

Subcarinal ventilation-assisted Y-shaped stent insertion under local anesthesia for patients with complex tracheobronchial stenosis: initial clinical experience

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PURPOSE

We aimed to report our preliminary results of subcarinal ventilation-assisted Y-shaped stent insertion under local anesthesia for patients with complex lower tracheal-carinal-main bronchial complex stenosis.

MATERIALS AND METHODS

Seven consecutive patients with lower tracheal-carinal-main bronchial complex stenosis underwent Y-shaped stent insertion under local anesthesia. During the procedure, subcarinal ventilation was performed using a 4 F angiographic catheter, and stent insertion was performed under the protection of ventilation. Data on technical success, clinical outcome, and follow-up were collected and analyzed.

RESULTS

Subcarinal ventilation-assisted Y-shaped stent insertion under local anesthesia was technically successful in all patients without any major procedure-related complications. Seven stents were inserted in seven patients. Respiratory function improved in all patients, with the Hugh-Jones classification of respiratory status improving from grade IV–V before stenting to grade I–II after stenting. During the follow-up, one patient experienced re-stenosis of the stent. Average survival time was 185.7 days (range, 96–285 days) after the stenting procedure.

CONCLUSION

Subcarinal ventilation-assisted Y-shaped stent insertion under local anesthesia can be an effective, simple, and safe method for lower tracheal-carinal-main bronchial complex stenosis.

Airway stenosis is usually caused by local primary lung cancer, esophageal cancer, or some other mediastinal tumors. Airway stent insertion is an effective and widely used method to manage this condition (1, 2). However, as the stent introducer sheath or bronchoscopy can aggravate hypoxia, asphyxia is the most serious procedure-related complication during airway stenting or interventional bronchoscopy. The incidence of asphyxia was reported in 1.5%–14.3% of cases undergoing airway stent insertion (2–4).

To overcome this complication, Dolan et al. (5) used a thin ventilation catheter to support tracheobronchial stent insertion for three patients with tracheobronchial stenosis. Before stent insertion, the distal tip of the ventilation catheter was placed across the stenosis for ventilation, and then the stent insertion was performed under the protection of ventilation. However, there is no similar technique used for placement of Y-shaped airway stent. In this study, we reported our initial clinical experience of subcarinal ventilation-assisted Y-shaped stent insertion under local anesthesia for seven patients with lower tracheal-carinal-main bronchial complex stenosis.

Materials and methods

Patients

Our Institutional Review Board approved this study, and informed consent was obtained from each patient. From May 2010 to June 2013, seven consecutive patients (five males and two females; age range, 56–75 years; mean age, 64.6 years) with lower tracheal-carinal-main bronchial complex stenosis were hospitalized. Patient characteristics are shown in Table 1. The cause of the airway stenosis was lung cancer in six patients and esophageal cancer in one patient. All patients presented with progressive dyspnea, stridor, and cough. Arterial oxygen saturation (SaO₂) was less than 90% in all patients, even with the administration of high-flow oxygen.

Diagnosis of airway stenosis was established by patient history and thoracic multislice spiral computed tomography (MSCT) findings. Bronchoscopic examination was not performed due to serious dyspnea. Dimensions of the stenotic site were measured using thoracic MSCT and three-dimensional airway reconstruction (Fig. 1).

Ventilation catheter

Ventilation catheter (Fig. 2) was a 4 F angled-tip catheter (Angiographic catheter; Cordis, Warren, New Jersey, USA). The angle of the catheter tip was 135°, which complied with the angle between the trachea and the main bronchus.

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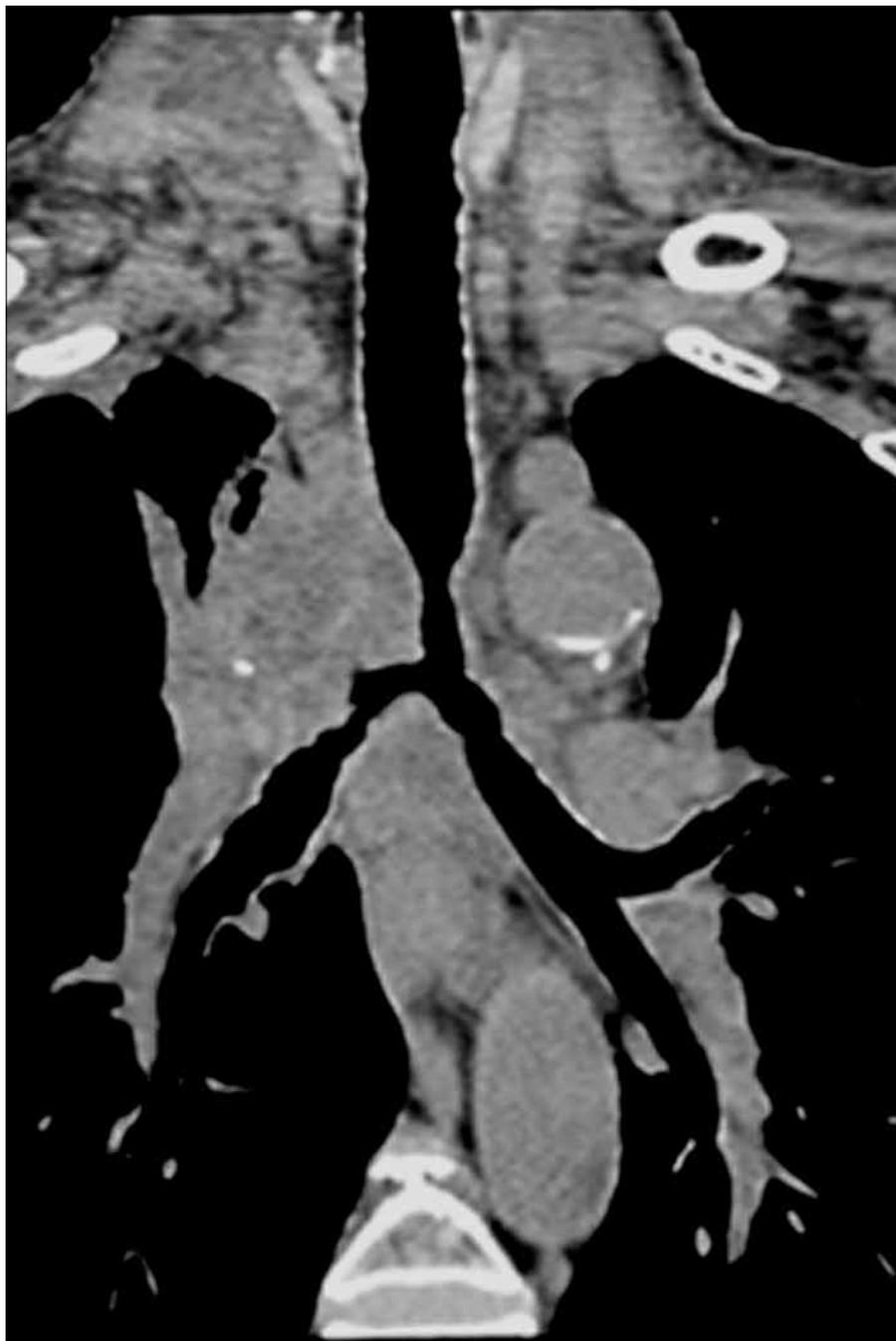


Figure 1. Preoperative oblique coronal reformatted image of the airways shows complex lower tracheal-carinal-right main bronchial stenosis.

Y-shaped stents

The size and type of the stents were chosen according to the results of thoracic MSCT and three-dimensional airway reconstruction. All stents were Y-shaped (Y-shaped integrated self-expanding nickel-titanium alloy airway stent; Micro-Tech, Nanjing, China). The stent body was 18–24 mm in diameter and 30–40 mm in length; the bronchial branches were 11–14 mm in diameter and 10–30 mm in length.

Placement of the ventilation catheters

All procedures were performed by interventional radiologists under fluoroscopic guidance with local pharyngeal anesthesia. Blood pressure, heart rate, SaO_2 , and respiratory rate were monitored throughout the procedure. The patient was placed in the right anterior or oblique or supine position, catheter was inserted into the trachea via a normal guidewire (0.035-inch guidewire; Terumo, Tokyo, Japan) from the nasal

cavity, and then the distal tip of the catheter was sent across the stenotic site into the unrestricted main bronchus or the less constricted of the two main bronchi. The proximal tip of the catheter was linked to the oxygen tube. The oxygen flow was set at 2–3 L/min according to the patient's condition.

Placement of the airway stents

Stent insertion was performed under oxygen supplement. A regular guidewire and another 4 F angled-tip catheter were inserted into one of the main bronchi, and the regular guidewire was exchanged with a stiff guidewire (0.035-inch stiff guidewire; Terumo). Then another stiff guidewire was placed into another main bronchus using the same method. A 27 F stent introducer sheath was passed over the two guidewires into the tracheal carina, and finally the stent was released over the ventilation catheter. Y-shaped stent deployment procedure was described elsewhere (6). After Y-shaped stent deployment, the ventilation catheter was smoothly removed (Fig 3).

All patients underwent three-dimensional C-arm conebeam computed tomography (CT) immediately after the procedure to ensure accurate stent placement.

Clinical assessment

All patients were observed three days after the procedure to evaluate respiratory function. The effect of stent placement was evaluated by Hugh-Jones (HJ) classification (1) and SaO_2 . All patients underwent thoracic MSCT three days after the procedure to evaluate the patency of the stent.

Technical success was defined as exact placement of the stent without any major procedure-related complications. Clinical success was defined as improvement of HJ classification by at least one grade within three days after the procedure. Major and minor complications were defined according to the Society of Interventional Radiology classification (7).

The patients underwent thoracic MSCT one month after the procedure, and every 2–3 months from then on, to evaluate the long-term efficacy of stenting and the presence of

stent-related complications. Patients' condition was followed by monthly interviews with the patients or their families. Patients were instructed to come to the hospital whenever they felt uncomfortable.

Results

Subcarinal ventilation-assisted Y-shaped stent insertion under local anesthesia was technically successful and well-tolerated in all patients. Total procedure time (from placement of the ventilation catheter to its removal, following the stent release) was 14–23 min (mean, 17.7 min). Duration of oxygen supplementation during the procedure was 11–21 min (mean, 15.3 min). Although one patient experi-

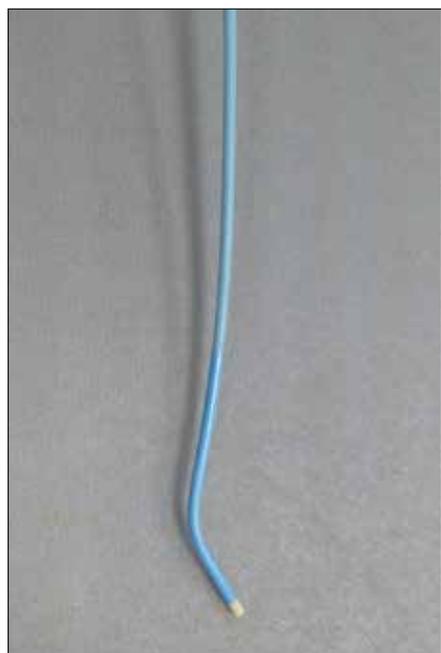


Figure 2. A 4 F angled tip catheter was used as the ventilation catheter.

enced mild hemoptysis, all patients were able to cooperate with us until the end of the procedure. After oxygen supplementation, the patients' SaO₂ value rapidly increased to 94%–97% (mean, 95.4%). When we passed the stent introducer sheath through the stenotic site and deployed the stent, SaO₂ values did not change obviously in any patient. No stent migrated after removal of the ventilation catheter, and C-arm conebeam CT confirmed full expansion and correct placement of all stents.

Seven stents were placed in seven patients. Clinical success was achieved in 100% of our patients. The HJ classification grade improved from IV-V before stenting to I-II after stenting; SaO₂ increased from 79%–86% before stenting to 94%–96% after stenting. Thoracic MSCT obtained three days after the procedure confirmed patency of all stents (Fig. 4).

During 4–10 months (mean, 6.7 months) of follow-up, one patient experienced re-stenosis of the stent 75 days after the procedure (Table 2). This patient was managed by Gamma knife surgery. Survival time after stenting was 96–285 days (mean, 185.7 days). Patients expired due to tumor progression (n=5) and pulmonary infection (n=2).

Discussion

This study evaluated the feasibility of subcarinal ventilation-assisted Y-shaped stent insertion under local anesthesia for patients with lower tracheal-carinal-main bronchial complex stenosis. Our preliminary results were positive. The stents were successfully

placed without major procedure-related complications and symptomatic efficacy was achieved in all patients. All of our patients were able to cooperate with us to finish the procedure.

In the past, the most commonly used Y-shaped stent was the silicone Dumon stent (6). However, placement of silicone Dumon stent requires rigid bronchoscopy and preliminary dilation. Yang et al. (6) designed a system specialized for delivery and deployment of self-expandable, metallic, inverted Y-stent, which simplified the procedure of Y-shaped stent placement. The stents used in this study were also of this type. However, the diameter of the Y-shaped stent introducer sheath is 27 F (9 mm), which is much larger than that of the 14 F tracheal stent introducer sheath (1, 6). Therefore, the incidence of procedure-related asphyxia may be higher with Y-shaped stent insertion.

Although Yang et al. (8) successfully placed the self-expandable, metallic, inverted Y-shaped stent under fluoroscopy and general anesthesia in three patients, there are some disadvantages: Distal tip of the tracheal tube is above the stenotic site, and thus, insufficient amounts of oxygen is sent to alveolus. Moreover, the 27 F stent introducer sheath cannot pass the tracheal tube (8), and thus, the tracheal tube should be removed before the stent insertion, which can also result in procedure-related asphyxia.

An effective ventilation model for patients with airway stenosis is sub-stenotic ventilation (5). In this study, our patients had airway stenosis involving the carina, and thus, the distal tip of

Table 1. Patient characteristics

No.	Age/gender	Disease	Stent size (mm×mm)			Hugh-Jones grade		Arterial oxygen saturation (%)		
			Trachea	LB	RB	Before	After	Before	Procedure	After
1	56/M	LC	18×40	12×20	12×30	V	II	83	95	96
2	65/F	LC	22×40	13×10	13×25	IV	I	79	96	95
3	66/M	EC	18×50	11×20	11×30	IV	I	86	97	94
4	75/M	LC	18×40	12×20	12×30	V	II	79	97	95
5	64/F	LC	24×30	14×15	14×25	IV	II	81	96	94
6	67/M	LC	20×50	14×30	14×20	V	I	80	94	94
7	59/M	LC	22×50	12×30	12×20	IV	I	84	97	95

LB, left bronchus; RB, right bronchus; M, male; LC, lung cancer; F, female; EC, esophageal cancer.

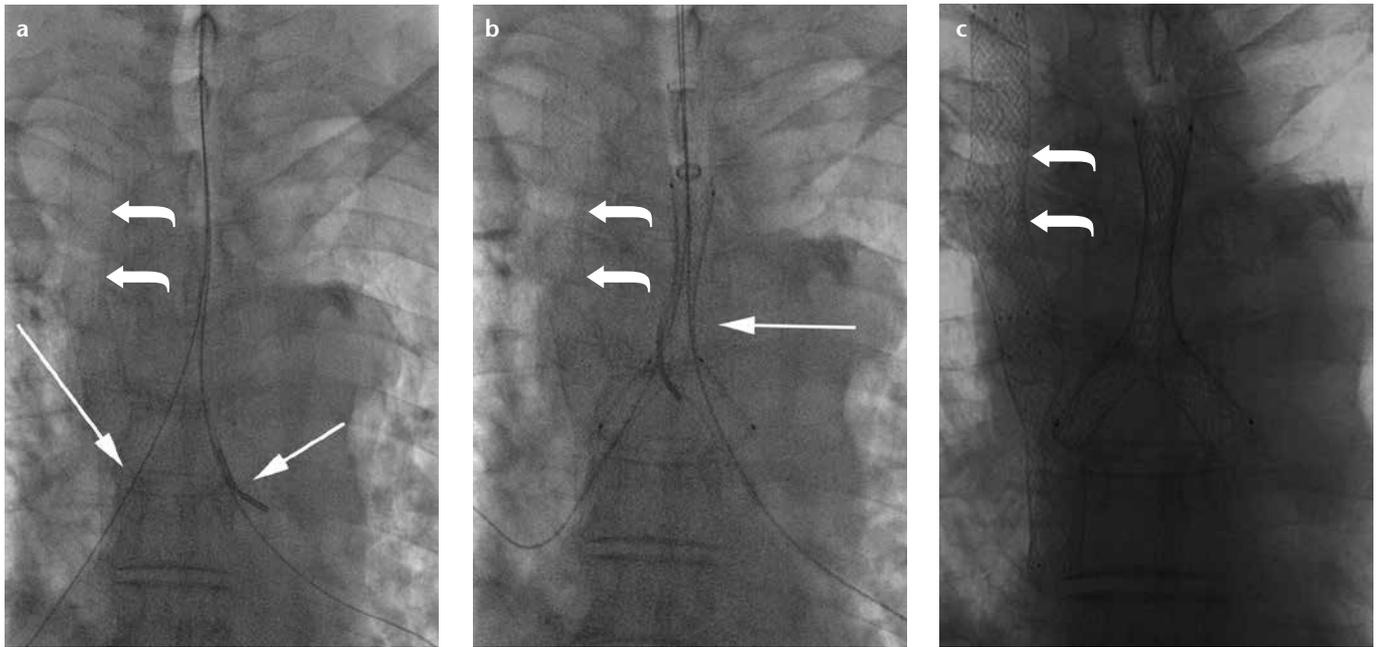


Figure 3. a–c. Subcarinal ventilation-assisted Y-shaped stent insertion. Distal tip of the 4 F catheter was placed in the left main bronchus (a, short arrow), and two stiff guidewires were placed into two main bronchi (long arrow). The stent was deployed (b, arrow) and the catheter was removed. After removal of the catheter, the stent did not migrate (c). Note the metallic stent in superior vena cava (a–c, curved arrows).

Table 2. Stent-related complications and prognosis

No.	Stent-related complication	Treatment for complication	Cause of death	Survival days
1	None	None	Tumor progression	285
2	None	None	Tumor progression	201
3	None	None	Pulmonary infection	102
4	None	None	Tumor progression	255
5	Re-stenosis	Gamma knife	Tumor progression	166
6	None	None	Tumor progression	195
7	None	None	Pulmonary infection	96

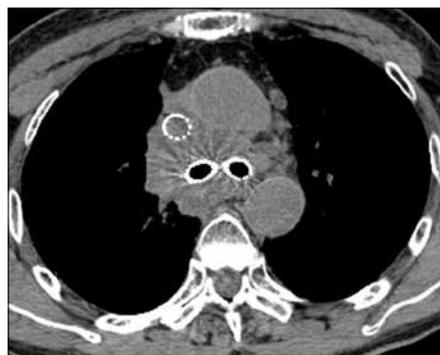


Figure 4. Multislice spiral computed tomography confirmed full expansion of the Y-shaped stent after removal of the ventilation catheter. Also note the metallic stent in superior vena cava.

the ventilation catheter was placed into the main bronchus. In this ventilation model, oxygen supplementation was not influenced by the stenot-

ic site. Moreover, oxygen supply was not influenced by the stent introducer sheath entering the trachea and the stenotic area, because oxygen supplementation and airway stenting were performed through their respective paths. These advantages can effectively increase patient's tolerance to stent insertion procedure and prevent procedure-related asphyxia.

We deployed the Y-shaped stents over the ventilation catheter to ensure that the oxygen supply could be maintained during the entire procedure. No stent migrated after removal of the catheter, and MSCT performed three days later confirmed the patency of all stents. This phenomenon was attributed to several factors: Firstly, the catheter wall was extremely smooth.

Secondly, the Y-shaped stent had an extremely strong stability because its three-tier structure conformed to the anatomy of the carina. Thirdly, the diameter of the catheter is only 4 F (1.33 mm), and therefore, there was only an extremely small space between the stent and the airway wall, which was rapidly sealed after catheter removal, by the expansion of the stent and the flexibility of the airway wall.

The subcarinal ventilation may increase the risk of barotrauma, because the dead space will be reduced and the alveolar volume will be enlarged (5). This risk can be limited by lowering the oxygen flow, as it can reduce ventilation capacity and the resistance of expiration (5). To minimize the risk of barotrauma, we set the oxygen flow at a relatively low rate (2–3 L/min). In addition, the patients were managed with local anesthesia, thus, the ventilation was only needed during the procedure. In terms of intraoperative SaO₂ values, we found that an oxygen flow rate of 2–3 L/min was sufficient for a procedure time of 14–23 min, with the duration of ventilation being 11–21 min.

There are some limitations to this study. First, this was not a comparative study and the sample size was small. Second, local pharyngeal anesthesia is occasionally insufficient, and some pa-

tients may experience retching, coughing, or pain during the stent insertion procedure.

In conclusion, although further clinical trials are needed, our preliminary results indicate that subcarinal ventilation-assisted Y-shaped stent insertion under local anesthesia can be a simple, effective, and safe method for patients with lower tracheal-carinal-main bronchial complex stenosis.

Conflict of interest disclosure

The authors declared no conflicts of interest.

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