Educational pathway, competence, indication and quality process of the new classification of echocardiography according to the appropriateness of use and application

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In continuation of a previous publication, the present study will take into account for each application and profile the clinical use, the minimal data settings, the echo data findings, the indications, the quality process, the accreditation requirements, educational tailored pathway contents and modalities. The aim of the present document was to define the main applications of echocardiography and to tailor for each application-derived profile, according with the previous definitions, requirements that clearly identify the indication, objective, clinical situation in which echocardiography is used, educational pathway and training, quality process and accreditation.

Keywords: appropriateness, echocardiography, educational pathway and training

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Introduction

A previous publication has stated that a reclassification of echocardiography according to its appropriateness of use and to its function and competence-based profile and applications.\textsuperscript{1} The reason was the confused picture of echocardiography use related to the explosion in the development of the technique and the different scenarios in which echocardiography is used owing to the different physicians, machines, locations, unclear educational and training pathway and, as a final result, examinations that were not always proper and appropriate. The aim was to define the main applications of echocardiography and to tailor for each application-derived profile their proper requirements regarding the type of machine, their location, the modalities used, the competent operator, the type of reporting and archiving, the recommended educational pathway and training.

In continuing this project, the present study will take into account for each application and profile the clinical use, the minimal data settings, the echo data findings, the indications, the quality process, the accreditation requirements, educational tailored pathway contents and modalities.

Objectives

The objectives of the present study are as follows:

1. Definition of clinical situation in which echo application, or specifically echo profile, is more appropriate and indicated
2. Definition of the objectives of the examinations in that specific clinical situation
3. Suggestion of the proper indications for each profile and application
4. Definition of the process for educational pathway and training, including the different modalities and the different types of competence
5. Recommendation on the quality process and suggestions of some modalities that could be used
6. Definition of accreditation requirements for each profile organization
Summary of requirement’s definitions and the new terms used in the present and in the previous study is as follows1:(Fig. 1)

(1) ‘Application’ has been defined as general comprehensive echocardiographic means: every profile for each application has been stated with reference to the above characteristics.

(2) ‘Profiles’ have been defined as the specific use with different modalities, within each general application.

(3) ‘Clinical situation’ represents the clinical condition of the patients in which the echo examination is performed such as emergency, diagnostic detection, functional and morphological assessment, follow-up, assistance to particular procedures, visit or physical examination completeness.

(4) ‘Objectives of the echo examination’ aim to state what is expected to obtain in performing the echo examination in that given clinical situation and location, using that given machine, performing that echo application or profile. This requirement also includes a different approach to the patient and echo examination.

(5) ‘Indications’ define the specific use of each application or profile to obtain the expected and possibly accurate parameters and data for the clinical situation in which echo is used. The list of indications is reported for each profile.

**Process for educational pathway and training**

For the appropriate use of function-related echocardiography, several different levels of expertise should be defined (Fig. 2). Each level is composed by a theoretical phase, training and final examination. The theoretical phase is composed of lesson and lecture presentations on defined topics with discussions and interactions (case presentation, role playing, seminar) represented by a specific presentation based on echo data integration with the clinical/therapeutically context. The training aims to let the attendee acquire the capability to perform examinations correctly, to recognize normal and abnormal structures and to discuss the data in the clinical context. The evaluation of attendees is achieved by an intermediate and final 2-h examination.

**Primary level**

All physicians (i.e. general practitioners, internists and emergency doctors) should attain this level of expertise. The objective of this educational pathway is to provide the trainees with basic knowledge and skills to perform fast echo examination oriented to obtain gross information during clinical evaluation and to define the patient’s pathway (hospital admission, medical therapy). This level will give the attendee the necessary requirements to interpret specific echo signs during clinical examination or emergency.

The first phase (theoretical) lasts 40 h and includes theoretical presentations (a total of 20 h) and interactive presentation/discussion (e.g., case presentations, role playing, team working) (a total of 20 h). Two additional hours should be planned for multiple-choice examination.

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Recategorization of echocardiography according to function, competence, application and profiles. In Advanced CV echo ‘Standard adult and pediatric’ includes TTE, TEE and Vascular Echo.
The second phase (training) lasts 40 h in the echo lab and 20 h (1 week) in the emergency room (CCU, ICU). In the echo lab, the attendee will be trained by a certified tutor on the equipment, probes and their correct use, approaches, sections, correct examination performance including long axis, short axis and four chamber view image acquisition and structure acquisition, aortic, carotid and inferior vena cava approach and image acquisition targeted to cardiac and vascular structure acquisition, correct use of colour Doppler and recognition of flow and its direction; acquisition of visual capability to detect dimensions, the presence of valvular abnormal flow, pericardial and pleural effusion, motion abnormality. A checklist of acquisition during training will lead the tutor to verify the effective completion of this phase.

In the emergency room, the attendee will get echo knowledge on pathological conditions and related findings with particular attention to dimensions, wall motion, rupture, abnormal flow direction, pericardial effusion, intracavitary mass, dissection, obstruction, aneurysm and reference to the clinical context and the specific presence of shock, dyspnoea, angina, pulseless electromechanical activity. At the end of the training, the attendee should have performed and reported 50 examinations.

The last phase of 2 h to be spent performing the final examination (multiple choice, video clip evaluation).

General level

All cardiologists or equivalent specialists and cardiology technicians (in Italy, those who have a 3-year degree in technician of cardiovascular pathophysiology) must attain this level of expertise. This level should provide the knowledge and experience necessary to perform and interpret resting transthoracic (TTE) and transesophageal (TEE) M-mode, 2D, Doppler and colour Doppler examinations.

The general level will give the attendee the competence to perform, interpret and report echocardiographic examinations (only performance knowledge for cardiology technicians), together with the necessary requirement to attend educational programmes for various special echo procedures (high and specific levels).

The first phase (theoretical) lasts 80 h and includes theoretical presentations (a total of 40 h) and interactive presentation/discussion (e.g. case presentations, role playing, team working) (a total of 40 h).

The second phase (training) lasts 80 h in the echo lab and 40 h in the coronary care unit/cardiology ward/outpatient service wherein the attendee will acquire the ability to perform, interpret and report TTE independently (only physicians) and the basic knowledge of TEE. The final number of examinations to be performed is 100.
A certified tutor will train the attendee in:

(1) Setting and controls of echo machine, typical artefacts and biological effects of ultrasound, probes and their correct use
(2) Approaches, sections, correct examination performance in all cardiovascular diseases
(3) Understanding the principles of Doppler echocardiography, being able to choose from different modalities (pulse wave – PW, continuous wave – CW, colour, tissue Doppler imaging – TDI) those that apply for adequate measurements with specific clinical use
(4) Reporting and communicating effectively echocardiography results to healthcare professionals and patients
(5) Specific application and modalities of echocardiography and other noninvasive imaging modalities (integration for better management of patients)
(6) Knowledge of reprocessing phase of transesophageal probe and related risk exposure for the patient and operator

The last phase of 2 h is spent performing the final examination (multiple choice, video clip evaluation).

**High level**

High level is for all those who have attained the general level but not technicians. This level will provide expertise that would enable the trainee to direct an echocardiography laboratory with great additional expertise in various special ultrasound procedures [at least three of the following: transesophageal, stress echo, wall dynamics, vascular (mandatory for vascular echo lab), 3/4D echo, paediatric echo (mandatory for pediatric echo lab)].

Evidence of competency is established through completion of a training programme; the pre-requisite is the general level.

The first phase (theoretical) lasts 40 h for each profile and includes theoretical presentations (a total of 20 h) and interactive presentation/discussion (e.g. case presentations, role playing, team working) (a total of 20 h).

The content of the theoretical phase is that defined by the Italian Society of Cardiovascular Echography and International Societies of Echocardiography for each profile.²⁻¹¹

The second phase (training) will last 40 h in the echo lab and 20 h (1 week) in specific activities for each profile. The content for each single profile and the number of examinations to be performed are those reported by the Italian Society of Cardiovascular Echography and International Societies of Echocardiography.

Final examination is the last phase, lasts 2 h to be spent for final examination (multiple choices, video clip evaluation).

**Specific level**

All cardiologists or equivalent specialists (anaesthetist, cardiac surgeon, intensivist) should attain this level after attending general level and high level in TEE (as prerequisites). This level provides expertise in a specific echo application field, such as:

(1) Echo in the coronary care unit (CCUE)
(2) Echo in the ICU (ICUE)
(3) Echo in the interventional cath-lab
(4) Echo in the interventional electrophysiology lab
(5) Echo in the operating room

The educational content of the theoretical phase, training and final examination will be different for each profile.

The first phase (theoretical) includes specific content for each type in all core issues. It consists of 24 h and includes 12 h of theoretical presentations and 12 h of interactive lessons (e.g. case presentations, role playing, team working).

The second phase (training) lasts 24 h within the specific echo application and a minimum number of 15 echo studies for each profile (observed and performed) that allows the trainee to acquire the ability to perform examination independently (pre, during and postprocedure) providing both anatomic and haemodynamic information, with the ability to collect and report all necessary data for patient management in any focused examination. Two additional weeks are required to spend in coronary/ICU or cath/electrophysiology lab.

Recommendations for training duration are used to facilitate the organization of a focused training programme. However, the aim is not based on a specific duration of training, but on obtaining the required expertise.

A specific echo check list with a minimum number of cases, validated by a tutor, to substantiate the experience acquired during training, shall be defined and implemented in accordance with international scientific societies.¹²⁻²⁰

The final phase (examination) lasts 2 h to be spent for final examination (multiple choices, video clip evaluation).

Modules represent the component of the educational programmes; each module is composed of 4 h. Two different types of module are suggested:

(1) Two hours of theoretical content and 2 h of interaction. In this case, the theoretical phase may be provided in subsequent days (short periods). Training will be performed separately in the theoretical phase in accredited echo laboratories under the supervision of a certified tutor, using a predefined checklist. This is suggested for scientific societies.
Table 1  Education for competence

<table>
<thead>
<tr>
<th>Educational level</th>
<th>Application</th>
<th>Pre-requrement</th>
<th>Training</th>
<th>Competence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary (PL)</td>
<td>Basic (noncardiologist)</td>
<td>FAST</td>
<td>Hours: 60</td>
<td>Visit-extended CV echo</td>
</tr>
<tr>
<td></td>
<td></td>
<td>//</td>
<td>Examinations: 50</td>
<td>First aid, On the road</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Hours: 120</td>
<td>Standard CV echo</td>
</tr>
<tr>
<td></td>
<td>General (GL)</td>
<td>Basic (cardiologist)</td>
<td>Examinations: 100</td>
<td>Visit-extended CV echo</td>
</tr>
<tr>
<td></td>
<td></td>
<td>//</td>
<td>Hours: 60</td>
<td>TEE, Stress, WD, 3D, paediatric, vascular</td>
</tr>
<tr>
<td></td>
<td>High (HL)</td>
<td>Advanced</td>
<td>Examinations: 50 for each profile</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>GL</td>
<td>Examinations: 200 for vascular</td>
<td></td>
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<tr>
<td></td>
<td>Specific (SL)</td>
<td>Focused</td>
<td>Hours: 24</td>
<td>CCU, ICU, cath-lab, electrolab, operating room</td>
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<tr>
<td></td>
<td></td>
<td>GL and High (TEE)</td>
<td>Examinations: 15 for each profile</td>
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</tbody>
</table>

(2) One hour of theoretical content, 1 h interaction, 2 h of training on the same topic. This may be provided in the subsequent weekend (long period) with homogeneous content and should be useful for a university programme.

A summary of the educational pathways is reported in Tables 1 and 2.

Quality, individual certification and laboratory accreditation

Quality involves the assurance and management of organization and processes and the control process of the products (quality, appropriateness, requirements, reporting, validation and so on of echocardiographic examination).

The quality management of organization is referred to competency educational pathways and to the activity and echo applications. The organizations shall be quality and accreditation certified. According to the international, national and scientific societies, rules, responsibility, organization, processes, products, operators, archiving and report modalities, quality control and improvement shall be defined and periodically applied and the improvement of the quality process of the laboratory involves all the professionals working in it. 24,21–23

The processes shall be clearly defined and applied regarding the educational/competence pathway, with particular reference to the input requirements, the phases, the modalities of achievement and control, and the management of output/outcome. The processes of organizations shall be clearly defined and periodically controlled and improved.

The product, as a competence certification, shall be defined with reference to modalities of obtaining and maintaining, the content of the pathway, the requirements of lecturers and the modalities of their selection, and the modality of evaluation and certification.

The product, as an echocardiographic examination, shall be defined and applied with reference to the modalities of obtaining, the minimal data setting, the reporting and archiving, customer satisfaction and the quality control and validation process. Regarding the latter, the registry is suggested for each application and profile. The registry shall have patient personal and clinical data, reporting including quantitative and qualitative analysis, images (video clip or image freeze) supporting reporting and validation processes (by means of audit periodically performed and finally signed and archived). 24–7,21–24

Applications

Basic echo

Definition  It is a cardiovascular ECHO with basic modalities and approaches oriented to obtain an initial diagnosis and a clinical conclusion in the patient pathway (after complete clinical examination), or to require an extension in clinical examination and advanced echocardiography (Table 3).

Clinical situation  Basic echo shall be used for primary gross diagnosis in the clinical evaluation and to complete the cardiological visit during consultation.

Profiles  The following profiles have been defined:

(1) Standard cardiovascular echo, performed by cardiologists in outpatient cardiology service (either located

Table 2  Maintenance of competence

<table>
<thead>
<tr>
<th>Level</th>
<th>Renewal years</th>
<th>No. of examinations/year</th>
<th>Log book case mix examinations</th>
<th>ECM credits/5/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary</td>
<td>5</td>
<td>50</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>General</td>
<td>5</td>
<td>300</td>
<td>50</td>
<td>10</td>
</tr>
<tr>
<td>High</td>
<td>5</td>
<td>30 paediatric</td>
<td>10 paediatric</td>
<td>10</td>
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<tr>
<td></td>
<td></td>
<td>150 vascular</td>
<td>90 vascular</td>
<td></td>
</tr>
<tr>
<td>Specific</td>
<td>3</td>
<td>10 per procedure</td>
<td>5</td>
<td>10</td>
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</table>

*Attendance in echo meetings related to the specific competence.
out of the hospital or in hospital as a dedicated section of echo lab), especially for first diagnosis
(2) Visit-extended cardiovascular echo, performed by cardiologists, internists, general practitioners at bedside in hospital ward, in outpatient cardiology care, general practice, to complete the clinical evaluation

Objectives and indications are reported in Table 3.

Education/training/competence included general (or basic/primary for general practitioners) level education pathway and competence is the minimum requirement. Certification competence is provided by scientific societies of echo.2–5

**Advanced echo**

**Definition** This is a high-level cardiovascular echography, reference for clinical and instrumental diagnosis of adult and paediatric cardiovascular abnormalities and function, for detailed indication of medical and surgical treatment, for integration with other imaging diagnostic tools, for education, for health technology assessment and for research.

<table>
<thead>
<tr>
<th>Table 3 Applications</th>
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<tbody>
<tr>
<td><strong>Clinical situation</strong></td>
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<tr>
<td>Basic: Clinical evaluation</td>
</tr>
<tr>
<td>Primary diagnosis</td>
</tr>
<tr>
<td>Visit completeness</td>
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<tr>
<td>Advanced Detailed diagnosis Functional: Assessment follow-up</td>
</tr>
<tr>
<td>Focused Diagnosis in critical care Procedure assisting</td>
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<tr>
<td>Focused Emergency Critical situation</td>
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</table>

**Clinical situation** It includes detailed diagnosis, assessment, follow-up and research. A comprehensive, detailed and complete examination of cardiovascular system is provided as well as a fine and detailed anatomically and functionally description of cardiovascular structures. Diagnosis of cardiovascular disease is finalized to medical/surgical treatment, prognosis, follow-up and research.

**Profiles**

They are represented by complete:

1. TTE and TEE
2. Wall dynamics, 3/4D and stress echo
3. Vascular echo
4. Paediatric echo.

Objectives and indications are reported in Table 3.

Education/training/competence included high-level education pathway and competence is required.

**Focused echo**

**Definition** This is a cardiovascular echography performed by specialist doctors, in different places and
Clinical settings to obtain information, which at that time they require. It is an examination that answers a specific diagnostic question. The objectives are to detect focused information and to answer specific questions in particular cardiovascular situations and context.

Clinical situation These applications provide diagnosis in critical care and in procedure assistance.

Profiles The following profiles have been defined:

1. CCUE
2. ICUE
3. Echo in the interventional cath-lab
4. Echo in the interventional electrophysiology lab
5. Echo in operating room
   a. CCCU and ICUE are focused cardiovascular echo oriented to gross diagnosis, to check the clinical situation and to focusing an emergency condition obtaining immediate information for the present clinical evaluation and therapeutic decision-making.  
   b. Echo in an interventional cath-lab is a focused cardiovascular echo performed in interventional cath-laboratory. Echo examination, followed by a previous detailed examination, is oriented to plan, monitor and finally assess the interventional procedure with particular attention to the onset of unexpected complications.
   c. Echo in an interventional electrophysiology lab is a focused cardiovascular echo performed in an interventional electrophysiology laboratory. Echo examination, followed by a previous detailed examination, is oriented to assess mechanical and electrical abnormalities, to plan, monitor and finally assess the interventional procedure with particular attention to the onset of unexpected complications.
   d. Echo in an operating room is a focused cardiovascular echo performed in an interventional operating room oriented to provide important anatomic, morphological and function information on the cardiac patient during surgery, echo examination, followed by a previous detailed examination, is oriented to surgical planning, monitoring and finally postoperative management of patients with particular attention to the onset of unexpected complications.

Objectives and indications are reported in Table 3.

Education/training/competence including basic/primary-level education pathway and competence is required.

Discussion

The different scenarios requiring the use of echocardiography have aroused the need for an updated redefinition of applications and profiles related to the appropriateness of function and to the different physicians, machines, locations, modalities and proper indications of examinations. The purpose of the present document was to provide, according with the previous definitions, requirements that clearly identify the indication, objective and clinical situation in which echocardiography is used, the educational pathway and training, quality process and accreditation. According to this, it is important to provide some statement in order to understand the main significance of the documents.

It is important to say and emphasize that echocardiography should be a method that belongs to those who know how to use it in a correct and appropriate way. This means that echo is a powerful diagnostic tool to be used not only in the echo lab or in outpatients services or in cardiology wards by cardiologists but also in many other clinical situations and locations by other specialists such as ICU, emergency, bedside by the general practitioner and anaesthetist if they are well trained and certified. In this case, an additional educational content and training should be administered regarding chest and abdominal scanning and presented to allow the operators to recognize the presence of liquid or air where they are
not usually present or pulmonary comets or organ fracture.  

Not all of the machines are suitable to perform a complete echocardiographic examination. Machines are classified as stationary, mobile, portable and pocket and this is not only related to the location and clinical situation in which echo examination is performed but also to what should be looked for and which modality is more suitable to use in that given situation. In this field, the present document aims to contribute to the validation of the equipment even if this should have been the responsibility of industry. In fact, industry often promotes and markets machines that are not completely validated and have a more or less long period of uncertainty whose cost has a social burden and impact. Publications exist on technical feasibility, less on diagnostic accuracy, rare or none on therapeutic, patient outcome and social impact. This is due to the incompletely or not applied process of health technology assessment before the machine is placed on the market. Despite this being the industry’s responsibility, the reclassification of echocardiography reported in the present and previous document tries to also provide indications of the appropriateness of use of the machines in addition to their possible incremental value in the clinical and diagnostic process.

As the scenario of echocardiography use involves different clinical situations, objectives and purposes, modalities, examination content, operators, machine types and locations, a suitable educational pathway and training has been defined for application and profile. An educational programme and training are the most important requirements for the different operators who want to use echocardiography in the clinical condition and location they are in. This pathway has been designed and tailored with specific objectives and diagnostic needs. A well trained operator taught by skilled tutors and holding their competence certification should be conditioning echocardiographic performance in any application; without this, the risks of mistakes, abuse and incorrect and inappropriate examinations could lead echocardiography to be dangerous.

Given that in Italy the only legal entities authorized to provide education and training are universities and that scientific societies may have a supportive and active role in promoting certified educational pathways (that for obvious reasons have a cultural but no legal validation) in addition to scientific and cultural events, educational pathways and training should be performed suitably and appropriately in respect of the above-reported levels, leading all attendees to their respective competence. It is our opinion that, with respect to the role, attributes and competences, respectively, recognized by universities and scientific societies, the cooperation of both entities, the first as legally authorized to education, the second for its specific competence in the field, will lead to a more qualified educational and training pathway and to recognized certification of attendees in the different levels. This cooperation could be provided in organizing post-degree education such as a masters degree in echocardiography (i.e. all the levels proposed).

Another point worth discussion is that regarding a sonographer. At present, this role does not exist in Italy. Therefore, it is evident that nurses or other individuals who have performed an educational pathway in echocardiography and at the end are competency certified, are not legally recognized in practicing this activity. This implies that any attendance of these individuals on a course or educational pathway shall be considered only as personal cultural enrichment. For this reason, the educational pathways reported in this study mention physicians and not nurses or other individuals who may attend anyway but only for cultural purposes. A different situation applies to those individuals who have a degree as a technician of cardiovascular pathophysiology because they are recognized cardiology technicians, and for this reason, we suggest that they may attend the educational pathway at the general level in echocardiography.

The quality of organization has an influence on all the activities of echocardiography. To control this means to have examinations of high quality, satisfied customers and the possibility to improve processes. In addition, the quality process is an important step in the validation of the echocardiographic examination to be performed periodically to improve accuracy, reliability, correctness, reproducibility and variability of echo examinations and skill, experience and competence of operators. Each in his own specific application/profile should compare data and opinions periodically with higher level competence (structure and/or skilled operator). A registry in which validated examinations are archived should be provided; this qualifies the improvement level of the echo lab and operator, giving guarantees of comparability and reproducibility and attesting the validated activity of both. Within this, a minimal data setting and accreditation requirements for each application/profile should be defined.

**Conclusion**

A suitable educational pathway and training are basic conditions to perform echocardiography in a correct and appropriate way. This should be properly tailored in accordance with the application of echo and its specific profiles. Echo indications, objectives and clinical situations should be constantly taken into account in order to differentiate information that are obtained for immediate clinical assessment from those necessary for diagnosis and detailed evaluation. Machines should be properly used for their specific purpose. The present classification has important political and economic implications regarding particularly the appropriate and cost-effective use of echocardiography, the choice of the correct and suitable
machine to be used for the defined purpose, the performance of echocardiography by well trained and certified operators. What can be expected is an increase of appropriate examinations and interpretation of physician’s clinical data, a major prevention of unexpected mistakes, a more appropriate assignment of the patient to therapeutic treatment or intervention, a decrease of risks, of inappropriate examinations, of unnecessary or wrong examinations, of improper use of machines and of consequent costs. On the contrary, an inappropriate use of echocardiography by an untrained operator and out of the clinical context could be dangerous, unnecessarily costly and ineffective. Finally, a quality process of organization and product periodically planned and achieved shall be a basic condition for reduction of mistakes and continuous improvement of cost-effectiveness, efficiency and appropriateness.

References


