Learning Experiences Among GP Registrars After a Focused Cardiac Ultrasound Training Program: A Qualitative Interview Study

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Abstract

Background: Until recently, clinical ultrasound technology was limited to the hospital-based disciplines, and few studies assessed training in focused cardiac ultrasound (FCU) in primary care. We designed an interview study among general practitioner (GP) registrars taking part in an FCU training program and discussed their experiences compared to their documented skills.

Methods: This qualitative content analysis used an inductive approach. Five GP registrars and their tutor participated in semi-structured individual interviews during April–July 2017. Participants were interviewed after they each had conducted 20 supervised and 7–10 independent examinations and were encouraged to complete self-directed study using video tutorials on web-based platforms. FCU examinations of study patients recruited from primary care clinics were conducted with a hand-held device (Vscan 1.2) at the Centre of Clinical Research, Östersund Hospital, Sweden.

Results: We identified two categories of information: the *prerequisites of learning FCU* and the *acquisition of skills for professional development*. Combining theoretical education with hands-on tutorials was an essential part of FCU learning. However, participants suggested that the training program should include group tutorials to give a deeper understanding of scanning positions and a reference standard for evaluating the FCU recordings. In skill acquisition, participants experienced more confidence in performing the technical aspects of FCU than in interpreting the images to evaluate cardiac function. The participants saw several possibilities for applying FCU in primary care, including as a screening tool in rural clinics or to support referrals to specialized care.

Conclusions: After completing 20 supervised FCU training sessions, previously inexperienced examiners felt that assessment of cardiac function was more difficult than acquiring adequate ultrasound images. To gain confidence in assessment of cardiac function, respondents suggested personal feedback and group tutorials with discussion of clinical examples in smaller groups for improvement of learning. Demographic differences between patients seen in hospital wards and primary care clinics should also be considered in the design of FCU training programs.

Trial registration: NTC02939157, ClinicalTrials.gov.

Background

Evaluation of patients with symptoms indicative of heart failure (HF), e.g. breathlessness, ankle edema, and/or deficient physical ability [1], is difficult, especially in the general practice setting with limited access to cardiac ultrasound facilities. The prevalence of HF is estimated at 1%-2% in the Western population and increases with age [2]. In patients >65 years of age consulting with general practitioners (GPs) because of exertional dyspnea, about one in six ultimately are diagnosed with HF [3, 4]. To confirm the HF diagnosis, the history and physical examination should be supported by a cardiac ultrasound examination [5-9], such as focused cardiac ultrasound (FCU) conducted at the point-of-care [10-13]. Until recently, clinical ultrasound technology was limited to the hospital-based disciplines [14-22], and few

studies have assessed FCU training in primary care [23, 24]. Thus, design and assessment of FCU training programs intended for primary care should be done with patients recruited from primary care clinics.

The major concerns of such training programs are image acquisition of a sufficient standard and reliable assessment of cardiac function, based on the ultrasound findings [20, 25-27]. Training programs in clinical examination techniques could be evaluated in numeric terms and through an interview to assess experiences that cannot be easily quantified. For this reason, we designed an interview study among GP registrars taking part in an FCU training program and discussed their experiences compared to their documented skills in image acquisition and assessment of left ventricular ejection fraction [28].

Methods

We performed qualitative content analysis, with an inductive approach [29, 30].

Participants and training program

Potential study participants were five GP registrars engaged in the FCU training program (three women and two men), and their tutor, a qualified ultrasound technician (a woman), previously engaged in cardiac ultrasound teaching of registrars in cardiology and clinical physiology. We contacted all of these potential participants by telephone to provide information about the interview study and to make an appointment for an interview. All eligible individuals volunteered to participate in the qualitative interview. None of the GP registrars had any prior experience in cardiac ultrasound examinations. The FCU training program comprised 20 supervised training sessions. The participants also were encouraged to engage in self-directed study of video tutorials of cardiac ultrasound provided as an e-book and on a web-based platform [31, 32]. A description of the FCU training program was published previously [28].

Data collection

Data were acquired using open-ended interview questions to evaluate whether respondents experienced the training program as sufficient for achievement of technical skill and ability to evaluate recorded FCU examinations. To maintain structure in the interviews, we used an interview guide so that interviewees could speak about and reflect on the same areas of interest. The interview guide included questions such as: "Describe your experiences of the training program, theoretically and practically," "Which moments were easy or difficult?", and "What possibilities or obstacles did the program present?" Follow-up questions included "Earlier, you said something about –, could you explain that further?" or "Can you give me an example from one of your examinations?" The interviews, which lasted 45 to 60 min, were recorded on digital files and then transcribed verbatim. The participants could speak freely without pre-specified time restrictions. All participants were encouraged to provide any additional information at the end of the interview. RS, a researcher qualified in qualitative research methodology, conducted the interviews from April to July 2017. Participants were interviewed after they had conducted 20 supervised examinations and 7–10 independent examinations each.

Data analysis

The recorded text files were analyzed by RS and CK, following the steps presented by Graneheim and Lundman [33]. According to the study aim, the entire transcribed text was read several times to get a sense of the whole. The text was first analyzed for content, then divided into meaning units, followed by identification of condensed meaning units (short descriptions of the text). Codes were identified from the condensed meaning units and then labeled with terms related as closely as possible to the content of the text. Next, we compared the codes to each other and sorted codes of similar meaning into categories and subcategories (Table 1). The intention was to maintain the character of the content without altering the links between the whole text and the individual parts. RS and CK analyzed the text material, first independently in parallel and then together. The analyses were performed on a descriptive level, and discussion lasted until a consensus was reached. The final coding of data was approved after discussions that involved all authors.

Table 1 The process of qualitative content analysis, an example

Meaning unit	Condensed meaning unit	Code	Categories	Sub-category
The tutorials were good but the instructions to the tutor should be more specific, since she was uncertain if she was supposed to tell us about which findings were normal or not. Important with clear instructions about the role of the tutor, what she can tell and do.	The tutorials were good, but the tutor needs to have clear instructions on what she can tell students, e.g. about findings that are normal or not.	Tutorials good. Clear instructions required.	Prerequisites for focused cardiac ultrasound learning.	Tutorial

Results

The text analysis revealed two categories (I and II) and six subcategories of information. The categories were *prerequisites for learning FCU* and *acquisition of skills for professional development*. The categories, subcategories, and results are shown below, illustrated with quotations. Participants are referred to with a number in parentheses.

Category I: prerequisites for learning FCU

Our analysis demonstrated the importance of combining theoretical education with hands-on tutorials at appropriate time intervals to facilitate the learning process of FCU.

Subcategory: theoretical education

Respondents experienced the education in ultrasound principles, including web-based instructions, as inspiring, and with a positive effect on further learning.

I knew nothing about this before, not about ultrasound ... The theoretical education has been somewhat scanty in my case, since I have not done much reading, spent more time viewing the film sequences ... and that's been very good actually, with lots of examples of hearts in different conditions (participant 1).

The GP registrars expressed a need for specific reading instructions and instructions about which film sequences were particularly important. The findings revealed differences among the participants in the responsibility taken and the effort applied to studying the provided material:

There was plentiful material provided; more guidance in where to begin would have been nice (participant 2).

... [for example, guidance on] how much and which parts [we needed] to read, and which films were recommended (participant 1).

They also expressed a need for more education about the theoretical foundation before commencing with the supervised examinations. The tutor also referenced this need: *"A little more theoretical education before practice, yes, just so"* (participant 6).

Subcategory: learning through practice

During the 20 supervised training sessions, examination skills increased over time, according to all participants. The most challenging part was assessing cardiac function based on the recorded film sequences:

... yes, but the most crucial was to watch these film sequences, after reading about it, and then transferring it into practice (participant 4).

It also became clear to the participants that the different study patients had considerable differences in anatomy, with an impact on the difficulties the examiners experienced during the examination sessions:

Then, you noticed that it [the anatomy] differs a lot; [it influences] how easily patients are examined. Some are very easy and some are very difficult [to examine]... when I have a difficult patient, I still think it's a challenge. In that respect, I think it would have been better to have more patients to examine [in the practical training period] (participant 3).

The examiners expressed a feeling of being "thrown into practical training" when they felt their theoretical knowledge to be insufficient. The tutor also commented on this problem: *"But I think they were courageous; they had no background knowledge and were thrown out into the darkness"* (participant 6).

Subcategory: experiences from the tutorials

Concerning the assessment of cardiac function, the registrars expressed uncertainty about whether their evaluations were correct. They suggested that group tutorials should be included in the training program to give them an opportunity to discuss their evaluations of recorded film sequences compared to a

reference standard. The analysis revealed that the GP registrars had not been able to reflect on and discuss their findings in a group. In addition to group sessions, they also requested better timing and an opportunity to prepare:

... it [the group tutorial] should be conducted fairly soon after training, while the patient is fresh in mind ... also, I must have access to my examination protocol, with the patient's identification number, to be able to refer to the health record. Then I could have a look at the evaluation performed by the ultrasound professionals to determine whether I might have missed something catastrophic ... (participant 5).

There was also uncertainty about how the tutor should behave during the examination sessions:

What could be improved is more clarity about the role of the tutor; for example, what is the tutor supposed to say about findings that are normal or not normal? (participant 4).

The GP registrars found it less instructive to take part in supervised examinations performed by their colleagues. They perceived that it was more relevant to practice more of their own examinations:

In the beginning, you sat watching as much as possible, [taking in] everything ... but then, it became so that I did my own examinations and spent my time reading or writing while the others did their examinations (participant 3).

Subcategory: time aspects

The time interval between the education period and the start of the supervised examination sessions was thought to be too long (October–December 2016). This experience resulted in a waning of some of the initial gain in knowledge and inspiration by the time the examination period started. The registrars expressed a wish that the formal education and the examination sessions had occurred consecutively, but some of them also thought that an ideal interval between the education and examination sessions was about 2 weeks, to provide time for reflection:

Yes, there was some delay ... we were very excited at the start, so there was some frustration that we could not begin at once. ... this freshness you felt at the beginning, an excitement, to be focused on something new ... it would have been great to have done some examinations right at the start (participant 2).

According to the GP registrars, the time constraints of the examination sessions and tutorials contributed to a feeling of stress about the examination. However, they also desired a minimum number of patients to examine each day so that the entire examination time period would not become protracted. In addition, they experienced difficulties finding sufficient time to attend the theoretical learning and examination sessions because their curriculum as GP registrars was quite full.

The participants expressed concerns about the possibilities of introducing FCU into practice because of limitations on time schedules for consultations in primary care: *"There are possibilities for using*

ultrasound in primary care, but also obstacles, due to time constraints" (participant 4).

Category II: Acquiring skills for professional development

After the training program, the registrars were confident in the technical aspects of handling the equipment but generally expressed more uncertainty about the evaluation of the examinations. Another concern was how to maintain their level of competence after the education program ended.

Subcategory: achievement of technical skill

During the training program, the GP registrars expressed increasing confidence in obtaining good images in the standard scanning positions and in handling the device: *"I feel sure about handling the device"* (participant 1). They could also see several other diagnostic possibilities for ultrasound technology:

We have been examining the heart, but you could also examine patients for fluid in the lung or pleura fairly easily. It's certainly possible to expand the concept, to use the probe in more applications, and this will probably come naturally" (participant 2).

Another issue raised was whether FCU should be available at all primary care centers in the future.

Subcategory: professional development

The participants were generally positive and could see several possibilities for the application of FCU in primary care. Among these, they felt that it could be used as a screening tool, primarily in the rural setting, and for support in referral decisions to specialized care:

Certainly, I believe it could be a very good complement, especially in rural practice ... And if you notice something suspicious, then you refer the patient to a comprehensive examination, but [ultrasound] would be a good aid along the way (participant 3).

The examiners mentioned a gap between the technical aspects of FCU and the evaluation of cardiac function, based on the recordings: *"In the beginning, we were very focused on getting good images, and we were less concerned about the importance of what we were looking at"* (participant 1).

The examiners also mentioned the lack of a clear reference standard for distinguishing between normal and pathologic findings. This gap contributed to uncertainty about the diagnostic assessment:

The most difficult issue was the assessment. How am I to judge this in a good way? I can see [how to judge] when there are major signs of pathology, but it's more difficult when it comes to minor or moderate impairments (participant 5).

Yes, I feel more confident than I expected. But I still lack supervision, and I need to have a reference standard to lean on; I don't know if I'm doing it right ... (participant 4).

Overall, the analysis revealed that the participants had the ambition to perform correct examinations and evaluations. The learning curve was considered steep in the beginning but later leveled off.

Discussion

On the results

After completing the training program, assessment of cardiac function was generally experienced as more difficult than acquiring adequate ultrasound images in specific imaging views. To be useful at the point-of-care, FCU requires both a sufficient standard of image acquisition and a reliable assessment of recorded images, so both aspects of training need to be addressed [34]. Previously inexperienced users can learn to operate a hand-carried ultrasound device within a limited training program, according to studies conducted in clinics of cardiology and internal medicine [35-38]. The difficulties our informants cited could be related to the specific characteristics of the primary care setting, with a predominance of HF with preserved ejection fraction, compared to other types of impaired cardiac function [28]. Learning curves may also vary for achievement of technical skill and competence in interpretation of FCU examinations, but accounting for such differences is methodologically difficult [20, 39].

The main focus of the hands-on tutorials was acquisition of adequate cardiac images, whereas competence in evaluating cardiac function depended more on self-study of recorded examples provided on web-based platforms. Self-directed studies of clinical examples may be insufficient to confer confidence in assessment of cardiac function, even if the total hours of supervised training are adequate. Respondents expressed their difficulties in assessment of cardiac function as a lack of a reference standard and uncertainty about detecting minor or moderate impairments correctly. The greater difficulties that they expressed about assessment of cardiac function compared to the technical aspects of image acquisition corresponded closely with our previous findings in numeric terms: 80% of acceptable images in the major imaging views, but with poor agreement vs. reference (Cohen's kappa value = 0.22) [28]. In a recent review on the use of hand-held ultrasound scanners in medical education (training time 1–25 hours, and self-directed vs. lectures and hands-on training), the pooled values of accuracy for the detection of left ventricular dysfunction, after assessment by students, were far more impressive, with sensitivity and specificity of about 80% – 90% [40]. Training programs of diagnostic ultrasound of a single anatomic area (e.g., the heart, lungs, aorta, abdomen) intended for GPs ranges typically between approximately 2 and 30 h, but without any overall association between length of training and diagnostic accuracy [41]. Our findings indicate that in assessing the most prevalent types and grades of pathologic findings, FCU training programs should account for demographic differences between patients seen in cardiology wards and in primary care clinics.

Respondents also expressed concern about the timing of the theory and practical training sessions because of a lag of about 2 months between the first theory lecture and the start of the supervised examination series. Although this lag was mostly described as a negative experience, it also offered the possibility of self-study. The difficulties in finding the time necessary for private study contrasted with a

wish for more frequent examination periods and more patients to examine. The issue of time constraints as a barrier to the use of ultrasound in primary care clinics has been reported previously [42].

Despite the uncertainty about diagnostic assessment, respondents still regarded FCU as a potential screening tool for supporting referral decisions. The relationship between technological skills (learned in hands-on tutorials) and assessment skills (learned in clinical examples and by accumulating experience) reflected the complexity involved in validating clinical competence, where skills and knowledge of different kinds are integrated [43]. As our informants also suggesting, FCU in group tutorials may be one way to bridge the gap between the technological and experience-based aspects of the FCU learning process [44].

On the method

With qualitative methods, it is important to consider the credibility, conformability, subjectivity, and transferability of the methods [29, 36]. In our interview study, the six participants varied in age, work experience, sex, and employment location, and none of them declined to participate. The interviews were conducted according to an interview guide so that they followed the same structure. Moreover, similar follow-up questions were posed to each participant, and data were collected only by RS, who gave identical instructions to each participant. The interviews took place when the GP registrars had finished the 20 supervised FCU examinations of the learning program and had begun to examine study patients independently. RS and CK discussed and analyzed the material, first independently in parallel processes, then together. Parallel analysis is an important step in validating the analysis [45-48]. The parallel analysis continued until consensus was reached. All the authors discussed the defining categories and subcategories until agreement was reached among the authors. Quotations clarified and confirmed the findings.

This study had some limitations. The sample of participants was small, and all participants were recruited from primary care clinics within one Swedish region. This factor should be considered when evaluating the transferability of our findings to other environments of medical education. The interview study was designed and carried out with the aim of covering areas related to the learning process beyond what can be assessed through validation with numeric outcomes. Thus, our findings should be regarded as complementary to validation with a numeric reference standard.

Conclusion

After completing 20 supervised FCU training sessions, previously inexperienced examiners felt that assessment of cardiac function was generally more difficult than acquiring adequate ultrasound images. To gain confidence in assessment of cardiac function, these respondents suggested that personal feedback and group tutorials with discussion of clinical examples in smaller groups would improve learning. Demographic differences between patients who are seen in hospital wards versus in primary care clinics should also be taken into account in the design of FCU training programs.

Abbreviations

FCU: Focused cardiac ultrasound

GP: general practitioner

HF: Heart failure

Declarations

Ethics approval and consent to participate

The participants were informed that participation in the interview study was voluntary and did not affect participation in the training program. The interviews were conducted after appointment with participants, individually. The study was approved by the Regional Ethics Review Board at Umeå University (Dnr. 2016-526-32M). The study patients were enrolled after providing written informed consent to participate in the study: <http://www.clinicaltrials.gov>; unique ID: NCT02939157.

Consent for publication

Participants were informed that participation in the interview study was voluntary and that completing the interview would indicate consent to participate in the study. In the manuscript, participant comments are reported anonymized.

Availability of data and material

The datasets used and analyzed in the study will be available from the corresponding author, by reasonable request and approval from the Regional Ethics Review Board at Umeå University.

Competing interests

The authors declare that they have no competing interests. The sponsor had no input in study design, interpretation of data or writing of the manuscript.

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Authors' contributions

RS, CK, LS and GN conceived the study design and drafted the manuscript. RS performed the interviews. RS and CK performed the text analysis. All authors read and approved the final manuscript.

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References

1. Ponikowski P, Voors AA, Anker SD, Bueno H, Cleland JG, Coats AJ, et al. 2016 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure: The Task Force for the diagnosis and treatment of acute and chronic heart failure of the European Society of Cardiology (ESC) Developed with the special contribution of the Heart Failure Association (HFA) of the ESC. *Eur Heart J*. 2016;37:2129-2200.
2. Mosterd A, Hoes AW. Clinical epidemiology of heart failure. *Heart*. 2007;93:1137-1146.
3. Filippatos G, Parissis JT. Heart failure diagnosis and prognosis in the elderly: the proof of the pudding is in the eating. *Eur J Heart Fail*. 2011;13:467-471.
4. van Riet EE, Hoes AW, Limburg A, Landman MA, van der Hoeven H, Rutten FH. Prevalence of unrecognized heart failure in older persons with shortness of breath on exertion. *Eur J Heart Fail*. 2014;16:772-777.
5. Fonseca C. Diagnosis of heart failure in primary care. *Heart Fail Rev*. 2006;11:95-107.
6. Gimelli A, Lancellotti P, Badano LP, Lombardi M, Gerber B, Plein S, et al. Non-invasive cardiac imaging evaluation of patients with chronic systolic heart failure: a report from the European Association of Cardiovascular Imaging (EACVI). *Eur Heart J*. 2014;35:3417-3425.
7. Kelder JC, Cramer MJ, van Wijngaarden J, van Tooren R, Mosterd A, Moons KG, et al. The diagnostic value of physical examination and additional testing in primary care patients with suspected heart failure. *Circulation*. 2011;124:2865-2873.
8. Lang RM, Badano LP, Mor-Avi V, Afilalo J, Armstrong A, Ernande L, et al. Recommendations for cardiac chamber quantification by echocardiography in adults: an update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. *Eur Heart J Cardiovasc Imaging*. 2015;16:233-270.
9. Oudejans I, Mosterd A, Bloemen JA, Valk MJ, van Velzen E, Wielders JP, et al. Clinical evaluation of geriatric outpatients with suspected heart failure: value of symptoms, signs, and additional tests. *Eur J Heart Fail*. 2011;13:518-527.
10. Andersen GN, Graven T, Skjetne K, Mjølstad OC, Kleinau JO, Olsen O, et al. Diagnostic influence of routine point-of-care pocket-size ultrasound examinations performed by medical residents. *J Ultrasound Med*. 2015;34:627-636.
11. Bhagra A, Tierney DM, Sekiguchi H, Soni NJ. Point-of-Care Ultrasonography for Primary Care Physicians and General Internists. *Mayo Clin Proc*. 2016;91:1811-1827.
12. Martin LD, Ziegelstein RC, Howell EE, Martire C, Hellmann DB, Hirsch GA. Hospitalists' ability to use hand-carried ultrasound for central venous pressure estimation after a brief training intervention: a pilot study. *J Hosp Med*. 2013;8:711-714.

13. Mirabel M, Celermajer D, Beraud AS, Jouven X, Marijon E, Hagege AA. Pocket-sized focused cardiac ultrasound: strengths and limitations. *Arch Cardiovasc Dis.* 2015;108:197-205.
14. Di Bello V, La Carrubba S, Conte L, Fabiani I, Posteraro A, Antonini-Canterin F, et al. Incremental Value of Pocket-Sized Echocardiography in Addition to Physical Examination during Inpatient Cardiology Evaluation: A Multicenter Italian Study (SIEC). *Echocardiography.* 2015;32:1463-1470.
15. Gianstefani S, Catibog N, Whittaker AR, Ioannidis AG, Vecchio F, Wathen PT, et al. Pocket-size imaging device: effectiveness for ward-based transthoracic studies. *Eur Heart J Cardiovasc Imaging.* 2013;14:1132-1139.
16. Gustafsson M, Alehagen U, Johansson P. Imaging Congestion With a Pocket Ultrasound Device: Prognostic Implications in Patients With Chronic Heart Failure. *J Card Fail.* 2015;21:548-554.
17. Kini V, Mehta N, Mazurek JA, Ferrari VA, Epstein AJ, Groeneveld PW, et al. Focused Cardiac Ultrasound in Place of Repeat Echocardiography: Reliability and Cost Implications. *J Am Soc Echocardiogr.* 2015;28:1053-1059.
18. Kobal SL, Liel-Cohen N, Shimony S, Neuman Y, Konstantino Y, Dray EM, et al. Impact of Point-of-Care Ultrasound Examination on Triage of Patients With Suspected Cardiac Disease. *Am J Cardiol.* 2016;118:1583-1587.
19. Neskovic AN, Edvardsen T, Galderisi M, Garbi M, Gullace G, Jurcut R, et al. Focus cardiac ultrasound: the European Association of Cardiovascular Imaging viewpoint. *Eur Heart J Cardiovasc Imaging.* 2014;15:956-960.
20. Prinz C, Dohrmann J, van Buuren F, Bitter T, Bogunovic N, Horstkotte D, et al. The importance of training in echocardiography: a validation study using pocket echocardiography. *J Cardiovasc Med (Hagerstown).* 2012;13:700-707.
21. Prinz C, Voigt JU. Diagnostic accuracy of a hand-held ultrasound scanner in routine patients referred for echocardiography. *J Am Soc Echocardiogr.* 2011;24:111-116.
22. Testuz A, Muller H, Keller PF, Meyer P, Stampfli T, Sekoranza L, et al. Diagnostic accuracy of pocket-size handheld echocardiographs used by cardiologists in the acute care setting. *Eur Heart J Cardiovasc Imaging.* 2013;14:38-42.
23. Evangelista A, Galuppo V, Mendez J, Evangelista L, Arpal L, Rubio C, et al. Hand-held cardiac ultrasound screening performed by family doctors with remote expert support interpretation. *Heart.* 2016;102:376-382.
24. Mjølstad OC, Snare SR, Folkvord L, Helland F, Grimsmo A, Torp H, et al. Assessment of left ventricular function by GPs using pocket-sized ultrasound. *Fam Pract.* 2012;29:534-540.
25. Pelliccia F, Palmiero P, Maiello M, Losi MA. Italian chapter of the International Society of cardiovascular ultrasound expert consensus document on training requirements for noncardiologists using hand-carried ultrasound devices. *Echocardiography.* 2012;29:745-750.
26. Ruddox V, Norum IB, Stokke TM, Edvardsen T, Otterstad JE. Focused cardiac ultrasound by unselected residents-the challenges. *BMC Med Imaging.* 2017;17:22.

27. Ruddox V, Stokke TM, Edvardsen T, Hjelmessaeth J, Aune E, Baekkevar M, et al. The diagnostic accuracy of pocket-size cardiac ultrasound performed by unselected residents with minimal training. *Int J Cardiovasc Imaging*. 2013;29:1749-1757.
28. Nilsson G, Söderström L, Alverlind K, Samuelsson E, Moee T. Hand-held cardiac ultrasound examinations performed in primary care patients by nonexperts to identify reduced ejection fraction. *BMC Med Educ*;2019;19:282.
29. Downe-Wamboldt B. Content analysis: method, applications, and issues. *Health Care Women int*. 1992;13:313-321.
30. Graneheim UH, Lindgren BM, Lundman B. Methodological challenges in qualitative content analysis: A discussion paper. *Nurse Educ Today*. 2017;56:29-34.
31. Soni NJ, Arntfield R, Kory P. *Point-of-Care Ultrasound*. Philadelphia: Elsevier Saunders; 2015.
32. Society of Ultrasound in Medical Education. <http://www.susme.org/learning-modules/>. Accessed 4 June 2018.
33. Graneheim UH, Lundman B. Qualitative content analysis in nursing research: concepts, procedures and measures to achieve trustworthiness. *Nurse Educ Today*. 2004;24:105-112.
34. Lucas BP, Candotti C, Margeta B, Evans AT, Mba B, Baru J, et al. Diagnostic accuracy of hospitalist-performed hand-carried ultrasound echocardiography after a brief training program. *J Hosp Med*. 2009;4:340-349.
35. Andersen GN, Viset A, Mjølstad OC, Salvesen O, Dalen H, Haugen BO. Feasibility and accuracy of point-of-care pocket-size ultrasonography performed by medical students. *BMC Med Educ*. 2014;14:156.
36. Decara JM, Kirkpatrick JN, Spencer KT, Ward RP, Kasza K, Furlong K, et al. Use of hand-carried ultrasound devices to augment the accuracy of medical student bedside cardiac diagnoses. *J Am Soc Echocardiogr*. 2005;18:257-263.
37. Panoulas VF, Daigeler AL, Malaweera AS, Lota AS, Baskaran D, Rahman S, et al. Pocket-size hand-held cardiac ultrasound as an adjunct to clinical examination in the hands of medical students and junior doctors. *Eur Heart J Cardiovasc Imaging*. 2013;14:323-330.
38. Mjølstad OC, Andersen GN, Dalen H, Graven T, Skjetne K, Kleinau JO, et al. Feasibility and reliability of point-of-care pocket-size echocardiography performed by medical residents. *Eur Heart J Cardiovasc Imaging*. 2013;14:1195-1202.
39. Hellmann DB, Whiting-O'Keefe Q, Shapiro EP, Martin LD, Martire C, Ziegelstein RC. The rate at which residents learn to use hand-held echocardiography at the bedside. *Am J Med*. 2005;118:1010-1018.
40. Galusko V, Khanji MY, Bodger O, Weston C, Chambers J, Ionescu A. Hand-held Ultrasound Scanners in Medical Education: A Systematic Review. *J Cardiovasc Ultrasound*. 2017 Sep;25(3):75-83.
41. Andersen CA, Holden S, Vela J, Rathleff MS, Jensen MB. Point-of-Care Ultrasound in General Practice: A Systematic Review. *Ann Fam Med*. 2019 Jan;17(1):61-69. doi: 10.1370/afm.2330.

42. Mengel-Jørgensen T, Jensen MB. Variation in the use of point-of-care ultrasound in general practice in various European countries. Results of a survey among experts. *Eur J Gen Pract*. 2016 Dec;22(4):274-277.
43. Baig L, Violato C, Crutcher R. A construct validity study of clinical competence: a multitrait multimethod matrix approach. *J Contin Educ Health Prof*. 2010;30:19-25.
44. Kobal SL, Lior Y, Ben-Sasson A, Liel-Cohen N, Galante O, Fuchs L. The feasibility and efficacy of implementing a focused cardiac ultrasound course into a medical school curriculum. *BMC Med Educ*. 2017;17:94.
45. Cavanagh S. Content analysis: concepts, methods and applications. *Nurse Res*. 1997;4:5-16.
46. Polit DF, Beck CT. Analysis of Qualitative Data. In: *Essentials of Nursing Research*. 8 ed. Philadelphia: Wolters Kluwer Health: Lippincott Williams & Wilkins; 2014. p. 300-319.
47. Svensson PG. Förståelse, trovärdighet eller validitet? In: Svensson PG, Starrin B, Editors. *Kvalitativa studier i teori och praktik [Qualitative Studies in Theory and Practice]*; in Swedish. Lund: Studentlitteratur; 1996: p. 209-227.
48. Patton MQ. Enhancing the Quality and Credibility of Qualitative Analysis. In: *Qualitative Research and Evaluation Methods*, 3rd ed. Thousand Oaks: Sage Publications; 2002. p. 559-560.

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