Organisation of paediatric echocardiography laboratories and governance of echocardiography services and training in Europe: current status, disparities, and potential solutions: a survey from the Association for European Paediatric and Congenital Cardiology (AEPC) imaging working group

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Abstract

Background: There is limited data on the organisation of paediatric echocardiography laboratories in Europe. *Methods:* A structured and approved questionnaire was circulated across all 95 Association for European Paediatric and Congenital Cardiology affiliated centres. The aims were to evaluate: (1) facilities in paediatric echocardiography laboratories across Europe, (2) accredited laboratories, (3) medical/paramedical staff employed, (4) time for echocardiographic studies and reporting, and (5) training, teaching, quality improvement, and research programs. *Results:* Respondents from forty-three centres (45%) in 22 countries completed the survey. Thirty-six centres (84%) have a dedicated paediatric echocardiography laboratory, only five (12%) of which reported they were European Association of Cardiovascular Imaging accredited. The median number of echocardiography rooms was three (range 1–12), and echocardiography machines was four (range 1–12). Only half of all the centres have dedicated imaging physiologists and/or nursing staff, while the majority (79%) have specialist imaging cardiologist(s). The median (range) duration of time for a new examination was 45 (20–60) minutes, and for repeat examination was 20 (5–30) minutes. More than half of respondents (58%) have dedicated time for reporting. An organised training program was present in most centres (78%), 44% undertake quality assurance, and 79% perform research. Guidelines for performing echocardiography were available in 32 centres (74%). *Conclusion:* Facilities, staffing levels, study times, standards in teaching/training, and quality assurance vary widely across paediatric echocardiography laboratories in Europe. Greater support and investment to facilitate improvements in staffing levels, equipment, and governance would potentially improve European paediatric echocardiography laboratories.

Europe is a large continent made up of a myriad of countries of different cultures, size, economic wealth, and levels of healthcare organisation.[1] Recent studies have highlighted marked variation in training for paediatric and adult congenital cardiology trainees across Europe.[1] Previous reports have called for standardisation and accreditation of adult echocardiography laboratories across Europe.[2] These reports have led us to examine the current organisational level and governance of paediatric echocardiography laboratories and services across Europe. It is also unclear what facilities exist across European centres in terms of infrastructure (echocardiography rooms, machines), staffing levels (cardiologists, imaging sonographers and nursing staff), and governance (quality monitoring, morbidity and mortality, and research). Quality improvement processes have been proposed by multiple sources to reduce diagnostic errors,[3–7] optimise the quality of reporting,[8,9] and data interpretation,[10] but a standardised approach is still lacking. Despite being essential for quality improvement as well as structured teaching programmes,[11–13] accreditation of echocardiographic laboratories[14–16] is often lacking in cardiology programmes.

Any laboratory is eligible to apply for European Association for Cardiovascular Imaging certification (in transthoracic echocardiography) once two criteria have been met: (1) the laboratory has been in existence for greater than 3 years and (2) either the laboratory head, lead or one of the imaging cardiologists holds the individual European Association of Cardiovascular Imaging certification. This holds true for adult and paediatric echocardiography laboratories and also for private and public hospitals. https://www.escardio.org/Education/Career-Development/Accreditation/EACVI-Laboratory-accreditation/eacvi-laboratory-accreditation-in-echocardiography

Accreditation of echocardiography laboratories in general has specific objectives:

to raise quality standards of practice and equipment, to be used as an educational tool to improve the quality of echocardiography laboratories, to provide standards for benchmarking and lastly to provide evidence for the need to upgrade equipment and facilities in laboratories without such facilities. There are also further educational, scientific, research, and economic benefits (https://www.escardio.org).

Given this knowledge gap, this study sought to determine (1) what facilities exist in paediatric echocardiography laboratories across Europe, (2) how many centres have European Association of Cardiovascular Imaging accredited laboratories, (3) which medical/paramedical staff are employed in these labs, (4) how much time is allocated to echocardiographic studies and reporting of studies, (5) what training, teaching, quality improvement, and research programmes exists in these centres. Are paediatric cardiologists across Europe provided with sufficient equipment, facilities, and time for echocardiographic examination, diagnosis, reporting, teaching, and for undertaking research? What is the level of satisfaction among medical staff and what are the options for improving quality of echocardiographic lab performance?

Methods

The Association for European Paediatric and Congenital Cardiology is the largest democratically administered global association in the field of congenital cardiology with an overall membership of more than 1000 members across 32 European countries. (https://www.aepc.org/about-AEPC). The Association for European Paediatric and Congenital Cardiology is further subdivided into 12 specialist working groups, the largest amongst these is the Imaging Working Group with over 200 members. A structured and approved detailed survey (Appendix 1) was constructed by the Association for European Paediatric and Congenital Cardiology Imaging Management Committee and was circulated to all Imaging Working Group members in all 95 Association for European Paediatric and Congenital Cardiology affiliated centres. The survey was in SurveyMonkey® format to facilitate ease of completion. If there was no answer to the initial invitation, a second and third email was circulated to the member.

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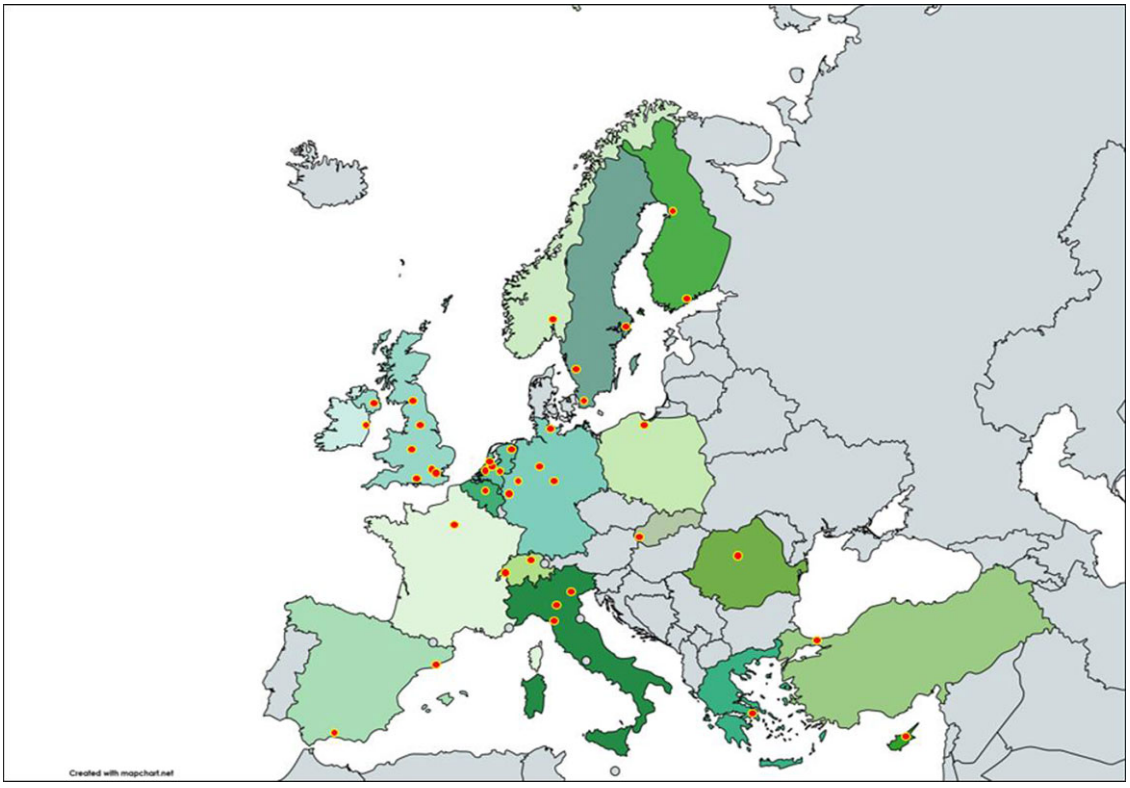

Figure 1. Centres participating in European paediatric echocardiography laboratory study.

Statistical analysis: Data was presented as median (range).

The Ethics department at Children's Health Ireland, Crumlin, Dublin, Ireland waived ethical approval as this was a survey-based study.

Definitions

'Accreditation' is defined as the act of being recognised officially as providing a specific high standard of cardiovascular imaging by the European Association of Cardiovascular Imaging.

'Imaging Working Group' is a specialist working group of the Association for European Paediatric and Congenital Cardiology society, which is focused on cardiac imaging, specifically echocardiography, magnetic resonance imaging, and computed tomography. The management committee group consists of eight elected office holders.

'Imaging working group members' are all Association for European Paediatric and Congenital Cardiology members who register as belonging to the cohort of paediatric cardiologists who are trained, practice and work in cardiovascular imaging. There are approximately 200 members and this is the largest group within the Association for European Paediatric and Congenital Cardiology organisation.

'Trainees' were defined as physician or doctor trainees in paediatric cardiology training centres undertaking paediatric cardiology training.

Results

Paediatric cardiologists, who were imaging working group members, from ninety-five European paediatric cardiology centres were initially invited to participate in the survey. After repeated invitations, delegates from forty-three paediatric cardiology centres (45%) from 22 different European countries completed the survey (Fig. 1). The median number of transthoracic echocardiograms per annum was 7,500 (range 2,500–20,000). The median number of cardiopulmonary bypass procedures per annum was 250 (range 175–550).

European echocardiography facilities

Guidelines for performing echocardiography were available in 32 centres (76%). Thirty-six centres (84%) reported having an identifiable echocardiography laboratory and all 36 were stand-alone dedicated paediatric laboratories. Seven respondents reported that they did not have an identifiable laboratory. Most laboratories were located in or adjacent to the outpatient department (n = 26, 60%); however, in every centre, echocardiography was undertaken at multiple locations, including the cardiology department, ICU and operating room. The median number of echocardiography rooms was three (range 1–12) (Fig. 2) and the median number of echocardiography machines in use was four (range 1–12) (Fig. 3). Sedated echocardiography (Fig. 4) was available in 39 laboratories (91%) and in 22 (52%), sedated echocardiography was performed in a dedicated clinical space. A protocol for sedated echocardiography was utilised in 34 centres (79%). Guidelines for transthoracic, trans-oesophageal, and fetal echocardiography were available in 74, 45 and 63% of centres, respectively.

3D-capable echocardiography machines were present in 24 centres (56%). Twenty-nine (67%) centres have a separate fetal echocardiography area. Fetal echocardiography is performed in the paediatric cardiology department in less than half of the cases (20 centres, 47%), and in the maternity hospital separate from the cardiac unit in the remainder (23 centres, 53%).

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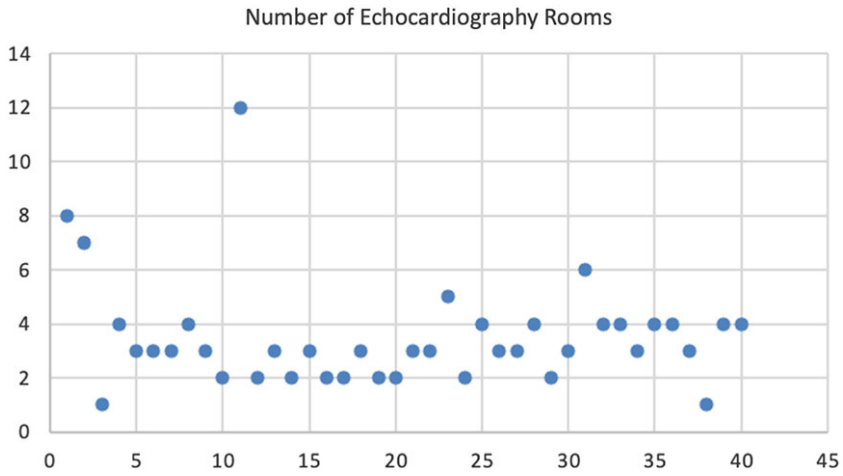

Figure 2. Distribution of echo room numbers across echo laboratories.

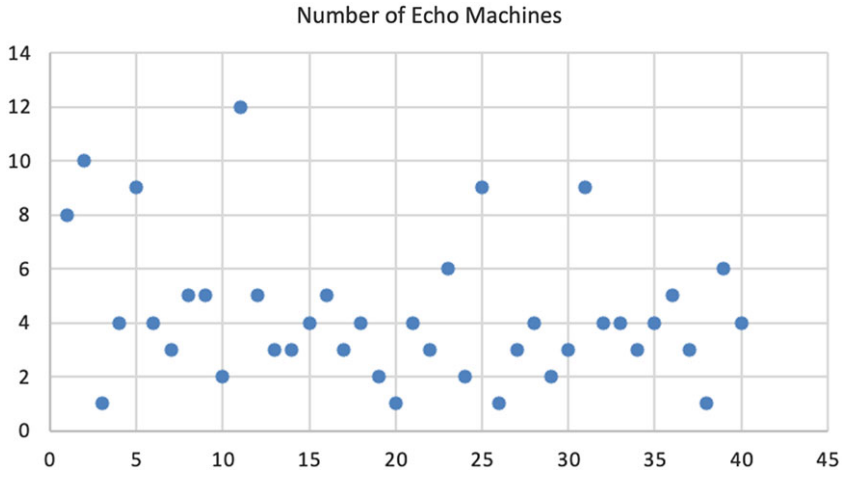

Figure 3. Distribution of echo machines across echo laboratories.

Accredited labs

A minority of the centres (n = 5, 12%) reported they had European Association of Cardiovascular Imaging laboratory accreditation (Fig. 5). More than half (59%) of non-accredited laboratories were interested in achieving accreditation (Fig. 6). Only two countries (Italy and UK) reported a national accreditation system (Italian National Accreditation Society of Cardiovascular Imaging and the British Society Echocardiography).

Staffing of European echocardiography laboratories

Cardiologists perform most of the echocardiograms in half of the centres (23 centres, 55%), as only half of the centres (22 centres, 51%) have dedicated imaging physiologists (median 4, range 0–15). In 14 centres (35%), cardiac physiologists perform the majority of studies. Nearly all the cardiologists report echocardiographic examinations (98%); however, only 79% (33) of the centres have specialist imaging cardiologists.

Individual CHD-Echo certification is available to doctors, nurses, and physiologists via a structured curriculum-based examination process overseen jointly by the European Association of Cardiovascular Imaging and the Association for European Paediatric and Congenital Cardiology. In five centres (12%), all cardiologists were (European Association of Cardiovascular Imaging-Association for European Paediatric and Congenital Cardiology) certified in CHD Echocardiography. In 24%, most of the cardiologists had some form of certification (National or European Association of Cardiovascular Imaging-Association for European Paediatric and Congenital Cardiology). Less than half (20 centres, 47%) of echocardiography centres have nursing staff specifically dedicated to the echocardiography service.

Echocardiography examination and reporting organisation (time, slots)

In 77% of responders, a first echocardiographic examination takes < 1 hour, and in 65% a repeat examination takes < 30 minutes. The median duration of time for a first examination was 45 minutes (range 30–60 minutes depending on the complexity) and repeat examination was 20 minutes (range 5–40 minutes). Thirty-two centres (74%) reported use of guidelines for performing echocardiography in their laboratories. Twenty-nine laboratories (65%) have assigned time slots for studies.

Reporting is accomplished in a dedicated reporting session in 59%, while in 43% is performed as part of the actual examination. Most centres (72%) report their echocardiograms in multiple locations (echocardiography laboratory, outpatients, and office) (Fig. 7), and 71% have reporting work stations adjacent to the echocardiography room(s).

Training, teaching, quality improvement, and research

Training

Thirty-two (78%) centres have an organised training programme (Figs. 8 and 9), nine centres (23%) have training "bootcamp" for

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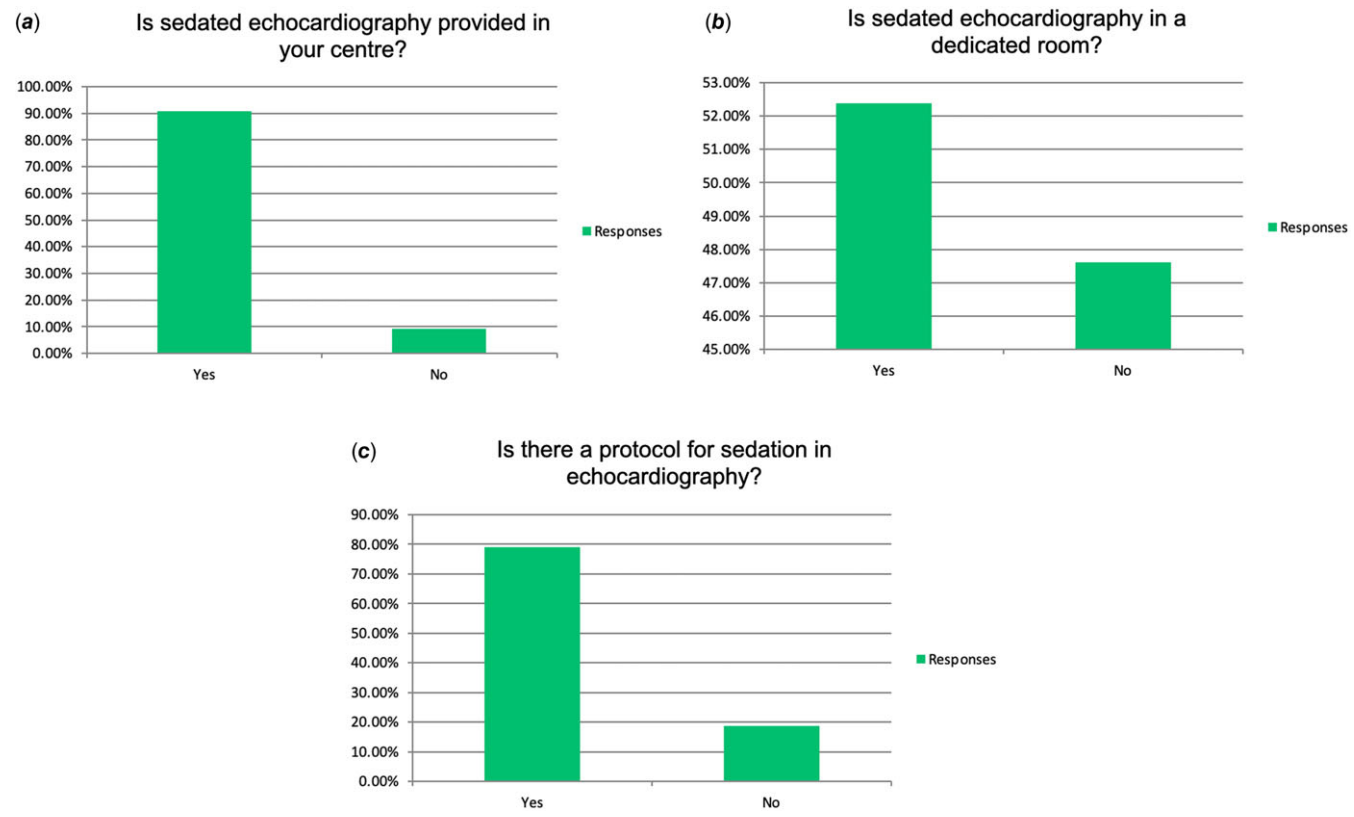

Figure 4. A, B, C. sedation provided in echocardiography laboratories. A. B. C.

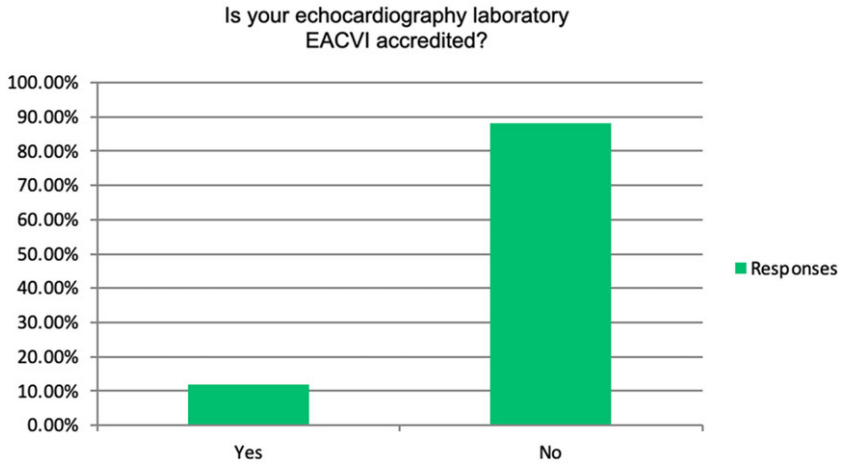

Figure 5. European Association of Cardiovascular Imaging accredited laboratories in 43 centres from 22 countries.

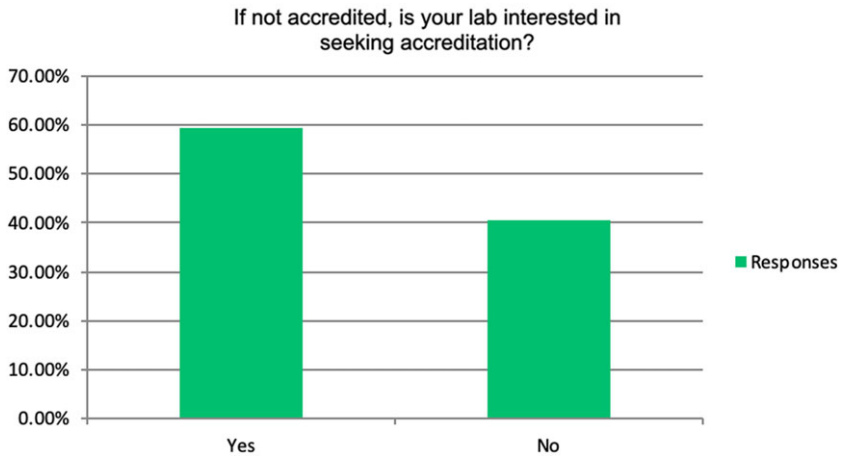

Figure 6. Desire to achieve European Association of Cardiovascular Imaging accreditation among non-accredited laboratories.

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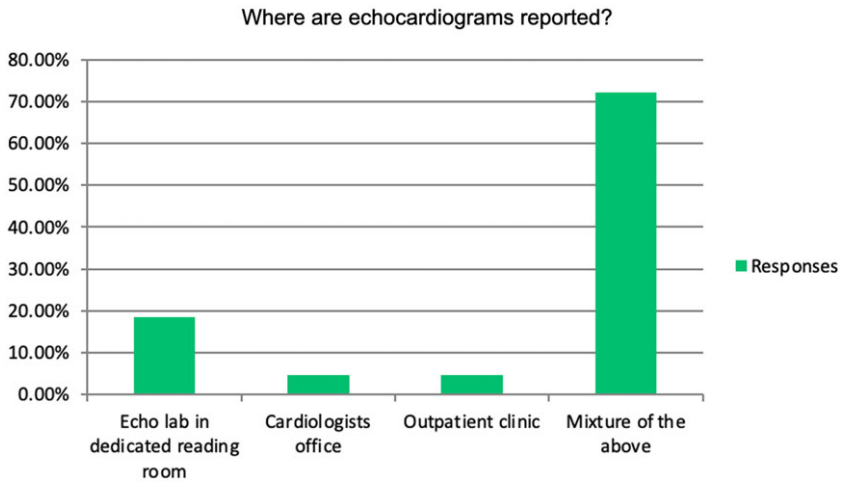

Figure 7. Location echocardiogram reporting 43 centres from 22 European countries.

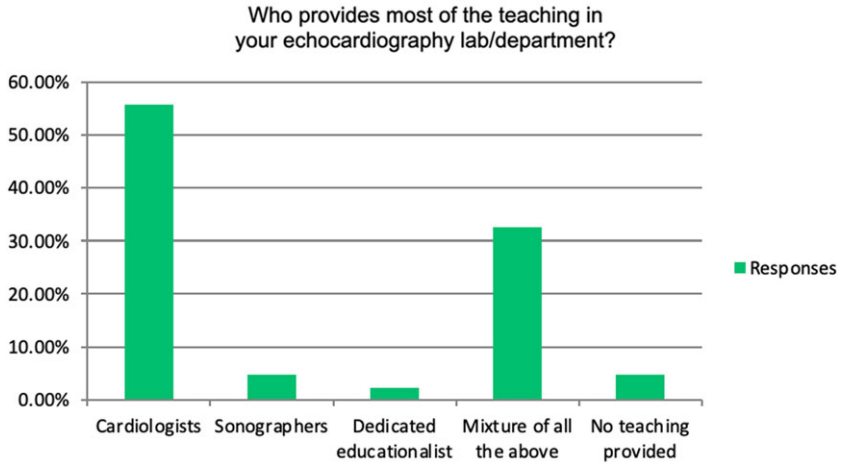

Figure 8. Who provides most of the teaching in your department?

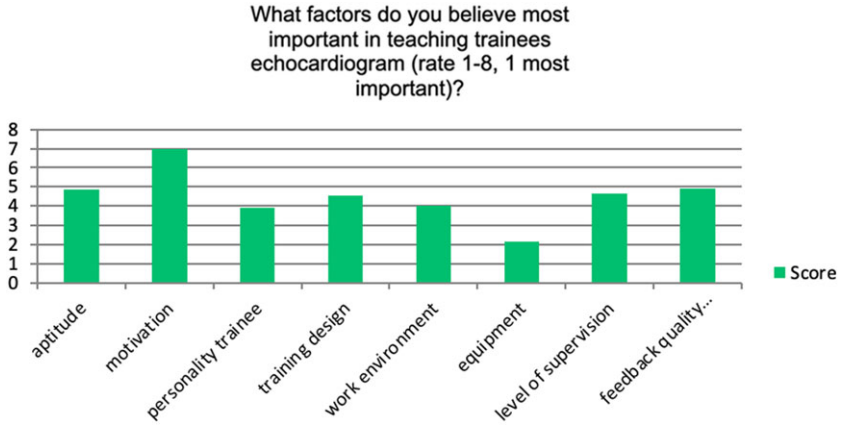

Figure 9. Most important factors in training fellows echocardiography.

new starters, and 37% used a simulator for training. However, a course in congenital heart echocardiography before starting clinical training in echocardiography is not required in more than half of centres (64%), and a morphology course is not mandatory in most (79%). Training is provided by cardiologists in most cases (55%), followed by sonographers (5%), while dedicated educationalists are rarely present (e.g. only 2%). Sixty-four percent of respondents reported that trainees in their centre were encouraged to take European Association of Cardiovascular Imaging-Association for European Paediatric and Congenital Cardiology CHD echocardiography certification.

In most of the cases, trainees follow a sequential segmental approach (93%, 39 centres), complete a preliminary report after performing echocardiography (76%), and receive frequent, regular

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Table 1. Physician recommended strategies for improving imaging across European centres

Standardized imaging guidelines and recommendations.
Acceptance of uniform views (upside down image discussion).
More courses and regular online educational days.
Greater availability of grants to access imaging courses and meetings.
Regular imaging workshops/ courses, echo simulators, online tools or apps with structured videos/ images for echo and CMR with normal echocardiography and a range of pathology.
Formalised and standardised training pathways.
More research on how best to train young trainees.
Trainers should acquire European Association of Cardiovascular Imaging examinations.
Greater research collaboration and funding for collaborative research between centres.
More sessions at international meetings.
Networking for imaging congenital cardiologists.
Support for cardiologists from small or solo practice centres to maintain or improve imaging skills.
Support for paediatricians with special expertise in cardiology trainees in imaging.

feedback. Initial admission echocardiograms by trainees are checked on the same day (88%) or the day after an on-call night (88%). Fellows are usually also trained in setting up the machine (84%), and in optimising image acquisition (86%), as part of initial orientation.

Multiple areas for training improvement were highlighted, including more time (37%) and dedicated personnel (11%) for training, the need for newer facilities (9%) and for specific training programmes (23%). For educational improvement, greater standardisation of imaging (25%), the availability of more training courses (21%), obligatory training and/or certification (15%), and more space and the adoption of newer techniques were highlighted.

There is a wide variation in how training is delivered, time interval before trainees image independently, and how feedback is delivered. In most of the centres, there is no fixed period before trainees are allowed to image independently, rather autonomy is driven by acquisition of competencies. The time before trainees are left on-call varied greatly, from 4 weeks to 1 year. Trainee motivation, aptitude, training design, and feedback delivery were deemed most important factors in successful training.

Quality improvement

Eighteen centres (44%) undertake quality assurance (near-miss reviews). In 44%, there is a regular morbidity and mortality conference on echocardiogram errors and potential impact on the patient, while in 8%, this is only done occasionally. Eighteen centres (44%) reported undertaking quality improvement projects including optimising appointment attendance, imaging times, and quality of echocardiography images. The median number of quality improvement projects was 1 per annum per centre.

Research

Research was undertaken in 34 (79%) echocardiography labs of which 42% was funded. Published imaging research was achieved in 71% of centres. Most of the respondents (59%) believe that cardiac imaging research is not well organised in Europe. They expressed a desire for improving research through greater cooperation among centres with multicentre studies and registries, greater time for research, funding, standardisation, and guidelines in imaging.

Recommendations for improvement of echocardiography laboratories and imaging

When asked what improvements imaging cardiologists would like to see adopted by governing bodies, there were several suggestions towards improvement (Table 1). The main focus should be on developing standardised imaging protocols and recommendations, greater time allocated for training, training grants, more imaging sessions at international meetings, and greater support for trainees and faculty.

A pertinent point made was: "As it has always been, personal guidance is the key. Bad teaching will not propagate, good teaching will, indeed, independent of technology." (R31)

Thirty-seven of 43 respondents found the survey helpful. "It helped me think over the differences between hospital and private based paediatric cardiology and my own expectations in a field with quite many mishaps in hospitals. I have always had my discontent with the term "echo lab". Your survey made this clear once again. A laboratory is definitely something else." (R32)

"Yes, I think despite living in a country with a good public health system with less resources, we still do things really well with what we have . . . but of course it would be amazing to have more trained staff, better training programmes in Paediatric Cardiology and more funding for research." (R38)

Discussion

Paediatric cardiology is a subspeciality, which developed organically often in response to the needs of patients, rather than with a preconceived funded strategy. Similarly, echocardiography laboratories often started from humble beginnings with 1–2 machines often in a single room. Previous studies[1] revealed how training in paediatric and congenital adult cardiology varies markedly across Europe. The present survey reveals how there is also a great discrepancy among different European centres in terms of the organisation of paediatric echocardiography labs. Our study highlighted a great variation in facilities (rooms, echocardiography machines), human resources (medical/paramedical staff), time dedicated to examination and reporting, training, quality improvement, and research programmes.

Although there are several large well-resourced centres with excellent space, facilities (e.g. echocardiography machines with up to date 3D software and dedicated reporting stations) and staff, there are several smaller centres with very limited resources without a dedicated paediatric echocardiography space, never mind the presence of an accredited laboratory. European Association of Cardiovascular Imaging laboratory accreditation[15] although deemed important was not achieved by the majority of centres. This may be related to different regulations in different countries or the fact that if European Association of Cardiovascular Imaging accreditation presents no advantage in that country, in terms of daily practice, training, or income generation; the centre may deem the effort to achieve accreditation too much. However, is European Association of Cardiovascular Imaging laboratory accreditation in itself, the holy grail, or is it

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more realistic to aim for high-quality standards by European echocardiography practitioners? The two are not mutually exclusive and quality rather than certification may be the priority for most laboratories. This may be especially true of those smaller laboratories or indeed centres without a current "laboratory set-up" because of limited resources.

How do we define an echocardiography laboratory?

An important finding of this study was the number of centres that do not have an actual echocardiography laboratory. One can argue about the definition of "echocardiography laboratory" but for this study, we arbitrarily defined it as having two or more echocardiography machines with either an imaging physiologist or imaging cardiologist. This is somewhat arbitrary and does not take into account the achievement of certification or presence of specific quality measures. Should we be more selective and define an echocardiography laboratory to include in addition to a specific number of rooms and echocardiography machines, dedicated imaging cardiologists and physiologists, and a location dedicated for reporting studies, not to mention performing advanced imaging (strain, 3D echocardiography)? Then the number of centres reaching criteria for having an echocardiography laboratory may even be less than reported in this study.

Disparity in support and facilities for echocardiography laboratories throughout Europe becomes readily apparent in this study. Larger centres have multiple echocardiographic rooms, imaging physiologists, facilities for sedation (Fig. 4), 3D imaging, fetal cardiac imaging, and advanced cardiac imaging capabilities. However, many of the centres surveyed in this study have few of these facilities. These same smaller centres voiced the need for more personnel, facilities and time as a common theme. Only half of laboratories have physiologist and nursing staff support, and many cardiologists often work alone in busy clinical settings with limited support. Expectations to deliver a comparable service to large centres in North America under such circumstances would appear totally untenable in terms of patient care, research and quality assurance.

European Association of Cardiovascular Imaging accreditation standards[15] suggest allocating 30–40 minutes for standard studies and up to 1 hour for a complex study. These time intervals are respected for a first complex examination, while the time allocated for repeat examinations varied greatly, being very low in some cases (down to 5 minutes in some responses). Time and space for reporting varied greatly and reporting is often accomplished at the end of the examination. The lack of dedicated sonographers or imaging physiologists is common in continental Europe, which represents a sharp difference to the organisation of work in Anglo-Saxon countries (U.K., U.S.A., Canada, Australia, and New Zealand).[17]

Although significant time and energy are committed to training, limited recommendation/ guidelines papers exist on basic requirements of training,[18–20] particularly in terms of duration of training and criteria to judge trainee's autonomy, the latter of which appears relatively subjective. A minimum requirement of examinations is required for certification but is clearly insufficient to reach autonomy. American guidelines suggest a minimum of 150 examinations to be performed and interpreted (plus an additional 100 examinations) during a 3-year period.[19]

European Association of Cardiovascular Imaging-Association for European Paediatric and Congenital Cardiology certification[20] in CHD echocardiography requires an examination and a logbook of 250 cases. Basic and advanced training courses exist in some countries (e.g. UK, Italy). The British Society of Echocardiography[21] requires an examination and a logbook of 200 cases for individual accreditation in congenital echocardiography. The Italian Society of Echocardiography[22] requires a logbook of only 100 cases but specifies a rotation of at least 3 months in a tertiary accredited department as a requirement before the examination. Quality standards of the German Society of Paediatric Cardiology recommend a completed training in paediatrics and paediatric cardiology as well as 400 echocardiography examinations in children with cardiac diseases.[23]

Over one half of the respondents outlined the lack of structured quality improvement processes. Regular near-miss reviews, morbidity, and mortality conference on echocardiographic errors with potential clinical relevance, and development of quality improvement process should be encouraged,[3,4] to reduce preventable errors. Attention should be given to those conditions predisposing to errors such as examination performed at night and during weekends.[6,7] Echocardiograms, particularly pre-operative/pre-interventional scans, should undergo departmental review and be repeated in case of doubts.[6,7] The use of sedation,[10,16,24,25] which is available in most of the labs, with focused protocols[10,16] should be encouraged. These practices[10,16] may improve the accuracy of pre-operative and post-operative examinations, which are often too fast (as outlined by most of the responders) and not comprehensive. Greater availability of sonographers in European centres may allow for improved standards in data acquisition, and improved allocation of time and resources, allowing the physician to spend more time in reporting, teaching, and conducting research.

Limitations

Not all centres affiliated with Association for European Paediatric and Congenital Cardiology participated in the survey, and there may have been centres not affiliated with Association for European Paediatric and Congenital Cardiology, which were excluded. However, 43 centres represent a significant sample size. We relied on respondents to provide accurate data regarding their centre. Although the findings of this survey highlight a marked disparity in resources, further guidelines are required to improve the standards of congenital echocardiography laboratories across Europe. These guidelines/recommendations should (1) define the basic requirement for paediatric/congenital echocardiography facilities, medical/paramedical staff, individual certification and laboratory accreditation, (2) defined time slots should be allocated for new and repeat examinations and reporting, including increased time necessary for off-line measurements of newer echocardiographic techniques (3D, strain, blood speckle tracking), (3) harmonise training programmes and define autonomy level acquisition, and (4) promote quality improvement processes, continuous medical education, and research.

Conclusions

There is wide variation in facilities, staffing levels, and equipment in paediatric/congenital echocardiography laboratories across Europe. Compared to North America, there is limited time for echocardiography examinations and reporting. Cardiologists expressed an interest in improving standards of teaching/ training in their centres as well as improving quality assurance across paediatric echocardiographic laboratories in Europe.

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