then switched to ceftriaxone, 2 g once daily for 4 weeks, and then switched to amoxicillin for an additional 5 months.

**Discussion**

A diagnosis of actinomycosis cannot be made from sputum cytology and/or culture unless obtained directly from the bronchus, as it can be found in 30 to 50% of normal saliva specimens. Thoracic Actinomycosis were diagnosed by thoracotomy in the past. Fiberoptic bronchoscopy allows a minimally invasive approach to make the diagnosis. However, the reported diagnostic yields on BAL, bronchial wash, and bronchial biopsies reported have been low. It has been reported that physiologic saline solution, which is commonly used for BAL, inhibits the growth of pathogenic Actinomyces. Some authors have suggested that in a small crushed bronchial biopsy, the morphologic appearance of the sulfur granule may get distorted, making diagnosis difficult. The Wang needle aspirate obtained a submucosal tissue sample unlike the mucosal biopsies and was diagnostic of Actinomycosis. A literature review of the past 25 years uncovered no reported case of endobronchial actinomycosis diagnosed using Wang needle aspiration. Dissemination by biopsy is a theoretical possibility, but no reference could be found in the literature regarding it. In our case, the history of a tooth abscess preceding the patient's initial pneumonia may be relevant. A diagnosis delayed up to 44 months from the beginning of symptoms is reported by all authors, as was the case in our patient. The hallmark of actinomycosis is the formation of yellow sulfur granules. Although they may be abundant, only a single granule was identified in 26% of specimens in one series.

**Conclusion**

Endobronchial actinomycosis is rare and should be considered in a patient with recurrent pneumonia and an endobronchial mass. Fiberoptic bronchoscopy could help avoid a surgical procedure and aid in making a diagnosis. Wang needle aspirate by bronchoscopy may be used to obtain clinical material for diagnosis.

**References**


**The Use of Endoscopic Argon Plasma Coagulation in Airway Complications After Solid Organ Transplantation**

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The objective of the study was to describe a safe and effective treatment option for endobronchial complications after solid organ transplantation. A retrospective analysis was performed in a tertiary-care university hospital. The use of bronchoscopic argon plasma coagulation (APC) for the treatment of endobronchial lesions was studied in five solid organ transplant recipients. Four patients presented with variable degrees of endobronchial obstruction, and one patient presented with massive hemoptysis. Two of the patients with endobronchial obstruction were double lung transplant recipients who developed anastomotic strictures. The strictures were opened with endobronchial stents but became obstructed again by inflammatory granulation tissue growth through endobronchial stents. Airway patency was reestablished with several treatments with APC. Another kidney transplant recipient developed subglottic and tracheal papillomatosis that was effectively removed with APC. A heart transplant recipient was referred with recurrent massive hemoptysis refractory to bronchial artery embolization. The bleeding was caused by hemorrhagic polypoid lesions, which were completely ablated by APC. Bronchoscopic use of the argon plasma coagulator is a safe and simple technique that can be used effectively to treat endobronchial pathology in solid organ transplant patients.

**Key words:** argon plasma coagulation; endobronchial obstruction; hemoptysis; transplant

**Abbreviations:** APC = argon plasma coagulation; FEF_{25–75} = forced expiratory flow, midexpiratory phase

**T**herapeutic bronchoscopy has developed several alternatives to overcome endobronchial obstruction that originates from endobronchial neoplasias or from benign
lesions such as postsurgical or posttraumatic strictures, granulation tissue growth, and others. Recipients of solid organ transplantation are at risk to develop obstructive endobronchial pathology secondary to serious opportunistic infections, or secondary to anastomotic pathology in the case of lung transplantation. The techniques available to overcome endobronchial lesions include bronchoscopic electrocautery, cryotherapy, and Nd-YAG laser therapy.1

Laser therapy requires special training, expensive equipment and, frequently, the use of a rigid bronchoscope. Cryotherapy has been used to treat benign endobronchial lesions with only minor complications, but it requires a long duration of therapy and repeated treatments.

Most recently, the use of argon plasma coagulation (APC) has been described in the surgical and gastroenterology literature.2–4 Its successful use in endoscopic polypectomy3 and GI hemostasis makes it an appealing tool to adapt to bronchoscopy. Only a handful of articles in the otolaryngology literature have detailed the use of APC in the lower tracheobronchial tree.5 APC has been used in Europe for palliative therapy in patients with endobronchial neoplasia7 and has recently been applied at one center in the United States.8

PC uses a high-frequency electrical current fed from a probe tip through ionized argon plasma to cause superficial thermal coagulation of tissue. The probe used for this purpose is small enough to fit through the 2.5-mm working channel of a fiberoptic bronchoscope. Tissue contact with the probe is not required in order to achieve a predictable and reproducible penetration depth of 2 to 3 mm. Because argon coagulation is dependent on the water content of the targeted tissue, desiccation of the treated area prevents deeper thermal effect and damage to underlying structures. Argon coagulation does not result in tissue carbonization or vaporization. Desiccated tissue can be removed with forceps or allowed to slough as the underlying mucosa heals. Repeat APC treatments may be required to fully ablate large lesions. Alternatively, a snare-forceps with APC can be used to remove larger polypoid lesions.

The APC device is portable and can be used in the endoscopy suite or at the patient’s bedside. APC appears to be superior in achieving effective hemostasis. In our institution, the APC device was available and was used primarily by the GI endoscopy team with good results and minimal morbidity.

When solid organ transplant patients presented with endobronchial obstructive lesions, we explored the use of APC in the lower tracheobronchial tree. In addition to the lung transplant patient who develops refractory endobronchial obstruction after stent placement, other immunosuppressed solid organ transplant recipients are at risk for obstructive endobronchial pathology.

We report our preliminary experiences with this device in solid organ transplant patients.

**Materials and Methods**

This retrospective review details our early experience with the use of APC and bronchoscopy in solid organ transplant recipients. The interventional pulmonology service at our institution performed all procedures from October 1999 to date. After informed consent was obtained, all patients underwent diagnostic bronchoscopy with video assistance (Pentax Precision Instrument Corporation; Orangeburg, NY).

All procedures were performed in the endoscopy suite. Sedation was achieved with a combination of midazolam and meperidine in adherence with the institution’s conscious sedation policy. Additional local anesthesia was achieved using nebulized 4% lidocaine, viscous lidocaine, and topical 2% lidocaine. Oxygen was administered by nasal cannula, mask, or endotracheal tube to maintain oxygen saturation at > 90%. Oxygen was discontinued intermittently when the APC was in use because of the risk of endobronchial combustion. Pulse oximetry, BP, and heart rate and rhythm were continuously monitored. Resuscitation, intubation, and suctioning equipment were available at all times at the bedside.

After adequate sedation was achieved, diagnostic bronchoscopy was performed to obtain cultures and specimens for pathologic examination, if necessary. Endobronchial lesions then were identified and photographed. To minimize iatrogenic bleeding, 3 mL epinephrine (1:10,000) and saline solution were applied topically to the lesions targeted for APC ablation.

The equipment for APC includes an APC probe, an argon gas source, and a high-frequency coagulation unit (APC 300, ICC 350; Erbe Elektromedizin; Tuebingen, Germany). No mechanical adaptation of the probe or the unit was required for use with the adult bronchoscope. The 1.5-mm probe was passed through the 2.5-mm working channel of the bronchoscope until the tip and the first distal black marker were visible. This ensured that the working tip was always in view and that it was adequately extended to prevent thermal damage to the bronchoscope. The argon flow was set between 0.5 and 1.0 L/min, and the current was set at 40 to 60 W. The probe was placed between 3 and 5 mm from and in a tangential position to the lesion of interest. Coagulation was activated by a foot pedal and repeatedly applied for 1- to 5-s intervals until the lesion appeared to be desiccated. Activating the probe and dragging the bronchoscope over the length of the lesion were used to treat large areas. Loose debris was removed with suction or forceps.

**Case Report 1**

A 30-year-old woman had undergone double lung transplantation for cystic fibrosis in July 1999. Before undergoing transplantation, her pulmonary function tests revealed the following: FVC, 1.12 L (34% predicted); FEV1, 0.68 L (23%); and forced expiratory flow, midexpiratory phase (FEF25–75), 0.35 L/s (9%). The patient’s severe restrictive and obstructive pattern on pulmonary function tests before transplantation was greatly improved immediately after surgery. By September, she developed progressive dyspnea on exertion, bilateral wheezing, and cough. Her spirometry revealed an increased obstructive pattern. Bronchoscopy initially identified a left mainstem anastomotic stricture (Fig 1, top left, A). She required left mainstem balloon bronchoplasty and endobronchial stent (Cook Z Stent/Gianturco-Rosch Biliary Design; Wilson-Cook Medical; Winston-Salem, NC) placement in late September (Fig 1, top middle, B). Subsequently, granulation tissue began to obstruct the left airway by growing exuberantly through the stent mesh and occluding segmental airways that were not amenable to stenting (Fig 1, top right, C). APC treatments were applied to this area to progressively widen the reduced lumen and to establish patency of the distal airways (Fig 1, bottom left, D, and bottom middle, E). Figure 1, bottom right, F, shows the long-term result in a follow-up bronchoscopy performed 14 months after transplantation.

In mid-October, 3 months after undergoing transplantation, a
critical obstruction of the patient’s right anastomosis developed (Fig 2, top left, A). She underwent balloon bronchoplasty of the right mainstem (Fig 2, top middle, B). APC therapy was used to remove excess granulation and inflammatory tissue until full patency of the right main and right upper lobe bronchi was achieved (Fig 2, top right, C, and bottom left, D). Follow-up bronchoscopy revealed the formation of a well-healed and widely patent right main anastomosis (Fig 2, bottom middle, E). The area distal to the anastomosis required stent insertion to maintain the patent lumen. Long-term follow-up (14 months) has shown full patency of the distal right main bronchi (Fig 2, bottom right, F).

This patient was orotracheally intubated for each bronchoplasty and APC treatment. After each procedure, she was immediately extubated. She required a total of six APC treatments for each anastomatic stricture. Each APC therapy session typically lasted 15 to 20 min. As her treatments were administered, her dyspnea resolved progressively and her flow-volume loop normalized. Her chest radiograph revealed full expansion of both lungs with stents positioned in both main airways.

We have observed this patient for 15 months after transplantation. Currently, she is asymptomatic and works full-time as a teacher. Repeated bronchoscopies have not shown a recurrence of granulation tissue formation, and both anastomoses remain patent and widely open (Fig 2, bottom middle, E, and bottom right, F). Her pulmonary function study 14 months after undergoing transplantation reveals the following: FVC, 2.96 L (91%); FEV1, 2.28 L (79%); FEV1/FVC ratio, 77%; and FEF25–75, 2.04 L/s (56%).

**Case Report 2**

A 20-year-old man underwent double lung transplantation for cystic fibrosis in August 1999 at another institution. His pretransplant spirometry showed the following: FVC, 0.97 L (20%); FEV1, 0.49 L (13%); and FEF25–75, 0.17 L/s (4%). Before discharge from that hospital in September 1999, he required left mainstem stent placement (Wallstent; Schneider Inc; Minneapolis, MN) for an anastomotic stricture. In November, the patient experienced increased dyspnea, and spirometry demonstrated worsening obstruction. A stricture in the right mainstem was identified (Fig 3, top left, A). The initial management of this stricture included balloon bronchoplasty with resolution of clinical symptoms and improvement in spirometric variables. Granulation tissue that was identified in the left stent was removed with APC without damage to the stent.

In mid-December, because of the recurrence of symptoms, a balloon bronchoplasty was performed again in the right mainstem, which was followed immediately by stent placement. The right upper lobe orifice showed obstruction because of granulation tissue and was successfully ablated with APC. Bronchoscopy repeated 1 month later revealed near obstruction of the right mainstem stent by granulation tissue (Wallstent, Schneider Inc, Minneapolis, MN) for an anastomotic stricture. In November, the patient experienced increased dyspnea, and spirometry demonstrated worsening obstruction. A stricture in the right mainstem was identified (Fig 3, top left, A). The initial management of this stricture included balloon bronchoplasty with resolution of clinical symptoms and improvement in spirometric variables. Granulation tissue that was identified in the left stent was removed with APC without damage to the stent.

**Figure 1.** Case 1: a patient with cystic fibrosis after double lung transplantation; left anastomosis. Top left, A: significant narrowing, inflammation, and necrotic changes at the left anastomosis level. Top middle, B: anastomosis after stent placement. Top right, C: subsequent growth of granulation tissue through the metallic stent. Bottom left, D: same area undergoing APC therapy. Bottom middle, E: same area after APC therapy. Bottom right, F: anastomosis reviewed during the 1-year posttransplant follow-up. The lumen remains patent, and the stent remains in good position. The area no longer shows growth of granulation tissue.
Case Report 3

Mediastinal and left mainstem zygomycosis (endobronchial mucormycosis) was diagnosed by mediastinoscopy and endobronchial biopsies in May 1999 in a 33-year-old woman who had undergone renal transplantation in July 1995. The etiology of her renal failure was brittle and poorly controlled diabetes mellitus. A CT scan of her sinuses failed to show mucormycosis. Immediately after undergoing mediastinoscopy, she required intubation and mechanical ventilation because of complete atelectasis of the left lung and respiratory failure. Bronchoscopy revealed the complete occlusion of the left main bronchus, because of severe edema of the bronchial walls and plugging of the main lumen by dense purulent pseudomembranes (Fig 4, top left, A). Three Gianturco stents were placed to create a patent airway from the main carina (Fig 4, top middle left, B) through the length of the left mainstem bronchus (Fig 4, top middle right, C) to the level of the left upper and lower lobe subcarina.

Initial antimicrobial therapy included daily IV amphotericin and nebulized amphotericin. Cumulative doses over the first 3 months of therapy were as follows: 0.08 g IV amphotericin B; 20.5 g IV amphotericin B lipid complex (standard and lipid complex amphotericin B were used alternately, depending on the patient’s renal function); and 1.95 g amphotericin B via nebulizer. Despite this aggressive approach, fungal forms persisted on follow-up endobronchial biopsies after 12 weeks of combined therapy. In late July, because of persistent endobronchial fungal growth, she began receiving daily endobronchial instillations of amphotericin, 25 mg, into the left mainstem via bronchoscopy. After 21 days of daily endobronchial (total dose, 500 mg amphotericin B) and 4 months of daily IV amphotericin, endobronchial biopsy findings became negative for mucormycosis.

During the course of the patient’s 133-day ICU stay, she underwent percutaneous tracheostomy and treatment for several episodes of ventilator-associated pneumonia with ARDS. Other complications included a stroke that resulted in transient cortical blindness. A below-the-knee amputation was required after an arterial embolus produced ischemic necrosis of her foot. She suffered two episodes of massive hemoptysis that resulted in cardiopulmonary arrest with successful resuscitation. Despite her grim prognosis, she did eventually recover, had persistently negative tissue cultures, and was progressively weaned from mechanical ventilation. As a late complication, however, her left mainstem bronchus developed nearly complete obstruction by excessive granulation tissue protruding through the stents (Fig 4, top middle right, C, and top right, D). It is unclear whether her granulation response, which was first noted in early July just before the start of endobronchial amphotericin therapy, was the result of her fungal disease or a result of the prolonged use of topical amphotericin via nebulizations and direct instillations.

The patient underwent the first of five APC treatments as an inpatient in October 1999. Her tracheostomy was maintained for secretion management, and all bronchoscopies were performed via the tracheostomy. APC was applied to the extensive obstruction in the left mainstem at 2-week intervals. After she was discharged to a rehabilitation facility in early November, she returned as an outpatient for bronchoscopy and APC. Her fifth and final treatment was in mid-December, and it demonstrated a significantly enlarged left mainstem and segmental airway diam-
eter, and intact, epithelialized stents (Fig 4, bottom middle left, F, bottom middle right, G, and bottom right, H). She was eventually discharged to home free of respiratory symptoms and did not require oxygen therapy. Her chest radiograph revealed the full expansion of both lungs and the complete clearing of all infiltrates. She subsequently died because of complications of her diabetes but did not develop respiratory symptoms up to the time of her death.

**Figure 3.** Case 2: a patient with cystic fibrosis after double lung transplantation; right anastomosis. Top left, A: right anastomosis showing severe narrowing and inflammatory changes. Top middle, B: right anastomosis with a metallic stent in place with significant growth of granulation tissue into the airway lumen. Top right, C: close-up of the area shown in top middle, B. Bottom left, D: same area after the initial APC session. Bottom middle, E: same area after further APC. Bottom right, F: follow-up bronchoscopy 1-year after transplantation. The anastomosis remains open, the stent remains in good position, and no further granulation tissue is present.

**Figure 4.** Case 3: renal transplant patient with diabetes and endobronchial mucormycosis. Top left, A: the left main bronchus is completely occluded by a severe, necrotizing inflammatory process (biopsy was positive for mucormycosis). Top middle left, B: same area reopened with metallic stents. Severe inflammation remains from the carina up to the distal airways. Top middle right, C: the left main bronchus is patent after stent insertion. Necrotizing pseudomembranes cover the bronchial mucosa. Top right, D: late formation of severe granulation tissue after aggressive systemic and topical treatment with amphotericin (fungal structures are no longer present in biopsies). Bottom left, E: severe granulation tissue in the distal lumen of the left main bronchus produces severe narrowing of the airways. Bottom middle left, F: same area undergoing APC therapy. Bottom middle right, G: same area after APC therapy. Bottom right, H: distal aspect of the left main bronchus after APC therapy.
Case Report 4

A 41-year-old man had undergone renal and pancreatic transplantation 10 years prior to consultation. In the previous year, he had been followed up by otolaryngology for recurrent pharyngeal and laryngeal papillomatosis. He was hospitalized to treat a community-acquired pneumonia and required diagnostic bronchoscopy to rule out opportunistic infection. Multiple pharyngeal, laryngeal, and tracheal papillomas were discovered (Fig 5, top left, A). The tracheal papillomas were large, just distal to the vocal cords, and were producing partial airway obstruction. They were obliterated, and the tracheal diameter was increased after APC treatment (Fig 5, top right, B, bottom left, C, bottom right, D). Although the lesions were friable and quite vascular, hemostasis was achieved easily with APC. The patient did not require intubation for this procedure. This patient will require follow-up studies because of the persistently recurrent nature of papillomatosis.

Case Report 5

A 37-year-old patient with idiopathic cardiomyopathy was the recipient of a heart transplant in 1991. Two weeks before transfer to our institution in January 2000, he had been treated unsuccessfully for recurrent massive hemoptysis at another center for at least 3 weeks. Bronchoscopy performed at that institution failed to reveal a specific bleeding source, and bronchial artery embolization only halted the hemorrhage temporarily. When evaluated at our institution, bronchoscopy revealed multiple bilateral endobronchial nodules that were quite friable and produced significant bleeding (Fig 6, top left, A, and top right, B). All identified nodules were treated with topical epinephrine followed by APC until desiccated (Figs 6, bottom left, C, and bottom right, D). This process achieved hemostasis immediately, and the patient has had no subsequent hemoptysis after prolonged observation. The etiology of the nodules is unclear, but a BAL fluid culture produced Cryptococcus neoformans. The patient has not developed further hemoptysis in the 10 months after APC therapy.

Discussion

There are currently a limited number of endobronchial interventions available to the pulmonologist who treats solid organ transplant patients. If repeated balloon bronchoplasty fails to maintain patent airways in the lung transplant patient with anastomotic strictures, stenting of the airway is usually indicated. Several types of stents are available to manage malignant and benign airway obstructions. There are no comparative trials to define which is the best stent to use in lung transplant recipients with significant stricture at the level of the surgical anastomosis. Lung transplant recipients have difficulty clearing secre-
tions due denervation of the graft, impaired cough reflex, and, occasionally, transient diaphragmatic dysfunction. The insertion of silicone stents into these patients is commonly complicated by inspissation of thick mucus within the stent lumen. In immunocompromised patients, this recurrent obstruction favors the development of recurrent purulent bronchitis and pneumonitis. Distal migration of these stents is another complication. Alternatively, the insertion of metallic stents can be used. In most cases, the insertion of this stent will be followed by the limited growth of mucosa covering the wires of the stent, creating a patent and efficient resolution of an anastomotic stricture. Occasionally, metallic stents can be complicated by the growth of granulation tissue, usually in the context of an underlying inflammatory or infectious process. Once granulation tissue develops, there are few alternatives to tedious and bloody endobronchial debridement with forceps. Such debridement places the patient at risk for bronchial wall perforation because the depth of tissue removal is imprecise.

The use of laser therapy frequently will produce a fracture of the stent. Our use of APC in treating this complication of lung transplantation has been effective and well tolerated. In our experience, the presence of a stent is not a contraindication to the use of APC because the current is not conducted along the metal framework. In fact, dissolution of the nonmetallic component at the rim of the stent using APC can improve stent and airway diameter expansion after the initial placement.

Solid organ transplant recipients are at risk for developing endobronchial disease and obstructions from a variety of infectious and neoplastic causes. Although it offers no diagnostic application, the therapeutic possibilities of APC are numerous. Our limited experience has demonstrated no adverse effects in the immunocompromised patient population. Endobronchial perforation is a possible, although unlikely, complication and has been described in only 0.3% of GI procedures.9 Precautions to avoid combustion are important. During APC treatment, we transiently interrupted oxygen administration in order to minimize the possibility of argon-ignited intratracheal combustion. Continuous monitoring of pulse oximetry allowed the transient interruption of a high fraction of inspired oxygen long enough to apply APC intermittently. Oxygen therapy was restarted once arterial oxygen saturation dropped to < 90%. Laser-ignited airway combustion has been described,10 and similar precautions need to be taken with APC.

Two patients noted transient cough and the expectoration of small amounts of necrotic debris after treatment. Reichle et al11 have recently reported the use of 482 APC treatments in 364 patients. The indication was mostly to palliate the growth of endobronchial tumors or to recanalize stents that had been invaded by malignant tumors or granulation tissue. Acute hemostasis of bleeding was the indication in 119 cases in their series, many of them occurring after laser therapy. They reported five cases of bronchial or tracheal perforation.

**Figure 6.** Case 5: heart transplant recipient with severe recurrent hemoptysis. Top left, A: friable, hemorrhagic nodule present in right upper lobe bronchus. Top right, B: close-up of same area. Bottom left, C: area treated with APC. Bottom right, D: same area after treatment. Full hemostasis has been achieved.
with subcutaneous emphysema and pneumothorax. All patients in the five cases recovered. Two patients with multimorbidity and carcinomatosis in this series died within 24 h of undergoing APC. The authors did not think that their deaths were related to APC. Other reported complications included necrosis of the area treated, two episodes of burns in the tip of the bronchoscope, and one case of visible “flash burn” that did not produce significant clinical damage. Their reported incidence of complications was 3.7% in a population with significant morbidity. The perforation of airways and the potential for fire hazards during APC can be avoided by using argon gas flows of <1.5 L/m, by limiting the APC activation time to <5 s, and by interrupting the enriched oxygen supply during the activation of APC.

CONCLUSION

The use of APC with the adult, flexible bronchoscope for the therapeutic intervention of endobronchial pathology appears to be safe and effective. Additional experience in transplantation patients is needed to fully appreciate the range of indications, contraindications, and possible adverse effects. APC bronchoscopy is simple to learn and can be readily adapted from the available gastroenterology equipment.

APC adds one more alternative to laser therapy and cryotherapy in overcoming obstructive or hemorrhagic endobronchial lesions. This technique appears to be as effective or better than the other alternatives and uses less expensive equipment that is fully transportable, facilitating the use of this technique in the operative suite, in the endoscopic suite, or at the patient’s bedside.

REFERENCES