other cause	Rheumatic heart disease	Hypertension Aortic stenosis Genetic hypertrophic CMP

RV right ventricle, *LV* left ventricle, *LA* left atrium, *CMP* cardiomyopathy, *TB* tuberculosis, *HIV* human immunodeficiency virus

[a] Use the parasternal long axis to differentiate between pleural and pericardial effusions. Pericardial effusions continue anterior to the descending aorta, whereas pleural effusions are found posterior to the descending aorta

Advantages of the CURLs Protocol

The CURLs protocol has the following advantages in the assessment of cardiovascular causes of dyspnea using Focused Cardiac Ultrasound:

- CURLs is tailored for the Low and Middle Income Country healthcare context, unlike protocols developed in resource rich settings.
- It narrows on the five most common cardiac conditions. It has concise learning material, and is potentially easy to train and oversee.
- This simplicity allows for rapid execution by trainees in acute, busy settings.
- All the five cardiac abnormalities represented in the CURLS protocol can be identified from images obtained using basic ultrasound imaging applications (cardiac or curvilinear probe) from the sub-xiphoid view.

CURLs protocol usefulness as a training tool for FoCUS in the LMIC context is however yet to be ascertained(12). To determine this, novices trained in Focused Cardiac Ultrasound using the CURLs protocol have to be assessed using Competence assessment tools. The tools are described in Chapter 3.

2.16 Justification and Significance

The prevalence of cardiovascular disease in low and middle income countries such as Kenya is on the rise(34). Patients often present with breathlessness as the cardinal symptom(14,16). Timely, relevant information regarding the heart and circulation in acutely ill patients can be obtained by non-experts using rapid echocardiography scanning protocols(2).

Echocardiography equipment and expertise are not always available in resource-limited settings. As at 2019, Kenya had about 50 registered adult cardiologists, 356 internal medicine specialists and 30 registered cardiac sonographers for a population of about 30.1 million adults(6). To improve access to diagnosis and care, the Kenyan CVD guidelines recommend availability of an echocardiography machine for screening at Level IV facilities. A trained echocardiographer and physician, among others, are also required as human resource(18).

Despite these recommendations, most level IV and V facilities in Kenya lack specialists. The ratio of general practitioners to the population in Kenya has been gradually increasing and, in 2019, stood at approximately 25 per 100,000 people(32). This makes them potentially a valuable resource for Cardiovascular Disease Care, Focused Cardiac Ultrasound skills training and capacity building. It remains to be seen whether task shifting of Focused Cardiac Ultrasound to non-specialists can bridge the access to care gap in LMICs(29).

The impact of Focused Cardiac Ultrasound among non-experts in low and middle countries to improve the accuracy of diagnosing dyspnea of cardiovascular origin has been established(8,9). Non experts can achieve Competence after a brief training in FoCUS protocols. Cardiac Ultrasound for Limited Settings (CURLS) is a simple training protocol that may be particularly suited for resource-limited settings. In low and middle income countries, comprehensive echocardiography or other imaging modalities may be unavailable or impossible due to costs, logistics and scarcity of specialists(6,10).

The CURLS protocol has not been evaluated as a FoCUS training tool in low and middle income countries(12). Establishing Competence of novices after brief training in basic Focused Cardiac Ultrasound skills using the Cardiac Ultrasound for Resource-limited Settings protocol will inform its applicability in resource-limited settings.

2.17 Study Question

Can graduate medical pre-interns attain Competence in Image Interpretation and limited FoCUS Image Acquisition Skills after a brief training?

2.18 Objectives

Broad objective

To assess acquired Trainee Competence in evaluating Cardiovascular Causes of Dyspnea using FoCUS after a brief training

Primary Objective

To determine post-training Competence of 2022 UoN graduate medical pre-interns in differentiating cardiovascular causes of dyspnea using the CURLS protocol in the following domains:

1. Image Interpretation
2. Focused Cardiac Ultrasound Sub-Xiphoid View Image Acquisition Skills
3. Quality of Trainee-obtained Images

3. METHODOLOGY

3.1 Study Design

This was a quasi-experimental study.

3.2 Study Area Description

The study was conducted at the Kenyatta National Hospital (KNH) and The University of Nairobi College of Health Sciences in Nairobi, Kenya. KNH is a tertiary multi-specialty center with a bed capacity of 1800. It is staffed with medical critical care specialists trained in FoCUS skills, two who are CPoCUS (Canadian Point of Care Ultrasound Society) expert trainers. A critical care specialist with PoCUS and FoCUS expertise was the primary supervisor in the study. A consultant cardiologist-critical care specialist was consulted as the second expert.

3.3 Study Population

The study population consisted of the University of Nairobi 2022 Bachelor of Medicine and Bachelor of Surgery graduates awaiting posting for internship and residing in Nairobi County at the time of the study.

3.4 Sample Size Determination

The sampling frame was 300 graduate medical pre-interns from the University of Nairobi class of 2022. The initial sample size was calculated followed by adjustment for the population size. At the time of this study, the proportion of trainees attaining Competence after FoCUS training with CURLS protocol was unknown.

The sample size (n_1) calculation formula(15)

$$n_1 = \frac{z^2 \times p\,(1 - p)}{e^2}$$

Adjusting for the size of the population using the following equation;

$$n_2 = n_1 \frac{N}{N + n_1}$$

e – desired margin of error

z – value corresponding to a desired level of confidence

p – proportion of the population with the characteristic of interest

N – population size

Based on an online class survey, the number of the pre-interns with the characteristic of interest (medical pre-interns of The University of Nairobi residing within Nairobi during the anticipated study period) were 48. This became our population size N.

For this study, an anticipated Competence rate of 50% was used (p = 0.5)

Level of significance is 0.05 corresponding to $Z\alpha/_{2}$ of 1.96

Margin of error (e = $\pm$ 0.05)

$$n_1 = \frac{1.96^2 \times 0.5(1-0.5)}{0.05^2}$$

$$n_1 = 384.16$$

$$n_2 = 384.16 \times \frac{48}{48 + 384.16}$$

$$n_2 = 42.6686$$

$$n = 42.6686 \approx \mathbf{43}$$

A Sample size of 43 medical officer pre-interns would be required for the study. An inflation rate of 10 % was applied to cater for attrition making the sample size 47.

3.5 Sampling Procedure

A consecutive sampling procedure was applied using a convenience technique. The convenience criteria were geographic proximity to the study site (KNH, Nairobi) during the study period and willingness to participate. All who met the convenience criteria were consecutively enrolled till the desired sample size was met.

3.6 Eligibility Criteria

a) Trainees Eligibility Criteria

Inclusion Criteria

- The University of Nairobi medical graduates who were available for study and
- Willing to participate

Exclusion Criteria

- Prior formal training in Point of Care Cardiac Ultrasound or Echocardiography

b) Volunteer Study Models Eligibility Criteria

Inclusion Criteria

- Healthy, living
- 20-25 years of age: more likely to be available during study period and of good health
- Availability for the study period

Exclusion Criteria

- Prior known history of any cardiovascular/ structural heart disease

3.7 Conduct of Study

3.7.1 Enrollment

The study's research assistant made calls for recruitment through WhatsApp forums. She used a Google™ form questionnaire to capture subject bio-data, interest in participation, availability and prior training in echocardiography applications. Participation was voluntary and informed consent was obtained (See Appendix 4.4). Consecutive sampling using a convenience technique from the pool of available respondents was done to achieve the desired sample size of 47. Six consenting healthy living models were also consecutively enrolled from a pool of 10 volunteers for the practical aspects of the study (See Appendix 4.5).

3.7.2 CURLS Protocol and FoCUS Skills Didactic Training

In-person theory training on basic ultrasound physics, review of normal cardiac anatomy, and CURLS (Cardiac Ultrasound for Resource-limited Settings) protocol was conducted over five consecutive days. The principle investigator (PI) who is a POCUS/FoCUS expert with 3 years of experience delivered the training. A cardiac sonographer dedicated to the study with European Association of Cardiovascular Imaging (EACVI) Focused Cardiac Ultrasound certification and 4 years' experience assisted in training. The two study experts supervised the didactic training. The training was conducted in a lecture hall within the University of Nairobi School of Medicine at the KNH Campus. The research assistant, a medical officer pre-intern, maintained attendance records. Cardiac ultrasound images obtained from the Breathlessness Study were used for this training phase. The images had already been reviewed by experts in that study for quality assurance. One hundred image interpretation case-based learning scenarios were conducted using these images. The cases encompassed the 5 diagnostic scenarios contained in the CURLs protocol.

3.7.3 FoCUS Image Acquisition Skills Training and Supervised Practice

Training and practice of FoCUS skills were conducted in the Nursing Skills lab at the KNH for a duration of four days. Training was conducted as an in-person skills work-shop. The training material consisted of technical ultrasound aspects (knobology, B-mode, M-mode, frequency, gain and depth), sub-xiphoid image acquisition and optimization, and identification of cardiac tomographic anatomy. Two training and practice stations with a GE Versanna Active™ and Mindray TE7™ portable ultrasound machines installed with basic ultrasound applications and phased array probes were set up. Both the PI and the study's cardiac sonographer facilitated the skills training sessions under supervision from the study's experts. The study's research assistant maintained records of attendance and organized the flow of trainees among the two practice stations.

Trainees practiced on four consenting healthy living models in rotation. Each trainee was required to perform at least ten (10) examinations on any of the 4 healthy volunteers over the 4 days. The eligibility criteria that was used to select the healthy living models is outlined in 3.6 part (b) above. The EACVI FoCUS Curriculum Guidelines 2018 were adopted for skills training. Practice sessions performed per trainee were entered by the research assistant in a log book.

3.8 Description of Study Tools for Competence Assessment in Focused Cardiac Ultrasound

The CURLS protocol does not provide specific criteria for competence assessment. This necessitated adoption of other competence assessment tools. The 2018 European Society of Cardiology (EACVI) FoCUS Core Curriculum and Core Syllabus guidelines were adopted to the Cardiac Ultrasound for Resource-limited Settings protocol for Competence assessment. The three main domains of assessing trainee FoCUS Competence are image interpretation, image acquisition skills and quality of trainee obtained images.

3.8.1 Image Interpretation Competency Testing

The 2018 EACVI Guidelines recommend trainee assessment in the following thematic targets of a FoCUS examination: global left and right ventricular function, global left and right ventricular size, pericardial effusion (+/- tamponade), gross signs of chronic cardiac disease, gross valvular abnormalities and intravascular volume assessment. The five cardiac abnormalities represented in CURLS were incorporated into the EACVI FoCUS targets as shown below. For each FoCUS target, the guidelines provide a minimum of 4 pre-recorded cases to be correctly reviewed or interpreted by a trainee to demonstrate competence (See Table 2).

Table 2: Scoring of Competence Criteria in Image Interpretation

CURLS feature/ finding/ condition	2018 EACVI FoCUS Training/ Competence Assessment Target Area	Reviewed or interpreted images required to meet EACVI Competence criteria (no)
A. Is there a pericardial effusion? Anechoic fluid rim around the heart	Pericardial Effusion/ Tamponade	4
B. Is the left ventricular function reduced? Global enlargement of cardiac chambers Reduced LV global systolic excursion Reduced mitral valve excursion	Global Left Ventricular Systolic Function and Size	4
C. Is the right ventricle larger than the left ventricle? Dilated RV>LV (RV:LV > 0.7)	Global Right Ventricular Systolic Function and Size	4
D. Is the left atrium larger than the left ventricle? Dilated left atrium, thickened mitral valve, flail leaflets, diastolic valve hypomobility	Gross Valvular Abnormalities Gross Signs of Cardiac Disease	4
E. Is the LV septum > 12 mm on M mode?	Gross Signs of Cardiac Disease	4

The 2018 EACVI FoCUS curriculum allows for stored FoCUS image loops with simulated clinical scenarios to be used for case-based training, and for testing image interpretation competence. A fitting clinical context needs to be provided alongside the image loops to allow for image interpretation. Sub-xiphoid image loops used during image interpretation competence assessment were obtained from the breathlessness study. (See section 3.7.2).

3.8.2 FoCUS Image Acquisition Skills Competency Testing

The European Association of Cardiovascular Imaging (EACVI) Core Syllabus in FoCUS examination 2018 provides a comprehensive list of assessment criteria for image acquisition skills competence. They are categorized as follows:

i. Basic ultrasound instrumentation and machine operation (knobology)
ii. Anatomy and basic physiology of the heart and great vessels
iii. FoCUS image acquisition: patient positioning, acquisition of different views, imaging modes, pitfalls and limitations of Focused Cardiac Ultrasound

Hands-on Imaging Skills Competence testing in accredited FoCUS trainings take an Objective Structured Clinical Examination (OSCE) format. An expert witnesses a trainees' hands-on imaging skills and grades them. Trainees are required to demonstrate the image acquisition skills contained in a check-list used to grade competence. Skills demonstration can be done on non-living simulator models, healthy living models or on patients. The expert uses the skills checklist to indicate the presence or absence of a skill. The skills demonstrated by the trainee are then scored in a count and/or percentage format.

The EACVI Training Curriculum and Recommendations has a FoCUS hands-on imaging skills list. Components of the list specific to imaging from the sub-xiphoid view on healthy living models will be adopted for training and to test for competence in this study (See Table 3 below).

The EACVI FoCUS guidelines do not provide a pass mark to grade competence in image acquisition. However, the guidelines are drawn from expert recommendations and various established FoCUS and comprehensive echocardiography curricula. These curricula use a Competence pass mark ranging from 70% to 80%.

Table 3: Sub-xiphoid FoCUS Image Acquisition Skills Assessment Checklist

Sub-Xiphoid FoCUS Hands-on Imaging Skills	**Witnessed Skill**	**Scoring**
Demonstrates knowledge on ultrasound instrumentation for FoCUS	Selects cardiac/ phased array probe	Yes- 1, No- 0
Demonstrates FoCUS imaging modes selection	Can use B-mode Can use M- mode	Yes- 1, No- 0 Yes- 1, No- 0
Ability of trainee to obtain sub-xiphoid view	Correct Patient positioning Correct Probe placement Demonstrates Sub costal-4 chamber view Demonstrates Sub costal- Inferior Vena Cava view	Yes- 1, No- 0 Yes- 1, No- 0 Yes- 1, No- 0 Yes- 1, No- 0
Ability to recognize relevant sonographic anatomy	Can Identify Cardiac Structures - Right Ventricle - Right Atrium - Left Ventricle - Left Atrium - Inter Ventricular Septum - Mitral valve - Tricuspid Valve - Pericardium - Liver Inferior Vena Cava	Per Structure Yes- 1, No- 0 Yes- 1, No- 0 Yes- 1, No- 0 Yes- 1, No- 0 Yes- 1, No- 0 Yes- 1, No- 0 Yes- 1, No- 0 Yes- 1, No- 0 Yes- 1, No- 0 Yes- 1, No- 0

3.8.3 Image Quality Grading

The EACVI FoCUS criteria do not provide an assessment tool for image quality. The American College of Emergency Physician Emergency Ultrasound (ACEP) 5-point image quality assurance grading scale can be incorporated in assessing image quality. A good quality image scores 3 out of 5 points or above (See Table 4 below and appendix).

The hands-on imaging skills and image quality checklist have been incorporated to make the Sub-Xiphoid FoCUS Cardiac Ultrasound Skills Checklist in Table 4 above. For this study, subjects obtained a Sub-Xiphoid 4 chamber view and Sub-Xiphoid inferior vena-cava view image loops and stored them for assessment of image quality by an expert using the ACEP image quality grading scale. A second expert reviewed the stored images for quality assurance.

Table 4: ACEP Image Quality Assessment tool

IMAGE QUALITY GRADING	
Image Quality Rating Criteria (American College of Emergency Physicians 5 Point Image Quality Assurance Grading Scale)	**Points**
No recognizable structure, no objective data can be gathered	1
Minimally recognizable structures but insufficient for diagnosis	2
Minimal criteria met for diagnosis, recognizable structures but with technical or other flaws	3
Minimal criteria met for diagnosis, all structures imaged well and diagnosis easily supported	4
Minimal criteria met for diagnosis, all structures imaged with excellent image quality and diagnosis completely supported	5

3.8.4 Competence Assessment

Competence was assessed in three (3) domains: an in-person written test assessing identification of CURLS features and image interpretation, an objective structured clinical examination (OSCE) skills test assessing image acquisition hands-on skills, and image quality assessment of trainee-obtained images by experts. Both image interpretation and image acquisition skills testing took 1 day.

a) ***Image Interpretation Test:*** Trainees took an in-person multiple choice question (MCQ) test lasting 1 hour. The test was projected using Microsoft Power Point™ slides. Each slide was projected for 2 minutes. Every slide contained one question consisting of a written clinical case scenario. The case scenario described a patient presenting with acute breathlessness and a sub-xiphoid image cine loop acquired from the patient had been attached. Test responses comprised of 4 possible ultrasound features of cardiac abnormalities or image interpretations. The answering format was single best answer. (see Figure 9 below).

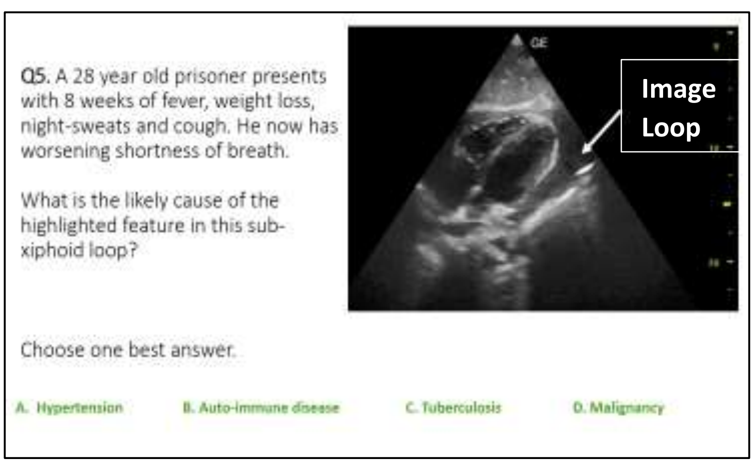


Figure 8: Image Interpretation Question/Case Format

The trainees were tested on the five diagnostic categories of the CURLS protocol namely: Pericardial Effusion, Dilated Cardiomyopathy, Left Atrial Enlargement, Right Ventricular Enlargement and Left Ventricular Hypertrophy. Six clinical case scenarios were allocated for each of the five categories to make a total of 30 questions/ cases (See Table 5 Below).

b) FoCUS Image Acquisition Skills Test: A Focused Cardiac Ultrasound Image Acquisition skills test was conducted at the Nursing School Skills Lab at the Kenyatta National Hospital. Image Acquisition Skills were tested in an Objective Structured Clinical Examination (OSCE) format. There were two OSCE stations. Each OSCE station had one healthy living model. The trainee acquired one sub-xiphoid 4 chamber view (S4C) and one sub-xiphoid inferior vena-cava view for each model. Witnessed hands on skills were captured using the Sub-Xiphoid FoCUS Image Acquisition Skills assessment checklist by an expert (See Table 5, page 35 below). The total number of skills correctly demonstrated at each of the 2 OSCE stations were recorded. Two (2) Sub-xiphoid 4 chamber image loops obtained by each trainee in this stage were stored in a dedicated flash drive for expert image quality rating.

c) Image Quality Grading: Two experts later reviewed the 2 saved image loops acquired and stored by the trainees for quality. Image quality was graded using the 2018 ACEP 5 Point Image Quality Assurance Grading Scale.

3.9 Study Variables

3.9.1 Outcome Variables per Objective

A. Competence in Image Interpretation

Competence was computed from the trainee performance image interpretation MCQ test described in 3.8.4 (a) above.

a) ***Aggregate Image Interpretation Competence***: Aggregate image interpretation competence was set at a score of ≥ 21 out of 30 (70 %). Based on the 2018 EACVI FoCUS training recommendations in section 3.8 above, trainees scoring ≥ 70 % were categorized as competent.

b) ***Category Specific Image Interpretation Competence Score***: There are five CURLS diagnostic categories. Trainees were required to correctly answer at least four out of six questions in each of the five CURLS diagnostic categories demonstrate category specific image interpretation competence. (See Table 5 below).

Table 5: Category Specific Image Interpretation Competence Scoring Criteria

CURLS feature/ finding/ diagnostic category	Interpretation/ Likely DDx	No of cases per category	Correctly Interpreted/ Diagnosed images required to meet EACVI Competence criteria (no)
A. Is there a pericardial effusion? Anechoic fluid rim around the heart	Pericardial effusion due to any of: TB pericarditis, Malignancy, Uremia, Massive Fluid Overload, Viral pericarditis, Autoimmune pericarditis	6	4
B. Is the left ventricular function reduced? Global enlargement of cardiac chambers Reduced LV global systolic excursion Reduced mitral valve excursion	Dilated cardiomyopathy due to: Idiopathic DCM, Alcoholic DCM, HIV associated DCM, Peri-partum DCM, Ischemic Heart disease	6	4
C. Is the right ventricle larger than the left ventricle? Dilated RV>LV (RV:LV > 0.7)	RV enlargement/ failure due to: Pulmonary Embolism or Pulmonary Hypertension of other cause	6	4
D. Is the left atrium larger than the left ventricle? Dilated left atrium, thickened mitral valve, flail leaflets, diastolic valve hypo-mobility	Left Atrial Enlargement likely due to Rheumatic Heart Disease	6	4
E. Is the LV septum > 12 mm on M mode?	Left ventricular hypertrophy due to: Hypertension, Aortic Stenosis/ regurgitation, Hypertrophic Cardiomyopathy	6	4
TOTAL QUESTIONS/ CASES		**30**	

B. Competence in Focused Cardiac Ultrasound Image Acquisition Skills

Competence was computed from witnessed FoCUS Hands-on Imaging Skills scores in the two OSCE stations. Scores from the Sub-Xiphoid FoCUS Image Acquisition Skills assessment tool were used (See Table 6 below). Witnessed hands-on skills were rated out of 17 marks per OSCE station. The sum of scores from the two stations were calculated to derive an aggregate score (out of 34 marks).

A percentage was computed from the aggregate score for each trainee. Based on the 2018 EACVI FoCUS training recommendations outlined in 3.8 above, subjects scoring ≥ 24/34 points (70 %) were considered competent in witnessed hands-on imaging skills.

Table 6: FoCUS Image Acquisition Skills Checklist

FoCUS Hands-on Imaging Skills	**Witnessed Skill**	**Scoring- Station 1**	**Scoring- Station 2**
Demonstrates knowledge on ultrasound instrumentation for FoCUS	Selects cardiac/ phased array probe	Yes- 1, No- 0	Yes- 1, No- 0
Demonstrates FoCUS imaging modes selection	Can use B-mode Can use M- mode	Yes- 1, No- 0 Yes- 1, No- 0	Yes- 1, No- 0 Yes- 1, No- 0
Ability of trainee to obtain sub-xiphoid view	Correct Patient positioning Correct Probe placement Demonstrates Sub costal-4 chamber view Demonstrates Sub costal- Inferior Vena Cava view	Yes- 1, No- 0 Yes- 1, No- 0 Yes- 1, No- 0 Yes- 1, No- 0	Yes- 1, No- 0 Yes- 1, No- 0 Yes- 1, No- 0 Yes- 1, No- 0
Ability to recognize relevant sonographic anatomy	Cardiac Structures - Right Ventricle - Right Atrium - Left Ventricle - Left Atrium - Inter Ventricular Septum - Mitral valve - Tricuspid Valve - Pericardium - Liver Inferior Vena Cava	Per Structure Yes- 1, No- 0 Yes- 1, No- 0 Yes- 1, No- 0 Yes- 1, No- 0 Yes- 1, No- 0 Yes- 1, No- 0 Yes- 1, No- 0 Yes- 1, No- 0 Yes- 1, No- 0 Yes- 1, No- 0	Per Structure Yes- 1, No- 0 Yes- 1, No- 0 Yes- 1, No- 0 Yes- 1, No- 0 Yes- 1, No- 0 Yes- 1, No- 0 Yes- 1, No- 0 Yes- 1, No- 0 Yes- 1, No- 0 Yes- 1, No- 0
SKILL RATING SCORE PER OSCE STATION		OUT OF 17 MARKS	OUT OF 17 MARKS
TOTAL SCORE		**(OUT OF 34 MARKS)**	
PERCENTAGE SCORE		**OUT OF 100%**	

C. Competence in Image Quality Grading

The 2018 American College of Emergency Physicians 5 Point Image Quality Assurance Grading Scale was used to rate trainee acquired images. A good quality image loop scores 3 or more out 5 points. Image loops obtained and stored by the trainees were rated by two experts. Where experts differed in rating scores, a consensus score was sought. The sum of the image quality scores of the two images were computed. A trainee obtained good quality images if they attain an aggregate image quality score of 6 or more out of 10. (See Table 7 below).

Table 7: Quality grading of trainee acquired images

Image Quality Rating Criteria (American College of Emergency Physicians 5 Point Image Quality Assurance Grading Scale)	Grading for Image 1	Grading for Image 2
No recognizable structure, no objective data can be gathered	1	1
Minimally recognizable structures but insufficient for diagnosis	2	2
Minimal criteria met for diagnosis, recognizable structures but with technical or other flaws	3	3
Minimal criteria met for diagnosis, all structures imaged well and diagnosis easily supported	4	4
Minimal criteria met for diagnosis, all structures imaged with excellent image quality and diagnosis completely supported	5	5

3.9.2 Subject Related Variables

a) Subject biodata:
- Sex- Male or Female

b) Attendance and practice log
- Attendance during theory training- Present or Absent
- Attendance during skills training- Present or Absent
- Number of supervised practice cases
- Image Interpretation Attendance – Present or Absent
- FoCUS OSCE Skills Test Attendance - Present or Absent

Subject related variables were documented but were not be analyzed.

3.10 Quality Assurance

The principal investigator has undergone a 3-month formal preceptorship in comprehensive adult trans-thoracic echocardiography. The training involved 2 weeks of in-person didactic lectures and 10 weeks of a cumulative 200 hours of hands-on practice. Competency requirements in the training involved performing, reporting and reviewing 150 comprehensive trans-thoracic echocardiogram studies with the course supervisors. The course also comprised of weekly thematic seminars to discuss various aspects of transthoracic echocardiography in the assessment of adult cardiac pathologies. At the end of the training, the PI underwent and passed a written and practical exam for certification. The PI has been actively practicing echocardiography over the last 4 years and has since logged more than 1500 comprehensive trans-thoracic echocardiogram procedures. He has participated in various continuous development trainings in different forums such as the Kenya Cardiac Society-Africa STEMI Live Point of Care Ultrasound Workshop 2019 and Trans-Thoracic Echocardiography Workshop 2022. He has also done online trainings with the European Society of Echocardiography and on-site training with the Canadian Point of Care Ultrasound Society (CPoCUS). He has PoCUS Academy accreditation from the American Registry for Diagnostic Medical Sonography (ARDMS™) and the Alliance for Physician Certification and Advancement (APCA™). He is also a registered practitioner for the Canadian Point of Care Ultrasound Society (CPoCUS) and an active member of the European Association of Cardiovascular Imaging (EACVI).

For this study, training was done by a multidisciplinary team consisting of the principle investigator, a Critical Care Pulmonologist PoCUS/ FoCUS expert trainer, a cardiologist and Critical Care Specialist PoCUS and FoCUS expert trainer, and a Cardiac Sonographer PoCUS/ FoCUS expert trainer. Study participants had access to the trainers and supervisors during the study. The research assistant dedicated to the study was a Pre-Intern Medical Officer.

An encrypted online database of pre-rated loops was used in the training and image interpretation test stages of the study. The loops had been reviewed and interpreted by two independent cardiologists and a radiologist. Consent was obtained during recording of the loops. The material used during didactic training was different from that used in the image interpretation tests to ensure internal validity. Two out of the six models were reserved for the skills testing phase of the study to ensure internal validity of results. A checklist adopted from the EACVI FoCUS curriculum 2018 and ACEP Image QA scale was used during practice and skills testing.

COVID 19 prevention protocols as per the 2021 MOH guidelines were adhered to.

3.11 Ethical Considerations

The study commenced once The Department of Clinical Medicine and Therapeutics, The University of Nairobi (UON) and the KNH/UON Ethics and Research Committee granted approval. The approval number is P832/11/2022. All recorded imaging used during this study were collected in a prior POCUS study in KNH where approval had been granted and patient consent obtained. The records were digitized, patient identity is withheld and are maintained in an encrypted database by the expert trainer. Data collected was in digital format and was similarly secured. Consent from models was obtained. Professional conduct was maintained during trainer-trainee and trainee-model interactions.

3.12 Data Management

3.12.1 Data Collection

Subject biodata, attendance, and practice logs were captured on online forms designed on Google Forms, a web-based data collection software. Image interpretation test answer sheets and Hands-on Skills checklists were in Google Forms digital answer sheets. To ensure data security, data collected was stored in a password protected Google drive database. The principal investigator, the research assistant and the study's biostatistician were the only ones with access to the data.

Data cleaning and analysis was done on R version 4.1.3, a web based data analytics software.

3.12.2 Statistical Analysis per Objective

Analysis of Competence in image interpretation and Competence in FoCUS skills was done using descriptive methods. Categorical variables were presented as percentages and proportions. Continuous variables were presented as means together with their standard deviations where normally distributed. Where the data was skewed, medians together and their interquartile ranges are used.

Ranges, medians, means, and 95% confidence intervals of trainees' scores were analyzed in the following:

- Aggregate Image Interpretation
    - Category-Specific Image Interpretation
- Aggregate FoCUS Hands-on Imaging Skills
- Aggregate ACEP Image Quality

Proportions of trainees who attained competency in the following domains were analyzed

- Aggregate Image Interpretation
    - Category-Specific Image Interpretation
- FoCUS Hands-on Image Acquisition Skills

- Obtained Images with a good Aggregate Image Quality Score

This ranges, medians, means and 95% confidence intervals were displayed in tables while proportions and percentages were displayed in pie-charts and bar graphs.

3.13 Dissemination of Results

Results were disseminated after presentation, marking, and approval by the University of Nairobi School of Medicine Department of Clinical Medicine and Therapeutics to the following:

a) The University of Nairobi Research Repository
b) The Kenyatta National Hospital Cardiology, Respiratory Medicine and Critical Care Departments
c) The Kenyatta National Hospital Research Department

3.14 Study Closure Plan

After presentation of study results and marking, the principal investigator adhered to the study closure procedures as outlined by the KNH-UoN ERC study closure policy version 1.1 of April 2016. The procedures pertinent to this study are as follows:

1. Procedure for closure: The PI shall initiate the closure procedures if the study has been completed including the data collection, verification and analysis has been completed.
2. Closure report: When the study has met the closure criteria, the PI must submit a closure report to the KNH-UoN ERC in addition to completion of closure application form. (KNH-UoN-ERC/FORM/SC/1B).
3. Closure report: The KNH-UoN ERC chair or appointee shall review the study closure report and issue an approval to indicate the permanent study closure.
4. Protection of study data: The PI shall ensure the safety and storage of all original records e.g. questionnaires, audio interviews records, research authorisation documents for anonymity and completion
5. Additional procedures: The PI shall be responsible for the final reporting procedures including reporting to the funders, sponsors and KNH-UoN ERC at the end of the research project including publications and results dissemination plan.

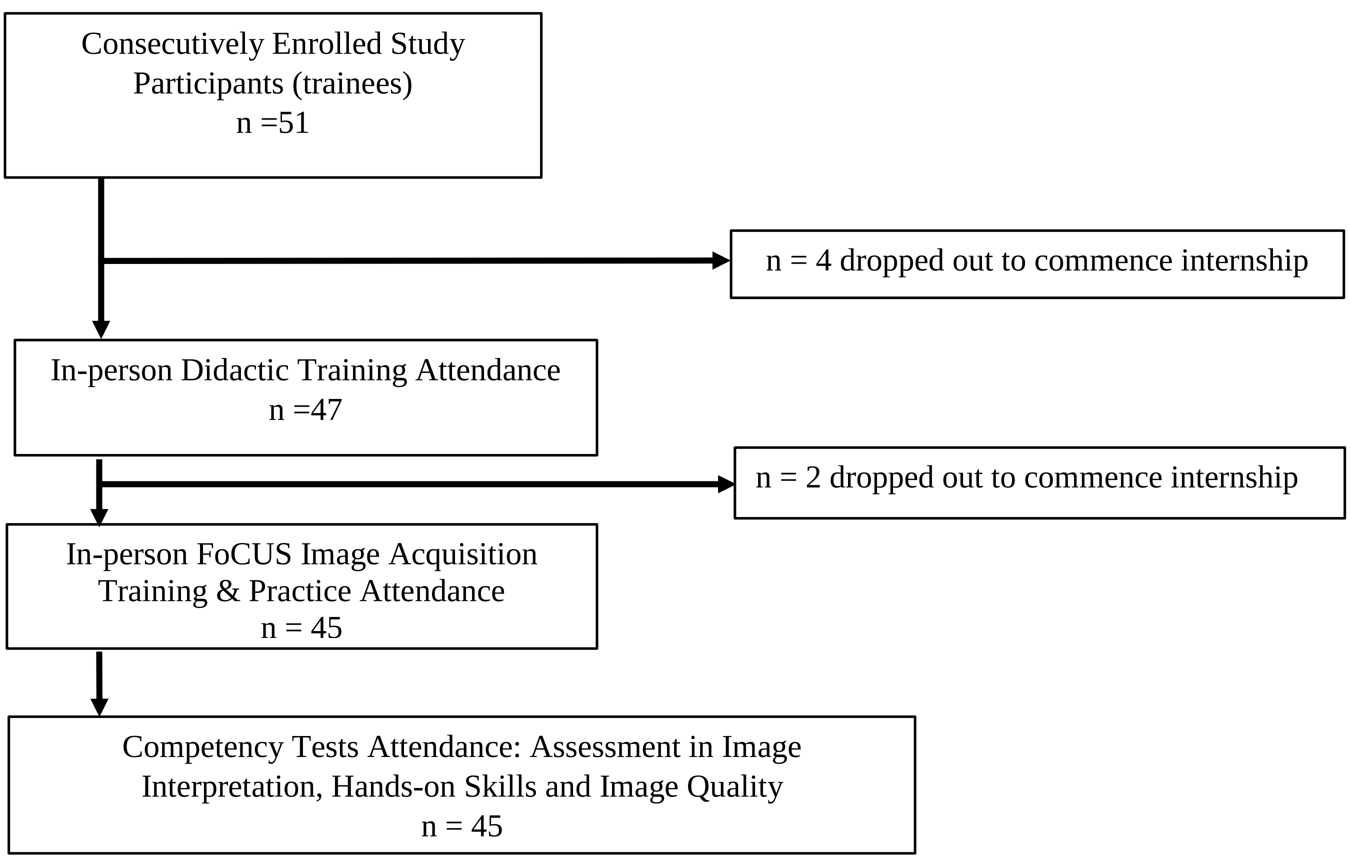
4 RESULTS

The study was conducted from the 1st to the 24th of February 2023 after KNH-ERC approval and study registration. This was designed to coincide with the transition period from undergraduate training to internship when prospective study participants would be available. Enrollment was done among those who were yet to report to their internship centers and were available for the study. Those willing to participate completed an online Google™ form questionnaire that captured bio-data, availability during the study period and prior training in echocardiography applications. The online forms were reviewed by the research assistant to select eligible participants. Fifty-one participants met the eligibility criteria and were thus enrolled.

4.1 Enrollment, Trainee Characteristics and Attendance

Enrollment took 3 consecutive days. The enrollment procedure is depicted in the flow chart in Figure 9 below

Figure 9: Flow Chart Showing Study Subject Enrollment and Attrition during the Study



The participants available for all the stages of the study were 45. Four (4) of the enrolled trainees were unable to start the training phase of the study as they had to commence internship. Two (2) trainees dropped out before the hands-on imaging skills training sessions for a similar reason. The proportion of trainees who attended all training and competency assessment sessions was 88% (n=45). Of the 45 trainees available for the entire study duration, 18 (40%) were male and 27 (60%) were female.

4.2 Training

Didactic training was delivered in person in a lecture room within the University of Nairobi School of Medicine at KNH over five consecutive days. The didactic training was undertaken by the principal investigator, the cardiac sonographer, and supervised by the FoCUS expert. There were six didactic training sessions. Each session had a duration of 1 hour 30 minutes and the cumulative didactic training time for the trainees was 9 hours.

For hands-on skills training, two training and practice stations were set up in the KNH Nursing School skills lab. Each station had one of the four healthy living models and one of the two available portable ultrasound machines with their probes. Stations were manned by the cardio-sonographer attached to the study, the PI, and the research assistant. The study's FoCUS expert supervised the skills training and practice sessions.

Skills training was scheduled over four days. Each day, ten to twelve trainees were trained in FoCUS Hands-on Image Acquisition Skills as follows. There were two training and practice sessions daily, one in the morning and another in the afternoon. An average of five to six trainees were trained per session as a group. Each skills training session lasted two hours. A skills training session had two consecutive segments; 10 minutes for Introduction to Image Acquisition Hands-on Skills, and 1 hour 50 minutes for Hands-on Practice. In the first segment, Basic Ultrasound Instrumentation Skills for FoCUS, Image Acquisition and Image Optimization of the Sub-Xiphoid cardiac 4 chamber, and Inferior Vena Cava views was demonstrated to the trainees. In the subsequent segment, trainees rotated between the two practice stations where they practiced Sub-Xiphoid FoCUS Image Acquisition under supervision. The four healthy living models were each imaged in rotation by individual trainees at the two Hands-on Skills Practice Stations to ensure a variety of practice conditions.

The cumulative duration of skills training and practice was 16 hours. Trainees were initially assisted by trainers during Hands-on Skills Practice to enhance their Sub-Xiphoid Image Acquisition technique. Trainees who demonstrated confidence and autonomy in Image Acquisition were eventually allowed to perform unassisted but supervised practice scans. The research assistant recorded the number of supervised practice scans performed by each trainee. Each trainee was required to log in a minimum of 10 supervised sub-xiphoid practice scans within their allowed practice time. The total supervised practice time for the trainees was 16 hours. The minimum number of Sub-Xiphoid 4 Chamber image acquisition practice scans performed per trainee was 4, maximum was 18, and a median of 14 scans.

4.3 Competency Assessment

Competency was assessed in Image Interpretation, Hands-on Image Acquisition Skills and Quality Trainee Acquired Images.

4.3.1 Image Interpretation Competency

a. Aggregate Image Interpretation Competency

Trainees scoring 20/30 (67 %) or more in the multiple choice question image interpretation test were classified as competent. Aggregate competence was attained by 84 % (n=38) of the 45 trainees. Out of 30 clinical case scenarios for image interpretation, the median score was 24 (80%). The lowest score was 15 out of 30, the highest was 28 out of 30 (See Table 7 below).

Table 8: Aggregate Performance in Image Interpretation Competency Test

	Range	**Median Score**	**Mean Score (95 % CI)**	**Standard Deviation**
Score out of 30	15 - 28	24	23.5 (22.4 – 24.6)	3.65
Percentage Score (%)	50% - 93%	80 %	78 % (74.4- 81.6)	12.17

b. Category-Specific Image Interpretation Competency

Competence was defined by correct interpretation of 4 or more out of the 6 images in the case scenarios in any of the five CURLS diagnostic categories. The proportion of trainees achieving competency in image interpretation for each category was as follows: Pericardial Effusion- 98%, Left Atrium Larger than Left Ventricle- 90%, Cardiomyopathy- 84%, Left Ventricular

Hypertrophy- 82%, Right Ventricle Larger than Left Ventricle- 64%. The median score in each of the 5 CURLS diagnostic categories was as follows: Pericardial Effusion- 6, Left Atrium Larger than Left Ventricle- 5, Cardiomyopathy- 5, Left Ventricular Hypertrophy- 5, Right Ventricle Larger than Left Ventricle- 4. (See Table 9 below)

Table 9: Performance in Category Specific in Image Interpretation

CURLS CATEGORY	Competent Trainees n (%)	Range	Median Score	Mean Score (95% CL)	Standard Deviation
Pericardial Effusion	44 (98 %)	2 – 6	6	5.7 (5.5 - 5.9)	0.79
Left Atrium Larger than Left Ventricle	40 (89%)	2 – 6	5	5 (4.7 - 5.3)	1.09
Cardiomyopathy	38 (84%)	2 – 6	5	4.7 (4.3 - 5.1)	1.16
Left Ventricular Hypertrophy	37 (82%)	1 – 6	5	4.4 (4.1 - 4.7)	1.07
Right Ventricle Larger than Left Ventricle	29 (64%)	1 – 6	4	3.7 (3.4 - 4.1)	1.16

The number of trainees who could competently diagnose all the 6 cases per category was 37 (82%) for pericardial effusion, 19 (42%) for Left Atrium larger than Left Ventricle, 13 (28%) for left ventricular hypertrophy, 4 (8%) for Cardiomyopathy, and 2 (4%) for Right Ventricle larger than Left Ventricle.

4.3.2 Image Acquisition Skills Competency

In each OSCE station, witnessed trainees' Hands-on Skills were checked using a skills checklist in an Objective Structured Clinical Examination (OSCE) format. The check-list was digitized in a Google form to ease data entry and ensure completeness of the data collected.

The lowest score was 6 out of 34 points (18 %) and the highest 34 out of 34 points (100 %). The median score was 24 out of 34 points. Overall, competence in image acquisition skills was attained by 80 % (n=38) of the trainees. Table 10 below shows performance in FoCUS Image Acquisition Skills.

Table 10: Performance in Focused Cardiac Ultrasound Image Acquisition Skills

	Range	Median Score	Mean Score (95% CI)	Standard Deviation
Score (out of 34)	6 - 34	24	24 (22 - 25)	3.7
Score (%)	18% - 100%	82 %	79 % 73% – 85%	20.2

a. Ultrasound instrumentation for FoCUS

Nearly all the trainees (98 %) were able to select the appropriate probe for image generation. One trainee did not select the appropriate probe. All trainees could optimize image quality using Brightness imaging mode (B-mode), and 81 % could use Motion imaging mode (M-mode) to assess the Inferior Vena Cava's collapsibility.

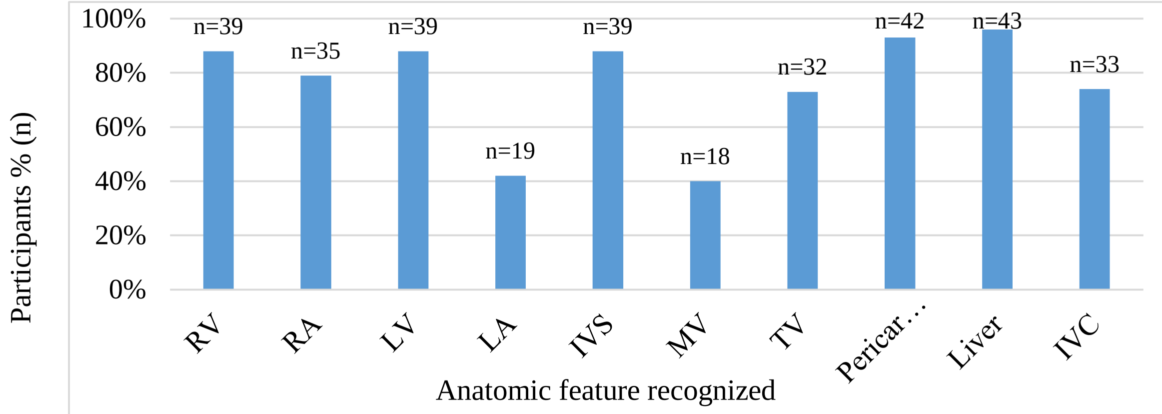
b. Ability to Obtain Sub-Xiphoid Cardiac Views

All trainees were able to appropriately position the model for image acquisition. In demonstrating appropriate probe placement on the model's sub-xiphoid area, 68% correctly placed the probe. Thirty-two trainees (70%) were able to obtain a sub-xiphoid 4 chamber view and thirty-four trainees (76%) were able to obtain a sub-costal inferior vena-cava views.

c. Ability to recognize relevant sonographic anatomy

The proportion of trainees able to correctly recognize relevant sonographic anatomy on the images they acquired was as follows: Right Ventricle - 88% (n=39), Right Atrium - 79% (n=35), Left Ventricle - 88% (n=39), Left Atrium - 42% (n=19), Interventricular Septum - 88% (n=39), Mitral Valve - 40% (n=18), Tricuspid Valve - 73%, (n=32) Pericardium - 93% (n=42), Liver - 96% (n=43), Inferior Vena Cava - 74% (n=33). More than 70% of the trainees could identify most of the Relevant Anatomy from the images they acquired. About 40% could not identify the Left Atrium and the Mitral Valve. See Figure 11 below.

Figure 10: Proportion of Trainees able to Recognize Relevant Anatomy during Sub-Xiphoid FoCUS Image Acquisition



KEY: RV- Right Ventricle, **RA-** Right Atrium, **LV-** Left Ventricle, **LA-** Left Atrium, **MV-** Mitral Valve, **TV-** Tricuspid Valve, **IVC-** Inferior Vena Cava

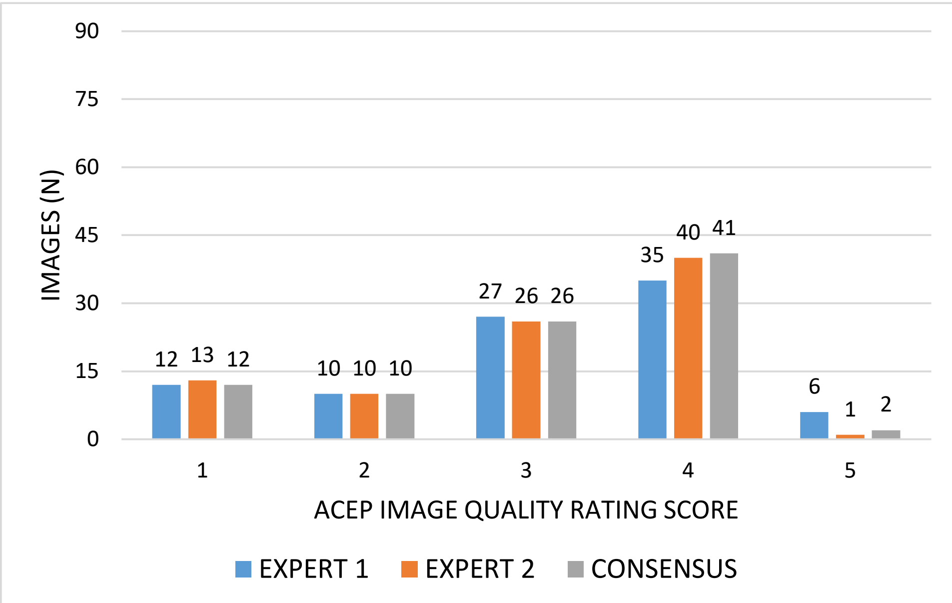
4.3.3 Quality of Images obtained by Trainees

Trainees obtained one sub-xiphoid 4 chamber image loop from each of 2 healthy living models for expert review and rating. The image loops were stored in a secure hard drive. The image loops were then uploaded to a secure online database and organized by unique trainee identity number. They were subsequently appended to an online Google form with the 2018 ACEP 5-point Image Quality Rating criteria linked to each image loop.

The Google form was shared with the two FoCUS experts for independent rating. Experts' image quality rating scores were then reviewed by the PI for agreement. For image loops where the experts had not agreed on a rating score, a meeting between the two FoCUS experts in the presence of the PI was held to review the image loops in contention and arrive at a consensus image quality rating score. Each image had a maximum possible ACEP image quality rating score of 5 with good quality image scoring 3 or more out of 5.

The bar graph below depicts the distribution of ACEP image quality scores (x axis) after independent expert rating and consensus. Each of the 45 Trainees obtained one image loop in 2 imaging stations making a total of 90 image loops (y axis). Image loops attaining an ACEP score of 3 or more were of good quality. The experts were in agreement that 77% (n=69) of trainee obtained image loops were of good quality.

Figure 11: Distribution of Image Quality Rating Scores as rated by Experts using the 2018 ACEP Criteria



2018 ACEP Score Key

1 - No recognizable structure

2 - Minimally recognizable structure, insufficient for diagnosis

3 - Recognizable structures, technical or other flaws

4 - All structures imaged well, diagnosis easily supported

5 - All structures imaged well with excellent image quality, diagnosis completely supported

Aggregate Image Quality Grading

The 2018 ACEP image quality scores by expert consensus for every two images obtained by one trainee (out of 5) were added up to make an aggregate image quality score out of 10. A good aggregate image quality is rated by a score of 6 or more out of 10. The proportion of trainees who attained a good aggregate image quality score was 69% (n=31).

The aggregate Image Quality Scores are shown in Table 11 below. The lowest aggregate image quality score was 2 points and the highest was 10 points. The mean aggregate score was 6.2 (95% CI 5.5 – 6.5). The median score was 7.

Table 11: Performance in Aggregate Image Quality

	Range	**Median Score**	**Mean Score (95% CI)**	**Standard Deviation**
Aggregate Score (out of 10)	2 - 10	7	6.2 (5.5 – 6.8)	2.18

5. DISCUSSION

We set out to determine the post-training competency of medical pre-interns in using Focused Cardiac Ultrasound to differentiate cardiovascular causes of dyspnea. Attained competency was assessed in 3 domains namely; Image Interpretation, Image Acquisition and Image Quality.

Image Interpretation Competency was demonstrated by more than three quarters of the trainees. Nearly all trainees attained Image Interpretation Competency in Pericardial Effusion (PEff). More than 80% of the trainees demonstrated competency in identifying Cardiomyopathy (CMP), recognizing Left Atrium as Larger than Left Ventricle (LA>LV) and Left Ventricular Hypertrophy (LVH). Two thirds of the trainees demonstrated competency in identifying the Right Ventricle as larger than the Left Ventricle (RV>LV) which was relatively lower compared to the other CURLS diagnostic categories.

To further evaluate Image Interpretation performance in the RV>LV category, a review of trainee responses from the Image Interpretation Test Case Scenarios in this category was done. Responses provided for each case scenario captured both the ultrasound feature and a possible differential diagnosis such as RV enlargement due to Acute Pulmonary Embolism or RV enlargement due to Chronic Pulmonary Hypertension. Overall, 83% of the trainees could identify the ultrasound feature of RV enlargement of any cause whereas only 64% of trainees were able to identify the specific differential diagnosis of RV enlargement from the availed responses in the clinical case scenarios. This resulted in relatively lower Image Interpretation Competency in the RV>LV category.

The high level of Image Interpretation Competency in our study could be attributed to the ease of training with the simplified didactic material from the CURLS protocol and case based training. The simplified didactic material from CURLS is tailored to the five most prevalent causes of cardiovascular dyspnea in low resource settings(12). Didactic training emphasized on mastering sonographic features the five prevalent causes of cardiovascular dyspnea and their corresponding differential diagnoses. In addition to the didactic material from the CURLS protocol, 100 cases (images & their case scenarios) derived from Breathlessness Study conducted in KNH in 2020 were used for training. Ultrasound features of gross cardiac abnormalities found among the 5 most prevalent cardiovascular causes of dyspnea as described in the CURLS protocol were represented in images from the 100 cases. Repetitive review of these ultrasound features during training enhanced pattern recognition among trainees thus resulting in high attained image interpretation competency(11).

The proportion of trainees attaining Image Acquisition Skills Competency exceeded three quarters. At least two thirds of the trainees could identify most anatomical structures visualized from the sub-xiphoid images they had acquired during Image Acquisition Skills Assessment. The Left Atrium and Mitral Valve could however not be identified by about a half of the trainees. This was due to errors in probe orientation during sub-xiphoid image acquisition with inadequate probe angulation and/ or rotation which resulted in the Left Atrium and Mitral Valve falling out of the field of view during image acquisition. Overall, more than two thirds of trainee-obtained images were of good quality.

The high level of Image Acquisition Skills Competency in our study can be attributed to the following factors. First, the trainees were required to master basic ultrasound technical skills namely image acquisition by using a single probe (phased array probe) to acquire a sub-xiphoid view, and image optimization using basic ultrasound software applications (Brightness Mode and Motion Mode)(12). Second, adequate guidance and supervision by trainers and experts were offered to the trainees during the Image Acquisition Skills Training. Consistent supervision and availability of FoCUS experts during the entire study period enhanced trainee confidence and improved the quality of training. Third, hands-on practice on healthy living models in a skills lab allowed trainees adequate time to practice in a neutral training environment. Fourth, repetitive hands-on skills practice led to development of the required psychomotor skills for image acquisition among trainees. The training was thus simple, concise, well supervised and of good quality resulting in a high level of attained Image Acquisition Skills competency(11).

Sub-Saharan Africa studies similar to ours are few, have applied varying study methodologies using different training protocols on trainees of diverse characteristics, and were conducted in sites with varied training resources. These studies also used different criteria to assess attained competency. One particular study done in 2013 in Rwanda assessed the impact of a simplified echo training strategy for Heart Failure diagnosis and management within an integrated Non-Communicable Disease clinic at 2 District Hospitals. Registered nurses were trained over a duration of 16 days in didactics of heart failure diagnosis using simple clinical signs and a basic echo diagnostic protocol, and protocol directed treatment/ intervention of diagnoses. The training curriculum was informed by the local epidemiology of heart failure based on literature review and clinical experience. After training, the nurses were taken to 2 district hospitals where they performed simple clinical assessment and simple qualitative diagnostic echo on 237 patients presenting with breathlessness at an NCD clinic and suspected to have heart failure. A follow up comprehensive echocardiogram was performed on the patients by a visiting cardiologist. Among 81% of the patients assessed, the nurses were in agreement with the cardiologist in diagnosing Left Ventricular Systolic Dysfunction (due to Hypertension or Cardiomyopathy), Rheumatic Mitral Valve Disease, Large Pericardial Effusion, Right Ventricular Enlargement or Dysfunction(29).

There are some similarities between our study and the 2013 Rwanda Study. Junior level health care workers were trained in Focused Cardiac Ultrasound or Simple Echo skills in both studies. Both trainings were tailored to assess breathlessness of cardiovascular origin targeting similar specific ultrasound features of gross cardiac abnormalities using evidence on local heart failure epidemiology. Trainees in both studies were equipped with basic ultrasound operational skills to enable independent image acquisition and interpretation at the point of care. In both studies, trainees attained a high level of competency in Image Acquisition and Interpretation after a brief training period.

However, there are also some differences. The goal of the 2013 Rwanda study was to assess the five-year impact of simplified echo training programs in the care of Heart Failure patients in Rwanda. Our study measured attained competency after a brief FoCUS training (3 weeks). The training protocol in the 2013 Rwanda study equipped registered nursing officers with simple clinical and 2-window basic echo diagnostic skills, and protocol directed treatment. Our study equipped medical officer pre-interns with Focused Cardiac Ultrasound Image Acquisition and Image Interpretation skills from the sub-xiphoid view using the CURLS protocol. Trainees in the 2013 Rwanda study did case based learning and supervised practice on patients in cardiac clinics. In contrast, trainees in our study reviewed simulated case scenarios and practiced image acquisition under supervision in a skills lab. Competency assessment in our study was through a formal image interpretation and image acquisition skills test. In the Rwanda study, agreement on a diagnosis with a cardiologist was documented. Overall, the study site, study goals and objectives, methodologies, training conditions and measures of attained competency among studies assessing the effectiveness and impact of FoCUS trainings differ which may limit direct comparison of study outcomes.

Our findings show that pre-intern medical officers can attain a high level of competency in FoCUS for differentiating cardiovascular causes of dyspnea after a brief training. The CURLS protocol is particularly suited for resource-limited settings. It is simple and it targets diagnostic ultrasound features from the 5 most prevalent causes of Dyspnea of Cardiovascular Origin in Sub-Saharan Africa. In contrast to echo, CURLS requires basic ultrasound hardware and software applications and the curvilinear probe to obtain images and make a diagnosis. In Kenya, such ultrasound equipment is widely available in Level V and Level IV public hospitals(30). Basic ultrasound technologies have also become more available in Kenya and Africa due to the proliferation of affordable portable ultrasound devices. Lower level public hospitals employ junior or less specialized practitioners. These employees form a crucial frontline workforce in the management and follow up of patients with cardiovascular disease. The basic technical requirements for training and using CURLS make it a potentially easy skill to equip non-specialized practitioners of other cadres. Such practitioners include medical officers, nurses and registered clinical officers(12).

FoCUS using the CURLS protocol can then be utilized by the non-specialized staff in the rapid differentiation of cardiovascular causes of dyspnea. Scanning can be done in out-patient clinics, in the accident and emergency department, or at the bedside in medical wards or critical care units during the assessment or monitoring of patients with dyspnea of cardiovascular origin. Obtaining a good quality single sub-xiphoid image takes less time compared to performing comprehensive echocardiography. Negative findings may mean the patient’s dyspnea is non-cardiovascular in origin prompting further diagnostic evaluation. Uncertain findings may warrant discussion with an expert and/ or referral for advanced cardiovascular and/or respiratory assessment and interventions. Identification of one of the 5 CURLS diagnostic possibilities can inform early and potentially life-saving interventions such as pericardiocentesis for tamponade or decongestion for decompensated heart failure while awaiting expert review and/or definitive care. This may potentially mitigate delays in differentiating cardiovascular causes of dyspnea due to the shortage of cardiology specialists and limited access to echocardiography equipment. The availability of ultrasound equipment and non-specialized healthcare practitioners trained in FoCUS protocols such as CURLS could potentially facilitate task-shifting of rapid differentiation of cardiovascular associated dyspnea from more specialized staff in resource-limited settings long term.

Study Strengths and Limitations

Participant Selection Bias: Trainees in this study were recruited based on willingness to participate.

Strength: Those who volunteered are motivated to perform better.

Limitation: The study results may thus not be generalizable to randomly selected trainees.

Training Conditions: This was a simulated training study rather than a real world study. Its findings may not be generalizable to the real-word.

Strength: The use of a simplified FoCUS protocol, availability of an in-person training site and a skills lab with healthy living models for practice, skilled trainers and supervisors and increased trainer-trainee contact time may positively impact trainee performance.

Limitation: The study results may not be generalizable to less ideal training conditions. Lack of equipment, expert trainers and supervisors in particular may adversely affect training outcomes.

Competency Retention: The duration between training and testing was brief. This may have positively impacted performance in the competency tests by mitigating knowledge decay leading to over-estimation of competency.

Trainees could be followed up over time and re-tested to measure retained competency. However, regular application of learned skills is expected to result in sustained competency.

6. CONCLUSIONS

Majority of trainees in our study attained competency in Focused Cardiac Ultrasound (FoCUS) after a brief training using the Cardiac Ultrasound for Resource-limited Settings (CURLS) protocol. At least two thirds of the trainees could identify the 5 most prevalent cardiovascular causes of dyspnea in an Image Interpretation test. Majority of trainees were able to competently and independently obtain good quality Sub-Xiphoid View images and identify relevant cardiac anatomy. The simplicity of training, ease of use and epidemiologic relevance of the CURLS protocol makes it a suitable tool for FoCUS training among junior cadre clinical staff in differentiating common cardiovascular causes of dyspnea in resource-limited settings.

Recommendations

1. Simplified FoCUS training protocols such as CURLS should be adopted in resource-limited settings in the training of junior cadre clinical personnel in the assessment of cardiovascular causes of dyspnea.
2. Studies assessing attained competency after FoCUS training using CURLS among other carders of healthcare practitioners such as Nursing Officers and Clinical Officers may further inform its applicability as a FoCUS training tool. T
3. he long term impact of the use of FoCUS protocols in resource-limited settings in the evaluation and management of patients with dyspnea of cardiovascular origin should be studied

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8 APPENDIX

8.1 Data collection form

TRAINEE ID:	

BIODATA		
AGE IN YEARS	SEX	
	Male/Female	

ATTENDANCE		
Theory Training	Present	Absent
Skills Training	Present	Absent
Image Interpretation Test	Present	Absent
OSCE Skills Test	Present	Absent

PRACTICE SESSIONS	
Count	

PERFORMANCE IN IMAGE INTERPRETATION TEST		
Aggregate Image Interpretation Score	__/30 marks	__%
Category Specific Image Interpretation Score		
Correctly interpreted Left Ventricular Dilatation/Dysfunction	N = ___	Out of 6
Correctly interpreted Right Ventricular Dilatation/Dysfunction	N = ___	Out of 6
Correctly interpreted Left Atrial Dilatation	N = ___	Out of 6
Correctly interpreted Pericardial Effusion/ Tamponade	N = ___	Out of 6
Correctly interpreted Left Ventricular Hypertrophy	N = ___	Out of 6

PERFORMANCE IN OSCE IMAGE ACQUISITION SKILLS TEST		
	Station 1	Station 2
Performance in FoCUS Hands-on Imaging Skills	__/17 marks	__/17 marks
Aggregate Image Acquisition Score	**__/34 marks**	**__ %**

2021 ACEP 5 POINT IMAGE QUALITY RATING	**Expert 1**	**Expert 2**
Image 1: Sub-xiphoid 4 Chamber healthy living model 1	__/5 Points	__/5 Points
Image 2: Sub-xiphoid 4 Chamber healthy living model 2	__/5 Points	__/5 Points
Consensus score Image 1	__/ 5 Points	
Consensus score Image 2	__/ 5 Points	
Aggregate Image Quality Score	__/ 10 Points	

8.2 2018 EACVI education/training requirements for achieving competence for performing focus 2018 guidelines

Table 2 Minimal education/training requirements for achieving competence for performing FoCUS

Part 1. Basic theoretical knowledge on cardiovascular disease[a]	
Acute coronary syndrome/acute myocardial infarction	
Mechanical complications of acute myocardial infarction	
Acute aortic syndrome/aortic dissection	
Acute pulmonary embolism	
Acute heart failure/cardiogenic shock	
Acute pericarditis	
Cardiac tamponade	
Acute myocarditis	
Cardiomyopathies	
Aortic stenosis	
Acute valvular regurgitation	
Ventricular hypertrophy	
Pneumothorax	
Endocarditis	
Cardiac sources of embolism (tumours and masses)	
Traumatic injuries of the heart	
Part 2. Pre-recorded cases review (25 cases)[b]	
LV dilatation/dysfunction	4
RV dilatation/dysfunction	4
Pericardial effusion	4
Tamponade	3
Hypovolemia	3
Cardiac arrest	3
Pleural effusion	2
LUS B-lines	2
Part 3. Mastering technique for performing FoCUS—log-book (50 cases) to include minimum number of the following conditions[c]:	
LV dilatation/dysfunction	5
RV dilatation/dysfunction	5
Pericardial effusion or tamponade	3
Hypovolemia	5
Cardiac arrest or peri-arrest	2
Pleural effusion	2
LUS B-lines	3

Table 3 Suggested targets of FoCUS examination and related emergency cardiovascular scenarios/conditions that might be addressed

Targets
Global LV systolic function and size
Global RV systolic function and size
Pericardial effusion, tamponade physiology[a]
Intravascular volume assessment
Gross signs of chronic cardiac disease[b]
Gross valvular abnormalities[c]
Large intracardiac masses[d]
Scenarios
Circulatory compromise/shock
Cardiac arrest
Chest pain/dyspnoea[e]
Chest/Cardiac trauma
Respiratory compromise
Syncope/presyncope
Conditions
Ischaemic LV/RV dysfunction
Mechanical post-MI complications
Cardiomyopathies (i.e. DCM, HCM, Takotsubo)
Myocarditis
Cardiac tamponade
Pulmonary embolism
Hypovolaemia/shock

Modified from references 3 and 32.

[a]Based on detection of 2D signs of compression of right-sided chambers (systolic collapse of the right atrium, diastolic collapse of the right ventricle) rather than Doppler-based study of intracardiac flows.

[b]Major LV dilatation or severe hypertrophy, right ventricular hypertrophy, major atrial dilatation.

[c]Recognizable by FoCUS without the use of Doppler-based techniques (e.g. massive disruption or marked thickening of leaflets, flail, anatomic gaps).

[d]Large valve vegetations or visible intracardiac or inferior vena cava masses/thrombi.

[e]Subtle regional wall motion abnormalities as well echocardiographic signs of acute aortic syndrome are not evidence-based targets for FoCUS; therefore, despite actual FoCUS findings, all patients with chest pain and suspected acute coronary syndrome or acute aortic syndrome, should be referred as soon as possible to comprehensive echocardiography.

Courtesy: Focus cardiac ultrasound core curriculum and core syllabus of the European Association of Cardiovascular Imaging- Table 2 (2)

8.3 2018 American college of emergency physicians 5 point image quality grading scale

Quality assurance:

Suggested Quality Assurance Grading Scale

	1	2	3	4	5
Grading Scale Definitions	No recognizable structures, no objective data can be gathered	Minimally recognizable structures but insufficient for diagnosis	Minimal criteria met for diagnosis, recognizable structures but with some technical or other flaws	Minimal criteria met for diagnosis, all structures imaged well and diagnosis easily supported	Minimal criteria met for diagnosis, all structures imaged with excellent image quality and diagnosis completely supported

Courtesy: Emergency Ultrasound Standard Reporting Guidelines Quality Assurance Grading Scale(35)

8.4 Trainee consent form

TITLE OF STUDY: FOCUSED CARDIAC ULTRASOUND COMPETENCE AMONG MEDICAL OFFICER TRAINEES IN DIFFERENTIATING CARDIAC CAUSES OF DYSPNOEA

PRINCIPAL INVESTIGATOR
DANIEL M. MURIUKI

REGISTAR- MMED IN INTERNAL MEDICINE

TEL: +254 713341561

EMAIL: muriuki.md@gmail.com

PURPOSE OF THE STUDY
You are being asked to take part in a research study. Before you decide to participate in this study, it is important that you understand why the research is being done and what it will involve. Please read the following information carefully. Please ask the researcher if there is anything that is not clear or if you need more information.

The purpose of this study is to determine post training Competence in the use of Focused Cardiac Ultrasound in assessing cardiovascular causes of breathlessness among medical officer pre-interns.

STUDY PROCEDURES
After enrollment, the study will be conducted as follows:

- **Didactic training:** 1 day in person training at the University of Nairobi College of Health Sciences on- Basics of ultrasound, Cardiac anatomy, physiology, pathophysiology of common conditions and their cardiac ultrasound findings. Experts will be available for this training.
- **Skills Training:** 1 day of in-person FoCUS sub-xiphoid view image acquisition training on healthy living models supervised by a cardiac technologist
- **Practice:** 5 days of supervised image acquisition practice
- **Tests of competence:** A projected power-point slide 30 question MCQ spot test and an OSCE hands on skills test

RISKS
There are no foreseeable risks to the trainee during the study. You will however be required to wear a protective lab-coat during the skills and OSCE sessions. A protective face mask and gloves shall be provided for the trainees safety. You may terminate your involvement at any time if you choose.

BENEFITS
This will be an introductory course to the use of ultrasound for assessment of breathlessness. Your active participation will hopefully leave you with point of care ultrasound skills you can build on as you enter active clinical practice.

CONFIDENTIALITY
Your responses to this study will be anonymous. You will be provided with a unique identifier (ID) for this study. Except for your unique ID, please do not write any other identifying information on data collection forms provided.

COMPENSATION
A certificate of participation will be awarded.

CONTACT INFORMATION
If you have questions regarding your rights as a research participant, or if problems arise which you do not feel you can discuss with the Primary Investigator, please contact the University of Nairobi Kenyatta National Hospital Ethics Review Commission through : uonknh_erc@uonbi.ac.ke

VOLUNTARY PARTICIPATION
Your participation in this study is voluntary. It is up to you to decide whether or not to take part in this study. If you decide to take part in this study, you will be asked to sign a consent form. After you sign the consent form, you are still free to withdraw at any time and without giving a reason. Withdrawing from this study will not affect the relationship you have, if any, with the researcher. If you withdraw from the study before data collection is completed, your data will be discarded.

CONSENT

I have read and I understand the provided information and have had the opportunity to ask questions. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving a reason and without cost. I understand that I will be given a copy of this consent form. I voluntarily agree to take part in this study.

Participant's signature ________________________________ Date __________

Investigator's signature ______________________________ Date __________

For further inquiries or concerns, kindly contact the principal investigator or the following:

LEAD SUPERVISOR

Prof. M. D. Joshi

Associate Professor of Medicine

Consultant Physician, and Cardiologist

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KNH-UoN ERC CONTACTS

Email: uonknh_erc@uonbi.ac.ke

Tel: 726300-9 Ext 44355, 44102

8.5 Model consent form

LIMITED ULTRASOUND IMAGING OF THE HEART

TITLE OF STUDY: FOCUSED CARDIAC ULTRASOUND COMPETENCE AMONG MEDICAL OFFICER TRAINEES IN DIFFERENTIATING CARDIAC CAUSES OF DYSPNOEA

PRINCIPAL INVESTIGATOR
DANIEL M. MURIUKI

REGISTAR- MMED IN INTERNAL MEDICINE

TEL: +254 713341561

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What is limited ultrasound imaging of the heart?

Ultrasound imaging is used to take pictures of the unborn child, as well as other body parts such as the liver or kidneys, for diagnostic purposes. Pictures of the heart are taken by doctors to assess the heart function as a routinely or when checking for causes of breathlessness.

Why do I need to give my consent?

The Kenyatta National Hospital- University of Nairobi Ethics Research Committee recommends that anyone undergoing tests such as ultrasound imaging for training or research purposes gives their informed consent.

Are there any risks?

There are no known adverse effects of ultrasound imaging but, since ultrasound is a form of energy with the potential to produce a biological effect on tissue, it should be used with care as if there is a risk (however small). COVID-19 prevention protocols will be observed.

What do I need to know about the scanning procedure?

You will be asked to remain still while a probe is placed on your skin over the area being scanned. You may be required to change position from time to time. A water-based gel is used to improve contact with the skin. Should any unforeseen abnormality be found while scanning your heart, you would be informed of this and referred to see a doctor.

A letter explaining the reason for referral will be provided. The person performing the scan would not be able to give you a diagnosis as this requires a medically qualified person.

Compensation

A daily fee will be agreed upon.

CONSENT

I, ____, give my consent to have pictures taken of my heart for teaching/research purposes. I confirm that, I have been told of the risks of the scanning technique. I agree to the procedure for reporting any unforeseen abnormality.

Signed ________________________________ Name in capitals __________________

Witness ______________________________

For further inquiries or concerns, kindly contact the principal investigator or the following:

LEAD SUPERVISOR

Prof. M. D. Joshi

Associate Professor of Medicine

Consultant Physician, and Cardiologist

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8.6 Plagiarism screening report

Focused Cardiac Ultrasound Competency Among Medical Officer Trainees In Differentiating Cardiac Causes Of Dyspnoea

ORIGINALITY REPORT

13%	10%	9%	3%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

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8	Submitted to Kettering College of Medical Arts	Student Paper	<1%

9 LEAD SUPERVISOR AND CHAIRMAN OF DEPARTMENT APPROVAL

This dissertation has been submitted with the approval of my lead supervisor and the chairman of the Department of Clinical Medicine and Therapeutics

Lead supervisor:

Prof. M. D. Joshi

Associate Professor of Medicine

Consultant Physician, and Cardiologist

Department of Clinical Medicine and Therapeutics

The University of Nairobi

Sign______________ Date 8/11/2023

Chairman of the department

Prof. E. O. Amayo

Professor, Consultant Physician and Neurologist

Chairman, Department of Clinical Medicine and Therapeutics

The University of Nairobi

UNIVERSITY OF NAIROBI
COLLEGE OF HEALTH SCIENCES
THERAPEUTICS

Sign______________ Date 16/11/2023