

Losing open approach surgical skills and techniques to minimally invasive surgery in the era of artificial intelligence: A narrative review



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Abstract Despite advancements in technology, a substantial portion of the global population still resides in rural areas and low-income countries where access to these advanced technologies is limited or nonexistent, emphasizing the continued importance of open surgical approaches. The rapid integration of artificial intelligence (AI) and robotic technologies into surgical practice raises significant concerns regarding the erosion of essential open surgical skills. Integrated minimally invasive surgery (MIS) combined with AI may offer benefits such as enhanced precision and improved patient outcomes, but these should not come at the cost of the erosion of open surgical skills. This narrative review discusses the drawbacks of relying heavily on minimally invasive surgery and AI, particularly the potential degradation of traditional manual techniques that are crucial for effective surgical care. While robotic-assisted surgeries can lead to reduced recovery times and fewer complications, evidence indicates a decline in proficiency in open techniques among surgeons who predominantly utilize these systems. This skill degradation poses substantial risks, especially in situations where technology fails or is unavailable, such as in emergency settings or resource-limited environments. To address these challenges, the review discusses strategies such as hybrid training approaches that combine robotic and manual techniques, skills preservation programs aimed at maintaining traditional competencies, and modular curricula integrating both technological and conventional aspects of surgery. It also highlights the necessity for ongoing research to assess the effectiveness of these strategies, ensuring that surgeons remain proficient in both advanced technologies and fundamental manual skills. A balanced approach is vital for maintaining comprehensive surgical care in the era of AI, particularly for populations that still rely on open surgical methods.

Keywords: AI (artificial intelligence), aptitude, operative surgical, surgery

1. Introduction

The integration of artificial intelligence (AI) and advanced robotic technologies into surgical practice has significantly transformed the field, enhancing precision, reducing variability, and improving patient outcomes. Technologies such as robotic-assisted surgery, AI-driven diagnostic tools, and advanced simulation systems offer numerous benefits, including increased efficiency and reduced surgical errors (Bobade, 2024). Robotic systems like the da Vinci Surgical System provide enhanced control and precision, which can lead to fewer complications and quicker recovery times (Bobade & Asutkar, 2024). However, these technological advancements also bring concerns about the potential erosion of traditional surgical skills. As reliance on these technologies grows, there is apprehension that fundamental manual techniques may deteriorate (Abbasi & Hussain, 2024). This erosion of traditional skills poses risks, particularly in scenarios where technology is unavailable or fails, such as in emergency situations or resource-limited settings (Lanfranco et al., 2004). The shift in focus towards proficiency with robotic systems and AI-driven tools may lead to a decline in the development of essential manual techniques. Training programs increasingly emphasize technological skills, potentially at the expense of traditional hands-on practice. This narrative review aims to explore the impact of AI and robotics on surgical skills, evaluating current trends and strategies to preserve traditional techniques amidst technological innovation. By analyzing recent literature and expert opinions, this review will provide insights into the balance required between embracing technological advancements and maintaining proficiency in fundamental surgical skills.

2. Methods

A comprehensive literature review was conducted using electronic databases such as PubMed, Google Scholar, and Scopus. Search terms included "surgical skills," "artificial intelligence in surgery," "skill degradation," and "surgical training." The review focused on peer-reviewed articles published in the past decade that addressed the implications of AI on surgical



practice, particularly regarding skill degradation and changes in training methodologies. Both qualitative and quantitative studies were analyzed to provide a broad perspective on the current state of research.

3. Discussion

3.1. Impact of AI on surgical training

AI and robotic systems have significantly altered surgical training by introducing advanced simulation platforms and robotic assistance. For example, the da Vinci Surgical System, one of the most widely used robotic systems, allows for enhanced precision and control, leading to improved surgical outcomes and reduced recovery times (DiMaio et al., 2011). Studies have demonstrated that robotic-assisted surgeries can reduce intraoperative complications and postoperative pain, contributing to better overall patient care (Zechmeister et al., 2015). Despite these advantages, there is growing concern that an overreliance on these technologies may impact the development of fundamental manual skills. Training programs increasingly emphasize proficiency with AI systems and robotic devices, potentially at the expense of traditional hands-on techniques. This shift in focus may lead to a generation of surgeons who are less skilled in performing manual procedures, which could be problematic in scenarios where technology is unavailable or fails (Corcione et al., 2005). A study by Boal et al. (2024) highlighted this issue, showing that surgeons who primarily use robotic systems exhibited a decline in manual suturing skills compared to those who engaged in both robotic and traditional techniques (Boal et al., 2024). Research indicates that complex robotic surgical systems, while offering advanced capabilities, can introduce challenges such as increased risk of technical malfunctions, heightened communication needs among team members, and occasional limitations in maintaining a clear view of the surgical area. These factors can impact efficiency and require significant coordination to address potential disruptions effectively and ensure patient safety throughout procedures (Catchpole et al., 2016).

3.2. Skill degradation

The phenomenon of skill degradation in the context of AI integration is a significant concern. Research has indicated that as AI and robotic systems become more prevalent, there is a risk that surgeons may experience a decline in proficiency in manual techniques. This degradation is particularly concerning in situations where technology fails or is unavailable, such as in emergency scenarios or resource-limited settings (Guseila, 2014).

A notable example of skill degradation is highlighted in a study by Sugihara et al., which investigated the impact of prolonged absence on laparoscopic surgical skills, specifically through nephrectomy procedures, using data from a large Japanese medical database. The study concluded that extended intervals between surgeries significantly increased operative times, suggesting that skill deterioration can occur when surgeons go long periods without performing laparoscopic procedures (Yang et al., 2015). Additionally, it was generally observed that surgeons who exclusively relied on robotic systems showed reduced dexterity and manual coordination compared to their peers who maintained proficiency in both robotic and manual techniques. This underscores the importance of regular practice or refresher training to maintain surgical proficiency and minimize potential skill degradation due to inactivity. This decline in manual skills can affect patient safety and surgical outcomes, especially in complex cases where traditional techniques are necessary (Vincent et al., 2004).

The acquisition of motor skills in surgery is essential but inherently challenging due to the high standards for performance and the risks of errors, which are increasingly scrutinized by society and legal regulations. As Charles Mayo pointed out, relying solely on "experience" may result in repetitive mistakes, underscoring the need for innovative learning tools that allow surgeons to build skills without posing risks to patients (Thomas, 2006). To address this, Fitts and Posner's three-stage model of motor skill acquisition provides a structured approach that is widely accepted in surgical education. In the initial stage, the learner begins with a cognitive understanding of the task, using demonstrations and explanations to form the foundation of the skill. The associative stage follows, where the learner engages in deliberate practice, refining their technique and reducing errors through targeted feedback. Finally, the learner reaches the autonomous stage, where skills become second nature, freeing cognitive resources to focus on more complex or critical aspects of the procedure rather than on individual motor actions (Reznick & MacRae 2006). This model highlights that as motor skills become automatic, surgeons are better prepared to handle dynamic or unexpected situations in the operating room, thus improving patient outcomes and supporting the high standards of modern surgical practice. In response to concerns about skill degradation, strategies such as regular practice, simulation training, and structured feedback should be implemented to help maintain and refine these essential skills over time.

3.3. Current trends and adaptations

In response to the challenges posed by AI and robotic technologies, there has been a growing trend towards hybrid training approaches that combine technological advancements with traditional methods. These hybrid approaches aim to provide a comprehensive training experience that encompasses both advanced technologies and fundamental manual skills. One example of a hybrid training approach is the use of simulation-based training programs that incorporate both robotic systems and traditional exercises. A study by Prinz at the Medical University of Vienna assessed the effectiveness of a novel

3D-animated program, "Ophthalmic Operation Vienna," in enhancing medical students' understanding of cataract and glaucoma surgeries. The findings showed that students who used 3D animations performed significantly better in both topographical and theoretical comprehension compared to those who viewed traditional surgical videos alone. Interestingly, the 3D animations had a notably positive effect on female students, suggesting that multimedia teaching tools might support different learning preferences or needs among genders. The results support the use of 3D animation as a valuable complement to traditional surgical training materials (Prinz et al., 2005).

3.4. Expert opinions

Kneebone (2003) discusses the vital role of simulation in surgical training, emphasizing its capacity to provide safe, realistic learning environments for repeated practice with immediate feedback. This simulation-based training can bridge the gap between theoretical knowledge and practical skill development. However, the paper highlights challenges in evaluating these simulations, particularly due to the lack of longitudinal data and the rapid pace of technological advancements. The shift from focusing solely on technology to integrating simulation with clinical practice suggests that an educational framework is essential for aligning technical skills with the broader knowledge and attitudes required in real-world medical settings (Kneebone, 2003).

Kotsis and Chung (2013) argue that while the traditional "see one, do one, teach one" method in surgical training has been criticized due to concerns about patient safety, it remains valuable when integrated with modern teaching strategies. The combination of adult learning principles such as deliberate practice and mentoring, along with the use of advanced simulators (e.g., virtual reality and high-fidelity mannequins), can enhance the learning process. They emphasize that this traditional approach must evolve to ensure residents receive adequate training while maintaining patient safety and adhering to competency-based education systems (Kotsis & Chung, 2013).

3.5. Shift from open surgical approaches to minimally invasive surgery

The transition from open surgical approaches to minimally invasive surgery (MIS) represents one of the most significant advancements in modern surgical practice. Open surgery, traditionally characterized by large incisions, has been associated with longer recovery times, increased risk of complications, and greater postoperative pain.

For example, open cholecystectomy, a common procedure for gallbladder removal, typically involves a large abdominal incision, leading to extended recovery periods and higher rates of postoperative complications. In contrast, minimally invasive techniques, including laparoscopic and endoscopic surgery, have demonstrated considerable advantages. According to a meta-analysis by Antoniou (2014), laparoscopic cholecystectomy results in less postoperative pain, shorter hospital stays, and faster return to normal activities compared to open cholecystectomy.

The study by Ghezzi (2010) demonstrates that laparoscopic hysterectomy results in significantly less postoperative pain and a reduced need for rescue analgesia compared to vaginal hysterectomy. Patients who underwent laparoscopic surgery experienced lower pain scores at all postoperative time points and had shorter hospital stays. The findings highlight laparoscopic hysterectomy as a preferable option in terms of postoperative recovery, although both techniques yielded similar perioperative outcomes (Ghezzi et al., 2010).

For instance, robotic-assisted prostatectomy has shown to reduce positive surgical margins and improve functional outcomes compared to open prostatectomy (Hu et al., 2006).

In a randomized controlled trial comparing robotic-assisted laparoscopic surgery to traditional laparoscopy for endometrial cancer, robotic surgery demonstrated a significantly shorter operation time and total time in the operating room. Both groups showed similar outcomes in terms of lymph node harvest, complications, and hospital stay, making robotic surgery a faster and equally effective option for endometrial cancer surgery (Mäenpää et al., 2016).

Despite these advancements, the shift towards MIS raises concerns about the potential erosion of traditional open surgical skills (Yang et al., 2015).

3.6. Drawbacks of the shift from open surgical approaches to minimally invasive surgery

The shift from open surgery to MIS has revolutionized surgical practice by offering benefits such as reduced postoperative pain, shorter recovery times, and improved precision. However, this transition has also raised concerns about the preservation of traditional surgical skills, particularly among surgical residents and new surgeons.

3.6.1. Skill degradation in traditional techniques

One major drawback of the shift to MIS is the potential degradation of traditional open surgical skills. Research indicates that as MIS becomes more prevalent, there is a growing concern that residents and new surgeons may lose proficiency in open techniques.

The integration of AI and robotic systems in surgery presents several negative aspects. First, it may contribute to skill degradation, as reliance on technology can lead to a decline in manual dexterity and coordination, particularly if surgeons do

not regularly practice traditional techniques (Guseila, 2014; Vincent et al., 2004). Furthermore, in emergency or resource-limited settings, where technology may not be available, this degradation could result in worse outcomes due to a surgeon's reduced ability to perform necessary manual interventions (Yang et al., 2015). Additionally, the use of robotic systems can create an over-reliance on technology, leading to a diminished understanding and application of basic surgical skills, which can be detrimental in critical situations requiring immediate decision-making and quick, efficient execution (Thomas, 2006).

3.6.2. *Reduced exposure to open surgery*

Surgical training programs increasingly emphasize MIS techniques, which can lead to reduced exposure to open surgery for residents. A study reveals a significant decline in the number of open surgeries performed by general surgery residents, despite an overall increase in surgical case volume. From 1999–2000 to 2017–2018, the average number of open procedures dropped by 34.9%, with open appendectomies falling from 30.7 to 6.8 ($p < 0.01$) and open colectomies from 46.1 to 33.4 ($p < 0.02$). In contrast, laparoscopic procedures saw a dramatic rise, with laparoscopic appendectomies increasing by 362%, from 13.1 to 58.4 ($p < 0.02$). This shift suggests that while minimally invasive surgery is more prevalent, the reduced exposure to open procedures could lead to a lack of essential manual surgical skills among residents (Bingmer et al., 2020).

3.6.3. *Diminished confidence and competence*

The decline in traditional skills can affect surgeons' confidence and competence in open procedures. Graduating general surgery residents report low confidence in performing specific open vascular maneuvers, with only 70% feeling confident in vascular anastomosis and less than 25% in other key vascular procedures. This lack of confidence varies based on factors such as program size, geographic location, and future fellowship plans, highlighting the need for improved exposure and training in vascular surgery during residency (Fonseca et al., 2015). This diminished confidence can impact the ability to manage complex cases where open techniques are necessary.

3.6.4. *Challenges in emergency situations*

The erosion of open surgical skills can pose significant challenges in emergency situations where MIS or robotics is not feasible. Also, robotic-assisted surgery can disrupt team dynamics and communication, leading to potential errors and inefficiencies in the operating room. The added complexity of managing robotic systems can overwhelm surgical teams, especially when familiarity and experience with the technology are lacking, hindering optimal performance (Gillespie et al., 2021).

3.7. *Future directions*

Looking ahead, several areas of research and development are critical for addressing the challenges posed by AI and robotics in surgical practice. Conducting longitudinal studies to assess the long-term impact of AI and robotic technologies on skill retention and surgical outcomes will be crucial. These studies will help to identify trends and potential issues related to open surgical skill degradation over time (Bobade, 2024).

4. **Conclusion**

The integration of AI and robotic technologies into surgical practice represents a significant advancement with the potential to improve precision, outcomes, and efficiency. However, this technological evolution also presents challenges related to the preservation of traditional surgical skills. The risk of skill degradation due to increased reliance on technology necessitates a balanced approach that incorporates both advanced technologies and fundamental manual techniques. By adopting hybrid training methods, conducting regular skill assessments, and engaging in ongoing research, the surgical community can address these challenges and ensure that surgeons remain proficient in all aspects of their practice. Continued innovation and adaptation in training methodologies will be crucial for maintaining the effectiveness and adaptability of surgical care in the era of AI.

Ethical Considerations

Not applicable.

Conflict of Interest

The authors declare that they have no conflicts of interest.

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