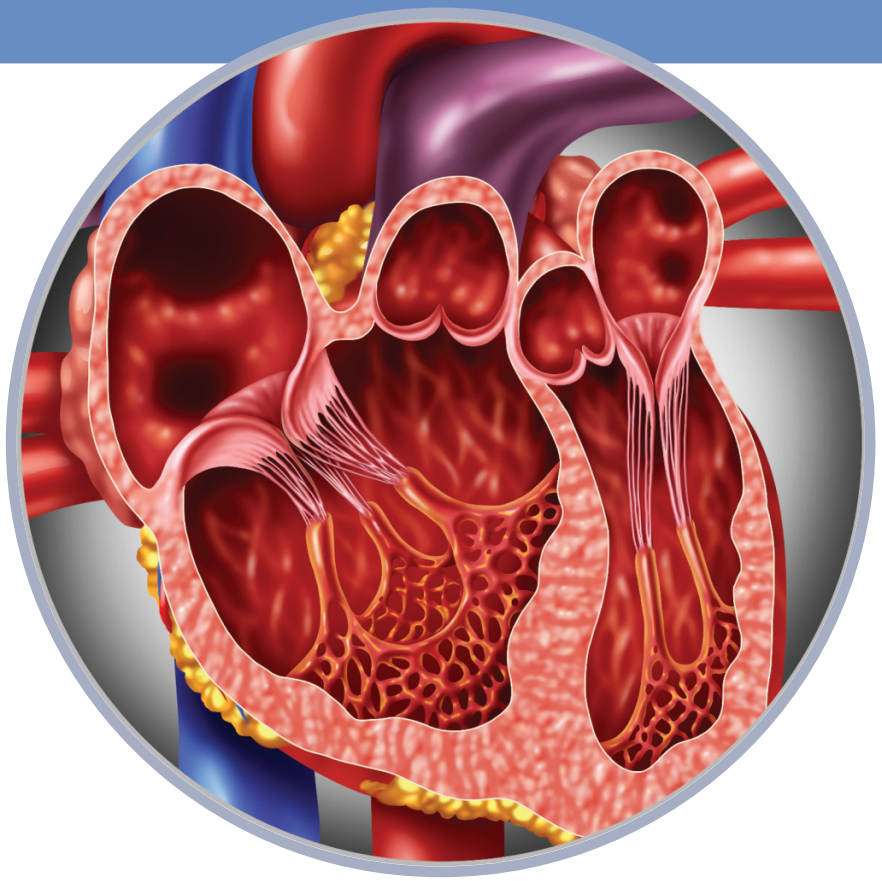
British Heart Valve Society

Improving Care for Patients with Heart Valve Disease

Management of Echocardiography Requests for the Detection and Follow-up of Heart Valve Disease



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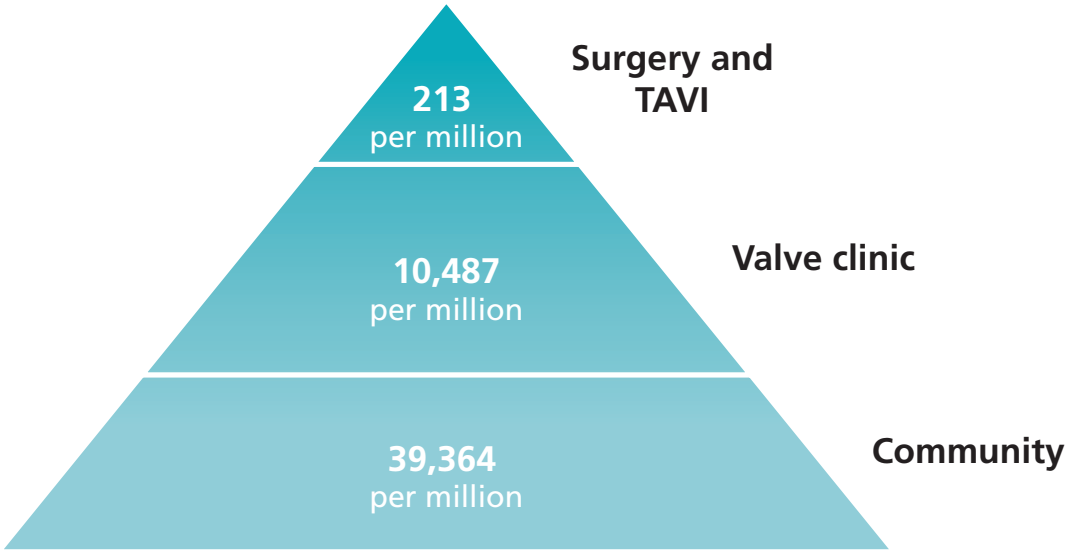
Management of Echocardiography Requests for the Detection & Follow-up of Heart Valve Disease

Statement of the problem

Heart Valve Disease (HVD) is common, but frequently undetected. In 2020/21 the estimated prevalence of HVD in England and Wales was 39,364 per million, but only 10,487 per million were seen in outpatient clinics[1-4] (*Figure 1*).

Figure 1: Pyramid of Valve Disease



All numbers are from England and Wales in 2020/21. **Tip of the pyramid:** There were 4178 aortic valve replacements, 6730 TAVI and 1813 mitral procedures (1118 repairs and 695 replacements).[3,4] **Valve clinic:** From OxVALVE[1] 625,000 people aged >65 were projected to have moderate or severe valve disease detected. **Community prevalence:** 1,750,000 people aged >65 were projected to have detected or undetected moderate or severe HVD[1] and to this was added 1% of the population or 596,000[2] as a conservative estimate of younger patients with bicuspid valves and mitral prolapse. On census day 2021 the population of England and Wales was 59,597,542.[2]

Under-detection leads to late presentation[5] and premature death.[6] At surgery, 55% of patients have severe (grade III/IV) symptoms.[5] This increases inpatient and later mortality and limits recovery of LV function compared with operating with minimal or no symptoms. Moderate or severe HVD is common in patients with acute de novo heart failure, 30% with mitral regurgitation, 8% with aortic stenosis and 5% with aortic regurgitation.[7] In a community study, 10-year survival with undetected HVD was 60% but 78% with no HVD.[6]

Strategies for improving detection in the community have been discussed[8] but the main obstacle currently is the waiting time for outpatient transthoracic echocardiography (TTE). Early in 2022, 155,000 people in England were waiting for TTE and 66,000 had waited longer than 6 weeks compared with 3,238 in Feb 2020.[9,10] Surveys show that an open access or outpatient study is indicated for a murmur in 30-59% of cases.[11-13] This means that in England, early in 2022, between 46,500 and 91,450 people might have been waiting for an echocardiogram indicated by a murmur. Of these about 18%[11] or between 8300 and 16000 were expected to have moderate or severe HVD and be at potential risk of decompensation. However it is usually impossible to differentiate those at risk from those with mild or no HVD based on the request form alone.

Meanwhile, staffing levels remain inadequate to cope with demand. A survey by the British Society of Echo cardiography[10] in Feb 2022 noted that one or sometimes 2 level 7 cardiac physiologists in every department were locums and locums made up over 10% of the workforce at all grades. The survey did not ask how many posts were unfilled, but free comments showed that this was a significant problem with some trusts reporting 3 posts unfilled.

Solutions incorporating basic/level 1 studies and focussed studies

This demand/activity imbalance in the face of inadequate staffing levels requires a rethink of attitudes to echocardiography.

It is not appropriate to require a comprehensive study[14] in every case taking a minimum 45 minutes with the help of a support worker[15] adding potentially disease specific views and measurements even in the absence of evidence of pathology. This reduces echocardiography to an imaging exercise when its real function is as a clinical tool. Furthermore expending time in the hope of not missing pathology in the small number of patients receiving a comprehensive scan leaves the majority of patients with HVD undetected on a waiting list. In the apparent pursuit of safety for an individual case the safety of the wider community is compromised. Fortunately, there is abundant evidence that basic (or level 1) and focussed echocardiograms are safe and sufficient to answer most clinical questions when performed by appropriately trained and experienced specialists.

Table 1 describes the 4 levels of echocardiogram. In the outpatient setting the basic/level 1 scan is a systematic 'screen' for pathology in patients at low risk of disease. A focussed study has 'add-ons' either in response to minor abnormalities found on the basic scan, e.g. aortic valve thickening, or to answer a focussed clinical question. The minimum standard study is the minimum set of views and measurements necessary in patients who are ill or in whom there is the possibility of cardiac disease *(Annex 1 and 2)*. To this, disease-specific 'add-ons' are determined by the pathology detected *(Annex 3)*.

Table 1: The four levels of echocardiogram (TTE) see also Table 2 and Annex 1 and 2

Basic/level 1 - this is effectively an extension of the clinical examination and can be performed with a hand-held device with colour Doppler or a higher-end machine by an accredited* and highly experienced echocardiographer.** It typically takes up to 20 min and is used:

- To detect pathology requiring immediate correction in the emergency setting (often performed by the physician in charge of the case)
- To detect non acute pathology[16-21] and determine what further investigations are needed including further echocardiography
- To exclude the need for a minimum standard study in a patient at low clinical risk of disease e.g. asymptomatic murmur[18,20-22]

Focussed - typically performed using a mid-range machine although hand-held devices with spectral Doppler are now available e.g. Clarius, Butterfly. This is a basic/level 1 study with additional views directed by the clinical question *(Table 2)* and must be performed by an accredited* and highly experienced echocardiographer** with scientific or medical training. It typically takes up to 20 min and is used:

- To identify specific abnormalities in screening projects e.g. HVD.[17-19,23]
- To detect significant change requiring a comprehensive study in patients with previous minimum standard studies e.g. moderate valve disease in a specialist valve clinic.
- To answer clinically-directed focussed questions *(Table 2)*.

Minimum Standard - performed with at least a mid-range machine by an accredited* and experienced echocardiographer.** It typically takes up to 45 min.

- This is the set of views and measurements without which a study cannot be relied on to exclude significant pathology. It is needed if the basic/level 1 study suggests HVD or other pathology (*Annex 1 and 2)*.

Disease specific – performed using a high-end machine by an accredited* and highly experienced echocardiographer.** It can take up to 60 min.

- This is a minimum standard study with additional disease specific measurements for known or newly diagnosed HVD *(Annex 3).*

* *accredited for minimum standard and disease-specific echocardiography by a recognised national board or system e.g. British Society of Echocardiography, European Association of Cardiovascular Imaging, American Society of Echocardiography, Australian BSc.*

** *highly experienced echocardiographers are expected to notice mild abnormalities requiring a more extended study more readily than junior echocardiographers.*

In the early literature, now 15-20 years old, comparisons with basic/level 1 studies using a hand-held machine against standard TTE on a high-end machine occasionally showed that abnormalities might be missed. A study of 107 patients using a hand-held machine as a clinical tool on a ward round missed one case of moderate mitral regurgitation and one of possible pulmonary hypertension.[24] However even with early technology the negative predictive accuracy was 90-97%.[25]

Since then machines and practice have advanced. The American Society of Echocardiography published guidelines covering indications, practice and training in basic/level 1 and focussed studies in 2013.[26] The European Society published guidance in 2011[20] with an update in 2019[21] stressing that hand-held devices were inevitable and desirable. These articles formulated approaches to practical concerns like indications and training.[20.21.26]

More recent clinical studies have used defined protocols for a basic/level 1 study *(Table 2)* with qualified and appropriately experienced personnel and a hierarchical approach progressing to a broader study *(Table 1)* guided by abnormalities in the basic/level 1 study. In these clinical validation papers, significant pathology has not been missed.[18] A recent report[27] showed that a basic/level 1 study could be supplemented by focussed 'add-ons' according to the clinical question with no safety concerns and significant saving of time. In a chest pain clinic, basic/level 1 studies detected unexpected HVD with a median scan time of 7 minutes.[28] The adoption of a basic/level 1 protocol in place of a comprehensive study cut the waiting time for an outpatient echocardiogram from 42 to 14 days and a recent meta-analysis also confirmed the safety and efficacy of hand-held scans for assessing LV function.[29]

Table 2: Features of basic/level 1 and focussed studies

Basic/level 1 study

Features

Basic views, usually: 1) parasternal long- and 2) short-axis (scanning from papillary muscles to aorta); 3) apical 4- then tilting to 5-chamber; 4) subcostal *(Fig 2)*. Individual departments may supplement these *(Fig 2)*.

Systematic assessment of key cardiac structures: 1) LV size and function; 2) RV size and function and IVC; 3) Valves; 4) Presence of pericardial fluid.

Includes colour as well as imaging to detect valve disease.

Classification of the result

1. Major abnormality requiring immediate action e.g. pericardial tamponade, RV dilatation (as a surrogate for massive pulmonary embolism); ***or***
2. Normal and not requiring further TTE; ***or***
3. Requiring higher level TTE (which can often be done immediately if equipment and operator appropriate) e.g. more than trivial abnormalities, or basic/level 1 study apparently normal but patient unwell.

Focussed study

This is a basic/level 1 study with 'add-ons' determined by a clinical or research protocol or as directed by the clinician in charge of the case.

Examples of add-ons

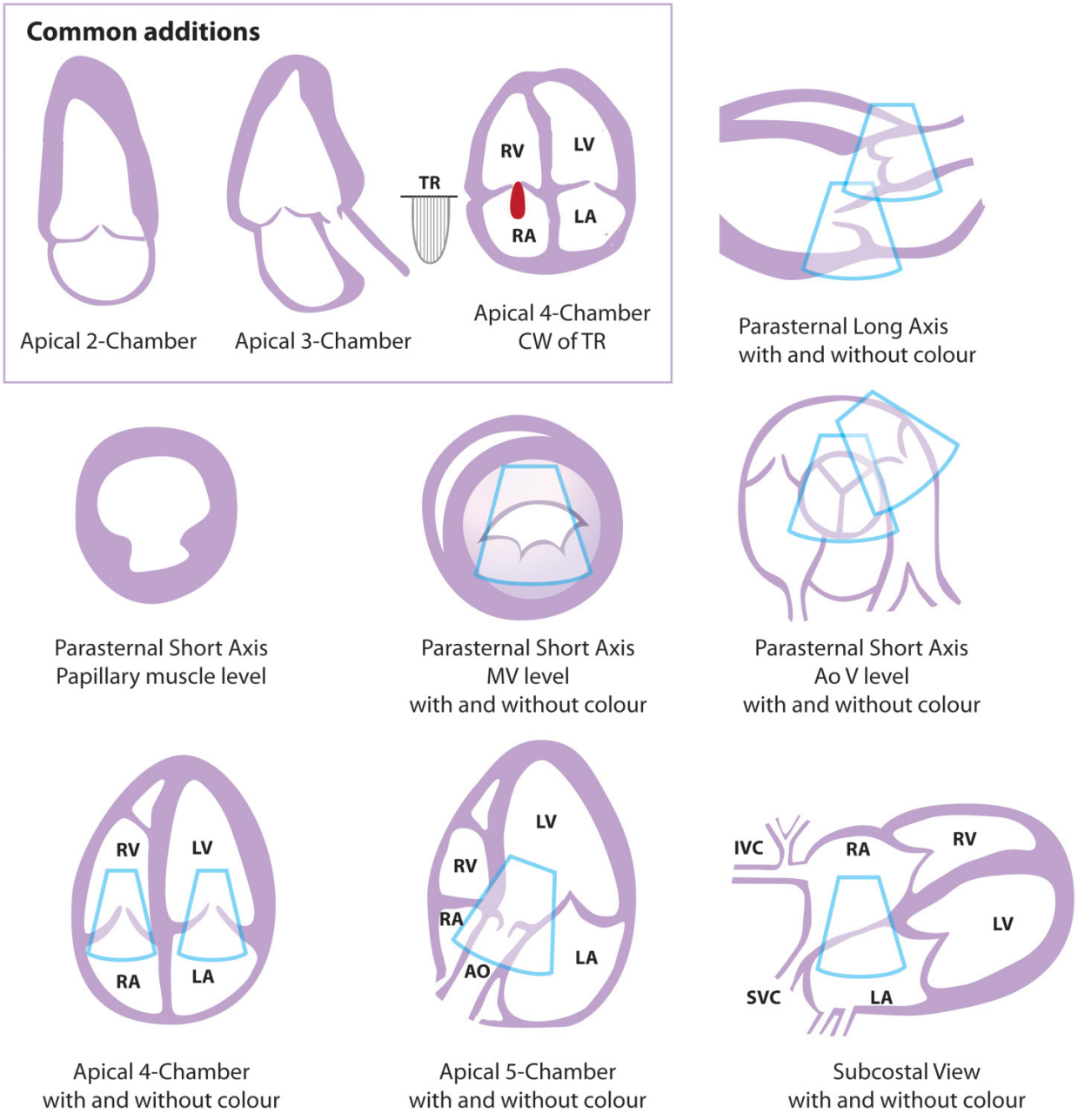
- TR V max if more than mild TR shown
- RV tissue Doppler S' velocity, TAPSE and TR Vmax in sickle cell disease, SLE, or in pulmonary embolism before and after thrombolysis
- Aortic dimensions and assessment of aortic regurgitation in a patient in an aortopathy clinic
- LV measurements to estimate LV mass in hypertension
- LV size and systolic and diastolic functional assessment (include TDI, 3D and strain) in follow-up heart failure clinics

Abbreviations:
LV = left ventricle RV = Right ventricle SLE = Systemic lupus erythematosus TAPSE = Itricuspid annulus peak systolic excursion TDI = Tissue Doppler Imaging TR = Tricuspid regurgitation Vmax = Peak velocity

A suggested aide-memoire for a basic/level 1 study is given in Fig 2 but individual laboratories may add extra views or measurements as routine e.g. apical 2-chamber view, measurement of LV septal thickness, TR Vmax if tricuspid regurgitation is detected or LA diameter in an electrophysiology request. This underlines that the boundary between a basic/level 1 and a focussed study is porous and can be set by individual departments according to the echocardiography request.

Furthermore, patterns of working have evolved in the 20 years since basic/level 1 studies were introduced. Technicians have become physiologists and increasingly clinical scientists and the demands of Modernising Scientific Careers mean that echocardiographers are expected to be able to modify the type of study performed according to the clinical question and any ongoing clinical and technical findings. Different disciplines do not work in silos but in teams and the cardiologist can discuss or direct the echocardiographer in the type of study required. This is particularly appropriate in a valve clinic but also applies in general lists.[27]

Figure 2: An aide-memoire showing views for a basic/level 1 echocardiogram



From C. Demetrescu, S Hothi, J Chambers. **Echocardiography: a practical guide for reporting and interpretation.** 4th ed CRC Press Taylor and Francis, publication date March 2023.

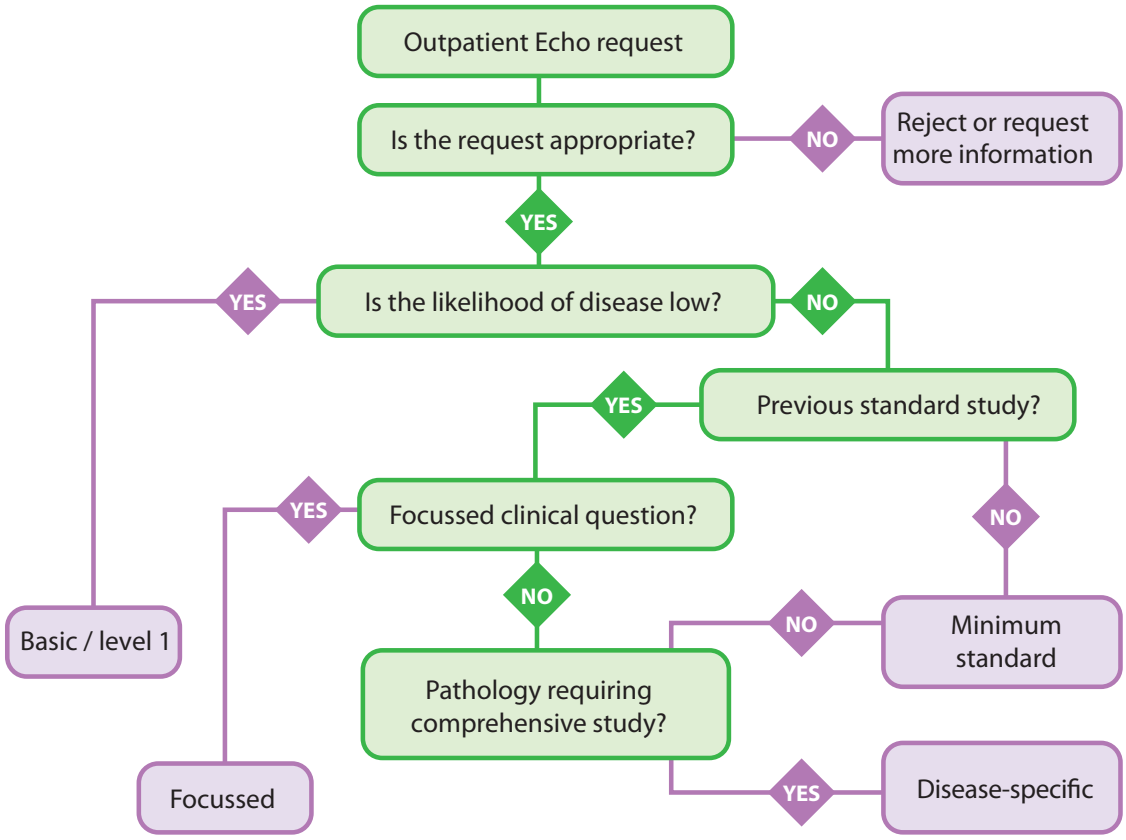
This BHVS statement lists a set of recommendations to improve the demand/capacity imbalance for both waiting lists and new requests.

BHVS Recommendations

Outpatient requests indicated by murmur

New requests need to be appropriately triaged before being booked for echocardiography *(Figure 3).* The forms of patients on the outpatient waiting list may need to be reviewed.

Figure 3. Choosing the level of echocardiogram



Modified from C. Demetrescu, S Hothi, J Chambers. Echocardiography: a practical guide for reporting and interpretation. 4th ed CRC Press Taylor and Francis, publication date March 2023.

Recommendation 1

Patients with a murmur and a critical symptom (e.g. exertional chest pain or syncope or new or severe breathlessness) should be scanned urgently usually within 2 weeks, ideally in a specialist heart valve clinic.

Background to recommendation 1

The risk of death or LV dysfunction rises sharply in all HVD after the onset of symptoms. This is particularly the case for severe aortic stenosis in which the risk of sudden death in patients with no symptoms is <1% p.a. but this rises to 3 or 4% in the first 3 months after the onset of symptoms and may be as high as 11.6% at 6 months on a surgical waiting list.[30] It may also be as high as 24% per year in newly presenting severe symptomatic aortic regurgitation.[31].

Recommendation 2

Patients without previously known valve disease having a murmur and minor stable breathlessness should be scanned as soon as possible depending on local demand/capacity but no later than 6 weeks.

Background to recommendation 2
Breathlessness is a non-specific symptom often caused by obesity or lung pathology. However, it may also indicate HVD. It places the patient below those with a critical symptom but above those with an asymptomatic murmur in terms of the urgency of echocardiography.

Recommendation 3

Requests in asymptomatic murmur without a previous echocardiogram, a basic/level 1 study should be used to triage the need for a minimum standard TTE.

Background to recommendation 3
In TTE indicated for murmur the yield of moderate or severe HVD is 11-18%.[11,32] Over a half have no disease and many do not even have a murmur when auscultated at a specialist murmur clinic.[32]

Differentiating a flow murmur from a pathological murmur from the form alone is usually impossible since the required characteristics e.g. soft second heart sound are not included. Furthermore, clinicians are rarely skilled at auscultation[33] making the original description of the murmur unreliable.

It is therefore a waste of resources to perform comprehensive studies in all patients with a murmur.

The basic/level 1 study needs to be performed by a fully accredited and experienced clinical scientist or physiologist who can recognise signs of mild disease requiring a minimum standard TTE *(Table 1)*.

One model, as used at GSTT, is a murmur clinic *(Box 1)*[32] but requests can also be included in a general basic/level 1 list[18,27] *(Box 2)*. An alternative model is a focussed study with 'add-ons' of a pulmonary valve view and a colour map of the ventricular septum in the 4-chamber view.

Further time saving can be arranged locally using health care assistants to prepare patients for all scans including basic/level 1 studies.

Box 1. GSTT murmur clinic for asymptomatic murmur[32]

Open access requests indicated by asymptomatic murmur are booked in a designated clinic with 20 minutes allocated per basic/level 1 study and a 40-minute slot in the middle and at the end of the list to accommodate minimum standard studies if needed.

The clinical scientist/physiologist performs auscultation and a basic/level 1 study and only proceeds to a minimum standard study if an abnormality is shown. Although the clinical scientists/physiologists running this service attended clinical examination modules the requirement is only to hear a loud ejection systolic murmur pointing to pulmonary stenosis or a VSD that might be missed by a basic/level 1 study. This requires minimal training with a cardiologist at a valve clinic.

Validation[32]

A study of 100 patients had both a basic/level 1 study and a minimum standard TTE. No murmur was evident in 29, there was a flow murmur in 47 and 24 had murmurs judged to be pathological. The basic/level 1 study missed no pathology and 46 hours of scanning time would have been saved using a combination of a basic/level 1 study as triage and a minimum standard study only when abnormality was identified.

Recommendation 4

Determine whether echocardiography is indicated or not. If indicated, determine what level of echocardiography is appropriate for the clinical question *(Figure 3)*.

Background to recommendation 4
Triage requires collaboration between clinician and echocardiographer. The decision is based on:

- The likelihood of disease (e.g. low in asymptomatic young patient with murmur)
- Symptoms.
- The results of previous studies
- The clinical question

Examples of studies not indicated are:

- Repeat studies for any HVD earlier than recommended by guideline in the absence of a clinical change
- Repeat studies for normally functioning mechanical valves after the immediate postoperative study in the absence of other indications (e.g. coexistent HVD or dilated aorta)
- Repeat studied for normally functioning biological valves before guideline indications[34] (e.g.10 years for Perimount or Hancock II or 5 years for valves in the mitral or tricuspid positions)
- Repeat study for most mild native valve regurgitation and for studies previously shown to be normal

Examples of indications requiring an initial basic/Level 1 study:

- Asymptomatic murmur. These can be assigned to a murmur clinic[32] or a general outpatient basic/level 1 echocardiography session[18]

Examples of indications requiring a focussed study:

The cardiologist has a specific clinical question that can be answered by a focussed scan usually in the context of a specialist valve clinic where the clinical assessment and echocardiogram are done at the same time. These are therefore unlikely to appear on a general outpatient list

- In an asymptomatic patient to look for thickening of a biological aortic valve replacement
- In a patient with asymptomatic severe aortic stenosis to detect a fall in LV ejection fraction or a rise in the peak velocity of tricuspid regurgitation
- In a patient with asymptomatic moderate or severe mitral regurgitation to detect a fall in LV ejection fraction or a rise in the peak velocity of tricuspid regurgitation
- Previous mild HVD to detect progression requiring a minimum standard study

Examples of indications requiring a minimum standard study:

- Previous studies show significant HVD and the request is at a guideline-compliant frequency or otherwise clinically justified.

Box 2. Swindon Great Western programme of basic/level 1 study with focussed add-ons[27]

Clinically requested basic/level 1 study with focussed 'add-ons' were requested for replacement valves, suspected endocarditis, LV function, RV function and detecting possible pulmonary hypertension, congenital disease, LA size in atrial fibrillation *(see Table 2 for common 'add-ons')*. These were booked on a dedicated session or at the end of routine sessions during the COVID-19 pandemic.

Of 116 scans one half were normal and 12% showed a significant new pathology. Scan times (excluding preparation and reporting) were under 10 mins for up to 2 add-ons and under 15 minutes with 3 add-ons. For 4 add-ons the scan times were longer than the comprehensive study which took a scan time between 15-20 minutes. Comprehensive TTE were done in 22% of cases mostly to follow BSE guidance or complete training logbooks. Senior review of all studies showed a missed wall-motion abnormality in a comprehensive TTE but no direct or indirect signs of missed pathology in the focussed scans. The clinical question was answered in every case.

Inpatient requests

Recommendation 5

Discuss clinical urgency and level of echocardiography with a clinician.

Background to recommendation 5
The need for clinical collaboration is greater for inpatient than for outpatient requests since the presentation may be acute, not necessarily associated with a murmur and the dangers of progression much higher.

There can be no safe target time-delays and every case must be considered individually.

No level of echocardiography is universally applicable. A combination of a basic/level 1 study can be used to exclude life-threatening pathology and a minimum standard study performed at greater leisure if required.

Examples of studies often not indicated:

- Fever with a low clinical likelihood of infective endocarditis *(see Recommendation 6)*
- Recent TTE with no evidence of clinical deterioration

Examples of indications suitable for an initial basic/level 1 study:

- Incidental murmur in a patient admitted with a non-valve problem e.g. hip fracture. It is reasonable to perform a basic/level 1 study in patients with a murmur as an emergency if identifying HVD will change management
- After insertion of an electrical device or other invasive intervention a basic/level 1 study is frequently sufficient to exclude a new pericardial effusion
- In an acutely unwell patient, a basic/level 1 study may indicate the need for immediate life-saving treatment

Examples of indications suitable for a focussed study:

- Predischarge after cardiac surgery to detect pathology that might require immediate management e.g. large pericardial effusion or LV or prosthetic valve dysfunction

Examples of indications requiring a minimum standard study:

- Patients with known HVD admitted with heart failure will usually need restudy using a minimum standard or comprehensive protocol *(Annex 1, 2 and 3)*
- Murmur after acute myocardial infarction should have a minimum standard study since it may indicate mitral regurgitation or a VSD
- Urgent echocardiography should be done if there is unexplained LV failure or shock since these might complicate critical HVD

Recommendation 6

Echocardiography is indicated if infective endocarditis is likely from the presentation and from the results of initial tests particularly blood cultures. It should not be used as a fever screen.

Background to recommendation 6
Inappropriate requests indicated by fever alone are common. There is a trend to use the Duke criteria as a protocol for tests. The Duke criteria are intended as a research tool or to aid the formulation in clinical practice. The initial suspicion of infective endocarditis is based on clinical characteristics and not fever alone.

Using echocardiography as a fever screen wastes resources since the yield is very low[35,36] and risks minor abnormalities or normal variants confounding the diagnosis e.g. minor calcification, fibrin strands.

Early antibiotic therapy is key and particularly important for reducing the risk of embolization. Therefore, patients with a moderate or high likelihood of infective endocarditis should have echocardiography on the day of the request. If the patient is in heart failure or critically ill and might require urgent or emergency surgery the study should be performed immediately. Ideally a member of the infective endocarditis team will guide the clinical urgency.

A comprehensive advanced study and not a basic/level 1 or focussed study is required since multiple views may be needed to show vegetations and local complications including an aortic root abscess.

Improving the recognition of HVD

Recommendation 7

Every echocardiography department should have a system of alerts when significant HVD is identified.

Background to recommendation 7
There is anecdotal evidence that the presence of HVD may not be communicated to an appropriate clinician. The department needs to have a system for reporting significant HVD to the clinical scientist/physiologist running the department, the referring clinician or a supervising cardiologist preferably the cardiologist in charge of the valve clinic.

GPs are rarely trained to understand echocardiography reports[37] and it is particularly important that open access studies showing HVD are given to a cardiologist to write recommendations for management. Some centres already arrange an appointment to a valve clinic automatically if clinically appropriate which cuts out delays between the hospital and GP and is popular with GPs.

Ensuring easy access to echocardiography

Recommendation 8

Departments should offer easy access to GPs for patients with suspected HVD.

Background to recommendation 8
TThe usual method of referral is within an open access service. The 2022 BSE survey[10] showed that only 65 (76%) departments offered this while 43 (40%) performed studies in the community.

Ways of extending access locally have been explored e.g. hand-held devices in a GP practice[23] or screening people in a flu-vaccination clinic.[38] None have been shown to be viable.

HVD is more likely in the presence of atrial fibrillation than sinus rhythm.[1] An analysis of GP open-access requests showed that in addition to murmur, the inclusion of atrial fibrillation, or any possible cardiac symptom including disproportionate breathlessness in COPD doubled the numbers of valve disease detected with very little loss of sensitivity.[11]

Summary of recommendations

1. **Any forms suggesting the combination of murmur and a critical symptom (e.g. exertional chest pain or syncope) should be scanned urgently usually within 2 weeks and ideally at a valve clinic.**
2. **Patients with no previously known valve disease having a murmur and minor stable breathlessness should be scanned as soon as possible depending on the local demand/capacity balance but no later than 6 weeks.**
3. **In asymptomatic murmur without a previous study, a basic/level 1 study should be used to triage the need for a minimum standard study.**
4. **Triage according to whether a TTE is indicated or not. If indicated determine what level of echocardiography *(Table 1 and Fig 3)* is appropriate for the clinical question.**
5. **Discuss clinical urgency and level of echocardiography with a clinician.**
6. **Echocardiography is indicated if infective endocarditis is likely from the presentation and the results of initial tests particularly blood cultures. It should not be used as a fever screen.**
7. **Every echocardiography department should have a system of alerts when significant HVD is identified.**
8. **Departments should offer easy access to GPs for patients with suspected HVD.**

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Annex 1: Minimum standard echocardiogram: views

View	Imaging modalities considered essential
P/S Long Axis	2D, Colour Doppler
P/S RV inflow	2D, Colour Doppler
	CW of TV if TR found
P/S RV outflow	2D, Colour Doppler
P/S Short Axis at AV	2D, Zoom, Colour Doppler
	PW in RV outflow
	CW of PV and main PA;
	CW of PR
	CW of TV if TR found
P/S Short Axis at MV	2D, Colour Doppler*
P/S Short Axis at Pap muscles	2D, Colour Doppler*
P/S Short Axis at apex	2D, Colour Doppler*
Apical 4 chamber	2D, Colour Doppler
	PW of MV
	CW of TV if TR found
	Tissue Doppler lateral and medial MV annulus
RV/RA modified Apical 4 chamber	2D, Colour Doppler of TV
	M-mode TAPSE ± tissue Doppler CW of TV if TR
Apical 5 chamber	2D, Colour Doppler
	PW of LVOT
	CW of AV
Apical 2 chamber	2D, Colour Doppler
Apical long axis	2D, Colour Doppler
Subcostal long axis	2D, Zoom on IVC and IAS,
	Colour Doppler (IAS; Hep Vein)
	IVC reactivity by eye
Subcostal short axis	2D, Colour Doppler
Subcostal abdo aorta	2D, Colour Doppler
Suprasternal notch - aortic arch	2D, Colour Doppler

** to exclude a VSD*

Abbreviations:

LV = left ventricle
LVDD = LV diastolic diameter
LVSD = LV systolic diameter
PWd = posterior wall thickness
LVDVi and LVSDi = indexed LV diastolic and systolic volumes
LVEF = LV ejection fraction
LVOT = LV outflow tract
VTI = velocity time integral
BSA = body surface area
RV = right ventricle
TAPSE = tricuspid annular plane systolic excursion
TR = tricuspid regurgitation
Vmax = peak systolic velocity
PW = pulsed Doppler
RA = right atrium
CW = continuous wave.

Annex 2: Minimum standard echocardiogram: measurements

Left Ventricle		
Diameters 2D: LVDD; LVSD, IVSd; PWd		
2D volumes or 3D (when available) - BSA indexed*: LVDVi and LVSVi		
LVEF (using 2D or 3D volumes)	LVOT VTI	
Mitral E/A and E/E' ratio using E' at septum ± lateral ± averaged according to local protocols		
Left Atrium	2D Volume (biplane method) or 3D - BSA indexed	
Right Ventricle	RV basal diameter	TAPSE and/or S' on tissue Doppler
	TR Vmax	Acceleration time of PW in RV outflow
	Inferior vena cava (inspiratory change): RA pressure assessment	
Right atrium	2D area - BSA indexed	2D Volume or 3D (when available) - BSA indexed
Aorta:	2D diameter at sinuses, sinotubular junction and ascending aorta indexed to height if at extremes of height	
Aortic Valve	CW Vmax	

** If (BMI> 30 kg/m²); do not index to BSA which underestimates the degree of cardiac remodelling*

Abbreviations:

LV = left ventricle
LVDD = LV diastolic diameter
LVSD = LV systolic diameter
PWd = posterior wall thickness
LVDVi and LVSDi = indexed LV diastolic and systolic volumes
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CW = continuous wave.

Annex 3: Disease-specific add-ons to the minimum standard echocardiogram for heart valve disease

Pathology	View	Measurements/observation
Aortic stenosis	Zoom in LVOT Stand-alone CW at apex and right intercostal space and if necessary suprasternal notch Views of aortic root, ascending aorta, arch and descending thoracic aorta	LVOT diameter, V max, Mean pressure gradient, Effective Orifice Area CW to exclude coarctation Evidence of pulmonary hypertension (already obtained in minimum standard study)
Aortic regurgitation	Zoom aortic root Views of ascending aorta, arch and descending thoracic aorta Aortic regurgitation CW Colour M-mode suprasternal	Colour jet/vena contracta width Aortic regurgitation pressure half-time Flow reversal in descending aorta (PW and colour)
Mitral regurgitation	Zoom mitral valve (imaging and colour) in all views: P/S long axis; A3/P3 with TV inflow tilt; A2/P2: standard; A1/P1 with RV outflow tilt Short axis: 4-chamber: A3/P3 with coronary sinus tilt; A2/P2 in standard 4Ch view; A1/P1 with 5-chamber tilt 2-chamber: 3-chamber (as for P/S long axis) Multiplane imaging if 3D available Pulsed Doppler in pulmonary veins	Detailed valve morphology and mechanism of mitral regurgitation Mitral valve annulus size Tenting height/ area for secondary mitral regurgitation PISA (proximal isovelocity surface area/vena contracta calculations) Evidence of pulmonary hypertension
Mitral stenosis	Zoomed MV in all views Multiplane if 3D available	Mitral valve orifice area by planimetry V max, pressure half-time (and estimated area), mean gradient Evidence of pulmonary hypertension