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Future applications of Artificial Intelligence in Urology: an update for future clinicians

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Discussion Starter

Future applications of Artificial Intelligence in Urology: an update for future clinicians

DISCUSSION STARTER

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ABSTRACT

Artificial Intelligence (AI) is becoming an increasingly prevalent tool across medical and surgical disciplines, with numerous specialities looking to implement this powerful technology in day-to-day clinical practice. Current and future medical students will begin to frequently encounter AI in their careers, and here we analyse the potential role of AI in urology. With growing pressures on urology departments globally, could AI be the solution to managing urological diseases in a growing population with increasing comorbidities? With a number of clinical applications, this work identifies several key domains where AI can make a substantive difference to urology. Working symbiotically with urologists, AI can be harnessed to improve the surgical outcomes of patients, while also enhancing surgical education and decision-making. From increased clinician productivity to enhanced anatomical training, embracing AI will modernise the practice of urology. Research has already been undertaken to demonstrate AI's value in urology, and further attention must be given to integrate this powerful tool into the urologist's arsenal.

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INTRODUCTION

In an era where artificial intelligence (AI) has become a dominant force for research and interest, where can urology utilise and exploit the benefits of this emerging technology? This manuscript aims to identify clinical applications for AI within the speciality of urology, while also identifying potential limitations of this technology. Current and future medical students should be aware of the potential role of AI in urology, as it becomes more widely implemented in day-to-day clinical practice, particularly in urology.
To fully understand AI's potential, we must first understand what AI is. Whilst AI can be explained to varying degrees of complexity, in its simplest form, AI is a computer-based technology that aims to solve problems using human-like intelligence. (1) AI can be further subdivided into categories such as large language models (LLMs), machine learning (both supervised and unsupervised), deep learning and more (see figure 1).

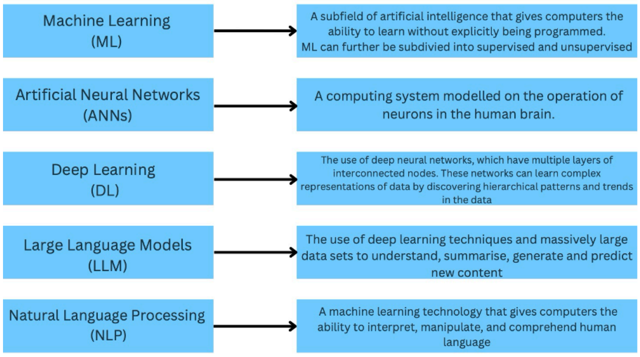

Figure 1: Frequently encountered terminology within Artificial Intelligence (AI)

Hospitals and care providers around the world, especially in developed economies, are increasingly using digital technologies, such as AI, machine learning, smart sensors, robots and big data analytics for improved quality of care and operational efficiency. (2) Numerous specialities in medicine have begun to harness the powers of AI, with significant research taking place in areas such as cardiology, gastroenterology, dermatology etc, (3-5), with these studies demonstrating that AI has already helped to improve clinical outcomes for patients. For example, in one open, non-blinded trial, consecutive patients were prospectively randomised to undergo diagnostic colonoscopy with or without the assistance of a real-time automatic polyp detection system (AI), which provided a simultaneous visual notice and sound alarm on polyp detection. The cohort that utilised AI in the colonoscopy had a 10% higher polyp detection rate compared to the clinician-alone approach. (6) This is just one example of a study demonstrating the positive utilisation of AI to improve patient outcomes, with similar applications in urology. Significant applications of AI in urology include improved disease screening, improved clinical productivity, robotic surgery, and medical education.

DISEASE SCREENING

In the UK, despite increasing public awareness and treatment efficacy of prostate cancer, it is still the 2nd most common cause of cancer death in men. (7) Furthermore, an increasing volume of prostate biopsies and a worldwide shortage of urological pathologists puts a strain on pathology departments, which are essential to prostate cancer diagnosis. (8)

Currently, there is growing evidence to support the use of multiparametric MRI (mpMRI) in the diagnosis of prostate cancer. (9) Despite this, a definitive diagnosis of prostate cancer is made based on histopathologic Gleason grading, which has traditionally shown an excellent correlation with clinical outcomes. (10) However, the Gleason grading system has limitations, such as subjective reporting by pathologists, who are also subject to human error, resulting in important discrepancies persisting between biopsy tumour grading and final whole-organ pathological assessment after radical prostatectomy. (9,10) To bridge the gap and improve patient outcomes, AI has the potential to screen radiological and pathological images to improve clinical accuracy and efficiency in prostate cancer diagnosis. (11)

A recent Swedish study saw researchers develop an AI system that was trained to detect and grade prostate cancer biopsies with similar accuracy to expert pathologists. (12) Clinical application could include reducing the urological pathology workload by reducing the assessment of benign biopsies and by automating the task of measuring cancer length in positive biopsy cores. With further development and research, an AI system with expert-level grading performance might aid in standardising grading and provide urological pathology expertise in parts of the world where pathology services are not easily accessible, be it due to geographical, logistical or financial limitations. AI implementation in these areas could further contribute to improving global health outcomes (see figure 2).

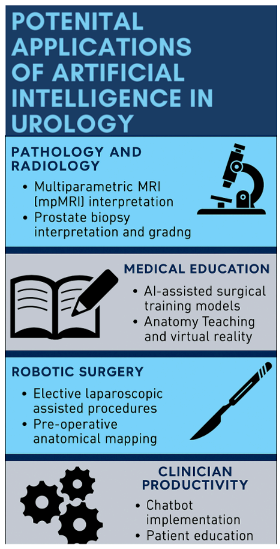

Figure 1: Potential applications of AI in urology

CLINICIAN PRODUCTIVITY

Whilst not a domain that always attracts attention in healthcare, improved productivity saves not only time but also money and resources. With growing pressures on urology services, AI has the potential to safely aid in patient treatment and contribute to better outcomes. One easily implementable function would be the wider introduction of urology-based "chatbots". A chatbot is a software application designed to mimic human conversation through text or voice interactions. Chatbot technology can be installed on basic electronic devices, including computers, smartphones and tablets, allowing relatively easy implementations for users on a day-to-day basis, without the requirement of further purchase of equipment. A recently published study by Talyshinskii et al. explored the benefits a chatbot could have within urology. (13) Practical applications of these chatbots apply to both the clinical and administrative domains. By programming these chat boxes effectively, urology patients could have AI-led routine follow-up appointments which do not require face-to-face contact, whilst also identifying risk factors that may prompt more urgent reviews face-to-face.

Further actions could also include streamlining repetitive tasks like scheduling appointments, managing repeat medications, and tracking symptoms, giving Urologists time to concentrate on challenging or complex patient cases. Chatbots can be used to educate and inform patients with urological diseases, aiding the routine practice of Urologists. A study by Kim et al saw the development of one such chatbot to promote self-management of interstitial cystitis. (14) Over 6 weeks, patients in the study received AI-generated supportive messages to encourage patient-led interventions such as pelvic floor therapy and guided mindfulness practices (see figure 3).

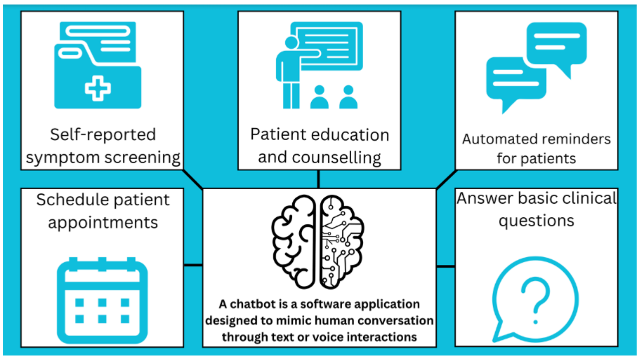

Figure 3: The potential role of "chatbots" in urology

Chatbots can ensure patients receive information on their urological conditions, treatment options, and preventive care measures, thus improving patient knowledge. Urologists, all in all, should not fear replacement by AI but should instead utilise it to maximise their productivity and enable focus elsewhere.

ROBOTIC SURGERY

In the operating theatre, urologists have been at the forefront of pioneering AI-assisted robotic surgery, most notably in the domain of robot-assisted laparoscopy. Emerging systems such as the standard da Vinci, Avatera, Hinotori and Revo-I es incorporate elements of artificial intelligence. (15) Whilst still in relative infancy, robot-assisted surgery has shown promise. (16-18) These technologies utilise 3-D views in high definition, which are generated by AI. This enhanced view improves anatomical situational awareness, while the technology also delivers key ergonomic advantages, including superior dexterity and access to areas otherwise hidden from sight. As interest and funding grow for robotic-assisted surgery, AI will inevitably be further utilised to improve the quality and reliability of it. (19) The domain of robotic surgery closely ties in with AI in medical education, a topic explored in greater depth further on. There are limitations of AI in operating theatres, as it appears that most are suited for elective cases where time is not always critical, and thus extensive mapping, planning and programming can take place before surgery, (15,17) and there does not currently seem to be an obvious role for AI in emergency settings particularly when it comes to acute urology surgery. However, it is likely robotic surgery will continue to become more prevalent in operating theatres for routine elective procedures, or complex operations where there is time to methodically plan an approach.

MEDICAL EDUCATION

A robust education and training programme using appropriate resources is essential for the continued personal development of urologists, beginning at medical school, all the way to specialised fellowships and beyond. With AI being increasingly utilised, educators must begin to integrate AI into the medical curriculum to ensure future clinicians understand the role AI can play in their speciality.

Most practical skills for surgery are best learnt in the operating theatre. Despite this, it is well documented that inexperienced surgeons are more prone to having adverse outcomes. (20) Therefore, a safer training model is clearly desirable for surgeons and patients; AI-based training presents a solution to this problem. A surgical training process where learning is based on simulation could improve surgeons' technical abilities and patient outcomes. AI-based models could provide feedback and progressively increase the complexity of the case according to the trainee's level, possibly reducing the risk of complications when a surgeon starts the operating learning curve on humans. (21) A comprehensive AI-based training system would allow the trainee to make mistakes without risking patient safety, whilst refining their core skillset in preparation for real-life implementation.

At present, real anatomy simulation is one of the most well-studied implications of digital technologies in urology. An example in urology is the use of virtual reality in surgical planning for percutaneous nephrolithotomies. Parkhomenko et al. studied 25 patients with nephrolithiasis whose computer tomography data were used to create virtual models (22). The study found that virtual reality improved the surgeons' understanding of the optimal calyx of entry, the stone's location, and altered the surgical approach in 40% of cases. Clinically, this is likely to improve patient outcomes when applied to the operating theatre, giving trainees greater knowledge and confidence.

LIMITATIONS

Whilst the benefits of AI are clearly put forward, there are limitations, such as the social and ethical issues associated with widespread AI use. AI relies on consuming vast amounts of patient data, which in turn must be ethically sourced and appropriately secured and protected. AI is vulnerable to a variety of targeted attacks, which could in turn lead to the accessibility of patient data. (23) As a result, this could compromise the trust and relationship between patients and clinicians. The cyber threat is extremely credible, such as in 2017, when the NHS was subject to a significant cyber-attack that affected one-third of all trusts in the UK and 8% of all GP practices. (24) The potential implementation of AI means the risk of data compromise could still be extremely high, and therefore, further resources must be committed to safeguard patient data at all levels.
Furthermore, patient perception regarding the reliability of AI is varied, with a meta-analysis by Wu et al, identifing key areas of public concern, including fears of compromised data protection, concerns over AI reliability and concerns regarding the loss of patient autonomy. (25)

To ethically obtain data for AI development, there must be patient trust and buy in. However, in one study of 4000 American adults, only 11% were willing to share health data with technology companies, vs 72% with physicians. (26) Therefore, patient education surrounding the use of AI and the use of their data must be improved.

Clinically, future doctors must ensure they avoid over-reliance on AI, as this risks de-skilling of humans due to a combination of over-reliance, poor understanding, and basic skill fade. Some of these negative phenomena have already been witnessed in other industries that have already undergone, or are undergoing, "automation revolutions", namely, commercial aviation and the automotive industry. (27) For instance, urologists must ensure they still retain and develop their basic surgical skills should a laparoscopic robot malfunction or the procedure be abandoned due to technical difficulties. Despite highlighting AI's limitations in emergency settings, even "routine" cases pose the risk of rapidly deteriorating, requiring urgent human intervention.

CONCLUSION

For urology, the clinical applications of artificial intelligence are vast and warrant further research and investment. The integration of AI into daily clinical practice has the potential to transform and modernise medicine as we know it, and current and future clinicians should ensure they remain familiar with AI advancements as they become common practice. The range of potential applications is extensive, from simulation training and improved disease diagnosis to greater clinical productivity. Simple implementations of artificial intelligence, such as chatbots, are a straightforward but beneficial way of combating the growing pressures faced by urology. In a longer-term strategy, investment in AI will result in better technology, such as surgical robots, as well as radiological and pathological tools, which will benefit urology patients. Further efforts must be made to alleviate patient concerns regarding clinical data protection and AI reliability through rigorous legislation and data governance rules, which will safeguard patient data. It is important to recognise that AI and the clinician must work symbiotically for our patients in all stages of treatment. Urology should continue to embrace AI technology for patient benefit.

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