Percutaneous or surgical tracheostomy: a meta-analysis

DULGUEROV, Pavel, et al.

Abstract
To compare percutaneous with surgical tracheostomy using a meta-analysis of studies published from 1960 to 1996.

Reference

PMID: 10470774
Percutaneous or surgical tracheostomy: A meta-analysis

Pavel Dulguerov, MD; Claudine Gysin, MD; Thomas V. Perneger, MD, PhD; Jean-Claude Chevrolet, MD

Objective: To compare percutaneous with surgical tracheostomy using a meta-analysis of studies published from 1960 to 1996.

Data Sources: Publications obtained through a MEDLINE database search with a Boolean combination (tracheostomy or tracheotomy) and complications, with constraints for human studies and English language.

Study Selection: Publications addressing all peri- and postoperative complications. Studies limited to specific tracheostomy complications or containing insufficient details were excluded. Two authors independently selected the publications.

Data Extraction: A list of relevant surgical variables and complications was compiled. Complications were divided into peri- and postoperative groups and further subclassified into severe, intermediate, and minor groups. Because most studies of percutaneous tracheostomy were published after 1985, surgical tracheostomy studies were divided into two periods: 1960 to 1984 and 1985 to 1996. The articles were analyzed independently by three investigators, and rare discrepancies were resolved through discussion and data reexamination.

Data Synthesis: Earlier surgical tracheostomy studies (n = 17; patients, 4185) have the highest rates of both peri- (8.5%) and postoperative (33%) complications. Comparison of recent surgical (n = 21; patients, 3512) and percutaneous (n = 27; patients, 1817) tracheostomy trials shows that perioperative complications are more frequent with the percutaneous technique (10% vs. 3%), whereas postoperative complications occur more often with surgical tracheostomy (10% vs. 7%). The bulk of the differences is in minor complications, except perioperative death (0.44% vs. 0.03%) and serious cardiorespiratory events (0.33% vs. 0.06%), which were higher with the percutaneous technique. Heterogeneity analysis of complication rates shows higher heterogeneity in older and surgical trials.

Conclusions: Percutaneous tracheostomy is associated with a higher prevalence of perioperative complications and, especially, perioperative deaths and cardiorespiratory arrests. Postoperative complication rates are higher with surgical tracheostomy. (Crit Care Med 1999; 27:1617-1625)

Key Words: tracheostomy; tracheotomy; percutaneous; surgery; complications; meta-analysis; mortality; review; endoscopy; devices

From the Department of Otolaryngology–Head and Neck Surgery (Drs. Dulguerov and Gysin), the Institute of Social and Preventive Medicine (Dr. Perneger), and Medical Intensive Care, Department of Internal Medicine (Dr. Chevrolet), University of Geneva Hospital, Geneva, Switzerland. Address requests for reprints to: Pavel Dulguerov, MD, Division of Head and Neck Surgery, University of Geneva Hospital, 24, rue Michel-du-Crest, Geneva, 1205 Switzerland. E-mail: Pavel.Dulguerov@hcuge.ch

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Crit Care Med 1999 Vol. 27, No. 8

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ing PcT complication rates higher than those for SgT have been published (22–28).

To critically evaluate the pros and cons of PcT, we reviewed the complication rates of tracheostomy, both surgical and percutaneous. Because the majority of literature on PcT appears after 1985, the review of SgT complications was subdivided into two periods: 1960 to 1984 (SgT1960–1984) and 1985 to 1996 (SgT1985–1996). This allowed comparison between the two procedures during the same period of medical care, with the hope of decreasing the role of other variables, such as intensive care equipment, monitoring, reanimation techniques and drugs, and posttracheostomy nursing protocols. In addition, the use of low-pressure cuffs has been standard for the last 15 yrs.

**MATERIALS AND METHODS**

**Literature Search and Article Selection.**

The MEDLINE database was searched from 1960 to 1996 with a Boolean combination: (tracheotomy or tracheostomy) and complications. Only human studies published in English were included. To locate recent publications not yet indexed in MEDLINE, the Current Content issues for the last 3 months of 1996 were reviewed. The search was supplemented by cross-checking the references in each article. The search was conducted independently by two investigators.

As previously stated, the publications on SgT complications were separated in two periods, 1960 to 1984 (SgT1960–1984) and 1985 to 1996 (SgT1985–1996). Three articles published in the early 1960s (10, 11, 29) clearly stated that the procedures were performed before 1960 and were, therefore, excluded. Also, two articles on PcT, published before 1985 (19, 23) and concerning nine patients, were excluded. We excluded publications with fewer than five patients (28, 30), because these were more likely to be selected case reports of adverse effects rather than studies of representative samples.

Review articles and publications limited to specific tracheostomy complications, such as tracheal stenosis and tracheoinnominate fistula, were excluded. To be included, publications had to address complications of tracheostomy during the procedure, in the early postoperative period, and delayed or long-term complications. Several articles were excluded because of insufficient data about the complications encountered (31–46).

Several publications stress that emergency tracheostomy (43, 47) and tracheostomy in pediatric patients (16, 48) are associated with a much higher rate of complications than elective procedures in adult patients. PcT is an elective procedure performed in intubated adult patients (20, 21, 23–27, 49–69). A single article on pediatric percutaneous tracheos-
Table 1. Characteristics of the studies included in the tracheostomy groups

<table>
<thead>
<tr>
<th></th>
<th>SgT1960-1984</th>
<th>SgT1985-1996</th>
<th>PcT</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of studies</td>
<td>17</td>
<td>21</td>
<td>27</td>
</tr>
<tr>
<td>Mean age</td>
<td>4185</td>
<td>3512</td>
<td>1817</td>
</tr>
<tr>
<td>Pediatric cases (%)</td>
<td>5.2 ± 1.5</td>
<td>64.5 ± 7.8</td>
<td>44.8 ± 6.9</td>
</tr>
<tr>
<td>Emergency cases (%)</td>
<td>21.5 ± 24</td>
<td>5.6 ± 7</td>
<td>1.4 ± 4.7</td>
</tr>
<tr>
<td>Days of intubation</td>
<td>4.0 ± 3.6</td>
<td>12.7 ± 5.2</td>
<td>13.1 ± 3.9</td>
</tr>
<tr>
<td>Duration of procedure (mins)</td>
<td>NA</td>
<td>26.9 ± 16.5</td>
<td>11.7 ± 6.5</td>
</tr>
<tr>
<td>Location: % in ICU</td>
<td>15.5 ± 24</td>
<td>65.9 ± 46</td>
<td>84.3 ± 27.6</td>
</tr>
</tbody>
</table>

SgT, surgical tracheostomy; PcT, percutaneous tracheostomy; ICU, intensive care unit; NA, not applicable.

RESULTS

Seventeen articles published between 1960 and 1984 and analyzing tracheostomy complications in 4188 patients constitute the SgT1960–1984 group (Table 1). In this group, the number of pediatric tracheostomies was specified in eight studies (17, 47, 85–90) with an average rate of pediatric cases of 6.5%. The percentage of emergency tracheostomies was specified in 12 publications (17, 18, 47, 85, 87–94), for an average of 31.5%. Only four studies indicated the number of intubation days (17, 18, 85, 87) and the location of the procedure (18, 85, 89, 90), with average numbers of 4 days and 15% intensive care unit (ICU) tracheostomies. No publication in this group indicated the duration of the procedure (Table 1).

Twelve-one publications concerning 3512 patients who underwent SgT between 1985 and 1996 constitute the SgT1985–1996 group (Table 1). Sixteen of these studies (26, 56, 57, 60, 64, 65, 68, 71, 73–78, 82, 84) clearly stated that no pediatric cases were included. The number of emergency tracheostomies was specified in 18 studies (26, 56, 57, 60, 64, 65, 68, 71, 73–76, 74, 77, 80–84) and averaged 5.6%. The number of intubation days was indicated in nine articles (26, 57, 65, 68, 71, 72, 76, 81, 82), with an average of 12.7 days. The duration of the procedure was specified in six publications (56, 57, 60, 64, 68, 83) and averaged 26.9 mins. The location of the surgery was indicated in 17 articles (26, 60, 64, 65, 68, 71–75, 77–80, 82–84), and the procedure was performed in the ICU in 66% of cases (Table 1).

Twenty-seven articles were published between 1985 and 1996 on percutaneous tracheostomies (PcT) in 1817 patients (Table 1). The majority (26) of publications did not contain pediatric cases. Only one article (49) indicated a pediatric PcT in one patient for an overall rate of 0.06%. The number of emergency tracheostomies was indicated in 24 articles (20, 21, 24–27, 49–51, 54–57, 59–69), for an average of 1.44%. The number of intubation days before tracheostomy was specified in 12 articles (21, 25, 26, 50, 51, 53, 55, 57, 65, 66, 68, 69) and the average was 13.1 days. The duration of the PcT was indicated in 12 publications (21, 24, 53, 56, 57, 59, 60, 62, 64, 66, 68, 69), for an average of 11.7 mins. In 19 publications (21, 24–26, 50, 53–57, 59, 60, 62–66, 68, 69), the average number of ICU PcT was 84% (Table 1).

Perioperative Complications (Table 2)

Serious perioperative complications, i.e., perioperative death, cardiorespiratory arrest, pneumothorax, or pneumomediastinum, were noted in 239 per 10,000 SgT1960–1984, in 86 per 10,000 SgT1985–1996, and in 149 per 10,000 PcT. These differences are statistically significant.

The perioperative death rates were ten times higher for SgT1960–1984 and PcT compared with SgT1985–1996 data ($p = .001$). Similarly, cardiorespiratory arrest rates were the highest for the SgT1960–1984 group, followed by the PcT group, and the lowest for the SgT1985–1996 group. The death rates are also displayed graphically in Figure 1, top left. Perioperative pneumothorax was more frequent in the older SgT group, with a similar frequency in the SgT1985–1996 and the PcT groups. In fact, perioperative pneumothorax accounted for approximately one-half of the serious complications in the SgT1960–1984 group and for close to the total of the SgT1985–1996 group.

Intermediate perioperative tracheostomy complications, i.e., desaturation or hypotension, lesions of the posterior tracheal wall, misplacement of the tracheostomy cannula, aspiration during the surgery, and switching to the surgical technique, were noted in 84 per 10,000 SgT1960–1984, in 46 per 10,000 SgT1985–1996, and in 254 per 10,000 PcT ($p < .05$). Desaturation and hypotension did not appear in the SgT1960–1984 publications, probably because of underre
Table 2. Perioperative complications classified as serious, intermediate, and minor in the three tracheostomy groups

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Serious (total)</td>
<td>239</td>
<td>&lt;0.000001*</td>
<td>86</td>
<td>0.049*</td>
<td>149</td>
</tr>
<tr>
<td>Death</td>
<td>38</td>
<td>0.00082</td>
<td>3</td>
<td>0.00114</td>
<td>44</td>
</tr>
<tr>
<td>Cardiopulmonary arrest</td>
<td>60</td>
<td>0.00002</td>
<td>6</td>
<td>0.02203</td>
<td>33</td>
</tr>
<tr>
<td>Pneumothorax</td>
<td>110</td>
<td>0.122</td>
<td>74</td>
<td>1.0</td>
<td>66</td>
</tr>
<tr>
<td>Pneumonœumadistinum</td>
<td>31</td>
<td>0.00487</td>
<td>3</td>
<td>0.864</td>
<td>6</td>
</tr>
<tr>
<td>Intermediate (total)</td>
<td>84</td>
<td>0.048*</td>
<td>46</td>
<td>&lt;0.00001*</td>
<td>254</td>
</tr>
<tr>
<td>Desaturation/hypertension</td>
<td>0</td>
<td>0.00264</td>
<td>23</td>
<td>0.00560</td>
<td>77</td>
</tr>
<tr>
<td>Posterior tracheal wall lesion</td>
<td>5</td>
<td>1.0</td>
<td>6</td>
<td>0.00183</td>
<td>50</td>
</tr>
<tr>
<td>Cannula displacement</td>
<td>55</td>
<td>0.00796</td>
<td>17</td>
<td>0.089</td>
<td>44</td>
</tr>
<tr>
<td>Switch to surgical technique</td>
<td></td>
<td></td>
<td></td>
<td>0.83</td>
<td></td>
</tr>
<tr>
<td>Aspiration</td>
<td>24</td>
<td>0.00264</td>
<td>0</td>
<td>0.628</td>
<td></td>
</tr>
<tr>
<td>Minor (total)</td>
<td>531</td>
<td>&lt;0.000001*</td>
<td>179</td>
<td>&lt;0.00001*</td>
<td>628</td>
</tr>
<tr>
<td>Hemorrhage</td>
<td>170</td>
<td>0.339</td>
<td>142</td>
<td>1.0</td>
<td>143</td>
</tr>
<tr>
<td>Difficult tube placement</td>
<td>0</td>
<td>0.008</td>
<td>6</td>
<td>0.00001</td>
<td>220</td>
</tr>
<tr>
<td>False passage</td>
<td>12</td>
<td>1.0</td>
<td>11</td>
<td>0.00001</td>
<td>160</td>
</tr>
<tr>
<td>Subcutaneous emphysema</td>
<td>349</td>
<td>0.00001</td>
<td>20</td>
<td>0.00007</td>
<td>105</td>
</tr>
<tr>
<td>Total perioperative complica</td>
<td>854</td>
<td>&lt;0.000001*</td>
<td>311</td>
<td>&lt;0.00001*</td>
<td>1031</td>
</tr>
</tbody>
</table>

SgT, surgical tracheostomy; PcT, percutaneous tracheostomy.

Results are expressed as events per 10,000 procedures.

*p Values were computed assuming an independence between complications within each category. If this hypothesis were incorrect, p values would be biased toward rejection of the null hypothesis.

Porting. These complications appear to be more frequent in PcT studies, similarly to lesions of the posterior tracheal wall. Cannula displacement was the least frequent with SgT1985-1996. A switch to the surgical technique is, by definition, a complication of PcT and occurred in <1% of PcT cases. Perioperative aspiration was not noted in recent studies of both PcT and SgT1985-1996 groups.

Minor perioperative tracheostomy complications, i.e., hemorrhage, difficulty in tracheostomy tube placement, false passage during the introduction of the tube, and subcutaneous emphysema, were noted in 531 per 10,000 SgT1960-1984, in 179 per 10,000 SgT1985-1996, and in 628 per 10,000 PcT. Postoperative mortality rates are ten times higher for SgT1960-1984 relative to both SgT1985-1996 and PcT data (p < .001). The postoperative mortality rates are also displayed graphically in Figure 1, top right.

For the majority of serious perioperative complications, the highest rates are found in the SgT1960-1984 publications. For most serious perioperative complications, the difference between SgT1960-1984 and SgT1985-1996 rates were statistically significant. The rates of serious perioperative complications were roughly similar for SgT1985-1996 and PcT data. The only complications significantly different between SgT1985-1996 and PcT data were intratracheal hemorrhage, which was more frequent in SgT1985-1996 and postoperative pneumonœum and tracheal stenosis, which were found more often with PcT.

Intermediate postoperative tracheostomy complications, i.e., pneumonia, atelectasis, aspiration, and lesions of tracheal cartilage (tracheomalacia, tracheal granuloma) were noted in 1063 per 10,000 SgT1960-1984, in 146 per 10,000 SgT1985-1996, and in 78 per 10,000 PcT. For each complication, the highest rates were found in the SgT1960-1984 group, with statistically significant differences between the SgT1960-1984 and SgT1985-1996 groups in all cases. For unclear reasons, pneumonia was absent in PcT data, and tracheal cartilage lesions were infrequent in SgT1985-1996 data.

Minor perioperative complications, i.e., external hemorrhage, wound infection, tracheitis, delayed closure of the tracheostomy wound after cannula ablation, keloids, and unsatisfactory scars, were noted in 1372 per 10,000 SgT1960-1984, in 561 per 10,000 SgT1985-1996 and in 342 per 10,000 PcT (p < .001). The occurrence of postoperative wound hemorrhage was similar in the three groups. Wound infection and tracheitis were more frequent with SgT techniques. Although the differences were not as important, delayed cutaneous closure, keloids, and unsatisfactory scars were also found more often in SgT1960-1984 data, with a much lower frequency in SgT1985-1996 and PcT studies. The subtotals for serious, intermediate, and minor complications are displayed across the three study groups in Figure 1, middle, for perioperative and in Figure 1, bottom, for postoperative events.

Heterogeneity

We performed 94 heterogeneity tests (31 complications in two surgical groups and 32 in the percutaneous group). By using a p value of .05, only six of 31 tests were compatible with homogeneity in the SgT1960-1985 group, 10 of 31 in the

Postoperative Complications (Table 3)

Serious postoperative complications, i.e., postoperative death attributable to the tracheostomy procedure, tracheoesophageal fistula, mediastinitis or sepsis, secondarily to the tracheostomy, pneumothorax, postoperative cannula obstruction or displacement, and tracheal stenosis were noted in 845 per 10,000 SgT1960-1984, in 256 per 10,000 SgT1985-1996, and in 278 per 10,000 PcT. Postoperative mortality rates are ten times higher for SgT1960-1984 relative to both SgT1985-1996 and PcT data (p < .001). The postoperative mortality rates are also displayed graphically in Figure 1, top right.

For the majority of serious postoperative complications, the highest rates are found in the SgT1960-1984 publications. For most serious postoperative complications, the difference between SgT1960-1984 and SgT1985-1996 rates were statistically significant. The rates of serious postoperative complications were roughly similar for SgT1985-1996 and PcT data. The only complications significantly different between SgT1985-1996 and PcT data were intratracheal hemorrhage, which was more frequent in SgT1985-1996 and postoperative pneumonœum and tracheal stenosis, which were found more often with PcT.
Intraoperative mortality, which may reflect technical problems with the procedure, indeed decreased during the first year when percutaneous tracheostomy was performed (Fig. 2, top). In contrast, postoperative mortality was virtually nil from the start (Fig. 2, bottom). On the other hand, postoperative mortality after surgical tracheostomy has decreased from >1% to zero between 1970 and 1990.

**PcT Complications with Different Techniques (Table 4)**

Comparison of different PcT methods revealed that techniques not using the progressive dilation technique had the highest complication rates, both perioperatively and postoperatively. Also, the lowest complication rates were found when endoscopic control was used during the progressive dilation technique. The difference reached statistical significance for the intermediate and minor perioperative complication groups.

Individual complications that reached statistical significance between the PcT groups include desaturation, cannula misplacement, difficult tube placement, and false passage for the perioperative complications and pneumothorax as the only postoperative complication.

**DISCUSSION**

Surgical tracheostomy is a well-established procedure. The advent of the percutaneous tracheostomy technique requires a critical examination of the published data to compare these two tracheostomy techniques. Advantages of PcT, according to PcT advocates, include smaller skin incision (20, 25, 49, 55-58), and less dissection and tissue trauma (20, 21, 24, 49, 55-57, 67, 68), which lead to less hemorrhage (20, 24, 25, 49, 54, 57, 58, 61, 68, 69), fewer infections (20, 24, 25, 49-51, 54-58, 61, 65, 68), fewer tracheal problems (21, 49, 51, 57, 59, 69), and fewer cosmetic deformities (24, 25, 50, 51, 55-57, 59-62, 68). The procedure can be performed at the bedside (20, 25, 26, 51, 53-64, 66-69), decreasing the risk and cost of patient transportation to the operating room (105, 106). PcT is also said to be faster (21, 24, 25, 49-51, 56, 57, 59-62, 64-69) and easier to perform (20, 21, 24, 49, 50, 53, 57, 59, 60, 62-64), to require less personnel (25, 49, 62) and equipment (25, 49, 60, 69), and therefore, is associated with lower cost (50, 53-55, 64, 66, 67, 69). Furthermore, PcT is
Table 3. Postoperative complications, classified as serious, intermediate, and minor, in the three tracheostomy groups

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Serious (total)</td>
<td>845</td>
<td>&lt;0.00001*</td>
<td>256</td>
<td>0.72*</td>
</tr>
<tr>
<td>Death</td>
<td>124</td>
<td>0.00001</td>
<td>14</td>
<td>1.0</td>
</tr>
<tr>
<td>Tracheoesophageal fistula</td>
<td>31</td>
<td>0.00040</td>
<td>0</td>
<td>0.03960</td>
</tr>
<tr>
<td>Mediastinitis</td>
<td>12</td>
<td>0.067</td>
<td>0</td>
<td>0.341</td>
</tr>
<tr>
<td>Sepsis</td>
<td>24</td>
<td>0.00264</td>
<td>6</td>
<td>0.00947</td>
</tr>
<tr>
<td>Hemorrhage, intratracheal</td>
<td>88</td>
<td>0.00001</td>
<td>71</td>
<td>0.00824</td>
</tr>
<tr>
<td>Pneumothorax</td>
<td>7</td>
<td>0.00001</td>
<td>0</td>
<td>0.673</td>
</tr>
<tr>
<td>Cannula obstruction</td>
<td>251</td>
<td>0.00001</td>
<td>48</td>
<td>0.135</td>
</tr>
<tr>
<td>Cannula displacement</td>
<td>148</td>
<td>0.02818</td>
<td>91</td>
<td>0.00073</td>
</tr>
<tr>
<td>Tracheal stenosis</td>
<td>160</td>
<td>0.00001</td>
<td>26</td>
<td>0.0001</td>
</tr>
<tr>
<td>Intermediate (total)</td>
<td>1063</td>
<td>&lt;0.00001*</td>
<td>146</td>
<td>0.052*</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>650</td>
<td>0.00001</td>
<td>131</td>
<td>0.00001</td>
</tr>
<tr>
<td>Atelectasis</td>
<td>263</td>
<td>0.00001</td>
<td>3</td>
<td>1.0</td>
</tr>
<tr>
<td>Aspiration</td>
<td>74</td>
<td>0.00001</td>
<td>9</td>
<td>0.556</td>
</tr>
<tr>
<td>Tracheal cartilage lesion</td>
<td>76</td>
<td>0.00001</td>
<td>3</td>
<td>0.00001</td>
</tr>
<tr>
<td>Minor (total)</td>
<td>1372</td>
<td>&lt;0.00001*</td>
<td>561</td>
<td>0.00064*</td>
</tr>
<tr>
<td>Hemorrhage, external</td>
<td>237</td>
<td>0.00001</td>
<td>253</td>
<td>0.180</td>
</tr>
<tr>
<td>Wound infection</td>
<td>559</td>
<td>0.00001</td>
<td>271</td>
<td>0.00002</td>
</tr>
<tr>
<td>Tracheitis</td>
<td>480</td>
<td>0.00001</td>
<td>23</td>
<td>0.413</td>
</tr>
<tr>
<td>Delayed cutaneous closure</td>
<td>38</td>
<td>0.00006</td>
<td>0</td>
<td>0.341</td>
</tr>
<tr>
<td>Keloid</td>
<td>22</td>
<td>0.00499</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Unaesthetic scar</td>
<td>36</td>
<td>0.074</td>
<td>14</td>
<td>1.0</td>
</tr>
<tr>
<td>Total postoperative complications</td>
<td>3280</td>
<td>&lt;0.00001*</td>
<td>983</td>
<td>0.0024*</td>
</tr>
</tbody>
</table>

SgT, surgical tracheostomy; PcT, percutaneous tracheostomy. Results are expressed as events per 10,000 procedures.

* p Values were computed assuming an independence between complications within each category. If this hypothesis were incorrect, p values would be biased toward rejection of the null hypothesis.

Our meta-analysis confirms that PcT is a faster procedure than SgT (11.7 vs. 26.9 mins). Also, a large number of PcT procedures were performed in the ICU, which confirms that the procedure can be performed safely at the bedside and probably argues that PcT is easy to perform. SgT procedures have been performed at the bedside since 1962 (107) and were done in the ICU in 66% of SgT1985–1996 cases. Therefore, the location of the operation remains largely a matter of personal choice on behalf of the physician.

A comparison of percutaneous tracheostomy with surgical tracheostomy (1960–1984) publications clearly demonstrates that the frequency of most complications is lower with percutaneous tracheostomy. As previously stated, the comparison is probably unfair because of the advances in medical care and, more specifically, in the design of the tracheostomy tubes and cuffs. SgT procedures performed during the last 10 yrs (SgT1985–1996) are also associated with lower rates of peri- and postoperative complications.

The comparison of PcT with SgT1985–1996 complication rates is less clear cut. Our results suggest that perioperative complications are more frequent with PcT, whereas postoperative complications still occur more often with SgT. In general, the bulk of the difference concerns complications we classified as minor (Tables 2 and 3). In terms of perioperative complications, significant differences are found in tracheostomy tube placement, noted as either operative difficulty or tube false passage. This is to be expected, because a SgT procedure proceeds under direct vision to the anterior tracheal wall, whereas PcT remains a “blind” operation. In addition, the most frequently used commercial PcT set uses a series of 10 dilators of progressively larger diameter to create a passage of the appropriate size, allowing for the introduction of the tracheostomy cannula. These numerous manipulations may lead to displacement of the guidewire tip in the pretracheal tissues and the creation of a false passage. Another minor perioperative complication, reported with a significantly higher frequency with PcT, is subcutaneous emphysema. This could be attributable to the tight fit of the dissected pretracheal tissue around the tracheostomy cannula, which prevents the escape of tracheal air through the skin incision.

The tight fit of the tracheostomy cannula to the surgical tract probably ex-
A comparison of percutaneous tracheostomy with surgical tracheostomy (1960–1984) publications clearly demonstrates that the frequency of most complications is lower with percutaneous tracheostomy.

Table 4. Peri- and postoperative complications, classified as serious, intermediate, and minor, in the three percutaneous tracheostomy (PcT) groups

<table>
<thead>
<tr>
<th>PDT-PcT with Endoscopic Control</th>
<th>Other PcT</th>
<th>Fischer's Exact Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of studies</td>
<td>17</td>
<td>5</td>
</tr>
<tr>
<td>No. of patients</td>
<td>1123</td>
<td>373</td>
</tr>
<tr>
<td>Serious perioperative</td>
<td>125</td>
<td>107</td>
</tr>
<tr>
<td>Intermediate perioperative</td>
<td>265</td>
<td>134</td>
</tr>
<tr>
<td>Minor perioperative</td>
<td>534</td>
<td>241</td>
</tr>
<tr>
<td>Total perioperative complications</td>
<td>864</td>
<td>482</td>
</tr>
<tr>
<td>Serious postoperative</td>
<td>294</td>
<td>134</td>
</tr>
<tr>
<td>Intermediate postoperative</td>
<td>89</td>
<td>27</td>
</tr>
<tr>
<td>Minor postoperative</td>
<td>392</td>
<td>375</td>
</tr>
<tr>
<td>Total postoperative complications</td>
<td>775</td>
<td>536</td>
</tr>
</tbody>
</table>

PDT, progressive dilation technique; PcT, percutaneous tracheostomy.

Results are expressed as events per 10,000 procedures.

* Values were computed assuming an independence between complications within each category.

If this hypothesis were incorrect, **p** values would be biased toward rejection of the null hypothesis.

 plains the difference in minor postoperative complications favoring the PcT technique. The tamponade of small vessels reduces external hemorrhage, and the lesser tissue dissection and exposure in the tracheostomy wound might explain the lower rates of wound infections. Therefore, our analysis tends to support claims that PcT causes less tissue trauma, wound infections, and bleeding. In contrast, fewer tracheal problems (tracheal stenosis and tracheal cartilage lesions) occur in SgT1985–1996 data relative to PcT.

Probably the most troublesome differences between PcT and SgT1985–1996 are in serious perioperative complications. Significant differences are present in terms of operative mortality and cardiorespiratory arrest, with totals of 77 per 10,000 for PcT and 9 per 10,000 with SgT1985–1996. Whether the learning curve is the only explanation remains to be demonstrated. Contributing factors may include a false passage, posterior tracheal wall lesions with resulting tracheoesophageal fistulas, and the “blind” nature of PcT dissection. However, patients in the ICU, who tend to be included more often in PcT articles, probably have inherently higher complication rates.

Published studies on complications of tracheostomy exhibited substantial heterogeneity, even within groups of studies that reported on similar procedures. Adequate data to explain between-study variations were not available. Plausible hypotheses include differences in patient populations, intervention technique, surgical skills, effectiveness of supportive services, choice of relevant complications, methods to assess complication occurrence, reporting format, and selective publication. The same variables that engender heterogeneity may also cause confounding in comparisons of the three study groups. Thus, all results presented in this analysis should be taken with caution because the heterogeneity analysis suggests that not all observed differences were attributable to intervention technique.

For example, the subset analysis of different PcT showed different complication rates. The lowest complication rates were obtained with the progressive dilation method (20) performed under endoscopic control (53). Nonprogressive dilation PcT techniques had the highest number of complications. Nevertheless, even when the PcT technique associated with the lowest complication rates, namely the endoscopically controlled progressive dilation technique, is compared with SgT1985–1996 data, the trend discussed earlier is confirmed: lower perioperative complications with SgT and lower postoperative complication rates with PcT.

Despite this heterogeneity of the studies included in each group, the claims of lower complication rates with PcT relative to SgT found in numerous publications (20, 21, 49–51, 53, 54, 56, 57, 59, 60, 62, 64, 66–69) seem unwarranted, when studies conducted during the same time frame are compared. Only prospective randomized trials, with a blinded evaluation of the individual complications, can definitively answer this question. Such trials are as yet to be published (108). Previous comparative studies are retrospective (26, 60), nonrandomized (24, 26, 56, 60, 64), or not evaluated by an observer blinded as to the surgical technique (57, 65, 68). However, because complications of tracheostomy are rare, the size of such a trial may be prohibitive.

Even though its superiority over SgT is not established, PcT is being reported and probably used with increasing frequency. The reported complication rates in 27 studies of almost 2,000 patients who have undergone the procedure are not prohibitive and compare favorably with complication rates of SgT published only 10 yrs ago. Most of the studies use one commercial PcT set, and future improvements in the devices used might render the technique even safer.

In conclusion, the available data suggest the following: a) PcT is not clearly superior to SgT when recent studies are compared; b) PcT is associated with more perioperative complications than SgT in the published articles; c) PcT compares favorably with SgT in terms of postoperative problems. However, these conclusions should be accepted with caution because of the heterogeneity of studies published and because of the difficulty in detecting real differences when the prevalence of complications is low. The choice of the tracheostomy technique should be based on personal experience, until compelling evidence favoring one technique becomes available.
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