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Management of Significant Airway Bleeding during Robotic Assisted Bronchoscopy: A Tailored Approach

Sebastian Fernandez-Bussy[a] David Abia-Trujillo[a] Adnan Majid[b] Erik E. Folch[c] Neal M. Patel[a] Felix J.F. Herth[d] Janani S. Reisenauer[e]

[a]Divisions of Pulmonary, Allergy, Sleep Medicine & Respiratory Services/Mayo Clinic, Jacksonville, FL, USA; [b]Division of Thoracic Surgery and Interventional Pulmonology/Beth Israel Deaconess Medical Center, Boston, MA, USA; [c]Department of Pulmonary and Critical Care Medicine/Massachusetts General Hospital, Boston, MA, USA; [d]Department of Pulmonology and Critical Care Medicine, Thoraxklinik at the University of Heidelberg, Heidelberg, Germany; [e]Division of General Thoracic Surgery/Mayo Clinic, Rochester, MN, USA

Established Facts

- Robotic assisted bronchoscopy (RAB) represents a major turning point in bronchoscopic history.
- Significant airway bleeding (SAB) is reported to complicate 2.4% of RABs. The management strategies to address SAB in this "robotic era" are not well documented, and further guidance is required.

Novel Insights

- We present our standardized approach for significant airway bleeding (SAB) during robotic assisted bronchoscopy (RAB).
- We included a video illustrating our management strategy using a combined and simultaneous flexible/robotic bronchoscopic approach if SAB during RAB is encountered.

Keywords
Robotic assisted bronchoscopy · Significant airway bleeding · Lung nodule

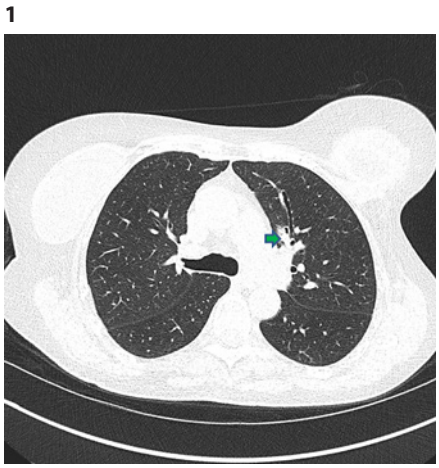
Abstract
Robotic assisted bronchoscopy represents a major turning point in bronchoscopic history. The management strategies to address significant airway bleeding in this "robotic era" are not well documented, and further guidance is required. We present a case report that exemplifies our approach and management strategy using a combined and simultaneous flexible/robotic bronchoscopy if this complication is encountered.

Introduction

Robotic assisted bronchoscopy (RAB) represents a major turning point in bronchoscopic history. However, data supporting its superiority are still limited [1].

karger@karger.com
www.karger.com/res

David Abia-Trujillo
Divisions of Pulmonary, Allergy, Sleep Medicine and Respiratory Services
Mayo Clinic, Jacksonville
4500 San Pablo Road, Jacksonville, FL 32224 (USA)
abiatrujillo.david@mayo.edu



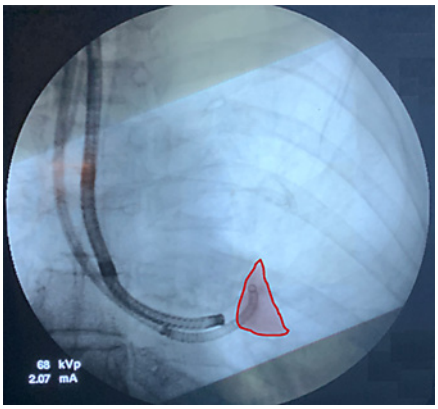


Fig. 1. Chest computed tomography showing the LUL nodule (green arrow). LUL, left upper lobe.
Fig. 2. Fluoroscopic image of simultaneous use of flexible and robotic bronchoscopy to manage severe airway bleeding. Bleeding is shaded in red.

The expectations around RAB are high, and it is a promising tool that could revolutionize peripheral bronchoscopic navigation, with substantial potential for ablative therapy [2]. This cutting-edge technology remains promising; however, it brings unknowns with respect to traditional bronchoscopy risk such as bleeding [3]. The management strategies to address significant airway bleeding (SAB) in this robotic era are not well documented, and further guidance is required. We present a case report that exemplifies our approach and management strategy if this complication is encountered.

Case Report

A 71-year-old woman and former smoker (6 pack/year history) with a remote medical history of breast cancer was referred for multiple lung nodules incidentally found during a workup for perforated left breast prosthesis. She had no pulmonary symptoms. A chest CT scan showed a 1-cm elongated nodular opacity along the anterior left upper lobe (LUL) bronchus and adjacent to a large blood vessel (3.8 mm) (Fig. 1). A robotic assisted bronchoscopic biopsy of the LUL lesion was recommended, and the procedure was performed by an expert bronchoscopist with specialized interventional pulmonology training. The RAB was performed under general anesthesia, and paralytics were used. The airway was accessed through a size 8 standard endotracheal tube (ET). The endobronchial navigation was performed after alveolar recruitment maneuver was performed and continued with a PEEP of 10 for the rest of the procedure. These maneuvers were performed with the intention to split open small subsegmental airways and facilitate the advancement of the scope beyond the 5th–6th generation without air insufflation.

The target lesion was reached utilizing the Fiber Optic RealShape technology for endoluminal navigation. Once the virtual target region was reached, the 3.5-mm-outer diameter catheter with a 2.0-mm working was locked in position, and utilizing a radial ultrasound probe, the lesion was confirmed by identifying a peribronchiolar lesion. The needle-pass sampling was aided with live fluoroscopy. Upon collecting tissue samples with a 21-G needle, bleeding was noted traveling proximally along the robotic catheter and on live fluoroscopic images (Fig. 2). Suction was applied to the proximal end of the robotic catheter. Simultaneously, a flexible bronchoscope (4 mm OD), with a 2.0-mm working channel, was inserted into the airways, parallel to the robotic scope, to help control the bleeding. The flexible bronchoscope was inserted through the nose, traversing the vocal cords parallel to the ET (Fig. 3a). The ET cuff was then partially deflated, and the bronchoscope was advanced into the distal trachea and distal left main stem bronchus (Fig. 3b–d). Bleeding was noted emanating from the LUL surrounding the wedged robotic bronchoscope (Fig. 2, 3g). Ice saline and epinephrine were instilled into the bronchial segment where the robotic scope was located. After bleeding ceased and under direct visualization with the flexible bronchoscope, the

Table 1. Airway bleeding management during robotic bronchoscopy

1.	Apply continuous suction to the proximal end of the robotic catheter
2.	Insert a 4.0-mm FB through the nose or mouth
3.	Advance the FB through the vocal cords and the ET
4.	Partially deflate the ET cuff and advance the FB to the bronchial segment or subsegment of interest
5.	Do not retract the RB
6.	Use the FB to apply, in a standard fashion, cold saline, diluted epinephrine 1:10,000, 5-Fr Fogarty balloon or any other hemostatic medication parallel to the RB
7.	When bleeding is controlled, retract the robotic scope slowly under direct visualization with the FB
8.	Suction or cryoextraction of the remaining clots from the airway

FB, flexible bronchoscope; RB, robotic bronchoscope; ET, endotracheal tube.

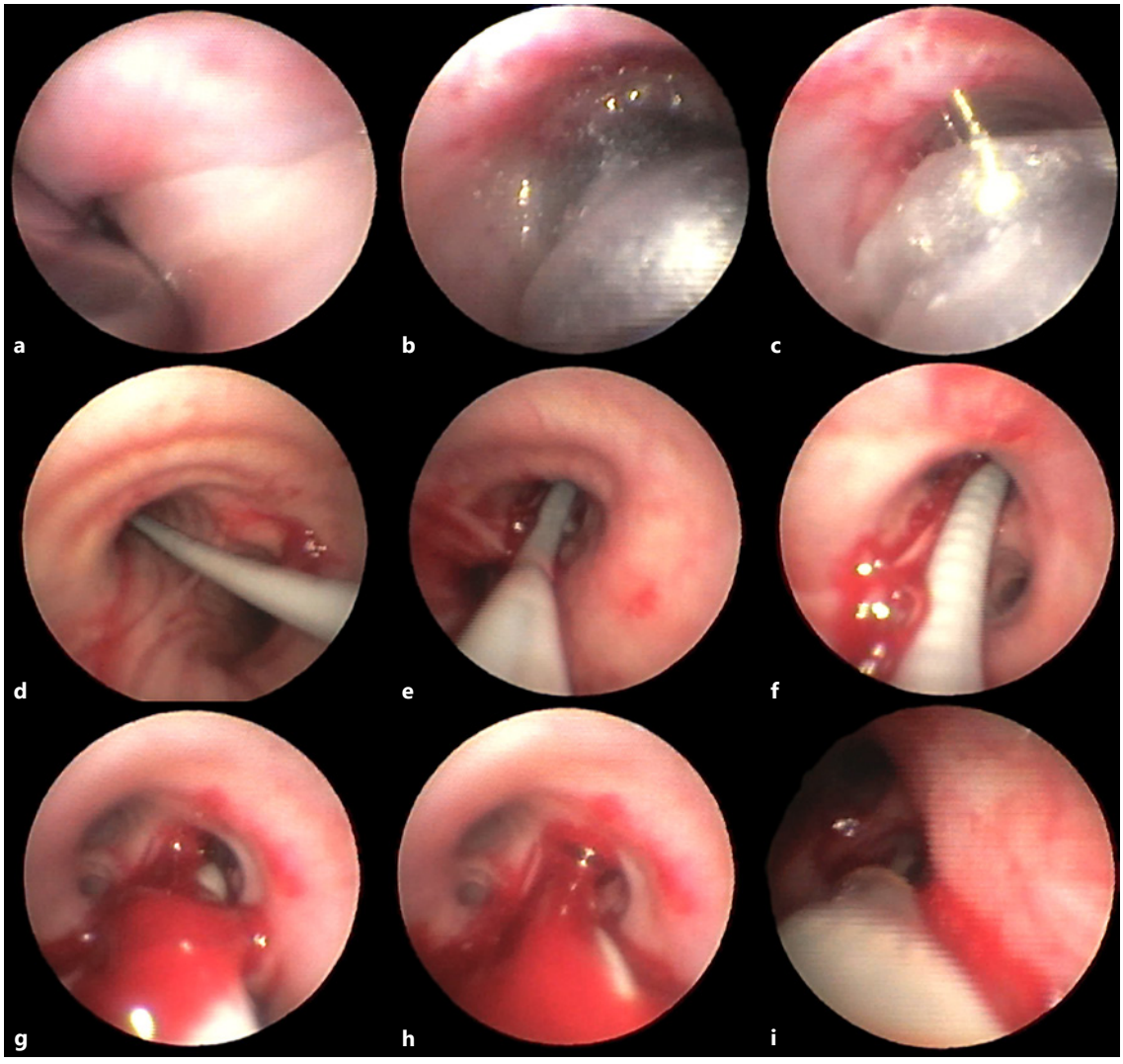


Fig. 3. Bronchoscopic images of the combined simultaneous approach of flexible and robotic bronchoscopy to manage severe airway bleeding. **a** Flexible bronchoscope passing parallel to the ET at the level of the vocal cords. **b**, **c** Partial deflation of the ET cuff and subsequent advancement of the flexible bronchoscope into the trachea. **d**, **e** Robotic bronchoscope noted with the flexible bronchoscope going into the left mainstem bronchus and subsequently into the bleeding segment. **f–i** Management of the LUL bleeding during robotic bronchoscopy. LUL, left upper lobe; ET, endotracheal tube.

robotic scope was retracted and the flexible bronchoscope was advanced into the bleeding segment to confirm successful hemostasis and to suction any remaining clots (Fig. 3h). Complete airway clearance was then performed. The robotic scope was reinserted to continue the procedure (Fig. 3i). Finally, once RAB was concluded, systematic mediastinal staging with EBUS was done. No pneumothorax, worsening hypoxemia, or other complications occurred. The patient was discharged home. Final pathology report revealed nonmalignant disease. A follow-up chest CT scan will be performed in 3 months.

Discussion/Conclusion

Bleeding occurring after a transbronchial lung biopsy using flexible bronchoscopy has standard definitions and accepted management strategies [3]. However, the experience with bleeding during RAB is limited. SAB during RAB is defined as one that requires the withdrawal of the robotic bronchoscope, and insertion of a flexible bronchoscope to manage the bleeding [4]. It is reported to complicate 2.4% of RABs [2, 4]. Its current treatment includes tamponade

and containment of the localized bleeding with distal wedging of the robotic bronchoscope [2]. The treatment modalities for SAB are limited, and this is in part due to the trade-off between the stability and reach needed for peripheral bronchoscopy against the delayed reaction capacity and small channel allowing for suboptimal suction. Fortunately, this complication appears to be rare; however, it remains a constant threat to patients, and a clear and effective treatment algorithm is required. If such an episode is encountered in the future, it is the authors' recommendation to implement our proposed management strategy with combined, simultaneous flexible and robotic bronchoscopy (Fig. 2) as a next immediate step (Table 1).

Statement of Ethics

Verbal and witnessed informed consent was obtained from the patient for publication of this case report and any accompanying images. The consent was obtained verbally and witnessed given the current COVID-19 pandemic and with the goal of limiting patient's visits to the healthcare facilities.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

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Author Contributions

All authors made substantial contributions to conception and design, analysis, and interpretation of the manuscript. All authors have revised and approved the final version of the manuscript for submission.

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