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Artificial Intelligence Surgery

Editorial

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Announcement of Consensus Conference on Definitions of Artificial Intelligence for the Next Generation of Surgeons

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Abstract

This editorial announces the need for a consensus conference on definitions of surgical nomenclature, which is evolving due to the introduction of non-human (hardware, software) devices and applications, including robotics. A recently created entity, the Artificial Intelligence Organization for Next Generation Surgeons (AIONS), comprised primarily of *AIS* editorial board members, has proposed updated definitions on the following terms: surgery, endoluminal surgery, percutaneous surgery, robots, robotic-assisted surgery (RAS), remote surgery, artificial intelligence surgery (AIS), robotic surgery, surgomics, non-invasive surgery. These definitions will be discussed during a Consensus Conference on Definitions of Artificial Intelligence, Surgery, Surgomics and Robotics, which is scheduled for February 12, 2025.

Keywords: Artificial intelligence surgery, robotic surgery, autonomous actions, guidelines

INTRODUCTION

The first issue of the journal, *Artificial Intelligence Surgery* (*AIS*), was published in December 2021, and the journal is awaiting its first official impact factor in early 2025. The scientific community's positive response to the journal has exceeded the Editorial Board's expectations. Therefore, the board has proposed establishing a new dedicated group based on the principles of AIS. To that end, members of the *AIS* Editorial Board, along with other experts in the surgical AI community, have founded AIONS (AIONS.ai), a not-for-profit organization, which will operate as a society dedicated to a wide range of aligned AI-related efforts within the global surgical domain. The name "AIONS" is derived from the Greek word for eternity and the mythical god of cyclic ages, also known as Eon in English. AIONS stands for the Artificial Intelligence Organization for Next Generation Surgeons. The overarching goal of AIONS is to create a collaborative platform where interventionalists from various disciplines can engage with computer scientists, ethicists, engineers, and others interested in the judicious utilization of AI in surgery.

The *AIS* board takes pride in being an inclusive Editorial Board that seeks out independent thinkers passionate about the passionate about the potential of artificial intelligence (AI) in revolutionizing surgical interventions. However, there has been growing concern that technology-driven decisions are being disproportionately influenced and controlled by a small, select group of entities seemingly not supportive of broader collaboration.

The idea for this journal originated from a simple question: Is the current complete robotic surgical system (CRSS) really a robot? Modern surgical robotics often evokes comparisons to the Mechanical Turk - a historical automaton that concealed a chess master who controlled its movements. Interestingly, the term "robot" comes from the Czech word "robota", meaning servant, forced labor, or perhaps more cynically, slave. Yet, in the context of current robotic systems, it is the surgeon who remains the one doing the work. This paradox highlights the diverse perspectives among surgeons regarding what constitutes a true robot. Simultaneously, the field of surgery is rapidly evolving, with procedures becoming increasingly less invasive and, in some instances, entirely non-invasive (e.g., radiation therapy and histotripsy)[1,2].

To address the nebulosity surrounding the evolving surgical discipline driven by increasing technological integration, we have decided to organize a Consensus Conference on the Definitions of Artificial Intelligence, Surgery, Surgomics and Robotics. The conference is now scheduled for February 12, 2025, at 15:00 CET and will be chaired by Professors Andrew Gumbs and Michele Diana. Participation is open to Senior and Junior Editorial Board members of *AIS* and registered members of AIONS. Key topics for discussion include definitions of surgery, endoluminal surgery, percutaneous surgery, robots, robotic-assisted surgery (RAS), remote surgery, AIS, robotic surgery, surgomics, and non-invasive surgery.

WHAT IS THE FUTURE OF SURGERY?

The essence of a surgeon's role has always been to use their hands to alleviate suffering. Historically, surgical interventions of all types have been the hallmark of the profession. Over the last several generations, minimal access or minimally invasive surgery has become a focal point for many surgeons. Driven by a strong desire for progress, surgeons have developed methods to perform complex procedures that previously required large incisions through minimally invasive incisions (e.g., laparoscopic and robotic-assisted), flexible endoscopy (e.g., endoscopic retrograde cholangiopancreatography and sphincterotomy), and percutaneous techniques (e.g., percutaneous cholecystostomy, hepatic tumor ablation, and gastrojejunostomy). Unfortunately, the hubris of many surgical leaders in the past led them to shun and marginalize these innovations, leaving them to be salvaged by a new wave of interventionalists: endoscopists and interventional proceduralists such as radiologists and cardiologists.

Although cardiothoracic surgeons remain a mighty force in some specialized centers worldwide, their role has become secondary to that of interventional cardiologists at many institutions, as cardiac stenting has grown increasingly safe, effective, and popular. In contrast, Urology is an example of a surgical specialty that has maintained its control over much of its operational domain. Urologists control all aspects of urologic surgery, cystoscopy, and percutaneous procedures on the urinary system, such as percutaneous nephrostomy. They also continue to manage the administration of intravesical chemotherapy for early-stage bladder cancer. Similarly, gynecologic surgeons who perform surgeries and hysteroscopies have developed the subspecialty of Gynecologic Oncology, which handles complex surgeries and oversees the delivery of intravenous chemotherapy and immunotherapy.

To emulate these disciplines, some Digestive Surgery departments have merged Surgery and Gastroenterology under a single department with one chairperson[3]. Tellingly, general surgery residents in the United States have been trained in traditional minimally invasive and robotic surgery, endoscopy, and percutaneous interventional vascular techniques for decades.

As healthcare delivery (medical and surgical) becomes increasingly managed in a more businesslike manner where economic upsides and clinical outcomes are not always aligned, patient care could be compromised as departments compete for patients. Fortunately, cancer patients benefit from Multidisciplinary tumor boards, developed to address this potential interdepartmental competition. Yet, one might wonder how patient care would differ if a single clinician could perform all necessary procedures, rather than having multiple physicians and departments involved. Such an approach might be the most effective way to eliminate conscious and subconscious biases in patient care decisions.

As the utilization of AI, along with advances in mechanical engineering, continues to ascend in the field of surgery, we can anticipate that even more complex procedures will be performed through smaller and fewer incisions. Moreover, the growth of autonomous systems may enable these procedures to be carried out not only via flexible endoscopy and percutaneous techniques, but also through non-invasive techniques, such as histotripsy, where high-amplitude ultrasound is delivered by an autonomously controlled robotic arm. Given these potentially challenging realities, we have decided to reach a consensus on what we believe should shape the future of endoscopic, percutaneous, robotic, and non-invasive interventions and, ultimately, the entire surgical domain.

DEFINITIONS

Surgery

Surgery today encompasses both open and minimally invasive surgery. Open surgery refers to procedures where a sufficiently large skin incision provides direct visual access to a target organ or structure, enabling safe intervention, such as an open cholecystectomy. In contrast, minimally invasive surgery involves much smaller incisions, sometimes multiple, and uses technology to provide an adequate field of view for safe intervention, such as in laparoscopic cholecystectomy. Minimally invasive surgery, often considered the most important shift in surgical practice, encompasses techniques like endoscopic (e.g., laparoscopic, arthroscopic, thorascopic) and so-called robot-assisted surgery[3]. Additionally, surgery, advanced endoscopy, and interventional radiology, all benefiting from advances in robotics and computer science, may eventually coalesce into a new hybrid specialty dedicated to patient care using these techniques (MIS Hybrid image-guided surgery). Given these advances, a more comprehensive definition of modern surgery may be an interventional medical procedure that manipulates organs, tissues, cells, or genes to restore the physiologic status of the organism, using physical and biological energies, guided by imaging systems, and powered by cognitive mechatronic and/or nanoworld technologies. In short, the definition of surgery must evolve to remain relevant in the future.

Endoluminal surgery

In addition to gastroenterologists, surgeons also perform flexible endoscopy. Flexible endoscopy, initially developed by surgeons, is still widely practiced by many surgeons around the world and can be considered a form of surgery. The term "endoluminal surgery" may be a more appropriate umbrella term to encompass interventional endoscopy (e.g., endoscopic retrograde cholangiopancreatography, endoscopic gastrojejunostomy, endoscopic bilio-enteric stenting) and Natural Orifice Translumenal Endoscopic Surgery (NOTES), as it highlights the surgical nature of these interventions. Furthermore, endoscopic mucosal resection (ESD) procedures, initiated in Japan in 1984 as the "strip body" technique, set the stage for more advanced and invasive endoluminal procedures[4]. Flexible endoscopic surgical platforms required for ESDs have undergone significant improvements, including studies on porcine colonic ESDs conducted in early 2013[5]. One notable development in this area, referred to as "Endoluminal Surgical Triangulation 2.0", emerged in 2017, featuring a reduced learning curve and enhanced efficacy in more complex surgical procedures[6].

Percutaneous surgery

Interventional percutaneous techniques are performed by various specialists, including radiologists, gastroenterologists, cardiologists, and pulmonologists. In some departments of hepato-biliary and pancreatic (HPB) surgery, surgeons also perform procedures traditionally done by interventional radiologists (e.g., portal vein embolization, percutaneous ablation of liver tumors). Additionally, some gastroenterologists perform ablations of hepatic and pancreatic lesions using endoscopic ultrasound and some surgeons conduct ablations using open and minimally invasive approaches. As a result, there may be some advantages for HPB surgeons to be skilled in percutaneous, endoscopic, laparoscopic, and open ablation techniques. To highlight the interventional nature of percutaneous procedures and encourage surgeons to take a more active role in performing them, the term "percutaneous surgery" should be considered.

Robots

Robots are defined as devices that can replicate or replace human actions. Before the advent of automated implantable cardioverter defibrillators (AICD), humans were responsible for obtaining EKG readings and delivering electric shocks to treat arrhythmias. In this context, an AICD can be viewed as a robot, as it performs functions previously carried out by humans. AICDs diagnose potentially life-threatening arrhythmias and provide life-saving treatment independently, without the involvement of a human doctor. Therefore, AICDs can be classified as fully autonomous devices (level 5 surgical autonomy) and may even be considered fully autonomous medical (and possibly surgical) robots.

RAS

The term “robotic surgery” or “RAS” can be potentially problematic because current CRSSs function only as tele-manipulators, representing level 1 surgical autonomy, and remain entirely under human control. RAS is a form of collaborative robot (cobot), which also includes handheld robotic devices and systems that enable surgeons to operate at the patient’s bedside. Consoles for robotic surgery can vary. Some are large units where the surgeon sits or stands in front of a large screen, with manipulators placed remotely from the operating room (OR) table, while others may be handheld consoles, allowing the surgeon to stay in the OR. This variety can make the term “console and non-console surgery” potentially confusing.

Remote surgery

Telemanipulator surgery is when the operating surgeon operates away from the OR table. Remote surgery has been defined as when the operating surgeon is not in the same room as the patient. Remote surgery can theoretically address the shortage of surgeons in surgical deserts, but whether it is the most cost-effective solution remains to be seen and is unlikely with current technology.

AIS

In its purest form, “AI” describes a computer program capable of replicating human decision-making capabilities/actions. As a result, the term “AIS” may be more appropriate for surgeries that involve levels 2-5 surgical autonomy.

Robotic surgery

“RAS” is best used to define devices that enable level 1 surgical autonomy (e.g., telemanipulation). “Collaborative robotic (or cobot) surgery” could be used to define procedures involving levels 2-4 surgical autonomy, where both the robot and surgeon collaborate. In addition, image guidance and augmented reality, when integrated with RAS, hold the promise of significantly enhancing patient safety by reducing surgery-related errors[7]. The term “robotic surgery” should perhaps be reserved exclusively for interventions performed completely independently of human input, corresponding to level 5 surgical autonomy.

Surgomics

Surgomics combines the word “surgery” with the suffix “-omics,” which means “whole” in Greek. It is a data science term focused on the analysis of multimodal data via computer vision and machine learning applications, primarily based on real-time data generated during surgery, and currently, primarily confined to the visible spectrum. However, efforts are underway to expand video analysis into the hyperspectral realm, which has shown promising results[8].

Additionally, surgomics also encompasses surgical-related data that are not gathered intraoperatively, which are traditionally video-based. For example, data collected postoperatively through radiological modalities can influence intraoperative tissue manipulation. Given this, it may be useful to distinguish between surgomic data collected during the intraoperative period and that collected preoperatively or postoperatively. Furthermore, there remains some uncertainty about whether the term should be “surgiomic” or “surgeomic”, or whether these terms should be used interchangeably.

Non-invasive surgery

Non-invasive surgery, though seemingly paradoxical, may represent the future of cancer treatment and beyond. As mentioned, two prime examples of this emerging approach are external beam radiation and histotripsy, also known as liver ultrasonic lithotripsy. The similarities between this type of treatment and traditional surgery are evident, particularly when we recall the Cyberknife - an autonomous robotic arm that delivers precise external beam therapy while dynamically adjusting to the patient's heartbeats and breathing patterns. Although patients currently receive histotripsy treatments under general anesthesia, they often wake up without pain[1,2]. To date, over 400 patients with primary and secondary liver cancers have been treated with histotripsy, and treatment centers are beginning to enroll patients with kidney and pancreatic cancers.

Similar to the effects seen after radiation therapy, an abscopal (Latin: away from the target) effect is noted in any residual tumors. However, unlike radiation therapy, which can only be applied every 2 years for full effect, histotripsy does not seem to damage neighboring structures and, in theory, can be used at much shorter intervals. For example, it appears that histotripsy only kills cancer cells without damaging blood vessels or bile ducts. If this technology achieves its full potential, and surgeons are no longer directly involved in its delivery and similar treatments that follow, the practice of surgery as we know it today may be considerably changed. Theoretically, if investments were redirected from current, legacy CRSS systems and designs to other forms of AIS, it could lead to a more cost-effective public health intervention[9].

ANNUAL CONFERENCE IN AIS

Lastly, we are excited to announce the inaugural AIONS Annual Conference, scheduled to take place at the American Hospital of Paris (AHP) in the Fall of 2025. *AIS* will become the official journal of AHP starting in 2025. The AHP is already affiliated with Cornell University and is transitioning into a university hospital in France. Its CEO has launched a new initiative to support the integration of advanced AI technologies into the care of its patients. Year 2 will see a conference in San Jose, California (in Silicon Valley), followed by a conference in Qingdao, China. Subsequent conferences will rotate between Europe/Africa and the Middle East (Year 1), the Americas (Year 2), and Asia (Year 3).

DISCUSSION

The utilization of robotics in the operating theater has expanded considerably since the deployment of the da Vinci Surgical System by Intuitive Surgical Inc. in 1999. As of 2021, over 8 million surgical procedures have utilized the da Vinci system, with more than 6,700 systems installed worldwide[10]. There are considerable advantages to using this and other competing systems, particularly true in the pelvis and the mediastinum, where a surgeon cannot easily operate due to ergonomic constraints. These advantages are evident in the short term (e.g., 3 months); however, at longer-term follow-ups (24 months), these benefits seem to disappear[11,12]. Notably, the market size for CRSS is projected to increase from 70 billion USD in 2022 to 120 billion US dollars by 2030 in the USA alone (https://gitnux.org/robotic-surgery-statistics/). Given the inequities in healthcare delivery in high-income countries, where robots are at least affordable, it raises the question: What will happen in low- and middle-income countries (LMICs)[13]?

The 2015 *Lancet* paper revealed that 60% of the world's population lacks access to a surgeon, and that providing surgical care to underserved populations is one of the most cost-effective public health interventions, second only to comprehensive vaccination programs[14]. It is estimated that 420 billion US dollars are needed to expand surgical services by 2030. More troublingly, failure to expand these services in LMICs could result in a cost of over 12 trillion US dollars to their economies[15].

When considering the cost of RAS in its current form and how this expense could potentially be used more effectively elsewhere, the market trend of expanding CRSS installation comes into question[16]. An argument could be made for investing in the development of smaller, less expensive robotic systems, specifically handheld robots and/or smaller CRSS without consoles, which would offer the advantages of decreased costs, continuous surgeon-patient contact, and superior haptic feedback[17]. An even stronger case could be made for the enhanced clinical value and overall economic benefit of coupling these less costly robots with innovative treatment modalities. For example, non-invasive histotripsy robotic "surgical" devices, which have recently entered the market, have shown very promising results.

Looking toward the future of surgery, it becomes ever more apparent that technology will play an ever-greater role. The role of AI in surgery spans the entire domain, and the transition from level 0 to level 5 autonomy is already underway. Perhaps we should reflect upon the comments made by Gary Kasparov, the Russian chess grandmaster (World Champion 1985-2000), who was the first human to lose a high-stakes chess match in 1997 to the IBM Deep Blue supercomputer program. In a 2021 Harvard Business Review publication, Kasparov discusses his views on the utilization of technology in general and the interaction between humans and machines. As he stated, "Weak human + machine + better process was superior to a strong computer alone and, more remarkably, superior to a strong human + machine + inferior process[18]."

DECLARATIONS

Authors' contributions

Conception and design of the study: Gumbs AA, Grasso SV, Diana M
Acquisition, analysis, and interpretation of data: Gumbs AA, Grasso SV, Chouillard E, Croner R, Dagher I, Spolverato G, Frigerio I, Milone L, Abu Hilal M, Diana M
Manuscript draft preparation: Gumbs AA, Grasso SV
Manuscript review and editing: Gumbs AA, Grasso SV, Chouillard E, Croner R, Dagher I, Spolverato G, Frigerio I, Milone L, Khalpey Z, Rashidian N, Messaoudi N, Rawicz-Pruszyński K, Abu Hilal M, Diana M

Availability of data and materials

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Conflicts of interest

Gumbs AA is the Editor-in-Chief of *Artificial Intelligence Surgery*. Grasso SV is the Director of Social Media and Strategy of *Artificial Intelligence Surgery*. Chouillard E, Croner R, Spolverato G, Frigerio I, and Abu Hilal M are Associate Editors of *Artificial Intelligence Surgery*. Milone L, Khalpey Z, and Diana M are Editorial Board members of *Artificial Intelligence Surgery*. Rashidian N, Messaoudi N, and Rawicz-Pruszyński K are Junior Editorial Board members of *Artificial Intelligence Surgery*. Gumbs AA, Grasso SV, Chouillard E, Croner R, Spolverato G, Frigerio I, Abu Hilal M, Milone L, Khalpey Z, Diana M, Rashidian N, Messaoudi N, and Rawicz-Pruszyński K were not involved in any steps of editorial processing, notably including reviewers' selection, manuscript handling and decision making. Dagher I declared that there are no conflicts of interest.

Ethical approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

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