A survey of investigations performed prior to permanent pacemaker implantation

SIR—Permanent pacemaker implantation is a highly effective treatment for bradycardia which is most commonly used in older patients, pacemaker recipients in the UK having a mean age of 76 years [1]. However, pacemaker implantation rates in the UK are substantially lower than in most other European countries; currently 468 per million of population compared with the Western European average of 700 per million [2–4]. There is also significant variation in pacemaker implantation rates between different regions of the UK, which persists when differences in population demographics are corrected for [4, 5]. The reasons for the low UK pacing rate and regional variation are not known, but restricted access to investigations has been considered as a possible explanation [6]. However, contemporary data on tests performed prior to pacemaker implantation are lacking. We have recently audited delays to pacemaker implantation in a UK cohort [7] and now describe how patients are identified for pacing and the investigations they undergo prior to device implantation.

Methods

Consecutive patients undergoing first pacemaker implantation for bradycardia indications at a single UK centre from 1 June 2006 to 31 August 2006 were included. Hospital records from referring and implanting centres were reviewed to determine the investigations performed prior to pacemaker implantation. The investigation diagnosing the pacing indication for the purpose of this study was determined by two cardiologists with an interest in pacing and defined as the first investigation that documented a Class I or Class IIa pacing indication according to the joint 2002 American College of Cardiology/American Heart Association/North American Society of Pacing and Electrophysiology guidelines [8] (current at the time of our audit, but now updated [9]). Common pacing indications and recommendation Class are summarised in Table 1. Baseline characteristics and delays from symptom onset to pacemaker implantation have been previously reported for this population [7]. Significant delays from presentation to pacing have been identified, which we have attributed in part to failure to recognise pacing indications [10]; in 33 (35%) of the 95 patients, the first documented Class I or IIa pacing indication did not trigger a pacing referral.

Results

Ninety-five patients were included: 48 were referred for pacing urgently as inpatient transfers (mean age 75.4 years, range 44–95) and 47 were referred electively via outpatient waiting lists (mean age 74.1 years, range 46–97). The decision to refer was made by a consultant. Urgently paced patients had a higher incidence of complete heart block (50% vs 11%, P < 0.0005) and lower incidence of second-degree heart block (4% vs 26%, P = 0.004). PACing referrals were made by cardiologists (54), general/elderly care physicians (27), cardiothoracic surgeons (four), accident and emergency physicians (two), general practitioners (two) and other specialties (six). Diagnostic investigations performed in secondary care were determined for all patients, as shown in Figure 1A. Although telemetry was frequently used to monitor cardiac rhythm in inpatients when a diagnosis had already been established by alternative investigations, this was not included as a ‘diagnostic’ investigation for study purposes. However, telemetry used to investigate the cause of a patient’s symptoms (as an alternative to formal 24-h ambulatory recording) was included as a diagnostic investigation. In four cases, the investigation diagnosing the pacing indication could not be accurately ascertained; Figure 1B shows the investigation diagnosing the pacing indication for the remaining 91 individuals.

Standard 12-lead electrocardiograms (ECGs) were performed in all 95 patients, and this was the investigation that first documented the pacing indication for 46 (51%) of the 91 patients for whom the diagnostic test could be reliably determined. However, 75 (79%) of the 95 patients also underwent one or more other specialist diagnostic investigations of heart rhythm, including Holter monitoring 61%, telemetry 32%, event recorders 5%, implantable loop recorders 3%, carotid sinus massage 11%, tilt testing and/or other specialist falls and syncope service investigation 4%.

The initial diagnostic test (which failed to trigger a pacing referral) was the 12-lead ECG in 21 (64%) of the 33 patients with an ‘overlooked’ pacing indication. Twenty-seven (82%) of patients with overlooked pacing indications had additional specialist tests after documentation of a pacing indication; these individuals often had multiple extra tests. Table 1 shows the initial diagnostic test and subsequent unnecessary investigations that were performed in the patients with overlooked pacing indications.

Case example

An 81-year-old man was admitted as an emergency under the general medical team following an episode of unex-
plained syncope. Twelve-lead ECG showed sinus rhythm with bifascicular block (right bundle branch block and left axis deviation), as shown in Figure 2A. Left ventricular function was normal on echocardiography. Syncope with bifascicular block is accepted as a Class IIa indication for pacing in the absence of another cause [8, 9].

Inpatient 24-h ambulatory ECG monitoring showed bifascicular block without evidence of high-grade atrioventricular block. He had a normal active stand without hypotension following discharge. Eight months later, he collapsed with a cardiac arrest; on arrival of the paramedics, he was unresponsive (GCS 4) and ECG showed profound

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**Table 1. Simplified summary of current pacing indications showing the first diagnostic investigation and subsequent tests performed in the 33 patients with overlooked pacing indications**

<table>
<thead>
<tr>
<th>ECG finding</th>
<th>Clinical indication [recommendation Class]</th>
<th>1st diagnostic test</th>
<th>Unnecessary specialist investigations subsequently performed</th>
</tr>
</thead>
<tbody>
<tr>
<td>3rd degree/Mobitz II AV block</td>
<td>Symptomatic bradycardia* [I]</td>
<td>ECG 24h tape</td>
<td>24h tape or Telemetry 24h tape ILR</td>
</tr>
<tr>
<td></td>
<td>Asymptomatic with awake pauses &gt;3s or escape rate ≤40/min (in sinus rhythm), or pauses &gt;5s (in AF) [I]</td>
<td>ECG</td>
<td>Telemetry 24h tape ILR</td>
</tr>
<tr>
<td></td>
<td>Asymptomatic with cardiomegaly/LV dysfunction [I]</td>
<td>24h tape</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Asymptomatic Mobitz II with escape rate &gt;40/min and broad QRS [I]</td>
<td>24h tape</td>
<td>Telemetry 24h tape</td>
</tr>
<tr>
<td></td>
<td>Asymptomatic with escape rate &gt;40/min [IIa]</td>
<td>24h tape</td>
<td>ECG 24h tape</td>
</tr>
<tr>
<td>Mobitz I AV block</td>
<td>Symptomatic bradycardia [I]</td>
<td>ECG 24h tape</td>
<td>ECG 24h tape FASS, AS (TPW)</td>
</tr>
<tr>
<td>Bi-/trifascicular block</td>
<td>Alternating bundle branch block or intermittent high-degree AV block [I]</td>
<td>ECG 24h tape</td>
<td>FASS, tilt or ECG FASS, AS</td>
</tr>
<tr>
<td></td>
<td>Symptomatic chronotropic incompetence [I]</td>
<td>ECG 24h tape</td>
<td>ECG FASS, AS</td>
</tr>
<tr>
<td></td>
<td>Bradycardia ≤40/min when a clear association between significant symptoms consistent with bradycardia and the actual presence of bradycardia has not been documented [IIa]</td>
<td>ECG 24h tape</td>
<td>24h tape ×2 or ECG 24h tape</td>
</tr>
<tr>
<td></td>
<td>Unexplained syncope when clinically significant abnormalities of sinus node function are discovered [IIa]</td>
<td>ECG 24h tape</td>
<td>24h tape, Event recorder or Cardiology referral</td>
</tr>
<tr>
<td>Sinus node dysfunction</td>
<td>Documented symptomatic bradycardia* [I]</td>
<td>ECG 24h tape</td>
<td>ECG 24h tape</td>
</tr>
<tr>
<td></td>
<td>Unexplained syncope caused by spontaneously occurring carotid sinus stimulation and carotid sinus pressure that induces ventricular asystole &gt;3 s [I]</td>
<td>CSM ILR</td>
<td>CSM Repeat CSM</td>
</tr>
<tr>
<td>Hypersensitive carotid sinus syndrome</td>
<td>Recurrent syncope caused by spontaneously occurring carotid sinus stimulation and carotid sinus pressure that induces ventricular asystole &gt;3 s [I]</td>
<td>CSM ILR</td>
<td>CSM Repeat CSM</td>
</tr>
</tbody>
</table>

*Bradycardia may be iatrogenic as a consequence of essential long-term drug therapy; AV block: atrioventricular block; LV: left ventricle; AF: atrial fibrillation; VT: ventricular tachycardia; CSM: carotid sinus massage; ECG: 12-lead electrocardiogram; 24h tape: 24-h ambulatory monitoring; FASS: falls and syncope service assessment; ILR: implantable loop recorder; CSM: carotid sinus massage; AS: active stand; TPW: temporary pacing wire. Class I recommendations are 'conditions for which there is evidence and/or general agreement that a given procedure or treatment is beneficial, useful or effective' and Class IIa recommendations are 'conditions for which there is conflicting evidence and/or a divergence of opinion about the usefulness/efficacy of a procedure or treatment, where the weight of evidence/opinion is in favour of usefulness/efficacy' [8].
bradycardia with heart rate 33/min and high-grade atrioventricular block, as shown in Figure 2B. A temporary pacing wire was inserted in accident and emergency with improvement in haemodynamic status. He was referred for permanent pacemaker implantation the same day.

**Discussion**

We have documented the diagnostic investigations that are performed prior to pacemaker implantation in contemporary UK practice. A high proportion (79%) of patients who receive permanent pacemakers undergo specialist cardiac rhythm investigation but, perhaps surprisingly, half of all pacing indications can be diagnosed by 12-lead ECG and clinical context alone, suggesting that much of this further investigation may be unnecessary. Furthermore, a third of patients undergo additional investigation once a pacing indication has already been documented. These data suggest that limitations in the interpretation of relevant investigations, rather than restricted access to them, may contribute to low pacing rates in the UK.

The pacemaker guidelines used for this study, and their subsequent revision, recognise as pacing indications situations in which symptoms and documented rhythm disturbance do not contemporaneously occur [8, 9]. For example, in the setting of chronic bi-/trifascicular block (defined as left bundle branch block or right bundle branch block plus left axis deviation, with or without PR interval prolongation), syncope not demonstrated to be due to atrioventricular block when other likely causes have been excluded constitutes a Class IIa indication. Similarly, ECG evidence of significant sinus node dysfunction ‘when a clear association between significant symptoms consistent with bradycardia and the actual presence of bradycardia has not been documented’ is a Class IIa indication. The fact

![Figure 1](image1.png)

**Figure 1.** Investigations that are performed prior to pacing (A) and first investigation diagnosing the pacing indication (B) in patients paced urgently and electively. ECG: 12-lead ECG; Holter: 24-h ambulatory ECG monitoring; ER: event recorder; ILR: implantable loop recorder; CSM: carotid sinus massage; FASS: tilt testing or other specialist falls and syncope service assessment.

![Figure 2](image2.png)

**Figure 2.** ECGs from the case example.
that abnormalities such as these are commonly detected on the 12-lead ECG alone contributes to the relatively high proportion of cases in which we found this to be the diagnostic test.

Manchanda and Ehsanullah reported that elderly patients with suspected cardiac syncope and normal ECGs were unlikely to have significant abnormalities on Holter monitoring, whereas those with abnormal ECGs (in particular sinus bradycardia and conduction defects) were highly likely to have significant abnormalities on ambulatory recordings [11]. This supports the approach recommended in the guidelines that further investigation is not required when significant abnormalities are evident on the resting ECG. Although all patients in our study had a 12-lead ECG, the significance of the ECG findings was not always appreciated; failure to recognise and act on pacing indications led to unnecessary tests and delays. All patients suspected of having significant symptoms attributable to bradycardia should have a 12-lead ECG performed and carefully reviewed prior to considering additional specialist investigations. Increased awareness of pacing indications may help to prevent the unnecessary investigations that are performed in a substantial proportion of patients and help to ensure such patients are managed in a swift and cost-effective way.

This study has several potential limitations. Pacing indications were retrospectively diagnosed by chart review and rigid adherence to guidelines, which led a very ‘black and white’ approach that may not reflect the complexity of clinical practice, particularly in an elderly population with multiple comorbidities. Pacing indications were diagnosed irrespective of concomitant drug therapy, an approach which is recognised by the guidelines for ‘necessary’ medications. To avoid subjective decisions about the appropriateness of medications, we assumed all treatments were necessary, although we recognise that this may be an oversimplification. Pacemaker implantation was the index event in our study, and we are therefore unable to assess the type and appropriateness of investigations performed in patients who have not been referred for pacing.

Conclusion

Although half of all indications are diagnosed from the 12-lead ECG, a high proportion of patients who receive pacemakers undergo specialist investigation prior to pacemaker implantation. Pacing indications are often unrecognised leading to additional unnecessary investigations. Careful history taking, interpretation of the 12-lead ECG and awareness of pacing indications may help to improve the recognition and treatment of patients with bradycardia.

Key points

- Seventy-nine percent of patients who receive pacemakers undergo specialist rhythm investigation, but 51% of pacing indications can be identified from the 12-lead ECG and clinical context alone.
- Pacing indications are frequently overlooked, which leads to additional unnecessary investigations.
- Careful history taking, interpretation of the 12-lead ECG and awareness of pacing indications may help to improve the recognition and treatment of patients with bradycardia.

Conflicts of interests

M.S.C., C.J.P. and J.M.M. have received financial support from devices companies for attending educational meetings. J.M.M. and C.J.P. have received honoraria for speaking from device companies and J.M.M. supervises a research fellow funded by an educational grant from a devices company.

Contributors

J.M.M. and C.J.P. designed the study, reviewed data and determined pacing indications. M.S.C. collected and analysed data. M.S.C. and J.M.M. drafted the manuscript. All authors were involved in the critical review of the manuscript.

Guarantor

J.M.M. is guarantor for the paper.

Ethics approval

The study was undertaken as a routine audit of current practice at our institution; it was registered with the institution audit department but local ethics committee approval was not required or sought.

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References

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