Clinical Research Paper

Tracheal stent implantation for the treatment of tumor-induced acute airway stenosis

Gang Ma,1,2,* Dao-Fang Wang,1,2 Quan-Guan Su,1,2 Ning Lou,1,2 Zi-Wei Zhu,1,2 Jian-Hua Fu1,3 and Mei-Xi Xu1,4

1State Key Laboratory of Oncology in South China; Guangzhou, Guangdong, P.R. China; 2Department of Intensive Care Unit; 3Department of Thoracic Surgery; 4Department of Anesthesiology; Sun Yat-sen University Cancer Center; Guangzhou, Guangdong, P.R. China

Key words: tracheal stent, tumor, airway stenosis, dyspnea

Background and Objective: Tumor-induced acute airway stenosis is a medical emergency. Metal airway stent implantation can relieve dyspnea of patients suffering from this symptom and provide time for their further treatments. This study was to investigate the clinical application, efficacy, and complication management of tracheal stent implantation for the treatment of tumor-induced acute airway stenosis. Methods: Nickel-titanium (Ni-Ti) alloy stent implantation was performed under the guidance of fiber-optic bronchoscopy in 52 patients with tumor-induced acute airway stenosis. Results: Stent implantation was successful in all 52 patients. Dyspnea in all patients was significantly relieved. Values of arterial partial pressure of oxygen (PaO2), arterial partial pressure of carbon dioxide (PaCO2), and Karnofsky performance status (KPS) changed from (7.74 ± 0.99) kPa, (5.37 ± 0.39) kPa, and 68.85 ± 8.08 preoperatively to (11.12 ± 0.61) kPa, (4.58 ± 0.30) kPa, and 84.62 ± 5.03 postoperatively (p < 0.01). The three-year survival rate was higher in lymphoma group than in lung cancer or esophageal cancer group. Postoperative complications were properly managed in all cases after symptomatic treatments. Conclusions: Tracheal stent implantation is an effective palliative treatment for acute dyspnea caused by local tumor compression or tumor invasion of large airways. It can rescue patients at risk for airway obstruction, improve the quality of life in terminal cancer patients, and provide further treatment opportunities for them.

Blockage or oppression on large respiratory airways caused by primary bronchial carcinoma or other malignant lung metastases may result in large airway stenosis. Some patients lose their opportunity for surgical treatment due to late detection. When the disease progresses, dyspnea would gradually aggravates. Some patients present with severe dyspnea when they come to the clinic, or even respiratory failure. Chemotherapy, microwave, photodynamic therapy or other therapeutic approaches have not achieved satisfactory results so far, some of which may even directly lead to death in these cases. In this study, self-expandable metallic stents were implanted in 52 patients with tumor-induced acute airway stenosis to alleviate dyspnea and provide sufficient time for the next-step treatments.

Data and Methods

General data. Fifty-two patients clinically diagnosed with large airway stenosis with severe respiratory difficulties caused by malignant tumor compression or invasion were selected from Sun Yat-sen University Cancer center from June 1998 to June 2003. Patients whose tumor compression area was ≥75% of the trachea or whose trachea was surrounded entirely by lymph nodes were excluded. All patients were followed up for three years, with complete records. There were 32 male and 20 female patients, aged from 37–75 years, with a median age of 57 years, including 30 cases caused by lung cancer; 13 cases by esophageal carcinoma, six cases by lymphoma and three cases with unknown pathology. Airway stenosis was found at the middle-lower trachea in 45 cases, at the right main bronchus in three cases, at the left main bronchus in two cases, coexisting at the trachea and one-sided bronchus in two cases. The preoperative image screening detected four cases of atelectasis.

Methods. Grouping. All cases were divided into three groups according to the location of the primary tumor: lung cancer group, esophageal carcinoma group and lymphoma group. Three cases with unknown pathology were not categorized into any groups.

Preoperative preparations. Respiratory functions of patients were determined according to preoperative physical examination and blood gas analysis. Chest X-rays, CT, fiber-optic bronchoscopy were performed to determine the location, length and stenosis degree of the lesion, which helped to select the stent and the best location for stent implantation.

Stent selection. Ultraflex self-expandable, non-membrane coated metallic stents were used for all patients. The stent was braided with a single strand of nickel-titanium alloy. Small circular barb rings at the tent were designed to prevent displacements.
Tracheal stent implantation for the treatment of tumor-induced acute airway stenosis

Anesthesia and stent implantation. In the interventional surgery room, patients were anesthetized using general anesthesia combined with superficial anesthesia. Disoprofol and fentanyl were intravenously administrated using a pump. Topical nasal anesthesia (tetracaine) was used to anesthetize the laryngopharynx. After anesthesia, the bronchoscope (LF-TP-model, Olympus company) was used for initial examination. Under the guidance of X-rays, the fiber-optic bronchoscope reached the superior part of the lesion site, where its corresponding site on the body surface was marked using alloy thread. If the bronchoscope was able to pass through the narrowed area, the corresponding spot on the body surface of the inferior part of the lesion was marked. The extent and length of stenosis were visually estimated during positioning. A guide wire was guided by a bronchoscope to pass through the stenosed area and kept there after the withdrawal of the fiberbronchoscope. A stent introducer apparatus was then placed at the appropriate position corresponding to body-surface markers with the help of the guide wire and X-rays. Subsequently, the introducer and the guide wire were withdrawn, followed by confirmation of the stent’s location and expansion using fiberbronchoscopy. Local bleeding was under control and suctioned. Patients were transferred to the intensive care unit. Vital life signs were monitored and postoperative respiratory care was performed. Chest X-rays were performed on the following day to determine re-expansion of collapsed lung lobes. Fiberbronchoscopy was conducted to reassess the placement and expansion of the stent.

Statistical analysis. All data were processed using SPSS10.0 statistic software. Preoperative and postoperative arterial partial pressure of oxygen (PaO₂), arterial partial pressure of carbon dioxide (PaCO₂) and Karnofsky performance status (KPS) were compared using t-test. Kaplan-Meier method was used to calculate the survival in each group.

Results

Arterial blood gas analysis and KPS scores of patients before and after stent implantation. Stent implantation was performed successfully in all 52 cases. Stent positioning during operation was accurate and the narrowed area of the airway was gradually expanded. Values of PaO₂, PaCO₂ and KPS were significantly improved postoperatively (Table 1). Reexpansion of collapsed lung lobes were observed in four cases. Dyspnea was remarkably relieved and the quality of life of patients was greatly improved.

Treatments for perioperative and postoperative complications. No serious complications were found during or after operation, such as asphyxia, massive hemorrhage, stent displacement, insufficient stent expansion, perforation of the trachea and the bronchus, rupture of the stent and so on. Bloody sputum appeared in 52 patients (100.0%), which was generally mild. Bleeding was controlled perioperatively and postoperatively after local and systemic treatments. A small amount of blood-streaked sputum was noted on the third day after operation in some patients. Chest pain occurred in 25 patients (48.0%), which was relieved after symptomatic treatments. Five patients (9.6%) had a minor fever of not higher than 38.5°C postoperatively, which disappeared without any specific medication. Pulmonary infection happened in four patients (7.7%), who developed hyperpyrexia. Bedside chest X-rays revealed focal consolidations of the lungs. Antibiotics were prescribed for those patients based on results of sputum culture. After atomization, coughing up sputum, and strengthening the airway management using fiberbronchoscopy, infections were all controlled. Tumor grew into the stent in eight patients (15.4%). Postoperative reobstruction of the airway was due to unsatisfactory or no anti-cancer treatment after implantation.

<table>
<thead>
<tr>
<th>PaO₂ (kPa)</th>
<th>PaCO₂ (kPa)</th>
<th>KPS value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before implantation</td>
<td>7.74±0.99</td>
<td>5.37±0.39</td>
</tr>
<tr>
<td>After implantation</td>
<td>11.12±0.61</td>
<td>4.58±0.30</td>
</tr>
<tr>
<td>T value</td>
<td>21.55</td>
<td>-15.07</td>
</tr>
<tr>
<td>P value</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

PaO₂, arterial partial pressure of oxygen; PaCO₂, arterial partial pressure of carbon dioxide; KPS: Karnofsky performance status.
Tracheal stent implantation for the treatment of tumor-induced acute airway stenosis

Figure 3. Postoperative image of the airway. The airway becomes open and smooth after successful stent implantation.

Figure 4. Postoperative chest CT image. The medium segment of the trachea is open and smooth.

Figure 5. Survival curves of different groups.

Discussion

Tracheal stent implantation is an essential measure for the treatment of airway stenosis, with significant therapeutic effect and few complications. Before operation, patients should be assessed of their situation to decide whether airway stent implantation is appropriate. If peripheral compression causes deformation of more than 75% areas of large airways or the trachea is surrounded entirely by the tumor or lymph nodes, the treatment efficacy of stent implantation is poor due to limited expansion force of the stent. It is estimated that the lumen diameter could not be at least 4 mm in those cases. Moreover, the unexpanded stent may further block already narrowed airways, resulting in aggravation of dyspnea and risking the life of the patient. We believe stent implantation should not be considered for those patients. Some scholars have recommended preoperative balloon dilatation. However, we do not agree that balloon dilatation is suitable for airway stenosis caused by malignant tumors, regardless of intraluminal or extraluminal type. Because cancerous tissues are fragile and prone to bleeding, thus balloon dilatation may easily cause massive hemorrhage of the tumor, airway lacerations or other serious complications.

Shah et al. and Wu have claimed that intratracheal airway stent implantation should be carried out under general anesthesia; while Han et al. suggest topical administration of narcotic drugs with a catheter, combined with oxygen supply a feasible method. We propose that as airway stenting poses much irritation to patients, utilization of topical anesthesia in combination with intravenous anesthesia may ensure smooth surgery, which not only reduces patients’ anxiety towards surgery, but also simplifies anesthetic procedures. By administration of a short-acting narcotic (disoprof) and an analgesic (fentanyl) using a micro-pump at a controlled speed, patients’ consciousness and breathing was satisfactorily monitored.

Normori et al. do not recommend using non-membrane coated metallic stent for patients with endogenous tumors. They think endogenous tumors can grow into the stent through the metal...
meshwork, and soon cause narrowing of the airway. We applied the non-membrane coated metallic stent for both malignant endogenous and exogenous growth tumors for the following reason: (1) Implantation with the non-membrane coated metallic stent achieved a successful effect to resolve emergent stenosis. In addition, the tumor did not grow into the stent as easily as expected. This may be because that the non-membrane coated stent does not compress the tumor as evenly as the membrane-coated stent, thus resulting in avascular necrosis of tumors, which is expelled with sputum. (2) Metal grids of the stent allowed airway epithelial cilia to maintain their upward swinging motion to clean respiratory secretion. The circular barbs located at both edges of the stent also reduced motility of the stent. (3) If the tumor progresses or tissue granulation invades into the stent, re-implantation of the airway stent or laser cauterization under the guidance of fiberopticoscopy may be considered.

The length of the implanted stent should be slightly longer than the tumor's length (about 5–10 mm), so that it can completely cover the stenosed area, overlapping with the normal mucosa layer. And the length of the stent should be appropriately measured to avoid obstruction of other airway passages. Implantation of the stent at the lower part of the trachea or at the right or left side of the bronchus should consider the influence of implantation on the opening of the right upper lobe or the opening of the lobar bronchus. Therefore the surgeon should carefully exam and analyze the most updated results of the chest X-rays, CT, bronchoscopy and other relevant examination of the patients to have better understanding of the location and length of the lesion to make an appropriate selection of the stent best suitable for implantation.

It remains controversial on the proper treatment for atelectasis after tracheal stent implantation. Nomori H et al. Conacher suggest that prolonged period of atelectasis may lead to little chance of re-expansion after stent implantation. We propose that active measures should be taken to restore the collapsed lung as likely as possible, such as suction of bloody sputum, clearance of necrotic tissues under fibrobronchoscopy, bronchial lavage, air purge, even if the period of atelectasis is extended to some extent. This may not only revitalize lung functions, but also reduce infection possibilities of the collapsed lung lobe. In our study, lung collapse in four cases lasted for about 2–3 weeks. After stent implantation and appropriate airway management, all collapsed lung lobes were ventilated and their respiratory functions were significantly improved.

We divided our patients into three groups according to their primary tumor location. The three-year survival rate was slightly higher in lung cancer group than in esophageal carcinoma group (p < 0.05), while was the highest in lymphoma group (p < 0.05). Occurrences of respiratory airway invasion and oppression happen in the late stage of lung cancer and esophageal carcinoma patients. Implantation of the stent is merely a palliative approach for these patients, providing them with short-term alleviation of dyspnea, temporary improvement of the life quality and further treatment opportunities. The efficacy of follow-up treatments is of utmost importance. Compared with lung cancer and esophageal carcinoma, as the chemotherapy regimen for lymphoma is relatively more mature, tracheal stent implantation is more significant. Patients underwent implantation would experience significant relief of respiratory failure, which creates suitable conditions for follow-up chemotherapy. For patients who receive radiotherapy after stent implantation, they may experience aggravation of chest pain during the early treatment induced by elevated exposure to scattered rays. This may be relieved by symptomatic treatments and would not affect further treatments. Stent removal may be considered if patients achieve CR and get their normal airway passages restored after stent implantation and anti-tumor therapy.

Along with the development of tissue materials and engineering science, application of different types of stents with various therapeutic effects will create more opportunities for the treatment of cancer patients. In our study, arterial blood gas findings, including PaO$_2$, PaCO$_2$ and KPS scores before and after tracheal stent implantation showed statistically significant. Remarked improvements in respiratory functions were achieved after the treatment. Early postoperative complications were not serious, and were properly managed in all cases after symptomatic treatments. All patients who had recurrence of stenosis during follow-up visits obtained satisfactory results after receiving laser therapy or stent re-implantations. Tracheal stent implantation is an effective palliative treatment for acute airway stenosis caused by malignant tumors.

References


