

## ORIGINAL RESEARCH

# Utility of chest x-ray for tracheostomy tube placement in pediatric patients

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**Abstract**

**Objective:** To evaluate the utility of ordering chest x-rays after pediatric tracheostomy tube placement in identifying acute, post-operative complications and how it impacts clinical decision-making.

**Methods:** In this retrospective cohort study, we identified tracheostomies performed in 139 pediatric patients through CPT codes over a 5-year period from 2013 to 2018. Manual chart review was performed for demographic and clinical characteristics, pre-procedure and post-procedure chest x-ray interpretations, and the presence of complications. Each complication was reviewed to see if action was taken due to post-procedure chest x-ray findings. Multivariable logistic regression was performed to determine associations with changes in pre-procedure versus post-procedure chest x-rays.

**Results:** In a cohort of 139 pediatric patients with pre-procedure and post-procedure chest x-rays, 40 (28.8%) of patients had new significant post-procedure chest x-ray findings compared to pre-procedure chest x-ray findings. Of these 40 instances of changes in pre-procedure versus post-procedure chest x-ray findings, only eight resulted in action being taken due to the observed findings. Among these eight instances of action being taken, only one instance involved in invasive action being taken with a bronchoscopy. With multivariable regression analysis, patient age, race, gender, and the presences of genetic syndromes, were not found to be significant risk factors in predicting changes in pre-procedure versus post-procedure chest x-ray.

**Conclusion:** In our study, post-procedure chest x-ray after tracheostomy tube placement did not significantly impact clinical decision making. It may be worth reconsidering the value in routine chest x-rays after tracheostomy tube placement in pediatric patients.

**KEYWORDS**

chest radiography, pediatrics, radiology, tracheostomy tube

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## 1 | INTRODUCTION

Although tracheostomy placement can be indicated for acute conditions, most pediatric tracheostomies are performed due to underlying chronic, often congenital, conditions. For example, a separate single-institutional study examining 215 children found that the three most common reasons for tracheostomy placement were chronic lung disease, neuromuscular disease, and cardiovascular disease.<sup>1</sup>

Although there is a high mortality rate in pediatric patients with tracheostomy, most of these deaths occur in relation to comorbidities such as bronchopulmonary dysplasia, congenital heart disease, or neurological impairment, rather than complications with the tracheostomy placement itself.<sup>2,3</sup> Similarly, a study examining tracheostomy complications in children with a complex chronic condition versus those without a complex chronic condition reported an odds ratio (OR) of 3.3 (95% CI, 1.1–9.9).<sup>4</sup>

Historically, chest x-ray immediately after tracheostomy placement is routinely used to verify tube placement. In the era of flexible tracheoscopy that allows for easier insertion and positioning changes, the purpose of these chest x-rays have shifted toward evaluation of postoperative complications, such as pneumothorax which may necessitate the need for chest tube placement or needle decompression. However, several retrospective studies on adult tracheostomy placement have questioned the utility of post-tracheostomy chest x-rays due to the relatively low rates of complications with minimal clinical implications.<sup>5–8</sup> Meanwhile, there appears to be a similar consensus on the utility of post-tracheostomy chest x-rays in the pediatric population, with most studies suggesting against routine post-procedure chest x-rays.<sup>9–12</sup> However, one study did recommend routine post-procedure chest x-rays based on its findings, citing that the majority of its pediatric patients fell into a high-risk category.<sup>13</sup>

The complications of tracheostomy placement can be divided into early and late complications. In the adult population, early complications can include hemorrhage, pneumothorax, and emphysema, while late complications can include tracheomalacia, laryngotracheal stenosis, and fistula formation.<sup>14,15</sup> In the pediatric population, the data regarding tracheostomy complications is not as well-defined.

We aim to further explore how often post-tracheostomy chest x-rays result in new findings by characterizing the most common acute complications identified by post-procedure chest x-ray. In addition, the study examines whether these findings impact clinical decision-making and have necessitated a change in management in these scenarios.

## 2 | METHODS

A retrospective study was conducted on tracheostomies performed in pediatric patients under the age of 18 years in a single-center, quaternary academic setting. Patients were identified by searching through the institution's electronic health records for CPT codes 31600, 31601, 71010, 31603, or 71045, over a 5-year period from 2013 to 2018 (Table 1).

Charts were reviewed for age, sex, race, and the presence of genetic syndromes. In addition, the radiology reports of the pre-procedure and post-procedure chest x-rays were compared and evaluated for significant outcomes such as false passages, pneumothorax, subcutaneous emphysema, pleural effusion, atelectasis, and opacification. The post-procedure chest x-rays were performed immediately tracheostomy tube placement, with each postoperative report explicitly comparing any findings to the preoperative report for a comparison study. Each case was evaluated to see if action was taken due to the changes in the pre-procedure and post-procedure chest x-ray findings through chart review, based on progress notes and discharge summaries. Multivariable logistic regression was used to determine associations with changes in pre-procedure versus post-procedure chest x-rays.

## 3 | RESULTS

The final study evaluated 145 pediatric patients and ultimately included 139 patients with pre-procedure and post-procedure chest x-rays. Patients ranged in age from 0-years-old to 17-years-old at time of placement (mean = 6.08 years; SD = 6.86 years) (Table 2).

**TABLE 1** CPT codes in study cohort.

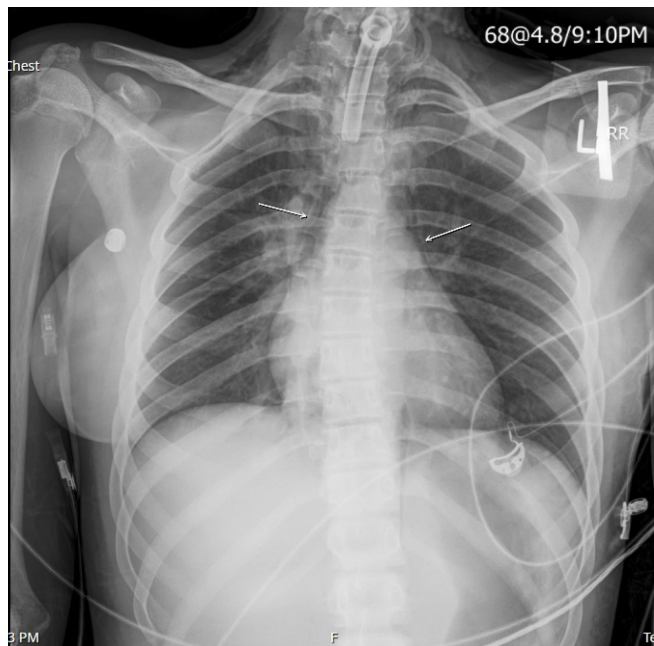
CPT code	Descriptions
31600	Tracheostomy, planned (separate procedure)
31601	Tracheostomy, planned (separate procedure); younger than 2 years
71010	Chest radiograph
31603	Incision procedures on the trachea and bronchi
71045	Radiologic examination, chest

**TABLE 2** Patient demographics.

Patient demographics	Number (n = 139)
Gender, no. (%)	
Male	76 (54.7)
Female	63 (45.3)
Ethnicity, no (%)	
Hispanic or Latino	8 (5.8)
Non-Hispanic/Latino	126 (90.6)
Unknown/not reported	5 (3.6)
Race, no. (%)	
White	93 (66.9)
Black	33 (23.7)
Hispanic	8 (5.8)
Other or unknown	5 (3.6)
Age, years. (SD)	6.08 (6.86)

Of the total study group, 71.2% ( $n = 99$ ) had no change in post-procedure chest x-ray when compared to the pre-procedure chest x-ray. New significant chest x-ray findings were found in 28.8% ( $n = 40$ ) of patients. Among the most common chest x-ray findings, 20.1% ( $n = 28$ ) showed atelectasis, 5.8% ( $n = 8$ ) showed pleural effusion, and 4.3% ( $n = 6$ ) showed opacifications. Meanwhile, only 0.7% ( $n = 1$ ) showed subcutaneous emphysema (Figure 1) and there were zero instances of false passage or pneumothorax.

Of these 40 instances of changes in pre-procedure versus post-procedure chest x-ray, 20.0% ( $n = 8$ ) resulted in action being taken



**FIGURE 1** Placement of tracheostomy tube with appropriate tip placement at the T3 level. Moderate amount of subcutaneous gas within the supraclavicular region with mild to moderate amount of pneumomediastinum (white arrows).

**TABLE 3** Unadjusted and unadjusted odds ratios for age, race/ethnicity, gender, and presence of genetic syndromes, and its impact on the likelihood of seeing differences between pre-procedure and post-procedure chest x-rays.

Variable	Unadjusted			Adjusted		
	OR	CI 95%	p-value	OR	CI 95%	p-value
Age (years)	1.05	[1.00, 1.11]	.062	0.40	[0.98, 1.11]	.175
Race						
White	1.00			1.00		
Black	1.22	[0.51, 2.83]	.809	1.41	[0.57, 3.44]	.446
Hispanic	0.82	[0.11, 3.80]	.644	0.94	[0.13, 4.74]	.941
Gender						
Male	1.00			1.00		
Female	0.64	[0.30, 1.34]	.240	0.64	[0.29, 1.38]	.258
Syndrome						
No	1.00			1.00		
Yes	0.65	[0.30, 1.40]	.280	0.79	[0.33, 1.86]	.590

Abbreviations: OR, odds ratio; UB and LB, upper and lower bounds of 95% confidence interval.

due to these changes. In these eight instances where action was taken, five were due to atelectasis, two were due to pleural effusion, and one was due to opacification. In all but one instance, only non-invasive actions were taken, such as administering oxygen or hypertonic saline, medications (e.g., furosemide, dornase alfa), or hyperinflation therapy. In one instance of atelectasis found after tracheostomy placement, a pulmonary consult resulted in bronchoscopy. Of these eight instances where action was taken, in six instances the post-procedure chest x-rays did not alter management because these actions were taken based on clinical presentation such as hypoxemia and other signs of respiratory distress upon physical exam. In the two remaining instances where management changed directly due to the post-procedure chest x-ray findings, diuretic medication was prescribed due to a pleural effusion secondary to cardiopulmonary congestion and a consult for bronchoscopy was placed due to lung opacifications in two separate instances.

In multivariable regression, patient age at the time of tracheostomy tube placement, race, gender, and the presence of genetic syndromes, were not found to be significant risk factors for predicting changes in pre-procedure versus post-procedure chest x-ray (Table 3). All elements of this study were approved by the Vanderbilt University Medical Center Institutional Review Board (IRB #103580).

## 4 | DISCUSSION

Tracheostomy is one of the most commonly performed procedures in the adult ICU. Contrary to adult practice, tracheostomy is a much less common procedure in the pediatric ICU, being performed in less than 3% of patients.<sup>16</sup> Indications for pediatric tracheostomy placement have shifted over the decades due to readily available vaccines for pathogens such as *Haemophilus influenzae* and *Corynebacterium diphtheria*, as well as advances in neonatal care for premature infants.<sup>17</sup> Most pediatric tracheostomies are placed secondary to upper airway-related abnormalities in premature infants or children with chronic

conditions. This shift also correlates with improvements in neonatal and pediatric ICU care.<sup>18</sup> This in turn, has resulted in higher rates of prolonged tracheotomies in children.<sup>19</sup>

In light of these shifting trends, we sought to better describe the acute complications in tracheostomy placement in the pediatric population. It has been shown that children with complex chronic conditions have significantly increased rates of tracheostomy complications.<sup>4,20</sup> Meanwhile, a recent meta-analysis examining 49 articles on pediatric tracheostomy complications found an average complication rate of 40%, with increased risk in those with lower age, lower birthweight, or prematurity.<sup>21</sup> In this review, the most common complications included skin lesions (1245 reports; 23.7%), granuloma formation (1073 reports; 20.4%), and tracheocutaneous fistulas (497 reports; 9.5%). Meanwhile, the most common complications detectable on chest x-ray included pneumothorax (222 reports; 4.2%), pneumomediastinum (179 reports; 3.4%), and pneumonia (61 cases; 1.2%). Overall, the commonly reported complications were non-pulmonary in nature and therefore not identified on plain film chest radiographs.

It is estimated that the complication rate of tracheostomy tube placement is 15%–19% in the pediatric population, similar to the estimated 15% in the adult population.<sup>4,22</sup> These complications are divided into early complications and delayed complications—with the purpose of the post-procedure chest x-ray being to capture early complications. The most serious early complications include subcutaneous emphysema, pneumothorax, and pneumomediastinum, which occur at an estimated rate of 3%–9%.<sup>23</sup> In our study cohort, there was only one concurrent instance of subcutaneous emphysema and pneumomediastinum and no instances of pneumothorax.

Overall, although 28.8% of the 139 pediatric patients had new significant chest x-ray findings after tracheostomy tube placement, there was only one instance of subcutaneous emphysema and zero instances of false passages or pneumothorax. Clinically significant x-ray findings are also unlikely to occur without clinically significant changes to ventilation or vital signs. However, rather than making a blanket recommendation against post-procedure chest x-rays, our findings suggest that the practice of ordering post-operative chest x-rays should be reserved for medically complex patients or in patients with perceived increased risk of complications. In pediatric patients with no significant comorbidities or elevated risk of post-operative complications, chest x-rays may not be warranted.

## 5 | CONCLUSION

Our single-institution study suggests routine chest x-rays after tracheostomy tube placement in pediatric patients do not significantly impact clinical management, even when new findings are present compared to pre-procedure chest x-rays. Despite there being several retrospective studies supporting the cessation of routine chest x-rays, many of these are single-institution, retrospective studies with relatively small cohorts of patients and limited data. Future studies would benefit from a multi-institutional protocol to better study this patient

population with the broader aim of examining the clinical utility of routine post-procedure chest x-rays after tracheostomy tube placement.

## CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

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