Role of routine chest radiography after percutaneous dilatational tracheostomy

V. M. Kumar1, C. A. Grant1*, M. W. Hughes1, E. Clarke1, E. Hill1, T. M. Jones2 and G. A. Dempsey1

1Critical Care Unit and 2Ear, Nose and Throat Department, University Hospital Aintree, Liverpool, UK
*Corresponding author. E-mail: cg@doctors.net.uk

Background. The role of routine chest radiography (CXR) after percutaneous dilatational tracheostomy (PDT) has been questioned.

Methods. We performed a prospective observational study, on a mixed medical/surgical critical care unit in a university teaching hospital. We studied all patients undergoing PDT as part of their critical care management from November 1, 2003 until July 31, 2007. All PDTs were performed under bronchoscopic guidance. After PDT, we reviewed the immediate post-procedural films to assess the utility of routine postoperative CXR. For the purposes of CXR review, we considered a procedure to be either uncomplicated or technically difficult. Clinically relevant CXR findings were new barotrauma (pneumothorax, pneumomediastinum) or a significant change in consolidation from the pre-procedure film.

Results. A total of 384 patients underwent PDT during the study period. Of these, 345 had immediate post-procedural CXRs available for review. There were 252 PDTs (73%) documented as uncomplicated. There were 93 (27%) technically difficult procedures, with 107 adverse events recorded. In 82 (24%) procedures, these difficulties were described as minor procedural complications [multiple attempts at needle insertion (>3), minor bleeding or tracheal ring fracture]. Significant complications (mal-placement in the anterior mediastinum and major bleeding) were documented in 12 (3.5%) patients. New abnormalities were noted on 8 (2.3%) immediate post-procedural CXRs. In only one patient was there a new CXR change in an uncomplicated PDT.

Conclusions. Immediate CXR after uncomplicated PDT performed under bronchoscopic guidance rarely reveals unexpected radiological abnormalities. The role of CXR after PDT appears to be restricted to those patients undergoing technically difficult and complicated procedures. A change in practice to this effect will lead to reductions in both medical costs and exposure of staff and patients to ionizing radiation.

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Percutaneous dilatational tracheostomy (PDT) has become a commonly performed procedure in the intensive care unit (ICU) in those patients subjected to prolonged mechanical ventilation.1 It has largely replaced the conventional surgical tracheostomy in critical care patients, with benefits in terms of cost, ease of performance, and reduced complications.2 Significant complications associated with PDT, including haemorrhage,3 pneumothorax,4 and paratracheal placement,5 have ranged in various series from 3 to 18%.6 7 Several authors have claimed that bronchoscopic guidance during PDT provides a higher degree of safety and decreases the incidence and severity of complications.8 9 The role of the post-procedural chest X-ray (CXR) has been investigated by other authors. Their work concluded that there is little or no role for routine CXR after PDT.10–13 15 However, because of the small sample sizes used, these conclusions have been criticized.14

Post-procedural CXR has been a standard practice in our institution since the introduction of PDT more than...
14 years ago. It has been our impression that this investigation rarely impacts upon patient management. The aim of this study was, therefore, to determine whether routine CXR after insertion of a PDT resulted in the detection of unexpected clinically significant complications. We also sought to address criticisms of previous work by investigating a larger patient population in a prospective manner.

Methods
This prospective study was undertaken at University Hospital Aintree (UHA) Critical Care Unit, a 19 bedded mixed medical/surgical unit performing 110–120 tracheostomies per annum, 97% of which are PDTs. As no additional interventions were performed, this was considered to be under the remit of audit and hence consent was deemed unnecessary.

All patients undergoing PDT from November 2003 to July 2007 were studied. All procedures were performed at the bedside under bronchoscopic control using a Ciaglia Blue Rhino® Percutaneous Tracheostomy Introducer Set (Cook Medical). The CXR examined was the immediate post-procedural film. Clinically relevant CXR findings were considered to be new barotrauma (pneumothorax and pneumomediastinum) and a significant change in consolidation from the most recent pre-procedure film. Other data recorded included age, sex, time to insertion of tracheostomy from ICU admission, and seniority of a supervising doctor.

In defining a complicated procedure, for the purposes of CXR review, we felt that it was important to include PDTs that were technically challenging in addition to the more traditional classifications of a complicated procedure. Our institution’s tracheostomy proforma requires all procedural related events to be documented by the operator. This allows for recording of technical difficulties and documentation of clinically insignificant events and periprocedural events with clinical sequelae. A PDT was considered technically difficult if there was one or more of the following during the procedure: oxygen desaturation (major if ≤90%, minor if ≥2% desaturation from baseline), multiple attempts (≥3) at tracheal cannulation, bleeding (major if ≥3 swabs, minor if <3 swabs), tracheostomy tube misplacement, surgical emphysema, cardiovascular instability, supra-stomal tracheal ring fracture, and posterior tracheal wall injury (major if mucosal tear, minor if single puncture).

Each PDT was, therefore, considered to be either technically difficult or uncomplicated for the purposes of CXR analysis.

Results
During the study period, 384 patients underwent a PDT as part of their critical care management. There were 345 (90%) immediate post-procedural films available for review. As our institution has recently moved to a digital radiology system, this accounts for some films being unavailable.

The characteristics for the 345 PDT patients are shown in Table 1. The most senior physician present during the PDT was a consultant in 223 (67%) procedures, an advanced level critical care trainee in 94 (28%) procedures and a registrar in 16 (5%) procedures.

There were 107 adverse events recorded during 93 (27%) technically difficult PDTs. The majority of these were minor procedural complications (Table 2). Significant procedural complications occurred during 12 (3.5%) PDTs, these consisted of significant (>3 soaked swabs) bleeding (3), mal-positioning of the tracheostomy tube (4), severe surgical emphysema (4), and significant posterior tracheal wall injury (1). There were a total of eight significant new abnormalities on immediate post-procedural CXRs. Of these abnormalities, one occurred in the uncomplicated group and seven occurred in the technically difficult group. The new CXR abnormality in the uncomplicated group was subcutaneous emphysema; however, this was overlooked by the critical care clinicians. In this patient, a tension pneumothorax developed within 24 h of the PDT. The seven CXR abnormalities in the complicated group consisted of two pneumothoraces, one pneumomediastinum (after tracheostomy tube misplacement), and four episodes of significant surgical emphysema. There were no instances of a significant change in consolidation between the pre- and post-procedural films.

Discussion
The overall complication rate of 27% post-PDT under bronchoscopic guidance in our institution would initially appear disproportionately high. However, we feel that this can be explained by our broadening the definition of a ‘complicated’ procedure to include technical difficulties in addition to conventional complications. Our liberal interpretation of a complicated PDT was, we felt, necessary as technical difficulties, which do not necessarily result in clinical sequelae, are not included in the traditional description of what comprises a complication but could feasibly result in CXR changes. The true value of the post-procedural CXR cannot be appreciated if it is used indiscriminately.

The data we present suggest that by targeting these technically difficult procedures, which actually means a CXR

<table>
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<tr>
<th>Table 1</th>
<th>Patient characteristics. Data are given as mean (sd) or median [IQR]</th>
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<tbody>
<tr>
<td>Age (yr)</td>
<td>59 (15.3)</td>
</tr>
<tr>
<td>Admission APACHE II score</td>
<td>19 (5.3)</td>
</tr>
<tr>
<td>Male, n</td>
<td>196</td>
</tr>
<tr>
<td>Medical, n</td>
<td>160</td>
</tr>
<tr>
<td>Day to PDT</td>
<td>5 [4]</td>
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</tbody>
</table>
for 27% of PDTs, we direct the radiological investigation more effectively. So, when making recommendations in the past regarding the value of post-procedural CXR, it could be argued that poor yields were, in part, as a result of the widespread use of this investigation. Our rate of traditionally defined significant complications was actually 3.5% and is in keeping with the low rates reported by others.16

In this study there were two pneumothoraces detected on the immediate post-procedural CXR, giving an incidence after PDT of 0.6%. Despite the use of bronchoscopic control, the tracheostomy tube was misplaced during four PDTs, resulting in significant subcutaneous emphysema. On three occasions, the tube was placed in the anterior neck/mediastinum, resulting in a CXR finding of pneumomediastinum in one patient, and on one occasion the tube was inserted through the crico-thyroid membrane. In the three cases of extra-tracheal placement, tracheal tube sizes were such that effective ventilation of the lungs was inadequate with a bronchoscope in situ. The bronchoscope was, therefore, used to confirm correct placement of the guide wire within the trachea. Thereafter, the bronchoscope was removed to allow continued ventilation. It was subsequently re-inserted to confirm or refute intra-tracheal tube placement.

Given the low incidence of complications during PDT, it is likely that routine use of CXRs post operatively will have a low detection rate of new CXR findings. It is therefore unsurprising that the overall detection rate for new CXR findings after operation was 2.3% (8/345). We have shown that in the 252 uncomplicated PDTs there was one unexpected CXR finding on the immediate post-procedural film which ultimately resulted in a tension pneumothorax. Therefore, in seven of the eight cases the new CXR changes were found in the technically difficult group (two pneumothoraces, one pneumomediastinum and four cases of subcutaneous emphysema). In the cases of those patients with subcutaneous emphysema, this was immediately diagnosed clinically. In no patient was there an underlying pneumothorax, despite there being new CXR changes, and so clinical management remained unaltered.

Our study differs from earlier work in that it is both prospective and significantly larger than earlier published studies. In introducing the concept of a technically difficult PDT, it is immediately apparent that more CXRs will be performed than if one were restricting post-procedural CXRs to traditionally defined complicated PDTs. Indeed, previous authors have suggested that there is no role for routine CXR after PDT.10,17 From the data presented here; however, we would suggest that there is a role following a technically difficult PDT, which in the current series would amount to performing a post-procedural CXR in 27% patients. The paper by Datta and colleagues10 was criticized for recommending that post-procedural CXR was not necessary after a retrospective assessment of only 60 patients. Haddad and colleagues17 studied 239 patients but used a conventional definition of a ‘complication’ and hence may account for their only new finding of atelectasis in 10% of patients. In our 252 patients undergoing uncomplicated PDT, the detection rate for new abnormalities on CXR was 0.4%. In the 93 patients undergoing a technically difficult PDT, the detection rate for new CXR abnormalities was 7.5%. Given that the majority of these abnormalities were related to the presence of subcutaneous air, which was clinically evident in all cases before CXR, the yield of unexpected new abnormalities on CXR in this group was still low.

Since we have found only one new abnormality in the 73% patients who underwent an uncomplicated PDT on the immediate post-procedural CXR, there would appear to be little utility in this investigation in this group of patients. However, the failure to recognize this subcutaneous air subsequently led to the development of a tension pneumothorax. Had this subcutaneous air been recognized on the immediate CXR, it is still likely that there would have been no change in the initial post-PDT clinical management other than a greater degree of vigilance in the postoperative period. Therefore, we would still argue that there is no role for routine CXR in the setting of uncomplicated PDT. However, it could equally be argued that given the subsequent gravity of this complication post-procedural CXRs are still warranted in this group of patients.

If one accepts the argument that post-procedural CXRs are unnecessary after a truly uncomplicated PDT, then this will lead to modest cost savings and a reduction in the exposure of staff and patients to ionizing radiation (a single CXR equates to 0.1 mSv or 10 days of background radiation) within the critical care unit. In our institution, the distance of the tip of the tracheostomy tube from the carina is routinely measured with the bronroscope and so we do not require radiographic confirmation of this measurement.

We feel, therefore, that the rate of new CXR findings of 7.5% in the technically difficult group is high enough to justify continued routine utilization of post-procedural CXRs in this group. Only in truly uncomplicated PDTs, with a new abnormality rate on post-procedural CXR of 0.4%, there is, arguably, no role for routine post-procedural CXR.

Table 2 Technical difficulties

<table>
<thead>
<tr>
<th>Technical difficulty</th>
<th>Number</th>
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<tbody>
<tr>
<td>Multiple tracheal punctures (≥3)</td>
<td>34</td>
</tr>
<tr>
<td>Tracheal ring fracture</td>
<td>34</td>
</tr>
<tr>
<td>Posterior tracheal wall injury</td>
<td>9 (1 major)</td>
</tr>
<tr>
<td>Oxygen desaturation</td>
<td>4</td>
</tr>
<tr>
<td>Bleeding</td>
<td>18 (3 major)</td>
</tr>
<tr>
<td>Tracheostomy tube misplacement</td>
<td>4</td>
</tr>
<tr>
<td>Surgical emphysema</td>
<td>4</td>
</tr>
</tbody>
</table>

Chest X-ray after tracheostomy
References

1 Delaney A, Bagshaw SM, Nalos M. Percutaneous dilatational tracheostomy versus surgical tracheostomy in critically ill patients: a systematic review and meta-analysis. *Crit Care* 2006; **10**: R55

2 Ciaglia P, Graniero KD. Percutaneous dilatational tracheostomy. Results and long term follow up. *Chest* 1992; **101**: 464–7

3 Grant CA, Dempsey G, Harrison J, Jones T. Tracheo-innominate artery fistula after percutaneous tracheostomy: three case reports and a clinical review. *Br J Anaesth* 2006; **96**: 127–31

4 Brander L, Takala J. Tracheal tear and tension pneumothorax complicating bronchoscopy-guided percutaneous tracheostomy. *Heart Lung* 2006; **35**: 144–5


10 Datta D, Onyirimba F, McNamee Mj. The utility of chest radiographs following percutaneous dilatational tracheostomy. *Chest* 2003; **123**: 1603–6


12 Swanson GJ, Meleca RJ, Bander J, Stachler RJ. The utility of chest radiography following percutaneous dilational tracheostomy. *Arch Otolaryngol Head Neck Surg* 2002; **128**: 1253–4


14 Gonzalez I, Bonner S. Routine chest radiographs after endoscopically guided percutaneous dilatational tracheostomy. *Chest* 2004; **125**: 1173–4

