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# Cardiac Imaging in the Geriatric Population: What Do We Think We Know, and What Do We Need to Learn?

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ABSTRACT

Cardiac imaging plays an important role in coronary artery disease (CAD), congestive heart failure (HF) and valvular heart disease (VHD) in the elderly. Imaging defines the structure and function of the cardiac system, refining the understanding of patients' anatomy and physiology and informing a host of clinical care decisions, including prognosis. Yet there is a paucity of evidence to guide the rational use of many imaging modalities in patients of advanced age, a population with considerable clinical heterogeneity, high prevalence and burden of cardiovascular disease (CVD) and atypical presentations of CVD. This paper discusses important considerations for cardiac imaging for older adults, particularly in regard to CAD, VHD and HF, and then presents domains for future research to produce data that would inform clinical care guidelines, appropriate use criteria and imaging lab protocols to address the unique needs of the fast-growing elderly population.



It has been estimated that by 2050, the number of individuals ≥80 years of age living in the United States (US) will increase to approximately 25 million.[1] Cardiovascular (CV) disease (CVD) morbidity and mortality rates rapidly escalate as adults age into their senior years; adults aged ≥75 years account for only 6% of the US population but they account for over 60% of myocardial infarction (MI)-related morbidity and mortality events.[2] Similarly, clinical burdens related to chronic coronary artery disease (CAD), congestive heart failure (HF) and valvular heart disease (VHD) are all disproportionately represented in today's burgeoning elderly population.

Cardiac imaging plays an important role in all of these disease states. Imaging defines the structure and function of the cardiac system, refining the understanding of patients' anatomy and physiology and informing a host of clinical care decisions. Imaging is used for screening (detecting asymptomatic cardiac disease), diagnosing the cause of symptoms, defining the extent of cardiac disorder in a patient with known disease (including risk stratification), monitoring the progression (or regression) of disease, and guiding therapeutic management, including decisions about aggressive therapy. Imaging has long been used to guide surgical procedures, and there has been a recent increase in the use of cardiac imaging to guide catheter based procedures.[3] Yet, while all of these uses of cardiac imaging have a special relevance in the elderly, there is a paucity of evidence to guide the rational use of many imaging modalities in patients of advanced age.

This paper discusses important considerations for cardiac imaging for older adults, particularly in regard to CAD, VHD and HF. Current clinical applications and areas of proposed research are described. For the purposes of this paper, cardiac imaging modalities include those which employ echocardiography, radioisotope tracers (e.g. single-photon emission computerized tomography [SPECT], radionuclide techniques), computed tomography (CT) and cardiac magnetic resonance

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**Abbreviations and Acronyms**

**ACS** = acute coronary syndrome

**AS** = aortic stenosis

**AUC** = appropriate use criteria

**AV** = atrioventricular

**CAD** = coronary artery disease

**CIED** = cardiac implanted electronic device

**CMR** = cardiac magnetic resonance

**CT** = computed tomography

**CVD** = cardiovascular disease

**ECG** = electrocardiogram

**EF** = ejection fraction

**eGFR** = estimated glomerular filtration rate

**HF** = heart failure

**HFpEF** = heart failure with preserved ejection fraction

**HFrEF** = heart failure with reduced ejection fraction

**HRR** = heart rate recovery

**ICD** = implantable cardioverter defibrillator

**LV** = left ventricle

**METS** = metabolic equivalents

**MI** = myocardial infarction

**MR** = mitral regurgitation

**MV** = mitral valve

**PET** = positron emission tomography

**SPECT** = single-photon emission computerized tomography

**TAVR** = transcatheter aortic valve replacement

**TEE** = transesophageal echocardiography

**TTE** = transthoracic echocardiography

**VHD** = valvular heart disease

**VT** = ventricular tachycardia

(CMR). There are various definitions of the term 'old age' but we tried to focus on individuals aged 75 years and older. However, since there are no standardized stratifications of old age in the current literature, some of the studies that are described still refer to patients aged ≥65 years of age. The discussion of specific mechanisms, benefits and limitations of individual imaging modalities is beyond the scope of this document and will be briefly discussed only where appropriate.

## Clinical heterogeneity of the older population

In addition to age-related CVD, there are senescent effects in cardiac morphology and physiology as well as broader organ systems changes in elderly patients. Age-related cardiac changes that occur commonly in the elderly include reduced arterial compliance and left ventricular (LV) diastolic dysfunction, physiological states that compound the implications of cardiac pathologies such as CAD, VHD and secondary cardiomyopathies. The overall state of aging also adds to this underlying complexity of CV burden. The elderly are, for example, at an increased risk for age-related clinical burdens that add to CV management challenges, including multimorbidity, polypharmacy, and geriatric syndromes (e.g., cognition changes, falls, delirium).

"Frailty" is a geriatric syndrome that has been used to describe a state of declining reserves in strength and function that occurs in the elderly population. Using the definition, at least 9.5% of the population between 75 and 79 years, 16% between 80 and 84 years, and 25% ≥85 years are frail.[4] Frailty constitutes a syndrome which conveys an increased susceptibility to stressors and accounts for some of the differences between chronological and biological age in terms of disability. Frailty not only can affect CVD outcomes, it can also put individuals at increased risk for complications during diagnosis or treatment. The decision-making process regarding procedures and therapies becomes all the more complex in the frail elderly as risks and burdens more easily outweigh potential benefits, compared to younger patients. Results from cardiac imaging illuminate many of these decisions, but choices concerning whether and when to image and with what modality are greatly impacted by frailty and disability of older adults.[5]

The elderly subgroup is known to be at higher risk for development and progression of CVD, but none of the current trials have an adequately sized elderly group to be examined in isolation. More than half of all trials of CAD in the past decade did not enroll any patient ≥ 75 years of age. The elderly subgroup accounted for only 9% of all patients enrolled in trials.[2] Only three large community registries contributed data describing community elders with acute coronary syndrome (ACS), which included the National Registry of Myocardial Infarction (NRMI), Global Registry of Acute Coronary Events (GRACE), and Can Rapid Risk Stratification of Unstable Angina Patients Suppress Adverse Outcomes with Early Implementation of the ACC/AHA Guidelines (CRUSADE). Evidence supporting the value of cardiac imaging in the elderly population is even more difficult to ascertain. The ambiguous value of cardiac imaging in the elderly raises significant questions regarding the appropriate use of resources in this population.

## Appropriate imaging

Any discussion of imaging indications in the elderly must start with the Appropriate Use Criteria (AUC). The AUC were developed by the American College of Cardiology and other specialty societies in response to concerns over growing resource utilization in CV medicine. It has long been recognized that substantial societal resources are expended on cardiac diagnostic and therapeutic procedures and that there are substantial geographical variations in resource utilization.[6,7] With the goal of improving quality in cardiac resource utilization, the AUC seeks to guide the rational use of procedures, with the goal of defining and reducing the inappropriate use of these procedures. The AUC related to cardiac imaging were among the first AUC produced in the mid-2000s and were based on appropriate use criteria produced by the radiology community. Several of the AUC have undergone revisions, and more are planned. Currently, there are AUC addressing transthoracic (TTE), transesophageal (TEE) and stress echocardiography,[8] cardiac computed tomography,[9] and cardiac radionuclide imaging.[10] Also, there are more recent documents addressing the use of stress testing in stable CAD[11] and imaging in HF.[12]