Role of multi-modality imaging in the assessment of valvular heart disease

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Take Home Messages

- Assessment of valvular heart disease can be challenging, due to a number of different factors.
- CT, MRI and nuclear imaging add valuable complimentary information for a range of indications.
- There are exciting opportunities to use imaging information and biomarkers to identify those patients at risk of progression and/or suitability for earlier intervention.

Introduction

Trans-thoracic echocardiography (TTE) has traditionally been the bedrock for identification, quantification and monitoring of valvular disease (1, 2). Obtaining the minimum data set provides valuable information about valvular anatomy, presence and severity of pathology and subsequent impact on cardiac chambers and great vessels (3).

However, there are certain instances where further information is required, whether due to sub-optimal image quality, eccentric disease or conflicting data. This editorial aims to provide a brief overview into the value of some of the available imaging modalities which is summarised in **Figure 1**.

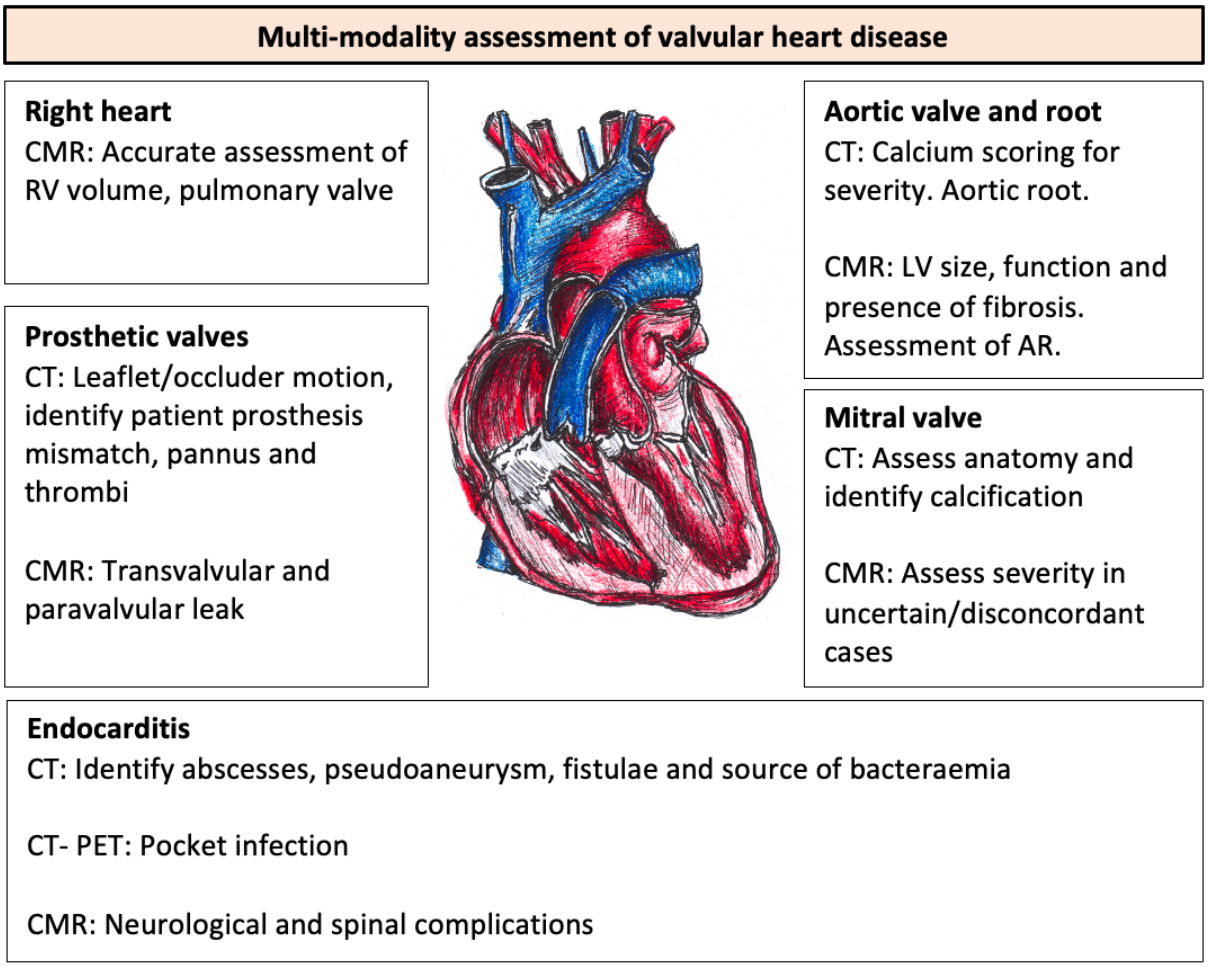

Figure 1, Summary of use of multiple modalities in assessment of valvular heart disease. Cardiac magnetic resonance (CMR), Computed tomography (CT), Positron emission tomography (PET), Right ventricle (RV), Left ventricle (LV), Aortic regurgitation (AR). Created by A Sheikh 2023.

Aortic valve disease and the aorta

Echocardiographic assessment of aortic stenosis (AS) relies on a mixture of visual assessment and objective parameters, which are well established (3, 4). However, this may be complicated by measurement errors, particularly in the left ventricular outflow tract (LVOT) or poor visualisation due to factors such as heavy calcification. This can lead to discordance in the parameter severity, which has been observed in up to a third of patients (5). This has important implications, given that severity dictates timing of surgery (1).

Computed tomography (CT) provides valuable anatomical information about the LVOT, annulus, aortic valve and aorta, with its use well established as part of workup for transcatheter aortic valve implantation (TAVI) (6). However, the prognostic value of combined CT/echocardiographic assessment of aortic valve area (AVA) has yet to be established and may be associated with error given consistent underestimation of LVOT via echocardiography (5,7). The strength of CT assessment lies in calcium

scoring, which allows for a reproducible quantitative assessment of AS severity using sex-specific thresholds of >2000 Agaston Units (AU) in males and >1250 AU in females (8). This could address issues with disconcordance and in specific cases such as paradoxical low flow low gradient AS with preserved ejection fraction (EF) (1, 9). The combination of PET-CT allows for assessment of calcification activity and may be used to predict progression of disease (10, 11).

Cardiac magnetic resonance (CMR) can also provide anatomical and functional information, being the gold standard technique to assess left ventricular (LV) size and function, which has important implications about timing of surgery (1). It is also useful in instances of aortic regurgitation (AR) when echocardiographic measurements are equivocal or disconcordant (1). CMR with LGE and T1 mapping also allows for tissue characterisation and detection of fibrosis, which could help to identify patients at greater risk of adverse events (12, 13). It can reliably track changes in LV mass, LV and matrix volumes following surgery with presence of scar predicting mortality (14, 15). There is ongoing work looking to identify whether early intervention in asymptomatic patients with mid-wall LGE leads to mortality benefit (16).

Lastly, in cases of aortic root dilation, CT is the preferred modality (1). It has the added benefit of identifying aortic root calcification which can have important implications during cardiac surgery. Calcification of the aorta is associated with increased risk of stroke and interferes with aortic cannulation, clamping and aortotomy (17).

Mitral valve disease

Echocardiography including 3D transoesophageal echocardiography (TOE) tends to be the core imaging modality for patients with mitral valve disease (1, 18). CMR can play a role in cases of suboptimal window and can help with quantification in uncertain or disconcordant cases (19, 20). CT can be useful to delineate underlying anatomy and identify mitral annular calcification, which can help to determine suitability for valve repair or need for replacement. (21).

Right heart disease

Echocardiography retains a key role in the initial identification of right sided heart disease, including in the congenital heart disease (ACHD) population (22). CMR is essential, facilitating accurate measurements and monitoring of right ventricular (RV) volume and function which is important in timing surgery. It also provides excellent assessment of the pulmonary valve including level of obstruction if present and involvement of branch pulmonary arteries. In contrast, CT isn't as useful for right heart disease, but has a role in assessment of concurrent lung pathology which may contribute to elevated right sided pressures.

Prosthetic heart valves

The combination of TTE/TOE is usually sufficient to identify valve obstruction or regurgitation, but may be difficult particularly with mechanical valves due to artefact. CT can be useful in this instance by providing excellent view of leaflet/occluder motion and ascertain aetiology of raised trans-valvular gradients by facilitating identification of patient prosthesis mismatch, pannus, thrombi and para-valvular pathology (23-25). CMR may be helpful to identify and quantify transvalvular and paravalvular leak.

Endocarditis

TTE/TOE are first line, though CT, CT-PET and MRI can provide useful additional information (26). CT can help to identify perivalvular/periprosthetic complications such as abscesses, pseudoaneurysms and fistulae as well distant lesions and source of bacteraemia. PET-CT is identification of pocket infection (27). Lastly, MRI is excellent at identifying neurological and spinal complications.

Limitations

Table 1. Limitations of each imaging modality.

Modality	Limitations
TTE	- Operator/patient dependent - Risk of suboptimal window depending on body habitus, chest wall shape, rib spaces - Susceptible to artefact from metallic prosthetic valves
Cardiac CT	- Use of ionizing radiation and iodinated contrast - Requires ECG gating, thus dependent on well controlled and regular heart rate - Susceptible to artefact from metallic prosthetic valves, cardiac devices and pacemaker leads
CMR	- Patient specific factors – tolerate long scan time in enclosed space, can lay flat and follow instructions such as breath holds. - Requires ECG gating, thus dependent on well controlled and regular heart rate - Contraindication due to certain cardiac devices (non-MRI conditional systems, leads from different manufacturers or redundant leads), presence of metallic foreign bodies

Trans-thoracic echocardiography (TTE), computed tomography (CT), cardiac magnetic resonance (CMR).

Summary

TTE remains an excellent initial investigation, which can cheaply and quickly provide valuable information. However, there are several well described limitations for which there is a need for additional/complimentary information. CT is useful across the spectrum of left sided valve disease, with particular strengths in assessment of prosthetic valves and endocarditis. CT-PET has a role in infective endocarditis, both in identifying local pocket infections and wider dissemination. CMR provides valuable information for a range of conditions, and is the mainstay in right sided and congenital heart

disease. The literatures also describes a variety of potentially prognostic information that can be acquired from these modalities, which could be used to identify high risk patients who require prompt intervention. Ultimately, comprehensive valvular assessment requires a multi-modality approach with several potential exciting areas for further research.

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