REVIEW
General Urology

Doi: 10.4274/jus.galenos.2024.2024-11-2
J Urol Surg 2025;12(1):1-5

Top 100 Articles on Artificial Intelligence in Urology

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Abstract

Artificial intelligence (AI) is rapidly increasing its importance in many fields today, including medicine and even urology. In this article, we have compiled the top 100 articles on this topic to provide insights into and guide future research for researchers. We selected the best-matched articles from 2019-2024 by typing "AI in urology" into the search bar on PubMed's website. We accepted the terms deep learning, machine learning, and neural networks. We have excluded the editorial letter and comments from the study. We reviewed 231 articles and selected the top 100 articles. We categorized the articles based on the date of printing, publication types, related sub-specialties, journal names, the quartile indexes of these journals, the number of references, and citations, the country of affiliation of the first author, and the number of centers involved. Every year, researchers are delving deeper into this topic. Currently, the majority of articles are review articles. High-quality journals are publishing studies on this topic. Researchers from America and Europe are the leading figures in this field. In AI, researchers focus the most on uro-oncology, which is the subspecialty of urology. We anticipate a substantial increase in the use of AI in urology in the future. It is imperative to acknowledge that there are numerous disadvantages, in addition to the advantages. Numerous original articles are necessary.

Keywords: Artificial intelligence, machine learning, deep learning, neural network

Introduction

In the realm of medicine, artificial intelligence (AI) is swiftly becoming prominent, and its impact on urology is profound. Validated and optimized AI leads to a speedier, more personalized, efficient, and focused search compared with traditional methods (1). The field of AI continues to advance rapidly. The patient-doctor relationship, as well as patient outcomes, is improving (2). The ability of AI to efficiently process vast quantities of data, in combination with the shift towards electronic patient records, results in increasingly larger "big data" sets. In the future, AI will be able to analyze and detect novel diagnostic and treatment patterns (3). Current advances in computer science have already led to the study and automated optimization of multiple, highly complex non-medical processes. If applied correctly, the development of AI models can lead to more effective processing and analysis of patient-related data, as well as optimized diagnosis and therapy for urological patients (4).

AI may soon automate and standardize many facets of routine work. In the near future, the most promising approach appears to be a model that enhances pathologists with second-review or real-time AI systems (5). To make patient-specific disease predictions, AI systems have combined clinical and histologic information. AI will likely play a major role in histopathological examination (6). This is a promising approach that has several possible clinical applications, resulting in increased speed and/or quality of pathology reports (7). Machine learning (ML) algorithms, fueled by vast datasets of medical images and patient records, are adept at detecting subtle abnormalities that might escape human observation. AI algorithms are proving invaluable in the interpretation of bladder and kidney scans, enabling clinicians to pinpoint pathology swiftly and accurately. This method has effectively utilized automatic tumor detection and grading in histopathological image analysis to assess the risk of recurrence, metastasis, or survival (8). It has grown in use over the years and continues to evolve, contributing to the decision-making process for modern cancer treatment (9).

Although deep learning (DL) enables the investigation of large data sets, the implementation of AI still faces considerable obstacles, such as heterogeneous data infrastructure between different health care organizations and the need for collaboration between computer scientists and surgeons. Modalities such as cystoscopy and robotic video/image-based data have shown promise, but initial studies require additional

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Received: 04.11.2024 **Accepted:** 28.11.2024 **Publication Date:** 21.02.2025

Cite this article as: Deniz ME, Kayra MV. Top 100 articles on artificial intelligence in urology. J Urol Surg. 2025;12(1):1-5.

research to establish more robust results and better ways to incorporate AI in an effort to improve patient outcomes (10). Most studies included a small sample of patients from a single institution, and most models did not undergo proper external validation. Further research through larger and well-designed studies is required to develop reliable AI tools (11).

In this study, we compiled research on AI in urology. We aimed to highlight AI's advantages and disadvantages, showing which areas it is most needed or lacking in urology, thereby guiding researchers in their future studies.

Materials and Methods

We entered the term "AI in urology" into PubMed's search bar, selected the "between 2019 and 2024" date range, and then sorted the articles using the "best matched" section. We accept the following terms in articles: "neural network", "DL", or "ML". We clicked on all available text and included all article types, with the exception of editorial letters and comments. After checking the articles to confirm their relevance to urology, we excluded unrelated papers. We scanned the first 231 articles on the list to identify the first 100 that met our inclusion criteria. No language restriction was applied.

On the Web of Science (WoS) websites, we verified the journals' quartile scores. We categorized the articles based on the date of printing, publication types, related sub-specialties, journal names, the quartile indexes of these journals, the number of references and citations, the country of affiliation of the first author, and the number of centers involved. We classified the articles by sub-specialties based on the European Association of Urology 2024 guidelines. The WoS website checked how many citations the articles had recently received.

This study did not seek ethical committee approval because it was a bibliometric study without any human subjects.

Limitations

We evaluated the Top 100 articles using the best-matched tab for keywords in PubMed, potentially excluding high-quality articles that did not match the relevant keywords from the list.

Results

The distribution of the top 100 articles in the study by year indicates that there were 3 articles in 2019, 13 in 2020, 16 in 2021, 19 in 2022, 28 in 2023, and 21 in 2024 up to this point (Table 1). The dominant type of article was a review study (n=59). The remainder consisted of 23 original articles, 9 research supports, 6 multicenter studies, 1 clinical study, 1 comparative study, and 1 meta-analysis (Table 2). The publications appeared in 53 different journals. It is evident that certain journals prioritize articles related to AI over others. During this period, Current Opinion in Urology holds the top rank with 15 publications about AI, followed by Urologic Clinics of North America with 9 publications, and Current Urology Reports with 6 publications (Table 3). Notably, 58% of these journals published their articles in the first quartile (Q1), 30% in the second quartile (Q2), 20% in the third quartile (Q3), and 2% in the fourth quartile (Q4) (Table 4). The average number of citations was 6.88 (range 0-58). All of the articles with 0 or 1 citation were published in 2023 or 2024. The first authors were from 28 different countries. The United States is clearly at the forefront of this ranking (n=61), followed by England (n=12), Germany (n=7), the Netherlands (n=6), Canada (n=5), and France (n=5), and these are followed by others with 1 or 2 articles (Table 5).

We found that based on their subspecialties, 53% of the articles focused on oncology. Out of these, 26 articles focused on prostate cancer (PCa), including topics such as pathology (n=6), genomics (n=3), follow-ups (n=4), radiology (n=9), education (n=2), and limitations (n=2). Additionally, 13 articles addressed bladder cancer (BCa), including diagnostic cystoscopy (n=3), cytology (n=3), histopathology (n=3), radiogenomics (n=1), lymph node metastases (n=2), and one article each on general oncology, kidney cancer (KCa), and quality of life (QoL). There were 17 articles on patient care, 10 articles on stone disease, 7 articles on endourology and robotic surgery, and 4 articles on men's health [lower urinary tract symptoms (n=1), infertility (n=2), and erectile dysfunction (n=1)]. There are 3 articles on surgical training and pediatrics, 2 articles on transplantation, and 1 article on neuro-urology and QoL (Table 6).

Table 1. Number of articles by years

	(n)
2019	3
2020	13
2021	16
2022	19
2023	28
2024	21

Table 2. Type of articles

	(n)
Review	59
Original article	23
Research support	9
Multicenter study	6
Clinical study	1
Comparative study	1
Meta-analysis	1

Table 3. The journals	
	(n)
Actas Urológicas Españolas	1
American Society of Clinical Oncology Educational Book	1
Annals of Surgical Oncology	1
Archivos Espanoles de Urologia	1
BJU International	2
BMC Cancer	1
BMC Medical Informatics and Decision Making	1
BMC Medicine	1
BMJ Open	1
Canadian Journal of Urology	1
Cancer Cytopathology	1
Cell Reports Medicine	1
Computer Methods and Programs in Biomedicine	1
Contrast Media Mol Imaging	1
Current Opinion in Urology	15
Current Urology Reports	6
Der Urologe	1
European Journal of Nuclear Medicine and Molecular Imaging	1
European Urology	2
European Urology Focus	3
European Urology Oncology	1
International Brazilian Journal of Urology	2
International Journal of Impotence Research	1
International Journal of Molecular Sciences	1
International Journal of Surgery	2
International Journal of Urology	1
International Urology and Nephrology	1
Investigative and Clinical Urology	2
JCO Clinical Cancer Informatics	1
Journal of Endourology	1
Journal of Nephrology	1
Journal of Pathology	1
Journal of Pediatric Urology	1
Journal of the National Cancer Institute	1
Journal of Translational Medicine	1
Journal of Urology	2
Lancet Digital Health	1
Lancet Oncology	1
Medicina (Lithuania)	1
Military Medical Research	1
Minerva Urology and Nephrology	3
Nature Reviews Urology	1
New England Journal of Medicine	1
PLoS One	1
Prostate	1
Prostate Cancer and Prostatic Diseases	3
Radiology	1
Urologe	2
Urologic Clinics of North America	9
Urologic Oncology	3

Table 3. Continued	
	(n)
Urologie	2
Urology Practice	1
World Journal of Urology	5

Table 4. The quartile numbers of the journals	
	(n)
Q1	58
Q2	30
Q3	10
Q4	2

Table 5. First author's country	
	(n)
USA	35
Germany	13
China	11
Italy	7
UK	5
France	5
Austria	2
Belgium	2
Canada	2
India	2
Japan	2
Korea	2
Netherlands	2
Singapore	2
Türkiye	2
Brasil	1
Greece	1
Kazakhstan	1
Russia	1
Spain	1
Taiwan	1

Table 6. Relevant subspeciality	
	n
Endourology and robotic surgery	7
Men's health	4
Neuro-urology	1
Oncology-bladder	13
Oncology-general	10
Oncology-kidney	3
Oncology-prostate	26
Oncology-quality of life	1
Patient care	17
Pediatric	3
Stone disease	10
Surgical training	3
Transplantation	2

Discussion

AI's primary application in urology is in the field of genitourinary cancers. Upon examining the statistics, it is evident that the majority of the articles fall within the field of urological oncology. Reviewing all the articles reveals the use of AI in diagnosis, particularly in pathological, radiological, and genomic contexts, focusing on PCa and BCa. Focusing on PCa, AI was applied for the prediction of prostate biopsy results. ML algorithms performed predicted recurrence-free probability and diagnostic evaluation for BCa. For KCa and testis cancer, anecdotal experiences were reported for staging and prediction of disease recurrence (12). Suarez-Ibarrola et al. (13) used radiomics and texture feature analysis for BCa studies. They focused on image-based cytology and algorithms for treatment response, tumor recurrence, and patient survival. PCa studies aim to develop Gleason score prediction, magnetic resonance imaging computer-aided diagnosis prediction, surgical outcomes prediction, and biochemical recurrence prediction. They looked into how ML and DL could be used in renal cell cancer, to differentiate between benign and malignant masses, determine the Fuhrman nuclear grade, and develop molecular signatures (13). By analyzing data using various methods, ML-based programs appear to be able to prevent undiagnoses, or missed diagnoses, but it is indisputable that a significant number of original studies are still required.

Perhaps one of the areas where AI is currently most beneficial is education. Regarding the simulation technology, many clinicians, residents, and medical students benefit from these developments. Khanna et al. (14) created a fully automated AI tool for robotic-assisted radical prostatectomy surgical video annotation. Automated surgical video analysis has immediate practical applications in surgeon video review, surgical training and education, quality and safety benchmarking, medical billing and documentation, and operating room logistics.

AI has also contributed to patient care. The plan is to provide more cost-effective services through the use of statistics on patient care both inside and outside the hospital. Reducing readmissions, strengthening patient-doctor relationships, and providing higher-quality services are among the primary goals of using AI in this field. Wendler et al. (15) discussed the role of various technologies at different stages of the surgical workflow, including surgical decision and planning, target localization and excision guidance, and surgical verification at the back table. Stai et al. (16) conducted a survey to compare confidence in human and computer-based diagnosis. Most participants express confidence in AI in providing medical diagnoses, sometimes even over human physicians. Despite their general concerns, participants mistakenly believe that surgical AI is already in use. There is currently no evidence that AI can identify the critical tasks of robot-assisted surgery that determine patient outcome. There is an urgent need for research on large datasets and external validation of the AI algorithms used (17).

Researchers also have expectations for AI in the field of men's health. Researchers use a variety of AI- and ML-based methods to assess sperm parameters and DNA integrity or damage, and to ensure the success of conventional testicular sperm extraction in patients with non-obstructive azoospermia. While AI and ML hold promise in accurately assessing semen analysis and providing correct information to clinicians, it is essential to address challenges such as data quality, standardization, and ethical considerations (18). Xiong et al. (19) reviewed 30 articles to summarize the current status, merits, and limitations of applying AI in diagnosing and predicting ED. The results showed that AI contributed to developing novel diagnostic questionnaires, equipment, expert systems, image classifiers, and predictive models.

There is substantial evidence that pediatric urologic publications using AI methodology have exponentially increased in recent years. While these studies show enormous promise for better understanding of disease and patient care, urologists should be realistic about the challenges arising from the nature of pediatric urologic conditions and practice in order to continue to produce high-impact research (20). For instance, the world of pediatric urology has been slow to fully accept robotic surgery, largely due to its initial application for adult use and its inherent high cost. However, as previously shown, it has now become the gold standard for adolescent pyeloplasty in the United States (21).

As the years passed, the transition from open surgery to endourology occurred in parallel with the use of instruments in urology, and this process subsequently evolved into minimally invasive interventions. With technological advancements in automated systems, AI is increasingly gaining prominence. In the coming years, we anticipate a gradual decrease in human factors' role in medicine. Currently, reviews predominate, but over time, original studies should contribute to the field of urology. Furthermore, prestigious academic journals are publishing AI-related results. As countries increase their investments in science and technology, it is not surprising to see a rise in the amount of research conducted on this topic. However, the clinical use of AI has not yet fully settled. Currently, clinicians only use AI to conduct detailed data analyses in clinical settings. Additionally, despite the availability of numerous computer programs, clinicians have yet to demonstrate proficiency in using them. We hope that in the future, AI can go beyond detailed data analyses used in diagnosis and instrumental technological advancements in surgery.

Conclusion

AI is currently at the center of attention, especially for young researchers, and stands out as one of the most popular topics. It is not surprising that clinicians want to benefit from the indispensable innovations that technology offers in every field. Not only is it quite natural for expectations to be high, but time will also tell whether AI can truly provide superhuman contributions.

Footnotes

Authorship Contributions

Surgical and Medical Practices: M.E.D., Concept: M.V.K., Design M.V.K., Data Collection or Processing: M.E.D., Analysis or Interpretation: M.V.K., Literature Search: M.E.D., Writing: M.E.D.

Conflict of Interest: No conflict of interest was declared by the author.

Financial Disclosure: The author declared that this study received no financial support.

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