

# Cardiovascular imaging practice in Europe: a report from the European Association of Cardiovascular Imaging

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The need for cardiovascular imaging (CVI) is expected to increase over the coming years due to the changes in CV disease epidemiology and ageing of the population. However, reliable statistics on CVI practice in Europe are lacking. Establishing the current status of the use of CVI across Europe has become the first comprehensive project of the European Association of Cardiovascular Imaging and the European Society of Cardiology Taskforce on CVI. In 2013, a survey with relevant information regarding CVI was sent to all National Imaging/Echocardiography Societies and Working Groups. Representatives from 41 countries returned the questionnaire. The present report provides key results of the survey, relating to existing education, training, certification and national accreditation programmes, healthcare organizations, and reimbursement systems.

**Keywords** cardiovascular imaging • certification • accreditation • training • survey

## Background

Cardiovascular imaging (CVI) is evolving rapidly, placing new demands on our profession for training, education, and advocacy.<sup>1–11</sup> Functional and anatomical CVI is pivotal to modern health care and is an essential component in the management of patients with cardiovascular conditions.<sup>12–18</sup> It is thus likely that the need for CVI will continue to increase over the coming years due to the changes in CV disease epidemiology and ageing of the population.<sup>19–22</sup> However, reliable statistics on CVI practice in Europe are lacking. Establishing the current status of the use of CVI in Europe has thus become a priority for the Imaging Taskforce of European Association of Cardiovascular Imaging (EACVI) and the

European Society of Cardiology (ESC). The present report aimed to provide information on the practice of transthoracic and transoesophageal echocardiography (TTE, TOE), stress echocardiography, cardiovascular magnetic resonance imaging (CMR), cardiac computed tomography (CT), cardiac nuclear imaging, and vascular ultrasound procedures based on the national health care, education, training, certification, and available reimbursement systems.

## Methodology

The 2012 leadership of the EACVI agreed upon the importance of obtaining as much current information as possible concerning the practice of

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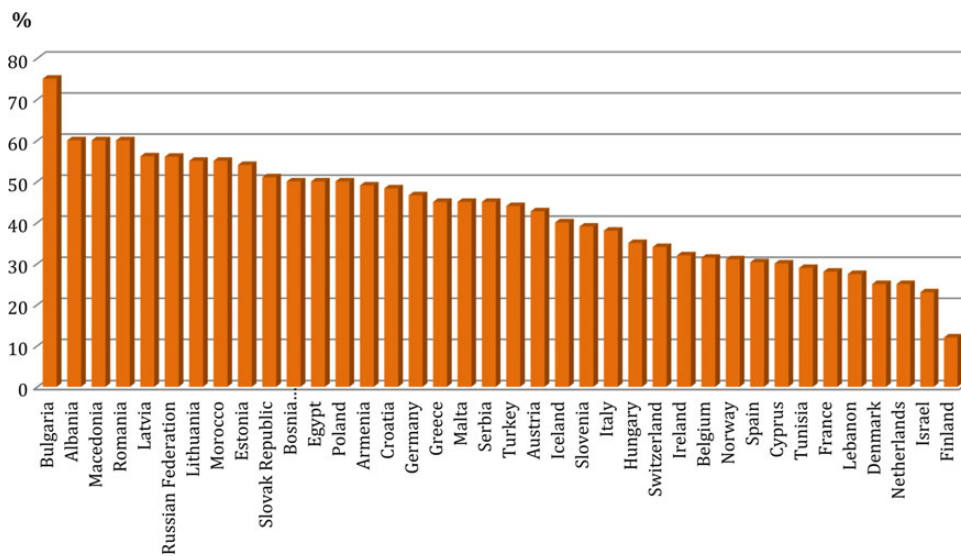
CVI in Europe. P.L., President of the EACVI 2012–2014, and E.P.-G., chair of the European Communities Committee 2012–2014, with the help of the EACVI board and the Chairs of National Societies prepared a

Questionnaire with the most relevant items to be featured. After a final revision in 2013, the Questionnaires were sent out to all the national imaging/echocardiography societies/working groups in Europe. Each

**Table I** List of countries who participated in the survey

<b>1. Albania</b> Prof. Spiro Qirko	<b>12. Finland</b> Dr Suvi Tuohinen	<b>22. Latvia</b> Dr Artem Kalinin	<b>33. Russian Federation</b> Prof. Simon Matskeplishvili
<b>2. Armenia</b> Dr Liana Tumasyan	<b>13. France</b> Dr Patrick Dehant	<b>23. Lebanon</b> Dr Ghassan Kiwan	<b>34. Serbia<sup>a</sup></b> Associate Prof. Biljana Putnikovic
<b>3. Austria</b> Prof. Jutta Bergler-Klein and Dr Franz Glaser	<b>14. Georgia</b> Dr George Kacharava	<b>24. Lithuania</b> Dr Tomas Lapinskas	<b>35. Slovak Republic<sup>a</sup></b> Dr Pavel Chnupa
<b>4. Belgium<sup>a</sup></b> Prof. Bernard Paelinck	<b>15. Germany</b> Prof. Andreas Hagendorff and Rainer Zimmermann	<b>25. Macedonia</b> Dr Irena Peovska Mitevska	<b>36. Slovenia<sup>a</sup></b> Prof. Mirta Kozelj
<b>5. Bosnia and Herzegovina</b> Prof. Zumreta Kusljagic	<b>16. Greece</b> Associate Prof. Loukianos Rallidis	<b>26. Malta</b> Dr Andrew Cassar	<b>37. Spain<sup>a</sup></b> Dr Jose Juan Gomez de Diego
<b>6. Bulgaria</b> Dr Krasimira Hristova	<b>17. Hungary<sup>a</sup></b> Dr Andras Temesvari	<b>27. Morocco</b> Dr Aatif Benyass	<b>38. Switzerland<sup>a</sup></b> Dr Xavier Jean Renaud
<b>7. Croatia<sup>a</sup></b> Prof. Jadranka Separovic Hanzevacki	<b>18. Iceland</b> Dr Thorarinn Gudnason	<b>28. Netherlands</b> Dr Berto Bouma	<b>39. Tunisia</b> Dr Soraya Benyoussef
<b>8. Cyprus</b> Dr Kyriakos Yiangou	<b>19. Ireland</b> Dr Angie Brown	<b>29. Norway</b> Dr Havard Dalen	<b>40. Turkey<sup>a</sup></b> Dr Leyla Elif Sade
<b>9. Denmark</b> Dr Ulrik Markus Mortensen	<b>20. Israel</b> Dr Yaron Shapira	<b>30. Poland</b> Prof. Andrzej Szyszka	<b>41. UK</b> Dr Bernard Prendergast
<b>10. Egypt</b> Dr May Amr	<b>21. Italy</b> Dr Fausto Rigo	<b>31. Portugal</b> Dr Ana Galrinho	
<b>11. Estonia</b> Dr Maire Kiitam		<b>32. Romania<sup>a</sup></b> Associate Prof. Adriana Iliesiu	

<sup>a</sup>Societies/Working groups on non-invasive cardiovascular imaging.



**Figure 1** Percentage of death resulting from cardiovascular disease in 2012 (most of the data come from the Ministry of Health).

chairperson was then asked to compile information about his/her country. The data gathered by the societies and Working Groups were from a number of national sources. Some countries, however, did not have available data for all of the sections of the survey. A random cross-check of the data quality was conducted with the help of the EACVI board members and some national volunteers. Once the crosscheck was completed, the National Societies or Working Groups were asked to verify and authorize the publication of the information. All data were entered into a central database. In case of missing or incomplete data, the national representatives were reminded repeatedly for completion or amendment. All the information was then compiled into the 'EACVI Highlight Book' presented during the 2014 EuroEcho-Imaging in Vienna. Results were reported as absolute numbers and percentages in the graphs.

## Results

The questionnaire was returned by representatives of 41 ESC National Countries (Table 1). The rate of CV disease remained a major healthcare burden in Europe, with substantial differences in CV mortality rates between East and North (Figure 1). A national registry on the practice of CVI was present in a very few countries (Albania, Armenia, Denmark, Germany, Greece, Hungary) (Table 2). There was a wide variety of healthcare systems, which involve public or private insurances, including mixed solutions, and co-payments.

### Performance and examination costs

The performance and reimbursement of CVI strongly depended on the type of imaging technique used. In most countries, echocardiography is in the hands of cardiologists while radiologists mainly performed/reported the CMR and CT examinations. Specialists in nuclear medicine were in charge of most PET and SPECT examinations (Figure 2). Interestingly, cardiologists performed/reported one-third of CMR and CT examinations. Vascular ultrasound was done by almost the same percentage of cardiologists and radiologists. The general financial cost profile per CVI technique was very heterogeneous. The highest costs were found for PET, CT, and CMR. TOE and stress echocardiography costs were however in the highest range in about one-fifth of the countries (>200€). Vascular ultrasound was by far the cheapest examination (<50€).

### Education, certification, and accreditation

The percentage of countries with a national certification in CVI for cardiologists was different between imaging modalities. TTE and TOE were commonly certified techniques. About one-third of the countries had a certification programme for the other imaging modalities. The majority of national societies recommended the EACVI certification, but one-fifth of them had their own national certification system (Figure 3). Whatever the CVI modality, a national accreditation for centres/laboratories was not required for practice in most countries (Figure 4).

### Training requirements and guidelines adherence

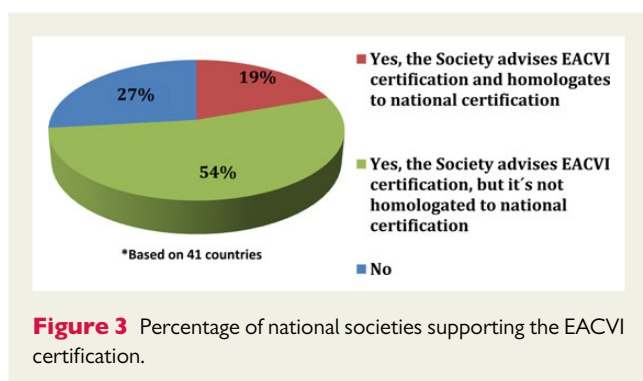
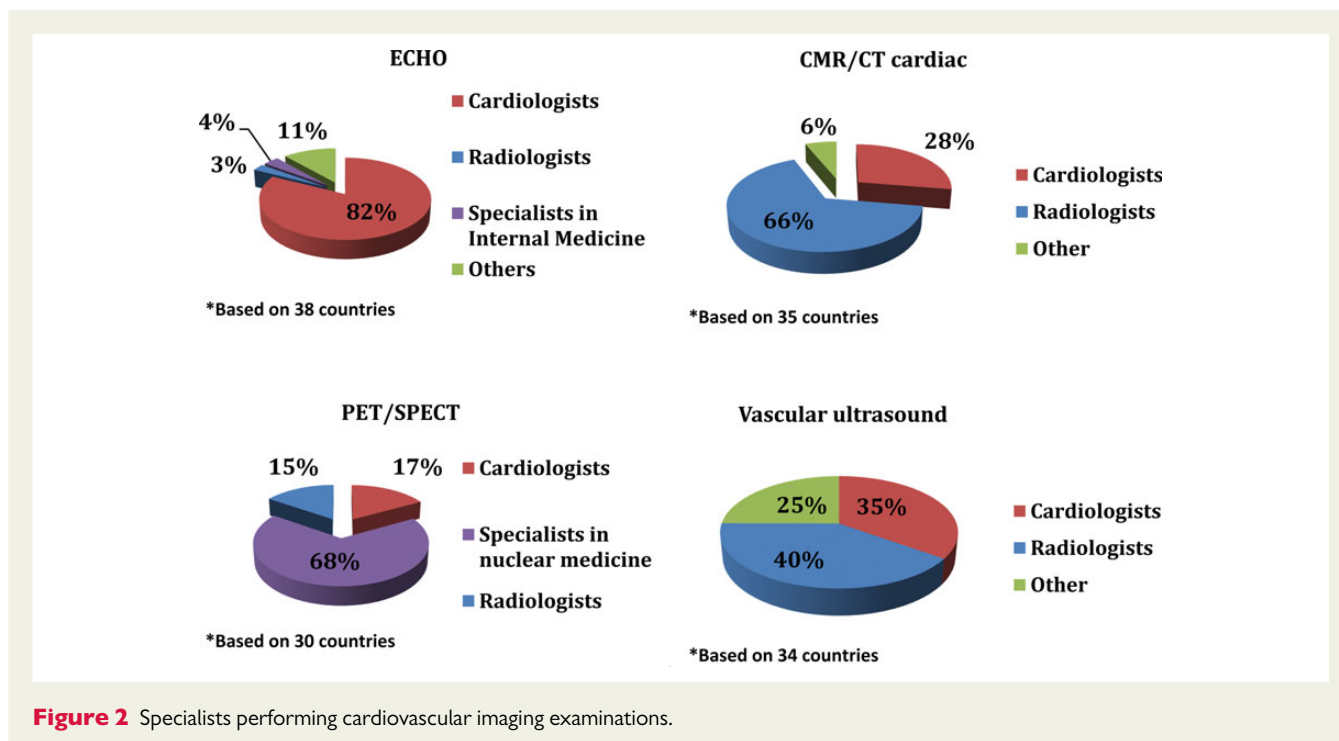
A specialty training (e.g. cardiology, radiology, nuclear imaging specialist, others) to perform CVI examinations was required in most countries. A minimum period of training was also required but with significant differences between CVI modalities. As examples, ~30%

**Table 2** National registry, certification, and competency guidelines

<i>n</i> = number of countries	No (%)	Yes (%)	NA (%)
National registry ( <i>n</i> = 41)			
ECHO	85	10	5
CMR/CT	83	7	10
SPECT/PET	78	2	20
Vascular ultrasound	88	2	10
National certification for cardiologists			
TTE ( <i>n</i> = 40)	47	53	–
TOE ( <i>n</i> = 39)	59	41	–
STRESS ECHO ( <i>n</i> = 38)	68	32	–
CMR ( <i>n</i> = 36)	67	33	–
CT ( <i>n</i> = 36)	67	33	–
SPECT ( <i>n</i> = 35)	69	31	–
PET ( <i>n</i> = 33)	70	27	3
Vascular ultrasound ( <i>n</i> = 36)	64	36	–
Specialty required to perform imaging ( <i>n</i> = 41)			
ECHO	17	83	–
CMR/CT	12	85	3
SPECT/PET	20	76	4
Vascular ultrasound	27	69	4
Required period of training to perform CVI examinations			
TTE	37	63	–
TOE	37	63	–
STRESS ECHO	37	56	7
CMR	46	39	15
CT	39	42	19
SPECT	37	41	22
PET	34	39	24
Vascular ultrasound	36	44	17
National competency guidelines to perform CVI examinations ( <i>n</i> = 41)			
TTE	66	32	2
TOE	66	29	5
STRESS ECHO	76	19	5
CMR	71	15	14
CT	68	15	17
SPECT	66	15	19
PET	66	10	24
Vascular ultrasound	73	10	17

Echo, echocardiography; NA, not available; TTE and TOE, transthoracic and transoesophageal echocardiography; CMR, cardiac magnetic resonance imaging; CT, cardiac computed tomography; SPECT, single photon emission computed tomography; PET, positron emission tomography.

of respondent countries did not report a specific period of training for TTE or TOE. This percentage was even higher for the other imaging modalities. Similarly, official national certification guidelines to perform CVI examinations existed in less than one-third of countries. However, missing data also increased with non-echo imaging techniques. Interestingly, about half of the countries adhered to European guidelines for CVI examinations while one-fifth used national guidelines (Figure 5). The need for ESC/EACVI guidelines translation



was claimed by 50% of countries. Of note, the average waiting time for examinations in public healthcare system varied among techniques but was less than a month for most (Table 3).

## Discussion

The current mapping of the practice of CVI techniques across Europe represents the first comprehensive project of the ESC/EACVI Taskforce on CVI. While practice variations can reflect patient preferences, local demographics, and a host of other factors, availabilities of techniques, educational platform, training requirements, certification guidelines, and reimbursement systems also significantly contribute to the current differences observed between European countries in terms of CVI practice. Overall, there were diverse country-specific regulations to perform CVI and a widespread lack of national certification/accreditation in CVI. However, the majority of countries recommended the EACVI certification and one-fifth of them

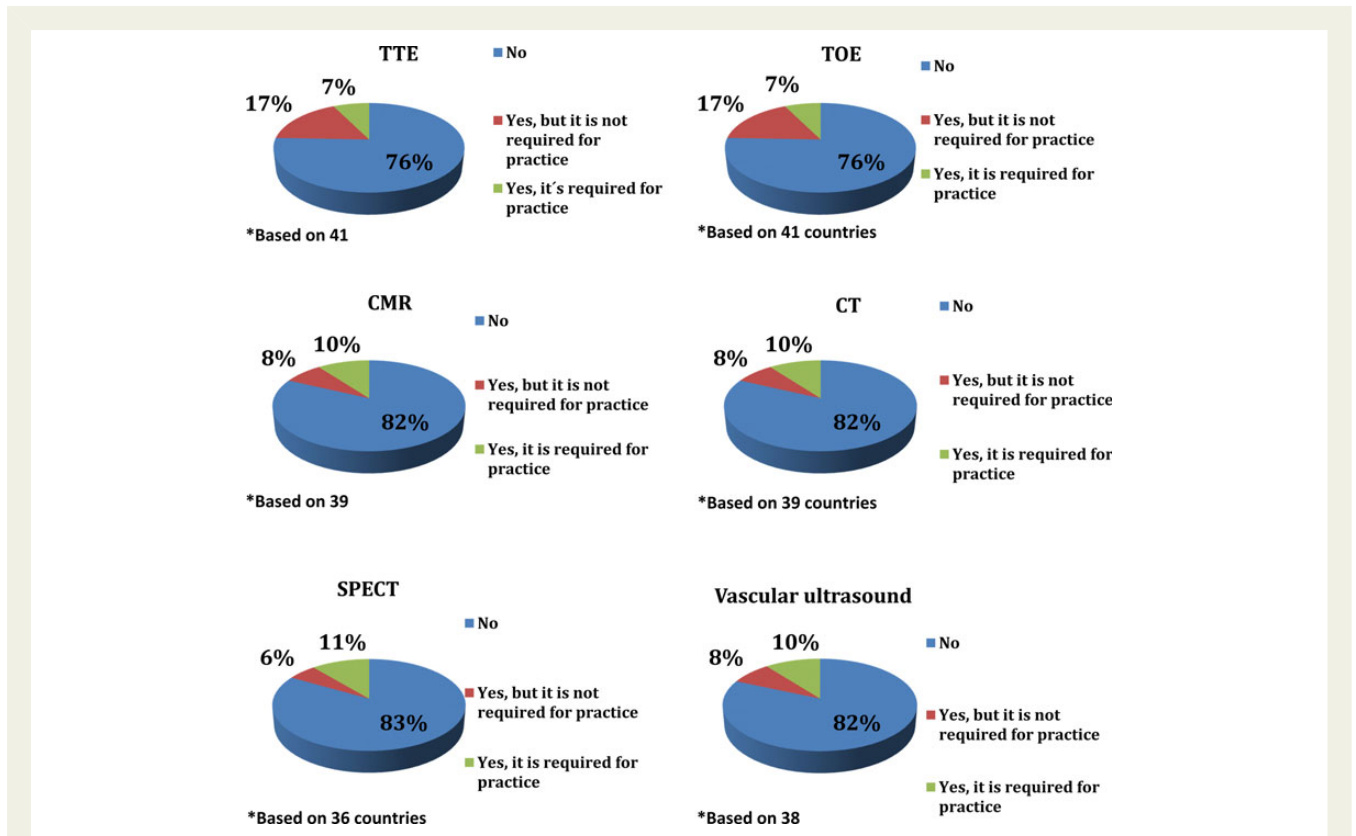
applied it as a national certification. Cardiologists commonly performed echocardiography but not CT, CMR, or nuclear imaging. However, medical imaging performance required a specialist license (e.g. cardiologist, radiologist, nuclear imaging specialist) in most countries. Unexpectedly, a predefined period of training in CVI during the specialty was absent in one-third of the countries. In addition, barely a few countries offered official national certification guidelines to perform CVI examinations. Interestingly, the adherence to ESC/EACVI guidelines in CVI was reported in a high number of European countries. Finally, the access to CVI examinations in public healthcare system was marked by a long waiting period in some countries.

## Limitations

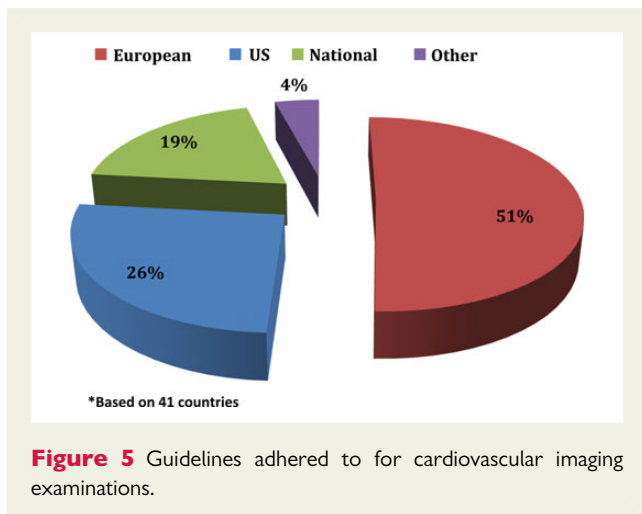
Some general cautions should be taken into account when interpreting our data. The process of gathering the data for the present report was complex and necessarily involved different sources among which the National Societies played a major role. As a result, some items were not reported or were based upon 'best estimation' by the National Society. Also the majority of the National Working Groups focussed on echocardiography at the time of the survey (less than 1/3 was multi-imaging). As a result, missing or unreported data mostly related to non-echocardiography imaging modalities and vascular ultrasound imaging.

## Future directions and perspectives

The present report symbolises a preliminary step for further data collection and networking with national imaging societies and working groups. It denotes a first valuable resource for those who seek European data on the current CVI practice across the continent. It provides some key figures about existing education, certification, and national



**Figure 4** Percentage of national accreditation per imaging for centres.



**Figure 5** Guidelines adhered to for cardiovascular imaging examinations.

**Table 3** Average waiting time for examinations in public healthcare system

	1–30 days (%)	>30 days (%)	>60 days (%)
TTE	62	20	18
TOE	65	27	8
STRESS ECHO	45	45	10
CMR	36	39	25
CT	58	24	18
SPECT	40	30	30
PET	30	44	26
Vascular ultrasound	68	13	19

Echo, echocardiography; NA, not available; TTE and TOE, transthoracic and transoesophageal echocardiography; CMR, cardiac magnetic resonance imaging; CT, cardiac computed tomography; SPECT, single photon emission computed tomography; PET, positron emission tomography.

accreditation programmes. It also highlights the lack of national CVI registries, which could facilitate the process of gathering data and improve their ‘certainty’. To feed this overall picture, future action should aim at collecting information on current procedures and current equipment, ordering procedure, indications, and impact on treatment. In the future, direct comparison among the different ESC countries should help standardize healthcare resources by promoting

knowledge of the status and bringing it to the attention of all public authorities. Hopefully such a data collection will contribute to improved quality of care through better use of resources (avoid unnecessary procedures and expenses) and consequent reduction in waiting time and increase the availability of CVI, when needed.

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**Conflict of interest:** None declared.

## References

- Lancellotti P, Habib G, Neglia D, Plein S. Cardiovascular imaging. *Eur Heart J* 2014;**35**: 1161–2.
- Weissman NJ, Lancellotti P. Learning from our European imaging colleagues. *JACC Cardiovasc Imaging* 2014;**7**:639–40.
- Garbi M, McDonagh T, Cosyns B, Bucciarelli-Ducci C, Edvardsen T, Kitsiou A et al. Appropriateness criteria for cardiovascular imaging use in heart failure: report of literature review. *Eur Heart J Cardiovasc Imaging* 2015;**16**:147–53.
- Cosyns B, De Diego JJ, Stefanidis A, Galderisi M, Ernande L, Underwood SR et al. E-learning in cardiovascular imaging: another step towards a structured educational approach. *Eur Heart J Cardiovasc Imaging* 2015;**16**:463–5.
- Lancellotti P, Anker SD, Donal E, Edvardsen T, Popescu BA, Farmakis D et al. EACVI/HFA Cardiac Oncology Toxicity Registry in breast cancer patients: rationale, study design, and methodology (EACVI/HFA COT Registry)-EURObservational Research Program of the European Society of Cardiology. *Eur Heart J Cardiovasc Imaging* 2015;**16**:466–70.
- Garbi M, Habib G, Plein S, Neglia D, Kitsiou A, Donal E et al. Appropriateness criteria for cardiovascular imaging use in clinical practice: a position statement of the ESC/EACVI taskforce. *Eur Heart J Cardiovasc Imaging* 2014;**15**:477–82.
- Popescu BA, Stefanidis A, Nihoyannopoulos P, Fox KF, Ray S, Cardim N et al. Updated standards and processes for accreditation of echocardiographic laboratories from The European Association of Cardiovascular Imaging. *Eur Heart J Cardiovasc Imaging* 2014;**15**:717–27.
- Gimelli A, Neglia D, Schindler TH, Cosyns B, Lancellotti P, Kitsiou A. Nuclear Cardiology Core Syllabus of the European Association of Cardiovascular Imaging (EACVI). *Eur Heart J Cardiovasc Imaging* 2015;**16**:349–50.
- Petersen SE, Almeida AG, Alpendurada F, Boubertakh R, Bucciarelli-Ducci C, Cosyns B et al. Update of the European Association of Cardiovascular Imaging (EACVI) Core Syllabus for the European Cardiovascular Magnetic Resonance Certification Exam. *Eur Heart J Cardiovasc Imaging* 2014;**15**:728–9.
- Cosyns B, Garbi M, Separovic J, Pasquet A, Lancellotti P; Education Committee of the European Association of Cardiovascular Imaging Association (EACVI). Update of the echocardiography core syllabus of the European Association of Cardiovascular Imaging (EACVI). *Eur Heart J Cardiovasc Imaging* 2013;**14**:837–9.
- Nieman K, Achenbach S, Pugliese F, Cosyns B, Lancellotti P, Kitsiou A. Cardiac computed tomography core syllabus of the European Association of Cardiovascular Imaging (EACVI). *Eur Heart J Cardiovasc Imaging* 2015;**16**:351–2.
- 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**:233–71.
- Cosyns B, Plein S, Nihoyannopoulos P, Smiseth O, Achenbach S, Andrade MJ et al. Multimodality imaging in pericardial disease. *Eur Heart J Cardiovasc Imaging* 2015;**16**:12–31.
- Lancellotti P, Nkomo VT, Badano LP, Bergler-Klein J, Bogaert J, Davin L et al. Expert consensus for multi-modality imaging evaluation of cardiovascular complications of radiotherapy in adults: a report from the European Association of Cardiovascular Imaging and the American Society of Echocardiography. *Eur Heart J Cardiovasc Imaging* 2013;**14**:721–40.
- Galderisi M, Cardim N, D'Andrea A, Bruder O, Cosyns B, Davin L et al. The multimodality cardiac imaging approach to the Athlete's heart: an expert consensus of the European Association of Cardiovascular Imaging. *Eur Heart J Cardiovasc Imaging* 2015;**16**:353.
- Cardim N, Galderisi M, Edvardsen T, Plein S, Popescu BA, D'Andrea A et al. Role of multimodality cardiac imaging in the management of patients with hypertrophic cardiomyopathy: an expert consensus of the European Association of Cardiovascular Imaging Endorsed by the Saudi Heart Association. *Eur Heart J Cardiovasc Imaging* 2015;**16**:280.
- Lancellotti P, Price S, Edvardsen T, Cosyns B, Neskovic AN, Dulgheru R et al. The use of echocardiography in acute cardiovascular care: recommendations of the European Association of Cardiovascular Imaging and the Acute Cardiovascular Care Association. *Eur Heart J Cardiovasc Imaging* 2015;**16**:119–46.
- Plana JC, Galderisi M, Barac A, Ewer MS, Ky B, Scherrer-Crosbie M et al. Expert consensus for multimodality imaging evaluation of adult patients during and after cancer therapy: a report from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. *Eur Heart J Cardiovasc Imaging* 2014;**15**: 1063–93.
- Garcia-Fernandez MA. Evolution of cardiac imaging according to the number of scientific articles in medical journals: a long and fruitful journey. *Rev Esp Cardiol* 2014;**67**: 920–4.
- Maleki M, Esmailzadeh M. The evolutionary development of echocardiography. *Iran J Med Sci* 2012;**37**:222–32.
- Nagel E, Narula J. Evolution and revolution in CMR imaging. *JACC Cardiovasc Imaging* 2013;**6**:837–8.
- Mittal TK, Nicol ED, Harden SP, Roobottom CA, Padley SP, Roditi G et al. The national evolution of cardiovascular CT practice: a UK NHS perspective. *Int J Cardiol* 2013;**168**:3001–3.