

## Airway Stents Implantation with Extra Pulmonary or Intrapulmonary Oxygen Support on Respiratory Failure Patients

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### ABSTRACT

Severe airway stenosis may result in respiratory failure. Airway stent implantation has been used to relieve the symptoms of airway stenosis. During stent implantation, how to provide oxygen support is more important. Up to now, there are two oxygen support methods including extra-pulmonary oxygen support and intrapulmonary oxygen support. The former method involves percutaneous cardiopulmonary support (PCPS) and extracorporeal membrane oxygenation (ECMO). In this way, stent implantation is more convenient because airway is not occupied by intubation tube. Furthermore, PCPS and ECMO can provide not only pulmonary but also cardiac support, which is advantageous for those patients

who suffer from severe airway stenosis and cardiovascular diseases. The intrapulmonary oxygen support methods include rigid bronchoscopy and tracheal intubation attached mechanical ventilation. Rigid bronchoscopy can be used to implant silicon and metallic stents. On intubated patients, more pulmonologists have performed stent insertion via fluoroscopy with/without flexible bronchoscopy. For avoiding X-ray exposure, flexible bronchoscope passing outside endotracheal tube or ultrathin bronchoscope have been ingeniously developed to implant airway stents. In conclusion, airway stents implantation on respiratory failure patients with extra pulmonary oxygen support (including PCPS and ECMO) which provide not only pulmonary but also cardiac support are more convenient, expensive and safer than airway stents implantation with intrapulmonary oxygen support methods. However, more experiences have been saved in airway implantation with intrapulmonary oxygen support. Clinical choice has to be decided on situation of patient.

**Key words:** Tracheobronchial stenosis; Extracorporeal membrane oxygenation; Stents; Intubation; Bronchoscopy

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### INTRODUCTION

Procedures of endobronchial intervention, including but not limited to tumor ablation, tumor resection, and airway stent implantation, are used to alleviate symptoms of airway stenosis. Airway stent implantation mainly focuses on airway stenosis, tracheo-esophageal or broncho-esophageal fistula. Airway stenosis, especially critical airway obstruction, always produces significant adverse effects on respiratory function. For those patients who have severe airway stenosis possibly resulting in respiratory failure, mechanical ventilation has to be used. Due to successfully solving the problems

of airway stenosis, stent implantation has been regarded as an effective method of liberating these patients from mechanical ventilation<sup>[1-2]</sup>.

Actually airway stent implantation is a professionally clinical technology with tremendous risk. Airway stenosis seriously restricted respiratory function of patients. Stent deliver catheter with/without bronchoscope in the airway during stent implantation furthers decrease pulmonary ventilation and oxygen saturation of patients. For some patients even whose airway stenosis is not so severe that they have not got respiratory failure, airway stent implantation might result in respiratory failure. Then operators have to face a hard fact of how to insert stent into airway stenosis site under the condition of insufficient oxygen support. In fact, during stent implantation, providing enough oxygen support is more important than performing stent insertion. Up to now there are two kinds of methods of providing enough oxygen support during airway stent implantation on respiratory failure patients. The one is extra-pulmonary oxygen support and the other is intrapulmonary oxygen support (Table 1).

### EXTRA-PULMONARY OXYGEN SUPPORT METHODS

Extra-pulmonary oxygen support includes percutaneous cardiopulmonary support (PCPS)<sup>[3-4]</sup> and extracorporeal membrane oxygenation (ECMO)<sup>[5-6]</sup>. PCPS is a relatively old cardiopulmonary bypass technology for emergency resuscitation. Its concept might trace back to 1937<sup>[7]</sup>. Several important steps including significant reduction in complexity and overall size<sup>[8]</sup>, the combination of portable cardiopulmonary bypass systems with improved percutaneous cannulas in conjunction with active venous drainage<sup>[9]</sup> allowed cardiopulmonary bypass technology to be a standard PCPS system. Though PCPS has been applied to much more clinical diseases, it was primarily used in severe cardiovascular events<sup>[10-12]</sup>. Different from PCPS, ECOM was primarily initiated for patients with severe respiratory failure. Rapid usage growth of ECMO has made it possible for being used in more disease processes, such as ARDS, cardiopulmonary arrest, and septic shock<sup>[6]</sup>. PCPS system can be put into a package, so it can be used as emergency treatment on spot and is more portable than ECMO. But ECMO which can be operated weeks is more powerful and long-term Performed.

Both PCPS and ECMO provide enough oxygen support via extra-pulmonary method. In this way, because of avoiding endotracheal intubation, airway is not occupied by intubation tube, which saves more airway space for stent implantation. Furthermore, PCPS and ECMO can provide not only pulmonary but also cardiac support. It is very important for those patients who suffer from severe airway stenosis with the comorbid cardiovascular diseases. Despite of these significant advantages, few reports have been published about using PCPS<sup>[3]</sup> or ECOM<sup>[4]</sup> to support oxygen supply while implanting airway stents. More operations are expected in the future and more experiences need to be summed up.

### INTRAPULMONARY OXYGEN SUPPORT METHODS

Rather than extra-pulmonary oxygen support, more patients received intrapulmonary method for oxygen support which contains two kinds of technologies: rigid bronchoscope connected to ventilator, and tracheal intubation attached mechanical ventilation.

The rigid bronchoscope is a straight hollow stainless steel tube. It is usually 40-45 cm long (but shorter tubes are available). Its calibre varies from 6.5 to 13.5 mm with the beveled distal end which allowing mechanical resection of obstructing lesions<sup>[13]</sup>. The proximal end consists of a central opening and several side ports where instruments can be placed or ventilation tubes can be connected.

When using rigid bronchoscopy, a totally intravenous general anesthesia is preferred with/without muscle relaxant. After insertion of rigid bronchoscope, a variety of ventilatory methods may be used, including spontaneous assisted ventilation, jet ventilation, apneic ventilation, and closed system ventilation. In most cases the simplest and most reliable ventilator approach is standard closed system ventilation<sup>[14]</sup>. Under this condition, the rigid bronchoscope which connects to ventilator is regarded as an endotracheal tube, with pauses in ventilation when the bronchoscope is opened for suctioning, biopsy, or stent placement. Beyond being an endotracheal tube for ventilation, rigid bronchoscope is also an effective manual channel which supports airway from collapse, and via which pulmonologists may perform more operations including ablation of tumor and stent implantation<sup>[15-16]</sup>. And at the usage of rigid bronchoscope, not only metallic but also silicon stents can be successfully implanted.

Comparing with rigid bronchoscope, flexible bronchoscope is more easily obtained and is becoming popular in metallic stent implantation<sup>[17-19]</sup>. But when implanting stents on ventilated patients, pulmonologists are faced with a difficult position. The diameter of the stent delivery catheter is about 4.0 mm (Micro-Tech (Nanjing), China) or 5.3mm (Boston Scientific, USA). The inner diameter of an endotracheal tube is about 8.0 mm, and the diameter of a flexible bronchoscope (BF260, Olympus, Tokyo, Japan) is 5.9 mm. Either the delivery catheter or bronchoscope can be successfully inserted into the endotracheal tube; however, it is not available for simultaneous insertion of the delivery catheter and bronchoscope. So for pulmonologists, it is impossible to deployed stents under the direct visualization of a standard BF260 bronchoscope via endotracheal tube.

To solve this problem, some ingenious processes have been developed. Some researchers used ultrathin bronchoscope to visualize the implantation of stents<sup>[20-21]</sup>. The outer diameter of ultrathin brohchoscope is less than 2.8mm. So it can be simultaneously inserted with stent delivery catheter into trachea or bronchus via intubation tube. Pulmonologists are able to implant airway stents under the direct visualization of ultrathin bronchoscope.

Apart from ultrathin bronchoscope guidance, flexible bronchoscopy under fluoroscopy<sup>[11]</sup> was also performed on intubated

**Table 1** Oxygen support methods during airway stents implantation on respiratory failure patients.

|  |   |   |
|--|---|---|
| Oxygen support during implanting airway stents on respiratory failure patients | Extra-pulmonary oxygen support methods                        | Extracorporeal membrane oxygenation (ECMO)              |
|  |   | Percutaneous cardiopulmonary support (PCPS)             |
|  | Intrapulmonary oxygen support methods                         | Rigid bronchoscopy while ventilation                    |
|  |   | Ultrathin bronchoscope while ventilation                |
|  |   | Flexible bronchoscopy and fluoroscopy while ventilation |
|  | Flexible bronchoscope outside tracheal tube while ventilation |   |

and ventilated patients for metallic stent implantation. In this way, flexible bronchoscope was used to place guide wire into the stenosis site. Under fluoroscopy guidance and bronchoscope visualization, metallic markers were put on the body surface to mark the location of the proximal and distal end of stenosis site. After withdrawing the bronchoscope, stent delivery catheter was inserted into airway advancing over guide wire. Then stent was deployed under the guidance of fluoroscopy. For the patients with tracheal stenosis, fluoroscopically guided placement of metallic stent without bronchoscopy was even performed<sup>[22]</sup>.

Though under guidance of fluoroscopy pulmonologists successfully perform airway stent implantation, fluoroscopy exposes patients and pulmonologists to X-ray radiation. In addition, rigid bronchoscope and ultrathin bronchoscope require special facilities that may not be available in every hospital. Furthermore flexible bronchoscope is operated more popularly than rigid bronchoscope and ultrathin bronchoscope. Thus, using a flexible bronchoscope without fluoroscopic guidance to implant metallic stents in mechanically ventilated patients is potentially promising for pulmonologists<sup>[23]</sup>.

The average diameter of an adult trachea is 20 mm<sup>[24]</sup>. After tracheal intubation, there is enough space for a bronchoscope passing outside the endotracheal tube because the outer diameter of tracheal tube is 10.7 mm. Simultaneously inserting a stent delivery catheter/bronchoscope through endotracheal tube and a bronchoscope/stent delivery catheter through airway outside the tube guarantees successful metallic stent implantation under the direct visualization of a bronchoscope<sup>[23,25]</sup>. To support the bronchoscopic procedure's success, two tips are encouraged. The first is the elevation of the oxygen concentration to 100% oxygen support during the operations. The second is that, a catheter is encouraged to be inserted through an endotracheal tube because stent delivery catheter is less flexible than a bronchoscope<sup>[25]</sup>. Winding through the airway outside the tracheal tube needs more skill and time. Inserting the delivery catheter through endotracheal tube and the bronchoscope through airway outside the tube can save operation time.

In conclusion, extra-pulmonary method including PCPS and ECMO provide enough oxygen support. In this way, stent implantation is more convenient because airway is not occupied by intubation tube. Furthermore, PCPS and ECMO which provide not only pulmonary but also cardiac support is very advantageous for those patients who suffer from severe airway stenosis combined with cardiovascular diseases. The intrapulmonary oxygen support methods for airway stent implantation include rigid bronchoscope connected to ventilator, and tracheal intubation attached mechanical ventilation. Rigid bronchoscopy can be used to implant silicon and metallic stents. On intubated patients, more pulmonologists have performed stent insertion via fluoroscopy with/without flexible bronchoscopy. For avoiding X-ray exposure, flexible bronchoscope passing outside endotracheal tube or ultrathin bronchoscope have been used to implant airway stents.

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