



Correspondence

Stress echocardiography: differences between practices in Greece. A survey of the Echocardiology Working Group of the Hellenic Society of Cardiology

Stress echo (SE) is an established imaging modality that has been used for almost 35 years^{1,2}, playing a pivotal role not only in the assessment of coronary artery disease (CAD) but also in valvular heart disease, cardiomyopathies, congenital heart disease, and heart failure^{3,4}. Despite the recommendations of the European Association of Cardiovascular Imaging (EACVI) and the American Society of Echocardiography (ASE)^{5,6}, the clinical practice varies not only among countries, but also among institutions within a country for reasons related to training, cost, equipment, and personnel availability. The aim of the current survey was to investigate the current SE practice in Greece and evaluate differences between centers in terms of protocols, personnel, and equipment.

In this prospective survey, an electronic questionnaire with information related to protocols, equipment, and personnel was e-mailed to the head of each participating center. Then a simple and short questionnaire for each SE study performed was provided to each center from October 24, 2017 to March/24, 2018.

A total of 2661 SE studies were uploaded from 45 centers, including 4 from Cyprus (Supplementary Figure). From the studies uploaded, 55% were from public hospitals (PH) and 45% from private hospitals or private practices (Private Sector - PS). Concerning the participating facilities, 14 were PH, 6 university hospitals, 13 private hospitals, 12 private practices (22 of the public and university hospitals are the official training centers (TC) for advanced echocardiographic techniques in Greece, including SE). There was no difference in the necessary equipment of the echo labs between the participating centers. However, there were significant differences in the number of physicians but not of nurses between the centers. The mean number of doctors who participated in the conduction of SE studies was 3 ± 2 in PS, 6 ± 3 in PH, and 6 ± 3 in TC ($p < 0.001$).

The indications for SE are presented in Table 1 with the assessment of CAD being the most common. Most of the SE studies uploaded (91%) were pharmacological (97% with dobutamine, 1.12% with dipyridamole, and 1.73% with adenosine). Exercise SE was performed mainly by treadmill (65.5%) compared to ergometric supine bike (34.5%). An important difference in the practice between TC and PS was the significantly more frequent use of the treadmill in TC than the bike (88% vs. 63%, $p < 0.001$).

Most of the patients (94%) had received an information leaflet before the test (TC 92%, PH 98%, and PS 95%). However, only half of them were asked to sign an informed consent (36% in TC, 47%

in PH, and 65% in PS, $p < 0.001$). Discontinuation of medications with negative inotropic action (NIA) was reported in 78% of the cases (in 53% one day, in 41% two days, and in only 6% three days before the test). This policy was different in the various settings, as the aforementioned medications were not discontinued in 1 out of 3 cases in TC, 1 out of 6 in PH, and 1 out of 4 cases in PS ($p = 0.025$).

One single physician performed the SE test in 44% of the cases, 2 physicians collaborated in 34%, and 3 or more in 22% of the cases. More participants usually represented trainees in teaching facilities. The number of participating physicians was significantly different between TC, PS, and PH ($p = 0.01$). Half of the centers (49%) conducted SE tests without a nurse.

The use of a contrast agent was reported in 63% of cases, being more frequent in PS (69% vs 55% in TC and 63% in PH, $p < 0.001$). Handgrip maneuver was used to achieve the target heart rate (HR) in 46% of the cases, mostly in PS (56%), and less systematically in TC (39%) or PH (29%) ($p < 0.01$). Almost half of SE studies (46%) were performed with the additional use of atropine with significant differences between TC (40%), PH (52%), and PS (51%) ($p < 0.001$). Coronary flow reserve (CFR) was included in 27% of all centers with TC 24%, PH 29%, and 18% in PS ($p < 0.001$).

The mean time required for performing and reporting each SE study was 36 ± 14 min [40 ± 10 in PH, 38 ± 14 in PS, and TC 34 ± 13 min, ($p < 0.001$)]. Importantly, this time was not associated with the number of participants in each study. Almost all centers (>90%) digitally stored the SE studies.

In 95% of the cases, the SE studies were considered diagnostic with remarkable variations between TC, PH, and PS (93% vs 93% vs 98%, $p < 0.001$). Considering CAD, 485 SE were reported as positive; 55% from TC and 36% from PH. The factors related to the diagnostic quality of the SE studies in the univariate analysis were the type of the practice (OR = 1.52, CI 1.31 – 1.78, and $p < 0.001$), the use of contrast agent (OR = 2.68, CI 1.83 – 3.94, and $p < 0.001$), and the number of days before the test that the medications with NIA were discontinued (OR = 2.5, CI 1.35 – 4.63, and $p < 0.001$). In the multivariate analysis, only the use of a contrast agent (OR = 2.38, CI 1.18 – 4.83, and $p < 0.001$) and the duration of discontinuation of the medications with NIA (OR = 2.17, CI 1.12 – 4.23, and $p < 0.001$) were important prognostic factors. Complications were observed in 20% of the cases (Table 2). TC reported a higher incidence of complications (22% vs 18% of PS and 17% in PH, and $p = 0.031$).

Table 1
Indications of stress echo

Indication	Percentage (%)
CORONARY ARTERY DISEASE	
Assessment of ischemia	94.3
Assessment of viability	6.1
Assessment of microcirculation	4.4
VALVULAR DISEASE	
Assessment of the severity of MR	0.7
Assessment of the severity of AR	0.2
Assessment of the severity of AS	1.3
Assessment of the severity of MS	0.2
CARDIOMYOPATHY	
Assessment of HCM	0.3
Assessment of DCM	0.3
Assessment of athlete	0.1
HFpEF	
Assessment of dyspnea	4.4
Assessment of diastolic dysfunction	0.2
CONGENITAL DISEASE	
Assessment of a congenital disease	0.2

MR, mitral regurgitation, AR aortic regurgitation, AS aortic stenosis, MS mitral stenosis, HCM hypertrophic cardiomyopathy, DCM dilated cardiomyopathy, and HFpEF Heart Failure with preserved Ejection Fraction.

This is the first registry organized by the EWG of the Hellenic Society of Cardiology (HSC) to identify centers and practices of SE in Greece. The new reimbursement policy for SE tests, 3 years ago, just a few months before the initiation of the registry was an important change that made this tool widely available to patients and significantly increased the number of centers that perform the test.

The mean number of studies is 137 per year per operator, which is comparable to the reported volume of the majority of operators in the UK.⁷ Most importantly, this number is in line with ASE and EACVI guidelines for maintaining competency (minimum of 100 SE per year)^{8,9}. In Greece, there are no sonographers and the participation of a nurse in the conduction of SE is not a prerequisite. This partly explains the large number of doctors who participate in the performance and/or the interpretation of the test in PH and TC. However, the most important reason is the training needs of residents in cardiology and trainees in the technique.

The vast majority of studies in Greece (91%) were pharmacological (mainly with dobutamine), while most of the exercise SE were

Table 2
Complications of stress echo

Complications	Percentage (%)
Major	
Death	0
Myocardial infarction	0.19
Sustained ventricular tachycardia	1.34
Ventricular Fibrillation	0.38
Nonsustained ventricular tachycardia	5.2
Allergic reaction	0
Minor	
Nausea	13.68
Headache	20.42
Hypotension	10.40
Hypertensive response	2.89
Vasovagal response (hypotension and bradycardia)	5.59
Atypical chest pain	10.59
Angina	9.2
Atrial fibrillation	5
Other (paroxysmal supraventricular tachycardia, ventricular ectopics, nonsustained ventricular tachycardia, conduction disorders, panic attack, shiver, discomfort in the epigastrium, dyspnea, formicary, and hiccups)	20.23

performed by treadmill. On the contrary, in Poland, Italy, and UK, the semi-supine bike is used more frequently than the treadmill^{7,10,11}. This may be attributed to several reasons: the limited availability of semi-supine bikes in Greece is because of the high cost, the expertise and the training needed, the technical difficulties, and the culture and the habits of Greek patients.

The rate of major complications is acceptable and comparable with the data from SE registries of other countries^{7,11}, demonstrating that SE is a safe diagnostic tool. It is remarkable that most of the complications occurred in TCs. This may be related to the severity of the cases performed in TCs, the scrutiny in reporting any complication, and/or the contribution of trainees in the performance of the tests.

The use of atropine and handgrip in half of the SE cases seems reasonable, taking into account that more than 78% of the studies were performed after the discontinuation of drugs with NIA. The use of contrast agent in 63% of the tests is higher than in other countries, where contrast is not reimbursed.¹¹ CFR was measured in a limited number of cases, possibly due to specific indications and/or the expertise needed. The mean time needed to perform and report a study was 36.2 ± 14 min, with the shortest one reported in TC (34 ± 13 min). This may be partially explained by the large number of tests that were performed in these centers daily and the great experience of the physicians in these laboratories.

Most of the tests (95%) were reported as diagnostic, which indicate appropriate and successful use of the technique. The diagnostic value was associated with the type of the medical center (TC, PH, or PS), the use of contrast agent, and the duration of negative inotropic drugs discontinuation, which validates the importance of training in SE and probably of more extensive use of contrast agents.

Limitations of the survey include: the lack of data concerning the application of 3D echo¹² and left ventricular global longitudinal strain¹³ in SE and the lack of follow up in patients with positive for ischemia SE tests to assess the sensitivity and the specificity of the method.

SE is an advanced imaging technique that is widely used in Greece. Despite the important differences among centers, SE procedure in Greece is generally harmonized with the international standards. Improvement in education and the homogenization of the technique among centers is part of the mission of the Echocardiology Working Group and the Hellenic Society of Cardiology.

Declaration of interest

The authors declare that they have no competing interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.hjc.2020.06.005>.

Appendix B

Working group of Echocardiology of the Hellenic Society of Cardiology Collaborators: **Constantina Aggeli**, 1st Department of Cardiology, National and Kapodestrian University of Athens, Athens, Greece; **Georgios Anastasiadis**, Cardiology Department, Laiko General Hospital, Athens Greece; **Maria Bonou**, Cardiology Department, Laiko General Hospital, Athens Greece; **Manolis**

Bountiukos, Private practice, Kozani, Greece; **Eftychia Chamodraka**, Echocardiography Department, Asckepeion Voulas Hospital, Athens Greece; **Dimitrios N. Chrissos**, Cardiology Department, General Panarcadian Hospital Tripolis, Tripolis, Greece; **Theodoros Christodoulides**, CardioHealth Center, Nicosia, Cyprus; **Georgios Dermitzakis**, Private Practice, Athens, Greece; **Constantinos Evdoridis**, Cardiology Department, Elpis General Hospital; **Jim Fotiadis**, Private Practice, Katerini, Pierias, Greece; **Emmanouil Foukarakis**, Venizeleio-Pananeio General Hospital of Heraklion; **Alexandra A Frogoudaki**, Second Cardiology Department, ATTIKON University Hospital, Athens University, Athens Greece; **Gerasimos Garidas**, Cardiology Department, Venizelio General Hospital, Heraklion, Crete, Greece; **Charalampos Grassos**, Cardiology Department of General Hospital of Attica "KAT", Athens, Greece; **Ignatios Ikonomidis**, 2nd Cardiology Department, Attikon Hospital, Medical School, National and Kapodistrian University of Athens, Athens, Greece; **Marios Ioannides**, Cardiology Department, Nicosia General Hospital, Cyprus; **Stefan Ionitsa**, Henry Dunant Hospital Center, Athens, Greece; **Nikolaos Kadoglou**, University of Cyprus, Nicosia, Cyprus; **Panayiotis Kafarakis**, Venizeleio-Pananeio Gen. Hospital of Heraklion; **Dimitrios Kaipis**, European Interbalkan Medical Centre, Thessaloniki, Greece; **Chris Kairis**, Private Practice, Drama, Greece; **Vasileios Kamperidis**, 1st Cardiology Department, AHEPA University Hospital, Thessaloniki, Greece; **Ilias Karabinos**, 3rd Cardiology Dept. Euroclinic of Athens, Athens, Greece; **Stefanos Karagiannis**, Echocardiology Dpt. Athens Medical Center, Athens, Greece; **Konstantina Karali**, Private Practice, Thessaloniki, Greece; **Alexandros G. Katranis**, Cardiology Department, General Panarcadian Hospital Tripolis, Tripolis, Greece; **Dimitrios Ketikoglou**, European Interbalkan Medical Centre, Thessaloniki, Greece; **Dimitrios Klettas**, Hippocrateion Hospital, University of Athens, Athens, Greece; **Maria Kokladi**, Hygeia Hospital, Athens, Greece; **Christoforos Komporozos**, Naval Hospital of Athens, Athens, Greece; **Panagiota G. Kostaki**, 3rd Cardiology Department, Euroclinic of Athens, Athens, Greece; **Vasileios Kostopoulos**, Cardiology Department, Thriassio Hospital, Elefsina, Greece; **Stavros Kounas**, Metropolitan General, Athens, Greece; **Georgios Koutroulis**, Private Practice, Athens, Greece; **Lampros Kypris**, CardioHealth Center, Nicosia, Cyprus; **Stamatis Kyrzopoulos**, Cardiology Department Onasis Cardiac Surgery Center, Athens, Greece; **Constantina Masoura**, Cardiology department, Laiko General Hospital; **Petros Mavrommatis**, Cardiac Care Centre Paphos, Cyprus; **Konstantinos Meidanis**, Cardiology Department, Venizelio General Hospital, Heraklion, Crete, Greece; **Nikolaos Michailidis**, Private Practice and 2nd cardiology Department, Diavalkaniko Iatriko, Thessaloniki Greece; **Dimitris Mytas**, Cardiology Department, Sismanogleio General Hospital, Athens Greece; **Konstantinos Pappas**, Cardiology Department, University Hospital Ioannina, Ioannina, Greece; **Argyrios Krommydas**, Adult Cardiac Ultrasound Department, MITERA Hospital-Hygeia Group, Athens, Greece; **Georgios Loukidelis**, 6th Cardiology Clinic, Hygeia Hospital, Athens, Greece; **Ioannis Matthaios**, Cardiology Department, Euromedica Dodekanisou Rhodes, Greece; **George Th. Nikitass**, Cardiology Department, General Panarcadian Hospital Tripolis, Tripolis, Greece; **Anastasios Papadopoulos**, 3rd Cardiology Department, Euroclinic of Athens, Athens, Greece; **Athanasios Papandreou**, Private Practice, Chalkida, Evia, Greece; **Alexandros Patrianakos**, Cardiology Department, Heraklion University Hospital, Crete, Greece; **Dimitrios Patsouras**, Mouwasat Hospital Dammam, Saudi Arabia; **Evdokia Petropoulou**, 2nd Cardiology Department, Metropolitan General Hospital; **Spyros Polymeros**, Department D, Henry Dunant Hospital, Athens, Greece; **Loukianos S Rallidis**, 2nd Department of Cardiology, University General

Hospital Attikon, Athens, Greece; **Vasileios Sachpekidis**, Papageorgiou General Hospital, Thessaloniki, Greece; **Dimitrios Savvalas**, Affidea Psychikou, Athens, Greece; **Ilias Sihlimiris**, Department of Cardiology, Patras University Hospital, Rion, Patras, Greece; **Agathi Stergiou**, Department of Cardiology, Metropolitan General Hospital, Athens, Greece; **Dimitrios Tsiapras**, Non Invasive Cardiology Department, Onassis Cardiac Surgery Center, Athens, Greece; **Elias Tsoungkos**, 6th Cardiology Clinic, Hygeia Hospital, Athens, Greece; **Athanasios Tsoukas**, Department of Cardiology, Asckepeion Voulas Hospital, Athens Greece; **Stavros Tzortzis**, Sismanoglio General Hospital of Attika, Athens Greece; **Vasileios Vachliotis**, Cardioprolipsis Heart Center, Athens, Greece; **Agathi-Rosa Vrettou**, 2nd Department of Cardiology, University General Hospital Attikon, Athens, Greece; **Kyriakos Yiangou**, The Cardio Clinic heart Center, Nicosia, Cyprus; and **Theodora Zaglavara**, Interbalkan Medical Center, Thessaloniki, Greece.

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Kalliopi Keramida*¹

^{2nd} Cardiology Department, Attikon University Hospital, National and Kapodistrian University of Athens Medical School, Athens, Greece

Christos Maniotis
Hygeia Group-network, Marousi, Athens, Greece

George Makavos
2nd Cardiology Department, Attikon University Hospital, National and Kapodistrian University of Athens Medical School, Athens, Greece

Constantinos H. Papadopoulos
2nd Cardiology Department, Korgialenio-Benakio Red Cross Hospital, Athens, Greece

Alexandros Stefanidis
1st Department of Cardiology, Echocardiography Laboratory, General Hospital of Nikea, Piraeus, Greece

Anastasios Theodossis Georgilas, Demetrios J. Beldekos²
Cardiology Department, Tzanio Hospital, Piraeus, Greece

Nikolaos Kouris, on behalf of the working group of Echocardiology of the Hellenic Society of Cardiology³
Cardiology Department, General Hospital of Elefsina Thriassio, Athens, Greece

* Corresponding author. Heart Failure Unit, Department of Cardiology, Attikon University Hospital, National and Kapodistrian University of Athens Medical School, Athens, Greece. Phone: +306947996393.
E-mail address: keramidakalliopi@hotmail.com (K. Keramida).

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¹ Address: Attikon University Hospital, Rimini 1, Haidari, 12462, Athens, Greece.

² Deceased.

³ The members of the working group of Echocardiology of the Hellenic Society of Cardiology are listed in the [Appendix](#) section