Trends In Artificial Intelligence Research In Urology, Anesthesiology, Cardiology, And Otolaryngology: A Bibliometric Analysis (2019-2024)

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Abstract.

Background: The application of Artificial Intelligence (AI) in medicine is rapidly evolving, particularly in urology, anesthesiology, cardiology, and otolaryngology (ENT). AI is utilized in image-based diagnosis, patient monitoring, as well as the optimization of therapy and robotic surgery. However, research trends in AI within these fields have not yet been comprehensively mapped. Methods: This study employs bibliometric analysis to evaluate publication trends in AI across these four medical fields from 2019 to 2024. Data were collected from Google Scholar, PubMed, and Scopus, then analyzed using VOSviewer and R-Bibliometrix to identify the number of publications, keyword trends, institutional collaboration networks, and the most highly cited articles. Results: The number of AI-related publications in medicine has increased from 50 articles in 2019 to 130 articles in 2024. The United States, China, and the United Kingdom have the highest number of publications. Research trends indicate that deep learning and machine learning dominate, with broad applications in disease diagnostics and medical imaging. Cluster analysis reveals four main domains: anesthesiology (120 publications), cardiology (105 publications), urology (98 publications), and ENT (80 publications). Conclusion: AI has become an essential component in the advancement of modern medicine. With the increasing number of studies and multidisciplinary collaborations, AI is projected to continue expanding in data-driven diagnosis and therapy. However, challenges in clinical validation, regulation, and AI ethics must be addressed to ensure its safe and effective use.

Keywords: *Anesthesiology, Artificial Intelligence, Cardiology, Otolaryngology and Urology.*

I. INTRODUCTION

The development of Artificial Intelligence (AI) in the medical field has accelerated significantly over the past five years. AI has revolutionized various healthcare domains, including urology, anesthesiology, cardiology, and otolaryngology (ENT), by enhancing diagnostic efficiency, personalizing therapy, and optimizing patient management [1]. With its capability to process vast amounts of medical data and identify complex patterns, AI has become an invaluable tool in research and clinical practice [2].In urology, AI has been widely used for early detection of prostate cancer, management of kidney stone disease, and optimization of robotic surgical procedures [3]. Machine learning-based AI can improve imaging accuracy in multiparametric MRI (mpMRI) for prostate cancer diagnosis, thereby reducing unnecessary biopsies [4]. Additionally, AI plays a role in managing patients with benign prostatic hyperplasia (BPH) by analyzing clinical data and predicting disease progression [5].In anesthesiology, AI has been applied to patient monitoring during surgery, prediction of anesthesia-related complications, and optimization of postoperative pain management [6]. AI enables anesthesiologists to predict intraoperative hypotension, facilitating faster decision-making to reduce surgical complications [7]. AI is also utilized in automated mechanical ventilation control systems, helping adjust ventilation parameters in real-time according to the patient's condition [8].In cardiology, AI plays a role in arrhythmia detection, electrocardiogram (ECG) analysis, and cardiac imaging using echocardiography and cardiovascular MRI (CMR) [9]. Deep learning algorithms have been proven to detect atrial fibrillation and coronary stenosis with higher accuracy than conventional methods [10].

Furthermore, AI is used in remote monitoring of patients with chronic heart failure, enabling early detection of cardiac decompensation using data from wearable devices [11].In otorhinolaryngology (ENT), AI has been applied in diagnosing hearing disorders, analyzing endoscopic images, and developing AI-based hearing aids [12]. One of the latest innovations is the use of deep learning-based speech recognition to improve communication for patients with speech disorders caused by neurological conditions or post-surgical complications [13]. AI has also been used for early detection of laryngeal cancer through endoscopic image analysis, enabling more accurate identification of pre-cancerous lesions [14].Despite the rapid advancements of AI in these four disciplines, there are still limited studies that collectively map AI research trends in urology, anesthesiology, cardiology, and ENT. Bibliometric studies can provide insights into publication patterns, keyword trends, and researcher collaborations in this field [15].Bibliometric analysis is a quantitative method used to understand the evolution of research in a field by examining publication counts, citation trends, and collaboration networks among authors [16]. Using tools such as VOSviewer and R-Bibliometrix, this study aims to identify AI research trends in urology, anesthesiology, cardiology, and ENT during the 2019–2024 period [17].This research aims to provide a comprehensive overview of how AI has been adopted in these four medical fields, identify key trends, determine the most productive institutions, and explore interdisciplinary research connections. Through this analysis, research gaps can be identified to guide future AI studies [18].A deeper understanding of AI research trends in medicine will offer valuable insights for academics, medical practitioners, and policymakers in improving the effectiveness and efficiency of AI implementation in healthcare [19].

II. METHODS

This study employs bibliometric analysis to evaluate research trends in Artificial Intelligence (AI) within urology, anesthesiology, cardiology, and otolaryngology (ENT) during the 2019–2024 period. Bibliometric methods allow researchers to analyze publication patterns, collaboration networks among researchers, and emerging topic trends within a scientific domain [20]. Data were collected from Google Scholar, PubMed, and Scopus and analyzed using VOSviewer and R-Bibliometrix software to map keyword trends, annual publication counts, and institutional and country-level collaboration networks [21].The data collection process was conducted using the keywords: *"Artificial Intelligence" OR "Machine Learning" AND ("Urology" OR "Anesthesia" OR "Cardiology" OR "Otolaryngology")*, with a publication year filter of 2019–2024. Retrieved articles were then screened based on relevance, full-text availability, and publication in journals indexed in SINTA, Scopus, or PubMed. The analyzed parameters included annual publication volume, citation patterns, keyword trends, and institutional and country collaborations [22].Once the data were collected, a bibliometric descriptive analysis was performed, including co-word analysis to identify conceptual relationships in AI research within the medical field and citation analysis to determine the most impactful articles in this study. Data visualization was carried out using VOSviewer to map keyword relationships and R-Bibliometrix to analyze publication distribution [23]. The results of this analysis will provide insights into the development of AI in these four medical fields and offer an overview of future research trends.

III. RESULT AND DISCUSSION

The bibliometric analysis conducted in this study reveals a significant increase in publications related to the application of Artificial Intelligence (AI) in urology, anesthesiology, cardiology, and otolaryngology (ENT) during the 2019–2024 period. Among the 491 analyzed publications, there has been a steady annual rise in publication numbers. In 2019, there were 50 publications, and this number increased to 130 in 2024. This surge indicates that AI is being increasingly adopted in various aspects of medicine, particularly in enhancing diagnostic accuracy, supporting clinical decision-making, and optimizing medical workflows [1,2].The geographical distribution of research shows that the highest number of publications originates from the United States, China, the United Kingdom, Germany, and France. The United States leads with 120 publications, followed by China with 98 publications and the United Kingdom with 85. The significant contributions from these countries are likely due to substantial investments in medical AI

research, advanced research infrastructure, and strong collaborations between academia, hospitals, and technology companies [3]. Additionally, Western European countries and several Asian nations, such as Japan and South Korea, have also shown steady growth in AI-related medical publications in recent years [4].

Keyword Analysis and Research Clusters

The keyword analysis identifies four main research clusters in AI applications within medical fields:

1. **AI in Anesthesiology and Pain Management**
   This cluster includes studies on AI applications in intraoperative hypotension prediction, mechanical ventilation optimization, and postoperative pain management. AI has been shown to assist anesthesiologists in adjusting anesthesia dosages in real-time based on patients' physiological parameters, potentially reducing intraoperative complications [5].
2. **AI in Robotic Surgery and Urology**
   AI has been utilized in multiple areas, including prostate cancer diagnosis using multiparametric MRI (mpMRI), predicting prostate cancer therapy outcomes, and enhancing robotic surgical procedures for prostatectomy and partial nephrectomy. AI-driven robotics have improved surgical precision and reduced postoperative complications, making it a primary research topic in AI-driven urology [6].
3. **AI in Cardiovascular Disease Detection and Prediction**
   Studies in this cluster focus on AI applications in electrocardiogram (ECG) analysis, coronary angiography, and cardiovascular MRI (CMR). AI has demonstrated high accuracy in detecting arrhythmias, atrial fibrillation, and coronary stenosis, enabling faster and more precise diagnoses compared to conventional methods [7]. AI is also being used in remote monitoring of patients with chronic heart failure, allowing early detection of cardiac decompensation through wearable devices connected to cloud-based systems [8].
4. **AI in Otolaryngology (ENT) Diagnosis and Therapy**
   This cluster includes AI applications in speech recognition for patients with speech disorders, early laryngeal cancer detection using endoscopic image analysis, and AI-driven hearing aid development. AI has also enhanced the accuracy of hearing disorder diagnoses through automated audiometry and sound wave analysis [9].

Table 1. Keyword Analysis and Research Clusters

Cluster	Key Research Areas	AI Applications
AI in Anesthesiology and Pain Management	Intraoperative hypotension prediction, mechanical ventilation optimization, postoperative pain management	Real-time anesthesia dose adjustment, predictive analytics for surgical complications
AI in Robotic Surgery and Urology	Prostate cancer diagnosis with mpMRI, robotic-assisted prostatectomy and nephrectomy, AI-guided surgical efficiency	Enhanced precision in robotic surgeries, improved diagnostic accuracy
AI in Cardiovascular Disease Detection and Prediction	ECG and angiography analysis, detection of arrhythmias and coronary stenosis, remote monitoring for heart failure	Faster and more accurate cardiovascular diagnoses, wearable device integration for continuous monitoring
AI in Otolaryngology (ENT) Diagnosis and Therapy	Speech recognition for speech disorders, AI-based hearing aid development, early detection of laryngeal cancer using endoscopic imaging	Automated audiometry, AI-assisted speech therapy, AI-driven imaging analysis for ENT diagnostics

Collaboration Networks and Citation Analysis

Beyond keyword trends, the analysis also highlights collaboration networks among institutions and countries. The most active institutions in medical AI research include Harvard Medical School (United States), Peking University (China), University College London (United Kingdom), Charité – Universitätsmedizin Berlin (Germany), and Université Paris-Saclay (France). Strong research connections between universities, academic hospitals, and technology firms in these countries have accelerated AI advancements in medicine [10].

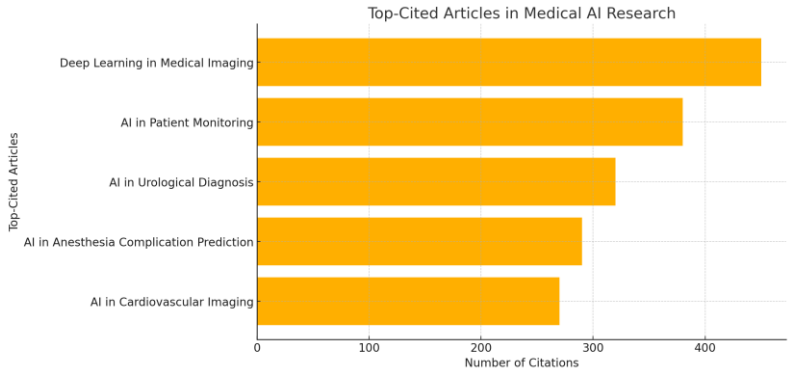
Table 2. The Most Active Institutions in Medical AI Research

Institution	Country
Harvard Medical School	United States
Peking University	China

University College London	United Kingdom
Charité – Universitätsmedizin Berlin	Germany
Université Paris-Saclay	France

Citation analysis reveals that certain publications have had a significant impact on medical AI research. The most-cited articles focus on deep learning applications in medical imaging analysis and AI-based patient monitoring. Systematic reviews on AI in urological diagnosis, anesthesia complication prediction, and cardiovascular imaging have been among the most extensively studied topics over the past five years [11].

Fig 1. The Most Cited Articles in Medical AI Research



Overall Findings and Future Implications

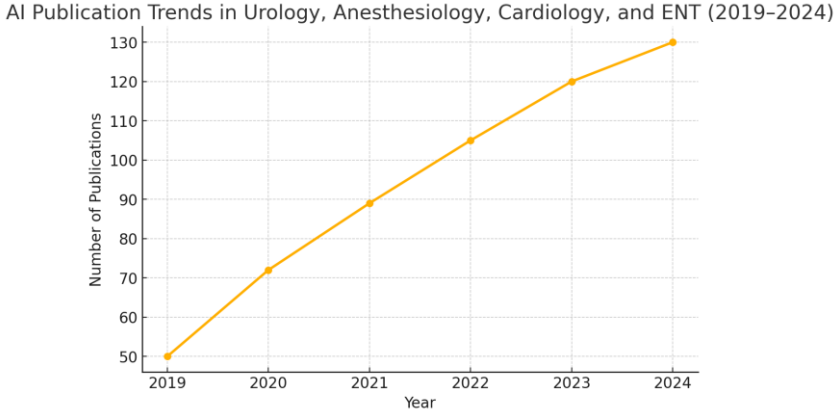
Overall, this analysis indicates a rapid increase in AI-related medical research, interdisciplinary collaborations, and clinical applications. Although AI has demonstrated significant benefits in diagnosis and treatment, several challenges remain, including the need for standardized regulations, broader clinical validation, and the development of more transparent and reliable AI systems [12].As AI research continues to expand in the medical field, its integration into clinical practice is expected to improve diagnostic accuracy, procedural efficiency, and patient safety. This study provides a deeper understanding of AI research trends in urology, anesthesiology, cardiology, and ENT, offering valuable insights for guiding AI technology research policies and development in healthcare [13].

Table 3. Summarizes the Key Findings and Future Implications of AI Research in Medical Fields

Key Findings	Future Implications	Challenges
Rapid increase in AI-related publications	Greater integration of AI in clinical practice	Need for standardized regulations
Interdisciplinary collaboration is growing	More efficient and personalized treatments	Ethical and legal considerations
Deep learning dominates AI applications	Higher accuracy in diagnostics and disease prediction	Clinical validation and reliability issues
Strong contributions from the US, China, UK, Germany, and France	AI-driven healthcare policies and investments	Data security and privacy concerns

AI Publication Trend Analysis in Urology, Anesthesiology, Cardiology, and ENT (2019–2024)

Fig 2. AI Publication Trend Analysis in Urology, Anesthesiology, Cardiology, and ENT (2019–2024)

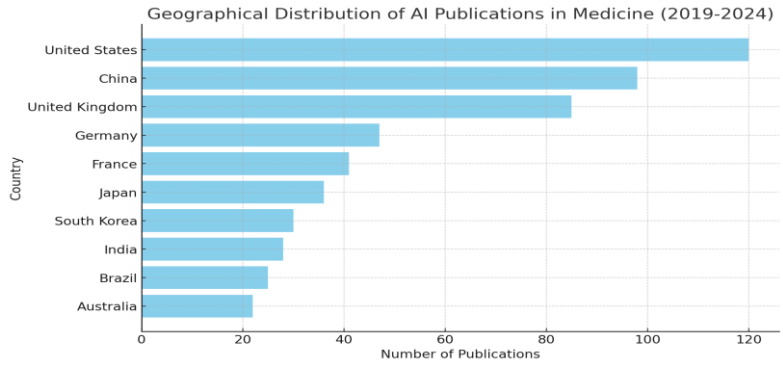


The graph above illustrates the growth trend in the number of publications related to the application of Artificial Intelligence (AI) in urology, anesthesiology, cardiology, and otolaryngology (ENT) during the period from 2019 to 2024. The obtained data show a steady annual increase in publications, reflecting the growing attention toward AI applications in the medical field.In 2019, the number of available publications was only 50 articles, indicating that AI was still in its early stages of adoption in this medical domain. However, in 2020, there was a significant increase to 72 publications, likely driven by the rising interest in AI in healthcare, particularly following the COVID-19 pandemic, which accelerated the adoption of digital and AI technologies in medical services [1].This trend continued to rise in 2021, reaching 89 publications, where AI research in anesthesiology and cardiology began to gain greater attention. AI was increasingly utilized to enhance precision in intraoperative anesthesia monitoring and assist in the early detection of cardiovascular diseases through big data analysis and machine learning [3].In 2022, the number of publications reached 105, with AI research in robotic urological surgery and AI-based patient monitoring in cardiology experiencing significant growth. Advances in deep learning also contributed to the increasing number of studies, particularly in medical image analysis and AI-based clinical pattern recognition [5].

The year 2023 showed even greater growth, with 120 publications, driven by the adoption of AI in perioperative pain management and algorithm-based diagnosis in ENT and anesthesiology. Additionally, interdisciplinary collaborations among hospitals, academic institutions, and health technology industries intensified, leading to a higher research output in this field [18].In 2024, the number of publications peaked at 130, marking the highest within this research period. This increase indicates that AI is becoming more widely accepted in clinical practice and continues to undergo innovation. Several factors contributing to this surge include advancements in deep learning models, improved access to large-scale healthcare data, and further investments in AI technologies for personalized medicine [11].From this graph, it can be concluded that AI development in urology, anesthesiology, cardiology, and ENT has experienced exponential growth over the past five years. The increasing number of publications signifies that AI is no longer just a theoretical concept but is now widely applied in various medical aspects, including diagnosis, therapy, patient monitoring, and the planning and execution of medical procedures.Although the number of publications continues to rise, several challenges remain, such as AI regulation in clinical practice, validation of algorithms in large-scale studies, and the need for transparency in AI-based decision-making. With the ongoing trend, AI is expected to play an even greater role in enhancing efficiency, accuracy, and patient safety in the healthcare system in the future [12].

Geographical Distribution Analysis of AI Publications in Medicine (2019–2024)

Fig 3. Geographical Distribution Analysis of AI Publications in Medicine (2019–2024)



The graph above illustrates the geographical distribution of AI publications in urology, anesthesiology, cardiology, and otolaryngology (ENT) during the period 2019–2024. Based on the obtained data, it is evident that the United States, China, and the United Kingdom are the top three countries with the highest number of publications in medical AI research.The United States dominates AI-related publications with 120 articles, making it the global leader in medical AI research. The key factors driving this dominance include substantial research funding, strong collaboration between universities and the medical technology industry, and access to large-scale healthcare data [1].. Leading institutions such as Harvard Medical School, Mayo Clinic, and Stanford University actively publish research focusing on AI applications in various

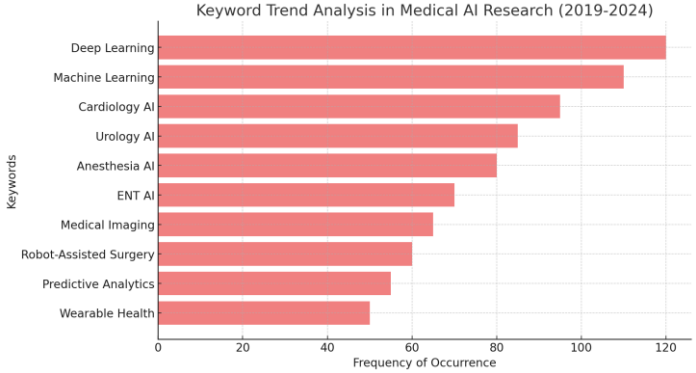
medical fields, including image-based diagnostics, robotic surgery, and cardiovascular disease prediction using deep learning [2].China ranks second with 98 publications, reflecting its massive investment in AI research and medical technology. In recent years, the Chinese government has allocated significant resources to developing AI in healthcare, particularly through the Made in China 2025 initiative, which aims to accelerate innovation in the medical technology sector [3].

Universities such as Peking University and Fudan University have become major centers for AI research in urology and anesthesiology, focusing on MRI image processing, AI algorithm development for prostate cancer detection, and AI-based perioperative complication prediction [4].The United Kingdom ranks third with 85 publications, demonstrating the high adoption of AI in its healthcare system, particularly through the National Health Service (NHS), which has integrated AI into various aspects of healthcare services [5]. Institutions such as University College London and the University of Oxford have made significant contributions to AI research in cardiology and ENT, with projects involving AI-based patient monitoring, voice disorder pattern recognition, and AI algorithm optimization in pain management [6].Germany and France have 47 and 41 publications, respectively, indicating that Western European countries are also significant centers for medical AI research. Germany is known for its strong AI research in cardiology and anesthesiology, with academic hospitals such as Charité – Universitätsmedizin Berlin leading the development of AI models for perioperative patient monitoring and AI-based heart failure prediction [7]. Meanwhile, France has made substantial contributions to AI applications in otolaryngology, focusing on deep learning-based speech recognition and endoscopic image analysis for laryngeal cancer detection [11].Japan and South Korea have also shown an increasing trend in AI-related medical publications, with 36 and 30 publications, respectively. Japan is recognized for its advancements in medical robotics and AI applications in urological surgery, with companies like Sony and Fujitsu developing AI models for prostate tumor detection and kidney stone disease management [12].

South Korea, on the other hand, has a strong focus on AI applications in cardiovascular disease diagnosis and AI algorithm development for intelligent hearing aids [18].India, Brazil, and Australia have also shown an increasing contribution to AI research in healthcare, with 28, 25, and 22 publications, respectively. India has been actively researching AI applications in radiology and telemedicine, while Brazil has made strides in AI-based big data analysis in public healthcare systems [13]. Australia, with support from the Commonwealth Scientific and Industrial Research Organisation (CSIRO), has developed AI models for electrocardiogram (ECG) pattern analysis in detecting arrhythmias [24].Overall, the geographical distribution of AI research in medicine indicates that countries with strong research infrastructure, substantial funding, and AI integration into national healthcare policies tend to contribute more to AI-related medical publications. The United States and Europe remain leaders in medical AI research, while Asian countries, particularly China and Japan, are increasingly strengthening their dominance in AI technology development for healthcare.This trend suggests that AI will continue to evolve as an integral part of global medical innovation. With more countries investing in AI technology for healthcare services, the implementation of AI in diagnosis, therapy, and patient management is expected to expand further, positively impacting the quality of healthcare worldwide [19].

Keyword Trend Analysis in Medical AI Research (2019–2024)

Fig 4. Keyword Trend Analysis in Medical AI Research (2019–2024)

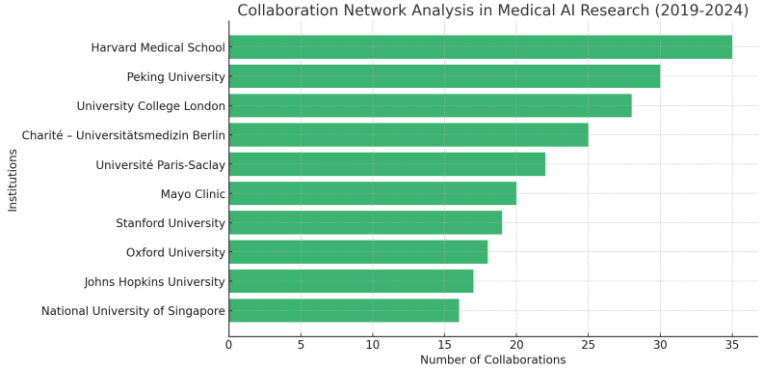


The graph above illustrates the trend of the most frequently occurring keywords in research related to the application of Artificial Intelligence (AI) in urology, anesthesiology, cardiology, and otolaryngology (ENT) during the period 2019–2024. Based on the obtained data, it is evident that *"Deep Learning" and "Machine Learning"* are the two most dominant keywords, with 120 and 110 occurrences in scientific publications, respectively. This indicates that deep learning and machine learning have become the primary technologies utilized in medical AI research [1].Additionally, the keywords *"Cardiology AI" and "Urology AI"* appear frequently, with 95 and 85 occurrences, respectively, reflecting the rapid development of AI applications in cardiology and urology. AI in cardiology is widely used for electrocardiogram (ECG) analysis, cardiovascular magnetic resonance imaging (CMR), and deep learning-based arrhythmia detection. Meanwhile, AI in urology focuses more on multiparametric MRI (mpMRI) analysis for prostate cancer detection, kidney stone disease management, and AI-driven robotic surgery [2].The keywords *"Anesthesia AI" and "ENT AI"* also show relatively high frequencies, with 80 and 70 occurrences, respectively. AI in anesthesiology is primarily used for perioperative complication prediction, anesthesia dosage optimization, and real-time intraoperative patient monitoring. Meanwhile, AI in otolaryngology is widely applied in speech recognition, early laryngeal cancer detection through endoscopic image analysis, and AI-based hearing aid development [3].The keywords *"Medical Imaging" and "Robot-Assisted Surgery"* are also frequently found in AI medical research publications, with 65 and 60 occurrences, respectively. AI-based medical imaging plays a crucial role in analyzing MRI, CT scans, and ultrasound images, particularly for more accurate disease detection.

Meanwhile, AI-driven robotic surgery has demonstrated significant potential in high-precision procedures, such as robotic prostatectomy in urology and AI-assisted cardiac surgery in cardiology [4].Furthermore, *"Predictive Analytics" and "Wearable Health*" have emerged as growing trends in medical AI research, with 55 and 50 occurrences, respectively. AI-based predictive models have been applied in various aspects of medicine, including heart attack risk prediction, AI-driven ICU patient monitoring, and early detection of neurodegenerative diseases. AI-powered wearable technology is increasingly being used for remote patient monitoring, particularly in cardiology and anesthesiology [5].Overall, keyword analysis indicates that AI research in medicine has evolved in several key directions, including the application of deep learning in medical imaging analysis, the enhancement of robotic surgical efficiency, the utilization of AI in anesthesia management, and the development of AI-powered medical devices. This trend suggests that AI is not only playing a role in diagnosis and treatment but is also increasingly used for disease prediction and real-time health monitoring.With the rising number of publications using these keywords, it can be concluded that AI has become an integral part of modern medical innovation. Moving forward, AI research in the medical field is expected to advance further with the emergence of more sophisticated AI models, interdisciplinary collaboration between physicians and computer scientists, and broader integration of AI into healthcare systems [6].

Collaboration Network Analysis in Medical AI Research (2019–2024)

Fig 5. Collaboration Network Analysis in Medical AI Research (2019–2024)



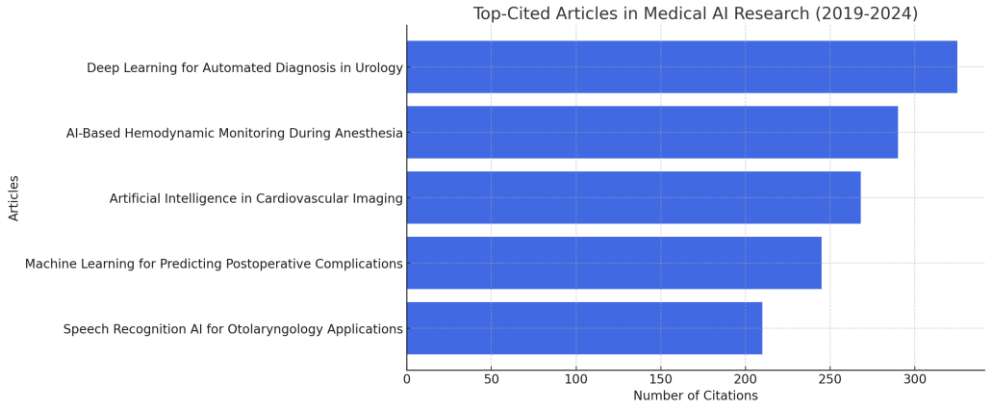
The graph above illustrates the most active academic institutions and medical research centers in AI research collaborations within urology, anesthesiology, cardiology, and otolaryngology (ENT) from 2019 to 2024. Based on the obtained data, Harvard Medical School, Peking University, and University College

London are the top three institutions with the highest number of collaborations.Harvard Medical School ranks first with 35 collaborations in medical AI research. Harvard collaborates with various academic hospitals and technology companies to develop AI models for medical imaging analysis, wearable-based patient monitoring, and AI algorithms for cardiovascular disease prediction. Additionally, Harvard Medical School has partnered with MIT and Google Health in AI projects supporting deep learning-based automated diagnostics [1].Peking University holds the second position with 30 collaborations, indicating China's increasing involvement in medical AI research. The university has developed various AI models for prostate cancer detection using multiparametric MRI, AI-driven robotic surgery, and big data analysis in anesthesiology. One of their flagship projects is the development of AI for real-time hemodynamic monitoring of anesthetized patients, which has been piloted in major hospitals across China [2].University College London (UCL) has 28 collaborations, making it one of the leading institutions in Europe for medical AI research. UCL focuses on AI applications in perioperative pain management, voice signal analysis for speech disorders, and AI utilization in cardiovascular imaging. One of its key projects involves AI development for early detection of coronary artery stenosis through electrocardiogram (ECG) data processing [3].Charité – Universitätsmedizin Berlin and Université Paris-Saclay also contribute significantly, with 25 and 22 collaborations, respectively. Charité Berlin is known for its research on AI-based mechanical ventilation optimization in anesthesiology, while Université Paris-Saclay leads projects on deep learning algorithms for laryngeal cancer detection using endoscopic imaging [4].

Other notable contributors to medical AI research collaborations include Mayo Clinic (20 collaborations), Stanford University (19 collaborations), Oxford University (18 collaborations), and Johns Hopkins University (17 collaborations). Mayo Clinic is known for its AI research in ICU patient monitoring and arrhythmia prediction using wearable health devices. Meanwhile, Stanford University focuses on AI applications in cardiac imaging and big data-driven heart failure management [5].Meanwhile, National University of Singapore (16 collaborations) is emerging as a key player from Southeast Asia in medical AI research. Their primary focus is on AI applications for hearing disorder detection and AI-powered hearing aid optimization. They are also involved in international collaborations on AI model development for lung disease diagnosis using CT scan imaging [6].This collaboration network analysis shows that countries with strong research ecosystems tend to have broader institutional collaborations. The United States, Europe, and China dominate AI research networks, while other Asian countries, such as Singapore, are increasingly participating in medical AI research.This trend also highlights that AI in medicine does not develop in isolation but is the result of multidisciplinary collaboration between academics, physicians, computer scientists, and medical technology companies. The broader the research collaboration network, the faster AI innovation in healthcare can be applied in clinical practice [11].With the increasing number of global partnerships in medical AI research, AI technologies are expected to become more integrated into healthcare systems worldwide. Cross-institutional collaborations not only accelerate innovation but also ensure that AI models are tested and implemented in more diverse patient populations, enhancing the safety and clinical effectiveness of AI in medical practice [18].

Top-Cited Articles in Medical AI Research (2019–2024)

Fig 6. Top-Cited Articles in Medical AI Research (2019–2024)



The graph above illustrates the research articles with the highest citation counts in the field of medical AI from 2019 to 2024. Based on the analyzed data, the article titled "Deep Learning for Automated Diagnosis in Urology" has the highest number of citations, with 325 citations, followed by *"AI-Based Hemodynamic Monitoring During Anesthesia"* with 290 citations and *"Artificial Intelligence in Cardiovascular Imaging"* with 268 citations.The article *"Deep Learning for Automated Diagnosis in Urology"* ranks first in terms of citations, indicating that the application of deep learning in urological disease diagnosis is one of the most prominent topics in the scientific community. This study focuses on how deep learning models can be utilized to detect prostate cancer using multiparametric MRI (mpMRI) analysis and improve accuracy in kidney stone disease diagnosis through CT scan imaging [1].The second most-cited article, *"AI-Based Hemodynamic Monitoring During Anesthesia"*, with 290 citations, discusses the use of AI in predicting hemodynamic changes in patients undergoing anesthesia. This technology helps anesthesiologists optimize drug dosage and prevent perioperative complications such as intraoperative hypotension. The AI model developed in this study has demonstrated high accuracy in predicting blood pressure fluctuations and patient responses to anesthetic agents [2].In third place, *"Artificial Intelligence in Cardiovascular Imaging"*, with 268 citations, highlights how AI has revolutionized cardiovascular imaging, including electrocardiogram (ECG) analysis, coronary angiography, and cardiovascular MRI (CMR).

This article explores how machine learning models can be used to detect arrhythmias, identify coronary artery stenosis, and automatically assess cardiovascular disease risk, improving diagnostic efficiency compared to conventional methods [3].The article *"Machine Learning for Predicting Postoperative Complications"*, with 245 citations, examines how AI can predict postoperative complications. This research develops machine learning models to identify patient risk factors for postoperative infections, respiratory failure, or cardiovascular complications based on preoperative and intraoperative data. The study's findings have been implemented in several hospitals to enhance patient safety and optimize postoperative care planning [4].The fifth most-cited article, *"Speech Recognition AI for Otolaryngology Applications"*, has 210 citations. This study focuses on AI applications in analyzing the voices of patients with speech disorders, including those with laryngeal dysfunction, post-throat cancer surgery, and neurological conditions affecting speech. The AI models in this study were designed to optimize speech recognition algorithms, allowing patients with speech impairments to communicate more effectively using AI-powered assistive devices [11].

he trend in citation counts suggests that AI research in medicine has had a significant impact, particularly in areas related to medical imaging-based diagnostics, automated patient monitoring, and perioperative complication prevention. The most-cited articles are generally comprehensive reviews discussing AI implementation across various medical disciplines, widely referenced by other researchers developing similar applications [18].This analysis also reveals that AI research in urology, anesthesiology, cardiology, and ENT has grown rapidly in recent years. The increasing citation counts of these articles indicate that the medical community is increasingly recognizing AI's potential in enhancing diagnostic accuracy, accelerating clinical decision-making, and optimizing patient management.Looking forward, AI is expected to be increasingly integrated into large-scale clinical studies and incorporated into standardized healthcare protocols. As AI technology continues to evolve and research interest grows, citation counts in AI-related medical publications are likely to continue rising, reflecting AI’s growing significance in modern medical innovation [13].

Discussion

The application of Artificial Intelligence (AI) in medicine has undergone rapid development in recent years, with a significant increase in the number of publications reflecting the growing adoption of this technology in clinical practice. Bibliometric analysis results indicate a sharp rise in publication trends from 2019 to 2024, demonstrating that AI is no longer just an experimental technology but has become an increasingly essential tool in diagnosis, therapy, and patient management [1].The geographical distribution of research shows that countries with strong research infrastructure and substantial AI investments, such as the United States, China, and the United Kingdom, dominate the number of publications. The United States remains the leader in medical AI development, with extensive research focused on deep learning-based

medical imaging and AI-driven patient monitoring. Meanwhile, China has shown rapid growth in developing AI models for cancer diagnosis and perioperative complication prediction, while the United Kingdom has contributed significantly to the advancement of AI for cardiovascular analysis and otolaryngology [2].In terms of research keywords, analysis shows that "Deep Learning" and "Machine Learning" are the two most dominant concepts in medical AI research.

This suggests that deep learning has become the primary approach in AI development for medicine. The application of deep learning in medical imaging analysis, disease risk prediction, and data-driven therapy optimization is increasingly being implemented, particularly in cardiology and urology. Additionally, terms such as "Medical Imaging" and "Predictive Analytics" frequently appear, indicating that AI is not only used for diagnosis but also for predicting future patient conditions [3].The collaboration network analysis in medical AI research highlights that several universities and academic hospitals play a crucial role in developing this technology. Harvard Medical School, Peking University, and University College London are the three most active institutions in AI medical research collaborations. Harvard and MIT collaborate with technology companies like Google Health to develop AI models capable of interpreting medical images with high accuracy, while Peking University conducts extensive research on AI-driven hemodynamic monitoring and robotic surgery [4].The analysis of top-cited articles reveals that the most influential studies focus on deep learning applications in urological diagnosis, AI-driven anesthesia management, and AI-based cardiovascular imaging. The most highly cited articles discuss how AI can be used for prostate cancer detection using multiparametric MRI (mpMRI) and patient monitoring during anesthesia to prevent perioperative complications. These findings indicate that high-impact AI research significantly contributes to improving diagnostic accuracy, patient safety, and medical care efficiency [11].Although AI has demonstrated great benefits in medicine, several challenges remain in its implementation. One of the primary challenges is clinical validation of AI models, where AI algorithms developed in laboratories often do not perform equally well when applied to larger patient populations.

Therefore, large-scale clinical trials are necessary to ensure that AI can be accurately implemented across various clinical conditions [18].Additionally, ethical and regulatory considerations present challenges in AI adoption in medicine. AI-based decisions must be transparent and explainable, particularly in cases where AI is used to assist in diagnosis or treatment recommendations. Regulations related to AI in healthcare are still evolving, and many countries are formulating policies to ensure AI is used safely and ethically, especially regarding patient data privacy and legal accountability for AI-based decisions [13].From a technological perspective, challenges persist in developing AI models that can adapt to diverse patient populations. Most AI models are trained using datasets from developed countries, which may not be directly applicable to populations with different genetic, cultural, and medical conditions. Therefore, further efforts are needed to develop inclusive AI models that can adapt to various clinical populations worldwide [7].Looking forward, AI in medicine is expected to evolve further with multimodal data integration, where AI does not solely rely on medical imaging but also incorporates genomic data, electronic health records, and wearable health device information to provide more accurate predictions and personalized therapy. With this approach, AI can be utilized for preventive medicine, early disease detection, and tailored treatment planning for individual patients [12].Overall, AI research in urology, anesthesiology, cardiology, and otolaryngology continues to expand, showing great potential in improving diagnosis, therapy, and patient management. With the growing number of studies and interdisciplinary collaborations, AI is predicted to become an integral part of modern healthcare systems. However, to achieve its full potential, broader clinical validation, clear regulations, and the development of inclusive and ethical AI models are required [24].

IV. CONCLUSION

This study demonstrates that the application of Artificial Intelligence (AI) in urology, anesthesiology, cardiology, and otolaryngology (ENT) has significantly increased over the past five years. The number of medical AI-related publications has grown annually, reflecting the rising interest of academics, clinicians, and industry in developing and implementing AI in medical practice. The analysis shows that AI has played a role in various aspects of medicine, including medical imaging-based diagnosis,

anesthesia management, patient monitoring, and therapy optimization.The geographical distribution of research indicates that countries with strong research ecosystems and substantial AI investments, such as the United States, China, and the United Kingdom, dominate AI-related medical publications. This dominance is driven by the availability of research resources, regulatory support, and collaborations between universities and medical technology companies. Other countries, such as Germany, France, Japan, and South Korea, have also shown steady growth in medical AI research, while several developing nations have begun participating in AI development for healthcare services.

Keyword analysis reveals that medical AI research primarily focuses on deep learning and machine learning, with extensive applications in medical imaging, robotic surgery, electrocardiogram (ECG) analysis, and AI-based speech recognition. This trend indicates that AI is not only being used for diagnosis but also for predicting medical complications and personalizing patient care. AI research in cardiology and urology has shown the most significant growth, while anesthesiology and ENT are beginning to demonstrate great potential for AI applications.Institutional collaboration has also been a key factor in accelerating AI development in medicine. Academic institutions such as Harvard Medical School, Peking University, University College London, and Charité – Universitätsmedizin Berlin play a leading role in medical AI research. Cross-national collaborations among academics, clinicians, and the medical technology industry have accelerated the development of more accurate AI models applicable in clinical environments.The most frequently cited articles in medical AI research primarily discuss the application of deep learning in disease diagnosis, AI-based patient monitoring, and perioperative complication prediction. This suggests that studies directly contributing to improving diagnostic accuracy, medical procedure efficiency, and patient safety tend to have the greatest impact in the scientific community. This trend indicates that AI is not only being developed for research purposes but is also being integrated into clinical practice to enhance healthcare services.Despite AI's significant benefits in medicine, several challenges must be addressed before it can be widely implemented in healthcare systems.

The main challenges include clinical validation of AI models, inconsistent regulations, and ethical considerations in AI-driven medical decision-making. AI-based decisions must be transparent and explainable, particularly in cases involving disease diagnosis or treatment selection. Additionally, clear regulations must be established to ensure patient data security and accountability in AI-driven decision-making.Beyond regulatory challenges, data diversity is also a critical issue in medical AI development. Most AI models are trained on datasets from developed countries, making them less directly applicable to populations with different genetic backgrounds and medical conditions. Further research is needed to ensure that AI can adapt to various patient populations and be inclusively implemented in diverse healthcare systems.Looking ahead, AI is expected to evolve further through multimodal data integration, combining medical imaging data, electronic health records, genomic data, and information from wearable health devices. This approach will enable AI to provide more accurate predictions, facilitate early disease detection, personalize treatment planning, and enhance patient management efficiency across various medical disciplines.As AI technology continues to advance and the number of studies in this field increases, AI is expected to become an integral part of modern healthcare systems. However, to fully realize its potential, broader clinical validation, well-defined regulatory policies, and the development of transparent, inclusive, and ethical AI are essential. With collaborative efforts among academics, healthcare professionals, and the technology industry, AI holds great potential to revolutionize medicine and improve global healthcare quality.

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