**A Prospective Study of Voice, Swallow and Airway Outcomes following Tracheostomy for COVID-19**

Maral J Rouhani MA MRCS DOHNS, Gemma Clunie MSc, Gerard Thong MCh MRCS DOHNS, Lindsay Lovell MA Cert. RCSLT, Justin Roe PhD FRCSLT, Margaret Ashcroft DipHE BSc ANP, Andrew Holroyd DipHE BSc RGN, Guri Sandhu MD FRCS, Chadwan Al Yaghchi PhD FRCS

National Centre for Airway Reconstruction, Charing Cross Hospital, Imperial College Healthcare NHS Trust, London, UK

Corresponding author: Dr Maral Rouhani, ENT Department, Imperial College Healthcare NHS Trust, maral.rouhani@nhs.net

Keywords: COVID-19, voice/dysphonia, dysphagia/swallow, airway stenosis

Running Title: Outcomes following Tracheostomy for COVID-19

Level of Evidence: Level 3

Funding: Gemma Clunie is funded by the National Institute for Health Research (NIHR) Imperial Biomedical Research Centre and the NIHR Clinical Doctoral Research Fellowship Programme CDRF-2017-03-028/ Integrated Clinical Academic Programme for this research project. Infrastructure support for this research was provided by the NIHR Imperial Biomedical Research Centre (BRC). This publication presents independent research funded by the National Institute for Health Research (NIHR). The views expressed are those of the author(s) and not necessarily those of the National Health Service, NIHR, or the Department of Health and Social Care.

Conflict of Interest: None declared

Abstract

**Objective**

The COVID-19 pandemic has led to unprecedented demands on healthcare with many requiring intubation. Tracheostomy insertion has often been delayed and the enduring effects of this on voice, swallow and airway outcomes in COVID-19 tracheostomy patients are unknown. The aim of this study was to prospectively assess these outcomes in this patient cohort following hospital discharge.

**Methods**

All COVID-19 patients who had undergone tracheostomy insertion, and were subsequently decannulated, were identified at our institution and followed up two months post-discharge. Patient-reported (PROMS) and clinician-reported outcome measures, endoscopic examination and spirometry were used to assess voice, swallow and airway outcomes.

**Results**

Forty-one patients were included in the study with a mean age of 56 years and male:female ratio of 28:13. Average duration of endotracheal intubation was 24 days and 63.4% of tracheostomies were performed at day 21-35 of intubation. 53.7% had an abnormal GRBAS score and 30% reported abnormal swallow on EAT-10 questionnaire. 81.1% had normal endoscopic examination of the larynx however positive endoscopic findings correlated with the patient self-reported VHI-10 (p=0.036) and EAT-10 scores (p=0.027). 22.5% had spirometric evidence of fixed upper airway obstruction using the Expiratory-Disproportion Index (EDI) and Spearman correlation analysis showed a positive trend between abnormal endoscopic findings and EDI scores over 50 (p<0.0001).

**Conclusion**

The preliminary results of this study reveal a high incidence of laryngeal injury among patients who underwent intubation and tracheostomy insertion during the COVID-19 pandemic. As these patients continue to be followed up, the evolution of these complications will be studied.

Introduction

The COVID-19 pandemic has led to unprecedented demands on healthcare systems globally, particularly critical care, due to the proportion of patients requiring mechanical ventilation. At the time of writing, there have been 13,710 admissions to critical care across 289 units in the United Kingdom(1).

Tracheostomy is a commonly performed procedure, generally 7-10 days post-intubation, to facilitate weaning from mechanical ventilation and to prevent the long-term detrimental sequelae of endotracheal intubation(2-4). In the context of COVID-19 the potential to free up scarce healthcare resources with timely ventilator weaning is an additional benefit of performing tracheostomy in critically ill patients(5). During the pandemic, however, there has been hesitancy to follow normal protocol in terms of tracheostomy timing, leading to prolonged intubation. This relates to lack of consensus regarding risk of aerosol transmission to healthcare workers during the procedure and in tracheostomy aftercare, as well as concern regarding accidental decannulation during proning, a manoeuvre many COVID-19 patients have undergone to improve oxygenation(6, 7). Indeed, a preliminary report from the COVIDTrach national collaborative study, which will evaluate the outcomes of COVID-19 tracheostomies across the UK, has found that the number of days from intubation to tracheostomy ranged from 0-35 (n=543)(8).

The detrimental effects on the larynx from prolonged intubation include voice, swallow and airway dysfunction such as vocal cord palsy, dysphagia and laryngotracheal stenosis(7, 9), which can impact on patient morbidity and mortality. Additionally, most upper respiratory tract viruses are associated with a laryngopharyngitis(10), however traditionally few are ventilated during the peak of these infections except in pandemic scenarios. This laryngopharyngitis as a result of COVID-19 may place the patient at greater risk of glottic and subglottic injury or stenosis following a period of intubation.

The enduring effect on voice, swallow and airway outcomes in COVID-19 tracheostomy patients, in the context of above-mentioned factors are unknown. The aim of this study was to prospectively assess these outcomes in this unique patient cohort following hospital discharge.

Materials and Methods

*Study design*

All COVID-19 patients who had undergone tracheostomy in our trust (an organisation that provides secondary health services, comprised of several acute hospitals) were identified and followed up approximately two months post-hospital discharge in our dedicated Airway and Laryngology clinic at the National Centre for Airway Reconstruction, Charing Cross Hospital, Imperial College Healthcare NHS Trust (ICHT). This service evaluation was approved by ICHT (reference ENT 408) and governance was provided via the ICHT Service Evaluation and Audit governance committee.

Demographic data, type of tracheostomy (surgical vs. percutaneous) and the dates of endotracheal intubation, tracheostomy insertion, decannulation and discharge from hospital were recorded.

*Outcome measures*

A selection of patient-reported (PROMS) and clinician-reported outcome measures were used to assess voice and swallowing outcomes. In the absence of a core outcome set for airway patients(11) usual clinical practice measures were completed. The Voice-Handicap Index (VHI-10)(12) and Reflux Symptom Index (RSI)(13) PROMs were used to assess patient perception of voice changes and signs of reflux, whilst the GRBAS (14) scale was used by clinicians to provide an auditory-perceptual evaluation of voice quality.

To assess swallow outcomes, the Eating Assessment Tool (EAT-10)(15) and Dysphagia Handicap Index (DHI)(16) PROMs were completed. Functional Oral Intake Scale (FOIS)(17) scores were recorded by clinicians.

The 100ml Water Swallow Test (WST)(18) was also performed. This involves the patient drinking 100ml of water as quickly and comfortably as possible. The test was timed, and the number of swallows counted. If the patient was unable to finish the water, or if the patient showed signs of aspiration, the test was immediately stopped, and the remaining water was measured. Comments were also recorded about potential signs of penetration and aspiration such as throat clearing or shortness of breath. Three performance measures were then calculated: 1) swallow volume (ml/swallow): by dividing the volume of water swallowed by the number of swallows; 2) swallow capacity (ml/second): by dividing the volume of water swallowed by the time taken and 3) swallow speed (seconds/swallow): by dividing time taken by number of swallows. If a patient had a known risk of aspiration they were not assessed and were scored 0 for volume, capacity and speed.

To assess airway outcomes, spirometry was performed with full flow-volume measurements to allow calculation of the Expiratory Disproportion Index (EDI) as a measure of fixed upper airway obstruction, calculated as FEV1/Peak Expiratory Flow Rate (PEFR) x 100(19).

All patients also underwent flexible nasoendoscopic assessment of the larynx to assess for laryngeal pathology such as granuloma, vocal cord palsy and evidence of subglottic stenosis.

*Statistical analysis*

Spearman correlation multivariate analysis was performed using GraphPad Prism 8.4 software.

Results

A total of 62 tracheostomies were performed in our trust in the period 1st April to 31st May 2020. 58 of these were performed surgically (93.5%) and four were undertaken percutaneously. Out of 62 patients, four patients died. The remaining 58 patients were offered follow up appointments two months following discharge from hospital in our dedicated Airway/Laryngology clinic. 17 patients were lost to follow up; Figure 1 demonstrates this patient flow.

*Demographic data*

Forty-one patients have been included in this study with a mean age of 56 years and male:female ratio of 28:13. Average BMI was 29.3 kg/m2. Average duration of endotracheal intubation was 24 days and average number of days from tracheostomy insertion to decannulation was 15 days (Table 1). This likely reflects the fact that tracheostomy insertion was performed late in the patients’ clinical course. The majority (63.4%) were performed at day 21-35 of intubation and a size 8.0 tracheostomy tube was inserted in over half of the patient cohort, 51.2% (Table 1). Patients were seen at an average of 54 days following discharge from hospital. At follow up, 100% of the patients included in the study had been decannulated.

*Voice outcomes*

PROMs and clinician-reported outcomes have been reported descriptively and where possible compared to normative values to determine trends related to voice and swallowing difficulties following tracheostomy insertion for COVID-19.

Thirty-eight patients completed the VHI-10 questionnaire; 5 patients (13.2%) reported a score >11 (range 12-35) which is considered abnormal(20). 39 patients completed the RSI questionnaire; 5 patients (12.8%) reported a score > 13 (range 21-41) indicative of likely laryngopharyngeal reflux symptoms(13).

53.7% (22 patients) had a GRBAS score that indicated perceptual abnormalities to voice quality (grade, roughness, breathiness, asthenia, strain; score of 0 considered no audible dysphonia). The highest scoring abnormality was asthenia, indicative of overall weakness of voice. Figure 2 depicts a summary of these voice outcomes.

*Swallow outcomes*

Forty patients completed the EAT-10 questionnaire; 12 patients (30%) reported a score > 2 (range 4-33) which indicates a potentially abnormal swallow. 34 patients (82.9%) had a FOIS score of 7: total oral diet with no restrictions. Three patients (7.3%) had a score of 6: total oral diet with multiple consistencies without special preparation but with specific food limitations; two (4.9%) had a score of 5: total oral diet with multiple consistencies, but requiring special preparation or compensations; two (4.9%) had a score of 3: tube dependent with consistent oral intake of food or liquid. The EAT-10 and FOIS scores are depicted in Figure 3.

Spearman multivariate correlation analysis between EAT-10 scores and 100ml WST scores for the whole patient cohort was performed demonstrating negative correlation between those patients who scored >2 on the EAT-10 questionnaire and swallow volume (r=-0.327, p=0.0425) and capacity (r=-0.494, p=0.0014), and positive correlation with swallow speed (r=0.339, p=0.035). These 12 patients were further analysed. Table 2 depicts their corresponding DHI questionnaire scores in each domain as well as the results of the 100ml WST and observed behaviours, with comparison to published age and sex matched norms. Due to the small number of subjects in each age range, it was not possible to perform significance analysis therefore description of trends has been completed. Eleven subjects (92%) had lower than normal swallowing volume and capacity. Swallowing speed was increased from normal range for eight (67%) subjects.

*Airway outcomes*

Four patients declined flexible nasoendoscopic examination of the larynx. In the remaining 37 patients, examination did not reveal any pathology in the majority (30 patients, 81.1%). The most common positive finding was unilateral cord palsy (3 patients, 7.9%) followed by subglottic stenosis (2 patients, 5.3%). One patient was found to have persistent ecchymosis of the right vocal cord and one patient had fixed bilateral vocal fold immobility with a subglottic granuloma; he is discussed in more detail below (Patient X). Interestingly, abnormal findings on endoscopy did not correlate with age (p=0.592), gender (p=0.855), method of tracheostomy (p=0.248), size of tracheostomy tube (p=0.78), height (p=0.28), weight (p=0.256), BMI (0.644), length of intubation (p=0.81) or length of tracheostomy (p=0.911). However, positive endoscopic findings correlated with the patient self-reported VHI-10 (r=0.341, p=0.036) and EAT-10 scores (r=0.4621, p=0.027).

Spirometry was performed in all but one patient, who was unable to accurately complete the test due to language barrier. The median EDI across the cohort was 36.8 (range 24.4-85.3); nine patients had an EDI score greater than 50 (22.5%). Table 3 depicts the scores for these nine patients and their corresponding clinical findings, as well as, conversely, the corresponding EDI scores for patients with pathology on endoscopic examination of the larynx to enable a comparison. Spearman analysis showed a positive correlation between abnormal endoscopic findings and EDI scores over 50 (r=0.860, p<0.0001).

*Patient X*

Patient X is the only patient in the cohort who has required reinsertion of tracheostomy. He was intubated with a size 8.0 endotracheal tube and tracheostomy was performed on day 33 of intubation using standard surgical technique; a size 8.0 tracheostomy tube was inserted, and he was decannulated 19 days later. He presented to clinic with soft inspiratory stridor and on endoscopic examination was diagnosed with bilateral vocal fold immobility (BVFI). His outcome measures are summarised in Table 4. His EDI was 76.8. We performed two right-sided laser arytenoidectomies, 4 weeks apart, to widen his glottic airway. Intraoperatively, he was found to have posterior glottic stenosis as well as florid subglottic and tracheal granulation tissue. Instrumental assessment of his swallow with repeated Fibreoptic Endoscopic Evaluations of Swallowing (FEES) has shown dysphagia leading to risk of silent aspiration, particularly when his airway deteriorated. Unfortunately, after each procedure he re-presented with stridor and the decision was made to perform emergency tracheostomy; the florid granulation is thought to be the likely cause for the failed laser procedures.

Discussion

This study offers the unique opportunity to prospectively examine the development and evolution of laryngeal injury resulting from intubation and tracheostomy insertion during the COVID 19 pandemic. As previously discussed in these patients, tracheostomy insertion was delayed for longer than the routine 7-10 days. The vast majority of tracheostomies were performed beyond day 14 of intubation (92.7%; Table 1) and size 8.0 and above tracheostomy tubes were inserted in 78% of the cohort (Table 1). Thus, we can study the impact of these factors on laryngeal injury in the short and medium term.

First, in terms of voice outcomes, only 13.2% of our cohort subjectively considered their voice to be abnormal, using a cut off score of > 11 in the VHI-10 questionnaire, whilst over half (53.7%) were found to have an abnormal voice on auditory-perceptual evaluation by a clinician using GRBAS scoring. This disparity indicates that even where the clinician rated the patient’s voice as perceptually disordered, patients themselves were unconcerned about the change. The requirement for voice therapy may therefore not be as great as initially suspected, however this must be placed in the context of the multiple other symptoms our patients were experiencing in their recovery from COVID-19 and their need to prioritise other issues, for example managing fatigue prior to focusing on their voice difficulties (21).

We also predicted that a substantial number of our patients would report reflux-related symptoms since many had been proned in Intensive Care (ICU) and it has been suggested laryngopharyngeal reflux may correlate with poorer clinical outcomes from COVID-19(22). However, only 12.8% of the cohort reported a score of >13, which is indicative of laryngopharyngeal reflux symptoms(13). This may be because any reflux has resolved by the time these patients were seen in our clinic. Nevertheless, it is vital to assess for laryngotracheal reflux in this population as evidence suggests it can worsen benign laryngotracheal stenosis(23).

In our cohort, 30% (12 patients) reported an element of dysphagia on the EAT-10 questionnaire with a score > 2 however the majority were managing a normal diet (82.9% had a FOIS score of 7). This is consistent with a known mismatch between different dysphagia outcome measures, for example PROMS versus clinician-rated scales (24).

11 patients (27%) from our cohort have required instrumental swallow assessment based on clinical evaluation of swallowing (potential aspiration and penetration) and have required ongoing SLT involvement for their swallow management. Despite managing a normal diet, there appears to be a significant incidence of dysphagia in this COVID-19 population, which may not be related to laryngeal injury. DHI scores for the 12 patients identified by the EAT-10 questionnaire were all abnormal indicating correlation between the two PROMS. The breakdown of the DHI into the 3 domains (physical, functional and emotional) was relatively evenly spread across all subjects. This indicates that patients experience multifactorial dysphagia as a result of COVID-19 with an impact on quality of life even for those who did not require ongoing SLT intervention. For most of these patients this was also reflected in abnormal 100ml WST performance scores (volume and capacity more than speed) indicative of a physiological change in swallowing status as a result of COVID-19 infection and tracheostomy.

Patient X is an interesting case of posterior glottic stenosis (BVFI) in this cohort, as previously described. Significantly, he was intubated for 33 days before his initial tracheostomy was performed. His VHI-10, RSI and GRBAS scores were abnormal, as expected (Table 4). Interestingly, he scored only 2 on EAT-10 questionnaire despite his dysphagia, indicative of the limitations of EAT-10 as a screening tool (25, 26). Patient X did score 14 with a severity score of 3 on the DHI demonstrating its sensitivity to swallowing difficulties that impact on quality of life. This was supported by swallowing volume and capacity scores that were lower than matched norms and a slower swallow speed, with signs of aspiration noted by the testing clinician. This demonstrates the importance of alternative, more sensitive outcome measures such as the DHI and the 100ml WST alongside EAT-10 to enable an accurate initial swallow assessment and allow appropriate triage to instrumental assessments of swallowing. This is particularly relevant for patient X as his dysphagia may be a partial cause of his failed laser procedures due to aspiration causing subglottic granulation. He will be offered laryngotracheal reconstruction once we are more confident his swallow has improved.

Comparing spirometry results of 217 cases of laryngotracheal stenosis with 9,357 healthy and non-stenosis pulmonary patients, Nouraei et al(19) found that at a threshold of >50, EDI had a sensitivity of 95.9% and specificity of 94.2% in differentiating between stenosis and non-stenosis cases; this includes BVFI but excludes unilateral vocal cord palsy (UVCP). Using this cut-off of 50, we found that nine of our patients (22.5%) had spirometric evidence of laryngotracheal stenosis. The exact incidence of post-intubation and post-tracheostomy stenosis is unknown, as such widely variable rates are quoted in the literature; figures from 1-30% have been reported, therefore our findings are definitively at the higher end of the scale(27-29). However, as demonstrated in Table 3, of these nine patients, our endoscopic findings correlate with the spirometry data in just two patients: one with evident subglottic stenosis and the other with BVFI and a subglottic granuloma (Patient X).

A further two patients with EDI >50 had endoscopic evidence of UVCP, one patient had unilateral cord ecchymosis and the remaining three patients had no pathology on endoscopic examination (the last patient declined examination). Conversely, one patient with evident subglottic stenosis, graded as 10-15% on flexible nasendoscopy, and another with unilateral cord palsy had normal EDI scores (32.6 and 29.6 respectively). These discrepancies are likely explained either by non-clinically significant stenoses or tracheal stenoses, which are not visible on endoscopic examination. Further investigation would have required microlaryngoscopy or bronchoscopy, however we felt this was not justified by the patients’ symptoms. It will therefore be essential to see if these patients develop significant pathology as they continue to be followed up.

Comparing our endoscopic results with the literature, 5.3% (two patients) had clinical evidence of subglottic stenosis and 2.7% (one patient) had BVFI causing posterior glottic stenosis; this compares favourably to the findings of a systematic review in 2017 by Brodsky *et al*(9) which found 12% subglottic stenosis and 6% glottic stenosis. They also found 21% incidence of UVFP, whilst we found an incidence of 7.9% (three patients). Of note, however, all the patients included in the systematic review were assessed within two weeks of extubation, much earlier than in our cohort. It is likely vocal fold immobility spontaneously improves over time however glottic and subglottic stenosis does not.

The limitations of this study mainly relate to the environment in which the data was collected. The study was conducted in a busy clinic with time pressures on clinicians; as such, patients were occasionally waiting longer than usual to be seen which may have led to questionnaires being skipped or examinations being declined, resulting in missing data points. The small sample size also possibly explains the lack of correlation between abnormal endoscopic findings and the known risk factors for airway stenosis in ICU patients such as length of intubation, size of tracheostomy and BMI.

Conclusion

The preliminary results of this study reveal a high incidence of laryngeal injury among patients who underwent endotracheal intubation and tracheostomy insertion during the COVID-19 pandemic. As these patients continue to be followed, we aim to study the evolution of these complications over the medium term, which may offer insight into the natural history of ICU related laryngeal injury. These findings will contribute to our understanding of this disease process and aid in the development of guidelines aimed at diagnosing and following up post-intubation and post-tracheostomy laryngotracheal injuries.

References

1. ICNARC. ICNARC report on COVID-19 in critical care 2020 [Available from: <https://www.icnarc.org/Our-Audit/Audits/Cmp/Reports>.

2. Takhar A, Walker A, Tricklebank S, Wyncoll D, Hart N, Jacob T, et al. Recommendation of a practical guideline for safe tracheostomy during the COVID-19 pandemic. Eur Arch Otorhinolaryngol. 2020;277(8):2173-84.

3. Griffiths J, Barber VS, Morgan L, Young JD. Systematic review and meta-analysis of studies of the timing of tracheostomy in adult patients undergoing artificial ventilation. BMJ. 2005;330(7502):1243.

4. Adly A, Youssef TA, El-Begermy MM, Younis HM. Timing of tracheostomy in patients with prolonged endotracheal intubation: a systematic review. Eur Arch Otorhinolaryngol. 2018;275(3):679-90.

5. Koch T, Hecker B, Hecker A, Brenck F, Preuss M, Schmelzer T, et al. Early tracheostomy decreases ventilation time but has no impact on mortality of intensive care patients: a randomized study. Langenbecks Arch Surg. 2012;397(6):1001-8.

6. McGrath BA, Brenner MJ, Warrillow SJ, Pandian V, Arora A, Cameron TS, et al. Tracheostomy in the COVID-19 era: global and multidisciplinary guidance. Lancet Respir Med. 2020;8(7):717-25.

7. Piazza C, Filauro M, Dikkers FG, Nouraei SAR, Sandu K, Sittel C, et al. Long-term intubation and high rate of tracheostomy in COVID-19 patients might determine an unprecedented increase of airway stenoses: a call to action from the European Laryngological Society. Eur Arch Otorhinolaryngol. 2020.

8. al HNe. COVIDTrach; the outcomes of mechanically ventilated COVID-19 patients undergoing

tracheostomy in the UK: Interim Report PREPRINT. 2020.

9. Brodsky MB, Levy MJ, Jedlanek E, Pandian V, Blackford B, Price C, et al. Laryngeal Injury and Upper Airway Symptoms After Oral Endotracheal Intubation With Mechanical Ventilation During Critical Care: A Systematic Review. Crit Care Med. 2018;46(12):2010-7.

10. van Doorn HR YH. Viral Respiratory Infections. . Hunter's Tropical Medicine and Emerging Infectious Diseases. 2020:284-8.

11. Clunie GM, Roe JWG, Alexander C, Sandhu G, McGregor A. Voice and Swallowing Outcomes Following Airway Reconstruction in Adults: A Systematic Review. Laryngoscope. 2020.

12. Rosen CA, Lee AS, Osborne J, Zullo T, Murry T. Development and Validation of the Voice Handicap Index-10. The Laryngoscope. 2004;114:1549-56.

13. Belafsky PC, Postma GN, Koufman JA. Validity and reliability of the reflux symptom index (RSI). J Voice. 2002;16(2):274-7.

14. Hirano M. Clinical Examination of Voice. New York: Springer Verlag; 1981.

15. Belafsky PC, Mouadeb DA, Rees CJ, Pryor JC, Postma GN, Allen J, et al. Validity and Reliability of the Eating Assessment Tool (EAT-10). Annals of Otology, Rhinology & Laryngology. 2008;117(12):919-24.

16. Silbergleit AK, Schultz L, Jacobson BH, Beardsley T, Johnson AF. The Dysphagia handicap index: development and validation. Dysphagia. 2012;27(1):46-52.

17. Crary MA, Mann GD, Groher ME. Initial psychometric assessment of a functional oral intake scale for dysphagia in stroke patients. Archives of physical medicine and rehabilitation. 2005;86(8):1516-20.

18. Patterson JM, Hildreth A, McColl E, Carding PN, Hamilton D, Wilson JA. The clinical application of the 100mL water swallow test in head and neck cancer. Oral oncology. 2011;47(3):180-4.

19. Nouraei SA, Nouraei SM, Patel A, Murphy K, Giussani DA, Koury EF, et al. Diagnosis of laryngotracheal stenosis from routine pulmonary physiology using the expiratory disproportion index. Laryngoscope. 2013;123(12):3099-104.

20. Arffa RE, Krishna P, Gartner-Schmidt J, Rosen CA. Normative values for the Voice Handicap Index-10. J Voice. 2012;26(4):462-5.

21. Carfi A, Bernabei R, Landi F, Gemelli Against C-P-ACSG. Persistent Symptoms in Patients After Acute COVID-19. JAMA. 2020;324(6):603-5.

22. Jiang G, Cai Y, Yi X, Li Y, Lin Y, Li Q, et al. The impact of laryngopharyngeal reflux disease on 95 hospitalized patients with COVID-19 in Wuhan, China: A retrospective study. J Med Virol. 2020.

23. Lorenz RR. Adult laryngotracheal stenosis: etiology and surgical management. Curr Opin Otolaryngol Head Neck Surg. 2003;11(6):467-72.

24. Pedersen A, Wilson J, McColl E, Carding P, Patterson J. Swallowing outcome measures in head and neck cancer--How do they compare? Oral oncology. 2016;52:104-8.

25. Wilmskoetter J, Bonilha H, Hong I, Hazelwood RJ, Martin-Harris B, Velozo C. Construct validity of the Eating Assessment Tool (EAT-10). Disabil Rehabil. 2019;41(5):549-59.

26. Heijnen BJ, Speyer R, Bulow M, Kuijpers LM. 'What About Swallowing?' Diagnostic Performance of Daily Clinical Practice Compared with the Eating Assessment Tool-10. Dysphagia. 2016;31(2):214-22.

27. Norwood S, Vallina VL, Short K, Saigusa M, Fernandez LG, McLarty JW. Incidence of tracheal stenosis and other late complications after percutaneous tracheostomy. Ann Surg. 2000;232(2):233-41.

28. Chang E, Wu L, Masters J, Lu J, Zhou S, Zhao W, et al. Iatrogenic subglottic tracheal stenosis after tracheostomy and endotracheal intubation: A cohort observational study of more severity in keloid phenotype. Acta Anaesthesiol Scand. 2019;63(7):905-12.

29. Hseu AF, Benninger MS, Haffey TM, Lorenz R. Subglottic stenosis: a ten-year review of treatment outcomes. Laryngoscope. 2014;124(3):736-41.

Figure Legends

Figure 1 - Patient flow chart. DNA; did not attend.

Figure 2 – Left panel: VHI-10 scores. Right panel: RSI scores. Bottom panel: GRBAS scores

Figure 3 – Left panel: EAT-10 scores. Right panel: FOIS scores