Primary research

Utility of postintubation chest radiographs in the intensive care unit

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Abstract

Objective: To determine the clinical usefulness of immediate (stat) chest radiographs after endotracheal intubation when performed by experienced critical care personnel.

Patients and methods: This was a prospective study. Endotracheal intubations in an 11-bed intensive care unit and a nine-bed intermediate intensive care unit were included. After intubations were performed by an experienced critical care operator, that individual recorded demographic and procedural data, and predicted radiographic findings on a data collection sheet. Experience at intubation was stratified into four levels of lifetime experience: fewer than 10 procedures, 10–20 procedures, 20–50 procedures, and more than 50 procedures. Radiographic findings evaluated included endotracheal tube position and procedure-related complications. The postintubation chest radiograph was then reviewed and the actual findings were also recorded.

Results: A total of 101 evaluable intubations were recorded, two of which were predicted to show tube malposition. Actual radiographic findings revealed 10 malpositions, three of which were too high and seven were too low (one at the level of the carina). A single witnessed aspiration that occurred during intubation was not radiographically apparent until 24 h later. Only the tube positioned at the carina was felt to be of acute clinical significance or to place the patient at any acute risk.

Conclusions: The incidence of endotracheal tube malposition after intubation was underestimated. However, when performed by experienced critical care personnel, acutely significant malpositions were rare (one out of 101 intubations). We conclude that, in the absence of specific pulmonary complications, endotracheal intubations performed by experienced operators may be followed by routine, rather than 'stat' chest radiographs.

Keywords: chest radiographs, complications, cost containment, endotracheal tube

CXR = chest radiograph; ICU = intensive care unit.

Introduction

Endotracheal intubation is a common procedure in intensive care units (ICUs), and may be performed for numerous reasons and under varying circumstances, both elective and emergent. This procedure is performed by individuals with disparate levels of training and experience, ranging from junior residents in various specialties to anesthesiology attending physicians. It is common practice to obtain an immediate (stat) chest radiograph (CXR) upon completion of an endotracheal intubation to assess parameters such as tube position and possible procedure-related complications. The preponderance of literature that addresses the utility of such films includes a significant amount of data on intubations performed by relatively junior, unskilled individuals [1–3]. The purpose of this investigation was to determine the clinical utility of stat CXRs after endotracheal intubations performed by experienced critical care personnel.

Patients and methods

Study design

This was a prospective, observational study of patients in an 11-bed adult medical/surgical/neurosurgical ICU and a nine-bed adult intermediate ICU. Intubations were performed on the basis of routine clinical criteria, with recording of procedure-related information. Consent was therefore not required. Our policy requires that intubations in the ICU and intermediate ICU ordinarily be performed by a member of the Critical Care Service (attending or fellow) or a member of the Department of Anesthesia.

Patients

All patients intubated by a critical care fellow (medical, surgical, or anesthesia in at least their fourth year of postmedical school training, ie PGY-4 or higher) or attending were eligible for inclusion.

Data collection

After each intubation the operator completed a data collection form that included operator and procedural details such as level of training, intubation experience (level 1, <10 intubations; level 2, 10–20 intubations; level 3, 20–50 intubations; level 4 >50 intubations), nature of the procedure (elective or emergent), indication, medications used, tube and blade size, cord visualization, number of attempts, and number of operators who attempted intubation before a successful intubation was achieved. Predicted CXR findings (tube placement, pulmonary complications) were recorded before review of postintubation films, which were obtained stat, in accordance with our unit protocol. Tube placement could be predicted as being high, low or normal, and if low, whether above the carina or in a mainstem bronchus. Operators were also asked to predict the likelihood of an abnormality or complication other than tube malposition being radiographically apparent (none, unlikely, probable, certain). Films were subsequently reviewed by members of the critical care team, and the results as determined by the critical care physician were then entered on the data forms in a separate section. Our criteria for endotracheal tube malposition are as follows: an endotracheal tube tip less than 2 cm above the carina was considered too low, and a tip higher than the clavicular heads was too high. Complications to be recorded were as follows: new infiltrate/aspiration, pneumothorax, or 'other' (to be described by the operator).

Statistical analysis

Sex-associated differences were compared using a χ^2 analysis.

Results

A total of 105 oral intubations were performed during the study period. Of these, 101 were performed by critical care personnel; the remaining four were performed by junior house staff at the PGY-1 or -2 level and were excluded from evaluation. Ninety-eight of the 101 intubations were performed by individuals at experience levels 3 or 4. Two were performed by an individual who had previously done 10–20 intubations, and one by a person at experience level one. Of the 101 evaluable patients, 53 were identified as females, 45 as males, and three data forms did not contain sex data. Endotracheal placement was confirmed in all cases by end-tidal carbon dioxide detection and physical findings (bilateral breath sounds, condensation within the tube). No endotracheal tube was secured at a distance of less than 20 cm or more than 24 cm at the lips. Of these 101 intubations, only two were predicted to show incorrect placement on CXR. One was predicted to show high tube placement, the other low. Actual CXR findings as interpreted by critical care physicians demonstrated 10 incorrect tube positions: three were too low and seven were too high. Of the two predicted position errors, the intubation predicted to be too high was confirmed by CXR. The predicted low intubation was felt to be in an appropriate position on CXR. Sensitivity of the clinician's predictions of technically incorrect tube position was poor, with sensitivity of zero for low tube placement (none out of three), 14% for high tube placement (one out of seven), and an overall sensitivity of 10% (one out of 10). None of the low intubations was into a mainstem bronchus, although one was noted to be at the level of the carina.

None of the tube malpositions occurred in patients whose sex was unrecorded; all 98 patients whose sex was recorded were included in the evaluation of sex-related differences in frequency of tube malposition. Six out of seven high tube placements occurred in men ($P<0.05$, χ^2), and two out of three low placements occurred in women ($P=0.6$, χ^2).

Four complicated intubations were reported: three esophageal intubations, all of which were recognized at

the time of intubation and which demonstrated no apparent clinical compromise, and one clinically observed aspiration. No CXR abnormalities were identified in the cases of esophageal intubation. Although radiographically apparent 24 h later, the stat CXR showed no abnormalities in the case of aspiration.

Discussion

In the present study critical care clinicians predicted incorrect endotracheal tube placement in only two out of 101 procedures (2%), although review of postintubation CXRs demonstrated a true incidence of 10 out of 101 (10%). Despite the relatively higher than predicted rate of 'incorrect' endotracheal tube positioning on CXR and the poor sensitivity of the clinical predictions, only one out of 101 intubations (the placement of one tube at the level of the carina) required intervention (repositioning the tube) acutely. Because of this, we favor the term 'suboptimal' to describe the great majority of cases in which the tube was not in the generally accepted appropriate position, but in which the patient is not at any significant acute risk. Although the ability of the operators to accurately predict tube position was limited, stat CXR did not provide information necessitating acute interventions when intubations were performed by experienced personnel. This is probably due to the ability of the operators to identify accurately intratracheal tube placement at a level above the carina based on physical and end-tidal carbon dioxide findings. Possible complications were actually overestimated by the clinicians, and no unexpected complications (aspiration, pneumothorax, etc) were identified on the stat films. In fact, although radiographically apparent 24 h later, the clinically identified aspiration was not present on the stat CXR.

Formal radiologic evaluation of these films was not part of the design of the present study. These procedures are often performed during hours when a radiologist is not readily available, and clinical decisions are made based upon the clinicians interpretation of the CXR. For these reasons only the clinician's predictions and interpretations were considered.

Existing literature suggests that the frequency of tube malposition after endotracheal intubation justifies the routine obtaining of stat CXR after such procedures. Schwartz *et al* [3] reported an overall incidence of 42 out of 271 malpositions, with 10 mainstem intubations (nine in women, one in a man). In a broader evaluation of postprocedural CXR in the ICU, Gray *et al* [2] reported an incidence of endotracheal tube malposition of 28 out of 112, although the number predicted by those performing the procedures was only six out of 112. Six unsuspected mainstem intubations were identified by the postintubation CXRs. Brunel *et al* [1] reported that 30 out of 219 intubations required repositioning, including 10 mainstem intubations. The rate of tube malposition we demonstrated (10 out of 101) is consistent with the data previously reported. In contrast, however, the present study demonstrated only one instance in which acute tube repositioning was necessary: a low tube placement that was still above the carina. We would characterize this as demonstrating one significant malposition requiring acute intervention, and nine suboptimal tube placements.

The difference in rates of clinically significant tube malpositions between the present study and the previous ones cited may be largely due to the experience of the operators performing the intubations. In our unit endotracheal intubations not performed by members of the Department of Anesthesia are all performed by critical care fellows or attendings. In the paper by Schwartz *et al* [3], 62% of intubations were performed by nonanesthesia house staff. The study by Brunel *et al* [1] included intubations performed by a variety of personnel. Most (62%) were performed by anesthesia residents, but 16% were performed by medical or surgical residents. Of the 10 mainstem intubations reported, two occurred after intubation by an attendant of the anesthesia department, and six when performed by residents under attending supervision. Although not explicitly stated, presumably the other two occurred when intubations were performed by unsupervized residents. Although Gray *et al* [2] did not specifically report how many of their intubations were performed by house staff, they acknowledge that over half of all the procedures they reviewed (which also included a variety of vascular procedures) were performed by junior house staff.

Although high endotracheal tube placement is potentially problematic because of the theoretic increased risk of inadvertent extubation or vocal cord injury, the studies on assessment of endotracheal tube positioning have not addressed this issue to any significant extent. Specific data on the actual likelihood of such complications as a function of tube position are lacking. Neither of two recent studies of unplanned extubations [4,5] evaluated tube position as a risk factor for such events. An earlier literature review by Grap *et al* [6] similarly yielded no published data on this issue. The failure of studies that assessed risk factors for unplanned extubation to evaluate this parameter suggests that there is little clinical concern about high tube placement in most circumstances. Endotracheal tubes deemed to be too high appear to 'require' repositioning as a matter of protocol and on the basis of a theoretic concern rather than because of an active threat. Clinically, however, a low intubation appears to have a much greater potential for actual harm than does a high one.

Owen and Cheney [7] presented data in 1987 that indicated that mainstem intubation could be avoided if the endotracheal tube was positioned so that the 23 cm mark was at the level of the upper incisors in 'normal' sized males and the 21 cm mark was at that position in 'normal'

sized females. Brunel *et al* [1], however, reported two mainstem intubations with the tube at the 21 cm mark. Schwartz *et al* [3] reported similar results, noting that external markings were less predictive of good tube position in women than in men. The present study demonstrated a significantly higher rate of high tube position in men than in women, but, possibly because of its low incidence, could demonstrate no difference between men and women in the frequency of low intubations. Our results suggest that using the distance markings on an endotracheal tube may help to avoid low tube placement, but does not eliminate the possibility of high positioning.

Although routinely obtained in settings such as the ICU and Emergency Department, stat CXR is seldom obtained when patients are intubated before undergoing general anesthesia, even if a prolonged anesthesia time is anticipated. 'Standard' techniques such as auscultation of bilaterally equal breath sounds, ballotment of the balloon in the suprasternal notch, and identification of the centimeter marking at the teeth or lips is usually deemed to provide adequate assessment of tube position under these conditions.

Stat CXR for a commonly performed procedure may increase the cost of care by resulting in more radiographs than would have ordinarily been performed in an individual patient. In addition, unnecessarily ordered stat CXRs may divert personnel from other, potentially more important work. Limitation of such orders can result in both cost savings and an overall increase in the quality of care provided. Although the present results demonstrate a moderate rate of technically incorrect or suboptimal endotracheal tube placement as demonstrated by CXR, only a very small percentage (1%) required acute intervention. Endotracheal tubes are often repositioned on the basis of CXR findings. It should be noted, however, that attempting to optimize tube position with an essentially elective repositioning should not be confused with urgent repositioning of a tube that is in a position likely to result in patient compromise. With regard to the identification of possible complications, the operators were actually overcautious in their predictions. Based on these results we conclude that intubations may be followed by routine scheduled CXR if no specific pulmonary complications are anticipated or observed, the operator is experienced in the procedure, and findings consistent with supracarinal endotracheal position of the tube are documented.

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