SPECIAL ARTICLE

Stress Echo Comprehensive Software (SECS) for state-of-art ABCDE protocol

Software integral de eco estrés para protocolo ABDCE de última generación

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ABSTRACT

Background: Several specialized softwares are commercially available for the elective storage of stress echo (SE) data. State-of-the-art SE is based upon novel parameters in addition to regional wall motion.
Objective: To develop a novel software for SE data storage and reporting.
Methods: We developed the prototype of a SE Comprehensive Software (SECS) with a minimum data set eventually allowing standardized collection of data. The software runs with medium-low performance computers as well as with the most popular operating systems (Windows, MAC OS and Linux). The export functions towards widely accepted formats allow easy data sharing. The software is able to generate a customized report which can be expanded in PDF and comma-separated values formats.
Results: The program prototype data entry requires < 2 min per study. The main pages focus on the 5 steps of ABCDE-SE: step A (regional wall motion); step B (B-lines with 4-site simplified scan); step C (contractile reserve with force derived from systolic blood pressure and end-systolic volume); step D (Doppler-based coronary flow velocity reserve in left anterior descending coronary artery); step E (EKG-based chronotropic reserve measured as peak/rest heart rate). The final page graphically summarizes the ABCDE information in a risk prediction model (cardiac death rate per year, from low risk < 1% to high risk > 3 %).
Conclusion: SECS may provide a suitable infrastructure for an advanced clinical and research application, with simple graphic format and convenient reporting option. It may represent a trade-off between exhaustive information required by scientific standards and smooth workflow priority of busy, high volume, clinically-driven activities. Large scale validation and adaptation from users' feedback is necessary prior to dissemination on demand.
Key words: Echocardiography, Stress – Software

RESUMEN

Introducción: Existen diversos softwares especializados en el mercado para el almacenamiento electivo de datos de eco estrés (EE). El EE de última generación incorpora nuevos parámetros además de la motilidad parietal.
Objetivo: Desarrollar un nuevo software para el almacenamiento de datos e informe de EE.
Métodos: Desarrollamos el prototipo de Software Integral de EE (SIEE) con un conjunto mínimo de datos que permite la eventual recolección estandarizada de datos. El software corre en computadoras con capacidad de trabajo mediana-baja y con los sistemas operativos más usados (Windows, MAC OS y Linux). Las funciones de exportación hacia formatos altamente aceptados permiten compartir los datos fácilmente. El software es capaz de generar un informe personalizado que se puede expandir en PDF y en formatos de valores separados por comas.
Resultados: El ingreso de datos en el programa prototipo requiere menos de 2 minutos por estudio. Las páginas principales se concentran en las 5 fases ABCDE del EE: fase A (motilidad parietal regional); fase B (líneas B con escaneo simplificado de 4 sitios); fase C (reserva contráctil con fuerza derivada de la presión arterial sistólica y volumen de fin de sístole; fase D (Doppler de reserva coronaria de la arteria descendente anterior); y fase E (reserva cronotrópica derivada del electrocardiograma medida como la razón de frecuencia cardíaca pico/reposo). La última página resume la información ABCDE en un modelo de predicción de riesgo (tasa de muerte cardiovascular anual, abarcando desde riesgo bajo <1% hasta riego alto >3%.
Conclusión: El SIEE puede proporcionar una infraestructura adecuada para una aplicación clínica y de investigación avanzada, con un formato gráfico simple y opción de informe satisfactoria. Puede representar una solución intermedia entre la información exhaustiva requerida por los estándares científicos y la prioridad de un flujo de trabajo fluido de actividades relacionadas a la clínica con gran volumen de pacientes. Su validación en gran escala y la adaptación de acuerdo a la opinión de los usuarios es necesaria antes de su difusión a demanda.

Palabras clave: Ecocardiografía de Estrés - Programas informáticos

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INTRODUCTION

Progress in science is made easier by sharing data. This has been successfully achieved in several disciplines (from genomics to laboratory medicine) by adopting uniform approaches to acquisition, archiving and reporting, eventually leading to standardization, traceability and harmonization of data. (1) The same principle may apply to stress echocardiography (SE). Ideally, the same technique of acquisition, the same set of parameters and the same clinical meaning attributed to observed findings should be part of image acquisition, interpretation and reporting (2, 3). SE is rapidly evolving and increasingly applied within (4, 5) and beyond CAD. (6, 7) In the contemporary ABCDE protocol, SE has been enriched by the assessment not only of step A (conventional regional wall motion abnormalities, still the time-honored cornerstone of diagnosis and risk stratification), but also of additional step B (lung water by B-lines), step C (left ventricular contractile reserve based on Force), step D (Doppler based assessment of coronary microcirculation), and non-imaging step E (EKG-based heart rate reserve) (8, 9). Each step focuses on a different pathophysiological target and window of clinical vulnerability of the patient: epicardial obstructive coronary artery stenosis in step A (10), lung congestion in step B (11-15), myocardial fibrosis and/or necrosis in step C (16,17), coronary microcirculation in step D (18-21) and cardiac autonomic function in step E (22). They all have shown incremental value over simple regional wall motion abnormalities in predicting outcome. (15,17-19) Yet the methodology, reporting and clinical meaning attributed to these findings is far from being standardized.

We present the prototype of a Stress Echo Comprehensive Software (SECS), part of the SE2020 study promoted by the Italian National Research Council and endorsed by the Italian Society of Echocardiography and Cardiovascular Imaging. (23) In this project, cardiologists team-worked with information technology experts over the years to produce a unified data format for SE data storage and reporting, instrumental to the implementation and dissemination of the SE 2020 study.

METHODS

The SE 2020 study was started in 2016 and now networks 50 accredited SE labs of 16 countries targeting the recruitment of 10,000 patients within the year 2020, in a variety of different diseases, from coronary artery disease to heart failure, from cardiomyopathy to congenital heart disease. To allow a standardized, flexible, and omnivorous comprehensive data entry, SECS prototype was developed, with a general data entry (patient-, disease- and stress-specific) and project-tailored pages.

From the integration of selected inputted data, some clinical risk scores are automatically calculated by the program. They include the pre-test likelihood in patients with suspected coronary artery disease on the basis of age, gender and type of angina (absent, typical or atypical) or dyspnea. (8)

RESULTS

The program prototype has been developed as a platform for testing among selected users. The data entry requires < 2 min per patient. The software runs with medium-low performance computers, and with the most popular operating systems such as Windows, MAC OS and Linux, in order to reach most users. The export functions towards widely accepted formats allow easy data sharing. The software is able to generate a customized report which can be expanded in PDF and comma-separated value formats. .

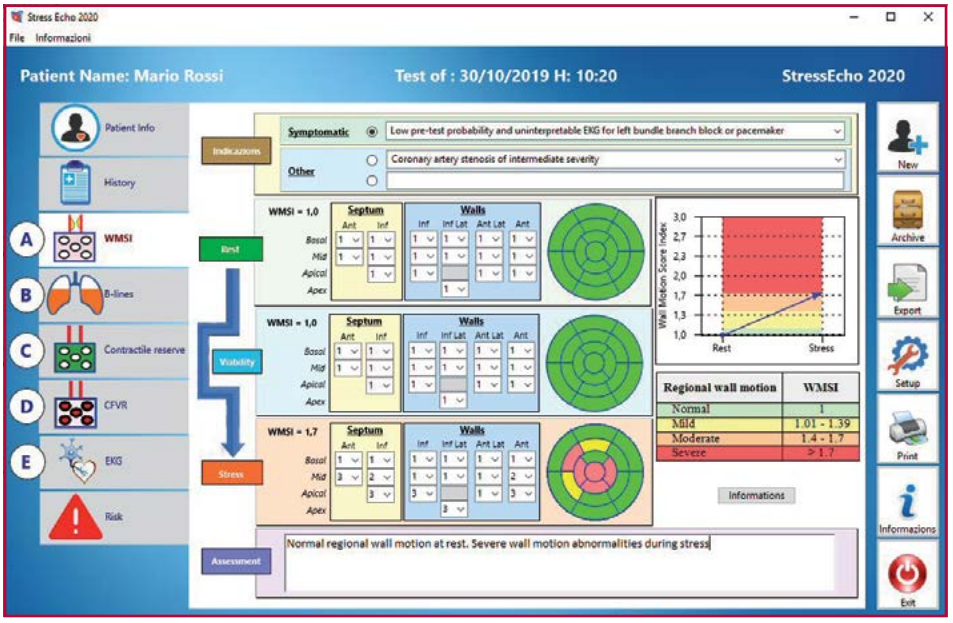
A simple graphical user interface opens different windows to enter clinical data and SE information. With simple input functions including demographics, age and gender, the user selects from a predetermined menu variables related to type of disease and type of parameter. The opening includes core clinical information. Subsequent pages are devoted to step A of regional wall motion (Figure 1), step B of B-lines by lung ultrasound (with simplified 4-site scan (Figure 2), step C of left ventricular contractile reserve (Figure 3), step D of coronary flow velocity reserve in left anterior descending coronary artery (Figure 4), and step E of heart rate reserve by EKG (Figure 5). For each step, a table reports normal ranges and abnormal values, always depicted in a color code from mild (yellow), moderate (orange) or severe (red) abnormal response. In the final page (Figure 6), the same information is provided in a graphic format with the same color-code representing the rest-stress response for every specific parameter, with the corresponding value of risk for hard events derived from available evidences.

DISCUSSION

SECS implementation in the SE2020 study network will have a potential beneficial impact on the clinical, scientific and communication interface of the daily clinical activities taking place in SE labs.

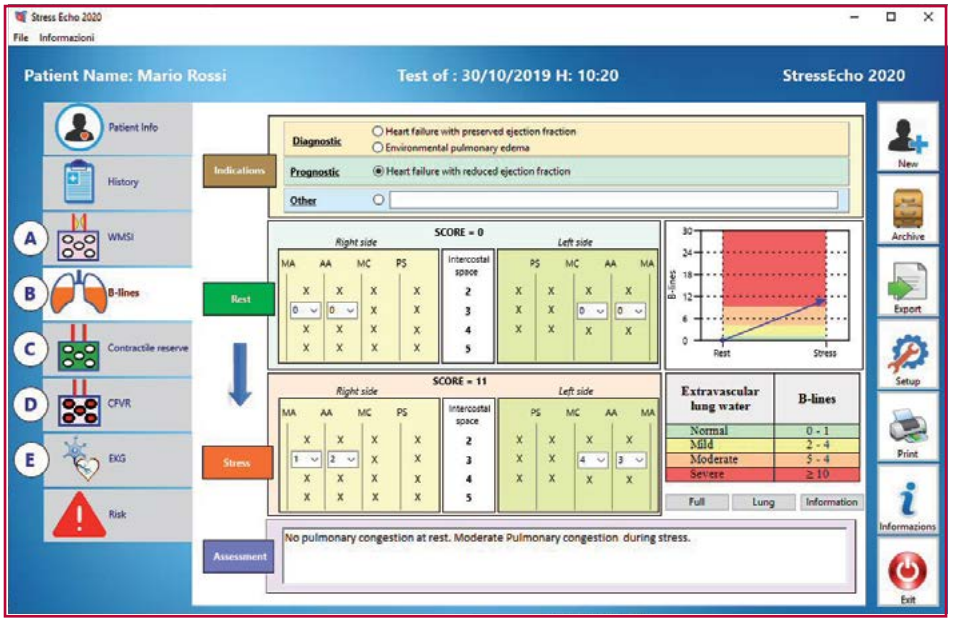
The clinical benefit

The implementation of a dedicated software plays a crucial role for the development of a standardized, uniform format for storage and reporting of clinical and echo data. Any software developed in an echocardiography environment should improve quality and efficiency, and the easiest place to start is a minimal set of standardized measurements tailored to the indications for the examination. Depending on the results, the software indicates whether the findings are normal, also proposing a grading of the abnormal response as mild, moderate and severe. As always happens in the information technology field, the program is continuously and periodically updated on the basis of the users' feedback and upgrading of knowledge, including the one generated within the SE2020 study. For instance, the ABCDE format is upgraded in valvular heart disease or hypertrophic cardiomyopathy with the F and G steps, with step F describing regur-



WMSI: Wall motion score index. CFVR: Coronary flow velocity reserve. EKG: Electrocardiogram. Ant: Anterior. Inf: Inferior. Inf Lat: Inferolateral . Ant Lat: Anterolateral.

Fig. 1. Computerized case report form for regional wall motion analysis (step A). In case of normal resting function, viability stage (middle panel) is not contemplated. A normal wall motion is present at rest (all segments coded in green). At peak stress, severe regional wall motion abnormalities (coded in red, dyskinesia; orange, akinesia; and yellow, hypokinesia) develop. The grading of the response is reported in tabular (right upper panel) and graphic (left lower panel) format, with normal range values in green and abnormal values in yellow (mild degree), orange (moderate degree) and red (severe degree).



WMSI: Wall motion score index. CFVR: Coronary flow velocity reserve. EKG: Electrocardiogram. MA: Mid-axillary. AA: Anterior axillary. MC: Mid-clavicular. PS: Parasternal.

Fig. 2. Computerized case report form for lung B-lines with simplified 4-site scan (step B). The grading of the response is reported in tabular (right upper panel) and graphic (left lower panel) format, with the same color-code as in Figure 2 (from green, normal, to red, severe abnormality).

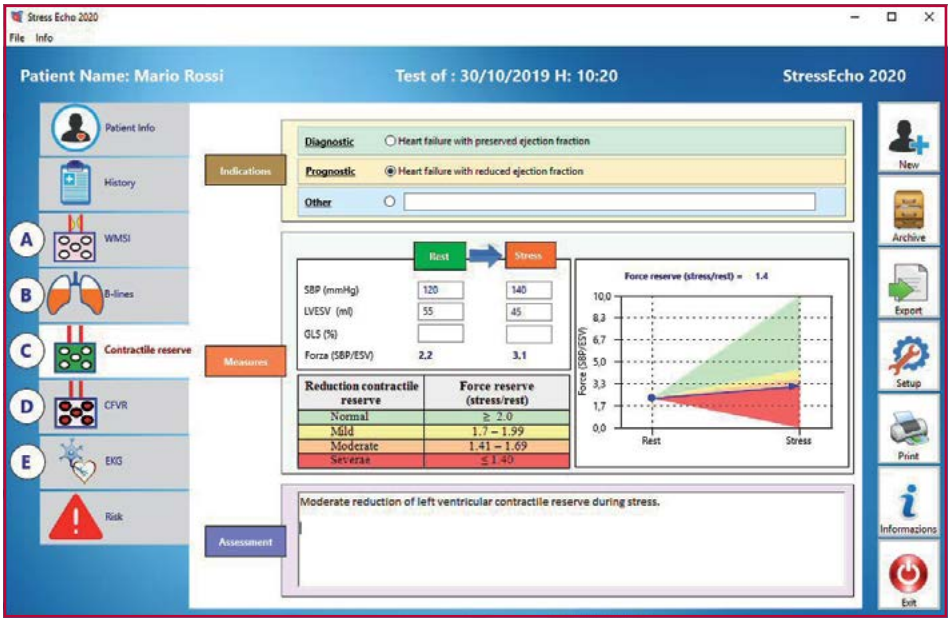
gitant flows (for instance in mitral insufficiency) and step G for gradients (valvular and intraventricular). In these patients, functional characterization, risk stratification and therapy are best obtained with the ABCDEFG approach.

The scientific benefit

The need of expanding evidence-based practice in the various fields of SE must be fed by large scale data acquired in specific subsets with an immaculate methodology. With the proposed software platform, all centers are gently forced to seek and store the same data set for any given pathology, with a single input for clinical data storage and scientific data archiving, avoiding the loss of time and accuracy inherent to duplicate entry of data. In addition, the data are frozen at the time of data entry in the centralized data bank, with the possibility of periodic follow-up updates. This can only increase the quality of the data, inputted in a central data bank by researchers not involved in data acquisition and analyzed by biostatisticians unaware of patient identity.

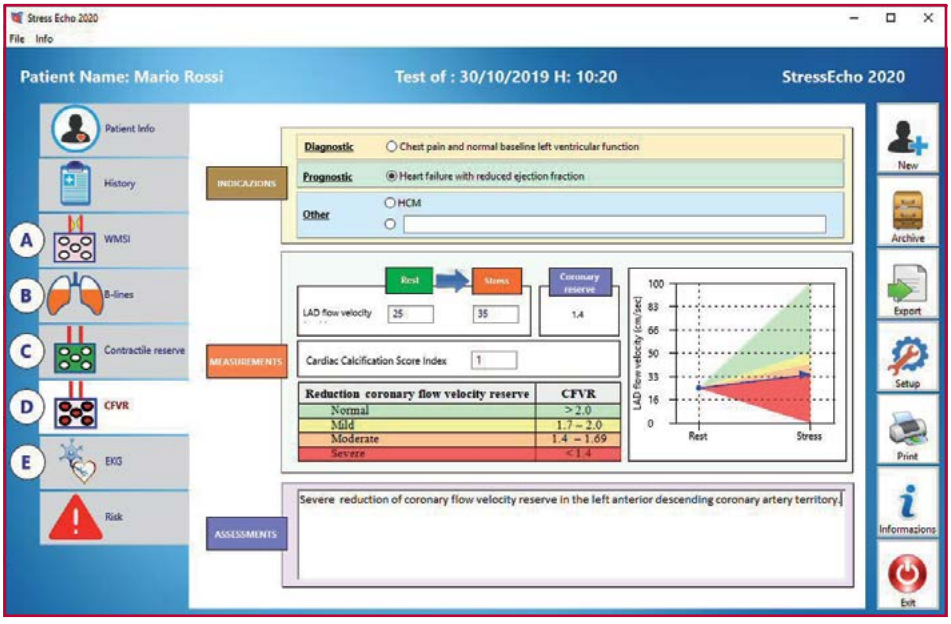
The communication benefit

Communication is of the utmost importance for an effective use of a novel or established method, and the



WMSI: Wall motion score index. CFVR: Coronary flow velocity reserve. EKG: Electrocardiogram. SBP: Systolic blood pressure. LVESV: Left ventricular end-systolic volume. GLS: Global longitudinal strain. ESV: End-systolic volume.

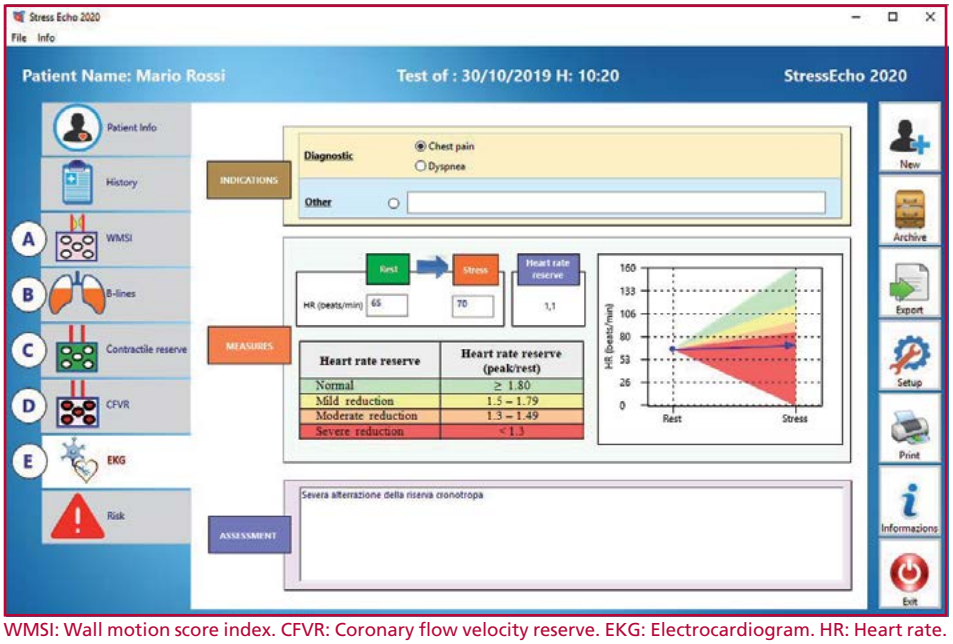
Fig. 3. Computerized case report form for left ventricular contractile reserve (step C). The left ventricular force values are derived from the raw data of resting and peak systolic blood pressure and left ventricular end-systolic volume. The grading of the response is reported in tabular (right upper panel) and graphic (left lower panel) format, with the same color-code as in Figure 2 (from green, normal, to red, severe abnormality)



WMSI: Wall motion score index. CFVR: Coronary flow velocity reserve. EKG: Electrocardiogram. HCM: Hypertrophic cardiomyopathy. LAD: Left anterior descending artery.

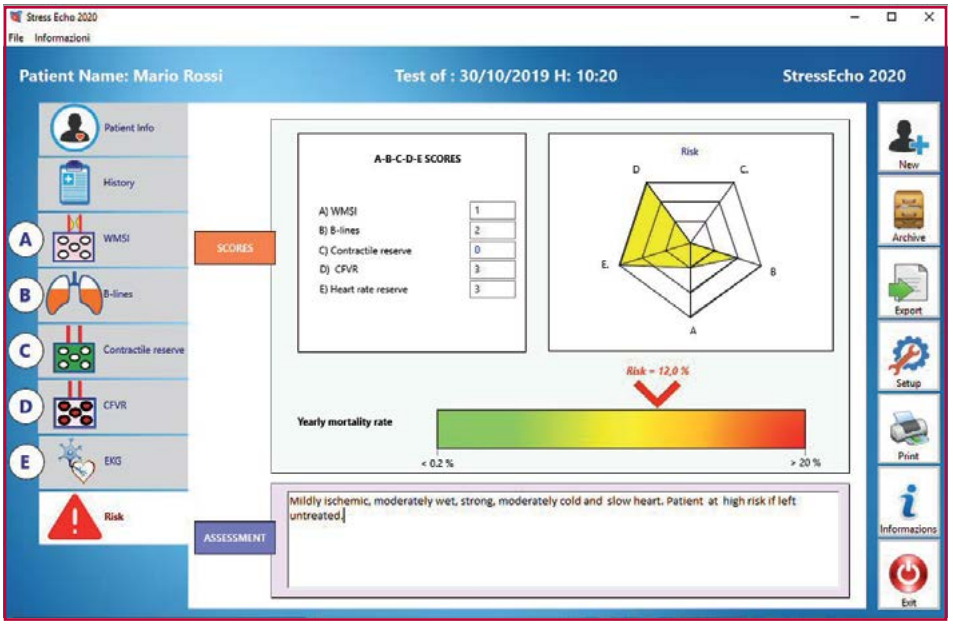
Fig. 4. Computerized case report form for coronary flow velocity reserve step D). The coronary flow reserve values are derived from the raw data of resting and peak coronary diastolic flow velocity. The grading of the response is reported in tabular (right upper panel) and graphic (left lower panel) format, with the same color-code as in Figure 2 (from green, normal, to red, severe abnormality).

quality of reporting is quintessential to ensure accuracy and consistency. With SECS dissemination, the same format of reporting might be adopted by all laboratories with the information in words coupled with a tabular and an image side, which may help the referring physician and the patient to capture at a glance the essence of the report, also avoiding some descriptive, clinically elusive reporting which plagues SE everyday life. As a consequence, there is today a methodological Tower of Babel with each laboratory applying its own approaches, ways of archiving and reporting, and criteria of interpretation of new parameters or old, established parameters applied to new pathologies. The dictionary of the SE Esperanto is a common software, which should share some basic features: user-friendly (clear and informative, requiring few minutes for data archiving); specific for disease and for type of echocardiographic parameter (since we know that what is good and important for a valvular patient is not necessarily relevant for an ischemic patient); with an intuitive graphic interface; and suitable for data merging and data analysis without further inputted data processing.



WMSI: Wall motion score index. CFVR: Coronary flow velocity reserve. EKG: Electrocardiogram. HR: Heart rate.

Fig. 5. Computerized case report form for chronotropic reserve (step E). The data of heart rate are shown at rest and peak stress. The grading of the response is reported in tabular (right upper panel) and graphic (left lower panel) format, with the same color-code (from green, normal, to red, severe abnormality)



WMSI: Wall motion score index. CFVR: Coronary flow velocity reserve. EKG: Electrocardiogram.

Fig. 6. Risk stratification on the basis of A-B-C-D-E parameters, from lowest risk (all parameters negative) to highest risk (all parameters positive).

Study limitations

The software only focuses on SE, and a similar approach might be helpful in other fields, such as resting transthoracic and transesophageal or pediatric echocardiography. The structure of the database implies that some history and clinical information must be added to complete the report. This is essential for the scientific use of the program, but it can be an extra-time for the workflow of a busy lab not interested in systematic storage and scientific handling of accumulated data.

Clinical implications

SECS may provide a suitable infrastructure for the SE 2020 multicenter study, with intuitive interface, eye-catching graphic format and convenient reporting option. It may represent a trade-off between gathering comprehensive information required by scientific standards and smooth workflow priority of busy, high volume, clinically-driven activities. This prototype may now undergo validation, implementation and later diffusion, as already done with a software for user-friendly calculation of radiological risk for cardiovascular examinations, and have a bedside tool to for a simple assessment of the risk-benefit balance of cardiovascular imaging examinations (25), as now recommended by major scientific cardiology societies. (26,27)

The overarching aim is to build the next genera-

tion stress echo lab without walls, with common and shared approach to different diseases by different labs, all speaking the same language replacing current deregulation which makes communication often difficult.

Authors' contribution and acknowledgments

Marco Paterni is the computer scientist who developed the software and modified it according to the users' criticism and suggestions. Quirino Ciampi contributed to the development of the software and its assessment in the initial, pre-dissemination, beta-testing phase; he also revised the manuscript with critically intellectual contribution. Clara Carpeggiani, Rodolfo Citro, Francesco Antonini-Canterin and Paolo Colonna revised the manuscript for critically intellectual content. Eugenio Picano had the original idea and drafted the manuscript.

Conflicts of interest

None declared.

(See authors' conflicts of interest forms on the website/ Supplementary material).

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