Recent Advances in Otolaryngology



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Chapter 15

Technological advances in laryngology

Richard Steven, Christopher Thompson, Samit Majumdar

INTRODUCTION

The renaissance of laryngology has been driven by significant advances in endoscopy, imaging, refinement of technique, research, and demand. From the original transoral minimally invasive techniques, through pioneering open procedures, the specialty has come full circle and is returning to office-based practice. This has been possible due to advances in technology and the individuals who have innovated and adapted to these advances to push the specialty forwards.

Technology that used to be limited to major academic institutions is now more accessible, bringing with it significant benefits to patients. Improved diagnostic capabilities, office-based treatments, better patient's outcomes and reduced costs have all been demonstrated [1,2]. In this chapter, we seek to highlight areas of technological advances in laryngology which are already in use, some which remain for the time being confined to specialist centres only and some which are still in the research phase, but have the potential to impact upon future practice.

ENDOSCOPE TECHNOLOGY

Advances in endoscope technology have been integral to many of the advances seen in medicine, and particularly so in the case of laryngology. Field visualisation has significantly improved with ever-improving optics and the introduction of flexible video endoscopes. This, along with relative cost reductions and the widespread dissemination of technology, has ensured an increasing number of patients are benefitting from these improvements.

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Traditionally, high-resolution images were only available with the use of rigid endoscopes which are often poorly tolerated by patients and impractical for regular clinic work. Flexible fibre-optic endoscopes offer a more acceptable solution, but the image quality was often not of a sufficient resolution to allow for accurate diagnosis and intervention. 'Chip on the tip' flexible endoscopic camera systems have revolutionised this technology to provide high-resolution images which can be utilised, not only for accurate diagnostic work but also for interventions [3,4]. Narrow-band imaging (NBI) and videostroboscopy (**Figure 15.1**) have also been shown to be of diagnostic value and the reduction in costs and increasing availability of this equipment means that these have become the endoscope technology of choice in many departments.

Narrow-band imaging

Narrow-band imaging has added another degree of sophistication to the endoscopic diagnostic toolbox. This technology works on the principle that specific wavelengths of light penetrate the mucosal surface to differing degrees. By selecting particular wavelengths of light (415 and 540 nm) rather than wide band white light, detailed images of vasculature in and under the mucosa can be observed [5,6]. The benefits to the patient are improvements in early diagnostic capabilities and a potential reduction in the need for examination under general anaesthesia, along with the associated reduction in costs.

Channelled endoscopes

The increasing use of channelled endoscopes for either diagnostic or interventional nasopharyngolaryngoscopy in the outpatient setting has also been seen. These endoscopes can facilitate biopsies of lesions of the upper airways and pharynx or provide delivery of local therapeutic agents in the outpatient clinic setting. This reduces the requirement for an examination and biopsy under general anaesthesia, the inherent associated risks and can lead to a reduced time to diagnosis. Procedures are safe and generally well-tolerated by patients and have the additional benefit of freeing up valuable theatre time and space.

There is an ever-expanding list of procedures which can be undertaken in the outpatient clinic setting. Using channelled endoscopes, sheathed needles can be used in the delivery of several treatments. This includes the injection of material to facilitate vocal fold medialisation or for direct therapeutic instillation of medicine such



Figure 15.1 A stroboscope, used increasingly in laryngological diagnostics.
(*Courtesy*: DP Medical Systems)

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as steroid, botulinum toxin or monoclonal antibodies for the treatment of laryngeal papillomatosis.

Transnasal oesophagoscopy

Transnasal oesophagoscopy has an ever-increasing role in the diagnostic pathways for patients presenting with upper gastrointestinal symptoms. Reducing the discomfort experienced by patients undergoing traditional oral intubation with oesophagogastroscopes, the transnasal route, with high-definition video endoscopes, allows for excellent image quality and the ability to obtain biopsies for histological analysis all while avoiding requirements for sedation, discomfort or general anaesthesia [7].

BALLOON DILATATION

Balloon dilatation for cricopharyngeal disorders and oesophageal strictures is also regularly performed in the outpatient setting utilising channelled endoscopes. An example of their utility is in the management of patients with dysphagia secondary to treatment for head and neck cancer. Often patients presenting with post-treatment strictures pose a high risk for general anaesthetic due to co-morbidities, potentially difficult intubations and challenging direct access. Transnasal balloon dilatation under topical anaesthesia provides a safe and effective way of managing these patients and has been shown to be beneficial in the treatment of dysphagia [8].

LASER TECHNOLOGY

Advances in laser technology have expanded their use in laryngology. While the carbon dioxide (CO_2) laser (**Figures 15.2 and 15.3**) remains the workhorse for laryngologists in



Figure 15.2 UNILAS touch CO_2 laser console. (*Courtesy:* Ocean Med and Limmer Laser GmbH).

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Figure 15.3 Microspot laser manipulator.
(*Courtesy*: Ocean Med and Limmer Laser GmbH)

the theatre setting, potassium titanyl phosphate (KTP), blue light and diode lasers are increasingly used [9,10]. While the CO_2 laser has the advantage of providing an accurate and focussed beam, its wavelength of 10,600 nm renders it readily absorbed by water and, therefore it has the potential to damage surrounding tissue and structures. Although fibre technology is available to direct the CO_2 beam, the application of this laser is often confined to the operating room with a surgical microscope and direct beam via a micromanipulator.

The KTP and the blue light laser have a shorter wavelength. The KTP laser, with a wavelength of 532 nm, is absorbed preferentially by oxyhaemoglobin [11,12]. This leads to selective photothermolysis and disruption of the blood supply to lesions. The blue-light laser (445 nm) also preferentially targets oxyhaemoglobin but additionally has cutting properties, combining the benefits of the CO_2 and KTP lasers. These lasers are directed by fibre, facilitating treatment of conditions where 'line-of-sight' may be challenging. This may occur in patients with difficult laryngeal access or when ablation of lesions on curved surfaces, such the inferomedial surface of the vocal fold, is required. A fibre-delivered laser beam can also be used in conjunction with channelled endoscopes to treat a greater number of conditions in the outpatient clinic setting. These conditions may include vocal fold polyps, aberrant vocal fold vessels, laryngeal papillomatosis, dysplasia, and malignancy [11,13-15].

SLEEP APNOEA AND UPPER AIRWAY STIMULATION

Obstructive sleep apnoea (OSA) affects around 5% of the population, has a significant impact on quality of life and is associated with a number of co-morbidities such as hypertension and heart disease. Several medical and surgical treatment options are available including mandibular advancement devices, continuous positive airway pressure (CPAP) (which remains the gold standard), as well as several surgical options. Despite this, tolerability and compliance (as low as 20% in CPAP) [16] remain poor and alternative treatment options have been sought.

Upper airway stimulation via the hypoglossal nerve has been described for the treatment of moderate to severe OSA in patients who cannot tolerate CPAP or in whom CPAP is ineffective [16]. The surgical procedure involves implantation of a device to stimulate the hypoglossal nerve, causing activation of the genioglossus muscle to prevent posterior prolapse of the tongue during sleep. Reported results have been very encouraging with a reduction in symptoms, improved quality of life measures and increased compliance over

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CPAP treatment [17,18]. Due to this, this technology is likely to play a significant role in certain patient groups in the future.

VACCINATION

Vaccination for the prevention of human papilloma virus (HPV) infection has been approved since 2006. This has been rolled out in different areas at varying rates and a 'catch up' programme has also been instigated. Previously, bivalent and quadrivalent vaccines were used, however, a 9-valent HPV vaccination is now available which has potential to provide further benefits in the prevention and treatment of HPV-related disease [19].

Research is emerging showing promising data that vaccination is already having an effect on the incidence of juvenile onset recurrent respiratory papillomatosis (JORRP) [20]. Given the significant burden which respiratory papillomatosis may have on a patient's life, these early results are extremely encouraging. The vaccine has also been shown to be effective at reducing oral HPV infection, however, further long-term studies are required to assess its effectiveness in the prevention of HPV-related head and neck cancer [21]. Due to the delay in time until HPV-related conditions become symptomatic, it may, however, be many years until we fully understand the effect this has had on conditions affecting the head and neck.

In addition to the emerging evidence for vaccination in the *prevention* of HPV-related head and neck disease, vaccination may also have benefits in the treatment of patients with *established* disease [22]. A meta-analysis has shown a reduction in the number of surgical procedures required per month in patients with established respiratory papillomatosis.

REGENERATIVE MEDICINE

Stem-cell therapy is an emerging area of research with the potential to have a significant impact on the management of patients with difficult or refractory laryngeal pathology. A focus for this technique has been on the management of vocal fold injury and scarring. Pre-existing treatments focus on speech therapy to improve function as a first line, then possible adjuvant treatment through injection of one of several materials to try and offset the effects of scarring or phonosurgery. Although still within the research phase, studies have shown the potential of stem-cell therapy. This may either stimulate existing endogenous stem-cell populations or function through tissue engineering and allografting of exogenous stem cells into the larynx or trachea [23]. Some groups have demonstrated the potential of tracheal allotransplantation in limited numbers with the use of a tracheal cartilage graft and buccal mucosa implanted in the radial forearm that was subsequently transplanted to replace a tracheal defect [24].

There have, however, been both theorised and realised difficulties with this, such as rejection and the potential need for immunosuppression. These studies remain, largely, confined to animal models and in the preclinical stages but hold promise and are an expanding area with the potential to transform the management of difficult to treat laryngeal conditions [25].

IMAGING

Optical coherence tomography (OCT) is an imaging technique which allows cross-sectional views of living tissue. The primary advantage of this is in differentiating benign from

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malignant conditions in vivo, without the need for biopsy by assessing the integrity of the basement membrane. This technology is particularly suited to use in the larynx due to the accessibility with channelled endoscopes and thin mucosa to allow for accurate imaging. The larynx is also a site where biopsy has the potential to impact function and, therefore, methods to reduce these risks would be advantageous [26]. To date, OCT has been confined to research, however, with the use of channelled endoscope systems, the OCT probe may be placed under direct vision onto the anaesthetised larynx to obtain images [27]. This technology has the potential to add another important instrument to the toolbox for diagnosing laryngeal pathology.

CONCLUSION

Modern life places increasing demands on the function of the upper aerodigestive tract. Clarity of voice is required for work, hobbies and social life and patients are now seeking alternatives to traditional methods of the management of laryngeal pathology to minimise the risk of disruption to function and other complications.

We are in the midst of an exciting time for the specialty of laryngology. New technologies and new techniques, combined with increasing access to equipment, are driving an expansion of what is possible. Patients are benefitting directly from these advancements through increasingly accurate means of diagnosis and a better understanding of disease processes. New and less invasive methods of treatment are also leading to better outcomes. As these techniques and technology spread to an increasing number of centres, more and more patients will be able to benefit from these advances.

Key points for clinical practice

- Rapidly evolving technology has driven the field of laryngology forwards in recent years.
- Endoscope technology has played a large part in this, from flexible endoscopes to ever-improving optics and NBI, to adjuncts such as biopsies or balloon dilatation.
- The advancement and incorporation of laser technology has also played a part, offering precise interventions in areas that are difficult to access.
- The use of vaccination as either an adjuvant or preventative treatment has been identified but may not yet have demonstrated its full potential.
- Regenerative medicine in the form of stem-cell transplantation or tissue engineering is an exciting future prospect in laryngology.
- The technological advances in imaging modalities, e.g. OCT has improved noninvasive diagnostic capabilities and will continue to evolve.

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Abir K Bhattacharyya, Consultant ENT Surgeon at Barts Health, is an eminent and leading ENT surgeon based in London, United Kingdom (UK). His academic and clinical contributions over the last three decades particularly in Laryngology and Otology has been well recognised and he is an international leader in his field. He has been a Visiting Professor and delivered invited guest lectures to prestigious Universities all over the world. He is a respected educationist and has been the Training Programme Director, Deputy Director of Medical Education and is currently Royal College Specialty Professional Advisor, Intercollegiate examiner for FRCS (ORL-HNS) and Council Member of ENT UK. As a highly regarded author and editor he has edited postgraduate textbooks on Laryngology and written an award-winning undergraduate book on ENT and published numerous peer reviewed publications. He is on the Editorial Board and a Trustee of the Journal of Laryngology and Otology, UK.

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