ISSN 2644-3228 (online)

Artificial Intelligence in *Cancer*

Artif Intell Cancer 2022 February 28; 3(1): 1-16

Published by Baishideng Publishing Group Inc

A I C

Artificial Intelligence in Cancer

Contents

Bimonthly Volume 3 Number 1 February 28, 2022

Contents

Artificial Intelligence in Cancer

Bimonthly Volume 3 Number 1 February 28, 2022

ABOUT COVER

Editorial Board Member of *Artificial Intelligence in Cancer*, Gizem Calibasi-Kocal, PhD, Associate Professor, Department of Translational Oncology, Institute of Oncology, Dokuz Eylul University, Izmir 35330, Turkey. gizemcalibasi@gmail.com

AIMS AND SCOPE

The primary aim of *Artificial Intelligence in Cancer* (*AIC*, *Artif Intell Cancer*) is to provide scholars and readers from various fields of artificial intelligence in cancer with a platform to publish high-quality basic and clinical research articles and communicate their research findings online.

AIC mainly publishes articles reporting research results obtained in the field of artificial intelligence in cancer and covering a wide range of topics, including artificial intelligence in bone oncology, breast cancer, gastrointestinal cancer, genitourinary cancer, gynecological cancer, head and neck cancer, hematologic malignancy, lung cancer, lymphoma and myeloma, pediatric oncology, and urologic oncology.

INDEXING/ABSTRACTING

There is currently no indexing.

RESPONSIBLE EDITORS FOR THIS ISSUE

Production Editor: *Hua-Ge Yu*; **Production Department Director:** *Xu Guo*; **Editorial Office Director:** *Jin-Lei Wang*.

NAME OF JOURNAL
Artificial Intelligence in Cancer

ISSN
ISSN 2644-3228 (online)

LAUNCH DATE
June 28, 2020

FREQUENCY
Bimonthly

EDITORS-IN-CHIEF
Mujib Ullah, Cedric Coulouarn, Massoud Mirshahi

EDITORIAL BOARD MEMBERS
https://www.wjgnet.com/2644-3228/editorialboard.htm

PUBLICATION DATE
February 28, 2022

COPYRIGHT
© 2022 Baishideng Publishing Group Inc

INSTRUCTIONS TO AUTHORS
https://www.wjgnet.com/bpg/gerinfo/204

GUIDELINES FOR ETHICS DOCUMENTS
https://www.wjgnet.com/bpg/GerInfo/287

GUIDELINES FOR NON-NATIVE SPEAKERS OF ENGLISH
https://www.wjgnet.com/bpg/gerinfo/240

PUBLICATION ETHICS
https://www.wjgnet.com/bpg/GerInfo/288

PUBLICATION MISCONDUCT
https://www.wjgnet.com/bpg/gerinfo/208

ARTICLE PROCESSING CHARGE
https://www.wjgnet.com/bpg/gerinfo/242

STEPS FOR SUBMITTING MANUSCRIPTS
https://www.wjgnet.com/bpg/GerInfo/239

ONLINE SUBMISSION
https://www.f6publishing.com

© 2022 Baishideng Publishing Group Inc. All rights reserved. 7041 Koll Center Parkway, Suite 160, Pleasanton, CA 94566, USA
E-mail: bpgoffice@wjgnet.com https://www.wjgnet.com

AIC Artificial Intelligence in Cancer

Submit a Manuscript: https://www.f6publishing.com

Artif Intell Cancer 2022 February 28; 3(1): 1-10

DOI: 10.35713/aic.v3.i1.1

ISSN 2644-3228 (online)

MINIREVIEWS

Potential and role of artificial intelligence in current medical healthcare

Chao-Ming Hung, Hon-Yi Shi, Po-Huang Lee, Chao-Sung Chang, Kun-Ming Rau, Hui-Ming Lee, Cheng-Hao Tseng, Sung-Nan Pei, Kuen-Jang Tsai, Chong-Chi Chiu

Specialty type: Health care sciences and services

Provenance and peer review: Invited article; externally peer reviewed.

Peer-review model: Single blind

Peer-review report's scientific quality classification

Grade A (Excellent): 0
Grade B (Very good): B
Grade C (Good): C
Grade D (Fair): D
Grade E (Poor): 0

P-Reviewer: Dabbakuti JRKKK, Hanada E, Wang P

Received: November 9, 2021
Peer-review started: November 9, 2021
First decision: December 13, 2021
Revised: December 31, 2021
Accepted: February 20, 2022
Article in press: February 20, 2022
Published online: February 28, 2022

Chao-Ming Hung, Hui-Ming Lee, Kuen-Jang Tsai, Chong-Chi Chiu, Department of General Surgery, E-Da Cancer Hospital, Kaohsiung 82445, Taiwan

Chao-Ming Hung, Po-Huang Lee, Hui-Ming Lee, College of Medicine, I-Shou University, Kaohsiung 82445, Taiwan

Hon-Yi Shi, Department of Healthcare Administration and Medical Informatics, Kaohsiung Medical University, Kaohsiung 80708, Taiwan

Hon-Yi Shi, Department of Business Management, National Sun Yat-Sen University, Kaohsiung 80420, Taiwan

Hon-Yi Shi, Department of Medical Research, Kaohsiung Medical University Hospital, Kaohsiung 80708, Taiwan

Hon-Yi Shi, Department of Medical Research, China Medical University Hospital, China Medical University, Taichung 40402, Taiwan

Po-Huang Lee, Department of Surgery, E-Da Hospital, Kaohsiung 82445, Taiwan

Chao-Sung Chang, Kun-Ming Rau, Sung-Nan Pei, Department of Hematology & Oncology, E-Da Cancer Hospital, Kaohsiung 82445, Taiwan

Chao-Sung Chang, School of Medicine for International Students, College of Medicine, I-Shou University, Kaohsiung 82445, Taiwan

Kun-Ming Rau, Cheng-Hao Tseng, Sung-Nan Pei, Chong-Chi Chiu, School of Medicine, College of Medicine, I-Shou University, Kaohsiung 82445, Taiwan

Cheng-Hao Tseng, Department of Gastroenterology and Hepatology, E-Da Cancer Hospital, Kaohsiung 82445, Taiwan

Cheng-Hao Tseng, Department of Gastroenterology and Hepatology, E-Da Hospital, Kaohsiung 82445, Taiwan

Chong-Chi Chiu, Department of Medical Education and Research, E-Da Cancer Hospital, Kaohsiung 82445, Taiwan

Corresponding author: Chong-Chi Chiu, MD, Professor, Department of General Surgery, E-Da Cancer Hospital, No. 21 Yi-Da Road, Jiao-Su Village, Yan-Chao District, Kaohsiung 82445, Taiwan. chiuchongchi@gmail.com

Abstract

Artificial intelligence (AI) is defined as the digital computer or computer-controlled robot's ability to mimic intelligent conduct and crucial thinking commonly associated with intelligent beings. The application of AI technology and machine learning in medicine have allowed medical practitioners to provide patients with better quality of services; and current advancements have led to a dramatic change in the healthcare system. However, many efficient applications are still in their initial stages, which need further evaluations to improve and develop these applications. Clinicians must recognize and acclimate themselves with the developments in AI technology to improve their delivery of healthcare services; but for this to be possible, a significant revision of medical education is needed to provide future leaders with the required competencies. This article reviews the potential and limitations of AI in healthcare, as well as the current medical application trends including healthcare administration, clinical decision assistance, patient health monitoring, healthcare resource allocation, medical research, and public health policy development. Also, future possibilities for further clinical and scientific practice were also summarized.

Key Words: Artificial intelligence; Machine learning; Potential; Limitation; Medical healthcare application; Coronavirus disease 19

©The Author(s) 2022. Published by Baishideng Publishing Group Inc. All rights reserved.

Core Tip: In this review, we explored the potential of powerful artificial intelligence (AI) for a more comprehensive application in the healthcare setting. Moreover, we also pointed out the demerits and problems in the current application of AI in medicine.

Citation: Hung CM, Shi HY, Lee PH, Chang CS, Rau KM, Lee HM, Tseng CH, Pei SN, Tsai KJ, Chiu CC. Potential and role of artificial intelligence in current medical healthcare. *Artif Intell Cancer* 2022; 3(1): 1-10
URL: https://www.wjgnet.com/2644-3228/full/v3/i1/1.htm
DOI: https://dx.doi.org/10.35713/aic.v3.i1.1

INTRODUCTION

McCarthy, one of the core founders of artificial intelligence (AI), defined AI as the science and engineering of making intelligent machines[1]. AI has come a long way since its conception in 1956[2]. AI research aims to establish a capable system with intelligence to overcome the Turing test, demonstrating intelligent behavior identical to humans. For the next 60 years, this specialty encountered several episodes of excitement and frustration with nearly no advancement. However, in 2010, deep learning achieved marked improvements. This achievement is a type of machine learning (ML) with multiple layers of nodes among the input and output layers, resulting in artificial neural networks capable of establishing excellent development in recognizing speech, classifying an image, and translating context[3].

AI has been applied to analyze complex and big data to deliver outputs beyond human input in diverse healthcare backgrounds[4]. Davenport *et al*[5] advocated that AI systems would not extensively take over human clinical professionals but would amplify their patient care achievements. In other words, the concept of professional advice from a digital helper is not better than the clinician, but the fusion and application of ML into clinical medicine would enhance accurate healthcare delivery[6]. Rather than traditional robotics, AI applications in current healthcare mainly affect clinicians and medical institutions accessing enormous data sets of crucial clinical knowledge. A scheme of medical information for patient care could use sophisticated algorithms to give real-time analysis[7], including diagnosis, management strategies and prognosis, recurrence and survival rates, and information collection rates of millions of patients, geographical distributions, and countless and sometimes interconnected health status of oncologic patients. This advanced computing power of AI can detect and analyze large and small trends from the available information, and even forecast through ML designed to classify possible health prognoses.

The importance of AI technology in medical healthcare provision and study is increasingly becoming apparent[8]. There is a rapid growth trend of related publications on this topic in the form of academic articles from medical professionals (Figure 1). Specialists have emphasized the effectiveness and

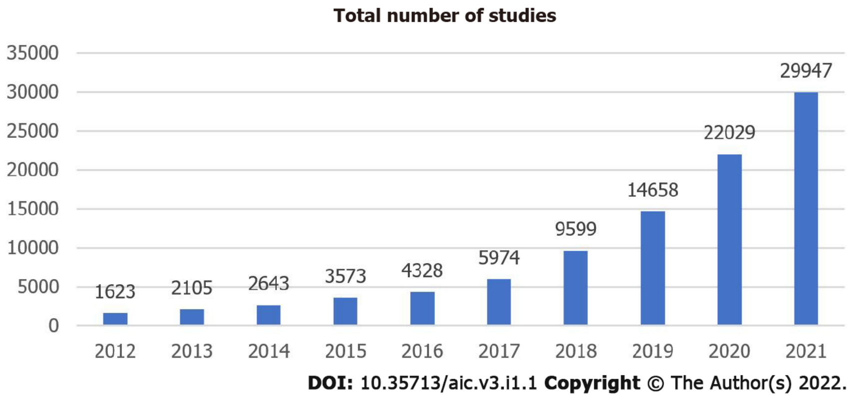

Figure 1 Number of medical artificial intelligence publications by year beginning in 2012 up to 2021, searched on Pubmed.com using the terms "machine learning" OR "deep learning".

capability of AI-empowered healthcare provision. Recently, more countries and private institutions have invested in this technological progress[9]. In addition, the United States Food and Drug Administration (FDA) has enthusiastically promoted AI-empowered instruments in the medical market[10].

In this study, the potentials of AI, its application in different fields of healthcare, and its current limitations will be discussed. Furthermore, we also investigated the advantages of clinicians over AI in clinical work and suggest different ways of cooperating with AI effectively.

RELEVANT POTENTIALS OF AI

AI is a collection of technologies consisting of abilities that could be applied in healthcare. Some particular AI technologies are paramount to healthcare (Figure 2).

Neural network and deep learning

Neural networks and deep learning are essential to ML, a statistical technology for fitting models to data and 'learning' by training models with data. The neural networks technology has been available since the 1960s for categorization applications[11]. A standard neural network comprises many simple, connected processors called neurons, each producing a sequence of real-valued activations[12]. It imitates the process of how neurons manage signals. It can determine if one person would suffer from a specific disease in his or her life. It views the disease based on the inputs, outputs, and weights of variables or parameters related to the inputs with outputs.

Deep learning is the most complicated form of ML, which involves neural network models with different levels of parameters to predict prognosis. Each character in a deep learning model usually has limited implications for clinical professionals. In other words, the explanation of the model's prognosis may be very challenging to interpret. Nowadays, the typical utilization of deep learning in healthcare involves the recognition of possibly cancerous lesions in radiologic imaging[13]. Currently, it is commonly applied to detect clinically specific features in imaging data, which is easily neglected by the human eye[14].

Natural language processing

Since the 1950s, AI researchers have strived to make sense of human language. Natural language processing aims to program machines to interpret human language as humans do. It comprises speech recognition, word analysis, sentence translation, and other intentions based on human language. Statistical natural language processing is related to deep learning neural networks. It has also contributed to increased recognition accuracy. A natural language processing system can duplicate patient interactions and operate conversational AI[15]. Furthermore, it has succeeded in scaling up partial roles of clinical decision-making, developing tools to stratify risks, and even identifying possible surgical complications from clinical records[16], and performing patient triage by identifying syndromes[17].

Rule-based expert systems

Expert systems could automatically alert patients and provide instructions according to the telemonitoring data. This is expected to increase patient self-care and improve clinical management[18].

In the 1980s, expert systems related to the 'if-then' rules were the primary technique for AI. Human experts and knowledge engineers were required to build up a set of guides in a specific knowledge domain. In the healthcare aspect, they were extensively applied to assist in making clinical decisions.

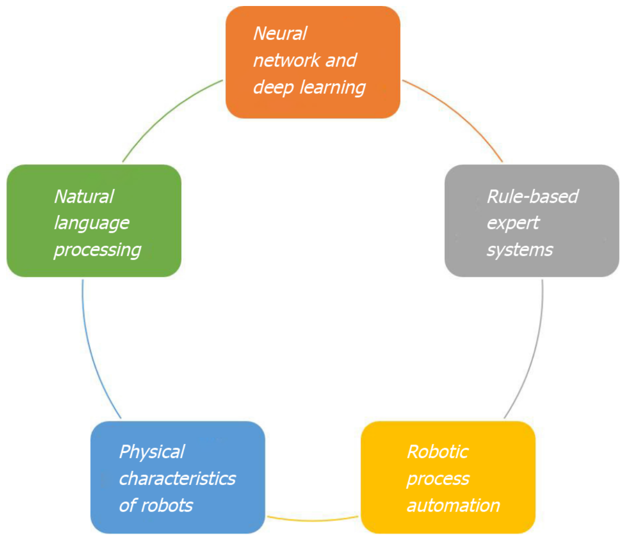

Figure 2 Relevant potentials of artificial intelligence.

This system consisted of an expert system and a statistical analysis system linked to a patient database [19]. They have been used for the past decades, but are more extensively used nowadays[20]. However, they are proposed to be replaced by more advanced ML algorithms, possibly because of their static nature. As these expert systems are applied to clinical use, this demerit becomes accentuated by the rapid generation rate of new knowledge, the regional differences related to the expression of many diseases, and the change rate of patient demographics and disease incidence in the future[19].

Physical characteristics of robots

Physical robots are well-known for performing repetitive and precise pre-defined work, such as elevating, locating, welding, or collecting objects during hospital supply delivery. Since the 1980s, there has been an incremental development of minimally invasive surgeries. However, this was limited by the complexity of surgery due to the technical constraint of traditional laparoscopic instruments. Robotic technology provides a 3-dimensional view of the operating field, allows filtering of physiological tremor, and permits greater precision and control through its articulated arms. These advantages offer solutions to the limitation of traditional laparoscopic instruments[21]. The United States initially approved robot-assisted surgery in 2000. Robots empower the surgeons and provide a clearer vision to perform accurate and minimally invasive surgery resulting in smaller surgical wounds[22]. Robotic-assisted prostatectomy, cystectomy, pyeloplasty, nephrectomy, and partial nephrectomy are all becoming increasingly common techniques used by surgeons[23]. Moreover, robots are becoming more intelligent, as other AI facilities are being installed in the operating systems. Of course, dominant decision-making is still made by humans during surgery.

Robotic process automation

"Automation" is defined as the application of robotics, AI, ML, machine vision, and similar emerging and mature digital technologies to allow human work to be substituted by robots[24]. This technique executes structured digital works for organizational goals. Robotic process automation involves mere computer programs on servers. It hinges on a set of work assignments, business guidelines, and a 'presentation layer' combination with information systems to mimic a semi-intelligent system operator. In the medical field, it is usually applied to perform repetitive work, *e.g.*, updating patient records or billing, extracting data from images into transactional systems, *etc*[25].

According to the study by Willis *et al*[26], many forms of automation already exist in the healthcare setting. Not only do they increase the productivity of human employees, but they also do not remove human tasks entirely. Automation has even unexpectedly created more work for the medical staff. Although automation has allowed humans to process tasks more efficiently, it has resulted in more administrative work.

PRACTICAL FIELDS OF AI APPLICATION IN HEALTHCARE

During the global health emergency related to coronavirus disease 19 (COVID-19), experts have worked day and night to explore new technologies to mitigate the pandemic. Due to this, the trend of AI

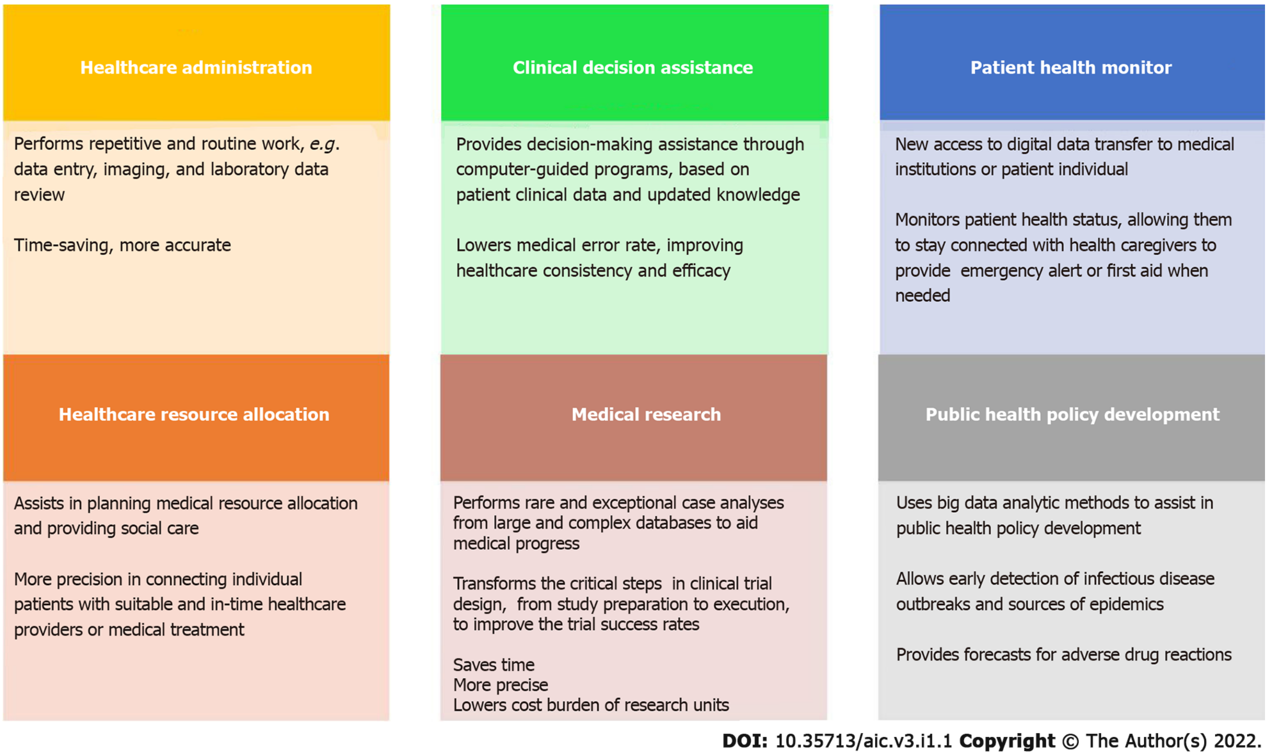

Figure 3 Practical fields of artificial intelligence application in healthcare.

application in healthcare has grown rapidly[9], and has involved the development of sophisticated algorithms to perform complicated work efficiently and effectively[27]. Recent research has shown that AI could greatly enhance COVID-19 screening, diagnostics, and prediction, resulting in better scale-up, a timely response, a more reliable and efficient outcome. Furthermore, it was found that sometimes it outperforms humans in certain healthcare tasks[28].

In summary, AI-empowered healthcare delivery exerts a significant impact on healthcare administration, clinical decision assistance, patient health monitoring, healthcare resource allocation, medical research, and public health policy development (Figure 3).

Healthcare administration

AI could save time, which the clinical staff could use to care for patients, by performing repetitive and routine work, such as data entry, imaging, and laboratory data review[2]. The connection of ML algorithms with digital medical records could help clinical staff and administrators gain accurate patient data[29]. The accuracy and speed of data searches could be refined using ML and concept-based information retrieval systems. AI has already been applied to identify diseases even in the early stages. For example, AI-assisted diagnosis of breast cancer has significant advantages over those without AI assistance. It helps radiologists act as a second interpreter during data interpretation and patient screening. According to the American Cancer Society, it also reduces false-positive diagnosis rates, eliminating the need for unnecessary biopsy and lowering medical expenses[30]. It can finish reviewing and reporting the findings in just a few seconds. Although innovative methods have been established to diagnose and distinguish breast cancer, none of those methods could identify all cancer patients.

Clinical decision assistance

Clinical decision assistance systems are computer-guided programs that assist clinicians in their decision-making based on patient clinical data and updated knowledge[31]. AI is a powerful tool that lowers the medical error rate and improves healthcare consistency and efficacy.

The trend of AI application in clinical decision assistance is rising tremendously. For example, the case number of the COVID-19 global pandemic has overcome current medical facilities and obligated the clinical professionals, patients, and families to make crucial determinations based on limited information and within a short time. ML methods have been previously applied to assist in making clinical decisions. There is currently a demand for ML-supported decisions based on acquired vital signs, laboratory data, prescription orders, and complications from caring for previous patients. In clinical practice, AI-related precision medicine can predict patients' most suitable treatment protocols based on different patient characteristics and the treatment context[32]. AI can also make individualized treatment protocols for patients based on the large-scale database and updated information[33]. In addition, it is expected to guide inexperienced hospital frontline and healthcare providers to perform appropriately with ample evidence under emergent situations[34].

Patient health monitoring

The popularity of smartphones and monitoring instruments has brought new access to digital data transfer to medical institutions. Using digital medical records also empowers the AI to monitor patient health status[29]. Through AI, patients with chronic diseases could be better informed about their health and stay connected with their health caregivers. Furthermore, AI-assisted home health monitoring instruments and techniques help low functioning and elderly patients to keep connected to assure that emergency medical technicians can immediately provide first aid when needed[35].

AI systems are also capable of following patient prognosis. For example, the National Institutes of Health has created the AiCure app to monitor medication used by patients. Moreover, those with hypertension or diabetes could benefit from AI's ability to track their health status through its clinically validated sensors and devices, effectively driving self-management[35]. Technology applications and apps boost more suitable actions in individuals and push one to follow a healthier lifestyle. In other words, it puts people in control of their health and well-being.

Healthcare resource allocation

Many governments use AI to plan medical resource allocation and provide social care services. AI could connect individual patients with suitable healthcare providers who could satisfy their needs based on their allocated medical budget.

Furthermore, AI could also design a specific treatment protocol and suggest more effective resource use for every patient[36]. For example, clinicians could identify potential risk factors associated with obesity using statistics, ML, and data visualization methods. AI systems can generate automated, personalized, contextual, and behavioral recommendations for obese patients during body weight control, including the suggestion of bariatric surgery, if indicated[37].

Shi *et al*[38] and Shi *et al*[39] used an artificial neural network model for predicting the 5-year mortality after surgery for hepatocellular carcinoma using the administrative claims data obtained from the Taiwan Bureau of National Health Insurance (BNHI). Their studies demonstrated that surgeon volume was the most crucial factor influencing 5-year mortality, followed by hospital volume and Charlson co-morbidity index. These parameters could be addressed in preoperative and postoperative healthcare consultations to educate the patients for better recovery and prognosis after hepatocellular carcinoma surgery. In addition, the government could also adjust the policy of healthcare resource allocation in hepatocellular carcinoma surgery with the aid of the AI-empowered analysis results of the BNHI database.

Medical research

Clinicians could use AI to analyze rare and exceptional cases from large and complex databases faster and more precisely than previously[40]. AI could also search for related scientific studies and information from the literature and combine different data to aid in medical progress[41]. In clinical trials, inappropriate patient selection and recruiting techniques, paired with ineffective patient monitoring and coaching could lead to high trial failure rates. AI can transform the critical steps of a clinical trial design, from study preparation to execution, to improve the trial success rates, thus lowering the cost burden of the research units[42]. It is expected to select the most precise patient data for relevant clinical studies and establish a database with a large population for more studies in the future.

Kiely *et al*[43] applied real-world data to screen for idiopathic pulmonary arterial hypertension, and the initial report was published in 2019. Their initial AI analysis algorithm has been used to provide a lower-cost screening at a significant population level, facilitate earlier diagnosis, and improve diagnostic rates and patient outcomes.

There was no reliably effective vaccine or specific drug invented for COVID-19 until the end of September 2020. Specialists have proposed several vaccines and drugs for COVID-19 by utilizing AI-based approaches. For example, the Harvard T.H. Chan School of Public Health and the Human Vaccines Project declared that they are using AI models to accelerate vaccine development by utilizing state-of-the-art techniques in epidemiology, immune monitoring, and network biology to explain effective immunity in older populations[44,45].

Public health policy development

Nowadays, many medical and health-related institutions use AI to assist in the early detection of infectious disease outbreaks and sources of epidemics[46]. Moreover, AI could also forecast adverse drug reactions, which causes about 6.5% of hospital admissions in the UK[47]. This indicates that AI could use big data analytic methods to assist in public health policy development.

When AI applications are deployed mainly in high-income countries, their use in low-income regions remains relatively nascent. However, AI systems in such low-income countries could support healthcare management in several ways. First, medical expert systems can assist clinicians in disease diagnosis and treatment plan selection, as performed in developed countries. AI could act as a human clinician in

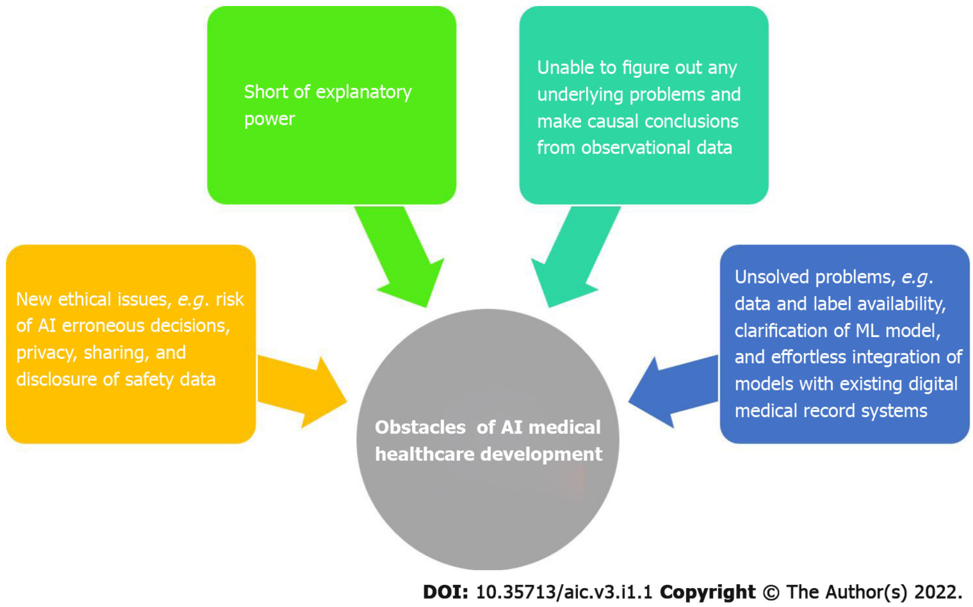

Figure 4 Current limitations of artificial intelligence medical healthcare development. AI: Artificial intelligence.

initial disease diagnosis in poor communities if one is not readily available. The sick could then be transferred to a suitable institution with the relevant medical resources. Furthermore, AI has already been used to forecast the disease model and delay its spread in epidemic situations worldwide, even in resource-poor regions[48].

LIMITATIONS OF AI MEDICAL HEALTHCARE DEVELOPMENT

Deep learning is short in explanatory power; deep neural networks cannot interpret how a diagnosis is made, and prejudice characteristics are difficult to identify[7]. This means that ML cannot determine underlying problems and is unable to make causal conclusions from observational data. Algorithms are efficient in outcome prediction, but predictors are not causes[49]. Furthermore, there are still problems that need to be solved, such as data and label availability, clarification of the ML model, and effortless integration of these models with existing digital medical record systems[50].

With the advent of AI development, new ethical issues have also been encountered after it intervened in medical practice, *e.g.*, risk of erroneous decisions by AI, responsibility of using AI in support decision-making, difficulties in confirmation of AI outputs, constitutive data biases in AI system training, sensitive data security crisis, assurance of public trust in AI medical interventions, and the possibility of AI being used for malicious goals[51]. Among these issues, privacy, sharing, and disclosure of safety data relating to AI applications must be strengthened and solved first (Figure 4).

ADVANTAGES OF CLINICIANS OVER AI IN PATIENT CARE

AI cannot replace the clinician's role in healthcare because it intrinsically lacks articulation and cannot generate insights[4]. However, AI could assuredly assist in making better clinical decisions and even provide more accurate judgment in specific healthcare fields[52]. ML has already alleviated much of the workload of radiologists and anatomical pathologists in many medical institutions due to its massive imaging database, accompanied by advanced innovation in computer vision. With rapid progress in AI performance, machine accuracy can overcome that of humans[53]. The expanding availability of healthcare databases and the fast progression of big data analytic methods have led to the success and popularity of AI applications in the healthcare field. In addition, powerful AI techniques can discover new clinical information hidden in the extensive database, further assisting clinical decision-making[54-56]. However, there are no universally applicable healthcare rules. AI must be complemented with clinician confirmation in many instances. Furthermore, the clinician-patient relationship is guided by associative thinking and could affect real-life treatment decisions. The impact of psychosocial and emotional factors on disease prognosis falls outside the AI scope, which should always be considered. Thus, most AI experts believe that a blend of human experience and digital augmentation should be the natural settling point for AI in healthcare (Table 1).

Table 1 Collaboration of human and artificial intelligence characteristics aiming to provide an ideal healthcare delivery

Human factors	AI factors
Clinicians could regard their patient as a fellow mortal, vulnerable being and gain detailed knowledge of the patient's disease related to their lives	AI continually coordinates new knowledge and perfects itself more rapidly than humans do
Clinicians know about social relationships and norms and could establish a genuinely intimate and empathetic connection with their patients	Automation of routine work could save time, such as documentation, administrative reporting, or even triaging images
The clinician-patient relationship could be guided by human associative thinking and affect real-life treatment strategies	AI could provide reliable diagnosis and treatment strategies, issue reminders for medication, provide precise analytics for pathology and images, and predict overall health according to the current medical database and patient information
The impact of psychosocial and emotional factors on disease prognosis and patient compliance could benefit from a good and close clinician-patient relationships	AI could provide simple mental health assistance *via* chatbot, monitor patient health, and predict disease progression

AI: Artificial intelligence.

CONCLUSION

Clinical medicine always requires professional staff to manage enormous amounts of data, from patient physiologic information to laboratory and imaging results. The capability of this complex management has separated excellent clinicians from others. AI has been regarded as an essential tool for clinicians in their daily practice. The increased application of AI technologies does not lower the value of face-to-face interaction with patients. On the contrary, because of AI, it is expected that clinicians would move toward the tasks that uniquely need social skills such as empathy, persuasion, and big-picture integration. Integrating the human clinician's 'hardware' with the AI's 'software' could provide an ideal healthcare delivery that exceeds what either could do alone. Perhaps the experts who refuse to apply AI technology in their clinical practice would be regarded as non-professional in the next decade.

FOOTNOTES

Author contributions: Shi HY, Rau KM, and Lee HM performed the literature search; Chiu CC drafted and supervised the manuscript; Hung CM, Tseng CH, Pei SN, and Tsai KJ edited and corrected the manuscript; Lee PH, Chang CS, and Chiu CC made critical revisions; all authors have read and approved the final manuscript.

Conflict-of-interest statement: All authors declare that they have no conflict of interest.

Open-Access: This article is an open-access article that was selected by an in-house editor and fully peer-reviewed by external reviewers. It is distributed in accordance with the Creative Commons Attribution NonCommercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: https://creativecommons.org/Licenses/by-nc/4.0/

Country/Territory of origin: Taiwan

ORCID number: Chao-Ming Hung 0000-0001-8348-1432; Hon-Yi Shi 0000-0003-4700-0190; Po-Huang Lee 0000-0002-5150-1136; Chao-Sung Chang 0000-0002-5409-9443; Kun-Ming Rau 0000-0002-1209-3043; Hui-Ming Lee 0000-0003-3298-7957; Cheng-Hao Tseng 0000-0003-4507-2414; Sung-Nan Pei 0000-0003-0791-7711; Kuen-Jang Tsai 0000-0001-6067-8495; Chong-Chi Chiu 0000-0002-1696-2648.

S-Editor: Liu JH
L-Editor: Webster JR
P-Editor: Liu JH

REFERENCES

1 **Laï MC**, Brian M, Mamzer MF. Perceptions of artificial intelligence in healthcare: findings from a qualitative survey study among actors in France. *J Transl Med* 2020; **18**: 14 [PMID: 31918710 DOI: 10.1186/s12967-019-02204-y]

2 **Ahuja AS**. The impact of artificial intelligence in medicine on the future role of the physician. *PeerJ* 2019; **7**: e7702 [PMID: 31592346 DOI: 10.7717/peerj.7702]

3 **The Lancet**. Artificial intelligence in health care: within touching distance. *Lancet* 2017; **390**: 2739 [PMID: 29303711 DOI: 10.1016/S0140-6736(17)31540-4]

4 **Ellahham S**, Ellahham N, Simsekler MCE. Application of Artificial Intelligence in the Health Care Safety Context: Opportunities and Challenges. *Am J Med Qual* 2020; **35**: 341-348 [PMID: 31581790 DOI: 10.1177/1062860619878515]

5 **Davenport T**, Kalakota R. The potential for artificial intelligence in healthcare. *Future Healthc J* 2019; **6**: 94-98 [PMID: 31363513 DOI: 10.7861/futurehosp.6-2-94]

6 **Char DS**, Shah NH, Magnus D. Implementing Machine Learning in Health Care - Addressing Ethical Challenges. *N Engl J Med* 2018; **378**: 981-983 [PMID: 29539284 DOI: 10.1056/NEJMp1714229]

7 **Tarassenko L**, Watkinson P. Artificial intelligence in health care: enabling informed care. *Lancet* 2018; **391**: 1260 [PMID: 29619956 DOI: 10.1016/S0140-6736(18)30701-3]

8 **Ramesh AN**, Kambhampati C, Monson JR, Drew PJ. Artificial intelligence in medicine. *Ann R Coll Surg Engl* 2004; **86**: 334-338 [PMID: 15333167 DOI: 10.1308/147870804290]

9 **He J**, Baxter SL, Xu J, Zhou X, Zhang K. The practical implementation of artificial intelligence technologies in medicine. *Nat Med* 2019; **25**: 30-36 [PMID: 30617336 DOI: 10.1038/s41591-018-0307-0]

10 **Harvey HB**, Gowda V. How the FDA Regulates AI. *Acad Radiol* 2020; **27**: 58-61 [PMID: 31818387 DOI: 10.1016/j.acra.2019.09.017]

11 **Shahid N**, Rappon T, Berta W. Applications of artificial neural networks in health care organizational decision-making: A scoping review. *PLoS One* 2019; **14**: e0212356 [PMID: 30779785 DOI: 10.1371/journal.pone.0212356]

12 **Schmidhuber J**. Deep learning in neural networks: an overview. *Neural Netw* 2015; **61**: 85-117 [PMID: 25462637 DOI: 10.1016/j.neunet.2014.09.003]

13 **Hosny A**, Parmar C, Quackenbush J, Schwartz LH, Aerts HJWL. Artificial intelligence in radiology. *Nat Rev Cancer* 2018; **18**: 500-510 [PMID: 29777175 DOI: 10.1038/s41568-018-0016-5]

14 **Vial A**, Stirling D, Field M, Ros M, Ritz C, Carolan M, Holloway L, Miller AA. The role of deep learning and radiomic feature extraction in cancer-specific predictive modelling: a review. *Transl Cancer Res* 2018; **7**: 803-816 [DOI: 10.21037/tcr.2018.05.02]

15 **Nadkarni PM**, Ohno-Machado L, Chapman WW. Natural language processing: an introduction. *J Am Med Inform Assoc* 2011; **18**: 544-551 [PMID: 21846786 DOI: 10.1136/amiajnl-2011-000464]

16 **Murff HJ**, FitzHenry F, Matheny ME, Gentry N, Kotter KL, Crimin K, Dittus RS, Rosen AK, Elkin PL, Brown SH, Speroff T. Automated identification of postoperative complications within an electronic medical record using natural language processing. *JAMA* 2011; **306**: 848-855 [PMID: 21862746 DOI: 10.1001/jama.2011.1204]

17 **Chapman WW**, Christensen LM, Wagner MM, Haug PJ, Ivanov O, Dowling JN, Olszewski RT. Classifying free-text triage chief complaints into syndromic categories with natural language processing. *Artif Intell Med* 2005; **33**: 31-40 [PMID: 15617980 DOI: 10.1016/j.artmed.2004.04.001]

18 **Seto E**, Leonard KJ, Cafazzo JA, Barnsley J, Masino C, Ross HJ. Developing healthcare rule-based expert systems: case study of a heart failure telemonitoring system. *Int J Med Inform* 2012; **81**: 556-565 [PMID: 22465288 DOI: 10.1016/j.ijmedinf.2012.03.001]

19 **Hughes CA**, Gose EE, Roseman DL. Overcoming deficiencies of the rule-based medical expert system. *Comput Methods Programs Biomed* 1990; **32**: 63-71 [PMID: 2401135 DOI: 10.1016/0169-2607(90)90086-o]

20 **Kulikowski CA**. Beginnings of Artificial Intelligence in Medicine (AIM): Computational Artifice Assisting Scientific Inquiry and Clinical Art - with Reflections on Present AIM Challenges. *Yearb Med Inform* 2019; **28**: 249-256 [PMID: 31022744 DOI: 10.1055/s-0039-1677895]

21 **Rassweiler JJ**, Autorino R, Klein J, Mottrie A, Goezen AS, Stolzenburg JU, Rha KH, Schurr M, Kaouk J, Patel V, Dasgupta P, Liatsikos E. Future of robotic surgery in urology. *BJU Int* 2017; **120**: 822-841 [PMID: 28319324 DOI: 10.1111/bju.13851]

22 **Wang P**, Su YJ, Jia CY. Current surgical practices of robotic-assisted tissue repair and reconstruction. *Chin J Traumatol* 2019; **22**: 88-92 [PMID: 30962128 DOI: 10.1016/j.cjtee.2019.01.003]

23 **Saglam R**, Muslumanoglu AY, Tokatlı Z, Caşkurlu T, Sarica K, Taşçi Aİ, Erkurt B, Süer E, Kabakci AS, Preminger G, Traxer O, Rassweiler JJ. A new robot for flexible ureteroscopy: development and early clinical results (IDEAL stage 1-2b). *Eur Urol* 2014; **66**: 1092-1100 [PMID: 25059998 DOI: 10.1016/j.eururo.2014.06.047]

24 **Grewal D**, Motyka D, Levy M. The evolution and future of retailing and retailing education. *J Mark Educ* 2018; **40**: 85-93 [DOI: 10.1177/0273475318755838]

25 **Hussain A**, Malik A, Halim MU, Ali AM. The use of robotics in surgery: a review. *Int J Clin Pract* 2014; **68**: 1376-1382 [PMID: 25283250 DOI: 10.1111/ijcp.12492]

26 **Willis M**, Duckworth P, Coulter A, Meyer ET, Osborne M. The Future of Health Care: Protocol for Measuring the Potential of Task Automation Grounded in the National Health Service Primary Care System. *JMIR Res Protoc* 2019; **8**: e11232 [PMID: 30964437 DOI: 10.2196/11232]

27 **Islam MM**, Poly TN, Alsinglawi B, Lin LF, Chien SC, Liu JC, Jian WS. Application of Artificial Intelligence in COVID-19 Pandemic: Bibliometric Analysis. *Healthcare (Basel)* 2021; **9** [PMID: 33918686 DOI: 10.3390/healthcare9040441]

28 **Khan M**, Mehran MT, Haq ZU, Ullah Z, Naqvi SR, Ihsan M, Abbass H. Applications of artificial intelligence in COVID-19 pandemic: A comprehensive review. *Expert Syst Appl* 2021; **185**: 115695 [PMID: 34400854 DOI: 10.1016/j.eswa.2021.115695]

29 **Rieke N**, Hancox J, Li W, Milletarì F, Roth HR, Albarqouni S, Bakas S, Galtier MN, Landman BA, Maier-Hein K, Ourselin S, Sheller M, Summers RM, Trask A, Xu D, Baust M, Cardoso MJ. The future of digital health with federated learning. *NPJ Digit Med* 2020; **3**: 119 [PMID: 33015372 DOI: 10.1038/s41746-020-00323-1]

30 **Sadoughi F**, Kazemy Z, Hamedan F, Owji L, Rahmanikatigari M, Azadboni TT. Artificial intelligence methods for the diagnosis of breast cancer by image processing: a review. *Breast Cancer (Dove Med Press)* 2018; **10**: 219-230 [PMID: 30555254 DOI: 10.2147/BCTT.S175311]

31 **Montani S**, Striani M. Artificial Intelligence in Clinical Decision Support: a Focused Literature Survey. *Yearb Med Inform* 2019; **28**: 120-127 [PMID: 31419824 DOI: 10.1055/s-0039-1677911]

32 **Lee SI**, Celik S, Logsdon BA, Lundberg SM, Martins TJ, Oehler VG, Estey EH, Miller CP, Chien S, Dai J, Saxena A, Blau CA, Becker PS. A machine learning approach to integrate big data for precision medicine in acute myeloid leukemia. *Nat Commun* 2018; **9**: 42 [PMID: 29298978 DOI: 10.1038/s41467-017-02465-5]

33 **Reddy S**, Fox J, Purohit MP. Artificial intelligence-enabled healthcare delivery. *J R Soc Med* 2019; **112**: 22-28 [PMID: 30507284 DOI: 10.1177/0141076818815510]

34 **Debnath S**, Barnaby DP, Coppa K, Makhnevich A, Kim EJ, Chatterjee S, Tóth V, Levy TJ, Paradis MD, Cohen SL, Hirsch JS, Zanos TP; Northwell COVID-19 Research Consortium. Machine learning to assist clinical decision-making during the COVID-19 pandemic. *Bioelectron Med* 2020; **6**: 14 [PMID: 32665967 DOI: 10.1186/s42234-020-00050-8]

35 **Hazarika I**. Artificial intelligence: opportunities and implications for the health workforce. *Int Health* 2020; **12**: 241-245 [PMID: 32300794 DOI: 10.1093/inthealth/ihaa007]

36 **Whitelaw S**, Mamas MA, Topol E, Van Spall HGC. Applications of digital technology in COVID-19 pandemic planning and response. *Lancet Digit Health* 2020; **2**: e435-e440 [PMID: 32835201 DOI: 10.1016/S2589-7500(20)30142-4]

37 **Chatterjee A**, Gerdes MW, Martinez SG. Identification of Risk Factors Associated with Obesity and Overweight-A Machine Learning Overview. *Sensors (Basel)* 2020; **20** [PMID: 32403349 DOI: 10.3390/s20092734]

38 **Shi HY**, Lee KT, Wang JJ, Sun DP, Lee HH, Chiu CC. Artificial neural network model for predicting 5-year mortality after surgery for hepatocellular carcinoma: a nationwide study. *J Gastrointest Surg* 2012; **16**: 2126-2131 [PMID: 22878787 DOI: 10.1007/s11605-012-1986-3]

39 **Shi HY**, Lee KT, Lee HH, Ho WH, Sun DP, Wang JJ, Chiu CC. Comparison of artificial neural network and logistic regression models for predicting in-hospital mortality after primary liver cancer surgery. *PLoS One* 2012; **7**: e35781 [PMID: 22563399 DOI: 10.1371/journal.pone.0035781]

40 **Brasil S**, Pascoal C, Francisco R, Dos Reis Ferreira V, Videira PA, Valadão AG. Artificial Intelligence (AI) in Rare Diseases: Is the Future Brighter? *Genes (Basel)* 2019; **10** [PMID: 31783696 DOI: 10.3390/genes10120978]

41 **O'Mara-Eves A**, Thomas J, McNaught J, Miwa M, Ananiadou S. Using text mining for study identification in systematic reviews: a systematic review of current approaches. *Syst Rev* 2015; **4**: 5 [PMID: 25588314 DOI: 10.1186/2046-4053-4-5]

42 **Harrer S**, Shah P, Antony B, Hu J. Artificial Intelligence for Clinical Trial Design. *Trends Pharmacol Sci* 2019; **40**: 577-591 [PMID: 31326235 DOI: 10.1016/j.tips.2019.05.005]

43 **Kiely DG**, Doyle O, Drage E, Jenner H, Salvatelli V, Daniels FA, Rigg J, Schmitt C, Samyshkin Y, Lawrie A, Bergemann R. Utilising artificial intelligence to determine patients at risk of a rare disease: idiopathic pulmonary arterial hypertension. *Pulm Circ* 2019; **9**: 2045894019890549 [PMID: 31798836 DOI: 10.1177/2045894019890549]

44 **Kaushik AC**, Raj U. AI-driven drug discovery: A boon against COVID-19? *AI Open* 2020; **1**: 1-4 [DOI: 10.1016/j.aiopen.2020.07.001]

45 **Shinde GR**, Kalamkar AB, Mahalle PN, Dey N, Chaki J, Hassanien AE. Forecasting Models for Coronavirus Disease (COVID-19): A Survey of the State-of-the-Art. *SN Comput Sci* 2020; **1**: 197 [PMID: 33063048 DOI: 10.1007/s42979-020-00209-9]

46 **Doshi R**, Falzon D, Thomas BV, Temesgen Z, Sadasivan L, Migliori GB, Raviglione M. Tuberculosis control, and the where and why of artificial intelligence. *ERJ Open Res* 2017; **3** [PMID: 28656130 DOI: 10.1183/23120541.00056-2017]

47 **Jamal S**, Goyal S, Shanker A, Grover A. Predicting neurological Adverse Drug Reactions based on biological, chemical and phenotypic properties of drugs using machine learning models. *Sci Rep* 2017; **7**: 872 [PMID: 28408735 DOI: 10.1038/s41598-017-00908-z]

48 **Wahl B**, Cossy-Gantner A, Germann S, Schwalbe NR. Artificial intelligence (AI) and global health: how can AI contribute to health in resource-poor settings? *BMJ Glob Health* 2018; **3**: e000798 [PMID: 30233828 DOI: 10.1136/bmjgh-2018-000798]

49 **Kleinberg J**, Ludwig J, Mullainathan S, Obermeyer Z. Prediction Policy Problems. *Am Econ Rev* 2015; **105**: 491-495 [PMID: 27199498 DOI: 10.1257/aer.p20151023]

50 **Goldstein BA**, Navar AM, Pencina MJ, Ioannidis JP. Opportunities and challenges in developing risk prediction models with electronic health records data: a systematic review. *J Am Med Inform Assoc* 2017; **24**: 198-208 [PMID: 27189013 DOI: 10.1093/jamia/ocw042]

51 **Gerke S**, Minssen T, Cohen G. Ethical and legal challenges of artificial intelligence-driven healthcare. *Artificial Intelligence in Healthcare* 2020; 295-336 [DOI: 10.1016/b978-0-12-818438-7.00012-5]

52 **Jiang F**, Jiang Y, Zhi H, Dong Y, Li H, Ma S, Wang Y, Dong Q, Shen H. Artificial intelligence in healthcare: past, present and future. *Stroke Vasc Neurol* 2017; **2**: 230-243 [PMID: 29507784 DOI: 10.1136/svn-2017-000101]

53 **Obermeyer Z**, Emanuel EJ. Predicting the Future - Big Data, Machine Learning, and Clinical Medicine. *N Engl J Med* 2016; **375**: 1216-1219 [PMID: 27682033 DOI: 10.1056/NEJMp1606181]

54 **Murdoch TB**, Detsky AS. The inevitable application of big data to health care. *JAMA* 2013; **309**: 1351-1352 [PMID: 23549579 DOI: 10.1001/jama.2013.393]

55 **Kolker E**, Özdemir V, Kolker E. How Healthcare Can Refocus on Its Super-Customers (Patients, *n* = 1) and Customers (Doctors and Nurses) by Leveraging Lessons from Amazon, Uber, and Watson. *OMICS* 2016; **20**: 329-333 [PMID: 27310474 DOI: 10.1089/omi.2016.0077]

56 **Dilsizian SE**, Siegel EL. Artificial intelligence in medicine and cardiac imaging: harnessing big data and advanced computing to provide personalized medical diagnosis and treatment. *Curr Cardiol Rep* 2014; **16**: 441 [PMID: 24338557 DOI: 10.1007/s11886-013-0441-8]

Artificial Intelligence in Cancer

Submit a Manuscript: https://www.f6publishing.com

Artif Intell Cancer 2022 February 28; 3(1): 11-16

DOI: 10.35713/aic.v3.i1.11

ISSN 2644-3228 (online)

MINIREVIEWS

Artificial intelligence as a future in cancer surgery

Morena Burati, Fulvio Tagliabue, Adriana Lomonaco, Marco Chiarelli, Mauro Zago, Gerardo Cioffi, Ugo Cioffi

Specialty type: Oncology

Provenance and peer review: Invited article; Externally peer reviewed.

Peer-review model: Single blind

Peer-review report's scientific quality classification

Grade A (Excellent): 0
Grade B (Very good): B
Grade C (Good): 0
Grade D (Fair): D, D
Grade E (Poor): 0

P-Reviewer: Boscá L, Dulskas A

Received: December 10, 2021
Peer-review started: December 10, 2021
First decision: December 13, 2021
Revised: December 24, 2021
Accepted: January 17, 2022
Article in press: January 17, 2022
Published online: February 28, 2022

Morena Burati, Fulvio Tagliabue, Adriana Lomonaco, Marco Chiarelli, Mauro Zago, Department of Robotic and Emergency Surgery, Ospedale A Manzoni, ASST Lecco, Lecco 23900, Italy

Gerardo Cioffi, Department of Sciences and Technologies, Unisannio, Benevento 82100, Italy

Ugo Cioffi, Department of Surgery, University of Milan, Milano 20122, Italy

Corresponding author: Ugo Cioffi, PhD, Professor, Surgeon, Department of Surgery, University of Milan, *Via* F. Sforza 35, Milano 20122, Italy. ugocioffi5@gmail.com

Abstract

Artificial intelligence (AI) is defined as the theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, and decision-making. Machine learning and deep learning (DL) are subfields of AI that are able to learn from experience in order to complete tasks. AI and its subfields, in particular DL, have been applied in numerous fields of medicine, especially in the cure of cancer. Computer vision (CV) system has improved diagnostic accuracy both in histopathology analyses and radiology. In surgery, CV has been used to design navigation system and robotic-assisted surgical tools that increased the safety and efficiency of oncological surgery by minimizing human error. By learning the basis of AI, surgeons can take part in this revolution to optimize surgical care of oncologic disease.

Key Words: Artificial intelligence; Surgery; Robotic surgery; Machine learning; Pattern recognition; Cancer

©The Author(s) 2022. Published by Baishideng Publishing Group Inc. All rights reserved.

Core Tip: Artificial intelligence (AI) has been applied in different fields of medicine to maximize the accuracy of diagnosis and treatment. AI-based navigating systems and surgical robots have helped surgeons to improve their results in terms of safety and efficacy in oncologic surgery. By learning the basis of AI, surgeons can take part in this revolution to optimize surgical care of oncologic disease.

Citation: Burati M, Tagliabue F, Lomonaco A, Chiarelli M, Zago M, Cioffi G, Cioffi U. Artificial intelligence as a future in cancer surgery. *Artif Intell Cancer* 2022; 3(1): 11-16
URL: https://www.wjgnet.com/2644-3228/full/v3/i1/11.htm
DOI: https://dx.doi.org/10.35713/aic.v3.i1.11

INTRODUCTION

Artificial intelligence (AI) is defined as the theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, and decision-making. Machine learning (ML) is a subset of AI. It is based on algorithms inspired by neural networks, developed to be able to learn to solve problems as a human brain would do[1]. A part of ML is deep learning (DL), based on artificial neural networks (ANNs) (such as deep neural networks, deep belief networks, deep reinforcement learning, recurrent neural networks, and convolutional neural networks). In DL, multiple layers of processing are used to extract progressively an higher level of features from data, with the final purpose 'to learn through experience'[2]. AI, ML, and DL are having greater and greater impact in everyday life and health care providing. Being developed faster and more reliably, they are expected to gain a relevant position in diagnostic and thera-peutic processes.

Cancer is still one of the most common causes of death in developed countries, destined to increase due to the global aging of the population[3]. An enormous effort has been made and it is still going on to employ AI and its future developments in cancer diagnosis and treatment, as it is still a huge priority worldwide. Approximately 30 years ago, surgeons witnessed the birth of robotic surgery, which has been constantly improved with AI technologies to improve its efficiency and minimize human mistake. To be truly part of this revolution, surgeons must understand the foundation of AI technologies.

The purpose of this minireview is to show the basis of AI and its subfields and its role in cancer surgery.

METHODS

A MEDLINE search on PubMed was performed. We screened the resulting articles to identify key concepts and techniques within AI, especially leading innovation in the field of oncologic surgery. Thirty-four articles are cited in our minireview, including reviews and meta-analyses.

AI IN MEDICINE

At present, AI is applied to computers and medical robots to mimic human intelli-gence, assisting in drug design, clinical diagnosis formulation, and robotic surgery[4]. In addition, sophisticated AI software is used to produce medical statistical datasets and recognize tumoral cellular patterns for histological diagnoses, including cancer[5].

In medicine, AI has two main branches: Virtual and physical[6]. The virtual component applies DL information management to control electronic health records and guide physicians to take treatment decisions. The physical branch is represented by robots[7]. Robotic systems have been used in surgery since the late 90 s; also robotic assistants are also used in the care of elderly patients and nanorobots are currently being developed to deliver drugs to a specific target[8]. In the next future, this new way to administer chemotherapy will change cancer treatment, improving its efficacy by reducing global toxicity.

Nevertheless, as any new technology introduced in a critical field like healthcare providing, societal and ethical controversies of these new technologies need a special focus on their true utility, economic and environmental sustainability, and constant widening of their applications[9].

SUBFIELDS IN AI: ML, NATURAL LANGUAGE PROCESSING, ARTIFICIAL NEURAL NETWORK, AND COMPUTER VISION

To better understand AI and its role in oncologic surgery, it is crucial to discuss AI's principal subfields and their role in medicine.

ML allows machines to recognize specific patterns and, by doing that, automats can learn and make predictions. Actually, there are two types of ML: Supervised and unsupervised. Supervised ML utilizes partial labelling of the data to predict a known result or outcome. Unsupervised ML, instead, analyses the structure detected in the data itself to find patterns within data[10]. ML is particularly useful to identify hidden patterns in large datasets. In fact, they can easily detect complex non-linear relationships and multivariate effects compared to conventional statistical analysis[11]. Also, part of ML is reinforcement learning, where accomplishing a task depends on previous success or failure.

Natural language processing focuses on machine's understanding of human language beyond simple word recognition including semantics and syntax. At present, it has been used to analyze large datasets in search of adverse events and postope-rative complications. Moreover, it has found an interesting use in surgery: By analyzing operative reports and postoperative notes, it has been able to elaborate an algorithm that predicts the anastomotic leak after colorectal surgery. Of interest, the software did not only include obvious data like the type of surgery and time to first oral feeding, but also could understand and codify how the patient was described by doctors (weak, irritated, at ease, *etc.*) and include this data in the analyses[12].

ANNs are the base of DL. They get their inspiration from human neural networks. These networks are made of many layers of connections and are able to learn from previous experiences. Based on previous feedbacks, in fact, in-put and out-put patterns change to complete the due task. In clinical practice, these technologies have been proved more accurate than traditional scores in predicting patients' outcomes[13].

Computer vision (CV) is the ability of computers to understand and process images. Its applications in clinical practice are huge and in continuous growth: Computer-aided diagnosis, image-guided surgery, and virtual colonoscopy are only few of the new technologies developed and introduced in everyday medical practice[14].

AI IN CANCER SURGERY

AI technologies, especially the field of DL, have a huge role in cancer diagnosis and treatment. At present, early detection is the key to preventing neoplastic affections to become incurable. The role of AI in the diagnostic field of oncologic affection is well known and widely described in the medical literature. As a matter of fact, DL has been applied to clinical radiology and histopathology to obviate the operator's sensitive level of precision. DL has proved great success rates in imaging pattern recognition, thus the expectations on its future clinical applications have grown exponentially in the last decade. Early results published in the literature showed how DL-based imaging recognition provided superior performances compared to traditional computer-mediated techniques, or in some cases, they were even more accurate than experienced physicians[15].

High impact examples of this are dermatologic software able to perform dermo-scopies to detect melanoma. In the literature, these technologies have been proved to have same accuracy as expert dermatologists[16]. CV has been extensively used in oncologic radiology. Recent studies have demonstrated that AI software is able to interpret mammographic images for breast cancer screening as an expert physician would do[17]. Moreover, computer aided-detection improved by ANN, generated a software program able to detect imaging alterations on computed tomography (CT), like enlarged lymph nodes and suspect colonic lesions for colon cancer early diagnosis[18].

Another interesting cancer-related field in great expansion is automatic histopa-thology analysis. Of interest, in cancer treatment, tissue biomarker positivity (expressed in scores) is essential to plan a chemotherapy schedule. Recently developed DL-based computational approaches can automatically score the presence of a specific biomarker. For example, a recent study demonstrated that the DL-mediated scoring of HER 2 in breast cancer samples was more accurate than the human-mediated scoring and lead to identification of few cases at high risk of misdiagnosis[19].

When explaining the role of AI in histopathology analyses, it is crucial to emphasize how ML-based increased accuracy can influence physicians' therapeutic choices and, therefore, a patients' history. In fact, DL models can recognize high risk cancer lesions at fine needle biopsy with greater accuracy than traditional methods. This can affect surgery too, since the diagnosis of a benign neoplasm can prevent or limit surgical excision, reducing patients' risk of developing complications or carrying impairing lesions. As an example, in an interesting study by Juwara *et al*[20], AI assistance significantly reduced mastectomies by 30.6% by increasing the detection of benign lesions at core biopsy, which usually were diagnosed only after extended surgery.

Surgical resection is often a crucial point in cancer treatment. AI subfield gets employed in computer assisted surgery (CAS), which has entered everyday clinical practice, and has improved its efficiency and efficacy in the management of oncologic diseases that need surgical attention[21]. CV is widely applied in image guidance and navigation, defined as a system designed to assist surgeons on the basis of pre-operative radiological CT images[22]. It is used to easily explore a patient's anatomy, recognize pathologic or noble structures, and plan their removal or sparing. Radiological imaging combined with specific tracking technologies installed in surgical instruments get set on the patient's coordinate system. The machine recognizes and indicates the structures of interest, even when they are hidden, helping surgeons to easily and safely find their way towards their operative targets[21]. At present, image guidance and navigation have found a prolific field of application in neurosurgery and orthopedic surgery, more in general in all kinds of surgery where anatomy do not get subverted by tissue shifting and organ moving[23]. In these cases, computer-based navigation has found limited application. Great efforts have been made to apply AI surgical navigation techniques to surgeries where plane dissection generates anatomical subversion, like abdominal surgery. As a result, new techniques in study can give insights and orientation for hidden anatomical features, like showing the position of the aorta and the ureter in relation to the instruments in laparoscopic rectal surgery[24]. Another successful example is computer-assisted liver map creation in liver cancer surgery[25]. In future, more structures will be ‘mapped’ on CT images and will be available for image-guided abdominal surgery like the spleen, pancreas, and esophagus[26,27].

The most popular field of CAS is robotic-assisted surgery. Robotic surgery boasts a 50-year-long history. The use of robotics in the surgery field has been hypothesized around 1964, but it took more than 30 years to finally be approved in medical practice by the United States Food and Drug Administration[28]. Originally, abdominal robotic surgery was thought intended for long-distance trauma surgery in battlefield settings. Since the first 2000 s, when surgical robots became commonly used in worldwide operating rooms, robotic surgery gained more and more popularity. Its advantages, in fact, have been shown in medical studies, international randomised controlled trial, and meta-analyses, winning the trust of the more skeptical physicians[29,30]. At present, the well-known advantages of robotic surgery, like 3-D vision, the elimination of hand tremor, and the expanded degrees of freedom of its tools, led robot-assisted surgery to become frequently used in pelvic surgery, like in prostatectomy and hysterectomy. In recent meta-analyses, robotic prostatectomy was connected to improved urinary function, lower intraoperative complication rates, and improvements in positive surgical margins compared to laparoscopic technique[31]. Thus, there is a chance for robotic prostatectomy to become gold standard for surgical treatment of prostate cancer[32]. Huge expectations rely in the field of robotic surgery. In the next future, assistance systems are expected to be integrated with surgical robots. This imple-mented CV technologies will provide surgeons with answers to their doubts about anatomical structures and resection margins by comparing intra-operative data with millions of inventory images [33].

Again, computer imaging is currently used to create virtual models of surgical fields on which surgeons can be trained to acquire the psychomotor skills and surgical knowledge necessary before operating on real patients. This kind of technology is not only useful to train new generations of surgeons, but in future, 3-D operative simula-tors of patients’ specific anatomies will be available. This will be revolutionary in oncologic surgery, allowing the deep anatomical understanding of hardly resectable tumors[34].

Looking at these new technological opportunities, it is easy to predict how the role of AI in oncologic surgery will grow fast and will be applied also to pre- and post-operative phases, aiming to a more patient-targeted type of health care that can minimize mortality and morbidity. As a result, surgeons have a key role in the application of ML and DL in the everyday surgical practice. By understanding the basis of AI, surgeons can be part of the designing process of new machine integrated with AI systems. In fact, by highlighting the surgical point of view and changing their skills to adapt to this new way of delivering clinical care, surgeons can be part of this new way to provide health care that will become more targeted, safer, and always more accurate, improving success rates and reducing mortality and postoperative morbidity.

LIMITATIONS

As a minireview, this article has potential limitations common to all reviews. These include potential bias, like the influence of the authors' personal viewpoints and gaps in literature searching that may lead to the omission of relevant data.

CONCLUSION

AI-based technologies, especially ML and DL, have entered the field of oncology, bringing new perspectives and improving accuracy in different fields. In surgery, new CV system and intra-operative image analyses are currently helping surgeons to be more accurate, reducing human error and improving survival. By learning the basis of AI, surgeons can take part in this revolution to optimize surgical care of oncologic disease.

ACKNOWLEDGEMENTS

We thank Dr. Gerardo Cioffi, a native speaker of English, for reviewing the English language.

FOOTNOTES

Author contributions: All authors contributed equally to this paper.

Conflict-of-interest statement: The authors report no conflicts of interest for this article.

Open-Access: This article is an open-access article that was selected by an in-house editor and fully peer-reviewed by external reviewers. It is distributed in accordance with the Creative Commons Attribution NonCommercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: https://creativecommons.org/Licenses/by-nc/4.0/

Country/Territory of origin: Italy

ORCID number: Morena Burati 0000-0003-2562-4760; Fulvio Tagliabue 0000-0002-4095-017X; Adriana Lomonaco 0000-0002-4270-4132; Marco Chiarelli 0000-0003-1729-4925; Mauro Zago 0000-0001-9322-0798; Gerardo Cioffi 0000-0001-6751-3335; Ugo Cioffi 0000-0002-5321-5828.

S-Editor: Wang JJ
L-Editor: Wang TQ
P-Editor: Wang JJ

REFERENCES

1 **Jiang F**, Jiang Y, Zhi H, Dong Y, Li H, Ma S, Wang Y, Dong Q, Shen H. Artificial intelligence in healthcare: past, present and future. *Stroke Vasc Neurol* 2017; **2**: 230-243 [PMID: 29507784 DOI: 10.1136/svn-2017-000101]

2 **Marblestone AH**, Wayne G, Kording KP. Toward an Integration of Deep Learning and Neuroscience. *Front Comput Neurosci* 2016; **10**: 94 [PMID: 27683554 DOI: 10.3389/fncom.2016.00094]

3 **Siegel RL**, Miller KD, Jemal A. Cancer statistics, 2020. *CA Cancer J Clin* 2020; **70**: 7-30 [PMID: 31912902 DOI: 10.3322/caac.21590]

4 **Iqbal MJ**, Javed Z, Sadia H, Qureshi IA, Irshad A, Ahmed R, Malik K, Raza S, Abbas A, Pezzani R, Sharifi-Rad J. Clinical applications of artificial intelligence and machine learning in cancer diagnosis: looking into the future. *Cancer Cell Int* 2021; **21**: 270 [PMID: 34020642 DOI: 10.1186/s12935-021-01981-1]

5 **Shimizu H**, Nakayama KI. Artificial intelligence in oncology. *Cancer Sci* 2020; **111**: 1452-1460 [PMID: 32133724 DOI: 10.1111/cas.14377]

6 **Hamet P**, Tremblay J. Artificial intelligence in medicine. *Metabolism* 2017; **69S**: S36-S40 [PMID: 28126242 DOI: 10.1016/j.metabol.2017.01.011]

7 **George EI**, Brand TC, LaPorta A, Marescaux J, Satava RM. Origins of Robotic Surgery: From Skepticism to Standard of Care. *JSLS* 2018; **22** [PMID: 30524184 DOI: 10.4293/JSLS.2018.00039]

8 **Patil S**, Rao RS, Majumdar B. Nanorobots: Changing Trends in Cancer Therapy. *J Contemp Dent Pract* 2015; **16**: i-ii [PMID: 26522606]

9 **Fiske A**, Henningsen P, Buyx A. Your Robot Therapist Will See You Now: Ethical Implications of Embodied Artificial Intelligence in Psychiatry, Psychology, and Psychotherapy. *J Med Internet Res* 2019; **21**: e13216 [PMID: 31094356 DOI: 10.2196/13216]

10 **Deo RC**. Machine Learning in Medicine. *Circulation* 2015; **132**: 1920-1930 [PMID: 26572668 DOI: 10.1161/CIRCULATIONAHA.115.001593]

11 **Miller RA**, Pople HE Jr, Myers JD. Internist-1, an experimental computer-based diagnostic consultant for general internal medicine. *N Engl J Med* 1982; **307**: 468-476 [PMID: 7048091 DOI: 10.1056/NEJM198208193070803]

12 **Soguero-Ruiz C**, Hindberg K, Rojo-Alvarez JL, Skrovseth SO, Godtliebsen F, Mortensen K, Revhaug A, Lindsetmo RO, Augestad KM, Jenssen R. Support Vector Feature Selection for Early Detection of Anastomosis Leakage From Bag-of-Words in Electronic Health Records. *IEEE J Biomed Health Inform* 2016; **20**: 1404-1415 [PMID: 25312965 DOI: 10.1109/JBHI.2014.2361688]

13 **Davenport T**, Kalakota R. The potential for artificial intelligence in healthcare. *Future Healthc J* 2019; **6**: 94-98 [PMID: 31363513 DOI: 10.7861/futurehosp.6-2-94]

14 **Esteva A**, Robicquet A, Ramsundar B, Kuleshov V, DePristo M, Chou K, Cui C, Corrado G, Thrun S, Dean J. A guide to deep learning in healthcare. *Nat Med* 2019; **25**: 24-29 [PMID: 30617335 DOI: 10.1038/s41591-018-0316-z]

15 **Chan HP**, Samala RK, Hadjiiski LM, Zhou C. Deep Learning in Medical Image Analysis. *Adv Exp Med Biol* 2020; **1213**: 3-21 [PMID: 32030660 DOI: 10.1007/978-3-030-33128-3_1]

16 **Esteva A**, Kuprel B, Novoa RA, Ko J, Swetter SM, Blau HM, Thrun S. Dermatologist-level classification of skin cancer with deep neural networks. *Nature* 2017; **542**: 115-118 [PMID: 28117445 DOI: 10.1038/nature21056]

17 **Rodriguez-Ruiz A**, Lång K, Gubern-Merida A, Broeders M, Gennaro G, Clauser P, Helbich TH, Chevalier M, Tan T, Mertelmeier T, Wallis MG, Andersson I, Zackrisson S, Mann RM, Sechopoulos I. Stand-Alone Artificial Intelligence for Breast Cancer Detection in Mammography: Comparison With 101 Radiologists. *J Natl Cancer Inst* 2019; **111**: 916-922 [PMID: 30834436 DOI: 10.1093/jnci/djy222]

18 **Roth HR**, Lu L, Liu J, Yao J, Seff A, Cherry K, Kim L, Summers RM. Improving Computer-Aided Detection Using Convolutional Neural Networks and Random View Aggregation. *IEEE Trans Med Imaging* 2016; **35**: 1170-1181 [PMID: 26441412 DOI: 10.1109/TMI.2015.2482920]

19 **Vandenberghe ME**, Scott ML, Scorer PW, Söderberg M, Balcerzak D, Barker C. Relevance of deep learning to facilitate the diagnosis of HER2 status in breast cancer. *Sci Rep* 2017; **7**: 45938 [PMID: 28378829 DOI: 10.1038/srep45938]

20 **Juwara L**, Arora N, Gornitsky M, Saha-Chaudhuri P, Velly AM. Identifying predictive factors for neuropathic pain after breast cancer surgery using machine learning. *Int J Med Inform* 2020; **141**: 104170 [PMID: 32544823 DOI: 10.1016/j.ijmedinf.2020.104170]

21 **Kenngott HG**, Wagner M, Nickel F, Wekerle AL, Preukschas A, Apitz M, Schulte T, Rempel R, Mietkowski P, Wagner F, Termer A, Müller-Stich BP. Computer-assisted abdominal surgery: new technologies. *Langenbecks Arch Surg* 2015; **400**: 273-281 [PMID: 25701196 DOI: 10.1007/s00423-015-1289-8]

22 **Nozaki T**, Fujiuchi Y, Komiya A, Fuse H. Efficacy of DynaCT for surgical navigation during complex laparoscopic surgery: an initial experience. *Surg Endosc* 2013; **27**: 903-909 [PMID: 23052511 DOI: 10.1007/s00464-012-2531-x]

23 **Mezger U**, Jendrewski C, Bartels M. Navigation in surgery. *Langenbecks Arch Surg* 2013; **398**: 501-514 [PMID: 23430289 DOI: 10.1007/s00423-013-1059-4]

24 **Okada T**, Kawada K, Sumii A, Itatani Y, Hida K, Hasegawa S, Sakai Y. Stereotactic Navigation for Rectal Surgery: Comparison of 3-Dimensional C-Arm-Based Registration to Paired-Point Registration. *Dis Colon Rectum* 2020; **63**: 693-700 [PMID: 32271219 DOI: 10.1097/DCR.0000000000001608]

25 **Kingham TP**, Scherer MA, Neese BW, Clements LW, Stefansic JD, Jarnagin WR. Image-guided liver surgery: intraoperative projection of computed tomography images utilizing tracked ultrasound. *HPB (Oxford)* 2012; **14**: 594-603 [PMID: 22882196 DOI: 10.1111/j.1477-2574.2012.00487.x]

26 **Kenngott HG**, Neuhaus J, Müller-Stich BP, Wolf I, Vetter M, Meinzer HP, Köninger J, Büchler MW, Gutt CN. Development of a navigation system for minimally invasive esophagectomy. *Surg Endosc* 2008; **22**: 1858-1865 [PMID: 18157716 DOI: 10.1007/s00464-007-9723-9]

27 **Onda S**, Okamoto T, Kanehira M, Suzuki F, Ito R, Fujioka S, Suzuki N, Hattori A, Yanaga K. Identification of inferior pancreaticoduodenal artery during pancreaticoduodenectomy using augmented reality-based navigation system. *J Hepatobiliary Pancreat Sci* 2014; **21**: 281-287 [PMID: 23970384 DOI: 10.1002/jhbp.25]

28 **Satava RM**. Robotic surgery: from past to future--a personal journey. *Surg Clin North Am* 2003; **83**: 1491-1500, xii [PMID: 14712882 DOI: 10.1016/S0039-6109(03)00168-3]

29 **Tagliabue F**, Burati M, Chiarelli M, Fumagalli L, Guttadauro A, Arborio E, De Simone M, Cioffi U. Robotic *vs* laparoscopic right colectomy - the burden of age and comorbidity in perioperative outcomes: An observational study. *World J Gastrointest Surg* 2020; **12**: 287-297 [PMID: 32774767 DOI: 10.4240/wjgs.v12.i6.287]

30 **Maza G**, Sharma A. Past, Present, and Future of Robotic Surgery. *Otolaryngol Clin North Am* 2020; **53**: 935-941 [PMID: 32838968 DOI: 10.1016/j.otc.2020.07.005]

31 **Cao L**, Yang Z, Qi L, Chen M. Robot-assisted and laparoscopic vs open radical prostatectomy in clinically localized prostate cancer: perioperative, functional, and oncological outcomes: A Systematic review and meta-analysis. *Medicine (Baltimore)* 2019; **98**: e15770 [PMID: 31145297 DOI: 10.1097/MD.0000000000015770]

32 **Sood A**, Jeong W, Peabody JO, Hemal AK, Menon M. Robot-assisted radical prostatectomy: inching toward gold standard. *Urol Clin North Am* 2014; **41**: 473-484 [PMID: 25306159 DOI: 10.1016/j.ucl.2014.07.002]

33 **Ngiam KY**, Khor IW. Big data and machine learning algorithms for health-care delivery. *Lancet Oncol* 2019; **20**: e262-e273 [PMID: 31044724 DOI: 10.1016/S1470-2045(19)30149-4]

34 **Aggarwal R**, Balasundaram I, Darzi A. Training opportunities and the role of virtual reality simulation in acquisition of basic laparoscopic skills. *J Surg Res* 2008; **145**: 80-86 [PMID: 17936796 DOI: 10.1016/j.jss.2007.04.027]

Published by **Baishideng Publishing Group Inc**
7041 Koll Center Parkway, Suite 160, Pleasanton, CA 94566, USA
Telephone: +1-925-3991568
E-mail: bpgoffice@wjgnet.com
Help Desk: https://www.f6publishing.com/helpdesk
https://www.wjgnet.com

© 2022 Baishideng Publishing Group Inc. All rights reserved.