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ORIGINAL ARTICLE

European Association of Cardiovascular Imaging survey on imaging for myocardial viability

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Abstract

Aims

To evaluate the current role and practice patterns in myocardial viability assessment through a European Association of Cardiovascular Imaging (EACVI) survey.

Methods and results

A total of 179 participants from 54 countries completed the survey. Most participants worked in tertiary centres (60.3%). Transthoracic echocardiography (TTE) was the most widely available modality (98.3%), followed by stress echocardiography (86.6%), cardiac computed tomography angiography (87.7%), and cardiovascular magnetic resonance (CMR, 84.9%). Single-photon emission computed tomography and positron emission tomography were less accessible (59.8 and 40.2%, respectively). CMR was the preferred imaging modality (76.0%), followed by TTE (41.9%), which were also the most frequently used techniques in clinical practice (42.7 and 38.7%, respectively). Viability imaging was regularly used by most respondents in patients with chronic ischaemic heart disease (57.0%) and prior to revascularization for chronic total occlusions (58.7%). Among late-presenting ST-elevation myocardial infarction patients, 60.7% of respondents assessed viability within index hospitalization or the first month, whereas 28.3% performed viability imaging after 1–3 months. However, considerable variation exists between respondents. Revascularization decisions were guided by

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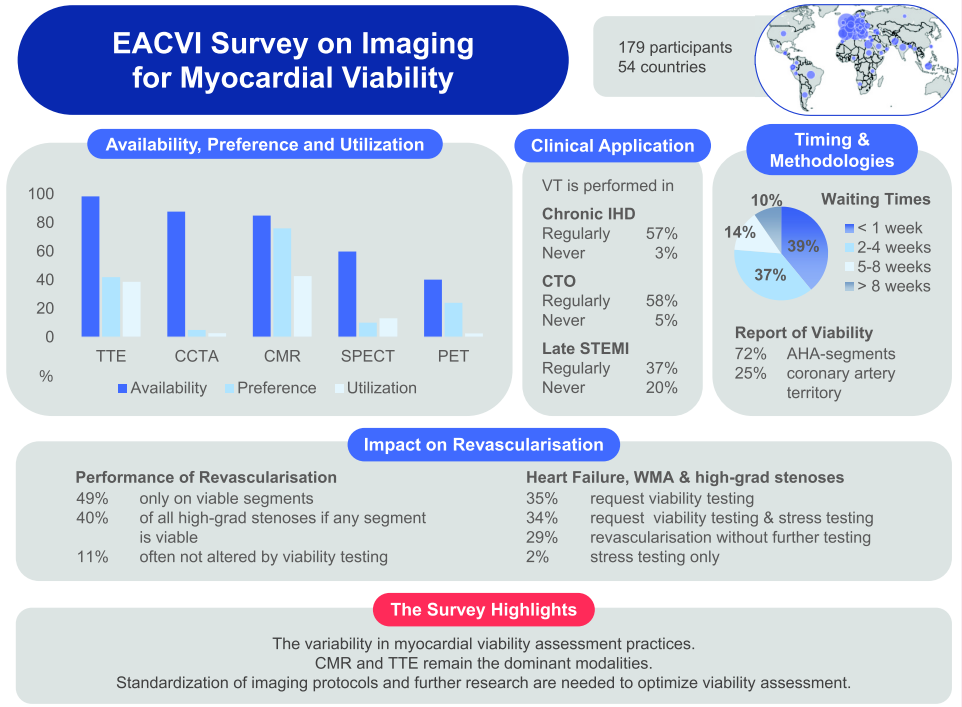
viability findings with revascularization of only viable segments in 49.1% of cases, while 40.0% reported revascularizing all high-grade stenoses if any viable myocardium was present.

Conclusion This study highlights the variability in myocardial viability imaging practices across Europe, with differences in availability, preferred modalities, and clinical application. While CMR and TTE remain the dominant modalities, standardization of imaging protocols and further research are needed to optimize viability assessment and its impact on revascularization decisions.

Graphical Abstract



EACVI survey on imaging for myocardial viability. AHA, American Heart Association; CMR, cardiovascular magnetic resonance; CCTA, cardiac computed tomography angiography; CTO, chronic total occlusion; IHD, ischaemic heart disease; PET, positron emission tomography. SPECT, single-photon emission computed tomography; STE, stress echocardiography; STEMI, ST-elevation myocardial infarction; TTE, transthoracic echocardiography; VT, viability testing; WMA, wall motion abnormalities.

Keywords myocardial viability • multimodality imaging • transthoracic echocardiography • stress echocardiography • cardiac computed tomography angiography • cardiovascular magnetic resonance • single-photon emission computed tomography • positron emission tomography • coronary artery disease • ischaemic heart disease

Introduction

Myocardial viability refers to the ability of dysfunctional but still living myocardial tissue to recover function after revascularization. This concept is particularly important in patients with ischaemic cardiomyopathy, as determining myocardial viability can guide the choice between revascularization and conservative medical therapy. Revascularization procedures such as percutaneous coronary intervention and coronary artery bypass grafting can restore perfusion and improve left ventricular function, but their success is dependent on the presence of viable myocardium. Although the role of viability assessment in guiding revascularization to improve survival has been questioned in light of recent trials,[1] identifying viable myocardium is considered valuable for optimizing patient selection for these interventions and improving clinical outcomes.[2] Over the past decades, various imaging modalities have been developed and refined for assessing myocardial viability. These techniques include transthoracic echocardiography (TTE) with low-dose dobutamine stress, cardiovascular magnetic resonance (CMR) with late gadolinium enhancement (LGE) and stress imaging, cardiac computed tomography angiography (CCTA), positron emission tomography (PET), and single-photon emission computed tomography (SPECT). Each modality provides unique insights into myocardial function, perfusion, and metabolism, contributing to a comprehensive evaluation of myocardial viability. However, despite advances in imaging, clinical practice remains variable across countries, with differences in availability, clinician preference, and local protocols.

The present study aimed to assess the current utilization of viability imaging techniques in routine clinical practice. Through a survey conducted among cardiovascular imagers, we sought to evaluate the availability of different imaging modalities, clinician preferences, and the impact of viability testing on clinical decision-making. Understanding these practice patterns is essential to identifying gaps in knowledge and standardizing myocardial viability assessment in patients with ischaemic cardiomyopathy.

Methods

Study population

The European Association of Cardiovascular Imaging (EACVI) Scientific Initiatives Committee conducted the survey in accordance with previously published criteria.[3] Between May and July 2024, clinicians were invited via the EACVI network and social media to complete an online survey comprising 25 questions. The survey aimed to explore the use of viability imaging in routine clinical practice for coronary artery disease (CAD). Specifically, it investigated the availability and preference of imaging modalities across different centres and regions in Europe, as well as the role of viability imaging in guiding revascularization and risk stratification. All participants provided their consent to take part in the study.

Results

In total, 179 participants from 54 countries participated in the study. The survey revealed a wide geographic distribution of respondents as shown in *Figure 1*, with significant participation from Italy (11.2%), Germany (10.1%), and the UK (9.6%). Most respondents work in tertiary care or university hospitals (60.34%), followed by secondary care or district hospitals (18.4%), private hospitals (14.5%), and primary care (6.7%) (*Figure 2*).

Availability of imaging modalities and facilities

The availability of imaging modalities varied across institutions as shown in *Figure 3*. Nearly all institutions had access to TTE (98.3%), while stress echocardiography (STE), CCTA, and CMR were also widely available, reported by 86.6, 87.7, and 84.9% of centres, respectively. SPECT was accessible in 59.8% of institutions, and PET in 40.2%.

Regarding facilities, most institutions had a cardiac catheterization laboratory (88.8%), while 68.7% offered cardiothoracic surgery for coronary artery bypass grafting. Additionally, in 77.7% of institutions, patient cases could be discussed within a multidisciplinary heart team.

Preferred imaging techniques

The survey revealed that CMR is the most preferred imaging modality for assessing myocardial viability, with 76.0% of respondents selecting it as their primary choice as shown in *Figure 4*. TTE was also widely favoured, with 41.9% of respondents indicating its use, reflecting its widespread availability and role in initial assessments. CCTA was the least commonly preferred modality, with only 5.0% selecting it. These preferences reflect the respondents' general inclination towards specific imaging techniques rather than the actual extent of their use in daily practice.

When asked to indicate how much (in percentage) each participant actually uses each modality in clinical practice (ensuring that the total added up to 100% per respondent), CMR and TTE (including STE) emerged as the most frequently employed, with an average utilization of $42.7 \pm 31.5\%$ and $38.7 \pm 31.2\%$, respectively. SPECT had a moderate usage rate ($13.2 \pm 16.8\%$), while PET and CCTA were the least commonly used, with mean utilization rates of $2.6 \pm 6.5\%$ and $2.8 \pm 9.3\%$, respectively. However, there was considerable variability among respondents, with some not using certain imaging modalities at all, while others relied on them exclusively. *Figure 4* shows the differences between participants' preferences and the actual use of imaging modalities.

Clinical application and timing

The survey highlighted the key clinical scenarios in which myocardial viability imaging is most frequently utilized. More than half of respondents (57.0%) reported performing viability imaging regularly in patients with chronic ischaemic heart disease, with 14.0% applying it to all such patients and 43.0% using it in most cases (>50%). Only 3.4% stated that they do not perform viability imaging at all.

Viability imaging is also commonly used before revascularization of chronic coronary artery occlusions, with 22.4% of respondents performing it in all cases and 36.3% in most cases (>50% of patients). Another 36.3% would perform it in some patients (≤50%), while 5% of respondents do not perform viability imaging in these patients. In terms of CAD severity, viability testing is predominantly applied in

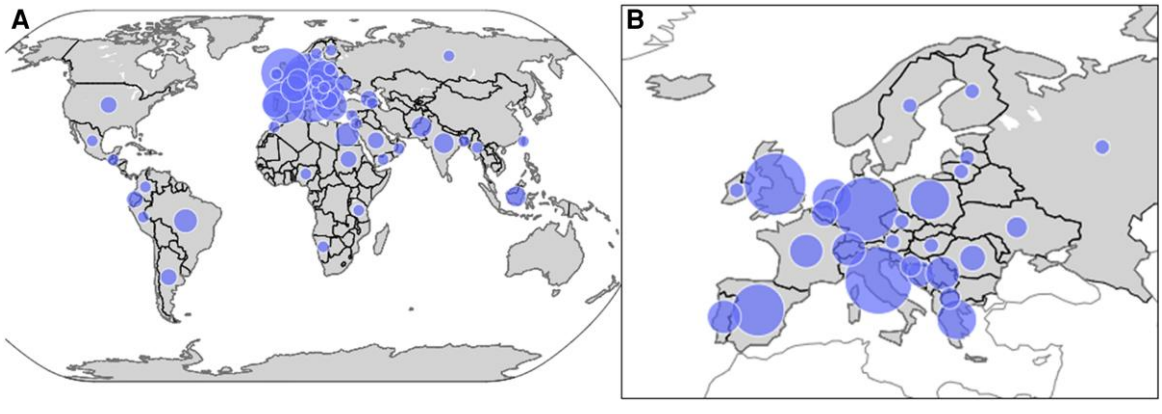


Figure 1 (*A*) A bubble map from the world and (*B*) Europe illustrating the geographic distribution of survey respondents. Each bubble is sized according to the percentage of participants from that country, highlighting the most represented locations (e.g. Italy, Germany, and the UK).

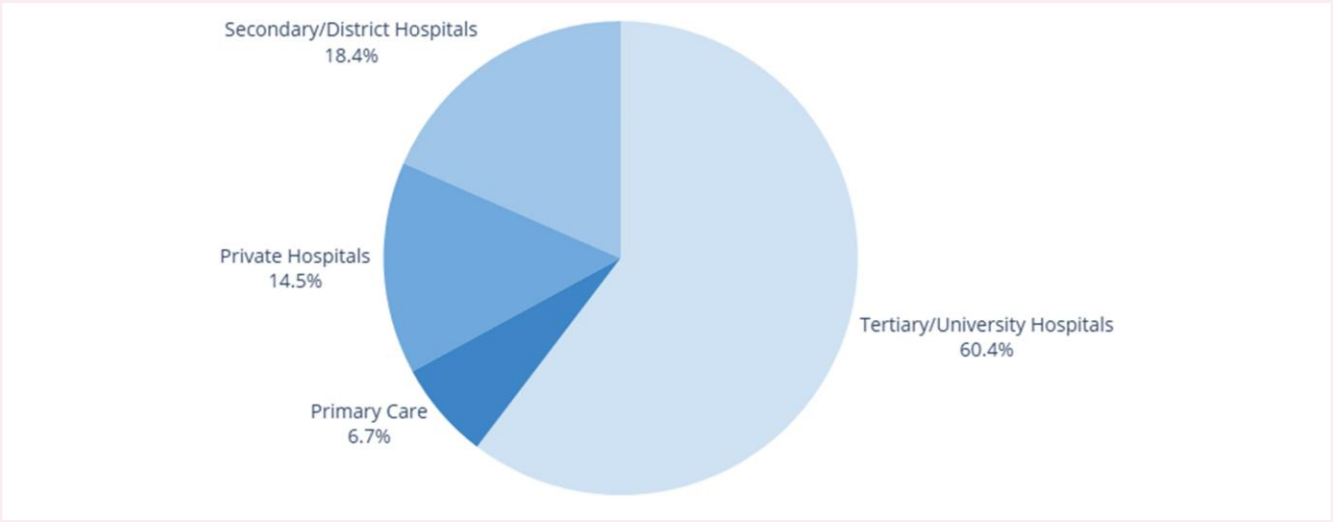


Figure 2 The distribution of survey participants by their primary workplace type.

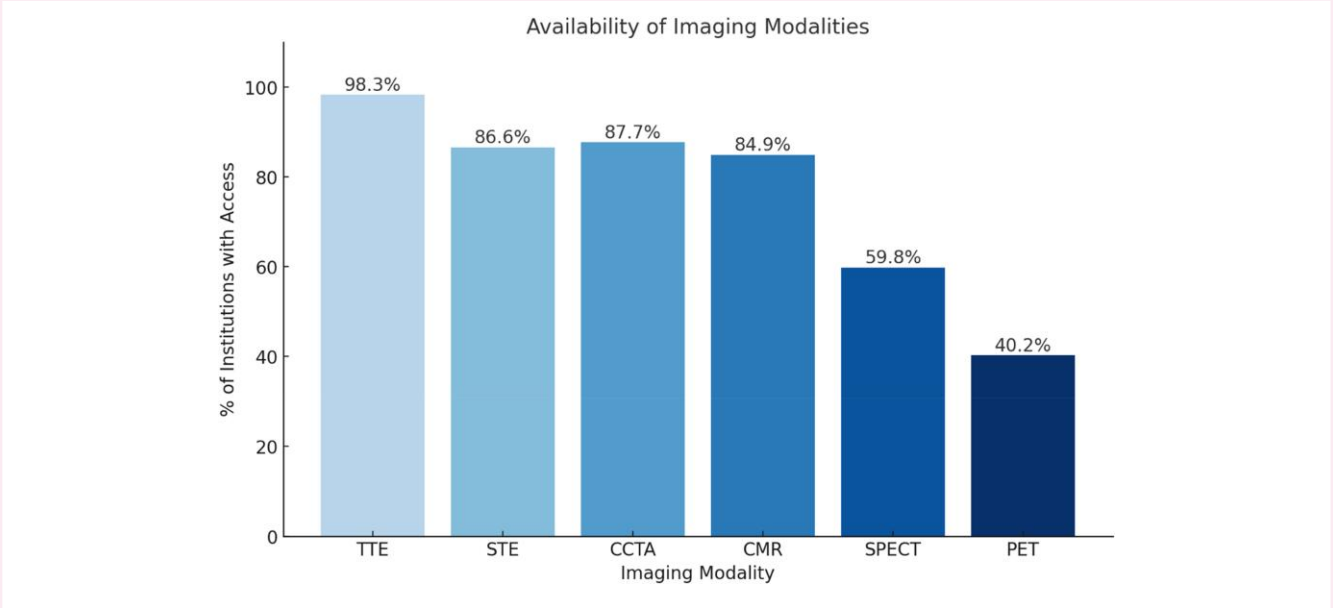


Figure 3 Bar chart showing the availability of imaging modalities among surveyed institutions. CCTA, cardiac computed tomography angiography; CMR, cardiovascular magnetic resonance; PET, positron emission tomography; SPECT, single-photon emission computed tomography; STE, stress echocardiography; TTE, transthoracic echocardiography.

multi-vessel disease (86.9%), while a significant proportion also use it for single-vessel chronic coronary artery occlusion (67.4%). Notably, 11.4% reported using viability imaging exclusively in cases of main stem stenosis.

Additionally, 37.4% indicated employing viability imaging in most patients presenting late (>3 days) with ST-elevation myocardial infarction (STEMI) (10.1% in all patients and 27.4% in most patients), a crucial step in determining the potential benefit of revascularization. 42.5% would perform it in some cases. However, 20.1% indicated that they do not perform viability imaging in late-presenting STEMI patients.

Among patients with CAD undergoing coronary artery bypass surgery, 41.8% of respondents reported performing viability imaging in all (16.4%) or most cases (25.4%), aiding in surgical planning and predicting postoperative recovery.

Regarding the timing of viability assessment in patients presenting late with STEMI, the majority of respondents assess viability in a timely manner: 42.2% during the index hospitalization and 18.5% within 1 month. Another 28.3% perform the assessment within 1–3 months, allowing time for myocardial recovery before making definitive decisions while 7.5% assess viability within 4–6 months and 3.5% after 6 months, reflecting varying practices based on institutional protocols and patient conditions.

In most centres, patients experience minimal waiting times for viability testing. According to the survey, 39.0% of respondents indicated

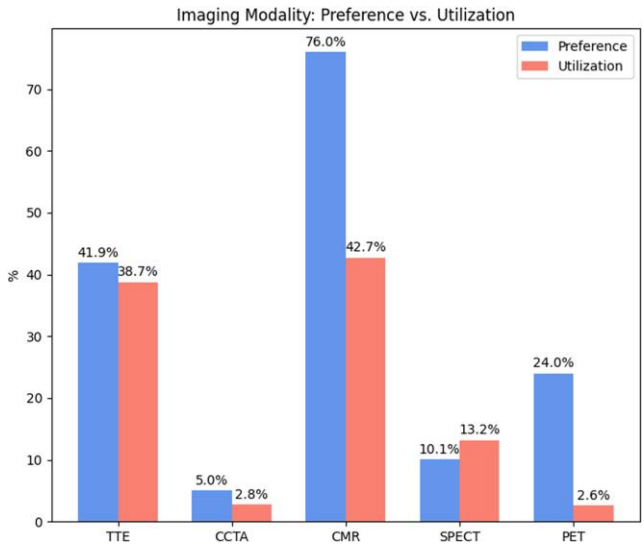


Figure 4 The participants image modality preference vs. actual use of the different imaging modalities. CCTA, cardiac computed tomography angiography; CMR, cardiovascular magnetic resonance; PET, positron emission tomography; SPECT, single-photon emission computed tomography; TTE, transthoracic echocardiography.

that patients receive testing within a week, while 37.3% reported a waiting period of 2–4 weeks. Notably, only 9.6% stated that patients wait longer than 8 weeks.

Methodologies and cut-offs

The survey examined the methodologies and cut-off thresholds used across various imaging modalities for assessing myocardial viability. For CMR, an overwhelming majority (94.1%) of respondents reported using LGE, a key technique for detecting myocardial fibrosis or scar tissue. Among them, 50.6% apply a transmural enhancement cut-off of >50%, while 34.3% use a threshold of >75% to define non-viable myocardium. Additionally, 62.4% incorporate wall motion analysis, and 54.1% assess wall thickness. In contrast, dobutamine stress CMR is utilized by only a smaller proportion (18.2%) of respondents, as well as myocardial strain (11.8%).

When assessing viability with nuclear imaging, 57.9% of respondents use SPECT myocardial perfusion imaging with 99mTc tracers, while 28.7% perform ^{18}F-FDG myocardial PET imaging. These modalities offer a comprehensive assessment of myocardial viability by evaluating both perfusion and metabolic activity. Hereby, most participants would use SPECT for perfusion as well as viability imaging (53.8%), followed by perfusion imaging with 99mTc or ^{201}Tl SPECT and viability assessment with ^{18}F-FDG PET. Only smaller fractions of respondents would use PET with different tracers for perfusion and viability assessment (11.9%). For ^{18}F-FDG myocardial PET, the most applied criterion for defining non-viable myocardium is the presence of a perfusion-metabolism mismatch (37.3%). Importantly, nearly one-third of respondents (29.3%) reported that nuclear imaging is not available at their institution.

In TTE, myocardial viability is primarily assessed using wall motion analysis (73.7%) and low-dose dobutamine STE (72.0%), with wall thickness analysis also being utilized by 56.6% of respondents.

Most participants report viability based on American Heart Association (AHA) segments (72.3%), while 45.1% classify it according to the assumed coronary artery territory. 25.4% report it to coronary artery territory only if coronary anatomy is known.

Impact on revascularization strategies

The survey highlighted the significant influence of viability imaging on revascularization strategies. According to the findings, 49.1% of respondents reported that revascularization is performed only on viable myocardial segments, an approach designed to maximize functional recovery. In contrast, 40.0% indicated that if viable myocardium is present in any coronary artery territory, all high-grade stenoses are revascularized, regardless of the specific territory. Interestingly, 10.9% stated that viability assessment often does not alter clinical management. Most participants (62.2%) revascularize a coronary artery if more than 50% of the segments in the corresponding territory are viable. However, nearly one-third (30.5%) would proceed with revascularization if any segment within the territory shows viability.

For patients with heart failure, wall motion abnormalities, and high-grade stenoses, clinical approaches vary considerably. While 35.6% of respondents would request a viability test, 33.9% would perform both a stress and viability test. In contrast, 28.7% would proceed directly to revascularization without additional viability imaging. Only 1.7% would perform a stress test without viability assessment.

In cases of multi-vessel CAD with high-grade stenoses in all three major coronary arteries, most participants favoured an individualized decision by the heart team if viability testing indicates non-viable myocardium in two out of three coronary territories (59.2%). However, 16.1% would still opt for aortocoronary bypass surgery, while 24.7% would limit revascularization to the left anterior descending artery only.

Discussion

The survey revealed a broad geographic distribution of respondents, encompassing participants from 54 countries. This diverse representation offers a comprehensive perspective on clinical practices across different regions, with Europe being the most well-represented continent. Most respondents (60.3%) were affiliated with tertiary care or university hospitals, where advanced diagnostic tools and specialized personnel facilitate complex imaging procedures. Secondary care or district

hospitals accounted for 18.4% of respondents, while 14.5% were from private hospitals. The increasing presence of advanced imaging modalities in private hospitals underscores their evolving role in delivering specialized cardiac care.

Utilization of imaging modalities

Our survey results highlight significant variability in the use and availability of myocardial viability imaging across different centres and regions. CMR and TTE including STE emerged as the most frequently used modalities, reflecting their widespread availability and strong evidence base in myocardial viability assessment.[4–7] The preference for CMR is likely driven by its ability to provide detailed myocardial tissue characterization, including the identification of scarred vs. viable myocardium through LGE. Additionally, its non-ionizing nature, high spatial resolution, and the possibility for simultaneous perfusion imaging without additional expense[2] further enhance its clinical utility in viability assessment.

On the other hand, TTE remains the cornerstone of clinical practice due to its accessibility, cost-effectiveness, and capability to assess contractile reserve through low-dose dobutamine stress testing. Despite its limitations in directly visualizing myocardial tissue characteristics, its widespread availability makes it an indispensable tool in viability assessment, particularly in settings where CMR or nuclear imaging is not available. SPECT and PET, while well-established techniques for myocardial viability assessment, were used less frequently. This may be attributed to limited availability and radiation exposure concerns. Nearly one-third of respondents reported nuclear imaging not available at their institution. Despite its ability to assess myocardial perfusion and viability, SPECT was moderately utilized, whereas PET had the lowest reported usage among respondents. PET's lower adoption may be due to its dependence on specialized infrastructure and expertise, as well as the need for radiotracer availability and high costs.

The considerable variability in the average use of different viability tests suggests that institutional practices and specialist preferences play a key role in test selection. While some respondents rely exclusively on a single imaging modality, others adopt a more integrative approach, distributing their usage across multiple techniques based on clinical indications and resource availability. However, CMR plays a central role in viability assessment, while other imaging modalities offer complementary value in specific clinical scenarios.

These findings align with the latest guidelines and reflect current limitations, as outlined in the EACVI consensus paper.[2] A direct comparison of the diagnostic accuracy of different myocardial viability imaging techniques remains challenging, as each modality evaluates distinct aspects of viability, and no definitive gold standard exists. Furthermore, the methodologies used in clinical trials to assess myocardial viability have varied considerably with disparate thresholds for defining viability, thereby introducing significant variability in outcome measurements.[8–10] Consequently, neither the EACVI nor the AHA guidelines do recommend a single imaging modality but rather emphasize that the choice of test should be guided by local availability, institutional expertise, and patient-specific factors.[2,11,12]

Clinical application of viability imaging

Viability testing is generally accessible in most centres, with relatively short waiting times allowing for timely clinical decision-making. Most respondents indicated that testing is typically conducted within a few weeks, with only a small proportion reporting significantly more prolonged delays. These findings suggest that viability imaging is well integrated into routine practice, minimizing delays in the evaluation process and enabling prompt revascularization planning where needed.

The findings provide valuable insights into the clinical scenarios where viability imaging is most frequently utilized. It is commonly employed in patients with chronic ischaemic heart disease and those undergoing revascularization for chronic total occlusions. Additionally, many respondents emphasized the role of viability assessment in surgical planning for coronary artery bypass grafting, aligning with current guideline recommendations.[2] However, many respondents reported that viability imaging is not routinely performed in late-presenting STEMI patients, despite its potential value in predicting functional recovery, guiding revascularization strategies[13] and adding prognostic insights through CMR-derived measures.[14,15]

Among patients with heart failure and multi-vessel disease with high-grade stenosis, most respondents indicated that they would perform either a viability test or a combined stress and viability assessment. While revascularization, in conjunction with optimal medical therapy, has been shown to improve left ventricular function and overall prognosis in ischaemic heart failure with reduced ejection fraction,[16] a definitive survival benefit of viability imaging in those patients has yet to be confirmed.[17] Revascularization also carries an increased procedural risk, particularly in patients with severely impaired LV function.[18] These considerations highlight the importance of careful patient selection to optimize outcomes and minimize risks.

Although outcome data on viability imaging is mixed, current guidelines outline specific clinical scenarios where it may be beneficial. Viability imaging can support revascularization planning in single- and multi-vessel CAD when there is uncertainty about myocardial viability and potential for functional recovery, such as in heart failure with late presentation of acute coronary syndrome. Additionally, it can aid decision-making for revascularization in patients with chronic total occlusions, particularly when regional wall motion abnormalities are present in the affected territory. The guidelines also emphasize that management decisions in ischaemic cardiomyopathy should integrate viability findings with coronary anatomy, comorbidities, and procedural risks.[2,19]

Regarding the timing of viability assessment in patients with late presentations of STEMI, most respondents assess viability either during the index hospitalization or within 1 month. This timely assessment supports efficient decision-making regarding revascularization. However, more than one-third of participants reported assessing viability within 1–3 months or later, reflecting varying practices based on institutional protocols and patient conditions.

Variability in methodologies and cut-off values

The survey revealed discrepancies in the methodologies and cut-off values used to define viable myocardium. In CMR imaging, most respondents relied on LGE with a transmurality threshold of ≥50%, while one-third of participants is using a threshold of >75% to define non-viable myocardium. For nuclear imaging, the presence of a perfusion-metabolism mismatch on PET was the most commonly applied criterion, whereas for TTE, myocardial viability is primarily assessed using wall motion analysis and low-dose dobutamine STE.

In the literature, the definition of myocardial viability varies across clinical trials and between methods.[2,8,9] Most studies have historically treated viability as a binary phenomenon.[8] For CMR, a 50% transmurality threshold is widely accepted, with a reported negative predictive value of 92% not recovering function after revascularization.[20] However, a 'grey zone' exists within the LGE range of 25% to 75% transmurality, where the potential for viability and functional recovery remains variable. The probability of recovery decreases as the extent of hyperenhancement increases, reinforcing the concept that myocardial viability is better understood as a continuum rather than a strictly binary parameter. Because of these limitations, the current diagnosis of myocardial viability is not yet standardized.

Impact on revascularization strategies

One of the key insights from our study is the impact of viability imaging on revascularization decisions. Nearly half of the respondents indicated that revascularization was performed selectively on viable myocardial segments, while a substantial proportion reported a more inclusive approach, revascularizing all high-grade stenoses if viability was detected in any coronary territory. This broader strategy aims to enhance overall myocardial perfusion. Interestingly, more than 10% of participants reported that viability assessment often does not alter clinical management, emphasizing that, in some cases, decisions are primarily guided by clinical judgment and the patient's overall condition rather than imaging results alone. In cases of multi-vessel CAD with high-grade stenoses in all three major coronary arteries and non-viable myocardium in two out of three coronary territories, most participants favoured an individualized decision by the heart team. These findings suggest that while viability assessment plays a significant role in decision-making, institutional protocols and clinician preferences vary widely.

Study limitations

Despite the valuable insights gained from our study, several limitations should be acknowledged. The survey was conducted primarily among EACVI-affiliated cardiovascular imagers, which may introduce selection bias and limit generalizability. Most survey participants were imaging specialists, and interventional cardiologists were likely underrepresented in discussions on revascularization strategies. Additionally, self-reported data may not always accurately reflect actual clinical practice.

Conclusion

In conclusion, our survey provides a comprehensive overview of current practices in myocardial viability assessment particularly across Europe. CMR is the most frequently preferred imaging modality, while CMR and TTE remain widely used in clinical routine. However, substantial variability exists in availability and application of imaging technologies, reflecting the lack of consensus on how to define and interpret myocardial viability. To enhance the role of viability imaging in managing ischaemic cardiomyopathy, efforts should focus on standardizing imaging approaches, establish validated thresholds, and clarify their prognostic value in guiding revascularization decisions. Large-scale randomized trials that allocate patients to treatment strategies based on their myocardial viability status are also needed to strengthen the evidence base for outcome benefit. The traditional binary concept of viability should be refined towards a more nuanced approach, with greater emphasis on matching viable myocardial regions to revascularizable coronary territories to optimize patient selection and therapeutic benefit.

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Data availability

The data underlying this article will be shared on reasonable request to the corresponding author.

Lead author biography

Verena Charlotte Wilzeck, MD, is a board-certified internist and cardiologist with specialized expertise in cardiac imaging. She earned her medical degree from the Technical University of Munich, Germany, and completed her residency in internal medicine at the Cantonal Hospital Baden, followed by cardiology training at the Cantonal Hospital Aarau and the University Hospital Zurich, Switzerland. Dr Wilzeck developed a focused interest in cardiovascular imaging early in her career. She completed an advanced echocardiography fellowship under Prof. Felix Tanner and subsequently undertook a cardiac MRI fellowship at the University Hospital Zurich under Prof. Robert Manka, where she gained in-depth expertise in cardiovascular magnetic resonance (CMR). She currently serves as a consultant cardiologist in the Departments of Cardiology and Radiology at the University Hospital Zurich and as a senior researcher at ETH Zurich. Her research centres on advanced CMR techniques, with particular focus on myocardial perfusion imaging, microvascular dysfunction, and cardiomyopathies. A major emphasis is placed on the phenotypic characterization and pathophysiological understanding of genetic forms.

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