

Standard Operating Procedure for the Diagnostic Evaluation of Adults with Laryngotracheal Stenosis and Malacia



CLINICAL HISTORY

1. The Integrated Foregut Clinical History
2. Birmingham Vasculitis Activity Score

Patient-Reported Outcome Measures

ADVS, Dyspnoea12 or CCO, VHI10, GETS, EAT10, Epworth, GETS, CET, FSSG14, STAI-5, EQ5D-3L, GESC. Abbreviated follow-up panel.

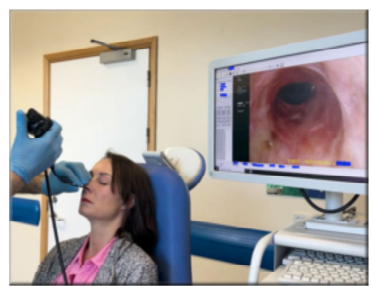
Blood tests (based on clinical indication)

FBC, U&E, LFT, TFT, Bone profile, HbA1C, ESR, CRP, RF, APL, ACE, dsDNA, ANA, ENA, c-ANCA, p-ANCA, ANCA-PR3, ANCA-MPO

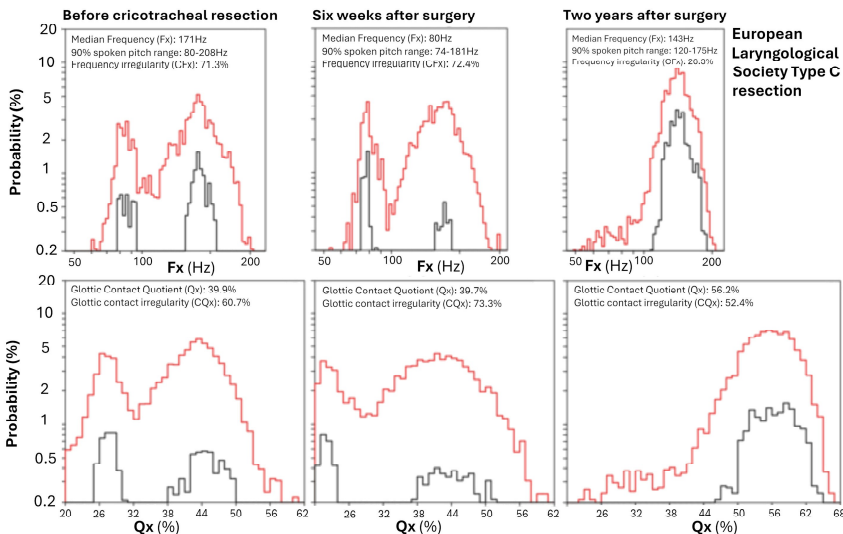
Urine analysis:

Total protein and red blood cell cast (?vasculitis)
24-hours urine Calcium (?Sarcoidosis)

MINIMUM POINT-OF-CARE TESTING



1. Pharyngolaryngoscopy with Stroboscopy
2. Proximal tracheoscopy (shown above)
3. 100ml timed water swallow test
4. Maximum-effort flow-volume loops
5. Connected-speech electroglottography (below)

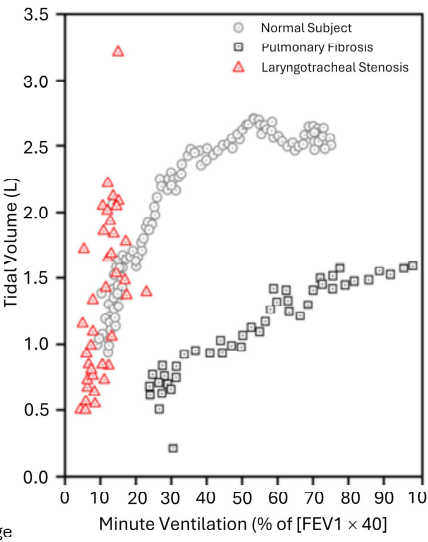
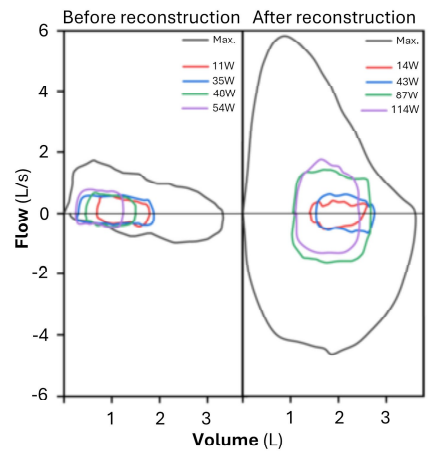


Connected-speech Electroglottography (EGG) requires the patient to read a phonetically-balanced passage (e.g. Arthur the rat or the rainbow passage). This patient had a diplophonic voice before surgery. The voice worsened in the early weeks after cricotracheal resection, and improved within six months and remained improved at 2 years. This patient had delays in treatment due to COVID19 which meant she was no longer amenable to minimally-invasive treatment. While the voice is regular, it has lowered pitch and a narrow pitch range. Given voice morbidity and availability of minimally-invasive treatments such as Serial Intralesional Steroid Injection (SILSI), a CIR is a last resort procedure.

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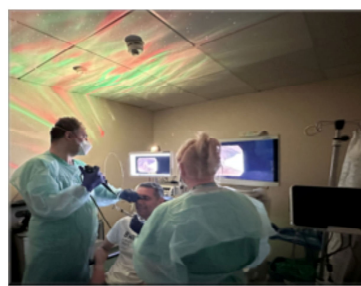
ADVS: Airway, Dyspnoea, Voice and Swallowing; **CCQ:** Clinical COPD Questionnaire; **VHI10:** Voice Handicap Index (10-item); **EAT10** (Eating Assessment Tool); **Epworth:** Epworth Sleepiness Score; **GETS:** Glasgow-Edinburgh Throat Scale; **CET:** Cough Evaluation Test; **FSSG14:** Frequency and Severity of Symptoms of GERD (14-item); **STAI-5:** State-Trait Anxiety Inventory (5-item); **EQ5D-3L** (EuroQol); **GESC:** Gastrointestinal Endoscopy Satisfaction Questionnaire; **FBC:** Full Blood Count; **U&E:** Urea and Electrolytes; **LFT:** Liver Function Test; **TFT:** Thyroid Function Test; **ESR:** Erythrocyte Sedimentation Rate; **CRP:** C-reactive protein; **RF:** Rheumatoid Factor; **APL:** Antiphospholipid; **ACE:** Angiotensin-converting enzyme; **dsDNA:** Double-strand DNA; **ANA:** Antinuclear antibody; **ENA:** Extractable nuclear antigen; **c-ANCA:** Cytoplasmic Antineutrophil Cytoplasmic Antibody; **p-ANCA:** Perinuclear ANCA; **ANCA-PR3:** Proteinase-3 ANCA; **ANCA-MPO:** Myeloperoxidase ANCA; **FEV1:** forced expiratory volume in one second; **FVC:** Forced Expiratory Volume.

LARYNGOPULMONARY PHYSIOLOGY

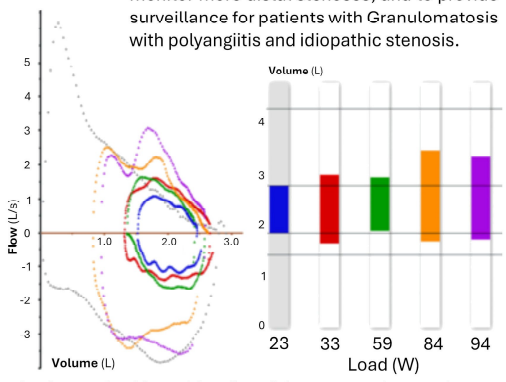


Maximum-effort (i.e. standard) flow-volume loops are measured at every visit. The top left and right plots show the impact of airway reconstruction on **maximum-effort** (Max) and on **exercise** flow-volume loops. Exercise loops are obtained at different exercise intensities (Watts) during Cardiopulmonary Exercise Test (CPET). Improving airway patency does not alter lung volumes; it improves airflow and restores the patient's ability to increase minute ventilation (how much air they can breathe in one minute) to match demand. Before surgery (top left), exercise loops were 'bounded'. The patient could not increase their minute ventilation except by taking deeper breaths. This was because the stenosis prevented higher flows. After airway reconstruction, the patient was able to first increase her tidal volume (at 14W and 43W) and then both tidal volume and flow (at 87W and 114W). This is the normal response to exercise, restored. The same is also shown in Plot 7 of CPET for 3 patients (figure below). The laryngotracheal stenosis patient, having lost **flow**, increased minute ventilation by increasing tidal volume. The patient with lung fibrosis, having lost **volume**, increased minute ventilation by increasing the respiratory rate. For a normal subject, the typical multislope response to exercise (first, increasing tidal volume and then, increasing both tidal volume and respiratory rate) is seen. Some airway patients, even after lumen restoration, do not 'trust' their respiratory system and retain the abnormal volume-dominant breathing pattern. This is key, highly anxiety-producing, but very treatable cause of persistent dyspnoea after laryngotracheal surgery.

TRANSNASAL TRACHEOBRONCHOSCOPY

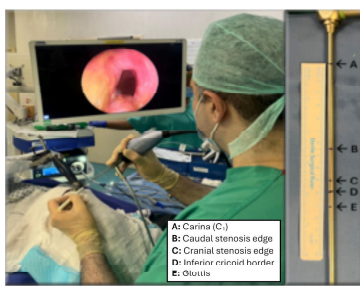


Transnasal Panendoscopy is performed for concurrent dysphagia (without gastro-duodenal symptoms) or recalcitrant throat symptoms. Transnasal LTB (lip-to-bronchus) dynamic assessment is performed to diagnose large-airway collapse (conventional bronchoscopy does not fully enable this), to monitor more distal stenoses, and to provide surveillance for patients with Granulomatosis with polyangiitis and idiopathic stenosis.

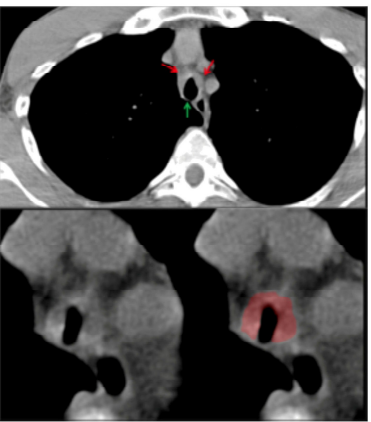


As the work of breathing (Load) increases, the need to increase minute ventilation increases pressures across the airway wall. If airway cartilages are weakened (tracheomalacia) or the trachealis-diaphragm activity is disordinated (Excessive Dynamic Airway Collapse), increased work of breathing destabilises the airway and this manifests as flow instability on exercise loops. This phenomenon helps diagnose malacic airway disease among the causes of "dyspnoea query cause". Here you can see increasing flow instability with increased load.

SUSPENSION LARYNGOTRACHEOSCOPY



Examination under anaesthesia is performed for all patients being considered for open airway surgery. Flexible examinations (e.g. transnasal, conventional, or the through an endotracheal tube) do not provide sufficient information to allow reliable planning.



Patients are often referred to the airway unit with scans already obtained. CT scans have general utility for pulmonary screening (high-resolution CT) can be requested for suspected concurrent lung fibrosis, for example). Standard CT scans have specific diagnostic utility (e.g. this case of trachealis-sparing airway thickening, which is pathognomonic for **relapsing chondritis**).