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CASE SERIES

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A customized multimodality approach for prolonged air leaks (PAL) in mechanically ventilated patients

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Abstract

ARDS in general and severe COVID ARDS (CARDS) is particularly associated with high rates of barotrauma. Two cases with severe CARDS developed bilateral pneumothorax with persistent air leak (PAL). Conservative management with prolonged chest tube drainage did not help in PAL resolution and both patients continued to be on high-end ventilatory support. The course was further complicated by the presence of septic shock. The 1st patient was taken up for a challenging procedure after spending 23 days on the mechanical ventilator. Diagnostic pleuroscopy revealed left-sided bullae and a surgical staple bullectomy was done. The right side showed a large bronchopleural fistula (BPF) on pleuroscopy, which was occluded using a customized endobronchial silicone blocker (CESB, described in 2018). This led to the reduction and finally, resolution of the bilateral PAL with subsequent removal of chest drains and weaning off the ventilator and oxygen. The second patient was managed with 2 CESB devices for occlusion of RUL anterior and posterior segment fistulae, followed by chest drain removal. These cases highlight effective out-of-the-box multimodality treatment using a combination of interventional pulmonary techniques and surgical stapling for a life-threatening bilateral PAL secondary to CARDS.

KEYWORDS
barotrauma, bronchoscopy, COVID ARDS, customized endobronchial silicone blocker (CESB), mechanical ventilator, persistent air leak (PAL)

INTRODUCTION

A prolonged air leak (PAL) is defined as an air leak that lasts beyond 5 days, usually due to an abnormal connection between the airways or lung parenchyma with the pleura.[1] PAL is due to an alveolar-pleural (APF) or a bronchopleural fistula (BPF). PALs can cause significant morbidity and mortality, especially when secondary to BPF.[2,3] Conservative management usually involves long-term chest drains. Traditional management of PAL has been surgical. Often these patients are poor candidates for surgical intervention due to comorbidities, limited functional status, or prior failed surgery. Historically, bronchoscopic methods appeared as the "last resort" for PAL, but of late have shown value as an alternative primary therapy for PAL treatment.[4]

Various bronchoscopic substances and devices have been developed to occlude an identified BPF or the segment related to the APF, which allows parenchymal rest and promotes distal healing, with variable success rates.[5–10] Expanding the armamentarium for PAL therapy, in 2018 we described an innovative method of PAL treatment using a customized endobronchial silicone blocker (CESB) via rigid bronchoscopy in 31 patients, with a success rate of 84%.[11]

CARDS was associated with significant barotrauma and PAL, especially in patients receiving higher doses of steroids and positive pressure ventilation for respiratory failure. PAL's were challenging to treat and associated with worse outcomes.[12] We describe a customized multimodality approach in 2 cases of life-threatening CARDS with bilateral barotrauma and PAL, with favourable outcomes.

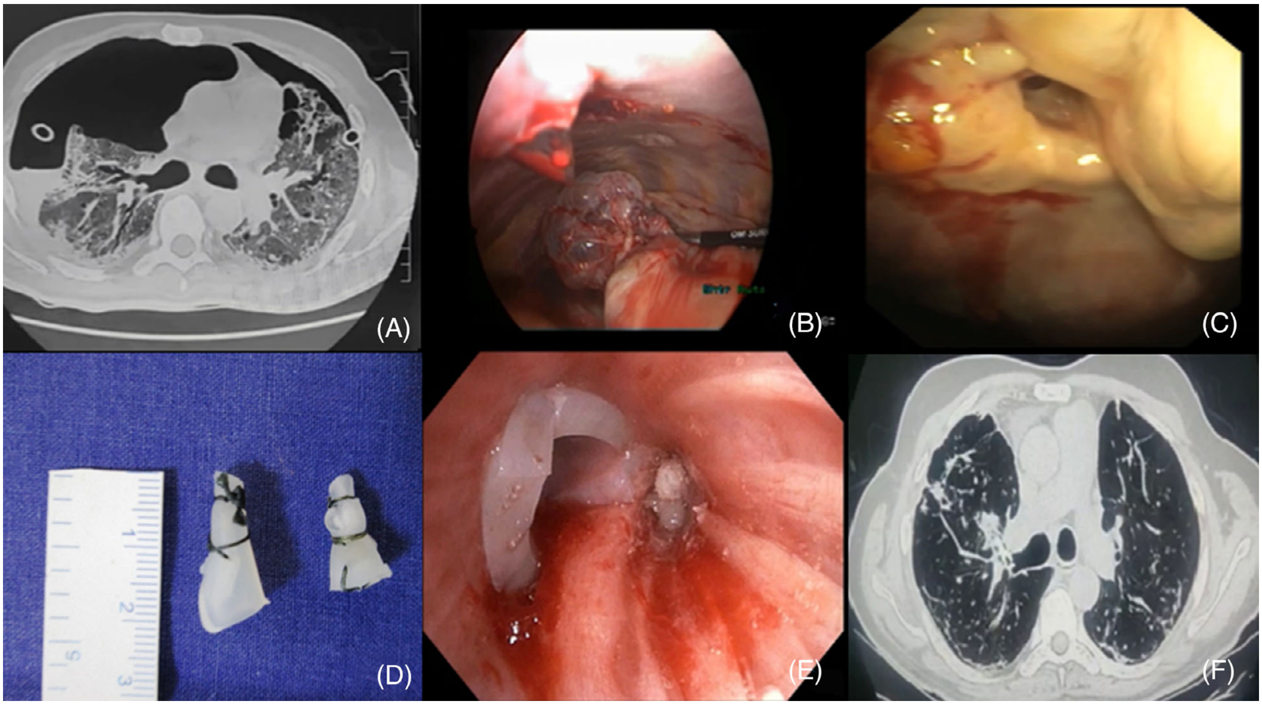

FIGURE 1 (A) CT scan showing b/l fibrocystic changes with ICD in situ. (B) Left VATS showing bullous lesions with stapler in situ. (C) Right pleuroscopy showing right upper lobe posterior segment fistula. (D) Customized endobronchial silicone blockers ex-vivo. (E) RUL showing CESB devices in situ. (F) Follow up CT scan showing resolution of pneumothorax.

CASE REPORT

Case I

A 47-year-old male was admitted for severe COVID pneumonia with CT Severity Score (CTSS) of 24/25.[13] On admission, he was tachypnoeic and needed about 4 litre/min oxygen (O_2) supplementation. He deteriorated despite therapy and required high-flow nasal O_2 therapy (HFNO). On the 7th day of hospitalization, he worsened and was mechanically ventilated requiring 0.7 FiO_2. On day 4 of mechanical ventilation, he developed a right-sided pneumothorax (PTX), and a right-sided intercostal drain (ICD) was inserted, followed by the development of an air leak on the ventilator. Two days later, he developed a left-sided PTX, and an additional ICD was inserted on the left. He had large air leaks bilaterally with difficulty in achieving tidal volumes and consequent hypercarbia. He was transferred to our center for further management after 15 days on the ventilator, with bilateral ICDs in situ.

The clinical picture was further complicated by septic shock. Computed chest tomography (CT chest) showed bilateral fibro-cystic changes with bilateral PTX (Figure 1A). Multiple bullous lesions were noted on the left lung and a fistula was localized to the RUL posterior segment. Septic shock treatment was intensified, and he was continued on broad-spectrum antibiotics as per the tracheal secretions' sensitivity pattern. He continued to have a large PAL bilaterally despite conservative management with chest drains. After the resolution of the septic shock, a high-risk interventional pulmonary procedure was planned for the PAL.

A bilateral diagnostic pleuroscopy was planned, with ECMO support as needed, as the baseline FiO_2 requirement was still 70%. Left pleuroscopy showed multiple bullous lesions (Figure 1B). Pleuroscopy ports were converted into 2 larger ports, and a staple bullectomy was done. In the same setting, right pleuroscopy showed a large BPF localized to the RUL region, not amenable to stapling (Figure 1C). A customized endobronchial silicone blocker (CESB – 2 cm × 6 mm × 2 mm) was inserted into this segment, which led to a significant reduction of the leak on the table. The CESB was reinforced with 0.5 mL cyanoacrylate glue to promote adhesion and prevent migration. The procedure was managed without initiating ECMO.

Following the procedure there was significant lung expansion and diminution of the PAL on both sides. The left ICD was removed after 3 days, and the right ICD was removed after 5 days after chest tube pleurodesis using betadine. This was done to prevent a recurrence. The patient was weaned off the ventilator 7 days post-procedure. A repeat CT scan done after 2 weeks showed significant lung expansion and the patient was discharged with home O_2 support without any chest drains. The CESB device was removed 3 months later as a day-care procedure and the CT scan months later (Figure 1F) showed remarkable resolution of the fibrocystic lesions. One year later, he is off O_2 with a productive quality of life.

Case 2

A 56-year-old hypertensive male, with severe COVID ARDS, was on the mechanical ventilator for 15 days. His CT scan showed bilateral significant fibrocystic opacities with intervening ground glass opacities. He developed pneumothorax bilaterally. Bilateral ICDs were inserted, however, there was a persistent air leak on the right, which led to difficult ventilation.

A repeat CT scan after ICD insertion localized the leak to the right upper lobe. After discussion, he was taken up for rigid bronchoscopy. Using a Fogarty balloon, the leak was further localized to the RUL anterior and posterior segments. Two CESB devices were placed in the anterior (2 cm × 7 mm × 3 mm) and the posterior segment (1.7 cm × 6 mm × 2.2 mm) (Figure 1D, E). Cyanoacrylate glue was also instilled to promote adhesion and prevent migration.

Post-procedure, the leak was reduced by >90% and subsequently the ICD was removed after ensuring complete lung expansion and chest-tube pleurodesis. The patient, however, succumbed later to COVID-related complications.

DISCUSSION

ARDS in general and severe COVID-19 pneumonia/ARDS were associated with higher rates of barotrauma.[12] Non-COVID ARDS is associated with a 3% incidence[14] of barotrauma. CARDS is associated with a much higher, close to 15% incidence in mechanically ventilated patients.[12] Barotrauma complicated by a PAL was associated with a prolonged course, with poor healing due to steroids, positive pressure ventilation, and superadded infection. Definitive therapies such as surgical correction were sparingly done as patients were too sick for surgery or had significant bilateral disease. Bronchoscopic interventions were the only option when surgery was not feasible.

Our cases were particularly challenging due to CARDS with severe lung damage and bilateral PAL with sepsis and mechanical ventilation with a high FiO_2 requirement. Conservative management was not successful, and an out-of-the-box approach was needed. The 1st patient was not a surgical/VATS candidate, and a triage pleuroscopy helped in forming a hybrid plan—a pleural approach with modified stapling using an extra port on one side, and bronchoscopic occlusion using the CESB's on the other side. Of note, lung isolation was not done with a double-lumen tube due to limited reserve on the opposite side, and the procedure was managed with conventional ventilation combined with brief episodes of hypoventilation to facilitate the procedure. The 2nd patient was managed with a pure bronchoscopic occlusion strategy.

There are scant interventional pulmonary options for PAL on the ventilator, especially with underlying badly damaged COVID lung. A review of the literature mentions various bronchoscopic sealants and occlusive devices for less critical situations, and different options based on whether it is an APF or BPF and the size of the bronchus.[5–11,15] However, there is scant data on CARDS with PAL. Sealants close the fistula with an adhesive-like substance. The sealants mentioned in the literature include collagen matrix plugs, collagen screw plugs, different bio-glues, synthetic hydrogels, and blood patches. However, most of the sealant utility is restricted to small BPF's and APF's. Occlusive devices work by blocking a large proximal culprit bronchus to close off the fistula. In APF, they prevent the entry of air into the involved segment and promote distal healing. Many occlusive devices are available and include various customized stents, ASD/VSD closure devices (Amplatzar), EBV's, EWS, lead shots, and occluding balloons.[4] These devices have their challenges. EBVs function as a one-way channel that blocks the entry of air but allows the exit of air during expiration. Their utility is mainly in smaller distal fistulae with a success rate of about 66%. A major limitation is that they are only available in smaller sizes (4–8.5 mm) and are expensive, with limited availability—*we do not have access to EBV's*.[16] The EWS has been useful for APF and small BPF closures with a 40%–50% success rate. However, they are also available in limited sizes (5–7 mm), are expensive and migration rates are high.[15]

The CESB device was described in 2018 for the management of PALs in 31 patients,[11] with complete cessation of PAL with these devices in 84% and reduction by more than 50% in another 6% of patients. The CESB was successfully deployed for both BPF and APF, with sizes used from 4 to 20 mm. It was even deployed in technically challenging locations such as the upper lobe apical segments. Advantages of the CESB include customization on-site to any size and shape to suit bronchial anatomy, including main bronchi. This ensures a good bronchial seal, irrespective of the size, shape, and location of the leak. The addition of glue serves as a "filler" and an "adhesive," reinforces the seal, and helps to reduce migration. Moreover, the bucket handle suture ensures easy removal later.

These cases illustrate how a customized approach can be used in ARDS-related PAL on mechanical ventilator: A multimodality hybrid approach in one case after triage pleuroscopy, and a pure bronchoscopic approach in the other case.

CONFLICT OF INTEREST STATEMENT

None declared.

DATA AVAILABILITY STATEMENT

The data that supports the findings of this study is available from the corresponding author upon reasonable request.

ETHICS STATEMENT

All relevant ethical guidelines have been followed, and any necessary IRB and/or ethics committee approvals have been obtained. The details of the IRB/oversight body that provided approval or exemption for the research described are given below: Institutional Ethics Committee (IEC)—Biomedical Research (BMR) of Apollo Hospitals, Bangalore.

The committee is constituted and approved as per ICH-GCP, national ethical guidelines for Biomedical and Health Research involving human participants (Indian Council of Medical Research 2017), and new drugs and clinical trial rules March 2019. The study was approved by this committee: Application No: AHB-BMR-004/09-20 Approval letter date 30/9/2020. Written informed consent has been obtained and archived for this publication.

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