Routine chest radiography after permanent pacemaker implantation: Is it necessary?

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ABSTRACT

Background and Aims: Chest radiographs (CXR)s are performed routinely after permanent pacemaker implantation to identify pacemaker lead position and exclude pneumothorax. We assessed the clinical value and need for this procedure.

Design: Retrospective analysis of pacemaker data and CXRs following permanent pacemaker insertion between December 2002 and February 2004.

Materials and Methods: Post-procedural CXRs were available in 125/126 consecutive patients after either first endocardial pacemaker implantation or insertion of at least one new lead. Subclavian vein puncture was used for venous access in all cases. CXRs were examined to establish the incidence of pneumothorax and assess pacing lead positions. The clinical records were examined in all patients who had subsequent CXRs or a further pacemaker procedure to identify the indication for these and to establish whether CXR had influenced patient management.

Results: In total, 192 post-procedural CXRs were performed, either postero-anterior (PA) and/or lateral views. Ventricular and/or atrial pacing lead contour and electrode position was considered radiographically appropriate in 86% CXRs. Fourteen per cent of post-procedural radiographs were considered to have radiologically sub-optimal pacemaker lead positioning. None of the patients with these “abnormal” radiographs experienced subsequent pacemaker complications or had further radiographs recorded at a later date. Later repeat CXRs were performed in 16 patients (13%) but only 3 patients (2%) had pacing abnormalities as the primary indication. All three had satisfactory pacing lead position on initial post-implantation and later radiographs, but required further procedures for lead re-positioning. Iatrogenic pneumothorax occurred in one patient (incidence 0.8%) in our series. CXR confirmed the clinical diagnosis and allowed an assessment of size to guide treatment.

Conclusion: Routine CXR after permanent pacemaker insertion is not necessary in uncomplicated cases with adequate pacing characteristics.

KEY WORDS: Chest radiographs, pacemaker, pneumothorax

In the late 1980s, concerns were raised about the provision and low rate of permanent pacing in the UK. In 1990, the UK implanted around 140 implants/million/year, which was only 27-41% the rate of other European nations.[1] To meet the needs of an ever-aging UK population, expansion was necessary and was primarily channelled through the district general hospitals setting (DGH). Twenty years on, and with ever increasing targets (implantation of new systems was set at 450 per million in 2002), DGHs have repeatedly been shown to provide convenient, safe and effective pacemaker services and hence now shoulder much of the pacing burden. Today over 180 centres are involved in pacemaker implantation and in 2000, implantation of new systems exceeded 23,000 in the UK and Ireland.[2]

Advances in pacing technology and techniques have made this a highly cost-effective and relatively safe procedure.[3] Virtually all pacing systems are implanted transvenously under local anaesthesia, using either the cephalic vein by cut down or direct puncture of the subclavian vein. The subclavian route, particularly with more inexperienced operators, is associated with a higher risk of procedural complications such as pneumothorax, arterial puncture, and wound haematoma. However, in experienced hands, the incidence of such problems is low. In addition, this route is quicker, requires less surgical expertise and facilitates insertion of more than one pacing lead.[4]

Elective pacing is performed as a day-case procedure in our unit and elsewhere. Traditionally, it has been standard protocol to assess lead position at the time of implantation using fluoroscopy, followed by postero-anterior (PA) and lateral chest radiographs immediately after pacemaker insertion.[5] The purpose of these radiographs is firstly to exclude pneumothorax in patients who have had direct subclavian puncture and secondly to record the position of the pacing leads and provide a comparison for future reference in case of pacing problems.[6,7]
We questioned the usefulness of routine chest radiography after pacemaker implantation. In the presence of an uncomplicated procedure and satisfactory pacing and sensing parameters, does it really add information that will change the clinical management?

Materials and Methods

All pacing procedures were performed in a district general hospital, serving a population catchment of 440,000. Patients admitted for elective day-case first endocardial permanent pacemaker insertion or revision of their system (including new lead insertion) between December 2002 and February 2004 were included. Patients undergoing simple generator change were excluded.

The age range was 31–95 years with an average age of 76 years, and a male preponderance (1.6:1.0). The three primary indications for pacemaker implantation were AV block, sino-atrial disease and neurally mediated syncope.

The procedures were performed by a consultant cardiologist or by a cardiology-trainee under close supervision. All three trainees were relatively inexperienced (involved in less than 50 cases each during the study) and performed 75% of implants in total. All operators achieved venous access by direct subclavian vein puncture.

Post-procedural PA and lateral CXRs were requested routinely after implantation. A consultant cardiologist or trainee examined these X-rays using a computerised radiography system. The Picture Archive Communication System (PACS) reads the image on the imaging plate by laser and converts it to a digital stream. These digital radiographs are viewed on computer monitors. A pacemaker check was performed approximately 4 hours after implantation and if all tests were satisfactory, patients were discharged with arrangement for a 6-week follow-up appointment in the technician-led pacemaker clinic. All patients received advice sheets regarding management of pacemaker and aftercare.

We performed a retrospective analysis of post-procedural chest X-rays for 126 consecutive patients. The following information was recorded:

1. Type of pacing system or revised system implanted.
2. The actual number of patients undergoing post-procedural PA and/or lateral chest X-rays after pacemaker implantation.
3. The adequacy of pacing lead contours and electrode position.
4. The presence of pneumothorax.

Satisfactory ventricular lead position on the PA film was considered to be in the right ventricular apex. The pacing lead should be seen to curve smoothly along the lateral wall of the right atrium, through the tricuspid valve with the tip at the apex directed anteriorly and inferriorly, just to the left of the spine. On the lateral film, the lead should be directed anteriorly and inferriorly, in order to differentiate coronary sinus or other cardiac venous positionings. The atrial lead on PA chest radiography should be seen to terminate over the right upper heart border, with a curve and tip-directed cephalad. On the lateral radiograph, the lead should follow a smooth anterior curve in the midportion of the heart with its tip angled cephalad into the lateral radiograph, the lead should follow a smooth anterior curve in the upper heart border, with a curve and tip-directed cephalad. On the PA chest radiography should be seen to terminate over the right coronary sinus or other cardiac venous positioning.

In the 15-month study period, 126 consecutive elective day-case patients were paced. One hundred and sixteen patients had implantation of new pacemaker systems (single or dual chamber) and 10 patients had system revisions (8 were upgraded from single to dual systems and 2 had new atrial and ventricular leads inserted).

Dual chamber systems (DDD) were implanted in 91 (72%) patients. Thirty-five patients (28%) had single chamber systems of which 30 (86%) were ventricular (VVI) and 5 (14%) were atrial (AAI).

Post-procedural PA chest radiograph was performed in 123/126 patients (98%). Three patients (2%) did not have a PA X-ray. Post-procedural lateral radiograph was performed in 69/126 (55%) patients only. In total, 60 patients (5 without PA and 57 without lateral x-rays) had only single view radiography immediately after pacing. One patient failed to have any post-procedural chest radiography. None of this patient group had any immediate or subsequent complications during pacemaker follow-up. The reasons for incomplete post-procedural radiographic studies were not established.

In the patients who underwent PA radiographs, the ventricular lead was visualised and considered correctly positioned in 86% for VVI and 96% for DDD systems. In the lateral view, the ventricular lead was deemed correct for 82% for VVI and 90% for DDD [Tables 1 and 2].

The atrial lead was considered correctly positioned in all five patients with AAI systems who underwent PA and lateral views. The atrial lead in DDD systems was judged correct in 91% on PA and 94% on the lateral view [Tables 2 and 3].

In total 192 post-procedural CXRs were performed. In 27 radiographs (14%) (16 PA and 11 lateral) either the ventricular, atrial or both leads were considered radiographically sub-optimal for lead contour and electrode position. All patients with these “abnormal” CXRs had satisfactory pacing parameters at follow-up pacing checks and did not report adverse symptoms. None required re-operation for lead re-positioning or further chest radiography for pacing-related problems.

Further chest radiographs were recorded for 16 patients from our series. We were able to access the medical notes and re-view the X-rays of 15 patients in this group [Table 4].

Three patients required further CXRs for pacing malfunction as the primary indication. All three patients had dual chamber
Table 1: Lead position in CXR in single chamber (Ventricular) pacemaker insertion

<table>
<thead>
<tr>
<th>Post-Pacing chest radiograph</th>
<th>PA = 29</th>
<th>Lateral = 17</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct Not Correct</td>
<td>Correct Not Correct</td>
<td></td>
</tr>
<tr>
<td>V Lead</td>
<td>25 (86%) 4 (14%)</td>
<td>14 (82%) 3 (18%)</td>
</tr>
</tbody>
</table>

Table 2: Lead position in CXR in double chamber pacemaker insertion

<table>
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<tr>
<th>Post-Pacing chest radiograph</th>
<th>PA = 89</th>
<th>Lateral = 50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct Not Correct</td>
<td>Correct Not Correct</td>
<td></td>
</tr>
<tr>
<td>V LEAD</td>
<td>85 (96%) 4 (4%)</td>
<td>45 (90%) 5 (10%)</td>
</tr>
<tr>
<td>A LEAD</td>
<td>81 (91%) 8 (9%)</td>
<td>47 (94%) 3 (6%)</td>
</tr>
</tbody>
</table>

Table 3: Lead position in single chamber (Atrial) pacemaker insertion

<table>
<thead>
<tr>
<th>Post-Pacing chest radiograph</th>
<th>PA = 5</th>
<th>Lateral = 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct Not Correct</td>
<td>Correct Not Correct</td>
<td></td>
</tr>
<tr>
<td>A Lead</td>
<td>5 (100%) 0</td>
<td>2 (100%) 0</td>
</tr>
</tbody>
</table>

Table 4: Indications for chest X-ray >1 day post procedure

- Pacemaker malfunction requiring lead re-positioning: 3
- Wound Infection: 1
- Another medical indication: 10
- Pneumothorax: 1

The purpose of this present analysis was to evaluate the need for continued routine chest radiography after pacemaker implantation. The role of routine radiography after pacemaker insertion is not clearly defined. In a Medline search, we identified only a single paper by Grier et al published in 1990 supporting a role for chest radiography. In this study, two radiologists retrospectively reviewed chest X-rays of 600 patients who had undergone pacemaker implantation. They identified radiographic abnormalities on CXRs of 131 patients (21.8%). Individual radiographic complications ranged from lung atelectasis (0.3%) to unsatisfactory lead position (5.5%). Despite this high number of radiographic abnormalities, only a few were clinically significant abnormalities which required intervention at that time or later in the clinical course. A total of 60 (10%) patients were considered to have either electrode tip malposition or loop abnormalities on their original chest X-rays. However, only three (0.5%) patients required lead repositioning because of pacing abnormalities.

In our case series, only 192 radiographs were performed in total after pacemaker implantation despite our hospital protocol for both PA and lateral views. Twenty-seven (14%) films were considered radiographically sub-optimal for pacing lead positioning after the procedure. However, all had satisfactory pacing parameters at the time of implantation, on subsequent interrogation and had no symptoms, so did not require further intervention. This view is supported by recent work published by Hildick-Smith et al, who reported no benefit from atrial lead repositioning in patients with satisfactory pacing parameters.

We have shown that pacing characteristics are the best means of identifying problems with pacemaker lead position. Post-procedural chest radiographs performed in our series did not influence further management. But do these initial radiographs serve a purpose for later comparison of lead positions? Sixteen patients (13%) from our series underwent further chest radiography at varying dates after pacemaker insertion. Five patients had X-rays for pacemaker-related indications. One patient had radiography to confirm lung re-expansion following iatrogenic pneumothorax. One patient had additional radiography following treatment for a wound infection. Three patients had radiography prior to and after lead re-positioning for pacing system malfunction. All three had PA and lateral radiographs after pacemaker implantation and repeat films prior to lead re-positioning, in which pacing lead positions appeared radiographically correct. Clearly, the need for explo-
ration of a pacing system and possible lead re-positioning is determined by unsatisfactory function of the pacing system and not by X-ray appearances.

The percentage figure for lead re-positioning in our study is similar to that in other studies. However, the number of dual chamber system implants (72%) was higher in our study compared to published national figures (53.7% in 2000). These systems are associated with higher re-positioning and complication rates, emphasizing that our lead displacement rate is acceptably low.

An undisputed indication for chest radiography after pacemaker insertion is to confirm the presence of clinically significant pneumothorax. Chest radiography will in this situation guide subsequent management, in terms of the decision to observe, aspirate or insert an intercostal drain. As we have demonstrated, the incidence of pneumothorax is low, less than 1% in our series of 126 patients. All patients had direct subclavian puncture and 75% of the procedures were performed by trainees who had performed less than 50 implants each. In our series, in the single case of pneumothorax, the operator thought a diagnosis of pneumothorax was very likely as air was aspirated at the time of subclavian puncture and the patient developed pleuritic pain. When pneumothorax is suspected or where there is unexplained clinical deterioration, it is clearly important that the patient has immediate chest radiography and other necessary investigations to define the cause.

But what about uncomplicated procedures where the subclavian vein is punctured at first pass or after use of the cephalic vein approach? In such cases, there is no realistic likelihood of pneumothorax. A limitation of this study is that we did not prospectively grade clinical suspicion as to the likelihood of an iatrogenic pneumothorax at the time of pacemaker insertion or the degree of difficulty experienced in obtaining subclavian vein access. It might be argued that chest radiography should be performed in patients in whom subclavian vein puncture proved difficult. This more selective approach may identify patients with clinically silent pneumothorax and guide the need for subsequent CXRs and continued observation. However, investigators have shown that clinically asymptomatic pneumothorax may be of little importance. Grier et al identified 15 pneumothorax in their cohort of 600 patients, yet only one required intervention. This same question has been posed following other procedures such as thoracocentesis, in which pneumothorax is a recognised complication. Investigators have shown that in symptom-free patients, the risk of developing pneumothorax with clinical consequences was so low that the practice of routine chest X-ray may not be justified. A more selective approach to post-pacing chest radiography may be supported, as has been suggested following thoracocentesis.

Given the results of this study, we are now prospectively collecting data on patients attending for elective new pacemaker implantation. Standard patient demographics, operator, route of implant and pacing data is recorded. In addition, the operator records the degree of difficulty in achieving venous access and performing the implant. We perform post-procedural chest radiographs only in patients with moderate to high likelihood of pneumothorax. We believe the radiological diagnosis of clinically significant pneumothorax will correlate with the operators’ clinical suspicion. We believe these selection criteria will be safe, will prevent patients undergoing further radiation exposure through unnecessary CXRs and improve speed of access for other patients requiring radiography.

**Conclusion**

Insertion of permanent pacemaker by experienced operators carries a low risk of complications. We have demonstrated that the key factors which dictate the need for further operative intervention are patient’s symptoms and pacing characteristics. The appearance of pacemaker lead position on chest radiographs performed after implantation does not influence the subsequent clinical course.

Our study suggests that routine chest radiography is not necessary after an uncomplicated pacing procedure with satisfactory pacing parameters and a clinically low probability of iatrogenic pneumothorax.

References

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18. Capizzi SA, Prakash UB. Chest roentgenography after outpatient thoracocen-
Chest X-rays (CXR) are routinely performed after pacemaker implantation on the premise that they can detect a pneumothorax which requires treatment, and that the lead position as seen on the CXR will identify patients who subsequently develop pacing failure. The authors of a retrospective analysis, published in this issue of the Journal, suggest that a routine CXR is not necessary after an uncomplicated pacemaker implantation. This proposal needs careful evaluation.

The incidence of pneumothorax is less than 2% after subclavian puncture, and those requiring intervention are even less frequent. Therefore, restricting the use of post-procedure chest radiography to patients with a high probability of pneumothorax seems reasonable. Extremes of body mass index (<20 and >30), number of needle passes, experience of the physician performing the procedure, previous subclavian catheterisation, and prior major surgery in the region, all increase the risk of complications. It would be wise to factor in such objective predictors while deciding on the need for a CXR rather than simply rely on the “operator’s suspicion” alone. Routine CXR can probably be skipped after lead insertion by extrathoracic subclavian puncture.

Fluoroscopy provides only a rough guide to lead positioning during pacemaker implantation. Lead “stability” and pacing parameters override any minor anomalies of position. Therefore, it is not surprising that the post-procedure CXR has generally not proven useful in predicting subsequent pacing failure. However, there are a few caveats. In children undergoing pacemaker implantation, serial post-procedure CXRs are invaluable in monitoring the “tightening” of the atrial loop with growth, and deciding on the timing of lead change. Another situation where the lead position on CXR can be useful is in patients receiving VDD pacemakers. It has been shown that atrial dipole position 6 cm or more below the carina predicts loss of AV synchrony. In these cases an erect film is probably more relevant because the atrial dipole can move away from the superior vena cava-right atrial junction (site of the sinoatrial node) on standing and can result in reduced atrial sensed amplitude.

And finally, a word in favour of the much beleaguered chest film is in order. A good quality CXR can rule out a significant pneumothorax with a high degree of certainty and adds little in terms of cost or radiation exposure to patients undergoing pacemaker implantation. Therefore there should be no hesitation in ordering one if it will help the physician (and the patient) sleep in peace.

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authors concluded that in this series of patients the need for patient intervention was governed by malfunction of the pacemaker system, and it was not influenced by the findings on routine and subsequent radiography. According to this report, “Immediate radiography may be reserved for those patients with at least moderate probability of iatrogenic pneumothorax.”

The conclusion from this report is the opposite of the current practice at my home institutions in Tucson, Arizona, USA, where chest radiographs are obtained after every cardiac pacemaker placement no matter the type or placement situation. It also is somewhat counter to my anecdotal experience of seeing 2-4 pneumothoraces per month in a population of patients receiving pacemakers from a busy cardiac specialty hospital and from patients receiving pacemakers from an active cardiology service at a university medical centre. The patients I am familiar with are a complex mix of those requiring elective pacemaker placement and those receiving a pacemaker in an emergency situation. The patients reported by the authors were admitted for elective day-case first endocardial permanent pacemaker insertion or revision of their system including new lead insertion.

The procedures were performed in a district general hospital in the United Kingdom. The interval between when the pacemaker was inserted and the chest radiograph was obtained was not specified in this report. It is well known that pneumothoraces resulting from lung biopsies or thoracentesis may be delayed in their presentations from 1-24 hours, and we routinely obtain post-procedural and 4-hour delayed chest radiographs in these situations. It has been my anecdotal experience that patient symptoms are an unreliable predictor for the presence of a pneumothorax. Of course, in these cases, there has been a direct violation of the pleural space.

The authors’ survey of the literature and my limited literature survey show that the post-procedural complication rate for elective placement of a cardiac pacemaker is low, and it is best determined by patient evaluation and by pacemaker monitoring. Pneumothoraces requiring treatment rather than watchful waiting occur less than 1% of the time. The question then remains that have the authors in their own practice stopped obtaining chest radiographs in asymptomatic patients after routine pacemaker placement? In other words, do they practice what they preach? The answer seems to be yes. According to the authors, “we perform post-procedural chest radiographs only in patients with moderate to high likelihood of pneumothorax.” They are also performing a prospective study to further look at this very question.

In our practice here we will continue to obtain post-pacemaker placement chest radiographs. Why? Because our patient population is different, and it probably consists of more difficult and emergent pacemaker placements. Also, we live in a land awash in malpractice litigation. Alas, the facts and the science often don’t often matter in this situation, but that is another story.

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References