32 Electrosurgery

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Equipment and Technical Background

Electrocautery (EC) or diathermy is the use of an electrical probe to conduct electrical current for heating target tissue in contact with or in close proximity to the probe. A high-frequency electrical generator is standard equipment in most hospitals, and high-frequency alternating electrical current is needed to avoid neural and muscular response. The system can be plugged in easily in any electrical socket, and many probes are readily available for an easy hook up. Electrical current can be conducted safely by the insulated metal wire probe toward the target tissue, and due to the voltage difference between the probe and tissue, electron current density generates heat at the point of contact as tissue resistance for electrons is high, resulting in coagulation or fulguration.

Argon plasma coagulation (APC) uses ionized argon plasma gas for conducting electrons to spray large tissue surfaces in a noncontact fashion, resulting in superficial homogeneous coagulative necrosis. The argon plasma stream easily conducts electrons around the corner to follow the many angulations of the segmental bronchial tree branches. APC is popular in gastrointestinal and trauma surgery for obtaining quick tissue fulguration over large surface area to create a homogeneous tissue necrotic crust of several millimeters in depth.

Various EC and APC applicators are available for the clinical practice: contact monopolar probe, bipolar probe, electric snare or loop, electric knife, and forward- and side-firing APC probes.

Every practitioner can choose any particular EC or APC method that can better suit each treatment purpose, based on personal skill and preference. Switching between the different methods and probes in a treatment session can be easily done.

Flux density of electrons is an important principle as the probe functions as a focusing point for electrons. The ultimate coagulative necrosis depends on voltage difference between probe and tissue, i.e., wattage setting; the surface area of contact, e.g., smaller probe has a smaller surface area of contact and much higher electron flux at the point of impact causing more intense heat generation; and the total duration of energy application. Mucus, blood, and any metal part within the target volume with better electric conductance may, however, cause electron leak that will reduce local heat formation.

In practice, the effect of tissue coagulation and fulguration is immediately visible for the bronchoscopist as tissue becomes white colored or charred. These changes match with the histological damage seen on the bronchial wall under microscopy. This is in practice important as visible effect provides an immediate visual feedback to the bronchoscopist. Tactile feedback by palpation using monopolar probe while coagulating is the advantage of the contact mode.

The familiarity of operators in using electric appliances should be taken into account. The wider availability of various easy interchangeable rigid and flexible applicators for EC and APC is of great practical advantage to easily perform coagulation or fulgurate tissue followed by mechanical debulking in quickly restoring airway passage. EC, APC, and cryotherapy (see separate chapters) can be used more comfortably as the equipments' setup is easy for use in an outpatient treatment setting of a bronchoscopy unit or in ICU care.

General Treatment Strategy

The use of EC contact mode, i.e., by palpation to coagulate or hot biopsy forceps for hemorrhagic tumor, has a similar handling as Nd:YAG laser using the sapphire probe for contact coagulation. The noncontact APC method is comparable to CO_2 laser for quickly obtaining superficial necrotic layer (see Fig. 32.1). The use of EC and APC and its reusable applicators is technically comparable to the noncontact firing of

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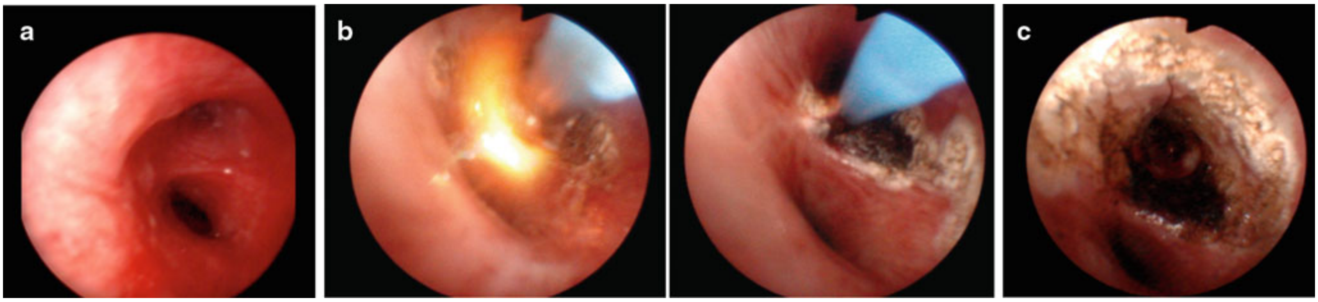

Fig. 32.1 A patient with GOLD III COPD, diabetes, and previous history of CABG and poor vascular condition used aspirin and was presented with hemorrhagic sputum. Superficial spreading squamous carcinoma reconfirmed by a panel of pathologists. Lesion extent was established under autofluorescence bronchoscopy extensive sampling of mucosal biopsies. (**a**) High-resolution CT scan with 1-mm slice thickness and FDG-PET scan did not show any abnormality; thus, this extensively spreading intraluminal lesion is classified as CT/PET occult. Locally, he was treated with argon plasma coagulation (**b**), and the necrotic crust can be seen immediately after APC treatment (**c**). He remains disease-free after 5 years follow-up. Recently, squamous cancer recurrence was diagnosed in the orifice of the superior part left upper lobe bronchus, and due to invisibility of distal tumor extension, external radiation treatment with respiratory gating has been commenced. There is a slight thickening on the HRCT scan seen, and locally FDG-PET scan shows local avidity

Nd:YAG and other lasers. Laser fibers are much more expensive, goggles and coverage of mirroring surfaces for protecting personnel from potential eye damage are necessary. Laser beam goes straight and cannot be flexibly angled around the corner in contrast to using EC probe and APC plasma flow. Arguments have been raised that compared to Nd:YAG laser, tissue effect of EC and APC is too superficial. Nd:YAG laser causes enormous heat sink effect, as photons of 1,064 nm deeply scatter in tissue for obtaining in depth necrosis. Electrons disperse, i.e., divergent flux, beneath the tissue layer leading to superficial crust of necrosis. End-stage lung cancer patients in the palliative setting have failed previous treatments, e.g., surgical resection and chemoradiotherapy. The central airway's anatomy is often changed, and together with the proximity of the major vessels, vigilance and expertise are required to avoid disaster. Tissue coagulation layer per layer, depending on assessment of tumor thickness, might well be more appropriate than instantly obtaining deep necrosis at once, e.g., using Nd:YAG laser. Slowly cooking can also be obtained using the blend mode of EC, i.e., applying the setting that uses alternating phases of high and lower voltages. With APC, one performs superficial welding of the target area layer per layer. The use of a monopolar probe allows palpation of the tracheobronchial wall giving important tactile feedback about target tissue and bronchial wall resistance in contrast to the noncontact firing of Nd:YAG laser.

APC can be used for burning superficial layer of early-stage mucosal cancer of several millimeter thickness. This is a comparable strategy to using CO_2 laser or ultraviolet light excitation of Photofrin II®, to deliberately obtain superficial rather than obtaining too deep necrosis.

Cryotherapy (see separate chapter) has the advantage of preserving bronchial cartilage with less scar tissue formation, which may be important in dealing with segmental and subsegmental location of tumors. However, results are not immediate, and tissue depth effect is difficult to predict while repeated cooling and thawing takes more time. The use of cryoablation has been recently reported in which larger surface area can be cryosprayed much faster.

Brachytherapy (see separate chapter) is a much more complex and expensive facility; special logistics and good collaboration with the radiation oncologist are essential. Even high-dose rate brachytherapy cannot provide immediate solace for emergencies, as several treatment fractions are needed. This is in stark contrast to heat tissue applications such as EC, APC, and lasers which can be obtained in a single treatment session. Therefore, tissue-heating methods, i.e., lasers, EC, or APC, are the only techniques that can provide immediate benefit for rapid recanalization of airway blockage.

Clinical Background

Unfortunately, interventional pulmonologists mostly deal with advanced-stage lung cancer with local tumor growth causing imminent suffocation and respiratory failure. Obstruction may be caused by intraluminal tumor growth as well as extraluminal airway compression by mediastinally located tumor and enlarged lymph node masses adjacent to the tracheobronchial tree, and bronchoscopic debulking or combined with stenting is the only treatment choice.

The majority of patients are usually presented with end-stage cancer and comorbidities; hence, their often poor condition and the negative selection of patients are such that morbidity or mortality of bronchoscopic intervention can be quite significant.

With such a clinical presentation, the easy logistics of EC and APC and familiarity of many with electrical appliances make their use for the clinical and outpatient setting more readily accepted.

Palliation and Treatment with Curative Intent

The effectiveness of interventional bronchoscopic treatment for immediate palliation of central airway obstruction has been established, often being the only treatment alternative left. Conceptually, the use of EC and APC is no different than applying Nd:YAG laser as described earlier. Easy logistics allow practical management in the daily practice of a bronchoscopy unit (2–4). As extensive investigations, e.g., CT scan, lung function measurements, and blood gas analysis, prior to intervention in patients with imminent respiratory failures are unfeasible, clinical findings of stridor and severe dyspnea justify immediate action. EC and APC can then be applied more easily for tumor coagulation prior to mechanical debulking and stenting.

EC and APC can better safeguard unexpected bleeding after taking biopsy as increasing number of patients at risk have cardiovascular comorbidities and are routinely taking aspirin and clopidogrel. Many educational workshops are now dealing with competency skill training that better prepare operator and team members to act properly and decisively in case of adverse events during bronchoscopy.

By either using the rigid scope or working through the endotracheal (ET) tube, the interventional pulmonologist can perform tissue coagulation with EC or APC probe and recanalize the central airways more effectively. The rigid scope with its larger working channel obviously better provides access for safer manipulation and primarily in safeguarding ventilation. Despite the wider acceptance of using only devices that suite the flexible bronchoscope, the blocking effect of the flexible bronchoscope can jeopardize safety. The proper execution of any interventional technique depends on the readiness and expertise of the team that is familiar with various procedures, including proficiency in using the rigid instruments. Therefore, one should always realize that technique per se is not the only factor that determines success regardless of the use of intraluminal tumor debulking that is easier to be applied.

Treatment for Intraluminal Non-lung Cancer Lesions

Interventional pulmonologists can also provide alternative treatment strategies after diligent consultation within the thoracic multidisciplinary team, for other intraluminally located tissue abnormalities.

Apart from lung cancer, involvement of central airways by tumor metastasis, benign lesions, and slow-growing lesions such as typical carcinoid, even malignant fibrosarcoma, does warrant a proactive role for the interventional pulmonologists to be involved in the care of these patients. The argument that a potential delay in surgery will jeopardize patients' outcome has not been proven in our longitudinal study with regard to bronchoscopic treatment of bronchial carcinoid. Given current knowledge on neuroendocrine tumors, this is in retrospect not surprising. Even after years of postponement, surgical resection would not have been different regarding extent of resection or outcome in the several cases that there was residual tumor or local recurrence in the bronchial wall. The various bronchoscopic techniques for benign processes must be seen in the same conceptual line as foreign body removal, in which surgical resection should remain the last resort. Any minimally invasive technique that can be first commenced in trying to solve the problem before performing major surgery is preferable rather than an immediate and hasty surgical approach.

Indeed, disease management has become a concerted effort between various disciplines by fully exploiting the different input from expert team members, including interventional pulmonologists. Increasing understanding about tumor behavior and clonal cell growth and behavior in current era of molecular biology and also in dealing with early-stage non-small-cell lung cancer is of paramount importance. The involvement of interventional pulmonologists in pulmonary medicine and medical oncology can be very supportive regarding early detection, staging, and treatment strategies, both for central airway and lung parenchymal abnormalities.

Future Strategies

Current interest in stage shift as the primary goal in a lung cancer screening setting poses a great challenge for its clinical management. As earliest stage cancer, i.e., carcinoma in situ and alveolar adenomatous hyperplasia, involves sub-centimeter lesions, relying only to the gold standard of histology classification and surgical resection is currently inappropriate.

One may still argue that nonsurgical approaches are still not acceptable until data from phase III prospective trials have shown similar efficacy. However, the potential values of alternative techniques such as interventional bronchoscopy and radiation therapy for clinically unfit patients have been established.

While attention has been put on screening the population at risk for relatively healthy individuals, we must not forget that the clinical reality of increasing number of ageing patients with comorbidities remains the bulk of our care. This is a great challenge to further explore the many potentials of non- and minimally invasive techniques in better preserving quality of life and in improving the cost efficiency of our medical care system rather than relying on accepted standard diagnostic and therapeutic avenues including major surgical approach.

For relatively healthy individuals with early cancer that can tolerate surgical resection, lead time in carcinogenesis increases the potential long-term effect of overdiagnosis, if combined only with aggressive management that has been implemented at the cost of quality of life.

The low positive predictive value of current diagnostic algorithms such as sputum cytology and low-dose spiral CT despite still requires much improvement. Although CT screening data show that more early-stage cancers are being detected and curatively treated, controversies about overdiagnosis are still heavily debated, and downstream morbidities and mortalities related to early detection programs may become a significant issue. Alternative approaches may significantly reduce downstream morbidities, mortalities, and costs not only in a screening program but also in our daily care of the patients by virtue of advancements of non- and minimally invasive technologies in terms of early detection, accurate minimally invasive staging, and local treatment that is potentially curative, as tumor stage is the most important determinant for cure.

Summary

Minimally invasive techniques in the field of interventional pulmonology have led to a better understanding of thoracic disease processes. Combined with current advances in non-invasive imaging, pathology, molecular biology, medical oncology, and radiation oncology, technical development allows us now to combine all expertise for optimally choosing a tailored and personalized strategy for each patient.

Proper consultations within members of the thoracic oncology and respiratory teams can better suit diagnostic, staging, and treatment incentives with optimal preservation of quality of life of the at-risk individuals involved. Increasingly in the ageing population, many individuals suffer from comorbidities, and a more coherent approach toward disease management is warranted.

Treatment use of electrocautery and argon plasma coagulation is just part of the armamentarium for optimizing our care in the daily routine of a bronchoscopy unit.

The encompassing issues of early detection, staging, tumor biological behavior, and treatment, however, are the important determining factors to be taken into account before making a proper decision about disease management that is aimed for a tailored strategy in each patient.

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