Long-term Outcome of Airway Stenosis in Granulomatosis With Polyangiitis (Wegener Granulomatosis) An Observational Study

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IMPORTANCE Airway stenosis occurs in patients with granulomatosis with polyangiitis (GPA or Wegener granulomatosis). It produces significant morbidity and contributes to mortality.

OBJECTIVE To investigate the frequency and distribution of airway stenoses in GPA and evaluate the efficacy of local interventions in maintaining airway patency.

DESIGN, SETTING, AND PARTICIPANTS A retrospective single-center study of 44 patients with GPA and airway stenosis assessed and treated as needed by a multidisciplinary team at a university medical center between 1997 and 2012. The median duration of observation for each patient from the time of diagnosis was 146 months.

INTERVENTIONS Patients who had critical stenoses underwent either dilatation or laser radial cuts to the lesion. In some cases, intralesional administration of steroids or topical mitomycin C was used.

MAIN OUTCOMES AND MEASURES The main outcome measure was airway patency for at least 12 months and the number of interventions required to achieve this end point. Details of patients and interventions were recorded at baseline and at each treatment.

RESULTS The median age at diagnosis was 37.6 years; 73% of patients were women (n = 34). The median follow-up after the initial intervention was 62.5 months. Subglottic stenosis was found in 36 patients, lower airway stenosis in 30. There were 213 interventions in 39 patients, including balloon and bougie dilatation and laser treatment. Adjuvant local treatment was used in 71 interventions. A 12-month period of airway stability was achieved in 34 of 36 cases (97%) (5 had no procedures and 3 had follow-up shorter than 12 months). The median interval between procedures was 4.9 months, and after the last intervention recorded, patients had at least 27 months of airway stability. Fourteen adverse events were recorded (6.6%).

CONCLUSIONS AND RELEVANCE The frequency and distribution of airway stenoses in 44 patients with GPA has been described. In the 39 patients who required intervention, multiple procedures were required, but 97% then achieved a prolonged period of airway patency. The procedures and adjuvant treatments were found to be safe. Our experience with a variety of techniques in this rare presentation has permitted design of a structured approach and an algorithm to manage and evaluate airway stenosis in GPA.
Granulomatosis with polyangiitis (GPA) is a primary systemic vasculitis syndrome that predominantly affects the lungs, kidneys, and otorhinolaryngologic (ENT) system. More than 70% of patients with GPA have ENT involvement at follow-up. Subglottic stenosis (SGS) is a less common, but serious, manifestation of ENT disease, and it is different from other ENT manifestations in that it can present at any time regardless of disease activity; it is the most common manifestation of ENT disease in children; and it follows a relapsing course often refractory to standard medical therapy.

Subglottic stenosis can also present as part of more extensive airway stenosis affecting the lower airways. Other pulmonary manifestations of GPA include lung nodules, cavities, and hemorrhagic alveolitis. In a large case series, Cordier et al found that 17% of patients had endobronchial stenosis.

Traditionally, airway stenoses in GPA are treated with immunosuppression followed by local interventions for persistent symptomatic stenoses. Some authors have suggested that stenoses should be treated during active disease with dilatation and intralesional glucocorticoids. Other local interventions include dilatation with balloons or bougies; laser resection, cryotherapy, or Argon-plasma coagulation. Topical mitomycin C has been used to reduce recurrence rates. Prompt medical therapy combined with local interventions has reduced the need for tracheostomies and stents. Stents are generally avoided because they contribute to persistent inflammation and disease reactivation. Sleeve excision of the stenosis and end-to-end tracheal repair has also been reported, but is uncommonly performed.

The purpose of this study was to determine whether patients with airway stenosis and GPA reach complete airway stability and to use the data from the disease course as well as published data to establish a strategy for the management of this condition.

Methods

Addenbrooke’s Hospital registered this retrospective cohort study project in the research and development department and decided that it did not require ethical approval.

Patients

The medical records were evaluated for all patients with airway stenosis and a diagnosis of GPA treated between 1997 and May 2012 by a multidisciplinary team in our tertiary referral center. The diagnosis of GPA was applied according to current classification guidelines. The demographic data of the patients were recorded, and a database was designed to record the distribution of the lesions, intervention details, and pulmonary function test results.

Data Collected

The data collected encompassed all interventions from diagnosis until May 2012. The general management of these patients is detailed in Table 1. The decision for active local intervention was based on the patients’ clinical progress (ie, breathlessness, reduced lung capacity or walking distance, and infection distal to the stenosis) and the presence of active vasculitis. Medical treatment was attempted in all patients before local intervention unless they had critical stenoses.

Beginning in 2007, stenoses in the distal main bronchi and their divisions were treated with balloon dilatation under sedation, and laser and bougies were used for proximal stenoses (subglottis, trachea, and main bronchi). A combination of general anesthesia or sedation was used between 1997 and 2007. Currently, intralesional glucocorticoid administration is used as an adjuvant therapy in active stenoses, and mitomycin C in fibrosed recurrent stenoses.

Active stenosis is diagnosed clinically in the presence of friable irregular tissue, and scarred, pale, nonfriable lesions are considered fibrosed stenoses.

Pulmonary function was assessed using the Empey index, calculated as the forced expiratory volume in 1 second (FEV1) (milliliters per second) divided by the peak expiratory flow rate (PEFR) (liters per minute), and the incremental shuttle walk test. An Empey index greater than 10 is considered abnormal. The walking test assesses the distance a patient walks with incremental speed between 2 fixed points, and an increase of 47.5 m is considered symptomatically significant. The aim of therapy was to achieve a 12-month period of stable airway patency defined by stability on direct visualization and clinically.

Analysis

Continuous data are summarized by medians and interquartile ranges (IQRs), while categorical and nominal data are summarized using percentages. Stable airway patency was defined as a period of 12 months or more of follow-up without intervention. Patients were subcategorized according to the sites affected: subglottic stenosis (SGS) only; main airways (SGS and/or trachea and main bronchi); secondary bronchi only; and widespread (main airways and secondary bronchi affected). Despite the large sample size compared with previous cohorts, the data were considered too heterogeneous for meaningful statistical analysis of outcomes.

Results

Patient Characteristics and Disease Manifestations

Forty-four (17.5%) of 251 patients with GPA seen at our institution had airway stenosis. The median age at diagnosis of airway stenosis was 37.6 years, and 73% were women (n = 34) (Table 2).

Over half of the patients had localized disease (ENT and/or lower airway stenosis only), and a quarter had renal involvement. Four of 5 myeloperoxidase–antineutrophil cytoplasmic antibody (MPO-ANCA)–positive patients had localized disease and almost all ANCA-negative patients (10 of 11) had lower airway involvement and constitutional symptoms without renal disease. Only 1 of the ANCA-negative patients presented with isolated SGS and constitutional symptoms, and the diagnosis was made by clinical assessment and biopsy.

The median time from diagnosis of GPA to diagnosis of endobronchial disease was 23 months (IQR, 0–69 months), with...
Distribution of Lesions
Bronchoscopic examination of the 44 patients revealed 110 lesions with the distribution shown in Figure 1. The median number of lesions per patient was 2 (IQR, 1-4). Subglottic stenosis was the most prevalent lesion (36 of 44, 82%), particularly among the 16 patients with only 1 lesion (n = 14). The remaining 2 patients with single lesions had tracheal and left upper lobe stenosis. Conversely, 14 of 15 patients with main bronchi involvement had more than 2 lesions, and 5 had bilateral stenoses of the main bronchi. There were 23 patients with lesions in the secondary bronchi: 9 were bilateral, and two-thirds of the lesions (15 of 23) presented in the left upper lobe. Eight patients had lesions in the subglottis, with more severe lesions in the secondary bronchi sparing the main bronchi.

Interventions
During the follow-up period, 213 interventions were recorded (Table 3). The most common procedure overall was balloon dilatation without adjunct local treatment, but patients with SGS only were treated with carbon dioxide laser and mitomycin C. Five (11.4%) did not require intervention, and 4 of these had only SGS (median follow-up, 69.1 months; IQR, 33.0-87.7 months). Three-quarters of the lesions in the subglottis (26 of 36), two-thirds of the lesions affecting the trachea or main bronchi (18 of 28), and half of the lesions in the secondary bronchi (23 of 46) received local treatment.

The median number of interventions per patient was 2, and only 3 patients had a single procedure (Table 3). Forty-three interventions (20.2%) were performed for critical stenoses during active GPA, with a median interval before the next intervention of 4.4 months (IQR, 2.4-11.5 months), and the median interval of those performed during remission of GPA was 5.2 months (IQR, 2.4-14.4 months). Following the last planned intervention, the median follow-up period was 27 months. Thirteen patients (30%) required tracheostomies during the follow-up period, and 7 of these were subsequently decannulated. After the change in management strategy in 2007, 1 patient had a temporary tracheostomy and was decannulated within 22 days.

All but 1 patient reached at least 1 period of airway stability (≥12 months between treatments). The median time patients spent without interventions was 27.6 months (IQR, 17.2-46.3 months), and overall, patients spent 45.7% of the follow-up time with a stable patent airway (IQR, 28.5-84.3 months). Five patients without interventions and 3 with short follow-up were excluded from this calculation. Most of the patients who required further treatment after more than 2 years of disease control presented with airway difficulties but no evident reactivation of GPA (11 patients, 12 of

### Table 1. Overview of the Management Strategy for Airway Stenosis in Granulomatosis With Polyangiitis

<table>
<thead>
<tr>
<th>Physical Interventions</th>
<th>Antimicrobial Therapy</th>
<th>Systemic Therapy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balloon dilation with or without cutting</td>
<td>Glucocorticoids</td>
<td>Prolonged antibiotic therapy for recurrent or persisting bacterial infections guided by antibiotic sensitivities</td>
</tr>
<tr>
<td>Bougie</td>
<td>Mitomycin C</td>
<td>Topical antibiotics if recurrent crusting</td>
</tr>
<tr>
<td>Laser</td>
<td>Alemtuzumab</td>
<td>Antifungal agents only if positive culture</td>
</tr>
<tr>
<td>Cryotherapy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diathermy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Argon-plasma coagulation</td>
<td></td>
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</tbody>
</table>

### Table 2. Characteristics of Patients With Airway Stenosis

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Measured Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Women</td>
<td>32 (73)</td>
</tr>
<tr>
<td>Age at GPA diagnosis, y</td>
<td>30.1 (19.9-43.2)</td>
</tr>
<tr>
<td>Age at airway stenosis diagnosis, y</td>
<td>37.6 (26.6-46.8)</td>
</tr>
<tr>
<td>Disease duration, mo</td>
<td>146.1 (91.4-228.8)</td>
</tr>
<tr>
<td>Immunosuppressants tried, No.</td>
<td>4 (3-5)</td>
</tr>
<tr>
<td>CYC exposure, mg/kg</td>
<td>140 (76-199)</td>
</tr>
<tr>
<td>Treated with antibiotics</td>
<td>18 (41)</td>
</tr>
</tbody>
</table>

### Abbreviations
- ANCA, antineutrophil cytoplasmic antibody
- CYC, cyclophosphamide
- ENT, otolaryngologic
- GPA, granulomatosis with polyangiitis
- IQR, interquartile range
- MPO, myeloperoxidase
- PR3, proteinase 3
- SGS, subglottic stenosis

The longest being 239 months. Twelve patients had airway stenosis at the time of diagnosis, of whom 4 had renal disease, and 2 had ENT involvement only. Ten of these patients were women.

### Distribution of Lesions
Bronchoscopic examination of the 44 patients revealed 110 lesions with the distribution shown in Figure 1. The median number of lesions per patient was 2 (IQR, 1-4). Subglottic stenosis was the most prevalent lesion (36 of 44, 82%), particularly among the 16 patients with only 1 lesion (n = 14). The remaining 2 patients with single lesions had tracheal and left upper lobe stenosis. Conversely, 14 of 15 patients with main bronchi involvement had more than 2 lesions, and 5 had bilateral stenoses of the main bronchi. There were 23 patients with lesions in the secondary bronchi: 9 were bilateral, and two-thirds of the lesions (15 of 23) presented in the left upper lobe. Eight patients had lesions in the subglottis, with more severe lesions in the secondary bronchi sparing the main bronchi.

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During the follow-up period, 213 interventions were recorded (Table 3). The most common procedure overall was balloon dilatation without adjunct local treatment, but patients with SGS only were treated with carbon dioxide laser and mitomycin C. Five (11.4%) did not require intervention, and 4 of these had only SGS (median follow-up, 69.1 months; IQR, 33.0-87.7 months). Three-quarters of the lesions in the subglottis (26 of 36), two-thirds of the lesions affecting the trachea or main bronchi (18 of 28), and half of the lesions in the secondary bronchi (23 of 46) received local treatment.

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All but 1 patient reached at least 1 period of airway stability (≥12 months between treatments). The median time patients spent without interventions was 27.6 months (IQR, 17.2-46.3 months), and overall, patients spent 45.7% of the follow-up time with a stable patent airway (IQR, 28.5-84.3 months). Five patients without interventions and 3 with short follow-up were excluded from this calculation. Most of the patients who required further treatment after more than 2 years of disease control presented with airway difficulties but no evident reactivation of GPA (11 patients, 12 of...
In addition, in 6 of these 11 patients, the lesion requiring further treatment changed over time. Four of 5 patients who had 2 to 4 intralesional injections with alemtuzumab in clinically fibrotic scars had a median intervention-free period of 42.5 months.

The results for each subgroup are listed in Table 4. Patients in the bronchi group had a more refractory course. This is also seen in patients in the widespread group with a stenotic lesion in each anatomical area of the bronchial tree (n = 9; median time with airway stability, 55.7 months; IQR, 46.9-98.7 months) and in those with SGS and stenosis in the secondary bronchi only (n = 8; median time with airway stability, 95.7 months; IQR, 83.8-98.2 months).

Pulmonary Function Tests

Twenty patients had pretreatment assessments, and 26 had data available for comparison before and after treatment. Data for pretreatment walking tests were present in 9 patients, and there were data for progress assessment for 19 patients. Before interventions, the median percentage of predicted FEV1 was 74.5% (IQR, 52.6%-83.2%); the median percentage of predicted PEFR was 45.8% (IQR, 37.1%-76.4%); the median Empey index was 9.89 (IQR, 8.0-11.4); and the median walking distance was 395 m (IQR, 285-445 m). After treatment, there was improvement in all the values (Table 5). The greatest increase in PEFR and greatest reduction in Empey index were seen in patients with SGS. The median change in walking distance was an improvement of 25 m (16.5%) in the 6 patients who had data before and after interventions.

Adverse Events

Major adverse events included postoperative hemorrhages in 2 patients and self-limiting perforation of the airway due to trauma from the bougie dilatation in 2 patients (Table 6). Two patients developed chest infections after intralesional injections of alemtuzumab, although they were also receiving this medication systemically. One patient developed polypoidal granulation tissue in the area treated with topical mitomycin C, which caused mild breathlessness and required excision using a flexible bronchoscope. One patient had stents inserted in the main bronchi in another hospital, and these subsequently required surgical removal after failed attempts at controlling restenosis with systemic treatment. Another patient died 5 months after a dilatation with no adjuvant treatment from respiratory and renal failure secondary to refractory active vasculitis. This patient...
had had a limited response to the dilatation, which suggests that there was alveolar disease.

Discussion

This medical record review is one of the largest published series describing the airway management in GPA. The prevalence of airway stenosis among patients with GPA in our institution was 17.5% (44 of 251), similar to that reported in other publications (12%-50%).2-4,9,15,22 Lower-airway involvement (30 of 44, 68.2%) was higher than figures quoted in the literature (28%-62.5%)10,17,22 and may reflect the focus on SGS in other series. As in previous reports, patients with airway stenosis presented at an earlier mean age (37.6 years) (published range, 26-40 years10,12,15,17) than the general GPA population (published range, 53-55 years23-25). However, the female predominance (73%) in our cohort is mirrored only by McDonald et al.4

The area most affected was the subglottis (36 of 44, 81.8%), and most patients with a single lesion had SGS (14 of 16). It is not clear whether stenoses with the appearance of mature scar tissue in GPA are fibrotic or whether there is an underlying inflammatory process.15,26 Our results with alemtuzumab suggest that even in fibrotic-looking lesions there may be an underlying inflammatory process.

The proportion of patients who required only 1 procedure was at the lower end of published data (11%-35%).10,12,15 This may be explained by the long follow-up period in this study and the refractory nature of the condition. The number of procedures performed (n = 213) and the fact that patients spent just under half (45.7%) of their follow-up time with a stable patient airway illustrates the refractory nature of the condition. Patients with lower airway stenoses had the most refractory course (Table 4).

The median interval between procedures was the same whether patients were treated during disease activity or not. Topical mitomycin C showed some benefit in patients treated with thermal techniques or persistent stenoses. Our experience using carbon dioxide laser was favorable and without long-lasting adverse events. Although there are no good comparative trials, most authors advocate the use of mechanical techniques of dilatations and/or radial incisions with intraluminal laser incision in GPA.10,12,13,14,26 Initial pulmonary function test results were consistent with airway obstruction, but 2 patients requiring treatment for symptoms had normal pulmonary function findings. Pulmonary function test results showed an improvement over time in objective and functional measures, but more consistent data are required to confirm these findings.

The incidence of adverse events was 9%, and the incidence of adverse events directly related to endoscopy was 5%. The rate of airway perforations (1.3%) was comparable to other

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Table 3. Characteristics of Procedures

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Measured Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous data, median No. (IQR)</td>
<td></td>
</tr>
<tr>
<td>Lesions per patient</td>
<td>2 (1-4)</td>
</tr>
<tr>
<td>Interventions per patient</td>
<td>3 (1-8)</td>
</tr>
<tr>
<td>Interval between procedures (median-IQR), mo</td>
<td>4.9 (2.3-14.1)</td>
</tr>
<tr>
<td>Follow-up duration after last procedure, mo</td>
<td>27 (6.2-47.5)</td>
</tr>
<tr>
<td>Procedures during active endobronchial disease(a)</td>
<td>43 (20.1)</td>
</tr>
<tr>
<td>Procedures during lung infection(b)</td>
<td>66 (30.4)</td>
</tr>
<tr>
<td>Methods of dilatation (n = 213)(c,d)</td>
<td></td>
</tr>
<tr>
<td>Balloon dilatation</td>
<td>130 (60.8)</td>
</tr>
<tr>
<td>Bougie dilatation</td>
<td>34 (15.9)</td>
</tr>
<tr>
<td>Laser dissection</td>
<td>24 (11.2)</td>
</tr>
<tr>
<td>Diathermy dissection</td>
<td>5 (2.34)</td>
</tr>
<tr>
<td>Argon-plasma coagulation</td>
<td>5 (2.34)</td>
</tr>
<tr>
<td>Cryotherapy</td>
<td>9 (4.21)</td>
</tr>
<tr>
<td>Adjuvant therapy</td>
<td></td>
</tr>
<tr>
<td>Intralobular glucocorticoids</td>
<td>24 (9.3)</td>
</tr>
<tr>
<td>Topical mitomycin C</td>
<td>38 (14.7)</td>
</tr>
<tr>
<td>Intralobular alemtuzumab</td>
<td>9 (3.5)</td>
</tr>
<tr>
<td>None</td>
<td>142 (55.0)</td>
</tr>
</tbody>
</table>

Abbreviation: IQR, interquartile range.
\(a\) Unless otherwise indicated, data are reported as number (percentage) of procedures.
\(b\) Infection was defined as positive cultures of bronchial lavage or sputum.
\(c\) Six patients treated with only glucocorticoids or alemtuzumab.
\(d\) A total of 53 dilatations (24.8%) were performed under general anesthesia.

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Table 4. Patient Phenotype and Outcome According to Disease Distribution

<table>
<thead>
<tr>
<th>Lesion Distribution(a)</th>
<th>Patients, No. (%)</th>
<th>Local Interventions, Median No.</th>
<th>Proportion of Time With Stable Airway, %(c,d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Localized (n = 23)</td>
<td>PR3-ANCA-Positive (n = 27)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SGS only (n = 14)</td>
<td>4 (17.4)</td>
<td>11 (78.6)</td>
<td>1</td>
</tr>
<tr>
<td>SGS, trachea, and/or main bronchi (n = 7)</td>
<td>5 (21.7)</td>
<td>5 (71.4)</td>
<td>10</td>
</tr>
<tr>
<td>Bronchi only (n = 6)</td>
<td>3 (13.0)</td>
<td>3 (50.0)</td>
<td>3.5</td>
</tr>
<tr>
<td>Widespread disease(f) (n = 17)</td>
<td>11 (64.7)</td>
<td>3 (33.3)</td>
<td>4</td>
</tr>
</tbody>
</table>

Abbreviations: ANCA, antineutrophil cytoplasmic antibody; PR3, proteinase 3; SGS, subglottic stenosis.
\(a\) Calculated from the sum of months with airway stability over total follow-up period.
\(b\) Six patients excluded: 4 had no interventions, and 2 had follow-up shorter than 12 months.
\(c\) Two patients excluded: 1 had no interventions, and 1 had follow-up shorter than 12 months.
\(d\) Any combination of main airways and secondary bronchi.
One patient had a complication directly attributable to mitomycin C (1 of 213, 0.5%) and required further intervention. Mitomycin C carries a risk of scarring,10,13,27-29 but our results show that the risks can be reduced when this treatment is used with caution, ie, no more than 4 applications of 0.5 mg each for less than 60 seconds. Seven of 13 patients who required tracheostomies were decannulated. This compares favorably with other published cohorts where the tracheostomy rates vary from 0% to 42%, of which 2.3% to 100% are permanent.10,12,15,26

The long follow-up in the present study allows the authors to draw useful conclusions on the course of the disease. However, a larger sample to enable comparison between treatment groups would have been advantageous, and more complete data on pulmonary function tests to assess functional outcomes would be desirable. The management and outcome analysis of airway stenosis in GPA is complex, as demonstrated by the fact that recurrence of stenosis is independent of disease activity and that over time the site of stenosis requiring treatment may change. Different outcome measures such as airway diameter, functional and symptomatic assessments, and intervals between procedures are not entirely satisfactory. Airway diameter and functional and symptomatic assessments lack consistency, and interprocedure interval measurements are blurred in those patients who have staged procedures (eg, the overall median interval in the present study was 4.9 months, while the median intervention-free period after the last planned procedure was 27 months). Using 12-month airway stability as the outcome seemed sensible for this data set, but the addition of a patient-reported outcome measure would be useful. Using our data and those of previous reports,10,14,15,30 we developed an algorithm for the assessment and management of these patients (Figure 2).

Table 5. Pulmonary Function Tests

<table>
<thead>
<tr>
<th>Lesion Distribution</th>
<th>Difference From Predicted Change, %</th>
<th>Change in Empey Index, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>SGS only</td>
<td>FEV1 8.5</td>
<td>PEFR 64.3</td>
</tr>
<tr>
<td>Main airways</td>
<td>FEV1 5.67</td>
<td>PEFR 10.16</td>
</tr>
<tr>
<td>SGS, trachea, and/or main bronchi</td>
<td>FEV1 29.32</td>
<td>PEFR 21.00</td>
</tr>
<tr>
<td>Widespread diseaseb</td>
<td>FEV1 4.11</td>
<td>PEFR 15.17</td>
</tr>
</tbody>
</table>

Abbreviations: FEV1, forced expiratory volume in 1 second; IQR, interquartile range; PEFR, peak expiratory flow rate.

b Any combination of main airways and secondary bronchi.

Table 6. Adverse Events and Outcomes

<table>
<thead>
<tr>
<th>Adverse Event</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infection (n=5)</td>
<td>Treated successfully; 1 mucus plug removed endoscopically; 1 lung infection after alemtuzumab treatment; 3 chronic lung infections following several courses of treatment</td>
</tr>
<tr>
<td>Polyps after treatment (n=1)</td>
<td>Excised with flexible bronchoscope</td>
</tr>
<tr>
<td>Bleeding (n=2)</td>
<td>Self-limiting</td>
</tr>
<tr>
<td>Perforation (n=2)</td>
<td>Healed spontaneously</td>
</tr>
<tr>
<td>Allergy to fentanyl (n=1)</td>
<td>No severe effects</td>
</tr>
<tr>
<td>Stent complications (granulation and displacement) (n=1)</td>
<td>Both stents were removed; 1 of the patients later developed bronchopleural fistula</td>
</tr>
<tr>
<td>Death (n=1)</td>
<td>Patient died of pneumonia and active pulmonary vasculitis 5 months after last intervention</td>
</tr>
</tbody>
</table>

Figure 2. Algorithm for Managing Patients With Granulomatosis With Polyangiitis and Suspected Airway Stenosis

Assessment
Symptoms and disease activity
Dynamic spirometry and incremental shuttle test
Nasendoscopy and bronchoscopy
Microbiology of nose, throat, BAL, and brushings
Chest CT scan

Local intervention
Subglottic, tracheal, or severe and/or recurrent main bronchial stenosis
Secondary bronchi or moderate and/or unilateral main bronchial stenosis

Antimicrobial therapy
Laser and/or bougie dilatation
Balloon dilatation cryotherapy
Chronic and/or fibrotic lesion, topical mitomycin C
Active lesion, intraleisonal glucocorticoid

Systemic vasculitis therapy

Periodic reassessment
Reassess
No Improvement
Yes

BAL indicates bronchoalveolar lavage; CT, computed tomography.
Conclusions

The frequency, distribution, and management of subglottic, tracheal, and bronchial stenoses occurring in patients with GPA has been described. Patients underwent various interventions, and multiple procedures were needed before a period of stable airway patency could be achieved. Prolonged airway stability periods were achieved in most patients, but stenosis of the airways often recurred. A multidisciplinary team comprising an ENT surgeon, respiratory physician, and vasculitis physician was assembled. We suggest tight control of infection and immunomodulatory therapy, lifelong follow-up, and an algorithm to structure the approach to these patients to assess the effect of each treatment modality.

REFERENCES