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Chiara Mozzini, Ulisse Garbin, Anna Maria Fratta Pasini & Luciano Cominacini

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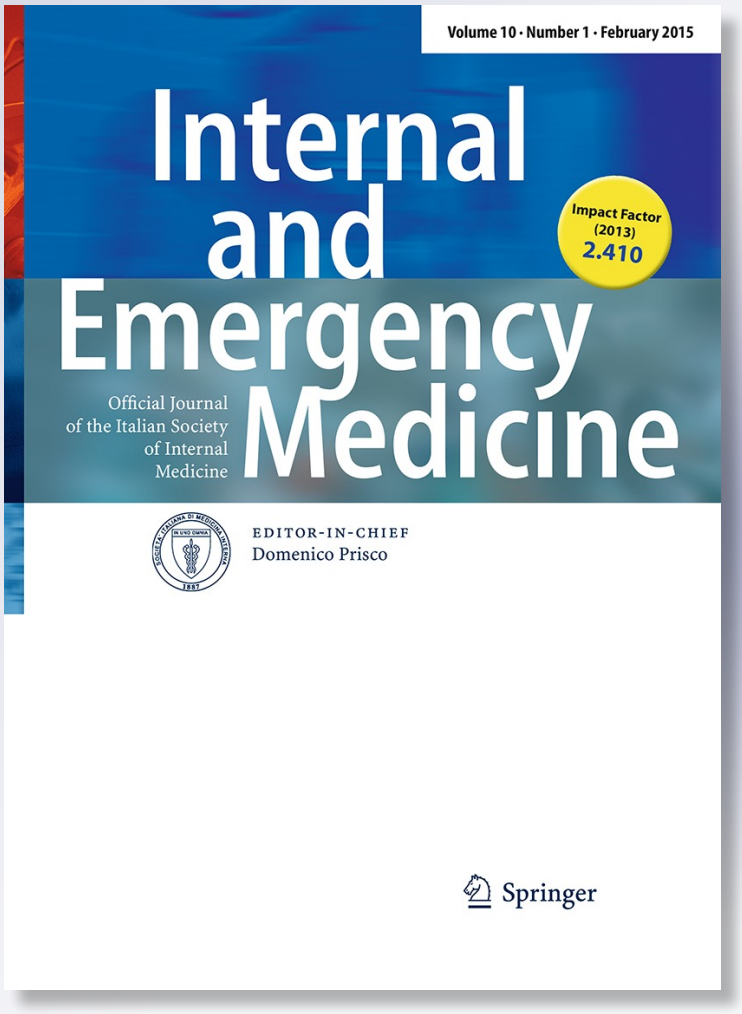

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Short training in focused cardiac ultrasound in an Internal Medicine department: what realistic skill targets could be achieved?

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Abstract The importance of focused cardiac ultrasound (FCU) in Internal Medicine care has been recognized by the American Society of Echocardiography. The aim of this study was to test what realistic skill targets could be achieved in FCU, with a relatively short training (theoretical and practical) of 9 h offered to Internal Medicine certification board attending students, and if the addition of further 9 h of training could significantly improve the level of competence. Kappa statistic was used to calculate the inter-observer agreement (trainees/tutor). The agreement between the trainees (who completed the entire training) and the tutor was, respectively, "substantial" ($k = 0.71$) for the identification of pericardial effusion, "moderate" ($k = 0.56$–0.54) for the identification of marked right ventricular and left ventricular enlargement, "substantial" ($k = 0.77$) for the assessment of global cardiac systolic function by visual inspection and "fair" ($k = 0.35$) for the assessment of size and respiratory change in the diameter of the inferior cave vein (IVC). 18 h training in FCU provided proficiency in obtaining adequate images from the parasternal window without providing the ability to correctly master the apical and subcostal windows. As concerns the interpretative skills, only pericardial effusion and visual estimation of global systolic function could be correctly identified, while ventricular enlargement and IVC prove to be more difficult to evaluate. This study supports incorporating FCU into Internal Medicine fellowship training programs, and should facilitate the design of other similar training courses.

C. Mozzini (✉) · U. Garbin · A. M. Fratta Pasini · L. Cominacini
Section of Internal Medicine, Department of Medicine, University of Verona, 10, Piazzale L.A. Scuro, 37134 Verona, Italy
e-mail: chiaramozzini@libero.it

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Introduction

Although considered a classic domain of Cardiologists, currently the use of cardiac ultrasound has extended to other specialities physicians, in particular, Anaesthesiologists/Intensivists [1–3] and Internists [4, 5].

In fact, cardiac ultrasound can permit rapid, accurate and noninvasive diagnosis of a broad range of acute cardiovascular pathologies, while the so-called "bedside echo" evaluation allows physicians to improve their clinical examination assessments of the patient.

Among the variety of terms that have been used to describe a focused ultrasound study of the heart, the American Society of Echocardiography (ASE) [6] recommends the use of the term "focused cardiac ultrasound" (FCU or FoCUS) to indicate a focused examination of the cardiovascular system by a physician using ultrasound as an adjunct to the physical examination to recognize specific ultrasonic signs that represent a narrow list of potential diagnoses in specific clinical settings.

Recently, the World Interactive Network Focused on Critical UltraSound (WINFOCUS) conducted an international, multispecialty, evidence-based, and methodologically rigorous consensus conference on FCU [7], providing a framework for FCU to standardize its application in different clinical settings around the world.

The term "Focused" defines its limited scope: to answer specific clinical questions in specific clinical contexts. The term "Cardiac ultrasound" (as opposed to "echocardiography") clarifies that it addresses a basic, simplified approach, clearly distinct from a comprehensive standard

echocardiographic examination. It is dictated by the patients' symptoms (problem oriented) and centered on the search of an answer or solution to a clinically relevant question or problem without necessarily aiming at establishing a precise final diagnosis.

Aim of FCU is the identification of the presence or absence of one or several specific findings using a defined, pre-established image acquisition protocol.

FCU is conceived to gather sufficient information to assess essential differential diagnoses, and the term "sufficient" defines the framework of this simplified approach [7].

The aim of this study was to test what realistic skill targets could be achieved in FCU, with a relatively short training of 9 h offered to Internal Medicine certification board attending students, and whether the addition of further 9 h of training could significantly improve the level of competence.

The desired level of competence consists in acquiring technical skills and interpretative skills, considering that the essence of FCU is mainly a dichotomous interpretations of the findings, and that the diagnostic approach is qualitative or semi quantitative [6, 7]. In fact, quantitative assessment of all these parameters is not a component of FCU, being even a disadvantage, because computing a calculation adds delay to a procedure for which rapid bedside evaluation is one of its major strengths, nevertheless a subjective categorization of the abnormalities is mandatory also in FCU, and then should be acquired by the trainees.

Moreover, trainees are tested to in the acquisition of secondary skill goals, which could overcome the objectives of a standard FCU evaluation.

Materials and methods

Participants

The study setting was the Internal Medicine department of the University Hospital of Verona, Italy, already certified as a first level ultrasound centre by the Società Italiana di Medicina Interna (SIMI).

Forty-three Internal Medicine certification board attending students (from the first to the fifth year of the school) with previous theoretical competence in general ultrasound (basic principles of ultrasound and basic knowledge of the devices), but without any practical experience, were invited to follow a short training in FCU (9 h of theoretical and practical training subdivided into 3 days) supervised by an echocardiography certified Internal Medicine specialist who acquired the formal competency from the Società Italiana di Ecografia Cardiovascolare (SIEC). A subgroup of students followed a further period of training (9 h subdivided into 3 days) after the first period.

Description of the training and evaluation program

After a brief theoretical summary of the basic principles of ultrasound and of the characteristics of the used device (Envisor, Philips, equipped with a sector transducer) tutor and students analysed the ASE appropriateness criteria for echocardiographic examination [8] and the ASE recommendations for quality echocardiography laboratory operations [9],

In particular, the rating criteria for defining the indication for echocardiographic examination as appropriate, inappropriate or uncertain with the used score were explained. The approach was to create five broad clinical scenarios regarding the possible use of echocardiography: (1) for initial diagnosis; (2) to guide therapy or management, regardless of symptom status; (3) to evaluate a change in clinical status or cardiac examination; (4) for early follow-up without change in clinical status; and (5) for late follow-up without change in clinical status.

Moreover the specific key elements of a standard echocardiographic report were explained.

Then, these precise lectures were proposed, with photos and records support materials, according to the ASE recommendations for the correct assessment of the echocardiographic examination [6, 7, 10–12] (that have been provided):

- the correct position of the patient during image acquisition (two photos);
- the classical transthoracic 2D-modality acoustic windows (parasternal, apical, subcostal and suprasternal) and the classical view (long-axis, short-axis and four chamber) with the recognition of the structures in different image sections (seven photos and two video clips);
- M-mode tracing modality (two photos and two video clips);
- basic principles of Doppler echocardiography (two video clips for each normal valve and two video clips for aortic, two for mitral, two for tricuspid and two for pulmonary valvular stenosis and regurgitation);
- normal range of principal cardiac parameters (in particular systolic and diastolic diameters, pressure gradients over valves, left ventricular M-Mode and aortic root and left atrium measurement, left and right ventricular end diastolic diameter, including septum thickness, diameter measurement of the IVC, quantification of the ejection fraction, EF, (modified Simpson's method) and wall motion score index (WMSI) (a

complete video clip with all the previous parameters and quantifications);
– cardiac tamponade assessment as referred to the observation on two-dimensional imaging of basic signs of compression of right-sided chambers (systolic collapse of the right atrium, diastolic collapse of the right ventricle).

These parameters were assessed according to the ASE recommendations [10, 11].

Then, during the first session for each group, the training was performed with healthy volunteers, while during the second and third session, patients enrolled from the same Internal Medicine department were studied. During the further training period (three sessions), only patients enrolled from the same department were examined.

More in detail, the desired level of competence consisted in acquiring technical skills: ability in generating the standard views and in recognizing anatomical structures, to visualize each target structure in at least two different views to confirm the findings, and interpretative skills: absence/presence of pericardial effusion; absence/presence of marked left ventricular enlargement; absence/presence of marked right ventricular enlargement (right ventricular to left ventricular diameter ratio, RV/LV ratio, >1); assessment of global cardiac systolic function by visual inspection; assessment of size and respiratory change in the diameter of the inferior cave vein (ICV), estimated by viewing.

More advances measurement skills were proposed and explained, but not considered essential objectives for the training, in particular:

– the classification of pericardial effusion (three different photos and the correspondent video clips);
– the gross assessment of valvular function and integrity [13] (three different photos and the correspondent video clips);
– the atrial chamber size (two photos and two video clips);
– the mitral and tricuspid annular plane systolic excursion (MAPSE and TAPSE indexes) (two video clips for each valve);
– the precise diameter of the IVC (two video clips);
– the aortic measurements (two photos and two video clips);
– the precise quantification of the ejection fraction (modified Simpson's rule) (two photos and two video clips);
– the regional function of the left ventricular, using the WMSI, considering the classical segmental scores (five video clips) [14].

Each trainees studied five volunteers the first day (tested as "without any cardiac abnormalities" by the trainer with an examination conducted during the teaching session) and five patients/day chosen from the department by the trainer (a complete echocardiography examination was already completed for each patient before the teaching session and a complete report was already performed by the trainer or by the hospital Cardiologist).

The trainees were blinded to the echocardiography examination report previously performed, but they have availability of all the clinical documentation of each patient, with the aim of creating a realistic clinical scenario.

The abilities were evaluated by the trainer examining the correct performance of the FCU on patients and the ability to make a correct focused diagnosis.

No specific attendance certification was issued.

Statistical analysis

Inter-observer agreement was assessed with kappa statistics based on Cohen and Fleiss' works [15, 16]. The strength of agreement of kappa coefficients was guided by the boundaries suggested by Landis and Koch [17]. Values less than 0.00 indicate "poor" reliability, 0.00–0.20 is "slight" reliability, 0.21–0.40 is "fair" reliability, 0.41–0.60 is "moderate" reliability, 0.61–0.80 is "substantial" agreement, 0.81–1.00 "excellent" or "almost perfect" agreement.

Results

The study was conducted from October 2013 to June 2014.

Thirty-five Internal Medicine certification board attending students agreed to participate in the training program (43 were the invited students, but 8 students were traveling outside of Verona to complete their certification board curriculum, so they were unable to participate).

The trainees were subdivided into seven groups of five students for each one.

Each student completed the first part of the training (9 h subdivided into 3 days), but only twelve students completed the entire training program with a further 9 h subdivided into 3 days.

Each trainee examined five healthy volunteers during the first day of the training.

Moreover, they examined 5 patients for each day of training (a total of 15 patients for the trainees who completed only the first part, and a total of 30 patents for the trainees who completed the entire course) blinded to each other as regarding the final diagnosis.

The patients were selected neither on the basis of any difficulty in image acquisition due to different acoustic windows nor on the basis of the diagnosis difficulty.

The average time to acquire and interpret FCU was tested only when patients were examined, while free time was allowed for healthy volunteer examination.

In the first 3 days, the trainees' average diagnosis time was 7 min (7 ± 1 min), while in the second 3 days, it was significantly different (4 ± 0.5 min, $p < 0.05$).

Baseline demographics of the patients and the indications to perform a FCU examination are reported in Table 1.

The agreement (k), and the strength of agreement between the trainees and the tutor in technical, interpretative and more advanced skills are displayed in Tables 2, 3 and 4.

Table 5 displays the utility of the FCU for the examined patients (the outgoing results were reported on the basis of the findings of the formal cardiac examination performed by the tutor or by the hospital Cardiologist).

More in detail, pericardiocentesis was performed for two patients and six patients underwent urgent percutaneous coronary intervention (PCI).

For the majority of the studied patients, changes in therapy or management included: for three patients the initiation of further work-up for evaluating the need for valvular replacement, for one patient the improvement of antihypertensive drug therapy, for six patients diuretics dosage implementation and β blockers introduction, for five patients confirmation of atrial enlargement and anticoagulant therapy continuation, for one patient introduction of antimicrobial drug, for two patients detection of severe cardiomegaly and the introduction of target therapy and further diagnostic evaluation.

Table 1 Baseline demographic characteristics of the examined patients and the indications requested by the physicians to perform a FCU examination

Characteristics/indications	$n = 30$ patients
Median age (years)	78 ± 5
Male/female	16/14
Obese: BMI (Kg/m^2) ≥30	9
Patient in the correct position (not supine)	21
Heart failure	5
Chest pain in suspected acute coronary syndrome	6
Atrial fibrillation	5
Suspected or known pericardial effusion	3
Suspected valvular disease (new murmur detected)	2
Fever with suspected endocarditis	1
Pulmonary embolism	2
ECG abnormalities	1
Syncope	1
Suspected pulmonary hypertension	1
Incidental finding of cardiomegaly (X-chest ray)	2
Organ damage in hypertension	1

BMI body mass index, *ECG* electrocardiogram

Discussion

This study has been designed to assess the feasibility and potential clinical utility of a short training in FCU for Internal Medicine certification board attending students with previous minimal theoretical competence in general ultrasound, with the aim of assessing what realistic skill targets could be achieved by the recognition of specific ultrasound signs that represent a narrow list of potential diagnoses in specific clinical settings.

The importance of this study also could help to collect further experiences that will promote the drawing up of more precise training protocols for FCU as already previously attempted [18]. There is still an important need for standardization in training programs and in methods to assess the trainees' proficiency, both in the evaluation of cardiac ultrasound knowledge and in the evaluation of scanning and interpretation skills.

As regarding the structure of the proposed training, the model of starting with normal volunteers seems to be a convenient and effective method to teach the key elements of image acquisition, ability in probe manipulation, generation of standard views, understanding of spatial orientation and normal anatomy. Another important point is that each measurement has been conducted based only on ASE recommendations and guidelines, to standardize each knowledge and skill. The cultural background of the statements and guidelines of this society should be mandatory, to perform a correct examination, and to create possibilities of the interpretation and approach to a complete echocardiographic examination. This is why the program has also included more advanced practical skills and notions, such as WMSI, TAPSE and MAPSE, the three measurements of the aorta etc., that are surely not required for FCU but bring about an approach to the complete echocardiographic examination.

The concept of FCU to obtain views pertinent only to the immediate clinical scenario holds the potential to greatly reduce image acquisition numbers and interpretation time while still maintaining diagnostic integrity.

This study suggests an acceptable level of skill in performing and interpreting FCU, but shows that some tasks are much more slowly learned with the apical and the subcostal view being particularly difficult to obtain. The parasternal view was the easiest to acquire and master because it is less dependent on patient positioning and body mass index. The apical, suprasternal and subcostal views were more difficult to master, and more training seems to be needed, with analogous results in other studies [18]. Left

Table 2 Agreement (*k*), 95 % confidence intervals and strength of agreement (suggested by Landis and Koch boundaries) between the trainees and the tutor in technical skills

Technical skills	9 h training students ($n = 35$)			9 + 9 h training students ($n = 12$)		
	k	95 % CI	Agreement strength	*k*	95 % CI	Agreement strength
Generation of parasternal view	0.30	0.28–0.33	Fair	0.71[a]	0.65–0.79	Substantial
Generation of apical view	0.33	0.29–0.40	Fair	0.45[a]	0.41–0.49	Moderate
Generation of subcostal view	0.28	0.25–030	Fair	0.30	0.27–0.32	Fair
Generation of suprasternal view	0.30	0.27–0.32	Fair	0.35	0.28–0.40	Fair
Recognition of anatomical structures	0.44	0.41–0.46	Moderate	0.86[a]	0.81–1.00	Excellent

CI confidence intervals

[a] Significantly different between the two groups

Table 3 Agreement (*k*), 95 % confidence intervals and strength of agreement (suggested by Landis and Koch boundaries) between the trainees and the tutor in interpretative skills

Interpretative skills	9 h training students ($n = 35$)			9 + 9 h training students ($n = 12$)		
	k	95 % CI	Agreement strength	*k*	95 % CI	Agreement strength
Absence/presence of pericardial effusion	0.30	0.28–0.33	Fair	0.71[a]	0.61–0.80	Substantial
Absence/presence of marked left ventricular enlargement	0.32	0.30–035	Fair	0.54[a]	0.49–0.59	Moderate
Absence/presence of marked right ventricular enlargement	0.28	0.26–0.31	Fair	0.56[a]	0.42–0.60	Moderate
Assessment of global cardiac systolic function by visual inspection	0.20	0.19–0.021	Slight	0.77[a]	0.73–0.80	Substantial
Assessment of size and respiratory change in the diameter of the ICV, estimated by viewing	0.14	0.11–0.16	Slight	0.35[a]	0.29–0.41	Fair

CI confidence intervals, *ICV* inferior cave vein

[a] Significantly different between the two groups

Table 4 Agreement (*k*), 95 % confidence intervals and strength of agreement (suggested by Landis and Koch boundaries) between the trainees and the tutor in more advanced skills

More advanced interpretative skills	9 h training students ($n = 35$)			9 + 9 h training students ($n = 12$)		
	k	95 % CI	Agreement strength	*k*	95 % CI	Agreement strength
Classification of pericardial effusion	n.t.	n.t.	n.t.	0.54	0.49–0.59	Moderate
Gross assessment of valvular function and integrity	n.t.	n.t.	n.t.	0.56	0.46–0.60	Moderate
Atrial chamber size	n.t.	n.t.	n.t.	0.66	0.61–0.72	Substantial
MAPSE and TAPSE indexes	n.t.	n.t.	n.t.	0.65	0.61–0.69	Substantial
Precise diameter of the IVC and collapsibility index	n.t.	n.t.	n.t.	0.14	0.11–0.16	Slight
Aortic measurements	n.t.	n.t.	n.t.	0.28	0.26–0.31	Fair
Precise quantification of ejection fraction	n.t.	n.t.	n.t.	0.42	0.41–0.43	Moderate
WMSI	n.t.	n.t.	n.t.	0.35	0.30–0.40	Fair

CI confidence intervals, *n.t.* not tested, *MAPSE* the mitral annular plane systolic excursion, *TAPSE* tricuspid annular plane systolic excursion, *IVC* inferior vein cave, *WMSI* wall motion score index

ventricular function and pericardial effusion can be assessed with limited training, but with a minimum of 18 h as shown by the results of this experience, while the assessment of valvular disease or other diagnosis requires more extensive training or experience, as has been the case with previous analogous experiences [4].

Compared to formal echocardiographic methods for the evaluation of left ventricular ejection fraction, visual estimation (eyeballing) can be done faster, and is often easier to perform, even in studies with poor visual quality. Visual ejection fraction (VEF) estimation on the parasternal long axis view closely correlated [19] with the modified

Table 5 FCU outcome for the examined patients

FCU outcome	$n = 30$ patients
Gave useful information and drove change in therapy	18
Affected immediate management	8
No useful information nor change in therapy	4

FCU focused cardiac ultrasound

Simpson's method (MSM, biplane method of discs) that is the method recommended by the ASE [10], therefore eyeballing is also confirmed to be a very good method in the present study.

The indications to perform FCU in this study, as described in the Results section, and in particular heart failure, chest pain and atrial fibrillation are confirmed as the most common indications in an Internal Medicine department [20, 21].

The importance of the knowledge of the appropriateness criteria has proven very useful in this learning context, with the possibility of commenting on the correct or incorrect appropriateness of the required examination.

FCU gave useful information, and led to a change in therapy in the majority of the analysed cases, while it affected immediate management in a consistent number of cases, but provided neither useful information nor change in therapy in only a few cases, as described in results section. This point underlines the importance of FCU.

As regarding the average time to acquire and interpret FCU, the results of this training are substantially in line with previous works, ranging from 8–10–11 min [1, 22, 23] to <5 or 3.5 [24, 25]. It is clear that a more rigorous standardization of the training programs will permit the determination of the maximum time needed to acquire and interpret the images, and also that each clinical setting will require specific time ranges (it is mandatory to remember that the standard echocardiographic examination requires approximately 1 h to obtain all the fundamental data, with additional time needed for complex cases).

The number of the trainees who completed the entire training program was limited, but the fact that they were selected neither on the basis of their interest in Cardiology nor on a prior expertise in general ultrasound, supports the quality of the results. Nevertheless, the program of Internal Medicine certification board prevented attendance for the entire duration time of the course due to the obligatory attendance in other departments.

Nevertheless, this study has several limitations: the results do not address what level of training or experience is needed to maintain the skills, but only shows the initial of training required.

Secondly, the tutor tested the skills immediately after the end of the lessons, so there are no data on long term (for example, 1 year) retention of the information.

It would also be of interest to test the trainees' ability to perform FCU without the presence of the tutor, and without the possibility of comparing their examination to the standard report.

Moreover this is a single centre experience, without allowing testing of patients derived directly from an emergency setting.

Another limitation is that the evaluation of the correlation between the trainees and the tutor was based both on quantitative but also on qualitative parameters, some of which were subjective.

In addition, there is a well-known inter- and intra-observer variability (IOV) that affects ultrasound, and so also echocardiography, not only transthoracic but also the more advanced techniques in this area [26]. In fact, intervention programs aimed in lowering the IOV have been proposed and sustained [27]. So this point could be considered a potential limitation in evaluating the success of the training programs, like this one, but the concept that a standardization of measuring methods and of training programs is necessary to minimize the IOV, has to be reinforced, considering also the different agreement in the measurements between novice but also in experienced cardiologists, with particular attention to the quantification of the EF and to the evaluation of the IVC [4, 18, 28, 29].

Finally, there is a growing use of hand-carried cardiac ultrasound devices, that are becoming commercially available, and have been used for training in FCU in several studies [1, 5, 30].

These devices do not have the all the complete technological features of the standard full-featured systems, but they are easy to use at the bedside with great usefulness for a FCU examination. In this study, the tutors preferred to use a standard ultrasound system with the possibility of changing the image platform at bedside. Hand-carried devices can be used to perform only direct studies, often without the possibility of storing the images, which can be a lack in a teaching context because all the studies can be reviewed and commented upon by the trainees. Still their small size is a tremendous advantage in the acute care environment where space is limited, and patients are receiving mechanical ventilation or continuous renal replacement therapy.

This study is intended to show that Internists can provide timely and clinically profitable echocardiographic information from their patients, allowing Cardiologists to spend more time in detecting expertise-demanding pathologies, using special echocardiographic procedures. This integrated model could be applied in various clinical settings. It is clear that a fully trained Cardiologist will

undoubtedly perform a better echocardiographic examination than an Internist, but the added value in having a diagnostic procedure performed by the same physician who is looking after the patient has to be considered: in fact, the internist will be better able to place any echocardiographic finding in a more appropriate context with the patient's other clinical problems.

Much work has to be done to standardize these training courses, trying to better identify the time to devote and the examination numbers necessary to have the ability to perform a useful FCU, because nowadays there are different protocols that consider different times and different minimum of examinations to be performed [18, 23, 31].

Conclusions

Eighteen hours training in FCU provided proficiency in obtaining adequate images from the parasternal window without providing the ability to correctly master the apical and subcostal windows. As concerns interpretative skills, only pericardial effusion and the visual estimation of global systolic function could be correctly identified, while ventricular enlargement and IVC were more difficult to evaluate. A shorter training (9 h) seems to be insufficient to reach the same results.

This study supports incorporating FCU into Internal Medicine fellowship training programs to maximize its integration into medical practice, and should facilitate the design of other training courses.

Conflict of interest None.

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