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The ImageGuideEcho Registry: Using Data Science to Understand and Improve Echocardiography

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Abstract

Purpose of Review To provide a contemporary update on the American Society of Echocardiography's ImageGuideEcho Registry and present a case study of an individual institution's experience with enrollment.

Recent Findings Technical innovation in clinical echocardiography has expanded the impact of echocardiography in cardiovascular care and provides new opportunities to leverage clinical data to inform quality improvement initiatives and research. The ImageGuideEcho Registry is the first echocardiography-specific imaging registry in the United States and provides a data infrastructure for quality improvement and multicenter research.

Summary The ImageGuideEcho Registry continues to grow, offering a window into echocardiography care across the United States in a variety of practice settings. This early experience highlights its value, opportunities, and ongoing challenges. Continued innovation, such as the addition of primary images, will further add to the substantial value of the registry.

Keywords Registry · ImageGuideEcho · Echocardiography · Quality · Data

Introduction

The American Society of Echocardiography (ASE) first conceived of the ImageGuideEcho Registry (IGE) in 2016 [1] as an opportunity to use imaging and report data collected from routine clinical echocardiography to better understand cardiac disease, optimize quality of care, and conduct research to improve cardiovascular health [2]. Echocardiography provides critical information in the diagnosis and management of cardiovascular [3, 4] and non-cardiovascular diseases [5]. Recent innovations in echocardiography including improvements in three-dimensional echocardiography [6] and strain analysis [7, 8] have expanded its diagnostic capabilities [3, 9], allowing for improved visualization of pathology, precision phenotyping, real-time risk stratification [3, 9, 10], and accurate guidance for procedures [11]. Recognizing both the importance of echocardiography in the multidisciplinary evaluation of patients [12] and variability of such imaging in practice [13–15], the IGE Registry provides an important toolkit for healthcare providers and administrators to evaluate individual and institutional performance. This will allow the ability to address critical gaps in education and real-time practice, while simultaneously ensuring quality standards are maintained across increasingly disparate settings in integrated delivery networks [16]. The IGE Registry provides an essential window into imaging care to complement increasingly interconnected clinical registries and serve as a powerful engine for innovation [17–19].

As the first U.S.-based national echocardiography registry, the IGE Registry provides an infrastructure to improve care quality and yield important healthcare insights across

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multiple disciplines. This review highlights the growing value that the IGE Registry provides to echocardiography laboratories, an implementation case report at a large multicenter institution, and introduces practical considerations for system-wide execution within echocardiography laboratories across the United States.

IGE Registry Overview

The IGE Registry uses a secure data platform, currently hosted by HealthCatalyst, the vendor involved in warehousing and maintaining American College of Cardiology National Cardiovascular Data Registries [20], to collect information on the indications, views, interpretations, and measurements made on individual echocardiograms [21]. Currently, the adult transthoracic echocardiography (TTE) module includes a total of 193 distinct data elements (Supplemental Table 1) across multiple domains (e.g., image quality, wall thickness, left ventricular function, right ventricular function, valvular function, pulmonary artery systolic pressure, pericardial disease, regional wall motion abnormalities, and diastolic function) that are captured during routine TTE.

Of note, unlike traditional registries which require significant ancillary support to input data, the IGE Registry utilizes automated data transfer. After a contract is executed between the ASE and individual institutions, there are two mechanisms to allow for data submission to the IGE Registry: (1) through a certified registry vendor or (2) direct data submission. In the former, if an institution is reporting through a reporting vendor that is certified by the ASE, submission to the registry runs in the background of clinical workflow. In this case, when a TTE report is finalized, both measurements (e.g. left atrial dimension) and categorical descriptions (e.g. mild, moderate, or severe mitral regurgitation) are electronically extracted, transformed into the correct units, screened for outliers, and ingested into the registry automatically. In the latter, if an institution is reporting through a non-certified vendor, the site must work with ASE staff and data-mapping consultants to create an initial, customized variable map that links the findings and measurements in the site's TTE report to the respective fields in the IGE Registry. For example, if a site reports the "left atrial anteroposterior dimension" in millimeters, this is reconciled as the same variable as the IGE Registry's - "left atrial dimension" in centimeters and the appropriate unit conversion is performed after the data is extracted. Once this initial mapping is completed for all variables, upon an interpreting physician finalizing a study, the respective fields are extracted, transformed into the required units, screened for outliers, and then ingested into the registry automatically in a process commonly known as Extract, Transform, Load (ETL). There is no need to re-map variables unless changes are made to the variable name or units in the reporting software. This system is intended to rapidly ingest data with minimal impact on clinical reporting. If sites participate in other clinical registries hosted by HealthCatalyst (e.g. CathPCI Registry, Society of Thoracic Surgery/American College of Cardiology Transcatheter Valve Replacement Registry, Chest Pain Registry) [20], then clinical information submitted to these registries by a given site can be linked to the TTE data in the IGE Registry, allowing for a fuller picture of an individual's health.

Once a site is enrolled in the IGE Registry and actively submitting data, they will have access to a dashboard which allows real-time visualization of performance metrics [2]. Specifically, dashboard users can benchmark performance across a number of quality metrics relative to national aggregate performance and further stratify by physician, sonographer, site, month, and year to evaluate granular performance data. Currently, through a partnership with the Intersocietal Accreditation Commission (IAC), there are 9 quality metrics that are visible to users (not all of which have undergone quality testing at the current time): (1) report turnaround time, (2) study completeness, (3) report completeness, (4) quantitative report completeness, (5) mean and peak gradients reported for valvular heart disease, (6) valve areas reported for stenotic valve lesions, (7) regurgitation severity reported for valvular regurgitation, (8) qualitative report completeness, and (9) strain utilization for chemotherapy, heart failure, or cardiomyopathy indications. Users can identify their performance on the overall measure, but also sub-measures (e.g. inpatient vs. outpatient TTE report turnaround time), allowing greater understanding of the source of any discrepancies identified. Users can directly submit these data to the IAC as evidence of meeting accreditation requirements, thus easing the burden of reaccreditation. Additional quality metrics are currently in development as well as additional modules for reporting of pediatric or congenital TTEs as well as perioperative or structural transesophageal echocardiograms. Moreover, while anonymized digital imaging and communication in medicine (DICOM) files can be uploaded to the IGE Registry and associated with the report data (e.g. interpretations and measurements), image upload is not routinely performed due to challenges with the size, number, and complexity of DICOM files as well as the need for stringent anonymization of both DICOM meta-data and burnt-in pixel data to avoid reidentification or disclosure of protected health information. Future initiatives are currently planned to create the capacity and capabilities for mass export, anonymization, and processing of DICOM files.

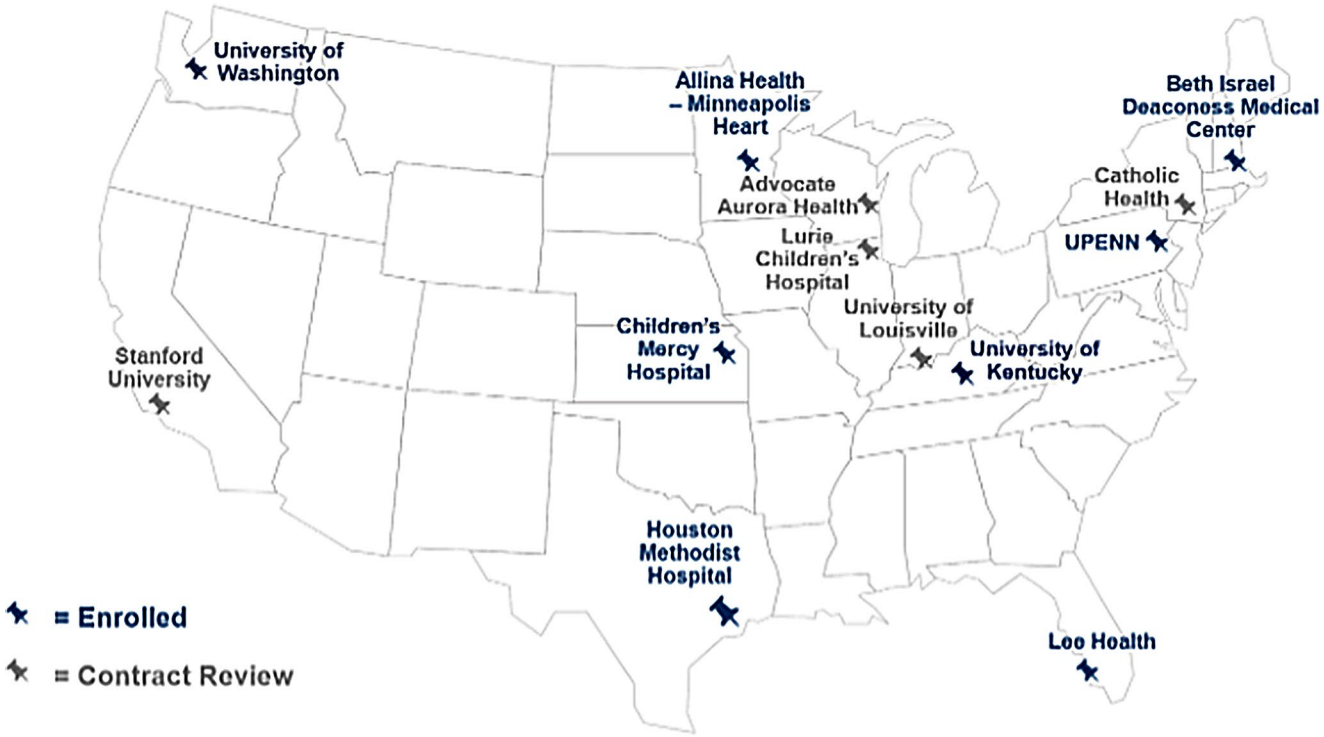

Fig. 1 Map of ImageGuideEcho Registry Participants. Shown is a map of the United States with *blue sites* indicating the eight institutions currently enrolled in the ImageGuideEcho registry. Additional *grey sites* indicate institutions that are currently under review for enrollment.

Table 1 Baseline characteristics of ImageGuideEcho Registry Cohort

Characteristic	Summary Statistic
Age– mean ± SD	63.1 ± 17.6
Female - %	49.6%
Race	55.2%
White	9.1%
Black	2.7%
Asian	0.1%
Other	32.9%
Not reported	
Inpatient - %	46.6%
Comprehensive Study - %	91.8%
Limited Study - %	8.2%
Technically Difficulty Quality - %	17.4%
Ultrasound Enhancing Agent Use - %	5.5%
Appropriate Use	95.6%
Appropriate	2.9%
May be appropriate	1.5%
Rarely appropriate	
Agitated Saline Contrast - %	3.5%
Abnormal Diastolic Function - %	19.5%
Elevated Left Ventricular Filling Pressure - %	9.4%
Normal Left Ventricular Ejection Fraction - %	88.5%

Shown is a selected list of summary characteristics on studies currently included in the ImageGuideEcho Registry

SD = standard deviation

IGE Registry Growth

Currently, eight institutions across the U.S., spanning private and academic hospitals across multiple geographic regions, are enrolled in the IGE Registry, including Allina Health, Beth Israel Deaconess Medical Center, Children's Mercy Hospital in Kansas City, Houston Methodist Hospital, Lee Health, University of Kentucky, University of Pennsylvania, and University of Washington (Fig. 1). The exponential growth of the IGE Registry (Supplemental Fig. 1) highlights the value proposition that the IGE Registry offers institutions. Currently, there are 319,051 TTEs represented in the registry (mean age 63.1 ± 17.6 years, 49.6% female) (Table 1) but projected estimates are greater than 1 million TTEs once all enrolled sites are submitting data.

There are multiple avenues of possible investigation made possible through ongoing growth of the registry that may provide new insights into cardiac pathophysiology and optimal imaging and management strategies. However, at the current time, access to the IGE Registry for research purposes is restricted until a critical volume of institutions are submitting data into the registry to protect patient health information (PHI) from re-identification. In the near future, it will be possible to request access to registry data from the ASE for the purposes of investigation. Unique access portals to registry data can be granted to individuals holding institutional review board approval and site-level approval

for use of specific and delimited portions of the registry data for a study, thus facilitating multicenter research to develop generalizable insights.

A Case Study: University of Pennsylvania Health System

The University of Pennsylvania Health System (UPHS) is an integrated care delivery network comprised of urban and regional hospitals and ambulatory practices in southeastern Pennsylvania and the greater Delaware Valley region. The UPHS includes 9 hospital-based echocardiography locations, each with at least one associated outpatient labs. UPHS operates a single instance of its Epic electronic health record (Verona, Wisconsin) across most sites and uses Epic Cupid for structured reporting (SR) of echocardiographic data. In partnership with ASE, UPHS undertook the successful design and implementation of an ETL of its echocardiographic structured data (Supplemental Fig. 2).

UPHS' echocardiography nomenclature includes both standard vendor-defined data elements and custom data elements developed by an internal governance committee. To facilitate the mapping of vendor and custom data elements to the IGE data dictionary, the Penn Center for Cardiovascular Informatics developed a web-based mapping tool to associate each IGE data element with a UPHS data element (Supplemental Fig. 3). This mapping tool abstracts the underlying database structure, allowing an end-user to focus on generating a clinical terminology map between UPHS' local data structure and IGE Registry (Supplemental Fig. 3). Once finalized, the terminology map was used to transform several quality assurance cases provided by ASE. The test case data was then validated for data structure and clinical appropriateness.

Current Challenges and Solutions

As the IGE Registry continues to grow, there are several specific challenges to note. First, there is a continued need to ensure standardization of reporting. While there has been tremendous progress across the field to standardizing the practice of echocardiography [22], there remains local variation in reporting within specific units and terminology (e.g., moderate-to-severe vs. moderate and severe). Reconciling inter-institutional variability is currently addressed at the data integration stage, when site-specific data is mapped to the registry framework. This process could be further streamlined with the adoption of a standardized echocardiographic report structure. An ASE guideline on the standardization of adult echocardiogram reporting is currently in production, with the goal of facilitating standardized communication and uniform extraction of data across sites. Data processing, including both cleaning data and addressing outliers, is an additional layer of standardization that can also be resource-intensive and introduce uncertainty, particularly in the treatment of outliers, which may represent extremes of physiology. To this end, consensus standards have been agreed upon by the ASE IGE Registry Committee to designate a given parameter value as an outlier (and thus nulled) or an extreme of physiology (Supplemental Table 2).

Second, there is the need to ensure adequate funding to support the maintenance and functionality of the registry, particularly as the registry continues to grow. Currently there are no fees assessed to sites participating in the registry, with the growth of the registry made possible through an industry advisory board and sponsorship. Ensuring continued growth and expansion of the IGE Registry may require additional funding support, which may come from a diverse array of sponsors.

A third challenge is navigating data ownership and access, particularly in the context of facilitating research across registry participant sites. Individual sites and their patients retain ownership of data and thus their data are not used for research without explicit consent and institutional review board approval. Nevertheless, navigating issues around data access and ownership will remain important and challenging as the registry expands to include TTE images.

Conclusions

The ImageGuideEcho Registry continues to expand its capabilities to better understand and improve echocardiography throughout the United States. The experience and growth of the registry has highlighted both the value and opportunities of this approach but also some of the continued challenges. Ongoing innovation, such as inclusion of primary image data and research using registry information, will further add to the value of the registry for participating echocardiography laboratories nationwide.

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Message from Former American Society of Echocardiography President, Allan Klein, Detailing his Original Vision for the ImageGuideEchoRegistry

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  White paper that describes the genesis and motivation behind the ImageGuideEcho Registry.

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Data Availability No datasets were generated or analysed during the current study.

Declarations

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

Competing Interests The authors declare no competing interests.

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