Nonstent Combination Interventional Therapy for Treatment of Benign Cicatricial Airway Stenosis

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Abstract

Background: Benign cicatricial airway stenosis (BCAS) is a life-threatening disease. While there are numerous therapies, all have their defects, and stenosis can easily become recurrent. This study aimed to investigate the efficacy and complications of nonstent combination interventional therapy (NSCIT) when used for the treatment of BCAS of different causes and types.

Methods: This study enrolled a cohort of patients with BCAS resulting from tuberculosis, intubation, tracheotomy, and other origins. The patients were assigned to three groups determined by their type of stenosis: Web-like stenosis, granulation stenosis, and complex stenosis, and all patients received NSCIT. The efficacy and complications of treatment in each group of patients were observed. The Chi-square test, one-factor analysis of variance (ANOVA), and the paired t-test were used to analyze different parameters.

Results: The 10 patients with web-like stenosis and six patients with granulation stenosis exhibited durable remission rates of 100%. Among 41 patients with complex stenosis, 36 cases (88%) experienced remission and 29 cases (71%) experienced durable remission. When five patients with airway collapse were eliminated from the analysis, the overall remission rate was 97%. The average treatment durations for patients with web-like stenosis, granulation stenosis, and complex stenosis were 101, 21, and 110 days, respectively, and the average number of treatments was five, two, and five, respectively.

Conclusions: NSCIT demonstrated good therapeutic efficacy and was associated with few complications. However, this approach was ineffective for treating patients with airway collapse or malacia.

Key words: Benign Airway Stenosis; Bronchoscopy; Complications; Efficacy; Interventional Therapy

Introduction

Benign cicatricial airway stenosis (BCAS) is a life-threatening disease which can result from tracheal intubation, tracheotomy, tracheobronchial tuberculosis, tracheobronchial anastomosis, chest trauma, stent implantation or inhalation injury. The most common causes are tracheal intubation and tracheotomy, as BCAS occurs following 19% and 65% of these procedures, respectively.[1,2] Unlike the United States and Europe, the main cause of benign airway stenosis (BAS) in China is tuberculosis, which accounts for 64.25% of BAS cases, followed by tracheal intubation and tracheotomy (15.03% of BAS cases).[3] While surgical reconstruction is the gold standard treatment for symptomatic BAS, the condition can be deemed inoperable due to the presence of long strictures, inflammation, or when BAS occurs after lung transplantation or in patients with poor respiratory or cardiovascular status.[4] BCAS can be divided into three types.[5] Web-like stenosis refers to an abrupt transition of an annular lesion which occurs as a result of simple cicatricial hyperplasia. Granulation stenosis refers to a luminal stenosis caused by intraluminal hyperplasia of granulation tissue. Complex stenosis refers to any type of stenosis except for the above-mentioned two types, and generally occurs concurrent with cicatrization and granulation tissue hyperplasia, and sometimes concurrent with airway malacia or collapse. Complex stenosis cannot be effectively resolved by using a high frequency electric knife or balloon dilatation, and eventually progresses to refractory airway stenosis, which is often treated by silicone stent implantation.[6,7] However, stent implantation can result in complications such as stent migration, hyperplasia of granulation tissue, formation of ulcerative tissue around the stent, and ischecis in the stent.[4] which can sometimes require emergency interventional bronchoscopic therapy. Repeated recurrence of refractory airway stenosis after treatment is the major cause of failed treatment, and occurs in 40–70% of cases.[8] We found that treatment itself could cause airway injuries, and especially during heat coagulation (including electric coagulation, argon plasma coagulation, and laser) and stent implantation.[9] In recent
years, the above-mentioned approaches have been avoided and replaced by nonstent combination interventional therapy (NSCIT), in which mechanical balloon expansion and cryotherapy are combined, and produce only minor damage to the airway. When necessary, an electric needle knife with a tiny cross-section of electric coagulation is used to remove the scar,[10] and in some patients with repeated cicatricial hyperplasia, mitomycin or paclitaxel is used to inhibit formation and recurrence of cicatrix.[8,11-15] This study was conducted to examine the therapeutic efficacy of NSCIT.

**Methods**

**Patients**

A cohort of patients with BCAS who were treated in the Department of Respiratory Diseases, Beijing Tiantan Hospital, Capital Medical University between January 2009 and April 2013 were enrolled in this study. All patients provided a signed informed consent giving permission for their participation in this study and use of their medical data. The protocol for this study was approved by the Institutional Ethics Committee of Beijing Tian Tan Hospital, Capital Medical University. The patients included in the study satisfied the following two criteria for eligibility: (1) Aged 18–70 years and diagnosed as BCAS; (2) no severe heart or lung dysfunctions. The study exclusion criteria were as follows: (1) The presence of a benign tumor; (2) noncicatricial hyperplasia, such as relapsing polychondritis or amyloidosis; (3) patients with severe airway stenosis or an occlusion unsuitable for interventional therapy. A total of 64 patients with BCAS resulting from tuberculosis, tracheal intubation/tracheotomy, and other origins (trauma, end-to-end anastomosis, and stent removal, etc.) were enrolled in the study. There were two patients with airway stenosis after removal of a metal stent. The first patient received a stent for tracheotomy, and the other for tuberculosis. One to four therapies, which were selected based on the type of lesion, were used in combination as NSCIT. A total of seven patients withdrew from the study (three patients were lost to follow-up after one session of treatment; three patients died of accidents due to delayed visits, and one patient refused to continue with treatment); therefore, the results from 57 patients were analyzed [Table 1]. Three patients died from accidents resulting from poor compliance due to their economic and living situations (e.g., living a long distance from a hospital or experiencing transportation problems, etc.) as well as giving inadequate attention to their medical condition. These patients did not comply with their follow-up schedule and died of acute asphyxia. However, their deaths were not attributable to poor treatment efficacy. Instead, their first treatment produced good results, but the airway stenosis became recurrent, and they died after not seeking a second treatment in a timely manner. As seen in Table 1, there were no statistically significant differences in age, gender, affected site or etiological factors among patients with different types of BCAS.

**Table 1: General characteristics of the enrolled patients with benign cicatricial airway stenosis**

| Characteristics                  | Web-like stenosis | Granulation stenosis | Complex stenosis | P     |
|---------------------------------|-------------------|----------------------|------------------|-------|
| Age (years, mean ± SD)          | 34.7 ± 12.0       | 39.0 ± 22.2          | 37.5 ± 16.1      | 0.848 |
| Gender, n (%)                   |                   |                      |                  | 0.151 |
| Male                            | 7 (70)            | 4 (67)               | 16 (39)          |       |
| Female                          | 3 (30)            | 2 (33)               | 25 (61)          |       |
| Sites, n (%)                    |                   |                      |                  | 0.378 |
| Trachea                         | 7 (70)            | 5 (83)               | 18 (44)          |       |
| Left principal bronchus         | 2 (20)            | 1 (17)               | 17 (42)          |       |
| Right principal bronchus        | 0                 | 0                    | 4 (10)           |       |
| Bronchus intermedius            | 1 (10)            | 0                    | 2 (5)            |       |
| Etiological factors, n (%)      |                   |                      |                  | 0.167 |
| Posttuberculosis                | 3 (30)            | 0                    | 21 (51)          |       |
| Posttracheal intubation and posttracheotomy | 5 (50) | 4 (67) | 13 (32) |       |
| Other origins                   | 2 (20)            | 2 (33)               | 7 (17)           |       |
| Total, n (%)                    | 10 (100)          | 6 (100)              | 41 (100)         |       |

SD: Standard deviation.

**Procedures**

Anesthesia selection was based on the patient’s age and severity of the disease. Local anesthesia + sedation and analgesia consisted of 2% lidocaine + midazolam and fentanyl. General anesthesia was administered by an anesthesiologist using a regimen of propofol, midazolam, remifentanil, and muscle relaxants in an operating room.

Sources of materials used in interventional procedures:

- Devices: (1) Balloon dilator: Boston Scientific Company, Boston, MA, USA; (2) Needle knife: MTW Company, Germany; (3) High frequency electronic equipment: ERBE Company Tübingen, Germany; (4) Cryotherapy equipment: ERBE Company, Germany; (5) Local instillation catheter: Self-made, 125-cm length and 2-mm diameter.
- Drugs: (1) Mitomycin (10 mg/bottle, Zhejiang Hisun Pharmaceutical Co., Ltd., China); 0.4 mg/ml × 1 ml/cm; (2) Paclitaxel (30 mg/bottle, Beijing Union Pharmaceutical Factory, China), 0.8 mg/ml × 1 ml/cm.

**Therapeutic regimens:**

- Regimen 1: A balloon dilator was initially used to expand the stenosis. If the scar was too tough to expand, a high frequency electric needle knife was used to cut the scar open and apply cryotherapy to the basal portion of the scar. For granulation tissue, a high frequency electric needle knife was used to remove the lesion and then apply cryotherapy to its basal portion. If the scar was too tough to expand, a needle knife was used to make a radial incision into the scar tissue, while avoiding its membranous parts. Sites for cryotherapy were determined by the location of residual scar and granulation tissue. Treatment was given at sites located 5 mm apart, and each site received three cycles of a one-minute freeze-thaw regimen.
Regimen 2: In cases of repeatedly recurring stenosis (stenosis which reoccurs after three previous treatment sessions), topical mitomycin or paclitaxel was administered using a self-made local instillation catheter, after each session of interventional therapy [Figure 1a].

Response assessment
While there is currently no consensus regarding the criteria that should be used for assessing a patient’s response to treatment of BAS,[16,17] we used the following criteria based on their practicality for use in evaluating clinical effects: (1) Durable remission: Duration of airway patency was >6 months, without the need for further treatment; (2) Remission: Duration of airway patency was 3–6 months, and may have required additional therapy; (3) No remission: Duration of airway patency was <3 months, and required additional treatment; (4) Failure: Unable to maintain airway patency, concurrent with airway malacia or collapse.

Complications and their severity
In this study, only complications directly related to the therapy and medications used to treat airway stenosis were included statistical analyses. The effects of topical drug administration on white blood cells (WBCs), as well as liver and kidney function were also monitored.

Statistical analysis
All statistical analyses were performed using SPSS for Windows, Version 16.0. SPSS Inc., Chicago, IL, USA. Results of analyses of normally distributed data are presented as the mean ± standard deviation (SD), while results of numerical data analyses are presented as frequency. The Chi-square test was used to analyze the following parameters: The etiological factors for different types of BAS; the efficacy of different types of interventional therapy; the efficacy of interventional therapy in treating airway stenosis of different origins; the relationship between the type of drug used and efficacy. One-factor analysis of variance (ANOVA) was used to analyze the duration and number of treatments required for airway stenosis of different types and origins. The paired t-test was used to analyze WBC levels, as well as liver and renal functions before and after treatment; $P < 0.05$ were considered statistically significant.

Results
Therapeutic effects of interventional bronchoscopic therapy for different types and origins of BCAS
The therapeutic effects of interventional bronchoscopic treatment on different types of BCAS are summarized in Table 2. Among 10 patients with web-like stenosis and six patients with granulation stenosis, all 16 patients (100%) experienced a durable remission. Among 41 patients with complex stenosis, 29 (71%) experienced durable remission, and 36 (88%) experienced a remission. However, none of the five patients with airway malacia in that group experienced a durable remission. Among 24 patients with airway stenosis after tuberculosis, 16 (67%) experienced durable remission, and 22 (92%) experienced remission. A durable remission rate of 76% (16/21) and remission rate of 100% (21/21) were achieved after eliminating three patients with airway malacia. Among 22 patients with airway stenosis after intubation and tracheotomy, 18 (82%) experienced durable remission, and 19 (86%) experienced remission. However, after eliminating two patients with airway malacia, the durable remission rate

![Figure 1: Local catheter instillation (a); prior to the first treatment session (July 13, 2010) (b); after the first treatment session (July 13, 2010) (c); prior to the third treatment session (September 1, 2010) (d); after the third treatment session (September 1, 2010) (e); after 1 year (November 15, 2011) (f).](image-url)
of 90% (18/20) and the remission rate of 95% (19/20). All 11 patients (100%) with airway stenosis of other origins experienced a durable remission.

Seven patients with complex stenosis satisfied the criteria for remission, and these included six patients who did not complete the 6 months of observation period. The remaining patient was a 54-year-old female with airway stenosis after tuberculosis. In that patient, the duration of airway patency was >3 months, even though the lesion measured 2.2 cm in length. However, her airway stenosis repeatedly re-occurred, and she failed to meet the criteria for a durable remission. Bronchoscopy showed partial airway malacia, and surgery or stent therapy was recommended.

Two patients with complex stenosis showed no remission. In the first case, a 40-year-old female experienced airway stenosis after tracheal intubation and presented with a lesion measuring 2 cm in length. She was placed on a once-every-2-week NSCIT regimen, but failed to maintain airway patency. Surgery was recommended after taking into account evidence of airway malacia shown by bronchoscopy. In the second case, a 31-year-old male patient developed airway stenosis after tracheotomy, and presented with a lesion measuring 2 cm in length. He was placed on a once-every-2-week NSCIT regimen for 2 months, but failed to show satisfactory results. Topical paclitaxel was administered and the treatment interval was extended to 1.5 months; however, airway stenosis still recurred on a frequent basis, and surgery was recommended.

Three patients diagnosed as complex stenosis failed treatment with NSCIT. The first patient was a 53-year-old male who experienced airway stenosis after tracheal intubation, and developed a lesion measuring 3 cm in length. The second patient was a 16-year-old female who experienced tracheal stenosis after tuberculosis and had a lesion 3 cm in length. The third patient was a 54-year-old female who developed left principal bronchial stenosis after tuberculosis. Because all three of these patients failed to maintain airway patency after balloon dilatation, and bronchoscopy showed evidence of airway malacia, they were judged to have failed treatment.

Statistical analyses stratified by two layers of remission and no remission showed no significant differences in the therapeutic effects of NSCIT when used to treat BCAS of different origins [Table 2].

Effects of topical drugs used for treating patients with BCAS

Among the seven patients who received treatment with mitomycin, all seven experienced a durable remission. Among 31 patients treated with paclitaxel, 26 experienced a durable remission, one experienced a remission, two experienced no remission, and two other patients failed treatment. Statistical analyses stratified by two layers of remission and no remission showed no significant differences regarding the therapeutic effects of different drugs used to treat patients with BCAS.

Duration and number of treatments required for durable remission of BCAS of different types and origins.

There were no statistically significant differences in the duration or number of treatments required to achieve a durable remission of BCAS of different types and origins [Table 3].

For patients with web-like stenosis, the average duration of treatment was 101 days, and the average number of treatments required was 4.6.

Table 2: Therapeutic effects of interventional bronchoscopic therapy for different types and origins of BCAS

| Items                        | Durable remission (n) | Remission (n) | No remission (n) | Failure (n) | Total (n) | Cure rate (%) | Remission rate (%) | P     |
|------------------------------|-----------------------|---------------|------------------|-------------|-----------|---------------|---------------------|-------|
| Type                         |                       |               |                  |             |           |               |                     | 0.343 |
| Web-like stenosis            | 10                    | 0             | 0                | 0           | 10        | 100           | 100                 |       |
| Granulation stenosis         | 6                     | 0             | 0                | 0           | 6         | 100           | 100                 |       |
| Complex stenosis             |                       |               |                  |             |           |               |                     |       |
| No airway malacia            | 29                    | 6             | 1                | 0           | 36        | 81            | 97                  |       |
| Airway malacia               | 0                     | 1             | 1                | 3           | 5         | 0             | 20                  |       |
| Origin                       |                       |               |                  |             |           |               |                     | 0.424 |
| Posttuberculosis (airway malacia) | 16               | 6 (1)         | 0                | 2 (2)       | 24        | 67            | 92                  |       |
| Posttracheal intubation and posttracheotomy (airway malacia) | 18               | 1             | 2 (1)            | 1 (1)       | 22        | 82            | 86                  |       |
| Other origins                | 11                    | 0             | 0                | 0           | 11        | 100           | 100                 |       |

BCAS: Benign cicatricial airway stenosis.

Table 3: Duration and number of treatments required to achieve a durable remission of BAS of different types and origins

| Items                        | Duration of treatment (days) | Number of treatments | P   |
|------------------------------|-----------------------------|----------------------|-----|
| Types                        |                             |                      | 0.131 | 0.051 |
| Web-like stenosis            | 101 ± 84                    | 4.6 ± 3.3            |     |
| Granulation stenosis         | 21 ± 21                     | 1.8 ± 0.4            |     |
| Complex stenosis             | 110 ± 107                   | 5.5 ± 3.5            |     |
| Origins                      |                             |                      | 0.628 | 0.871 |
| Posttuberculosis             | 106 ± 118                   | 4.7 ± 2.0            |     |
| Posttracheal intubation and posttracheotomy | 79 ± 92                   | 4.6 ± 4.2            |     |
| Other origins                | 110 ± 78                    | 5.3 ± 3.7            |     |

BAS: Benign airway stenosis.
treatments was five. For granulation stenosis, the average
duration of treatment was 21 days and the average number of
treatments was approximately two. For complex stenosis, the
average duration of treatment was 110 days and the average
number of treatments was approximately five.

The longest period of interventional therapy required to
achieve a durable remission of complex stenosis without
topical drug administration was 123 days, and occurred in
a 48-year-old female who developed airway stenosis after
end-to-end anastomosis of the trachea. She experienced
a durable remission after receiving two sessions of high
frequency electric knife therapy, three sessions of balloon
dilation, and four sessions of cryotherapy. The first session
of therapy was performed on July 13, 2010, and consisted
of needle electric knife + balloon dilatation + cryotherapy
[Figure 1b and c]. One month later, a radiological examination
showed evidence of a web-like neoplasm, and the 2nd session of
treatment (August 10, 2010) was performed using forceps + cryotherapy. Twenty days later, recurrence was again observed, and a third session of treatment was
performed (September 1, 2010) using needle electric knife + balloon dilatation + cryotherapy [Figure 1d and e].
However, 2.5 months later, another recurrence was observed,
and a fourth session of treatment was performed (November
16, 2010) using balloon dilatation + cryotherapy. After
the fourth treatment session, regular monitoring showed the
patient to have a stable scar that did not require further
treatment, and her condition was considered to be a durable
remission. The patient returned for a follow-up visit
1-year later, at which time the airway had maintained its
patency (November 15, 2011) [Figure 1f].

Among complex airway stenosis patients who satisfied the
criteria for durable remission with local drug administration,
a 26-year-old woman received the longest duration of
treatment. The woman developed left principal bronchial
stenosis after tuberculosis, and received 413 days of
treatment before being cured. Her treatments included 8
sessions of balloon dilation, 8 sessions of cryotherapy, and
6 sessions of local drug administration.

Complications

All patients in our study experienced some type of
complication. For example, small amounts of necrotic
tissue remained on the wound surface, regardless of drug
administration. However, no patient experienced an acute
airway obstruction requiring emergency surgery, and
no airway bronchomalacia or perforation related to the
interventional therapy was observed after the treatments
were completed. In addition, WBC counts and levels of
alanine transaminase, aspartate transaminase, and creatinine
before and after local drug administration were compared,
and showed no statistically significant differences [Table 4].

Discussion

Benign cicatricial airway stenosis is mainly treated
by surgery and interventional therapy, and surgical

Table 4: WBCs, ALT, AST, and creatinine in patients with
local drug administration before and after treatment

| Items       | Before treatment | After treatment | P     |
|-------------|------------------|-----------------|-------|
| WBC (10^3/L) | 5.87 ± 1.60      | 6.19 ± 1.75     | 0.440 |
| ALT (U/L)    | 12.26 ± 6.35     | 12.44 ± 5.26    | 0.909 |
| AST (U/L)    | 15.12 ± 3.51     | 14.18 ± 4.57    | 0.455 |
| Creatinine (μmol/L) | 53.72 ± 13.08 | 53.59 ± 11.55  | 0.943 |

WBCs: White blood cells; AST: Aspartate aminotransferase;
ALT: Alanine aminotransferase.
has decreased and the remission rate has been 82.34%. In some patients with repeated tracheal scar tissue hyperplasia, the inner diameter of the airway cannot be maintained by repeated interventional therapy. Because the therapeutic effect of airway stents is limited, the use of medications should be considered to inhibit airway scar tissue hyperplasia in such patients.

Scar hyperplasia is a common problem encountered in many areas of medicine, and the local application of drugs represents an important method of controlling such hyperplasia. Drugs used for inhibiting airway scar hyperplasia include mitomycin, paclitaxel, immunosuppressants, and antibiotics; however, topical application of mitomycin for airway cicatricial stenosis has received the greatest attention. Paclitaxel has been used to prevent restenosis associated with coronary stenting. A paclitaxel coated coronary stent can provide localized release of paclitaxel within the coronary artery vessel wall, thereby inhibiting hyperplasia of vascular intima scar tissue. In addition, some scholars speculate that paclitaxel-eluting stents can be implanted in the airway to inhibit proliferation of granulation tissue. In 2006, Choong et al. showed that a paclitaxel-eluting stent significantly inhibited the growth of granulation tissue, and thereby extended airway bypass stent patency time. Wang et al. and Chen et al. showed that paclitaxel had an inhibitory effect on human embryonic lung fibroblast cells, and thus provided a theoretical basis for application of paclitaxel. In addition, an animal study conducted by Wang et al. also confirmed the efficacy of paclitaxel for inhibiting the growth of scar tissue.

In our study, some patients with repeatedly recurring airway stenosis after balloon dilatation and cryotherapy received topical treatment with mitomycin or paclitaxel in the tracheal stenosis area to inhibit hyperplasia of scar and granulation tissue. In addition, we showed that a paclitaxel-eluting stent significantly inhibited the growth of granulation tissue, and thereby extended airway bypass stent patency time. Wang et al. and Chen et al. showed that paclitaxel had an inhibitory effect on human embryonic lung fibroblast cells, and thus provided a theoretical basis for application of paclitaxel. In addition, an animal study conducted by Wang et al. also confirmed the efficacy of paclitaxel for inhibiting the growth of scar tissue.

We also observed that after eliminating airway malacia patients, the remission rate for airway stenosis after tuberculosis was 100% (21/21), and the durable remission rate was 76.2% (16/21). The remission rate for airway stenosis occurring after intubation and tracheotomy was 95% (19/20), and the durable remission rate was 90% (18/20). The durable remission rate for airway stenosis of other origins was 100% (11/11). No statistically significant differences were found among these different durable remission rates, suggesting that NSCIT can obtain satisfactory results in treating various types of airway stenosis, despite their different causes. We found that mitomycin and paclitaxel had equivalent efficacies for inhibiting scar tissue hyperplasia. However, most patients who received paclitaxel were treated during a later phase of this study, and in the early phase, only a few patients were treated with mitomycin. Therefore, a further investigation is required to explore whether these two drugs may have different effects.

We found that the method employed for topical administration of drugs was related to their therapeutic effects. While various methods of local administration exist (inhalation, local cotton swabbing, local mucosal injection, etc.), the ideal method would permit accurate positioning, and be able to ensure that the proper dose of drug is administered to the mucosa of the airway stenosis segment. When using an inhalation method, it is very difficult to determine the actual dose and concentration of the drug received by the target tissue. Patients need to inhale a high dose of drug to achieve the ideal local concentration, which can result in systemic side effects. Likewise, it is difficult to calculate the amount of drug delivered to a tissue when using a cotton swab, because a large amount of drug can be absorbed by the swab material. While local mucosal injection can deliver an accurate quantity of the drug, scar tissue has a high density, making the drug delivery procedure very difficult to perform. Therefore, we utilized a self-made catheter to enable the localized administration of drugs. An ordinary lavage catheter tip is obstructed and has a tiny opening in its side which allows only one drop of liquid to exit, ensuring good absorption by the airway mucosa. It can also prevent liquid from flowing into the normal airway, thus, making it possible to achieve precise dosing of the airway mucosa. Based on the literature and our research results, the local concentrations of mitomycin and paclitaxel administered to the treated mucosal tissue were 0.4 mg/ml and 0.8 mg/ml, respectively. The total dose was calculated using the stenosis length, and an assumed absorption of 1 ml/cm.

Our study shows that when using balloon dilatation to treat airway stenosis, it may be necessary to utilize an electric needle knife to cut the scar or remove granulation tissue, and use cryotherapy to manage any residual scar and granulation tissue after expansion, and thereby assist in preventing recurrence of airway stenosis. This treatment regimen can produce a durable remission in most patients, and especially in those with web-like stenosis and granulation stenosis. In some patients with repeated recurrence of airway stenosis, as well as in most cases of complex stenosis, local application of mitomycin or paclitaxel inhibits proliferation of scar tissue, reduces the stenosis recurrence rate, and eventually allows the patient to achieve a durable remission. None of the patients who received NSCIT in our study underwent stent implantation, and most experienced a durable remission. From the study, we can see that NSCIT demonstrated...
good therapeutic effects and was associated with few complications.

It should be noted that some patients with repeatedly recurring airway stenosis may require additional cycles of NSCIT and prolonged durations of treatment, and thus the financial costs associated with NSCIT can be high. However, as shown in this study, such patients can achieve a durable remission with fewer complications. Additional studies with larger numbers of patients are required to further confirm the efficacy and safety of NSCIT. Finally, NSCIT was found to be ineffective in patients with airway collapse or malacia, where surgery or airway stent implantation is still recommended.

Our study showed that all patients with BCAS without accompanying airway collapse or malacia are suitable for NSCIT. Furthermore, NSCIT demonstrated good therapeutic efficacy and was associated with few complications. However, this approach is ineffective when treating patients with airway collapse or malacia, and either surgery or airway stent implantation is still recommended in such cases.

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