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RESEARCH ARTICLE

Best Rescue Strategy for Tracheal Intubation During Tracheal Stenting for Interventional Radiologists

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Abstract

Objective To analyze the usefulness of temporary sheath-assisted tracheal intubation during tracheal stenting (TS) under fluoroscopy.

Methods A total of 261 patients with airway stenosis due to malignant tumors underwent TS from May 2017 to January 2021, and 21 patients required tracheal intubation (TI) after air stenting because of viscous sputum blockage, endotracheal bleeding, and other conditions. The technique of temporary sheath-assisted TI was used. The vital signs (such as SpO2, blood pressure, heart rate, and respiratory), technical success, clinical success, and complications were analyzed.

Results Temporary sheath-assisted TI was successful in all patients, and the mean procedure time was 0.7 min, with a technical success rate of 100%. Hypoxia resolved in all patients, and sputum blockage or endotracheal bleeding could be treated easily through the TI channel under fluoroscopy. All the vital signs significantly increased after TI ($P < 0.05$). One patient died without successful TI removal, making for a clinical success rate of 95.2%. No serious complications occurred.

Conclusion Sheath-assisted TI is an easy and useful procedure during TS under fluoroscopy in emergency situations.

Keywords Tracheal intubation · Fluoroscopy · Interventional Radiology · Tracheal stenting

1 Introduction

Tracheal stenosis can be caused by local tumor invasion or compression, such as from thyroid carcinoma, lung cancer, metastatic tumor and esophageal carcinoma, resulting in rapidly progressive dyspnea [1, 2]. Tracheal stenting (TS) has been considered an effective solution to alleviate malignant tracheal stenosis for more than 40 years, especially for patients with severe dyspnea [3]. However, in some very weak patients with Karnofsky scores < 50, dyspnea may be aggravated even after the TS procedure. The reasons may be viscous sputum blockage, severe bleeding, respiratory muscle fatigue, or pneumothorax occurrence. Rapid tracheal intubation (TI) is needed for phlegm sucking, bleeding treatment or ventilation, especially for TS under local anesthesia in emergency situations. However, TI may be difficult or may fail in 0.2%–7% of patients, especially in the absence of thoracic surgeons, anesthesiologists, or endoscopic physicians [4]. Temporary sheath-assisted TI was devised as an effective method to solve this problem. This study describes the method of sheath-assisted TI during malignant trachea stenting under fluoroscopy.

2 Materials and Methods

2.1 Clinical Data

A total of 261 patients with malignant airway stenosis due to lung cancer or metastatic tumors underwent TS in our department from May 2017 to January 2021. Among them, 21 patients who needed emergency TI after the TS procedure were included in this retrospective study (Fig. 1). There are 15 men and 6 women, with a mean age of 61.4 ± 8.8 years (range 48–82 years). Malignant stenosis was confirmed by computed tomography (n = 11) or by bronchoscopy combined with computed tomography (n = 10). In total, 16 (76.2%) patients had undergone primary disease treatments, such as surgery (n = 7), chemotherapy combined with external radiotherapy (n = 5),

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Fig. 1 The workflow of this study is shown

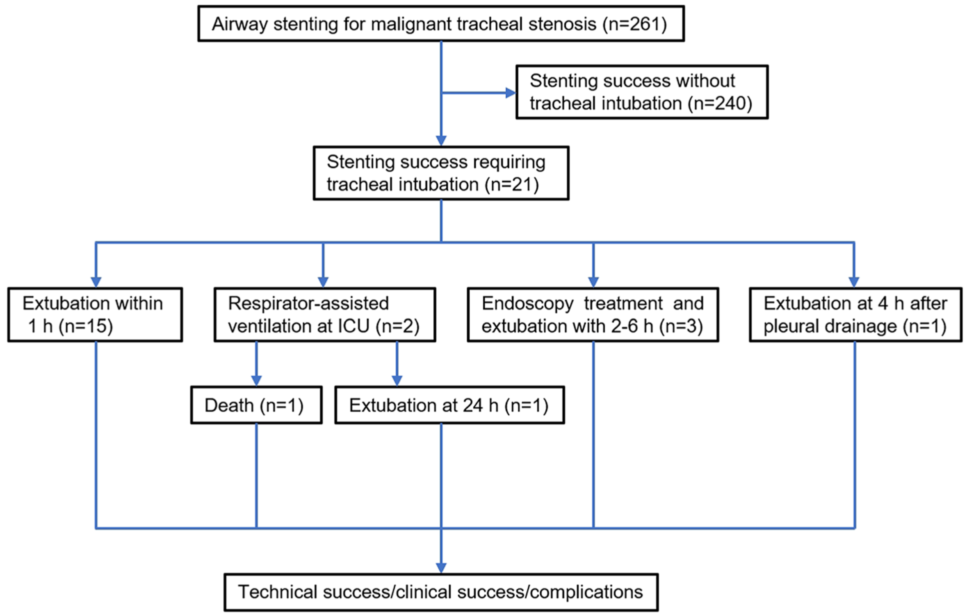

Table 1 Baseline characteristics of patients

Characteristics	Value (range)
Total patients (n)	21
Age (year)	61.4 ± 8.8 (48–82)
Male/Female (n)	15/6
Histology (n)	
Lung cancer	7
Thyroid carcinoma	6
Esophageal carcinoma	4
Metastasis	4
Mean karnofsky score	48.1 ± 9.8 (30–70)
Primary treatment (n)	
Surgery	7
Radiotherapy	5
Chemotherapy and radiotherapy	4
Stenosis length (mm)	27.9 ± 9.6(15–42)
Stenosis location (n)	21
Upper trachea	6
Middle trachea	12
Lower trachea	3

TI tracheal intubation, SPO_2 pulse oxygen saturation

and external radiotherapy (n = 4). All patients presented with severe dyspnea, and the mean pretreatment Karnofsky score was 48.1. After TS, the pulse oxygen saturation (SpO2) ranged from 21 to 75% (it showed the lowest value of SpO2, which reflects the actual demand state of all cases), even with high-flow oxygen administration. The detailed data are summarized in Table 1.

2.2 Fluoroscopy Guided TI

All TI procedures were performed under local anesthesia by two interventional doctors (Jiao DC and Li ZM). SpO2, blood pressure, heart rate, and other vital signs were monitored during TS. The TI system included an 80-cm-long 14 Fr sheath (Cook, USA) and a common tracheal cannula (Fig. 2). The 6.5–7.0-mm-ID tracheal cannula was mounted over the 14 Fr long sheath. All patients were placed in a supine position with the neck extended. First, 5 ml of 2% lidocaine was used to provide topical anesthesia and mouth-gag placement before TS. Then, a 0.035-inch soft guidewire (Terumo, Japan) with a 5 Fr Cobra catheter (Terumo, Japan) was advanced orally into the laryngeal and trachea under fluoroscopy. Second, the initial soft guidewire was exchanged with a 0.035-inch super-stiff guidewire (Cook, USA) to set up a "support path" across the stenosis. Along the super-stiff guidewire, the tracheal stent and its conveying system were sent to the airway, and the stent was released across the stenosis. Then, the conveying system was pushed out, and the super-stiff guidewire was retained. Third, the sheath-assisted TI system was advanced over the above super-stiff guidewire to the lower part of the tracheal stenosis. Fourth, the tracheal cannula (internal diameter, 6.5–7.0 mm) was advanced over the 14 Fr long sheath, which served as a support path. After passing across the stenosis, the sheath and super-stiff guide wire were pulled out, with the tracheal cannula retained in the trachea (Fig. 3). Through the TI channel, injection of epinephrine or other hemostatic agents, dilution and aspiration of viscous sputum and airbag- or respirator-assisted ventilation, if needed,

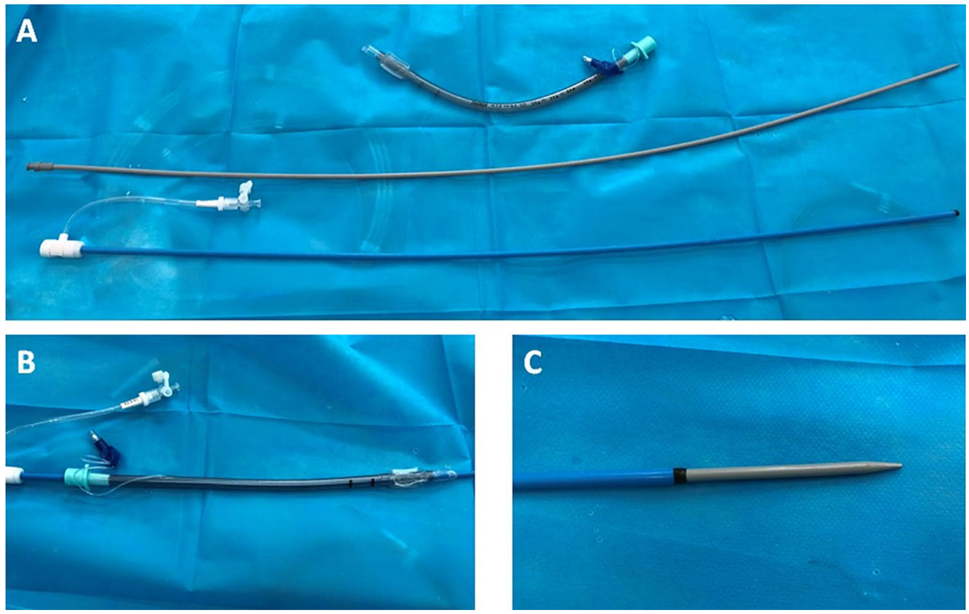

Fig. 2 A long, 14 Fr sheath was used in this study (**a**). The sheath-assisted tracheal intubation system (**b**). The tracheal cannula was mounted over the 14 Fr introducer sheath (*white arrow*)

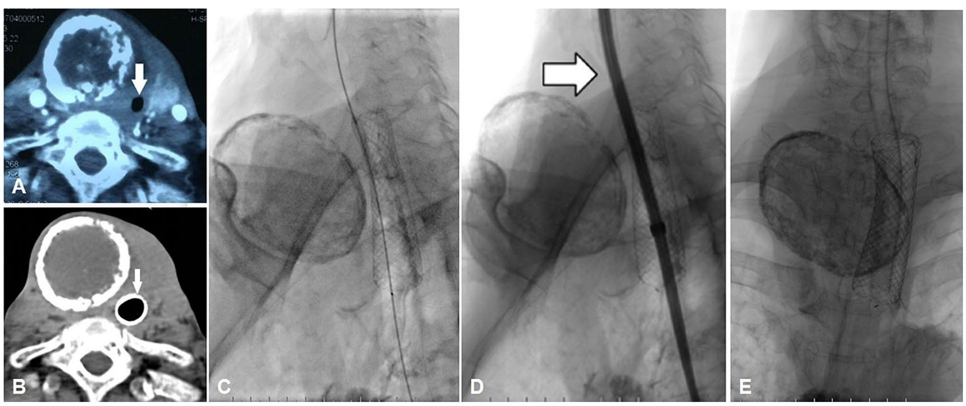

Fig. 3 An 82-year-old woman with thyroid carcinoma combined with severe calcification. Preoperative CT shows obvious narrowing of the trachea (*white arrow*) (**a**). The SpO2 is 45%, with massive viscous sputum expectoration after tracheal stenting (**b**). The tracheal intubation system was advanced over the super-stiff guide wire and passed through the stent (**c**). The tracheal cannula (*white arrow*) was retained in the trachea after the super-stiff guidewire was withdrawn (**d**). The clinical symptoms obviously improved after sputum dilution and suction after tracheal intubation, and extubation was done 30 min later. Postoperative CT showed an expandable tracheal stent 24 h later (*white arrow*) (**e**)

could be easily performed. After the patient had recovered for 20 min to 24 h, the tracheal cannula was withdrawn if the general condition was better.

2.3 Efficacy Evaluation

Technical success was defined as successful placement of TI after TS. Clinical success was defined as an obvious SpO2 increase, proper intubation position under fluoroscopy, general condition improvement, and successful TI removal. The vital signs (such as SpO2, blood pressure, heart rate, and respiratory) were compared before and after TI. Considering the dynamic changes of these indicators, we collected the lowest observed value for SpO2, and the highest value for blood pressure, heart rate, and respiratory rate before TI, and the corresponding index value were also recorded when they showed relative stability after TI.

2.4 Statistical Analysis

All statistical analyses were performed using SPSS for Windows version 11.0 (SPSS Inc., Chicago, IL). Continuous variables are presented as the mean ± standard deviation or the median. SpO2, blood pressure, heart rate, and respiratory were analyzed using the paired-samples *t*-test, and significance was accepted at a *P* value less than 0.05.

3 Results

Temporary sheath-assisted TI was successful in all patients, and the mean procedure time was 0.7 min (range 0.4–1.2 min). The SpO2 levels rose from 21–75% to 95–100% after TI ($P = 0.00$) and all proper intubation positions had been confirmed by real-time fluoroscopy. The other detailed vital signs such as blood pressure, heart rate, and respiratory rate were listed in Table 2. The clinical symptoms obviously improved in 15 (74.1%) patients after sputum dilution and suction after TI, and extubation was implemented within 1 h. Three (14.3%) patients were transferred to the endoscopy room and underwent endoscopic therapy, and extubation was implemented within 2–6 h. Two (9.5%) patients with severe hypoxia underwent respirator-assisted ventilation and were transferred to the intensive care unit for further observation. Extubation was done at 24 h after TS in one patient when his general condition had obviously improved. Another patient had heart failure and eventually died at day 6 without successful TI removal. One (4.8%) patient underwent closed pleural drainage because of pneumothorax, and extubation was done 4 h after TI (Fig. 1).

Hemoptysis (≤ 10 ml) occurred in 4 patients immediately after TI, and symptoms were stopped by the local application of adrenaline (1–3 mg) through the TI channel. No other severe complications, such as massive hemoptysis, severe hypotension, or cardiac arrest, occurred during TI.

4 Discussion

Rapidly progressive dyspnea resulting from malignant tracheal stenosis can be caused by advanced local or metastatic tumor invasion or compression [5]. Severe complications, including serious hypoxia, heart failure and even death, can occur due to a serious lack of oxygen and the accumulation of carbon dioxide. Although there are many alternative treatments, such as bronchoscope ablation, radiotherapy, and photodynamic therapy, to restore airway patency and improve patient quality of life, TS may be the preferred treatment for patients with severe dyspnea, especially for weak patients [6]. TS can relieve dyspnea quickly without requiring general anesthesia, but for some very weak patients with a Karnofsky score < 50, their dyspnea continues to worsen due to blockage by viscous sputum, pneumothorax, respiratory muscle fatigue, asphyxia, or severe bleeding, necessitating airbag- or ventilator assisted breathing even after TS. There are physical differences between weak patients with breathing difficulty and other patients who undergo TI in the common operating room. Different TI techniques should be considered, especially in the absence of an anesthesiologist, endoscopic physician, or thoracic surgeon. We developed a new technique for sheath-assisted TI for all difficulty emergency intubations, making full use of the super-stiff wire after stent release.

This study analyzed our team's original technique of temporary sheath-assisted TI during TS for malignant airway obstruction under fluoroscopy. We had 100% technical success and 95.2% clinical success, without TI-related severe complications and with an extremely fast time (0.7 min), which suggests that fluoroscopy-guided emergency TI through a super stiff guide wire is a simple and effective life-saving procedure and a stopgap until further treatments can be performed. The super-stiff support guidewire (support path) should not be withdrawn immediately after TS, especially in extremely weak patients, as this can be fully used to enable rapid emergency TI if the SpO2 and general condition of the patient do not improve after TS. All procedures here (including TS and TI) were performed under local anesthesia, and no drugs that depress spontaneous respiration were administered. This gave us enough time to find

Table 2 Study outcomes of the vital signs before and after TI

Vital signs	Mean ± SD (range)	*P* value
SPO_2 (%)		0.00
Before TI	48.7 ± 9.6 (range 21–75)	
After TI	96.3 ± 1.9 (range 95–100)	
Blood pressure		0.00
Before TI (Systolic/diastolic)	(179.9 ± 18.3)/(111.9 ± 7.7)	
After TI (Systolic/diastolic)	(130.1 ± 11.3)/(85.7 ± 12.7)	
Heart rate		0.00
Before TI	(119.6 ± 14.9) (range 97.0–155.0)	
After TI	(77.3 ± 12.8) (range 58.0–100.0)	
Respiratory rate		0.01
Before TI	(35.8 ± 6.2) (range 29.0–54.0)	
After TI	(23.0 ± 4.5) (range 17.0–33.0)	

SD standard deviation, *TI* tracheal intubation, SPO_2 pulse oxygen saturation the necessary equipment and recruit the personnel to secure the TS in case of failure. Jiao D et al. reported sheath tube-assisted TI to solve the difficult problem of intubation by the anesthesiologist in the operating room [7]. Of course, we can also apply the same method as an emergency strategy during the TS procedure.

The high technical success may be attributed to several factors. First, we made full use of the super-stiff support guidewire after tracheal stenting, which served as a safe mouth-throat-trachea support path. Second, TI was monitored under fluoroscopy to avoid blind intubation, especially in emergency care situations. Third, the long sheath facilitated its passage through the stent along the super-stiff guidewire, especially through the site of the malignant tracheal stenosis. Finally, the diameter of the sheath (14 Fr = 4.7 mm) was smaller than that of the tracheal cannula (6.5–7.0 mm), which indicates gradual expansion and placement.

5 Conclusion

The limitations of the study are its small sample size and lack of a control group. Future studies should examine a larger population using randomization with a control group to confirm the worth of these techniques. Above all, this study indicates that sheath-assisted TI is a simple, effective, and life-saving strategy during TS under fluoroscopy that can be used in cases of difficult TI.

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Authors' Contributions YL drafted the manuscript. YL and LW participated in the design of the study and performed the statistical analysis. KX collected the clinical data. DJ and XH conceived of the study, participated in its design and coordination, and helped to draft the manuscript. All authors read and approved the final manuscript.

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Data Availability Statement For supporting data, please contact the corresponding author of this contribution with explaining the reason for use. E-mail: jiaodechao007@126.com.

Declarations

Conflict of Interest The authors have no competing interests to declare that are relevant to the content of this article.

Ethics Approval Ethical approval was waived by the local Ethics Committee of the First Affiliated Hospital of Zhengzhou University in view of the retrospective nature of the study and all the procedures being performed were part of the routine care.

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