Artificial Intelligence-Driven Innovations in Surgery: Literature Overview

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ABSTRACT

Artificial Intelligence (AI) is improving the field of surgery by boosting precision, better decision-making, and leading to better patient results. This analysis studies the different roles of AI in every part of surgery, such as before, during, and after an operation, including changes, medical benefits, and ethical points.

At the onset, AI collects data from scans, records, and analyzes genomics to plan which treatment will work best for each patient. With machine learning, doctors can decide which approach is best and expect possible issues, and computer vision helps them correctly map the person's anatomy. Deep neural networks are as effective as specialist radiologists and dermatologists, creating a model for support in surgical decisions.

While a surgical procedure is underway, features of AI are brought together with robotics, such as da Vinci's system, to make surgery more precise, stable, and clear. With live computer vision and sensor readings, specialists are able to locate main structures and control surgical tools with close accuracy. AI technology making it possible to stitch with aids and to respond to a surgeon's gestures highlights the capabilities of semi-autonomous surgical methods. Using NLP (Natural Language Processing) patients can access patient information simply by speaking, which makes things more convenient and stress-free.

Patients' recovery is supported by devices and sensors that screen for early signs of issues such as infection or bleeding. These models make it possible to treat patients earlier, guide them on how to recover, and cut down on readmission cases.

But, using AI in healthcare can cause many difficulties. Because many models are not explainable, this raises questions about how informed patients are and how liable the people involved are in the clinical setting. If the training data contains bias, it often leads to unfair results, mostly for underserved groups. High prices for installing and using these technologies may make it difficult to use them in areas with few resources.

AI-based technology should be thoroughly tested and tested by doctors to guarantee a safe and equal adoption. Having set ethical standards and clear rules is important for responsible development. AI should rather strengthen than take away from what surgeons already contribute with their experience, understanding, and wise decisions.

All in all, AI looks likely to make surgery more accurate, safer, and tailored to each patient. It is necessary to strike a good balance between technological growth and the values important in surgical care to make use of this potential.

Keywords: *Artificial Intelligence, Machine Learning, Robotics, Semi-autonomous Surgical Methods, Natural Language Processing, AI-based technology.*

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1. INTRODUCTION

Artificial Intelligence (AI) has revolutionized how surgeries are handled by making advanced data analysis, better decision making, and automated process possible [1]. Increasingly digital healthcare can help surgery by using AI to find patterns in big data, including electronic health records, imaging studies, genetic information, and the results of surgeries [2]. They are likely to support better planning, more accurate work during the surgery, and improved supervision after the operation [3].

How surgery turned out in the past depended mostly on the abilities, decisions, and technical skills of the surgeon. Yet, due to the complexity of clinical decisions in various procedures, AI now helps by providing guidance that reduces the likelihood of errors by people [4]. Past surgical cases are studied by algorithms to help identify possible complications and give advice on the best methods. When applied to dermatology, AI with deep neural networks is just as accurate in medical image diagnosis as humans [3].

It is changing from a helper to an ally working closely with surgeons in the operating room. This trend is shown by the emergence of robots assisted by AI. Using the da Vinci Surgical System, surgeons gain more control and dexterity because the system magnifies some movements and filters tremors during surgeries [5]. Besides, according to Ma M et al., using supervised autonomous systems in soft-tissue procedures produces results at least as good as those seen by experienced human surgeons [6].

The use of data collected during surgeries and in the surgical setting to improve outcomes is a main part of how medical schools are transforming. Thanks to real-time data, AI assists in learning by immediately giving feedback or allowing gatherings of detailed information for reflection and improvement down the road. Navigation and detection of errors in procedures is supported by using computer vision information and sensor feedback, which makes us rely less on manual methods [7].

Artificial intelligence is being used more and more in risk assessment before surgeries and care after surgeries. By means of deep learning, AI can group patients at risk of death or illness and as a result assist in scheduling surgeries efficiently. During recovery, devices on the body constantly measure vital signs and send the information to algorithms, so any early signs of infection or problems with the organs can be found [8].

NLP makes it possible for AI to find useful data in unorganized medical records, which minimizes the workload for surgeons and allows them to get the patient's history and intraoperative findings faster [2]. They make it possible for care teams to understand each others' updates and identify important information.

Even though AI looks promising in medicine, there are many ethical, logistical, and legal issues when using it in surgical care. Issues with data privacy, how algorithms work, and bias in the system should be dealt with to ensure patients remain safe and trust the system [9]. In addition, the legal guidelines for AI-based actions are being created step by step, giving rise to questions about who should be held liable if things go wrong [10,11]. People in under-resourced settings need extra help with cost, availability of resources, and training in order to use AI-enhanced tools equally [5].

According to Sendak and colleagues, AI should be carefully tested and tested in clinical practice once it's viable. As AI plays a bigger role in surgery, it is still necessary to concentrate on the caring and ethical aspects of medicine. This review looks at the use of AI in surgery now and in the future, using solid evidence and following ethical practices.

2. SIGNIFICANT TECHNOLOGIES THAT DRIVE ARTIFICIAL INTELLIGENCE (AI) IN SURGERY

There are four main technologies behind the strong influence of AI on surgery: machine learning, computer vision, robotics, and natural language processing [1]. Adopting these different innovations helps surgeons perform more accurately, avoid more complications, and result in better patient outcomes. Since AI can review statistics in an efficient way and spot patterns, it helps doctors manage surgery effectively at each step.

Machine Learning (ML): is one of the main forces behind AI applications in surgery. Through it, algorithms look over past patient data, images, and archived outcomes to predict what complications might happen and offer solutions for the patient. In general healthcare, using ML has helped a lot—for example, artificial neural networks made by Esteva et al. can diagnose skin cancer as accurately as human dermatologists [3]. In this setting, ML helps with planning for each patient, predicting what can happen during surgery, and providing useful information for aftercare.

Computer Vision: Machines are able to interpret and process visual information taken from pictures and videos in medical practice [4]. It divides parts of the anatomy from CT (computed tomography) or MRI (magnetic resonance imaging) scans and enables making high-precision 3D models for planning a surgery. With computer vision, surgeons are able to find essential points for the procedure, verify the borders of the operation area, and guide resection, jobs previously based on subjective impressions.

Robotic Systems: Using AI, the da Vinci Surgical System delivers precise surgery by scaling movements, lowering tremors, and displaying everything in 3D [5]. They are used to allow doctors to do surgeries in a simpler and safer way. Today, AI helps direct and guide certain operations done by humans. According to Ma M et al., a robot was able to do soft tissue

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suturing by itself and produced outcomes like those from surgeons who have long years of experience in surgery [6]. As a result, a future might see automated systems to manage and carry out simple surgical tasks.

Surgical Navigation and Planning : Advanced imaging techniques use AI tools to plan out the patient's anatomy in 3D and suggest the best way to make incisions or place screws or implants [7]. With these aids, surgeons become more certain of their actions and fewer mistakes or problems happen inside the operating room [4].

Natural Language Processing (NLP): The techniques in Natural Language Processing enable the use of unstructured clinical notes and reports by making useful information available right away [2]. NLP systems help by bringing up past surgeries, allergies, and medication a doctor might need to consider when making a surgery plan or reacting during the operation. Less time writing reports and faster decisions using NLP help surgeons to improve their efficiency and rely on data more.

Postoperative Monitoring : AI is now being used to improve Postoperative Monitoring by means of wearable devices. Each device relies on sensors and accurate predictions to measure the heart rate, oxygen levels, and other essential signs and warn about any indications of infection, hemorrhage, or organ failure. Thanks to these tools, doctors can identify issues fast, which may prevent costly difficulties or extra visits to the hospital later [9].

Yet, these technologies are associated with issues that matter from both an ethical and legal point of view. As AI becomes more autonomous, there are issues about how clear its decisions are, mainly when it works in mysterious ways. In addition, there are still no clear solutions to defining who is responsible when AI impacts or carries out clinical decisions [11]. Because AI is being used more and more in operating rooms, it is especially important to answer these questions.

More people are limited in using cryptocurrency due to the challenges of building infrastructure, the need for training, and inequality in wealth. Many places still find it too expensive to use modern robotic equipment and technology with AI in imaging [5]. Dealing with these access problems will call for use of effective implementation strategies. He et al. believe it is important to carefully apply AI systems used in research at the bedside, check their effectiveness and cost, and ensure they are useful for doctors.

Together, they are bringing changes to how surgery is done. AI helps surgeries by improving how quickly, safely, and personally the surgeon can act instead of replacing them.

3. AI'S IMPACT ACROSS SURGICAL PHASES

AI plays a role in everything from preparing for surgery to directing operations and helping with recovery, since it provides guidance, improves results, and lessens complications [1]. Whereas other tools focus on part of the process, AI allows for effective and personalized care at all steps of the patient's path [2].

Preoperative Planning

AI helps a lot in processing complex data before surgeries. Special data about patients such as their history, tests, lab findings, and genes are handled by machine learning to help find risks of surgery, decide on the best treatment steps, and ensure informed consent [3]. They make it possible to find personalized answers instead of relying only on standard procedures. In actual use, predictive models are proven to calculate blood loss precisely, point out possible high-risk cases, and provide guidelines for prehabilitation [2]. Esteva et al. found that deep neural networks are especially skillful at image-based diagnostics and can therefore make a significant contribution to risk assessment and surgeons' planning [3].

Healthcare providers can also make 3D models of the body part that needs surgery using imaging information [4]. With these models, surgeons can understand space better and practice their approach to the surgery before starting it. Surgeons in these fields depend on 3D pictures to assist them in removing tumors without harming blood vessels.

Intraoperative Assistance

AI is also very important in what happens during an operation. Computer vision systems use live videos to find tissues, tell apart healthy from abnormal areas, and aide in identifying margins while doing surgery [4]. Using these instruments lessens the chance of error and makes sure the tumor is taken out without disturbing important healthy parts. Imaging inside the body performed by surgical navigation systems helps surgeons respond to any sudden changes along the way [7].

Robotic technologies boost the accuracy of surgeries taking place inside the body. Thanks to AI in the system, surgeons can eliminate tremors and enlarge their movements while operating in confined parts of the body [5]. AI supported autonomous machines did very consistent soft tissue surgery, according to Ma M et al., which could result in more automation in surgical procedures in the future [6].

It also aids surgeons by pulling out important clinical information from electronic data as the procedures are underway [2]. Because of this, it reduces mental stress and allows doctors to make fast decisions in emergency situations.

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Postoperative Monitoring

AI is useful in areas other than health-care work in hospitals. Often, complications after surgery are not easy to recognize at first; however, AI systems can monitor trends and signs in lab tests and spot early signals of infection, bleeding, or damage to vital organs [8]. The data from wearable devices is transmitted in the moment, so physicians are able to help when things are still minor. Morley and Floridi explain that such technologies can prevent hospital visits from being needed again and may shorten how long people stay in the hospital [9].

AI systems can further develop discharge plans according to how each patient responds to treatment, thereby making sure that vital schedules and therapy programs match each individual's needs [9]. Doubts arise in this step mainly about the correctness of autonomous reports or advice given. These authors underline the value of regulations to explain duties in processes that involve AI in recovery [10].

Because AI is being used more, the issue of accountability still remains. The author notes that fully trusting "black box" systems leaves clinicians unable to explain the decisions, which can cause challenges in seeking informed consent and avoiding liability [11]. What's also vital is the issue of accessibility. Both high expenses and technological needs ensure that not all patients can get AI-assisted care after surgery [5]. Sendak and colleagues suggest using strategies to guarantee that these systems work for everyone and do not grow any existing inequalities [12].

4. ADVANTAGES OF AI IN SURGERY

Across surgery, AI is useful for better accuracy, less chances of complications, a smoother approach to care, and more personalized treatment [1]. AI tools are now important partners in improving the outcome of surgeries since they process large data sets rapidly [2].

AI helps surgeons perform their work with much **greater precision**. ML algorithms notice small patterns in all kinds of clinical data, helping doctors to select the best anatomical sites and avoid harming too much tissue [3]. It is shown by Esteva et al. that deep neural networks can detect important signs and diseases in the field of dermatology, which is especially valuable for surgeons who need to identify them in real-time.

Error reduction: One more important advantage is the ability to **reduce errors**. With the help of computer vision and ML algorithms, surgeons can follow a steady path and promptly deal with any issues that appear during surgery [4]. AI systems encourage safe and reliable surgery by always sending feedback to the surgeon during surgery [4].

Robotic systems: Thanks to AI in the da Vinci Surgical System, robotic systems can remove shakiness from a doctor's actions, limit large movements to tiny controls, and provide visualizations in great detail [5]. Because of these technologies, surgeons have better control and patients take less time to recover. This step further, Ma M et al. demonstrated that autonomous robots guided by AI systems are able to do soft-tissue suturing and the results are as good as those performed by expert surgeons [6].

Preoperative personalization: Artificial intelligence helps in making preoperative decisions personalized. AI predicts the right treatment plan by taking into account each patient's imaging, relating medical conditions, and estimated risks [7]. Surgical simulation and correct orientation of implants in complex orthopedic or spinal cases are easier with the help of deep learning models [7].

With sensor and image analysis, **AI can give help to medical staff throughout surgery**. These tools allow surgeons to follow the correct route inside the body while working on difficult areas, with the help of the guidance system [4]. NLP software is also used to gather important data from patient charts, and it sends relevant alerts or summaries without disrupting the clean processes required in the OR [2].

Postoperative monitoring: AI is greatly helpful in the important task of postoperative monitoring. Wearable devices that use predictive analytics help in constantly monitoring important signs and detecting early symptoms of infection, bleeding, or problems with organs [8]. These methods commonly detect problems earlier, which makes it possible to treat and prevent more hospital visits [9].

Today, more **attention is being given to the ethics of AI**. Authors Morley and Floridi talk about the importance of having AI support both explainable and equitable outcomes in situations where algorithms play a big role in clinical decisions [9]. Char et al. also discuss how liability and transparency have not yet been settled when AI takes part in clinical decisions [10]. It is also noted by Topol that opaque, hard-to-explain models might erode a clinician's belief in a technology and a patient's decision to participate [11].

When describing use in practical settings, He et al. highlight the importance of checking AI tools in medical practice and using them in several steps to keep them safe [12].

Besides these important reasons, modern technology is driving new growth in AI. Ghassemi et al. studied major challenges in machine learning for health, mostly regarding how well the data reflects different sections of the population and how the results are checked for accuracy in such populations [13]. With the help of AI, augmented reality (AR) displays an image of

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the patient's structures in real time, making it easier for the surgeon to understand the patient's anatomy during the surgery [14]. It greatly helps during surgeries that are done using minimal intervention or with imaging.

Patient trust is now an important benefit of using AI. The Blease et al. European survey reported that patients experienced greater confidence when AI was involved in their medical treatment that requires exact results [15]. Such information often leads to better understanding of the procedures, which in turn prompts patients to follow the advice given.

Although AI is not yet cost-effective at the start, it can bring down expenses as time goes by. According to the research, the use of AI can decrease extra procedures and issues, which may benefit budgets and improve results for patients [16].

It is important for Topol to point out that AI should assist surgical teams rather than take control or eliminate their personal judgment, ethics, and empathy. Full use of what AI offers relies not only on improved technology but also on careful, fair, and physical health care practitioners-friendly application.

5. CHALLENGES AND FUTURE DIRECTIONS

Even though AI has a lot of potential in surgery, there are major difficulties in using it. Some of these are model transparency, trust in the doctor-patient relationship, suitable tech, legal uncertainty, and fair access for all [1].

Many people are worried about how understandable AI algorithms are. Although deep learning systems have impressive accuracy, they usually work as black boxes as you can't see their inner workings. Unless the AI's methods are easy to see, clinicians could struggle to rely on or discuss what decisions the AI provides. Esteva and his fellow researchers showed that AI worked very well in analyzing images, still, the thinking process behind its decisions was not clear [3].

When decisions during surgery are absolutely urgent, such a lack of transparency can be very troublesome. The authors underlined that having a clear view of decision steps is necessary for surgeons to guarantee safety, accuracy, and responsibility [4].

The use of AI in systems like the da Vinci Surgical System has made people more concerned about who should be in charge, AI or humans. Although these gadgets provide more accurate and convenient results, they raise fresh questions when autonomy is involved. Ma M et al. demonstrated that autonomous robots are capable of doing soft tissue operations, demonstrating their use and need of supervision [6].

AI is important in the planning phase before surgery, as systems analyze a patient's unique information to show likely results, choose the shortest possible incision points, and anticipate any dangers. According to Lambrechts et al., deep learning models did better than expert planning when used in spinal surgeries [8]. Still, these accomplishments depend on the variety of the records used in training.

The issue of bias in AI continues to be very important. According to Morley and Floridi, using algorithms that have limited exposure to various cases can strengthen healthcare inequities [9]. Also, Char et al. explain that when AI-based choices lead people to suffer harm, a suitable approach to assigning blame is not in place [10].

From an ethical viewpoint, Topol explains that when a black-box model is applied, the reasons behind the treatment choice are not well communicated to a patient. Doctors reviewing medical test results should always make the main decisions.

There are also big issues with the nation's infrastructure. In order to put AI systems in place, high-speed computers, support of various technologies, and proper training are needed, and these can present obstacles, mainly in places with fewer resources.

They suggest that besides being technologically ready, organizations must work together and involve staff from different departments for successful completion of the strategy [13].

The authors underline that strong validation is needed in different clinical areas to confirm the tool is reliable and applies generally [14].

It is also worrying when people depend too much on technology. As AI gets used more, the chance exists that doctors might follow the algorithms' thinking on tough questions. Topol advises against using machines to replace the human aspects of care and decision making [15]. AI should not be a substitute for the care given by people, but should enhance it.

To manage these issues, experts believe that we should put multidisciplinary approaches into place. According to Kelly et al., those who should guide the process include engineers, ethicists, clinicians, and patients [16]. The process guarantees that AI tools comply with both ethical and clinical aspects from the beginning.

Having equity at the top of the list is very important. Although AI has many positive effects, it should also be affordable and available for wide use. Should changes not be made, the difference between rich and poor schools will increase. According to Yu et al., transparent processes should be used with sufficient safeguards to help with equal use of health care across different groups in society [18].

All things considered, AI will change surgery for the better only if we handle matters related to interpretation, liabilities,

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infrastructure, and fairness. It is important to build smarter systems and at the same time to build them in a responsible, collaborative, and human way [1,18].

6. AI-DRIVEN INNOVATIONS IN ROBOTIC SURGERY

Using AI in robotic surgery is one of the most important ways technology and medicine come together. Robotic technology started with surgical benefits and now includes AI for greater precision, predicting possible issues, and helping the machine carry out some procedures on its own.

The change in surgery can be clearly seen in the technology known as the da Vinci Surgical System. It makes use of AI technology to clear tremors from the hands, control the robots' movements, and view scans and images in three dimensions during minimally invasive surgeries [2]. With the help of these tools, surgeons experience fewer mistakes in the operating room, spend less time at the hospital, and improve their working conditions.

Robots now have more ability for independence because of AI. The team of Ma M et al. developed a device that can complete sutures on soft tissues without help from surgeons, suggesting that surgical actions can be handled by machines with proper supervision [3]. Because of these skills, semiautonomous approaches can be used in repetitive parts of difficult procedures.

Because of computer vision, a main component of AI, surgeons can depend on surgical robots to spot anatomical features, recognize borders between tissues, and identify the sites of the operation in real time. Because of this, the tumor is removed more accurately and chances of hurting nerves or blood vessels are lessened.

As robots become more clever, data science in surgery becomes very important. The authors explain that using continuous data from robots in procedures to update AI algorithms can help them function better with time [5]. Using this approach, adaptations can be made according to surgeons' choices and the patient's situation.

Preparing for surgeries and deciding changes during surgery have become easier with the help of deep learning. Lambrechts et al. presented ways in which AI can find the optimal spot and path for screws in spine surgery by studying CT scans and patient-specific structures [6].

Such types of AI breakthroughs are also used beyond visual processing. Combining sensors such as force sensors or haptic feedback, makes it possible for robotic systems to measure pressure and the resistance of tissue. Ghassemi et al. state that because AI can read the signs, it is able to protect tissue from harm and detect complications early [7].

Besides, NLP and sensors that detect gestures are now introduced into robotic systems to make it easier for surgeons to communicate. Hashimoto et al. described how NLP allows doctors to get patient information during surgery without touching anything, improving the procedure's safety and access to relevant data [8].

It also helps to provide AR markers that lead robotic tools as they work on real objects. The overlays help surgeons find essential parts and get better spatial awareness within the body [9]. They indicated that using AR together with up-to-date AI boosts the accuracy and reassures surgeons [10].

It is important to focus on the benefits that patients get as well. Evidence indicates that patients become more comfortable with robotic surgery when it's pointed out that artificial intelligence adds to safety and precision [11]. It was shown by Blease et al. that AI is trusted more by patients if it is referred to as something that assists, not a tool that would completely replace, human experts [11].

Still, there are some issues that have not been resolved. Unresolved liability issues are pointed out by Char et al. for cases in which semi-autonomous systems are involved in negative events [12]. Morley and Floridi go on to say that worry about explainability is still important, especially when AI affect how a surgery is done or performed [13].

There are major financial issues to deal with. It is still very costly to buy, maintain, and teach robots for use. The authors claim that AI-powered robotics might increase existing gap in healthcare if implementation strategies cannot keep them affordable [14].

Further development of robotic platforms will most likely lead to robots working together in an autonomous way. In their proposal, AI helps out with easy or detailed work while human surgeons take over the lead when it comes to most challenging or judgmental tasks [15]. This way, computers and humans carefully work together.

They suggest that the success of robotic surgery will depend on effective use of new technologies, as well as how well they adapt to how things are usually done, the available learning programs, and regulations [16]. When these methods are used, robotic surgery driven by AI can greatly improve accuracy, reliability, and care focused on patients.

7. USE OF AI IN PREOPERATIVE PLANNING AND DECISION MAKING ON SURGICAL PROCEDURES

AI is more and more important in the planning process before surgery, allowing for better and personalized decisions. By using AI, clinicians can strengthen and prepare for better results before beginning the surgery [1].

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AI systems use a lot of data, such as medical images, results from labs, and patient histories, to guess issues that may arise and recommend the best treatments for them [2]. Esteva et al. showed that deep neural networks can be very accurate in dermatology and this idea is now used in AI for preoperative surgical planning [3].

They pointed out that surgical data science has arisen by using all types of clinical data to make predictions about the outcomes of surgeries [4]. Surgeons can practice different actions on anatomical models, which boosts their mental preparation and lessens doubt during the operation.

AI tools are now included in platforms like the da Vinci system to help surgeons with deciding on the port sites, comfortable positioning, and tool movements during surgery.[5]. They reduce the disturbance to healthy issue and make the procedure easier to perform.

As according to Ma M et al., AI helps build autonomous planning systems that work on their own to plan how robots will stitch the tissue [6]. It was also found by Lambrechts et al. that deep learning models help build effective strategies for placing screws in spinal surgery, making both precision and reproducibility better [7].

Using electronic health records, AI has the ability to spot possible risks for each patient. Such characteristics are most beneficial for understanding comorbidity, designing anesthesia procedures, and guessing the likelihood of postoperative risks. Morley and Floridi pointed out that using AI with a variety of and inclusive training data can lead to fairer surgical treatments [9].

Lawyers and doctors keep addressing legal and ethical matters. Those researchers questioned what happens if AI instructions cause harm, especially when doctors follow those instructions without careful examination [10]. He underlined the importance of being able to explain decisions clearly in ethical surgical work [11].

According to He et al., AI in planning should be properly validated in real clinical settings, in addition to performing well in tests [12]. Such technologies must be useful for various hospitals and surgery teams.

Ghassemi et al. further confirmed this by highlighting that tools made from limited or biased data can have poor results when used in the real world [13].

The use of sensor fusion is now involved in preparing for surgery. Previously, force-feedback and motion sensors were not used during planning, but today they are used to predict how tissue will react when the surgeon resects or sews [14]. This makes the training routine more accurate and complete.

Another aspect is brought in using augmented reality (AR). They described AR technology enhanced by AI that helps surgeons identify the best places and plans for cutting into the body [15]. Intraoperative elements and personal anatomy are taken into account by these systems and they respond instantly.

NLP helps in planning by identifying important parts of a patient's surgical history, previous complications, and allergies. The researchers indicated that using NLP could eliminate many manual review steps while improving the accuracy of patient profiles prior to surgery [16].

Kelly and colleagues pointed out that having clinicians take part in creating AI systems improves their suitability to real medical situations and not just how they are designed on paper [17]. Blease et al. claimed that telling patients about how AI supports their surgery boosts sharing of information and makes them more open and cooperative [18].

Topol noted that AI used in preoperative planning ought to help surgeons, instead of handling tasks solely by itself [1].

To note, according to Lee et al., explainability, usability, and equitable access become important factors for AI use in planning when the resources are limited [19].

8. REAL-TIME SURGICAL DECISION SUPPORT

Artificial Intelligence is now changing the way doctors decide during surgery, as it provides support right when it is needed [1]. Such systems are different from preoperative planning tools as they can adapt to new observation findings and review surgical videos as well as the path of instruments during an operation.

Hospitals are starting to use ML to notice abnormalities in procedures and advise the surgeons on what to do. They use their access to many surgical video recordings to improve their predictions by taking in new feedback during surgery [3]. Because of this, surgeons can usually prevent bleeding, shortage of blood, or damage to nerves from happening.

The main progress in these areas is driven by computer vision. It makes it possible to study tissues in real time to spot their boundaries, find important landmarks, and know if tools are close to parts of the body [4]. According to Maier-Hein et al., these tools play a role in helping surgeons remember their position since they do not have to use only memory, making these procedures safer [5].

These types of robotics surgical systems, for example, da Vinci, have AI feedback loops that help by reading the images and monitoring the force applied by the surgeon. They detect the smallest changes in tissue resistance and surprises related to

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bleeding, showing when the doctor presses too hard with an instrument [6].

Ma M et al. showed that AI can allow a robotic tool to address changes in tissue properties as suturing takes place during the operation.

According to Lambrechts et al., the concept was advanced further by incorporating real-time imaging and predictive analytics into tools that offer the best routes for positioning instruments and cutting out parts of the tumor [8].

Morley and Floridi highlight that even as AI helps with precision, making sure explanations are still clear is very important, especially when decisions on the table are high-risk \[9]. Doctors have to check and judge AI findings to preserve their ethical and legal position.

They add that rules for approving intraoperative AI actions have not yet been developed well in cases where the AI may suggest or order actions that could be considered the surgeon's fault or due to the AI's error [10].

Besides video and images, NLP has gained importance in natural language processing. Thanks to NLP, surgeons can learn about any allergies and recent lab findings verbally, without losing their sterile conditions.

Ghassemi et al. underline that AI may help find changes related to oxygen desaturation and rapid fluctuations in blood pressure, which experts might not notice during surgery that is going longer than expected. These insights help teams deal with issues as soon as they appear.

He et al. mention that real-time systems should be both accurate and reactive no matter the varying conditions in which they operate. For something to be used and safe, it must load fast, be easy to understand, and dovetail well with the equipment already in the hospital [13].

People's understanding of real-time AI assistance is advancing. Patients are more comfortable when doctors mention using AI in monitoring their surgery as an enhancement for the surgeon rather than as a replacement [14].

They consider that it is necessary to involve and test clinicians in trust-building and functional tests of AI tools to ensure their use in an operating room [15].

Yu et al. also state that supervising AI in surgery by a team of specialists is more appropriate, as it ensures that results from AI are easy to understand and can be used consistently with fairness [16].

Topol points out again that despite AI's real-time help, the ultimate decision needs to come from the clinician. Making decisions based on empathy, awareness of surroundings, and putting patients first is the only situation where augmented decision-making works [1].

Real-time AI should be flexible and available to all surgeons, so it is not restricted to large and advanced surgical centers, note Lee et al.

9. CONCLUSION

AI plays an important role in surgery, affecting every stage from pre-op planning to what is done during the surgery and afterwards. Although surgical robots offer improved accuracy, better operations, and more personalized care, there are issues related to equality, clear information, and faith in the technology.

At this first stage, AI assists doctors with checking for diseases, classifying patients, and predicting how the treatment will impact them. Doctors use these models to go over patient records, images, and lab results to figure out each person's surgical risk and create their unique surgical plan [2]. The authors found that deep neural networks were superior to human dermatologists when it came to classifying skin lesions, which proved to be an important step in recognizing AI's uses in diagnostics [3]. Today, tools used in surgery allow surgeons to use images along with anatomical models during the planning process [4]. According to Maier-Hein et al., surgical data science connects data analysis with the simulation of operations to make the process more streamlined [5].

While planning surgical steps, these surgical robotic systems help surgeons by making their movements more secure and improving how well they use the instruments [6]. Ma M et al. also noted that robots controlled by AI can manage soft-tissue sutures without the doctor's intervention [7]. According to Lambrechts et al., deep learning models perform screw placement suggestions in spinal surgery more reliably than people [8].

Intraoperative tools give doctors advice via computer vision, tracking instruments, and feedback from sensors. They give surgeons instructions for recognizing different body parts, understanding the location of tools, and avoiding problems afterwards \[9]. They underline that it is important for the codes embedded in technology to be interpretable to defend patients' rights and keep surgeons responsible [10]. Similarly, Char et al. indicate that having AI take part in clinical decisions during surgery is still unclear under the law [11].

Topol maintains that it is important for AI to assist, but not replace, clinicians when situations involve outcomes that are permanent [12]. For this reason, being transparent and traceable about AI outcomes matters a lot. Hashimoto et al. explain

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that NLP and real-time information retrieval provide easy access to patient records during sterile procedures [13].

Getting things validated and put into use comes with numerous logistical problems. It has been noted by He et al. that doing well in controlled trials does not ensure that those findings will carry over into different healthcare settings [14]. Specialists Ghassemi et al. highlighted that monitoring and routine reviews must take place to guarantee a safe release of fintech products [15]. In their opinion, Yu et al. explain that it is important to ensure AI surgical tools are explainable and monitored by surgeons at the early design stage. [16]

Developing countries also deal with major problems related to their finances and infrastructure. Substantial costs to use these technologies mean that they are mostly used in wealthy countries and do not help close the gaps around the world [17]. It was suggested by Kelly et al. that AI should be developed with active participation from clinicians to ensure the AI was usable, safe, and relevant for the medical field [18].

What patients think is not represented enough in society. Blease et al. noticed that AI trust goes up when people understand how the system works and it is introduced as something that assist them, not something that takes over their role [19]. Topol underlines that the true role of AI in medicine is to let doctors engage in empathy, intuition, and thinking through complex moral issues since machines are not able to do the same [20].

As the researchers see it, AI will be broadly useful only if it is clear about its approach, open to change, and connects with currently available clinical resources [21]. Such issues require engineers, ethicists, surgeons, and policymakers to cooperate together.

To sum it up, AI can help raise the level of accuracy and also offer a better experience for patients undergoing surgery. It will be properly integrated when focused on ethics, well-tested, and accessible to everyone. The research community argues that AI ought to join forces with surgeons, helping to achieve higher quality in surgery while still respecting surgeons' independence and concern for patients' wellbeing [23].

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