Routine Chest Radiographs Following Repositioning of Endotracheal Tubes Are Necessary to Assess Correct Position in Pediatric Patients*

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Attempts to correctly reposition endotracheal tubes (ETTs) are not always successful in pediatric patients, even when chest radiographs (CXRs) are measured to determine the distance that the ETT deviates from the correct position. We determined the frequency of continued ETT malposition after repositioning in a pediatric intensive care unit (PICU). Forty children with malpositioned ETTs were identified during a 4-month period. After repositioning, ten (25 percent) continued to be malpositioned on the next CXR. Of 47 children with correctly positioned ETTs, only one ETT (2 percent) was found to be incorrectly positioned on the next routine CXR obtained 24 h later. The difference in frequency of ETT malposition between these two groups of children is significant (p<0.0001). The children were similar in weight and age. Despite repositioning based on measurements taken from a CXR, a large percentage of pediatric patients had continued ETT malposition. However, after radiographic documentation of correct position, we demonstrated that significant movement was uncommon. Routine confirmation of ETT position by CXRs should be considered after repositioning ETTs in pediatric patients. (Chest 1994; 106:1508-10)

Chest radiographs (CXRs) are routinely obtained in critically ill patients to monitor both clinical condition and to evaluate placement of invasive instruments such as central venous catheters and endotracheal tubes (ETTs). A recent study in an adult intensive care unit (ICU) assessed the value of routine postprocedural CXRs to detect complications and appliance malposition following endotracheal intubation and central venous or pulmonary artery catheter placement. Without the aid of a CXR, physicians were unable to reliably predict ETT malposition. In this series, 29 percent of ETTs were unexpectedly malpositioned. The authors concluded that routine CXRs should be obtained following all endotracheal intubations.

While most medical studies evaluating daily CXRs in patients in the ICU have been in adult populations, a few on children are available. Pediatric reports have primarily evaluated complications of endotracheal intubation; however, one study demonstrated the efficacy of routine daily CXRs for identification of clinically unsuspected cardiopulmo-

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CXR=chest radiograph; ETT=endotracheal tube; PICU=pediatric intensive care unit

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nary changes and appliance malposition. These studies suggest that the practice of obtaining daily CXRs and repeated radiographic examinations following endotracheal intubation, is clinically beneficial in pediatric patients in the ICU. To our knowledge, no study has evaluated ETT position following repositioning of malpositioned ETTs in children. We prospectively studied ETT position after repositioning and the need for radiographic evaluation in critically ill children.

METHODS

Children’s Hospital and Medical Center is a 205-bed university-affiliated pediatric hospital with approximately 9,000 annual admissions and 900 pediatric ICU (PICU) admissions. The pediatric intensive care unit (PICU) is a 17-bed multidisciplinary unit admitting children from birth to 21 years of age. The average patient age is 28 months. The need for patient consent was waived by the hospital investigational review board for this study.

Daily CXRs are routinely obtained every morning on all intubated patients, and additional studies are obtained following placement of central venous catheters and at the attending physician’s discretion. Anteroposterior CXRs are obtained in intubated patients in the supine position with the x-ray beam perpendicular to the chest. The head is in a neutral position with a small towel under the neck. The head is positioned in the midline with no lateral rotation. If the child moves or is poorly positioned, the study is repeated. Two children were excluded from the study because follow-up CXRs demonstrated neck flexion, and repeated CXRs were not obtained to verify ETT position.

The radiographs are immediately reviewed by the pediatric house staff and/or intensive care fellows and later by radiology
staff. An ETT is considered to be in satisfactory position if the tip of the ETT is below the clavicles and ≥2 cm above the carina. If an ETT is found to be malpositioned on CXR, the distance on the CXR that the ETT must be moved to achieve satisfactory position is measured and used for repositioning. A member of the respiratory therapy department repositions and retapes the ETT and documents the changes on the patient record. All uncooperative children and infants requiring endotracheal intubation are routinely sedated with a morphine sulfate infusion (10 to 30 μg/kg/h) and bolus benzodiazepine administration as clinically needed. Muscle relaxants are not routinely given unless the child has significant cardiopulmonary instability. Immediate follow-up CXRs are obtained at the discretion of the attending physicians. A “routine” CXR is always obtained within 24 h on intubated patients.

During a 4-month period, we prospectively reviewed the CXRs of all intubated patients in our PICU. Observers were not involved in patient treatment. Patients who had malpositioned ETTs were selected for further observation (group 1). When a patient was enrolled in the study, demographic data were recorded. Documentation of ETT repositioning, charted by the respiratory therapists, was reviewed and confirmed for the study subjects. We then examined the patient’s next CXR to determine if the ETT malposition was corrected. All radiographs were obtained within 24 h after repositioning.

The control group consisted of all intubated patients whose initial CXR in the ICU demonstrated correct ETT position. The next daily CXR was compared with the initial CXR for evidence of continued appropriate ETT position. This group provided the frequency of “spontaneous” ETT movement to a clinically significant malposition.

Categorical data were compared with Fisher’s exact test; the Mann-Whitney U test was used to compare continuously distributed data. Significance was defined as p<0.05.

RESULTS

Group 1 consisted of 40 children who underwent ETT repositioning and group 2 were the subjects with correctly placed ETTs. The demographics for both groups are presented in Table 1. There are no statistical differences in patient age, weight, or ETT size between the groups.

Despite repositioning, ten (25 percent) of group 1 subjects had continued ETT malposition demonstrated on the next radiographic examination. Children within group 1 with continued ETT malposition were compared with group 1 children with corrected ETT position (Table 2). Although patients with continued malposition were younger and weighed less, the differences did not reach statistical significance. The respective p values for patient age and weight were p=0.25 and p=0.19. Endotracheal tube size and type were similar for both groups.

Forty-seven children were enrolled in group 2. Only one child (2 percent) experienced “spontaneous” ETT malposition documented on subsequent CXR. The difference between the ETT malposition rate in patients in group 1 and group 2 was significant (p<0.0001).

DISCUSSION

After elective repositioning of malpositioned ETTs, we observed a high rate (25 percent) of continued malposition. In contrast, after the ETT was documented to be correctly placed, the rate of “spontaneous” malposition was low (2 percent). It therefore seems likely that the children in group 1 with continued ETT malposition never had correctly repositioned ETTs, rather than having a correctly positioned ETT that moved to an incorrect position before the next CXR. Although one might expect that repositioning of an ETT with careful measurement would result in correct positioning, our data indicate that this is often not the case.

Children in group 1 with correct ETT position were older and heavier than those whose ETT remained incorrectly positioned; however, the differences were not statistically significant. Hauser et al12 reported that children younger than 3 years of age experienced a high rate of ETT malposition after intubation. It is possible that differences in our data might reach statistical significance in a larger study.

Endotracheal tube malposition is very common in children. Their small size makes initial ETT positioning more difficult in children and infants than in adults. The average distance from the carina to the larynx in a term newborn is only 5.7 cm.1 Head movement can significantly change ETT position. Paradoxically, neck flexion pushes the ETT distally. This occurs because the area extending from maxilla to the first cervical vertebra acts as a lever arm about

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Table 1—Study Patient Demographics

<table>
<thead>
<tr>
<th>Group No.</th>
<th>Subjects (M/F)</th>
<th>Median Age, mo</th>
<th>Median Weight, kg</th>
<th>ETT Size, mm</th>
<th>ETT Type, Oral/Nasal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40 (25/15)</td>
<td>13.5</td>
<td>8.2</td>
<td>4.5</td>
<td>34/6</td>
</tr>
<tr>
<td>2</td>
<td>47 (28/19)</td>
<td>13</td>
<td>9.7</td>
<td>4.5</td>
<td>40/7</td>
</tr>
</tbody>
</table>

Table 2—Group 1—After Endotracheal Tube Repositioning

<table>
<thead>
<tr>
<th>ETT Correct</th>
<th>ETT Incorrect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>21</td>
<td>9</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

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a fulcrum at the upper cervical spine.\textsuperscript{12} As the neck is flexed, the lever arm is angled inferiorly and the ETT advances distally. When the head is extended, the ETT moves cephalad. Ideally the CXR should be taken with the child's head in a neutral position. Inclusion of the lower edge of the mandible allows assessment of neck position. The uncooperative nature of infants and toddlers coupled with small size also make proper ETT repositioning difficult.

Despite repositioning based on examination of the CXR, 25 percent of pediatric subjects had continued malpositioned ETTS. Endotracheal tube malposition places the critically ill child at risk for accidental extubation if the ETT is too high in the trachea or right mainstem bronchial intubation if the ETT is too low in the trachea.\textsuperscript{10} The consequences may include atelectasis, increased barotrauma, patient discomfort, and impaired oxygenation and ventilation.\textsuperscript{1}

Our data indicate that careful elective ETT repositioning does not ensure correct ETT position. Confirmation of ETT position by flexible fiberoptic bronchoscopy is another accurate method; however, this technique requires significant operator skill and attention to not move the ETT during the procedure. Small ETT sizes prevent continuous ventilation during bronchoscopy that may not be well tolerated in critically ill children. Chest radiographs provide a safe, easy, and accurate method to ensure correct ETT position after ETT repositioning.

REFERENCES