Assessment of Constipation in Children With Tracheostomy

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Objective: To determine the prevalence of constipation among children with tracheostomy tubes compared with children without tracheostomy tubes. We theorize that patients with tracheostomy may be unable to achieve adequate subglottic pressure for the Valsalva maneuver, which may contribute to constipation.

Design: Prospective cohort study.

Setting: Tertiary care children’s hospital.

Patients: Consecutive series of 36 children with tracheostomy and 72 general pediatric otolaryngology patients without tracheostomy.

Interventions: A pediatric constipation questionnaire (from previously published references) was given to parents of the study participants. Data were collected regarding patient medications, neurological status, and use of positive pressure airway assistance, speaking valves, and feeding tubes. Data were evaluated using $\chi^2$ and $t$ tests. Logistic regression analysis was used to search for independent variables impacting presence of constipation.

Results: The mean ages for the tracheostomy and control groups were 6.8 and 4.7 years, respectively ($P = .07$). A history of constipation was elicited in 60% of children with tracheostomy compared with only 16.7% of controls ($P < .001$). More patients with tracheostomy tubes (80.0%) than controls (20.8%) were taking medication to treat constipation ($P < .001$). Constipation was also significantly associated with older age ($P = .02$), use of medications with constipation as a known adverse effect ($P = .02$), and the presence of neurodevelopmental impairment ($P < .001$). Constipation was still independently associated with the presence of a tracheostomy tube when correcting for age and the use of constipation-causing medications. When controlling for neurodevelopmental impairment, the presence of a tracheostomy tube was not proven to be an independent predictor of constipation.

Conclusion: Children with tracheostomy tubes are more likely to have a history of constipation, although a causal relationship between tracheostomy and constipation could not be determined due to the potentially confounding variable of neurodevelopmental delay.

RESULTS

A total of 108 children were recruited into the study, including 36 patients with tracheostomy tubes and 72 control participants without tracheostomy tubes. The most common diagnoses in the control group were recurrent acute otitis media, adenotonsillar hypertrophy, laryngomalacia, and laryngopharyngeal reflux. The mean (SD) age of tracheostomy patients was 6.8 (7.0) years (median, 3.0 years), compared with a mean (SD) age of 4.7

METHODS

All pediatric patients with tracheostomy tubes visiting the Pediatric Aerodigestive Center at Children’s Hospital of Pittsburgh, Pennsylvania (a tertiary care children’s hospital) from July 1, 2007, to December 31, 2007, were considered candidates for the study. During the same time period, general pediatric otolaryngology patients visiting one attending physician’s (D.L.M.) clinics were also approached regarding participation in the study as control participants. A study nurse was responsible for describing the study to parents, recruiting participants, and collecting and storing the data, which were all collected anonymously. The protocol underwent expedited review and approval by the University of Pittsburgh institutional review board, in compliance with the Health Insurance Portability and Accountability Act of 1996 (HIPAA) guidelines.

Parents of all pediatric participants in the study were given a 1-page questionnaire to fill out. Data collection included the age, sex, presence of a tracheostomy tube, and underlying medical diagnoses of the child. Parents were asked if the child had a history of constipation. Parents were asked to list all current medications, including those being taken for constipation. All medications being taken were then cross-checked with the Children’s Hospital of Pittsburgh’s Pediatric Drug Therapy Handbook and Formulary to determine if constipation was listed as an adverse effect.

Parents were also asked if the child had a surgical feeding tube and whether the child took most of his or her diet by mouth or by feeding tube. Additional data collected included the use of a speaking valve, the use of positive pressure airway assistance (CPAP or BiPAP), and whether there was any history of neurodevelopmental impairment.

For purposes of the study, the definition of constipation was based on 3 well-established references and definitions of constipation: the Rome II criteria for pediatric functional constipation, the Constipation Subcommittee of the North American Society for Pediatric Gastroenterology and Nutrition (NASPGN), and the Paris Consensus on Childhood Constipation Terminology (PACCT) Group. These 3 references yielded a total of 9 “yes or no” questions regarding constipation for parents to answer on the questionnaire. The wording of the questions was modified slightly to make the questions easier for parents to understand. These questions are listed in the Table.

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Data were transferred from the 1-page questionnaires to an Excel file (Microsoft Corp, Redmond, Washington), and then to SPSS statistical software (SPSS Inc, Chicago, Illinois). Any participant with missing data for any particular factor was left out of the analysis for that particular factor. We used χ² and Fisher exact tests to compare categorical data for each of the studied variables between tracheostomy and nontracheostomy groups. The 2-tailed t test was used to compare group statistics regarding mean ages and mean number of constipation symptoms. Logistic regression analysis was used to correct for differences in age among those participants with and without tracheostomy tubes and to search for independent variables that have an impact on the presence of constipation. For all of the statistical tests performed, $P < .05$ was considered statistically significant.

### Table. Parent Responses to Constipation Survey

<table>
<thead>
<tr>
<th>Questions</th>
<th>Tracheostomy Group</th>
<th>Control Group</th>
<th>$P$ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Has your child ever been diagnosed as having constipation?</td>
<td>21 of 35 (60.0)</td>
<td>12 of 72 (16.7)</td>
<td>.001a</td>
</tr>
<tr>
<td>Is your child currently taking medication for constipation?</td>
<td>28 of 35 (80.0)</td>
<td>15 of 72 (20.8)</td>
<td>.001b</td>
</tr>
<tr>
<td>Over the past 2 weeks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Has your child been having pebblelike or hard stools for most of his or her stools?</td>
<td>8 of 34 (22.9)</td>
<td>5 of 71 (7.0)</td>
<td>.02b</td>
</tr>
<tr>
<td>Has your child had hard or firm stools 2 or fewer times per week?</td>
<td>7 of 34 (20.6)</td>
<td>13 of 72 (18.1)</td>
<td>.88</td>
</tr>
<tr>
<td>Has there been a delay or difficulty in moving his or her bowels, sufficient to cause significant distress for your child?</td>
<td>6 of 35 (17.1)</td>
<td>7 of 70 (10.0)</td>
<td>.30</td>
</tr>
<tr>
<td>For the past 8 weeks has your child had any of the following signs or symptoms?</td>
<td>6 of 35 (17.1)</td>
<td>9 of 72 (12.5)</td>
<td>.52</td>
</tr>
<tr>
<td>Bowel movement less than 3 times per week?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stool stains on undergarments greater than once per week?</td>
<td>1 of 34 (2.9)</td>
<td>8 of 71 (11.3)</td>
<td>.27</td>
</tr>
<tr>
<td>Passage of large stools that clog the toilet?</td>
<td>3 of 32 (9.4)</td>
<td>5 of 70 (7.1)</td>
<td>.70</td>
</tr>
<tr>
<td>Mass in belly or rectum that can be felt on examination?</td>
<td>2 of 34 (5.9)</td>
<td>5 of 71 (7.0)</td>
<td>&gt;.99</td>
</tr>
<tr>
<td>Stool withholding behavior (not willing to move bowels)?</td>
<td>3 of 34 (8.8)</td>
<td>1 of 72 (1.4)</td>
<td>.96</td>
</tr>
<tr>
<td>Painful defecation (it hurts to move bowels)?</td>
<td>3 of 34 (8.8)</td>
<td>7 of 72 (9.7)</td>
<td>.88</td>
</tr>
</tbody>
</table>

a All answers were given as either “yes” or “no.”

b Statistically significant difference.

c The patient had been taking medicines with constipation as an adverse affect, according to the Pediatric Drug Therapy Handbook and Formulary: Department of Pharmacy, Children’s Hospital of Pittsburgh.

d According to the Rome II criteria for pediatric functional constipation; see Rasquin-Weber et al.

e According to the criteria of the Constipation Subcommittee of the North American Society for Pediatric Gastroenterology and Nutrition; see Baker et al.

All pediatric patients with tracheostomy tubes visiting the Pediatric Aerodigestive Center at Children’s Hospital of Pittsburgh, Pennsylvania (a tertiary care children’s hospital) from July 1, 2007, to December 31, 2007, were considered candidates for the study. During the same time period, general pediatric otolaryngology patients visiting one attending physician’s (D.L.M.) clinics were also approached regarding participation in the study as control participants. A study nurse was responsible for describing the study to parents, recruiting participants, and collecting and storing the data, which were all collected anonymously. The protocol underwent expedited review and approval by the University of Pittsburgh institutional review board, in compliance with the Health Insurance Portability and Accountability Act of 1996 (HIPAA) guidelines.

Parents of all pediatric participants in the study were given a 1-page questionnaire to fill out. Data collection included the age, sex, presence of a tracheostomy tube, and underlying medical diagnoses of the child. Parents were asked if the child had a history of constipation. Parents were asked to list all current medications, including those being taken for constipation. All medications being taken were then cross-checked with the Children’s Hospital of Pittsburgh’s Pediatric Drug Therapy Handbook and Formulary to determine if constipation was listed as an adverse effect.

Parents were also asked if the child had a surgical feeding tube and whether the child took most of his or her diet by mouth or by feeding tube. Additional data collected included the use of a speaking valve, the use of positive pressure airway assistance (CPAP or BiPAP), and whether there was any history of neurodevelopmental impairment.

For purposes of the study, the definition of constipation was based on 3 well-established references and definitions of constipation: the Rome II criteria for pediatric functional constipation, the Constipation Subcommittee of the North American Society for Pediatric Gastroenterology and Nutrition (NASPGN), and the Paris Consensus on Childhood Constipation Terminology (PACCT) Group. These 3 references yielded a total of 9 “yes or no” questions regarding constipation for parents to answer on the questionnaire. The wording of the questions was modified slightly to make the questions easier for parents to understand. These questions are listed in the Table.

Data were transferred from the 1-page questionnaires to an Excel file (Microsoft Corp, Redmond, Washington), and then to SPSS statistical software (SPSS Inc, Chicago, Illinois). Any participant with missing data for any particular factor was left out of the analysis for that particular factor. We used χ² and Fisher exact tests to compare categorical data for each of the studied variables between tracheostomy and nontracheostomy groups. The 2-tailed t test was used to compare group statistics regarding mean ages and mean number of constipation symptoms. Logistic regression analysis was used to correct for differences in age among those participants with and without tracheostomy tubes and to search for independent variables that have an impact on the presence of constipation. For all of the statistical tests performed, $P < .05$ was considered statistically significant.
A history of constipation was elicited in 21 of 35 children with a tracheostomy tube (60.0%) compared with only 12 of 72 controls (16.7%), and this difference was significant ($P<.001$). Among the 35 children with tracheostomy for whom data were available, 28 (80.0%) were currently taking medications for constipation, compared with just 15 of control participants (20.8%), and this also represented a significant difference ($P<.001$) (Table).

The most common medication for constipation taken by patients with tracheostomy was polyethylene glycol (Miralax or GoLYTELY; Braintree Tree Inc, Braintree, Massachusetts) (n=12 [34.3%]), followed by docusate sodium (Colace; Shire US Inc, Newport, Kentucky) (n=4 [11.4%]). Other agents being used for constipation reported by parents included lactulose, senna, prune juice, and a variety of suppositories (the names of which were not reported). The most commonly reported constipation medication for control participants was polyethylene glycol (n=5 [6.9%]), and others included docusate and over-the-counter enemas and suppositories.

When parents were asked about recent problems with constipation (over the past 2-8 weeks) with specific survey questions (from the Rome II, NASPGN, and PACCT consensus definitions), a significant difference between patients in the tracheostomy group and controls was detected for only 1 of the 9 detailed constipation questions on the questionnaire (see Table for $P$ values). More patients in the tracheostomy group had pebblelike or hard stools for most stools over the previous 2-week period (8 of 35 patients [22.9%]) compared with the control group (5 of 71 patients [7.0%]; $P=.02$). Among the 36 children with tracheostomy, 17 (47.2%) had at least 1 positive response among the 9 questions regarding recent constipation, compared with 22 of 72 control children without a tracheostomy (30.6%) ($P=.09$). The mean number of positive responses to any of the 9 questions regarding recent constipation was 1.08 for patients in the tracheostomy group compared with 0.83 for controls, which was also not a significant difference ($P=.41$).

**PARTICIPANT AGE**

Participants with a history of constipation were older than those without a history of constipation in both the tracheostomy group (mean age, 8.9 vs 3.5 years; $P=.02$) and in the control group (8.3 vs 3.9 years; $P=.003$). However, when logistic regression analysis was used to adjust for age, the presence of a tracheostomy tube was still significantly and independently associated with a history of constipation ($P=.001$).

**MEDICATIONS**

Among the 36 children with tracheostomy, 5 (13.9%) were taking at least 1 medication for which constipation was listed as an adverse effect in the *Children's Hospital of Pittsburgh Pediatric Drug Therapy Handbook and Formulary*:

- Baclofen
- Calcium carbonate
- Clonazepam
- Diazepam
- Glycopyrrolate
- Iron sulfate
- Lansoprazole
- Levetiracetam
- Mycophenolate mofetil
- Omeprazole magnesium
- Phenytoin sodium
- Ranitidine hydrochloride
- Tacrolimus
- Ursodeoxycholic acid

Among the 72 controls, 3 (4.1%) were taking at least 1 medication for which constipation was listed as an adverse effect. Patients in the tracheostomy group were more likely to be taking medications with constipation as a potential adverse effect ($P=.02$). Overall, 7 of 8 patients (87.5%) taking medications with constipation as a potential adverse effect had a history of constipation compared with 17 of 84 patients (20.2%) not taking these medications ($P<.001$). However, when controlling for these constipation-causing medications with logistic regression, the presence of a tracheostomy tube was still independently associated with constipation ($P=.006$).

**NEURODEVELOPMENTAL IMPAIRMENT**

Among all 67 study participants for whom this information was available, 26 (38.8%) had a history of neurodevelopmental impairment. Seventeen of 20 patients (85.0%) with known neurological status in the tracheostomy group had neurodevelopmental impairment, compared with 9 of 47 patients (19.1%) in the control group ($P<.001$). Overall, more patients with neurodevelopmental impairment had a history of constipation (18 of 26 [69.2%]) compared with patients without neurodevelopmental impairment (5 of 41 [12.2%]) ($P<.001$).

Among the 20 patients in the tracheostomy group for whom underlying neurological status data were available, a history of constipation was elicited from 11 of 17 participants (64.7%) with neurodevelopmental impairment (3 of 6 participants with cerebral palsy [50.0%] and 8 of 10 participants whose birth was premature or who had a congenital syndrome [80.0%]) compared with 2 of 3 patients in the tracheostomy group with no underlying neurological impairment (66.7%). This difference was not significant ($P=.52$).

Among 47 control participants for whom underlying neurological status data were available, a history of constipation was found in 7 of 9 participants (77.8%) with neurodevelopmental impairment (2 of 2 participants with cerebral palsy [100%] and 5 of 7 participants with other types of neurological impairment, including premature birth, a congenital syndrome, or Chiari malformation [71.4%]), compared with 4 of 38 participants with no underlying neurological impairment (10.5%). Among the control participants, a significantly greater number with
neurodevelopmental impairment had constipation ($P < .001$).

When controlling for neurodevelopmental impairment with logistic regression, the presence of a tracheostomy tube could not be demonstrated to be an independent predictor of constipation ($P = .93$).

**SURGICAL FEEDING TUBE USE**

Surgical feeding tubes were used for 29 of 35 children with tracheostomy (82.8%), compared with only 5 of 71 controls without tracheostomy tubes (7.0%) ($P < .001$). However, among the tracheostomy group, a history of constipation was similar among those with (18 of 28 [64.3%]) and those without (3 of 6 [50.0%]) feeding tubes ($P = .72$), and there was no significant association between the presence of an enteral feeding tube and a history of constipation ($P = .72$).

**SPEAKING VALVE USE**

Speaking valve use was reported in 13 of 34 children with tracheostomy (38.2%). Constipation prevalence was similar among those who used a speaking valve regularly (10 of 13 [76.9%]) and those who did not use a speaking valve regularly (10 of 21 [47.6%]) ($P = .09$).

**SUPPLEMENTAL MECHANICAL POSITIVE AIRWAY PRESSURE**

Supplemental positive airway pressure (CPAP or BiPAP or positive pressure administered with mechanical ventilation) was used regularly in 23 of 35 children with tracheostomy (65.7%). A history of constipation was found in 16 of 23 patients (69.6%) using mechanical positive airway pressure and 5 of 12 patients (41.7%) who were not using mechanical positive airway pressure assistance ($P = .11$). Constipation was therefore not significantly associated with the use of positive airway pressure.

This study intended to test the hypothesis that children with tracheostomy tubes would have a higher prevalence of constipation than controls without tracheostomy tubes. We theorized that constipation might be more prevalent in children with tracheostomy owing to the loss of an effective Valsalva maneuver in the presence of a patent tracheostomy tube. We are, of course, aware that the etiology of pediatric constipation is multifactorial and has been linked to diet and socioeconomic status as well as anatomical, neurophysiological, and behavioral variables.

The defecation act results from a chain of events that begins with the Valsalva maneuver, in which forced expiration against a closed glottis leads to an increase in intrathoracic and intra-abdominal pressure, with subsequent changes in sympathetic tone in the splanchnic vasculature and systemic blood pressure. The straining forces can be clinically significant enough in some patients to cause cardiac rhythm disturbances, and reduction in coronary and cerebral blood flow, resulting in defecation syncope and even death.

It is known that subglottic air pressure increases during swallowing, with successful swallowing seeming to require subglottic pressures above a threshold of 7 to 10 cm H2O. Any condition that can disrupt tracheal pressure generation at the time of the swallow, such as the presence of a tracheostomy tube, may place patients at risk for dysphagia. Deglutitive subglottic pressure can be restored in patients with tracheostomy by occluding the tube, for example with a speaking valve. We postulated that, similar to the findings with swallowing, defecation might also be expected to lead to an increase in subglottic pressure owing to the Valsalva maneuver, and that loss of this pressure from a tracheostomy tube may predispose a patient to constipation. However, analysis of our data showed that use of a speaking valve and/or mechanical positive airway pressure led to no significant change in the prevalence of history of constipation. Our inability to substantiate this hypothesis may possibly be explained by the presence of other confounding variables, such as neurodevelopmental delay, that are frequently associated with constipation and occurred with regularity in all patients with tracheostomy tubes in this study.

The current study found that children with tracheostomy tubes were more likely to have a history of constipation reported by parents than control participants (60.0% vs 16.7%). However, when parents were asked 9 specific questions based on published definitions of constipation scores were similar between the 2 groups for 8 of the 9 questions. One explanation for this similarity in responses may be the fact that these 9 questions asked only about recent constipation symptoms (over the past 2-8 weeks), and at the time of the study, 80.0% of patients with tracheostomy tubes were already taking medication intended to treat constipation (compared with only 20.8% of controls).

Although we determined that a parent-reported history of constipation was significantly more prevalent among our cohort of children with tracheostomy tubes, the next challenge was to determine if the presence of the tracheostomy tube was independently associated with constipation or if other confounding variables were involved.

We found that among patients with tracheostomy tubes and controls alike, children with a history of constipation were significantly older than those without constipation. However, logistic regression showed that the presence of a tracheostomy tube was still independently associated with a history of constipation, even with age taken into account. Whether there is a significant relationship between age and constipation in the general pediatric population is still a matter of debate in the literature, with no one particular age category having consistently emerged as being most associated with pediatric constipation.

The most likely confounding variable in the present study is the presence of neurodevelopmental delay. It is estimated that the worldwide prevalence of childhood constipation is 10.4% (range, 0.7%-29.6%). The prevalence of constipation is higher in nonambulatory children with severe neurological impairment (34%). and the prevalence may be as high as 74% among children...
with cerebral palsy. Children with developmental delay can be constipated due to inadequate dietary fiber and fluid intake, poor muscle tone, prolonged immobility without exercises, and lack of erect posture and the urge to defecate. Cerebral palsy encompasses a group of non-progressive disorders characterized by central nervous system damage during early development, associated with disorders of movement, posture, and tone. Colonic segmental transit time studies in patients with cerebral palsy and chronic constipation have shown a delay in the more proximal segments of the colon, suggesting disruption of neural modulation of colonic motility.

In our study, among all participants for whom data were available, 18 of 26 participants with neurological impairment (69.2%) had a history of constipation, compared with just 5 of 41 participants with normal neurological function (12.2%). However, most of this disparity occurred within the controls, in whom neurological impairment was strongly associated with constipation. Within the tracheostomy group, similar percentages of children with and without neurological impairment had a history of constipation, although there were only 3 patients in the tracheostomy group with no underlying neurodevelopmental impairment (of whom 2 had a history of constipation).

When controlling for neurodevelopmental impairment with logistic regression, the presence of a tracheostomy tube could not be demonstrated to be an independent predictor of constipation. This result may be because neurodevelopmental impairment is a true confounding factor. However, the presence of a tracheostomy tube and the presence of neurodevelopmental impairment coexisted so frequently that there were very few neurologically normal patients in the study who had a tracheostomy tube; thus, it might not have been possible to separate these 2 factors as independent predictors of constipation.

In our study, we found that children with tracheostomy tubes had a similarly high prevalence of a history of constipation regardless of whether a surgical feeding tube was used. In the literature, it has been suggested that constipation associated with enteral nutrition is uncommon, and when it does occur, it is usually associated with insufficient fluid or fiber intake, intestinal dysmotility or obstruction, or medications. In one study of 74 children with severe neurological impairment recommended for gastrostomy placement and assessed with a questionnaire, 26 (34%) had constipation before gastrostomy placement, 17 (23%) had constipation at the 3-month postgastrostomy follow-up, and 20 (27%) had constipation at the 6-month postgastrostomy follow-up. The decrease in constipation associated with the gastrostomy tube was thought to reflect improved dietary intake. The high osmolarity of enteral feeding can also lead to increased motility and decreased constipation.

Medications that can cause constipation as an adverse effect were also assessed in the current study. Patients in the tracheostomy group were more likely to be taking medications with constipation as a potential adverse effect. Indeed, patients taking medications with constipation as a potential adverse effect were more likely to have a history of constipation. However, when controlling for these constipation-causing medications with logistic regression, the presence of a tracheostomy tube was still independently associated with constipation.

One limitation of the current study is that the fact that our constipation questionnaire was not a validated questionnaire. However, there is currently no available validated pediatric constipation questionnaire, and the questions on our survey were derived from 3 respected consensus panels and definitions of pediatric constipation. Another weakness of our study is the lack of subglottic pressure measurements during defection, both with and without a speaking valve in place, to further investigate the theory that subglottic pressure during a Valsalva maneuver is an important component in preventing constipation. A third potential weakness of this study is that most of the children with tracheostomy tubes also had neurodevelopmental impairment, which thus introduces neurodevelopmental impairment as a potential confounding factor associated with constipation. Future prospective studies with larger numbers of patients with tracheostomy tubes who are not neurodevelopmentally delayed and with subglottic pressure measurements taken at baseline and during defection are required to further investigate this topic.

In conclusion, children with tracheostomy tubes are more likely to have a history of constipation and are more likely to be taking medications for constipation than children without tracheostomy tubes. Although we initially postulated that the presence of the tracheostomy tube itself may be a contributing factor to constipation, we were unable to demonstrate a causal relationship between the presence of a tracheostomy tube and a history of constipation. Although there is still a possibility that there could be a causal relationship between tracheostomy tube and constipation, the results of our study suggest that in order to explore such a hypothesis in the future, investigators would have to control for the potentially confounding factor of neurodevelopmental delay.

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Author Contributions: All authors had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Simons and Mandell. Acquisition of data: Simons and Mandell. Analysis and interpretation of data: Simons, Mehta, and Mandell. Drafting of the manuscript: Simons and Mandell. Critical revision of the manuscript for important intellectual content: Simons, Mehta, and Mandell. Administrative, technical, and material support: Simons. Study supervision: Mandell.

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REFERENCES


