The Use and Challenges of Artificial Intelligence in Otolaryngology

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Abstract

Otolaryngology (ENT) is a surgical speciality commonly known for its rapid advanceement and routine incorporation of newer technologies into routine clinical practice. Routine clinical integration of artificial intelligence (AI) is a field that is garnering significant interest. Within ENT, it holds a lot of potential. I will explore the use and challenges of AI in ENT by exploring case studies of particular pathologies, and look at some of its future applications.

Otolaryngology (ENT) is a surgical speciality involved with pathologies of the head and neck. Pathologies vary from very aggressive malignancies to benign, yet vastly functionally detrimental diseases for patients. ENT has classically been seen one of the surgical specialities with rapid advancement and routine incorporation of newer technologies into routine clinical practice. Interventional Technology and Imaging is a broad topic, and in particular I will explore the use or potential use of artificial intelligence, as well as new technologies/equipment involving artificial intelligence within ENT by exploring case studies of particular pathologies.

Artificial intelligence (AI) refers to machines demonstrating human-like intelligence and being able to perform 'human-intelligent' tasks. It revolves around the concepts of learning, problem solving and decision making. By definition, they should be able to perform tasks to the same standard or better than humans. [(1)] Despite this notion proving extremely popular in science fiction, it has rather been relatively slow to be adopted into current clinical practice. Clinical medicine is evidence-based, and as of yet currently there remains a distinct lack of wide-scale solid reliable evidence that suggests AI is more effective than clinical practice. This is one of the main challenges to its widespread adoption. Two fundamental principles of AI are machine learning and deep learning. [(2)] Machine learning involves learning via a feedback loop: the machine receives large volumes of data, it identifies patterns and relationships in the data, and then feeds it back in. Deep learning, however, involves algorithms structured in layers. Each subsequent layer is able to analyse a different part of the data and then feed it back. This allows the machine to progressively automatically analyse increasingly complex features from the initial data.

Benign paroxysmal positional vertigo (BPPV), by nature is a benign condition but it can have severe debilitating effects for patients. In fact, it is the most common cause of dizziness in the primary care setting. [(3)] Especially in elderly patients, the risk of falls secondary to BPPV can result in significant morbidity and mortality. As such it is important to ensure it is appropriately diagnosed and managed. Diagnosis is dependent on eliciting positional-dependent nystagmus. However, in clinical practice this can usually be difficult to detect, and patients undergo unnecessary imaging involving radiation. Using deep-learning, an algorithm was developed as a diagnostic decision support system. [(4)] 91,778 nystagmus videos, annotated by four ontological experts were fed into the network to train and establish the algorithm. It led to a highly sensitive and specific (both $> 80\%$) valid model for the diagnosis of BPPV. This holds huge potential implications. As a diagnostic aid, it can lead to earlier detection and then potentially less sequalae of the disease.

It can save costs within NHS, as a lot of these patients are treated repeatedly in primary care before referral to otologists. Primary care doctors in particular lack significant exposure to ENT pathologies within their training [(5)], and this can therefore ease their diagnostic uncertainty as well as be a learning tool. It can be used in rural areas as a screening tool where ENT services are not readily available. There is a potential for this program to be embedded into handheld technology, and therefore massively increase accessibility, especially as it tracks eye movements, which can in theory be performed by any camera.

Artificial intelligence as diagnostic aids has a lot of challenges to their adoption. In fact, a report released by the Royal College of Surgery (RCS) highlighted some key concerns to widespread adoption[(6)]: Both doctors and patients fear the medical personnel being replaced by machines, ones that lack the sensitive personal interaction associated with a doctor-patient relationship.[(7)] Ethics and governance of data remains a topical issue, as breach of huge volumes of patient confidential data is potentially exposed [(1)]. The algorithm generated is also heavily reliant on the data inputted, known as the black-box conundrum. This can lead to learning bias such as over gender or ethnicity. The complexity of AI decision making can potentially lead to an over-reliance on the system, despite only being an aid. A promise to overcome these concerns can help allay public and clinician fear. For example transparency over the use of data by private companies, further training and awareness of AI for all clinicians and strict guidelines and protocols regarding its use can all help ease a smooth transition into AI in healthcare, and in ENT in particular.

AI also holds further huge potential within ENT surgery. As well within the diagnostic process, treatment options can be optimised using AI. A deep learning model was used to predict the hearing outcomes for patients who had suffered sudden sensorineural hearing loss (SSNHL)[(8)]. This is a multifactorial disease, and as such outcomes typically vary widely from permanent hearing loss to complete resolution with no residual symptoms. There is currently no well-accepted and accurate predictive system. 149 predictive variables were identified amongst 1220 patients in this study. It showed that the AI model was far more accurate compared to a conventional logistical regression (LR) method of analysis. However, this only proved true with large data variables. In fact, once 3 main key predictive variables were identified: initial level of hearing, audiogram and time between onset of symptoms and entry into study, the AI model actually fared far less accurate than the standard LR method. In clinical practice, it is far easier to gather 3 key pieces of information than it is to gather data for 149 variables. Here-in lies a fundamental fault with AI- to be truly accurate, it requires a large set of data, and in practical terms, much of this gathered data is either inaccurate, incomplete or unobtainable. Extrapolating this even further in the treatment algorithm, AI also has a role to play in hearing aids. It can lead to quicker and more accurate fitting of cochlear implants [(9)]. An algorithm can be derived from large audiological data on hearing thresholds and audiogram results, and then used to automate the fitting process. An added advantage is that due to the automatization, it can be done remotely and allows a much more tailored service for the patient. Furthermore, a device has been developed to be used in rural remote regions. Building upon an automated diagnosis of otitis media system[(10)], AI has been incorporated into a smart-phone device attachment called 'HearScope' to reliably diagnose common pathologies of the ear. [(11)] In fact, the neural network used has an accuracy of 86%, which compares favourably to GPs and paediatricians using normal otoscopes. In developed countries, the fact that it doesn't hold a clear advantage over current practice is a hinderance, but the potential for use in developing countries, especially in communities with limited access to healthcare is immense.

The other major branch of ENT which has had advances in AI is head and neck oncology. Machine learning in particular is able help with clinical research as it can process large amounts of data, especially genetic data, and identify patterns. For example, it has already helped identify a 40 gene profile for predicting nodal disease in HPV-related oropharyngeal cancers. [(12)] The implication of this is that it can identify high risk patients and then tailor treatment for them personally before they are found to have nodal disease clinically. AI involving imaging also holds huge benefit. A machine learning algorithm was able to accurately visually identify oropharyngeal cancers using a combination of white light and narrow band imaging. Furthermore, examining pre-operative CT images, a neural network was able to identify nodal metastasis and extranodal extension. The aim of both of these were early detection. A classification algorithm has been developed that is able to distinguish between normal oral mucosa and malignant tissue on hyperspectral imaging alone.

[13] The consequence of this is it can be applied to 'on the table' tumour margins to prevent unnecessary re-operations when all the malignant tissue has not been removed.

Clearly the implications for AI within ENT are huge. However, there has yet to be of any real beneficial clinical applications. The majority of these advances in AI have been within the last few years, and as such a lot more studies demonstrating needs to be shown before it can be incorporated into today's evidence-based clinical medicine. Ethical considerations remain a challenge to adoption of AI.[14] The respect for autonomy is a key ethical principle in medicine. There is a severe lack of understanding around how the algorithm decides the output based on the data provided, in which case doctors will not be able to accurately disclose all the necessary information about the diagnosis and treatment to the patients. Likewise, the autonomy for patients is at serious risk because there is a huge potential risk of patient confidentiality with large multi-national corporations responsible for these AI systems. Also for the doctors, they may no longer be able to deviate from established algorithms, and that decision subjectivity is removed entirely. The AI system is entirely dependent on the data received and such if poor data is received, then the risk for maleficence to the patients is present. Also, patient-specific factors are potentially infinite, and there is no way a system will be able to account for all of those. No two patients may want the same treatment despite the machine determining that a specific treatment is best for both of them. As doctors, one can advocate for treatments that are most beneficial for the patients, something the machine will be unable to do. The cost and resources required to implement AI is a significant hinderance to its adoption. There is no way to ensure that location and hospital trusts do not play a role here. Some hospitals and regions will have more access to money, hence better AI services and in theory will be providing a better standard of treatment to patients.

In summary, artificial intelligence has a huge role to play in surgery. Within ENT particularly, the scope is immense: Applications can vary from diagnostic aids, imaging and risk stratifying patients to real-time operative applications. However, there still remains multiple barriers to widespread adoption of AI within ENT. As technology advances, and AI becomes more common in society, there will inevitability be an inevitability be a push to integrate it within surgery. It stands to reason then that ENT surgeons can proactively help support and participate in AI projects at this current fundamental highly developmental stage as it will ultimately influence future clinical practice.

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