Is sensible use being made of an inpatient Holter monitoring and transthoracic echocardiogram service within acute medicine?

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ABSTRACT – Transthoracic echocardiograms (TTE) and 24-hour Holter recordings are commonly requested investigations for patients presenting with symptoms thought to be due to underlying cardiac pathology. The objective of this study was to audit the use of inpatient TTE and Holter monitors in acute medical patients under the care of physicians other than cardiologists within a tertiary cardiology referral centre. This was accomplished by a retrospective analysis of 4,623 TTE and 3,145 Holters reported by cardiologists between 8 October 1999 and 3 November 2005. The age range for Holter monitoring was 16–104 years, mean 70 (SD 18) years. The age range for TTE was 16–101 years, mean 68 (SD 17) years. Of the Holters performed, 69.1% were within normal limits. Atrial fibrillation/flutter was the commonest arrhythmia, found in 787 patients (25.0%). A total of 99 patients were referred to a cardiologist; 47 of these patients were permanently paced. Of the TTE requests to assess left ventricular function, 44.8% were normal. A cardiac source of embolism was found in 1.8% of requests to assess for this. TTE requests for infective endocarditis confirmed the diagnosis in 4.1% of patients. Holter investigation and TTE were commonly requested investigations; a large proportion of both, however, were within normal limits. This suggests that more consideration is required before making the request for Holter investigation and TTE, as more appropriate investigations may be available.

KEY WORDS: Holter monitors, transthoracic echocardiogram

Introduction

The transthoracic echocardiogram (TTE) and the Holter recorder are two of the most commonly requested investigations for patients admitted to hospital. When used correctly, both can provide invaluable clinical information.

The Holter device, which is a time-consuming investigation for the patient, the cardiac physiologist who performs the tape analysis and the cardiologist who reports the tape, is a commonly requested investigation in patients presenting with palpitations and syncope, when other devices or investigations may be more appropriate. For example, 24-hour Holter monitoring has negligible yield in syncope,[1] and the investigation is of very little merit in patients hospitalised for syncope who commonly have no further symptoms and can be appropriately investigated as outpatients. Holter monitors are also used to investigate patients with non-specific symptoms, which are frequently not cardiac in origin. TTE is much less time-consuming; most departments, however, have only one or two TTE machines, which limits the number of patients that can be scanned.

We audited the use of Holter monitoring and TTE in patients under the care of physicians other than cardiologists within an acute district general hospital providing tertiary cardiology services to assess whether Holter monitoring and TTE are being used appropriately.

Method

The study was carried out at the Hull and East Yorkshire Hospitals NHS Trust. During the period from 8 October 1999 to 3 November 2005, the Cardiology Department performed 25,800 TTE, of which 12,400 were requested by cardiologists (887 inpatients, 11,513 outpatients). Of the remaining requests, 4,623 (37.6%) were requested by non-cardiologists for inpatients; these were retrospectively audited for age of patient, indication for TTE, and TTE result. Eight records were not used in the analysis because they were paediatric requests. A total of 1,102 records (391 inpatients, 711 outpatients) did not state the requesting consultant but were included in the analysis because all other relevant information was present.

During the same period, 15,789 Holters were requested, 7,950 of which were requested by cardiologists (1,097 inpatients, 6,853 outpatients). Of the remaining 7,839 Holter investigations, 3,145 (41%) were requested by non-cardiologists for inpatients; these were retrospectively audited for age of patient,

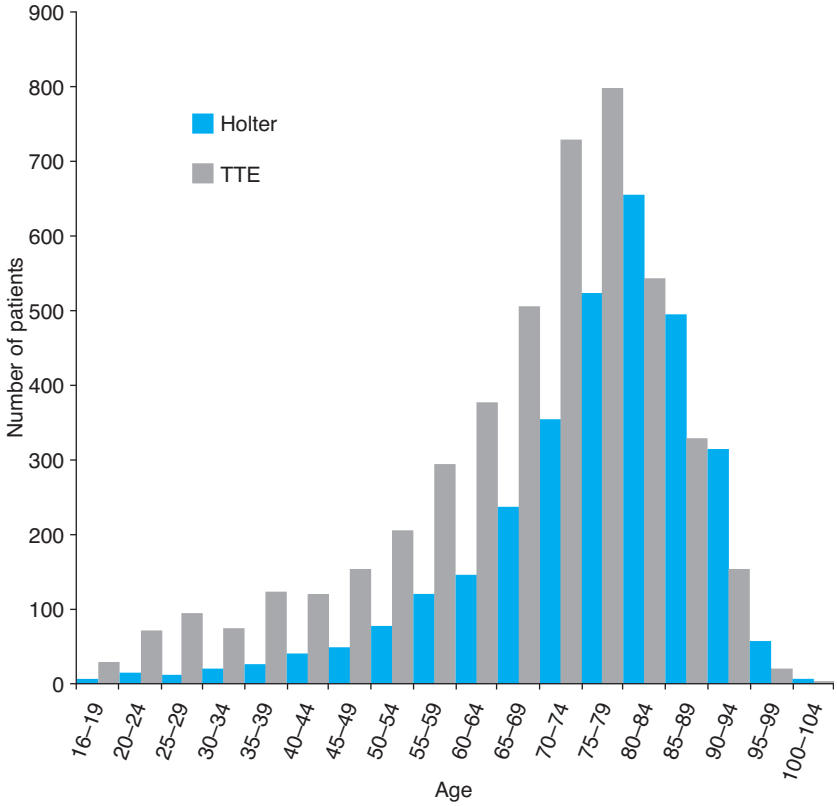

Fig 1. Age distribution of patients. TTE = transthoracic echocardiograms.

requesting consultant, and Holter result. A total of 164 records were not used in the analysis: 32 were paediatric requests (reported by paediatric cardiologists), 94 had incomplete data, 19 were exercise-tolerance tests entered on the wrong database, 11 were poor recordings necessitating repeat tests, 6 were for patients who removed the electrodes during the recording, and 2 were for patients who died during the recording.

A normal Holter was defined as normal sinus rhythm (NSR), ventricular or atrial ectopy, or non-sustained episodes (fewer than 10 consecutive beats) of atrial tachycardia, atrial flutter, atrial fibrillation, or sinus tachycardia. Holters showing episodes of NSR and atrial fibrillation (more than 10 consecutive beats) were defined as paroxysmal atrial fibrillation (PAF). Rate-controlled atrial fibrillation (AF-RC) was defined as atrial fibrillation with an average ventricular rate between 60 and 100 beats per minute (bpm), unless there were episodes of ventricular rates over 120 bpm lasting more than five minutes, which was defined as atrial fibrillation with a fast ventricular response (AF-FVR). If episodes of ventricular rates below 60 bpm lasting more than five minutes were seen, then this was defined as atrial fibrillation with a slow ventricular response (AF-SVR). Patients having episodes of both AF-FVR and AF-SVR were defined as having atrial fibrillation with tachy-brady syndrome (AF-TB). Ventricular tachycardia was defined as more than three consecutive beats of regular broad complex tachycardia with associated atrioventricular dissociation.

Results

The age range of patients undergoing Holter monitoring was 16–104 years, with a mean of 70 (SD 18) years, a median of 75 years and interquartile range 22. The age range of patients undergoing TTE was 16–101 years, with a mean of 68 (SD 17) years, a median of 72 years and interquartile range 20 (Fig 1).

The breakdown of Holter and TTE requests according to specialty is shown in Table 1. The indications for each TTE request (Table 2) were 1,965 (42.5%) for estimation of left ventricular function (Fig 2), 807 (17.5%) for assessment of suspected or known valvular heart disease, 534 (11.6%) for suspected infective endocarditis, 447 (9.7%) for investigation of pericardial disease, 347 (7.5%) for patients with arrhythmias, 342 (7.4%) to determine whether there was a cardiac source of emboli, 62 (1.3%) for assessment of pulmonary hypertension, and 119 (2.6%) for other reasons (evaluation of possible aortic disease and congenital abnormalities; assessment

Table 1. Breakdown of Holter and transthoracic echocardiogram (TTE) requests according to specialty.

		Holter (n=3,145) (%)		TTE (n=4,623) (%)	
General medicine	Endocrinology	140	(4.5)	281	(6.1)
	Gastroenterology	407	(12.9)	572	(12.4)
	Infectious diseases	40	(1.3)	296	(6.4)
	Renal	224	(7.1)	502	(10.9)
	Respiratory	180	(5.7)	417	(9.0)
	Rheumatology	245	(7.8)	423	(9.1)
Elderly medicine		1,590	(50.6)	608	(13.2)
Neurology		134	(4.3)	204	(4.4)
Surgery	Cardiothoracic	48	(1.5)	554	(12.0)
	General	43	(1.4)	194	(4.2)
	Neurosurgery	12	(0.4)	68	(1.5)
	Orthopaedic	47	(1.5)	46	(1.0)
	Vascular	20	(0.6)	144	(3.1)
	Other (ENT, urology, obstetrics and gynaecology, plastics)	15	(0.5)	35	(0.8)
Unknown		0	(0.0)	279	(6.0)

ENT = ear, nose and throat.

Table 2. Breakdown of the indication of transthoracic echocardiogram (TTE) requests according to specialty.

	General medicine (n=2,491) (%)	Elderly medicine (n=608) (%)	Neurology (n=204) (%)	Surgical specialties (n=1,041) (%)	Unknown (n=279) (%)
Arrhythmia	257 (10.3)	55 (9.0)	5 (2.5)	30 (2.9)	0 (0.0)
Cardiac emboli	105 (4.2)	59 (9.7)	118 (57.8)	60 (5.8)	0 (0.0)
IE	404 (16.2)	32 (5.3)	20 (9.8)	78 (7.5)	0 (0.0)
LV function	1,068 (42.9)	301 (49.5)	41 (20.1)	373 (35.8)	182 (65.2)
Pericardial disease	165 (6.6)	17 (2.8)	8 (3.9)	228 (21.9)	29 (10.4)
PHT	50 (2.0)	2 (0.3)	0 (0.0)	1 (0.1)	9 (3.2)
Valve disease	375 (15.1)	133 (21.0)	5 (2.5)	235 (22.6)	59 (21.1)
Other	67 (2.7)	9 (1.5)	7 (3.4)	36 (3.5)	0 (0.0)

IE = infective endocarditis; LV = left ventricular; PHT = pulmonary hypertension.

of patients with systemic hypertension or systemic disorders; and inpatient with suspected cardiac tumours).

Twenty-one (4.1%) of the TTE requests for suspected infective endocarditis confirmed the diagnosis; 15 of these patients (71.4%) were intravenous drug abusers, 1 patient (4.8%) had no pre-existing valve lesions, 2 patients (9.2%) were known to have valvular heart disease, and for 3 patients (14.3%) no other information was available.

Of the TTE requests to determine whether there was a cardiac source of emboli, 47 (13.7%) were following a peripheral embolus, 45 (13.1%) following a transient ischaemic attack, and 142 (41.4%) following a cerebrovascular accident; in 109 (31.8%) the location of the embolus was not available. Six of these requests (1.8%) confirmed a cardiac thrombus; all of these patients had at least moderate systolic left ventricular impairment.

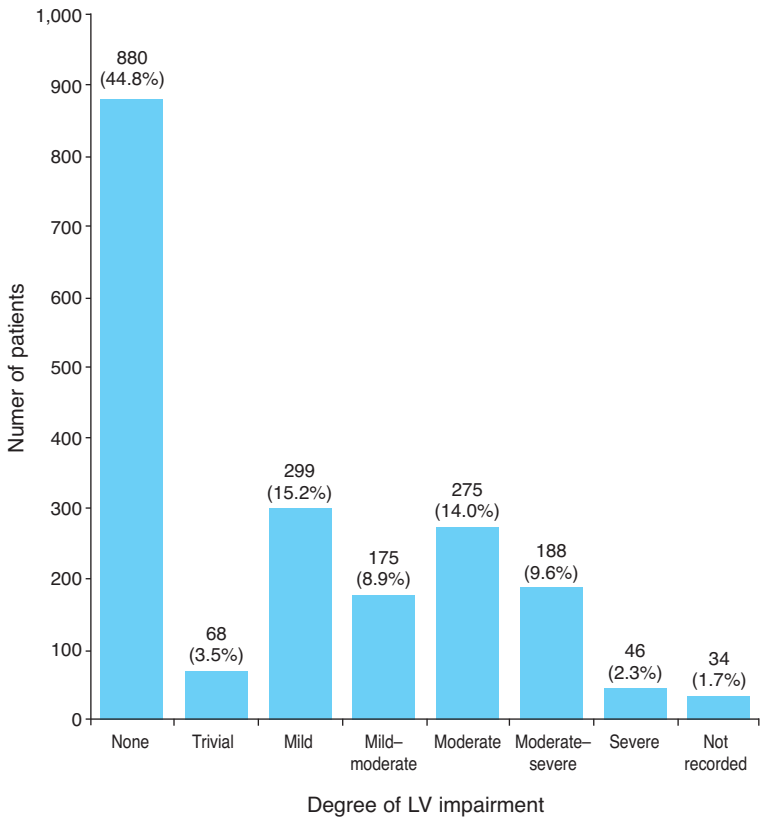

Fig 2. Result of transthoracic echocardiograms (TTE) requested to assess left ventricular (LV) function.

Holter monitoring was reported as being within normal limits in 890 general medical patients (72.0%), 1,063 elderly care patients (66.9%), 121 neurology patients (90.3%), and 102 surgical patients (55.1%) (Fig 3).

The commonest sustained arrhythmia was atrial fibrillation (Table 3), seen in 787 patients (25.0%). Of these patients, 333 had AF-RC (42.3%), 275 had PAF (34.9%), 114 had AF-FVR (14.5%), 51 had AF-SVR (6.5%), and 14 had AF-TB (1.8%).

Of the other arrhythmias seen, 39 patients (1.2%) had ventricular tachycardia, 51 (1.6%) had episodes of supraventricular tachycardia and 63 (2.0%) had evidence of bradycardia other than sinus bradycardia (second- or third-degree atrioventricular block or sick sinus syndrome).

The reporting cardiologist suggested referral to cardiology in 99 patients (3.1%) (26 general medicine, 62 elderly medicine, 2 neurology, 9 surgery). Of these, 47 patients (14 general medicine, 28 elderly medicine, 1 neurology, 4 surgery) were referred because they needed a pacemaker, 32 for second- or third-degree atrioventricular block, 3 for sick sinus syndrome, 9 for AF-SVR, and 3 for AF-TB.

Discussion

TTE and Holter monitoring are frequently requested to investigate patients presenting with a variety of symptoms thought to be due to underlying cardiac pathology. Unfortunately, both TTE and Holter monitoring are frequently requested inappropriately, resulting in a high number of tests within normal limits.

This audit confirms that both investigations are commonly requested for patients in hospital, with an average of 1.9 inpatient Holter monitors and 2.5 TTE

requests each day over the study period. If outpatient requests are also included, then this figure rises to just over 7 Holters and 11.6 TTE requests.

Over two-thirds (69.1%) of all Holters performed were within normal limits, which is in keeping with published results showing the low diagnostic yield of Holter monitoring.[2] Normal tests can be of some value in the diagnostic process by helping to eliminate certain diagnoses; if the test is requested inappropriately, however, such as Holter monitoring for the investigation of syncope, then a normal result is of little clinical value. This will ultimately result in further investigations being performed, and as a result will lead to a delay in establishing the correct diagnosis.

Holter monitors are commonly used to investigate patients presenting with palpitations or syncope, but is this appropriate? The average inpatient waited approximately two weeks from when Holter monitoring was performed to the result being available; coupled with the day spent recording the test, this can lead to unnecessary prolonged hospital stays for these patients, who commonly have no further symptoms. Outpatient investigations would be more appropriate; this would not only help to reduce costs but also may ease the anxiety perpetuated by prolonged hospital stays.

This is comparable to a prospective study by Kapoor *et al* which found that patients admitted for syncope remained in hospital for between 5 and 17 days, and this prolonged stay was responsible for the majority of the costs of looking after these patients.[3] In addition, approximately 50% of patients still had no diagnosis on discharge. The diagnostic yield from Holter monitoring in this scenario is less than 1%,[1] and therefore Holter monitoring should not be requested in this situation.

Diagnostic yields tend to be lower in patients experiencing infrequent symptoms, as the very nature of a continuous recording means that data are limited to 24–48 hours, during which time patients may not experience their symptoms.

Other devices such as transtelephonic recording devices ('cardiomemos') have been found to have better diagnostic yields than Holter monitors for

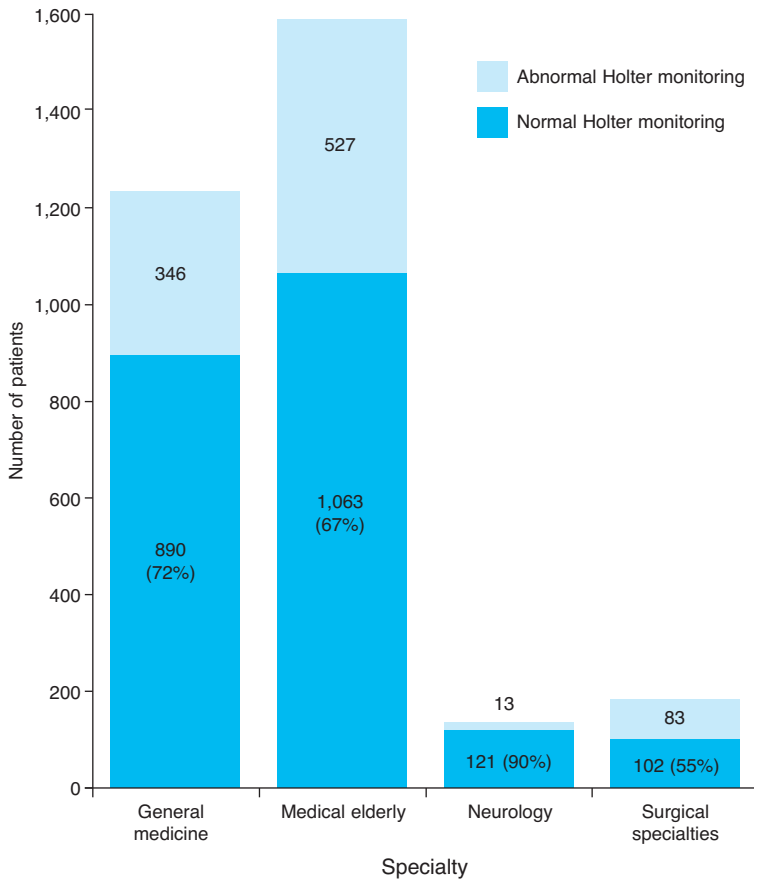

Fig 3. Number of normal Holters according to requesting specialty.

Table 3. Different arrhythmias seen within each specialty.

	General medicine (n=1,236) (%)	Elderly medicine (n=1,590) (%)	Neurology (n=134) (%)	Surgical specialties (n=185) (%)
Normal	890 (72.0)	1,063 (66.9)	121 (90.3)	102 (55.1)
SSS	3 (0.2)	4 (0.3)	0 (0.0)	0 (0.0)
Sinus bradycardia	7 (0.6)	12 (0.8)	3 (2.2)	4 (2.2)
Paced rhythm	13 (1.1)	18 (1.1)	0 (0.0)	3 (1.6)
Second- or third-degree AV block	19 (1.5)	30 (1.9)	1 (0.7)	6 (3.2)
SVT	22 (1.8)	24 (1.5)	0 (0.0)	5 (2.7)
AF-RC	107 (8.7)	169 (10.6)	3 (2.2)	54 (29.2)
PAF	95 (7.7)	156 (9.8)	1 (0.7)	23 (12.4)
AF-FVR	49 (4.0)	54 (3.4)	2 (1.5)	9 (4.9)
AF-SVR	19 (1.5)	29 (1.8)	2 (1.5)	1 (0.5)
AF-TB	5 (0.4)	7 (0.4)	0 (0.0)	2 (1.1)
VT	16 (1.3)	17 (1.1)	0 (0.0)	6 (3.2)
Cardiology referral	26 (2.1)	62 (3.9)	2 (1.5)	9 (4.9)
Permanent pacemaker implanted	14 (1.1)	28 (1.8)	1 (0.7)	4 (2.2)

AF-FVR = atrial fibrillation with fast ventricular response; AF-RC = rate-controlled atrial fibrillation; AF-SVR = atrial fibrillation with slow ventricular response; AF-TB = atrial fibrillation with tachy-brady syndrome; AV = atrioventricular; PAF = paroxysmal atrial fibrillation; SSS = sick sinus syndrome; SVT = supraventricular tachycardia; VT = ventricular tachycardia.

Key Points

Holter monitors and transthoracic echocardiograms are commonly requested investigations

Thought should be given to the frequency and nature of symptoms before requesting a Holter monitor

Simple clinical criteria can be used to reduce the number of normal transthoracic echocardiograms

investigating palpitations. Several studies have prospectively compared the two investigations: the diagnostic yield of Holters was only 35–39% compared with 66–83% with transtelephonic devices.[2] In addition, a cost comparison suggested that transtelephonic devices were significantly more cost effective than Holter monitors.[4]

In the investigation of patients with syncope, both Holter monitors and transtelephonic devices have positive diagnosis rates of 15% and 20–25%, respectively, and fare less well than the implantable loop recorder, which has a rate of nearly 70%.[2] Interestingly, patients having implantable loop recorders tend to have longer histories of recurrent syncope, reflecting the unwillingness to implant these costly devices until it is clear that the syncope is going to continue.[5] Based on data from Medicare (USA) reimbursements, the cost to a patient of Holter monitoring is approximately $353 and an implantable loop recorder $3,000;[2] taking into account the different diagnostic yields, however, a Holter tends to work out four to five times more expensive.[5]

For an accurate correlation to be made between a patient's symptoms and any recorded arrhythmia, the accompanying diary card needs to be completed. Unfortunately, it is not uncommon for this card to be returned blank, although the data are not available in the present study, and this can make it difficult to decide on the clinical significance of any results. In addition, continuous recording throws up the problem of arrhythmias recorded during sleep or when no symptoms were noticed. What is the significance of these arrhythmias? During sleep, there is variation of the autonomic tone, and a variety of arrhythmias such as sinus bradycardia (<40 bpm), sinus pauses (>2 seconds), first-degree atrioventricular block and Wenckebach second-degree atrioventricular block have all been seen in healthy subjects free of cardiac disease. These rhythm disturbances do not require treatment in the absence of symptoms.[6] Current permanent pacing guidelines advise that patients must meet bradycardia criteria while they are awake.[7]

Both Holter monitoring and TTE are used to investigate patients who have suffered from transient ischaemic attacks or cerebrovascular accidents. Holter monitoring is used to exclude paroxysmal atrial fibrillation, but there is little current evidence to support this. In 1986, a retrospective analysis of the Holters of 100 patients suffering from transient ischaemic attacks showed that five patients had atrial fibrillation, of whom four were already know to have atrial fibrillation from the resting electrocardiogram (ECG).[8] In 2004, a prospective trial of 425 patients having a Holter after a cerebral ischaemic event detected nine patients with PAF (2.1%), only three of whom (0.7%) were newly diagnosed. In five of these nine patients, new medication was commenced following the Holter result.[9] In our study, the number of patients with PAF was 275 (8.8%), but we do not know how many of these already had a diagnosis of PAF or atrial fibrillation.

Patients who had a cerebrovascular accident were the most likely to have a TTE requested to determine whether there was a cardiac source of emboli; the role of TTE in these patients, however, should essentially be to guide the management of cardiac conditions that have been picked up during examination, ECG, and chest X-ray.[10] In patients with no evidence of cardiac disease, the diagnostic yield from routine TTE is less than 2%, which compares with less than 19% in those with evidence of cardiac disease.[11] In young patients with no other reason for their ischaemic cerebrovascular accident, a TTE is often requested to look for a patent foramen ovale (PFO); a recent study has shown, however, that a PFO is not an independent risk factor for cerebrovascular accident in the general population.[12]

In keeping with previously published data, the audit confirms that assessment of left ventricular function is the commonest reason for requesting a TTE,[13] and in just under half of these patients (44.8%) the left ventricular function was normal. Many of these requests could have been avoided if the patient had had a normal 12-lead ECG, as this has been shown to have a 98% negative predictive value for normal left ventricular function.[14]

Infective endocarditis is a clinical diagnosis that requires the integration of clinical, microbiological, and echocardiographic data. Although TTE has been shown to have a sensitivity of 40–63% for the detection of a vegetation,[15] TTE is often requested in patients with a fever and a low clinical probability of infective endocarditis. Only 4.1% of TTE requests for suspected infective endocarditis confirmed the diagnosis, which is similar to published data[16] and confirms that TTE is not a cost-effective test in patients with a low suspicion of the diagnosis. Simple clinical criteria can be used to identify patients in whom TTE is not required. Greaves *et al* showed that there was a zero probability of a TTE showing infective endocarditis in the absence of the following five criteria: vasculitic or embolic phenomena, presence of central venous access, recent history of injected drug use, presence of prosthetic valve, and positive blood cultures.[16]

Conclusion

Holter monitoring and TTE are commonly requested investigations and can be useful in detecting serious cardiac rhythm disturbances and cardiac structural abnormalities. Holter monitors have been shown to have low diagnostic yields in patients presenting with infrequent palpitations or syncope, and in this study the great majority of investigations were within normal limits. This finding suggests that Holter monitoring is, in many patients, an inappropriate investigation when ordered for patients in hospital; more thought needs to be given to assessing the frequency and nature of the symptoms being investigated

before Holter monitoring is requested. Other investigations, such as transtelephonic devices and implantable loop recorders, may be more appropriate.

Similarly, TTE is useful as an aid to a suspected clinical diagnosis, as opposed to being used to make the diagnosis. It must be remembered that TTE is not a substitute for clinical assessment from a thorough history and examination, which ultimately can save a number of unnecessary requests. The number of normal TTE requests can also be reduced if simple clinical criteria are considered before making a request.

Guidelines for requesting TTE and Holter monitoring

Using published data and the results of our audit, we propose the following general guidelines for requesting TTE and Holter monitoring:

- An echocardiogram should be requested only for suspected left ventricular dysfunction if the 12-lead ECG is abnormal.*
- An echocardiogram for suspected endocarditis is not indicated in the absence of one or more of the following: evidence of vasculitic or embolic phenomena, recent central line insertion, history of recent injected drug use, prosthetic valve, and positive blood cultures.
- Holter monitoring is not indicated for the inpatient investigation of syncope.
- Holter monitoring has a role in patients with atrial fibrillation who are having ongoing cardiac symptoms, but it is of little benefit in patients who are asymptomatic.
- Patients with transient ischaemic attacks or cerebrovascular accidents do not routinely require TTE or Holter monitoring if no evidence of underlying cardiac disease is established from history, examination, ECG, or chest X-ray.

Limitations

There are three main limitations with the study. First, the indication for the Holter monitor has not been entered on to the database, which would have provided much more information with respect to the inappropriate use of the investigation. Second, the number of patients who filled in the diary was not recorded. Third, TTE performed out of hours or on the ward by the on-call cardiologist (average 5–10 daily) were not entered on to the database and, therefore, the number of TTE requests is underestimated.

Competing interests

None.

*Abnormal ECG: atrial fibrillation, previous myocardial infarction, left ventricular hypertrophy, bundle branch block, or left axis deviation.

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