ORIGINAL ARTICLE

Tracheal resection and reconstruction: A 3-year case series of 14 patients

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ABSTRACT

Introduction: Tracheal resection and reconstruction is one of the most challenging procedures and is seldom performed due to its complexity. Despite being a life-saving procedure, only a handful of centres are performing this procedure in Malaysia. We report our 3 years' experience in Hospital Kuala Lumpur performing tracheal resection and reconstruction in 14 patients.

Materials and Methods: Retrospective review of medical records of tracheal resection and reconstruction was performed from September 2018 till August 2021. Data that were extracted include demographic information, indication for surgery, intraoperative airway management, surgical approach, perioperative parameters, complications, and 1-year outcome.

Results: Fourteen patients with the mean age of 49.1 years underwent tracheal resection and reconstruction, consisting of 9 benign and 5 malignant diseases. Non-intubated airway approach was used in three patients. Transcervical surgical access was used in 10 patients whereas thoracotomy, video-assisted thoracoscopic surgery, and combination of thoracotomy, transcervical incision with manubrial split were used in 3 patients respectively. The mean length of trachea resected was 2.3cm, with the longest length of 4.5cm. All patients were extubated post-operatively except for one due to traumatic brain trauma. No anastomosis dehiscence was seen. We also did not see any post-operative stenosis and all the patients are alive.

Conclusion: Tracheal resection and anastomosis can be performed safely in complex stenosis and malignant tumours. Pre-operative planning with a multidisciplinary approach is vital to ensure a good outcome.

KEYWORDS:
Tracheal surgery, tracheal resection and reconstruction, tracheal stenosis, tracheal tumour

INTRODUCTION

The first recorded tracheal surgery was performed by Belsey in 1950.[1] Despite seven decades after its introduction, it remains as one of the most challenging procedures among surgeons. This is mainly due to the peculiar anatomy of the trachea, particularly its location both in the neck and mediastinum, length, structural rigidity, and blood supply.[2] The success rate of tracheal resection and reconstruction varies from 71 to 95% and the reported mortality rate is 1.2%.[3,4]

Though challenging, it is imperative for all thoracic surgeons to be competent in tracheal resection and reconstruction as it is a life-saving procedure. With the evolution of video technology, bronchoscopic intervention coupled along with surgery has achieved good outcomes for tracheal pathologies.

In this article, we report our early experience in tracheal surgery and its feasibility, safety, and short-term outcome. Tracheal resection and reconstruction was never performed in our unit before this.

MATERIALS AND METHODS

Medical records of all patients who underwent tracheal resection and reconstruction at the Thoracic Surgery Unit, Hospital Kuala Lumpur from September 2018 till August 2021 were reviewed retrospectively. All patients who underwent tracheal resection and reconstruction in Hospital Kuala Lumpur within the study period were included in this review. Descriptive analysis was performed. Informed consent for usage of clinical data was obtained from all patients in this study.

Patients' demographic information, indication for surgery, intraoperative airway management, surgical approach, perioperative parameters, and 1-year outcome were reviewed. No ethical approval was necessary as this was a retrospective observational study.

Perioperative preparations

Generally, all patients for tracheal surgery have undergone contrast-enhanced computed tomography scan (CECT) of neck and thorax with 3-dimensional (3D) reconstruction, bronchoscopy, and echocardiogram.

These patients would be reviewed by the anaesthetist for airway assessment, and subsequently referred to pulmonologist, ENT (ear, nose, throat), or thoracic surgeon. After the airway was secured either by emergent tracheostomy, debulking of tumour by rigid bronchoscopy or bronchoscopy-guided intubation, CECT neck, and thorax with 3D reconstruction were performed. These investigations

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enabled us to determine the site and distance of the tracheal stenosis or tumour from the vocal cord, carina, and the extent of circumferential involvement of the trachea along with extra tracheal involvement.

Anaesthetic technique
For patients with tracheal stenosis lumen sized 5.5mm and above and can be dilated, the airway was secured with an endotracheal tube (ETT) sized 6 passed beyond the stenotic segment. For stenosis not amenable for dilatation, ETT may either be placed above the stenosis, or a laryngeal mask airway used based on the patient's tolerability to lie flat. Once the trachea was transected distal to the lesion, a surgical field flexo-metallic ETT sized 7.5 was passed into the distal trachea.

All patients were subjected to total intravenous anaesthesia (TIVA) to prevent anaesthetic gas contamination during the intermittent opening of the airway during reconstruction. Remifentanil and propofol 1% were delivered by target-controlled infusion (TCI) using the Minto and Schnider model, respectively. The depth of anaesthesia was monitored using bispectral index between 40 and 60. TIVA was titrated to achieve spontaneous ventilation with minimal surgical field movement while always maintaining oxygen saturation above 95%. This enabled us to perform non-intubated tracheal resection in some of our patients. Extracorporeal membranous oxygenation (ECMO) was never used in our series.

After the surgery, an on-table bronchoscopy was performed to aspirate retained blood clots and to examine the anastomosis. The patients were aimed to be extubated immediately to prevent anastomotic complications.

Surgical technique
Approach to tracheal surgery was based on the location of the lesion. Cervical collar incision approach was used for patients with cervical tracheal lesion, with manubrium split if the lesion extends behind the manubrium. A right posterolateral thoracotomy or right video-assisted thoracoscopic surgery (VATS) approach was the method of choice for patients with mediastinal tracheal lesions. Depending on the length of resection, non-tension anastomosis can be achieved by releasing supra and infra laryngeal attachments, inferior pulmonary vein, and hilum. Anastomosis was achieved by long-absorbable monofilament 3/0 suture as described by Grillo.[5] Grillo's chin to chest suture was applied to all patients with the neck in a neutral position following skin closure to prevent neck extension.

Bronchoscopy was performed on post-operative day 5 to assess anastomotic integrity. The chin to chest suture was removed following bronchoscopy and soft cervical collar will be applied to maintain the neck in a neutral position. This collar will be maintained for a period of 6 weeks post-surgery. All patients underwent surveillance bronchoscopy at 1, 3, and 6 months after surgery for up to 2 years.

RESULTS

There were 14 patients who underwent tracheal surgery from September 2018 till August 2021. Out of the 14 patients, 6 (43%) were male and 8 (57%) were female with a mean age of 49.1 years old, ranging from 14–78 years old. The common presenting symptoms were dyspnoea (10 patients), stridor (3 patients), cough (2 patients), and haemoptysis (1 patient). Hypertension, diabetes mellitus, and bronchial asthma were the commonest comorbidities. However, those patients who were diagnosed with bronchial asthma were free from asthmatic attack after the tracheal resection and reconstruction. There were only three patients without any co-morbidity.

All patients that underwent tracheal resection had grade 2 (6 patients) and 3 (7 patients) Cotton Meyer's grading. One patient cannot be classified for stenosis due to acute tracheal tear secondary to trauma and was already intubated for cerebral protection. There were two patients presented with Karnofsky performance status scale of 50 while the remaining presented with the Karnofsky performance status scale of 90. (Table I) One of our patient required pre-operative debulking of tumour with rigid bronchoscopy to establish airway before undergoing definitive surgery.

The tracheal lesion requiring resection originated from the cervical trachea in six patients and mediastinal trachea in eight patients. All the primary tracheal tumours in our series were from the mediastinal trachea (Table II).

Various surgical approaches were used for tracheal resection and reconstruction. Most patients underwent surgery via transcervical approach (71%). The other approaches used were right thoracotomy, VATS, transcervical combined with right VATS and manubrial split and transcervical combined with right thoracotomy. The main aim during the reconstruction is to achieve non-tension anastomosis, which can be achieved by performing various release manoeuvres as described in Table III.

The intraoperative airway management was by intubated (11 patients) and non-intubated (3 patients) manner. The mean duration of surgery was 246.2 minutes (range 70-540 minutes) while the mean length of trachea resected was 2.3cm (range 1.0 - 4.5cm). The nearest resection of trachea from the carina was around 1cm. Only one patient (7%) was ventilated post-operatively and 10 patients required ICU/PACU admission with the mean stay of 1 day. The median duration of hospital stay was 9.5 days. Most frequent post-operative complication was dysphagia. One patient developed right vocal cord paralysis. There was no tracheal anastomotic leak as well as no mortality was observed. (Table IV)

There were five malignant tracheal tumours operated, and the average size of the tumour was 2.3cm (range 1.7-3.5cm). Out of the five patients, three patients (60%) had resected margin involved, which included two patients with papillary thyroid carcinoma where the tumour involved the thyroid cartilage. There was one patient who was pre-operatively diagnosed as granulomatous inflammation causing stenosis; with the final histopathological diagnosis of lymphoma. (Table IV)

DISCUSSION

Tracheal resection and anastomosis for both benign and malignant conditions are not widely performed, owing to the surgical complexity and complications involved. The success rate of tracheal resection is 89.5% and resectable malignant tracheal lesions stand a best chance of cure by surgical resection.[6,7] Post-intubation tracheal stenosis and malignant tracheal lesions were the main indications for tracheal surgery in our centre. There was no benign tumour of the trachea seen in our series, probably because endoscopic resection was already performed by the pulmonologist for such cases. These findings were similarly reported by Cordos et al, Marques P et al, and Hassan et al.[8-10]

The difficulty of the airway management in patients with tracheal lesions undergoing resection varies according to site and severity of the stenosis. All the patients in this cohort presented with symptoms of central airway obstruction with Cotton Meyer's grade 2 and 3. We advocate both intubated and non-intubated techniques of ventilation during tracheal resection. Intubated techniques are used in cases where at least an ETT sized 6.0 can be passed through the lesion. Alternatively, non-intubated technique is used in VATS tracheal resection and reconstruction to enable anastomosis to be performed without ETT interruption. Furthermore, the technique is used when ETT cannot be secured effectively in tight stenosis, which is located less than 3 cm from vocal cord. Non-intubated technique allows the patient to continue spontaneous ventilation with supraglottic airway assistance using laryngeal mask and TIVA. This method was described previously by Benedict et al.[11] and Liu et al.[12] With the advocation of non-intubated techniques, none of our patients required ECMO or cardiopulmonary bypass to perform complex tracheal resection and anastomosis.

The commonest surgical approach used for tracheal resection and reconstruction in this cohort was via the transcervical incision. The similar approach was also performed in some reported case series.[2] Transcervical incision can be used for benign tracheal stenosis resection as low as the T1 vertebra level. For lower stenosis near the carina, a sternotomy or right posterolateral thoracotomy can be the approach of choice. We have perfomed resection of mediastinal tracheal stenosis by a combination of right VATS and manubrial split, as well as a totally VATS tracheal resection. The manubrial split was performed to allow safe dissection of the severely adhered brachiocephalic artery to the crushed mediastinal trachea after trauma (Figure 1).

In cases of malignant tracheal lesions, the aim is to achieve clear resection margins and to remove as many paratracheal and precarinal lymph nodes as possible. If the tumour is located at cervical tracheal, transcervical approach is preferred.[12] However, if the tumour is at the mediastinal trachea, even at the level of T1 vertebra, a sternotomy, a right posterolateral thoracotomy or right VATS approaches can be used to ensure adequate tracheal mobilisation, good resection margin, and adequate lymph node clearance. In our series, we never used sternotomy to access the mediastinal trachea for malignant lesion. This is because of the surgeon's choice to avoid dissecting in between the major vessels (SVC, aorta, innominate vessels, and pulmonary artery) through a narrower quadrilateral space for radical lymph node dissection.[13] The advantage of using a trans-sternal approach is that the carina can be easily accessed. If need arises for left bronchial replacement to achieve extra tracheal length, it can be performed via the same incision.[14]

The length of trachea to be resected determines the extent of mobilisation. For cervical trachea lesions, all our patients underwent pretracheal fascia release, infralaryngeal, and precarinal dissection. For a resection of more than 3cm of cervical trachea, a supralarnygeal dissection was advocated as well. This will allow tension free anastomosis and reduce the risk of dehiscence. Despite the benefits, supralaryngeal release will cause dysphagia to the patient and may require to be on nasogastric tube feeding for 6 weeks after the surgery.[15,16] Tracheal mobilisation should be done mainly in the anterolateral aspect of the trachea, preventing dissection in the posterolateral plane to avoid disruption of the segmental tracheal blood supply.[17] None of our patients had pre or post-operative tracheostomy in the course of the management of tracheal stenosis as seen in other series.

For mediastinal trachea resection, laryngeal release has a minimal role in achieving extra tracheal remnant length.[18] Precarinal dissection, inferior pulmonary ligament dissection, and complete hilar release will provide extra length of around 1–2cm for mediastinal trachea anastomosis, especially near the carina. Three patients with mediastinal trachea resection with anastomosis near carina in our series underwent these mobilisation techniques with good outcome. In cases where around half the length of the trachea needs to be resected, the left main bronchus can be replaced on to the right bronchus intermedius to achieve greater remnant length.[5] Cervical flexion alone can reduce tension on the anastomosis by allowing descent of the cervical trachea into the mediastinum for up to 4cm.[19] Due to this, all our patients will be on chin chest suture post-operatively for 3–5 days until bronchoscopy is performed for anastomosis assessment. Neutral neck position is preferred. One must be cautious not to over flex the neck to avoid risking vertebral artery compression and stroke.[15]

The longest tracheal length resected in our series was 4.5cm for a patient with mediastinal tracheal squamous cell carcinoma. This patient underwent both transcervical approach and right posterolateral thoracotomy to achieve cervical, paratracheal as well as posterior carinal nodal clearance with anastomosis performed 1 cm from the carina. On-table frozen section of tracheal margin was sent to ensure tumour-free margin before anastomosis. The longest tracheal resected with successful reconstruction reported to date is 5.4cm by Mohsen et al.[19]

The complications we encountered were mainly related to dysphagia and lung collapse secondary to mucous plug. No anastomotic leak was seen. One patient with papillary thyroid carcinoma infiltrating the trachea and recurrent laryngeal nerve, developed left-sided vocal cord paralysis due to resection of the nerve. There was no mortality. In comparison with other published tracheal series, the complications seen in our series were lower.[3,4] This could be due to early referral by the primary team for surgical

Table I: Demographic characteristics

Parameters		Value
Age, years in mean (Range)		49.1 (14-78)
Sex, n (%)	Male	6 (43)
	Female	8 (57)
Presenting symptoms, n (%)	Dyspnoea	10 (71)
	Stridor	3 (21)
	Cough	3 (21)
	Reduced effort tolerance	2 (14)
	Hoarseness of voice	2 (14)
	Subcutaneous emphysema	2 (14)
	Odynophagia	2 (14)
	Haemoptysis	1 (7)
Comorbidity, n (%)	Nil	3 (21)
	Hypertension	7 (50)
	Diabetes mellitus	4 (29)
	Bronchial asthma	3 (21)
	Dyslipidaemia	3 (21)
	Ischaemic heart disease	1 (7)
	End stage renal failure/ CKD	2 (14)
	Paroxymal atrial fibrillation	1 (7)
	Chronic obstructive airway disease	1 (7)
	Endometrial carcinoma	1 (7)
	Hyperthyroidism	1 (7)
Cotton Meyer's Grading, n(%)	1	0
*One patient had acute tracheal	2	6 (46)
tear secondary to trauma without stenosis.	3	7 (54)
Karnofsky performance status Scale	90	6 (43)
	80	2 (14)
	70	3 (21)
	60	1 (7)
	50	2 (14)

Table II: Site of tracheal lesion with etiology

Site of lesion	Aetiology	No (n)
Cervical trachea	***Benign***	
	Tracheomalacia	2
	Traumatic tear	1
	Post intubation stenosis	1
	Malignant	
	Papillary thyroid carcinoma	2
	Total	6
Mediastinal trachea	Benign	
	Post traumatic stenosis	1
	Post intubation stenosis	4
	Malignant	
	Primary tracheal SCC[a]	1
	Primary tracheal adenocystic carcinoma	1
	Primary tracheal lymphoma	1
	Total	8

[a]Primary tracheal squamous cell carcinoma.

Table III: Surgical approaches

Variables	Types	Values
Surgical approach, n (%)	Transcervical	10 (71)
	Thoracotomy	1 (7)
	VATS[a]	1 (7)
	Transcervical combined with right VATS[a] and manubrial split	1 (7)
	Transcervical combined with right thoracotomy	1 (7)
Releasing manoeuvres, n (%)	Infrahyoid laryngeal release	13 (93)
	Suprahyoid laryngeal release	2 (14)
	Right hilar release	2 (14)

[a] VATS:video-assisted thoracoscopic surgery.

Table IV: Perioperative parameters

Variables	Total (n=14)
Airway management	
Intubated	11
Non-intubated	3
Duration of surgery, mean in minutes (range)	246.2 (70–540)
Blood loss, mean in mL (range)	185.7 (50–700)
Length of trachea resected, mean in cm (range)	2.3 (1.0–4.5)
Distance from vocal cords, mean in cm (range)	3.9 (1.0–8.4)
Distance from carina, mean in cm (range)	4.8 (1.0–8.0)
ICU/PACU[a] admission post operation, n (%)	10 (71)
Duration of ICU/PACU[a] stay, mean in days	1
Post op ventilation, n (%)	1 (7)
Duration of hospital stay, median in days (range)	9.5(4-29)
Post operative complications, n (%)	
Vocal cord paralysis	1 (7)
Dysphagia	3 (21)
Lung collapse due to mucous plug	2 (14)
Post op granuloma	1 (7)
Hospital acquired pneumonia	1 (7)
Anastomosis dehiscence	0
Post-operative mortality, n	0
Malignant lesions, n	5
Tumour size, mean in cm (range)	2.3 (1.7–3.5)
Margins involved, n (%)	
Yes	3 (60)
No	2 (40)

[a]ICU/PACU= Intensive care unit/post-operative acute care unit

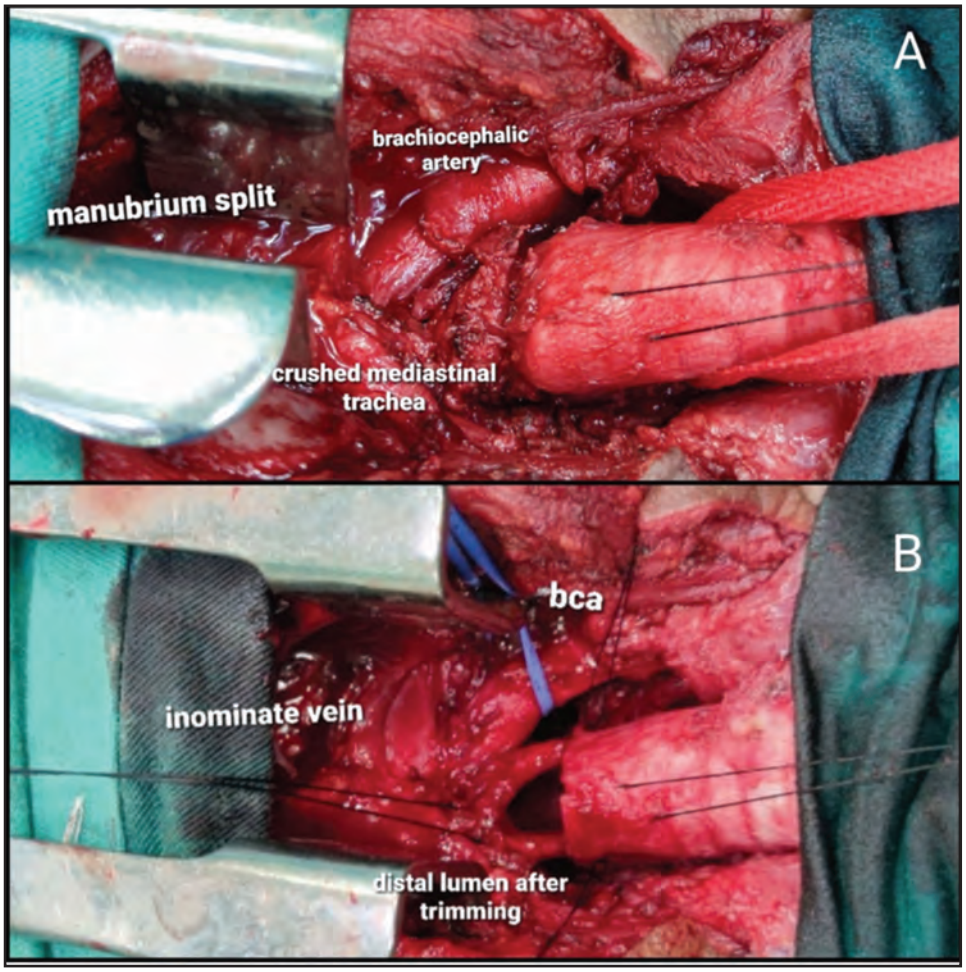

Fig. 1: (A) Case of traumatic injury to the mediastinal trachea where a manubrial split was performed to safely dissect the densely adhered brachiocephalic artery to the crushed trachea. (B) Right before anastomosis of the mediastinal trachea after resecting the crushed segment.

intervention as well as bias due to the low number of patients in our series.

CONCLUSION

Tracheal resection and anastomosis can be performed safely in complex stenosis and malignant tumours in experienced centres. Pre-operative planning with a multidisplinary approach is vital to ensure a good outcome. Capability of performing both intubated and non-intubated tracheal surgeries safely provide an option to manage the airway effectively without the need to use bypass procedures. Adequate release manoeuvres both in the larynx and mediastinum ensures tension-free anastomosis with minimal post-operative complications.

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