

# Procedural safety and outcome of rigid bronchoscopy in malignant central airway obstruction

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## ABSTRACT

**Introduction:** Malignant central airway obstruction (CAO) affects 20-30% of patients with primary lung cancer and is associated with poor prognosis without treatment. Therapeutic rigid bronchoscopy (RB) is an essential diagnostic and therapeutic tool in this group of patients. We aimed to assess the overall procedural outcomes and safety of RB for symptomatic malignant CAO at our institution.

**Materials and Methods:** Retrospective chart review included 57 patients with malignant CAO who underwent RB between March 2016 and June 2022.

**Results:** Our cohort comprised 75.4% males with a median age of 60 years. Isolated right and left main bronchus involvement was observed in 50% and 41.7% of the patients, respectively, with 21.1% experiencing concurrent tracheal involvement. In our cohort, 80% had primary lung cancer, with 35.1% of these cases being squamous cell carcinoma. The re-canalization success rate was 98%, with no intraoperative or immediate postoperative mortality. More than half of the patients (54.4%) required airway stenting to maintain patency after re-canalization. Patients with tracheal involvement, non-intrinsic type of CAO, and right main bronchus involvement had a higher likelihood of requiring airway stenting. There were 24 cases with mild, self-limiting complications and 3 cases with severe procedure-related complications. The 30-day survival rate of our cohort was 91.6%.

**Conclusion:** RB is a safe and effective procedure in patients with malignant CAO. Long term prospective data from multiple centers in our region are anticipated to determine long-term safety and outcomes.

## KEYWORDS:

*Rigid bronchoscopy, Malignant central airway obstruction*

## INTRODUCTION

Central airway obstruction (CAO) is defined as symptomatic airway obstruction with an endoluminal diameter of <50%, affecting the trachea, right or left main bronchus, or bronchus intermedius, as observed on imaging or bronchoscopy<sup>1</sup>. Malignancy is one of the most common causes of lung cancer globally<sup>1,2</sup>, often from primary lung cancer or lung metastases<sup>3</sup>.

In Malaysia, lung cancer is the most prevalent type of cancer and most patients are diagnosed at an advanced stage.<sup>4</sup> Hence, most patients with malignant CAO present life-threatening symptoms and are often ineligible for definitive treatment. Around 20-30% of primary lung cancer cases have malignant CAO at diagnosis,<sup>1</sup> and approximately 5% develop it during treatment.<sup>2</sup> This complication worsens the already dismal prognosis of lung cancer patients.<sup>4,5</sup>

Nowadays, interventional bronchoscopists typically classify malignant CAO into three categories: extraluminal (extrinsic), endoluminal (intrinsic), or mixed.<sup>6</sup> This classification is key for determining the bronchoscopic management. The EpiGETIF registry demonstrated that most malignant CAOs are intrinsic (43.3%) or mixed types (41.5%), as bronchogenic tumors are the primary cause.<sup>7</sup>

Rigid bronchoscopy (RB) is a minimally invasive technique within the realm of interventional pulmonology that allows effective restoration of airway patency in patients with symptomatic CAO. Surgery is often contraindicated, and systemic chemotherapy and radiotherapy may not provide immediate relief.<sup>8,9</sup> Therefore, RB is a crucial bridging therapy.

While RB for malignant CAO is well established in developed countries, data on its efficacy and safety in developing countries are limited. Thus, we conducted a retrospective observational study in a single institution in Malaysia to assess the demographic characteristics, overall procedural outcomes, and safety of RB in symptomatic malignant CAO.

## MATERIALS AND METHODS

### Study Design & Setting

This was a retrospective chart review of consecutive adult patients undergoing RB for malignant CAO from March 2016 to June 2022 at Sarawak General Hospital, Malaysia. The study protocol was approved by the Medical Research and Ethics Committee of the Ministry of Health Malaysia (NMRR-ID-23-00354-T5Q (IIR)). The requirement for informed consent was waived owing to the retrospective nature of the study.

### Rigid Bronchoscopy Procedure for Malignant CAO

#### i. Pre-procedural Planning

All patients underwent contrast-enhanced chest CT to

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evaluate airway invasion and pulmonary vascular integrity. The decision to proceed with airway intervention was tailored to each patient's fitness, imaging results, and, crucially, the multidisciplinary tumor board's assessment of treatment options and disease prognosis.

### Rigid Bronchoscopy Tumour Debulking

All patients scheduled for RB were first referred to an anesthesiologist for risk assessment and optimization, as most procedures were performed in emergency or semi-emergency situations in the operating theatre. At our institution, most cases were performed under total intravenous anesthesia (TIVA), with assisted ventilation, intermittent neuromuscular blockade, and invasive monitoring, including arterial blood pressure.

Rigid tracheoscopes and bronchoscopes of various sizes (*Efer-Dumon*<sup>®</sup>, *Efer Endoscopy, La Ciotat, France*) were used at our institution. In most cases, a flexible bronchoscopy system (*BF-1TH190, BF-H190, Olympus Medical, Japan*) was used in conjunction with a rigid bronchoscopy system to allow for more flexibility and reach.

The tumor-debulking modalities employed in our institution primarily comprise mechanical methods and thermal devices. Mechanical coring was performed using rigid tracheal or bronchial tubes and dilatation using various sizes of controlled radial expansion (CRE) balloon catheters (*CRE*<sup>®</sup>, *Boston Scientific, Natick, MA*). Thermal devices included an electrocautery snare or probe and argon plasma coagulation (APC) (*VIO 300D, Erbe Elektromedizin, Tübingen, Germany*), as well as cryo-technology (*ERBECRYO*<sup>®2</sup>, *Erbe Elektromedizin, Tübingen, Germany*) with at reusable 1.9-mm/2.4-mm cryoprobe or single use 1.1-mm/1.7-mm/2.4-mm flexible cryoprobe.

After the procedure, patients were monitored in the ICU or HDU for 24-48 hours. Chest radiography was performed to confirm lung re-expansion and identify any complications. An oncology referral was performed before discharge to ensure the timely initiation of treatment. The first surveillance bronchoscopy was typically scheduled 4-6 weeks post-RB.

### Airway Stenting

Airway stenting was considered when airway patency remained at <50% after debulking and dilatation. The bronchoscopist chose between metallic and silicone stents based on the airway's geometry and orientation. At our institution, partially covered or uncovered self-expanding metallic tracheobronchial stents (*SEMS, UltraflexTM 94, Boston Scientific, Natick, MA*) of various sizes were available. For silicone stents, the straight and Y-bifurcation stents (*DumonTM, Novatech, La Ciotat, France*) were available.

SEMS placement was performed under direct bronchoscopic vision, sometimes under fluoroscopy and guidewire guidance. Silicone stents were deployed using a dedicated stent loader and applicator, with the pulling-back technique being the most commonly used. On-site customization of the silicone stent is sometimes necessary to accommodate a patient's specific airway geometry.

### Definition

The primary outcome was defined as successful airway recanalization, with ≥50% patency achieved by eye balling<sup>10</sup>. As a secondary outcome, we assessed the proportion of patients who were able to undergo oncology treatment, inferred from their fitness for subsequent surveillance bronchoscopy.

Bleeding is classified according to standard definition<sup>11</sup> as follows:

- Grade 1: Bleeding is self-limiting and resolves with suctioning for <1 minute.
- Grade 2: Bleeding requires suctioning for >1 minute or instillation of a hemostatic agent.
- Grade 3: Bleeding necessitates balloon blockade for <20 minutes or premature termination of the procedure.
- Grade 4: Bleeding requires balloon blockade for >20 minutes, transfusion, admission to the ICU, resuscitation, or bronchial artery embolization.

### Statistical Analysis

SPSS (version 20; *Chicago, IL, USA*) was used for the data analysis. Normality was assessed using the Shapiro-Wilk test. The results are presented as mean ± standard deviation (SD) for normally distributed variables and as median and interquartile range (IQR) for non-normally distributed variables. Categorical data were expressed as absolute numbers and percentages, and compared using Pearson's chi-square test or Fisher's exact test. Independent sample t-tests and Mann-Whitney tests were used to compare normally and non-normally distributed variables, respectively, between the groups. A p-value of <0.05 was considered significant.

## RESULTS

A total of 61 RB procedures were performed during the study period, of which 57 (93.4%) were for indications of malignant CAO and were included in this study.

### Baseline demographic and obstruction characteristic

Our cohort comprised 75.4% male patients with an overall median age of 60.0 (IQR 54.0-68.5) years. No ethnic differences were observed.

Isolated unilateral main bronchi involvement was the most common, affecting RMB in 50.0% and LMB in 41.7% respectively. Out of these cases, trachea was concurrently involved in 21.1%. Concurrent segmental airway involvement was reported in 56.1% of the cases. The predominant obstructions were purely intrinsic (45.6%) and mixed (36.8%), while 17.5% were purely extrinsic.

The most common histological finding was primary lung cancer (of 45/57, 78.9%), with nearly one-third (35.1%) being squamous cell carcinoma. Secondary metastatic malignancy was observed in 21.1% (12/57) of the patients. The complete details can be found in Table I.

### Overall procedure characteristic and outcome

All RB procedures were performed in the operation theatre under TIVA with assisted ventilation and intermittent

Table I: Baseline demographic, obstruction and procedural characteristic

Clinical demographic and obstruction characteristic	
Median age (IQR), years	60.0 (54.0-68.5)
Gender, n (%)	
Male	43 (75.4)
Female	14 (24.6)
Race, n (%)	
Native Sarawak	21 (36.8)
Chinese	20 (35.1)
Malay	16 (28.1)
Obstruction site, n (%)	
Trachea	12 (21.1)
Right main bronchus	25 (43.9)
Bronchus intermedius	8 (14.0)
Left main bronchus	23 (40.4)
Segmental airway involvement, n (%)	32 (56.1)
Obstruction type, n (%)	
Pure Extrinsic	10 (17.5)
Pure Intrinsic	26 (45.6)
Mixed	21 (36.8)
Procedural characteristic and outcome	
Median procedural duration (IQR), minutes	90 (60-135)
Debulking modalities, n (%)	
Rigid forceps	40 (70.2)
Electrocautery	37 (64.9)
Cryoprobe	31 (54.4)
Argon plasma coagulation	18 (31.6)
Mechanical balloon dilatation	12 (21.1)
Recanalization success, n (%)	56 (98.0)
Patient requiring stent, n (%)	31 (54.4)
Stents, n (%)	
Self expanding metallic stent	15 (48.4)
Silicone stent	16 (51.6)
Patient fit for subsequent surveillance bronchoscopy, n (%)	33 (57.9)
<b>Final histology</b>	<b>N (%)</b>
Primary lung malignancy	45 (78.9)
Squamous cell carcinoma	20 (35.1)
Adenocarcinoma	11 (19.3)
Small cell carcinoma	8 (14.0)
Carcinoid	1 (1.8)
Adenoid cystic carcinoma	1 (1.8)
Mucoepidermoid carcinoma	1 (1.8)
Combined squamous and small cell carcinoma	1 (1.8)
Non-small cell pleomorphic carcinoma	1 (1.8)
Combined small and large cell neuroendocrine carcinoma	1 (1.8)
Secondary metastatic lung malignancy	12 (21.1)
Metastatic colorectal adenocarcinoma	3 (5.3)
Metastatic oesophageal carcinoma	2 (3.5)
Hodgkin's lymphoma	2 (3.5)
Metastatic breast adenocarcinoma	1 (1.8)
Metastatic thyroid adenocarcinoma	1 (1.8)
Metastatic ovarian adenocarcinoma	1 (1.8)
Metastatic renal adenocarcinoma	1 (1.8)
Metastatic pleomorphic liposacorma	1 (1.8)

neuromuscular blockade. The median procedural duration was 90 (IQR 60-135) minutes.

The debulking modalities in our cohort included energy devices, cryotechnology, and mechanical methods. Energy devices comprising electrocautery and APC were used in 64.9% and 54.4% of the cases, respectively. Cryoprobes was used for cryo-recanalization and cryo-extraction in 54.4% of cases. Mechanical recanalization involved rigid forceps (70.2%) and, a CRE balloon (21.1%) coupled with manual coring via the rigid tracheal or bronchial tube (Table II).

Primary recanalization was successful in 98% (56/57) of patients, with one unsuccessful attempt. Overall, 57.9% (33/57) of patients received systemic oncological therapy and underwent follow-up surveillance bronchoscopy. As shown in Table II, there were no significant differences in fitness for surveillance bronchoscopy based on malignancy type, sex, tracheal or main bronchi involvement, or airway stenting.

Among 32 patients with complete follow-up data, the 30-day survival rate was 91.6%. No intra-operative or short-term procedure-related mortality was observed in this cohort. Mild

**Table II: Factors associated with fitness for surveillance bronchoscopy post rigid bronchoscopy**

Factors		Fit, n (%)	p-value
Malignancy	Primary	26 (57.8)	0.972
	Metastatic	7 (58.3)	
Gender	Male	24 (55.8)	0.577
	Female	9 (64.3)	
Types of CAO	Intrinsic	12 (46.2)	0.115
	Non-intrinsic	21 (67.7)	
Trachea involvement	Involved	9 (75.0)	0.177
	Spared	24 (53.3)	
Left main bronchus involvement	Involved	16 (69.6)	0.142
	Spared	17 (50.0)	
Right main bronchus involvement	Involved	13 (52.0)	0.426
	Spared	20 (62.5)	
Bronchus intermedius involvement	Involved	3 (37.5)	0.208
	Spared	30 (61.2)	
Segmental airway involvement	Involved	20 (62.5)	0.426
	Spared	13 (52.0)	
Airway stent	Stented	21 (67.7)	0.100
	No stent	12 (46.2)	

**Table III: Factors associated with likelihood of airway stenting**

Factors		Stent, n (%)	p-value
Malignancy	Primary	27 (60.0)	0.099
	Metastatic	4 (33.3)	
Gender	Male	26 (60.5)	0.106
	Female	5 (35.7)	
Types of CAO	Intrinsic	0 (0.0)	<0.001
	Non-intrinsic	31 (100.0)	
Trachea involvement	Involved	11 (91.7)	0.004
	Spared	20 (44.4)	
Left main bronchus involvement	Involved	12 (52.2)	0.783
	Spared	19 (55.9)	
Right main bronchus involvement	Involved	19 (76.0)	0.004
	Spared	12 (37.5)	
Bronchus intermedius involvement	Involved	5 (62.5)	0.619
	Spared	26 (53.1)	
Segmental airway involvement	Involved	14 (43.8)	0.068
	Spared	17 (68.0)	

bleeding (Grade 1-2) was occurred in 42% (24/57) of the patients and was self-limiting. However, severe complications occurred in three patients (5.3%): one with grade 4 bleeding leading to premature procedure termination, another with a partial mucosal tear at the main bronchus requiring stenting, and one who developed post-procedure pneumothorax requiring intercostal chest tube drainage.

**Factors associated with likelihood of airway stenting**

Approximately 54.4% (31/57) required airway stenting to maintain the recanalization effect during the same RB procedure, with more silicone stents (51.6%) placed than SEMS (48.4%).

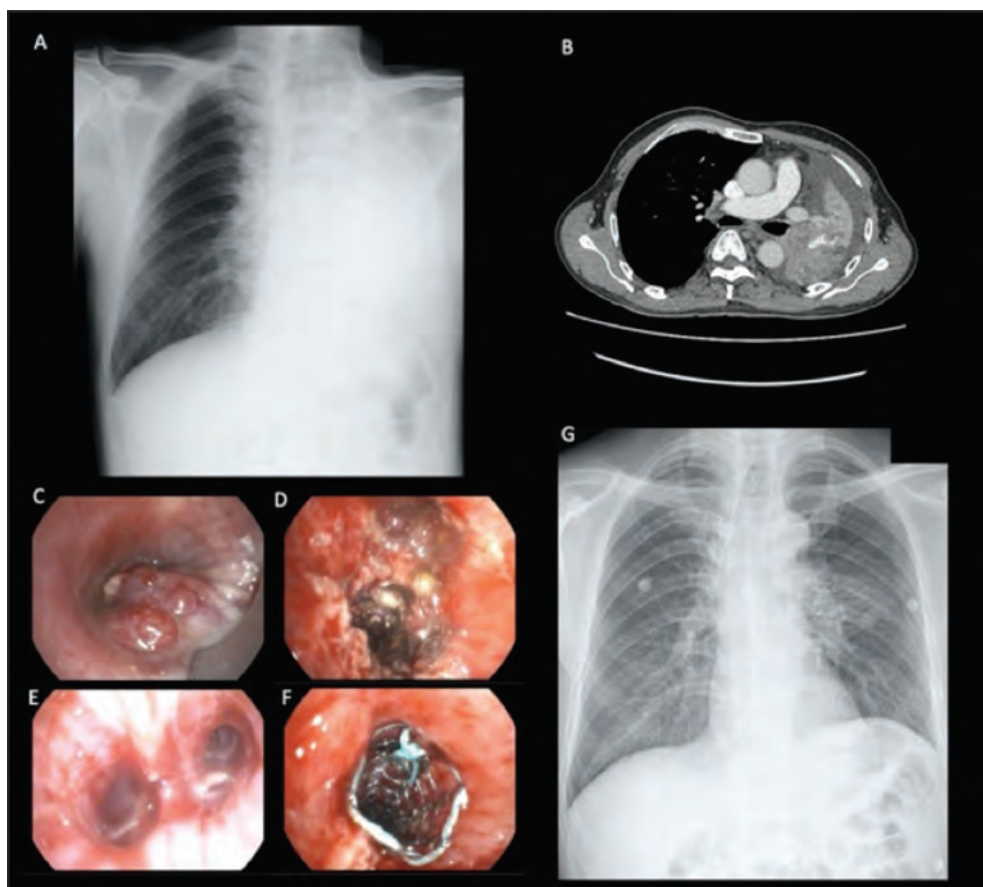
Among patients with tracheal involvement, 91.7% (11/12) required stenting. SEMS were placed in three patients, while Y-bifurcation silicone stents were placed in eight patients due to concurrent main bronchi involvement (Figure 2.0). In contrast, only 44.4% (20/45) of patients with main bronchi obstruction without tracheal involvement required stenting, with 12 SEMS and 8 straight silicone stents deployed (Figure 1.0).

Tracheal involvement significantly increased the need for stenting to maintain patency (91.7% vs. 44.4%; p<0.01). None of the patients with pure intrinsic CAO required a stent, whereas all patients with pure extrinsic or mixed types of CAO required stenting (p<0.001). Nonintrinsic CAO (p<0.001) and right main bronchus involvement (p<0.05) were associated with a higher likelihood of airway stenting in our cohort. (Table III)

For patients with airway stents, the overall stent-related complication rate was 35.5% (11/31), which included stent migration (n=4) and restenosis due to tumor ingrowth (n=7).

**DISCUSSION**

Our study demonstrated that RB is effective and safe for malignant CAO in our region. The primary success rate, defined as successful recanalization, was 98%, with 5.3% severe adverse events. This aligns with the literature, where the recanalization rate was 93.7-100%, and almost half of the patients reported symptomatic improvement in breathlessness and quality of life<sup>12-14</sup>. The EpiGETIF registry



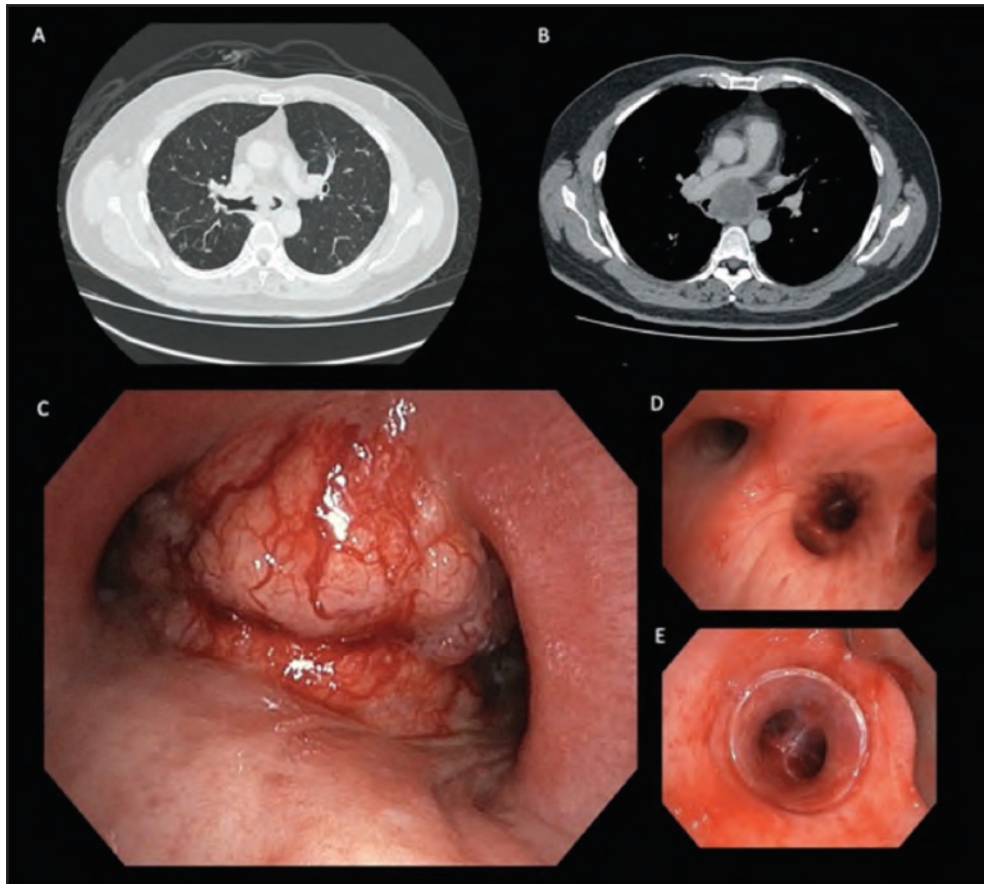
**Fig. 1:** Representative Case (1) – Small cell carcinoma causing left main bronchus malignant CAO. Patient presented with constitutional symptoms and exertional dyspnoea, chest radiograph on arrival shown complete left lung collapse (Panel A). Contrast enhanced CT thorax demonstrated a proximal hilar tumour eroding into the left main bronchus (LMB) with preserved pulmonary vasculature associated with distal atelectasis (Panel B). Rigid bronchoscope revealed a mixed type CAO in the LMB (Panel C) which was then debulked with hot and cold modalities to reveal the left upper and lower lobe bronchi (Panel D). The basal segment of left lower lobe was patent (Panel E) and a partially covered self-expanding metallic stent was deployed in the LMB across the LUL bronchus. Patient then underwent chemotherapy (carboplatin and etoposide) and remained well eight months later with left lung aeration (Panel G).

reported that 87.8% of patients achieved a mean improvement of 4.1 points in the Borg dyspnea score<sup>7</sup>. By contrast, Akash et al.<sup>13</sup> reported that 8.3% of severe adverse events required escalation of care, whereas Kim et al.<sup>14</sup> found a 17% rate of immediate post-procedural complications. Furthermore, the AQuIRE Registry reported an overall complication rate of 3.9% across 15 centers, ranging from 0.9% to 11.7%, whereas the EpiGETIF registry showed an overall complication rate of 10.9%<sup>7,15</sup>. Moreover, nearly two-thirds (57.9%) of our patients received systemic oncological therapy following RB intervention. Malignant CAO severely affect the survival of patients with lung cancer, with a median survival of 2-3 months<sup>16</sup>. Previous studies indicate that therapeutic bronchoscopy for CAO can yield median survival rates comparable to those without CAO (8.4 vs. 8.2 months)<sup>17</sup>. Hence, patients eligible for airway interventions should always be considered for RB when resources are permitted.

The median age and sex distribution of patients with malignant CAO in our cohort were in concordance with regional data from Asia and France, where the median age was 63 years and two-thirds of the patients were male<sup>7,13,14,18</sup>.

The finding that primary lung cancer was the leading cause of malignant CAO was also consistent with cohorts from Asia, France, and the UK<sup>1,7,13,14</sup>. This is an important observation, as NSCLC in our region is often linked to EGFR mutations, which respond well to oral tyrosine kinase inhibitors<sup>19</sup>. Therefore, efforts to relieve malignant CAO are essential to ensure that patients receive effective targeted treatment. In our cohort, adenocarcinoma was a minor cause of malignant CAO (19.3%) compared with other tumor types. Therefore, chemotherapy and immunotherapy are the preferred treatment options for patients with a performance status (PS) <2. Interestingly, most CAO types in our cohort were extrinsic and mixed, likely due to the predominance of NSCLC or SCLC in our cohort, which causes direct airway invasion or compression from lymphadenopathy, rather than tumors predominantly in the airway, such as carcinoid and salivary gland tumors<sup>20,21</sup>.

Multiple techniques were employed for airway recanalization. Rigid forceps and mechanical coring using a rigid tube were the most commonly used in our cohort. While effective in removing tumor tissue, these methods can be challenging when the axis of the airway cannot be



**Fig. 2:** Representative Case (2) - Metastatic squamous cell carcinoma with main carinal infiltration causing central airway obstruction. Patient presented to us with hemoptysis and exertional dyspnea with CECT Thorax showing intraluminal mass over the main carinal region obstructing bilateral main bronchi (Panel A) and a large subcarinal lymph node (Panel B). Under rigid bronchoscopy, main carinal infiltration was confirmed with a highly vascular tumour over the main carina causing a mixed type CAO (Panel C). Cautious bronchoscopic examination confirmed distal airway patency bilaterally (Panel D). A silicone Y-stent was deployed over the main carina which translated to immediate relief of breathlessness. Patient then went on to palliative chemotherapy.

confidently aligned with the rigid bevel or in angulated regions of the lung<sup>6,22</sup>. Hence, various flexible ancillary tools are used in tandem with flexible bronchoscopy, including an electrocautery probe/snare, APC, and cryotherapy. Combining flexible and rigid bronchoscopy harnesses the strengths of both systems, offering greater access to the airway while maintaining flexibility for interventions at acute angles.

In our cohort, 54.4% of patients required a stent to maintain airway patency after debulking. The factors associated with an increased likelihood of stenting included tracheal involvement, RMB involvement, and extrinsic CAO type. Notably, two of the (21.1%) patients presented with tracheal involvement. In these patients, either side of the main bronchi was invariably be involved, and we showed that the likelihood of stent insertion was significantly higher than those without tracheal involvement. This is consistent with the findings from other Asian centers. A Japanese cohort reported that 54% of stents were placed in the trachea and carina, while a Singaporean cohort found that 52% of CAO involving the trachea required stenting<sup>8,13</sup>. Akash et al.<sup>13</sup> noted a CAO incidence of 33.3% at the LMB compared to 29% at the RMB and BI, resulting in a higher stent requirement rate of 67% for the LMB. Conversely, the

Japanese cohort demonstrated a higher airway stenting rate in the RMB and BI (23%) than in the LMB (22%)<sup>8</sup>. Additionally, the Canadian and UK cohorts found a significantly higher CAO incidence in the RMB and BI (64.8% and 63%, respectively) than in the LMB (29.7% and 22%, respectively)<sup>1,12</sup>. The higher incidence of CAO in the RMB may be related to its anatomical characteristics – wider, shorter, and more aligned with the trachea, making it susceptible to the deposition of inhaled carcinogens. Additionally, increased airflow distribution to the right lung and the right lymphatic drainage system may also be contributing factors<sup>23,24</sup>, a hypothesis supported by extrapolating from our understanding that pulmonary tuberculosis is more common in the right lung<sup>25</sup>. Lastly, we have shown that in patients with pure extrinsic type of malignant CAO, a stent is invariably needed, in line with the literature<sup>6</sup>. Only around 4 in 10 patients with mixed-type CAO required airway stenting post intervention, as the debulking process itself likely addressed the intrinsic portion of the CAO, rendering stenting unnecessary.

We also reported a significant stent-related complication rate of 35.5%, primarily due to stent migration and restenosis due to tumor ingrowth. This rate exceeds the literature rate of 16.6% for stent migration and 42% for stent related infections

in the AQuIRE Registry<sup>15</sup> and the 0.7% complication rate in the EpiGETIF registry.<sup>7</sup> We attribute this to the limited stent options in our region to match the airway configuration in malignant CAO, which is often distorted and not in standard anatomical alignment. Although silicone stents allow customization<sup>26</sup>, the pressure points may not be ideal, leading to granulation tissue formation or migration. Customized three-dimensional printed stents based on individual airway anatomy may offer a future solution for this issue<sup>27</sup>.

Our study has several limitations. Its retrospective design and single-institution data limit its ability to draw firm conclusions. However, it provides valuable insights into CAO demographics in our region and represents the largest cohort in Malaysia to date, which will be useful for clinicians. While we reported low adverse events in the intraprocedural and immediate postprocedural periods, long-term data on survival, quality of life, and exercise tolerance are lacking. Additionally, performance status or the Borg Score Scale would be a better tool for evaluating the outcomes. However, we did not have access to this information owing to the retrospective nature of the study. Nonetheless, in 32 patients with full follow-up, the 30-day survival rate was 91.6%, similar to the 30-day mortality rate of 14.8% in the AQuIRE registry. Finally, further research is needed to determine the methods for monitoring and preventing stent-related complications.

## CONCLUSION

Rigid bronchoscopy is a safe and effective treatment for malignant CAO in patients with advanced malignancy. We achieved a recanalization success rate of 98%, with 54.4% of patients requiring airway stenting. Tracheal and right main bronchus involvement as well as non-intrinsic CAO were more likely to require stenting. Future multicenter studies in this region are expected to provide long-term safety and outcome data.

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