REVIEW ARTICLE

Transforming surgical landscapes: obstacles in the integration of robotic surgery in Pakistan -is cost the only limiting factor?

Zeeshan Raza, Sabah Uddin Saqib, Hasnain Zafar, Saleem Islam

Abstract

The advantages of Robotic Assisted Surgery (RAS) over laparoscopic surgery encompass enhanced precision, improved ergonomics, shorter learning curves, versatility in complex procedures, and the potential for remote surgery. These benefits contribute to improved patient outcomes which have led to a paradigm shift in robotic surgery worldwide and it is now being hailed as the future of surgery. Robotic surgery was introduced in Pakistan in 2011, but widespread adoption has been limited. The future of RAS in Pakistan demands a strategic and comprehensive plan due to the substantial investment in installation and maintenance costs. Considering Pakistan's status as a low to middle-income country, a well-designed economic model compatible with the existing health system is imperative. The debate over high investments in robotic surgery amid unmet basic surgical needs underscores the complex dynamics of healthcare challenges in the country. In this review, we discuss the potential benefits of robotics over other surgical techniques, where robotic surgery stands in Pakistan and the possible hurdles and barriers limiting its use along with solutions to overcome this in the future.

Keywords: Robotic surgery, Laparoscopy, Ergonomics, Health Care, Surgical training, Artificial intelligence, surgical landscapes.

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Introduction

The last two decades have seen a paradigm shift in Robot-assisted surgery which has shown many promises and potential benefits over conventional surgical techniques in terms of safety and recovery of surgical patients in all subspecialties. The first laparoscopic-RAS systems to be commercialized were the Intuitive Surgical, Inc. (Sunnyvale, CA, USA) da Vinci and the ZEUS system by Computer Motion (Golota, CA, USA), both introduced in the late 1990s and merged in 2003. Intuitive remains the most utilized robotic surgical system worldwide having gone through four generations (Classic, S, Si, X, and Xi,). There are now nearly 6000 da Vinci systems in operation that have performed 8.5 million procedures worldwide.[1] The 20-year reign of the da Vinci surgical system is approaching an end with the recent expiration of its patent. Therefore, other companies have come to the fold of proving robotic surgical systems with the notable ones being: Versius from Cambridge Medical Robotics (CMR) Surgical, Ottawa from Johnson and Johnson, and Hugo from Medtronic (Minneapolis, Minnesota, U.S). With the progress made in robotic surgery in the last 5 years, artificial intelligence and machine learning will play a huge role where algorithms observe and learn individual surgeons' techniques, assess performance, incorporate image guidance, and anticipate surgical outcomes with the potential to individualize surgical training and aid decision making in real-time. Along with this, future progress in robotics will also focus primarily on more durable haptic systems that would provide tactile and kinaesthetic input, miniaturization and micro-robotics, better visual feedback with higher fidelity detail and magnification, and autonomous robots.[2]

A key aspect of the programme success of RAS, in addition to patient outcomes, lies in meticulous financial analysis and market trend monitoring, enabling informed decision-making. Regular maintenance, periodic upgrades, continuous team training, and strategic recruitment are vital components of programme sustainability. The economic model should accommodate the need for these interventions at various phases, ensuring that the programme remains effective and up to date.

As an LMIC, Pakistan's healthcare system faces many challenges, including insufficient infrastructure, limited resources, and accessibility issues-especially in rural areas. The country already suffers an estimated annual deficit of

Department of Surgery, in Colorectal Surgery, University Hospital Coventry and Warwickshire Trust UK, [2]Department of Surgery, Aga Khan University Hospital, Karachi, Pakistan.

Correspondence: Sabah Uddin Saqib

Email: sabahuddin.bajwa@uhcw.nhs.uk

ORCID ID. 0000-0002-1103-181X

17 million operations on account of limited healthcare facilities and financial resources.[3] Achieving the adoption of robotic surgery in Pakistan is ambitious and hinges on assembling a well-trained team, cultivating a cadre of devoted and enthusiastic surgeons, securing support from hospital administration, identifying sufficient funding sources, and implementing an effective marketing strategy. In this review article, we discuss obstacles in implementing a robotic-assisted surgery programme in Pakistan and potential solutions to overcome challenges.

Benefits of Robotic Surgery over other surgical techniques

Robotic surgery offers several advantages over other conventional surgical techniques making it an attractive choice for many surgeons and patients. (Table 1) One key benefit lies in the enhanced precision and dexterity provided by robotic systems. The robotic arms are designed to mimic the natural movements of the human hand, granting surgeons a level of control and accuracy that surpasses traditional laparoscopic instruments. This precision is particularly crucial in delicate and intricate procedures where minute movements can have a significant impact on the outcome. Additionally, the advanced 3D visualization capabilities of robotic surgery provide surgeons with a detailed, high-definition view of the surgical field, improving their spatial awareness and depth perception.[4]

Improved ergonomics is another noteworthy advantage of robotic surgery. Furthermore, the ergonomic design of robotic surgery consoles contributes to reduced physical fatigue for surgeons during extended procedures, promoting better endurance and focus. This reduces the physical strain associated with traditional laparoscopic procedures, which often involve standing for extended periods.[5]

The steady camera control system in robotic surgery further enhances the surgeon's experience by providing a clear and stable view of the surgical site, minimizing the risk of visual disturbances. The reduced hand tremors afforded by robotic technology contribute to steady and controlled movements, enhancing the surgeon's ability to perform tasks with a high degree of precision. The shorter learning curve associated with robotic systems, thanks to their intuitive interface and similarity to natural hand movements, facilitates the adoption of this technology by surgeons, potentially expanding its accessibility across various medical specialties.[6,7]

The versatility of robotic surgery in complex procedures is a notable advantage, as the robotic arms can navigate challenging anatomical structures with greater ease than traditional laparoscopic instruments. This capability is particularly valuable in surgeries requiring intricate maneuvers or access to hard-to-reach areas.[8,9] The ability to control multiple robotic instruments simultaneously improves efficiency, allowing for more seamless coordination of tasks during surgery. Additionally, the customisable settings of robotic systems enable surgeons to tailor the equipment to their preferences and the specific requirements of the surgery, enhancing adaptability across different procedures.[10]

The minimally invasive nature of robotic surgery, characterized by smaller incisions, leads to shorter recovery times, reduced postoperative pain for patients, minimized scarring, and increased overall satisfaction with the surgical experience. Reduced blood loss is another advantage, particularly important in surgeries where minimizing blood loss is critical to patient safety.[11] Real-time feedback provided by robotic systems, including metrics such as instrument force and tissue resistance, enables surgeons to make immediate adjustments during surgery, enhancing their responsiveness to dynamic surgical situations.

Remote surgery capability further extends the reach of skilled surgeons, enabling them to perform procedures on patients located in distant or challenging environments. Telementoring and training capabilities in robotic surgery facilitate knowledge transfer among surgeons, allowing experienced practitioners to guide and mentor less experienced ones remotely.[12]

Table-1: shows a comparison among open, laparoscopic, and robotic surgery based on modern technological features.

Feature	Open surgery	Laparoscopic surgery	Robotic surgery
3 D vision	X	X	✓
7-degree freedom of movement	X	X	✓
Use Of AI	X	Minimal	Most Promising
Telemetry surgery	X	X	✓
Better ergonomics	X	X	✓
Simulated training	Wet models usually	Less available	More structured
Learning curve	Variable	Long	Short

Status of robotic surgery in Pakistan

Robotic-assisted surgery in Pakistan was first performed by using the Davinci surgical system in 2011 at the Sindh Government Qatar Hospital Karachi. The second robotic platform, which was more sophisticated and a

generation higher (DV-Si) than the previous one, was installed in Civil Hospital Karachi in 2013[13] In a study by Ghazanfar et al,[14] looking at 119 patients operated using the robotic platform from 2011 to 2017 in these hospitals, it was found to be a feasible and viable option with the major hindrance being the cost involved in setting up the system and recurring costs in terms of disposables. The procedures chosen in some of the programmes do not offer substantial patient benefits compared to conventional laparoscopic surgery resulting in criticism of poor utilization of resources.

Recently, another robotic system, the Versius robotic surgical system from CMR, a UK-based robotic system, was installed at SIUT Karachi, transitioning from the da Vinci to the Versius robotic systems. The SIUT robotics programme began in 2017 utilizing the da Vinci Si robotic system, transitioning to the Versius system in 2021. Similarly, the National Medical Centre in Karachi has used the CMR robot for several cases, but then due to cost-related issues halted them.

The strengths, weaknesses, opportunities, and threats (SWOT analysis) of robot-assisted surgery in Pakistan were published by Mujahid et al.[15] Among the strengths identified are the huge number of patients in Pakistan, shorter hospital stays, and the incorporation of robotics into the surgeon's arsenal which will provide increased precision and comfort for future robotic surgeons while the main weaknesses identified were the Robotic systems' high initial and on-going costs along with absence of suitable training facilities and low research productivity in Pakistan. Furthermore, medical tourism, standardization, and multi-disciplinary technology all create opportunities for advancement. However, there is a need to carefully manage threats such as training exposure, cost-effectiveness, and infection risks.

Hurdles in expanding robotic surgery programme in Pakistan:

Pakistan's healthcare delivery system consists of public and private sectors which work in isolation. Significant differences exist in stakeholders working in two entirely different setups. Where private hospitals may deter innovation and oppose robotic surgery because of expenses that mostly their patient’s bear, still few major public sector hospitals think that robotic surgery is the priority for their hospitals.

Regardless of this division, unfortunately, many experts in the country think that robotic surgery is for rich surgeons to serve well-off patients only. Many may not be aware of the advantages that robotic surgery can bring. A huge knowledge gap exists among qualified professionals regarding the potential benefits of robotic surgery and there could be a belief that RAS is for the surgeon's comfort only. On top of that, earlier adoption of technology was complicated by using the robot for procedures with no clear benefits and not following company protocols leading to the withdrawal of technical support by DaVinci.

Historically, this dilemma and refute to technology and innovation in Pakistan is not new. The country witnessed delayed and slow uptake of laparoscopic surgery ever since it came into existence. Most of the factors narrated while declining laparoscopic surgery are being witnessed today while rejecting robotic surgery. Yes, cost is the major issue, but it goes down with time as the technology becomes more available and more makers of robotic systems come into commercial markets. Also, many cost-cutting techniques have been highlighted in literature to reduce cost. Other than lack of willingness and cost, the biggest hurdle in implementing robotic surgery is corruption. An apparent lack of transparency in buying and maintaining robotic systems in public hospitals has been recently observed. When all these factors are combined many surgeons prefer to stick with their day-to-day jobs and deny technology and modern innovations. Unfortunately, robotic surgery which is seen as the future of surgery has not been adopted well in Pakistan so far because of these hurdles which are not new yet concerning.

Solutions for Overcoming Barriers to Robotic Surgery Adoption in Pakistan's Healthcare Landscape

Robot-assisted minimally invasive surgery has been hailed as the future of surgery. Hundreds of robotic systems are being used worldwide with most of them in place at tertiary care centres with a rapid expansion noted in its uptake in the last five years. With growing evidence of patient benefit in complex procedures and with adequate training, there is growing interest in novice and established surgeons alike towards learning the niche skill of robotic surgery. Published literature from robotic surgeons all over the world suggests that robotic surgery is safe and can enable surgeons to perform minimally invasive procedures, which are otherwise extremely challenging with a standard laparoscopic approach. However, in a third-world country, a few challenges need to be overcome to change the surgical landscape towards adopting robotic surgery (Table 2)

One of the main limiting factors in implementing a large-scale robotic surgery programme is the huge cost associated with it.[16] All Robotic surgical systems currently in use in the Western world are expensive, and the cost of procedures might be a significant concern for both

Table- 2: Shows a list of barriers to implementing robotic surgery programs in Pakistan and solutions to overcome barriers in implementing safe, cost-effective, and rationale-based robotic surgery programs.

COST	**Major limiting factor in widespread adoption of robotic surgery**
•	Cost-sharing subsidies or financial models for installation, maintenance and training
•	Government sponsored subsidiaries or independent private setups as stakeholders
•	Public and private sector partnerships can be utilized
AWARENESS	**Education of robotic surgery in public health care professionals**
•	Awareness campaigns, workshops and educational programs on large scale to create willingness and acceptance
•	Engagement through conferences and training sessions in different surgical subspecialties
	Surgeons in leadership and surgical societies can create awareness through targeted seminars and symposium
INFRASTRUCTURE	**Robust infrastructure is required for establishment of robotic surgery programs**
•	Acquisition of robotic systems and didactic training of surgeons, nurses and support staff
•	Establishment if dedicated robotic centres in tertiary care hospitals
•	Collaboration with international partners for knowledge transfer and training programs
STRUCTURED TRAINING	**Establishment of training programs and curriculums across surgical specialties**
•	Designing of robust surgical curriculum and standards in robotic surgery training
•	Collaboration with international training centres
•	Arrangement for fellowship opportunities for robotic surgery training for CPSP fellows
CULTURAL BELEIFS	**Cultural influence and beliefs can hamper uptake of innovative technologies**
•	Engagement with communities through culturally sensitive communication strategies
•	Highlighting success stories
•	Use of media to change societal perceptions
REGULTAROY BODY	**Regulatory framework to oversee training and credentialing**
•	Collaboration with regulatory bodies to establish local guidelines for the safe implementation of robotic surgery
•	Establishment of national robotic data base
•	Regular audits of performances

healthcare providers and patients in a third-world country.[17] Therefore, options for cost-sharing, subsidies, or financing models need to be explored to make robotic surgeries more financially viable. The long-term cost-effectiveness and potential reductions in hospital stays and recovery periods which come as an added benefit of robotic surgery need to be highlighted while obtaining the funding and support. This can be obtained through government-sponsored subsidiaries and independent private setups. Private sectors may be more suitable due to affordability issues, but only a limited number of people can benefit there. Therefore, sponsorship from the government will help alleviate the cost from the patients' perspective in both the short and long term.

The introduction of robotics in public sector hospitals has previously been demonstrated to be quite a challenging task considering Pakistan's current economic state. This was initially seen in a facility where the first robot was installed initial robotic system utilized did not achieve the desired output due to the unavailability of funds to sustain the robotic platform. Hence, the major hurdle and biggest concern in setting up a robotic programme in low-income countries like Pakistan is the burden of the cost associated with installation, annual maintenance, and replacement of discarded instruments. Also, expenses on robotic surgery training for surgeons will be incurred besides all these. The cost savings usually come in the form of reduced hospital stay therefore making more beds available for further surgeries and for the patients who return to work earlier. The financial impact of a robotic system on a hospital has been looked into by various studies which usually assume that justification can be made and return on investment increases as the

number of cases increases and hospital days are saved.[18]

Awareness and education form an integral part of the introduction of innovation in any field. There is a general lack of awareness and understanding about robotic surgery among the public and even healthcare professionals. In this regard, awareness campaigns, workshops, and educational programmes need to be conducted on a large scale to disseminate information about the benefits and safety of robotic surgery. All medical professionals need to be engaged through conferences and training sessions in different subspecialties wanting to adopt robotic surgery. Surgeons in leadership roles can be asked to participate and contribute to this regard. Equally, surgical societies can create awareness through targeted seminars and symposiums.

As most Infrastructures in the country are lacking and inadequate from a robotic surgery perspective, this is a major hurdle toward establishment and general uptake of robotic surgery. Along with this, a shortage of trained personnel for operating and maintaining robotic systems is required which is also deficient. Therefore, a dedicated investment is required in building infrastructure for robotic surgery, including the acquisition of robotic systems and the training of surgeons, nurses, and support staff. Also, collaboration with international partners for knowledge transfer and training programmes needs to be conducted to facilitate this.

Another key issue is setting priorities for Pakistani healthcare, where the predominant form of payment remains 'out of pocket' therefore the cost is fully borne by the patient, as opposed to any form of third-party payers (health insurance). If there is a large deficit of needed surgical procedures in the country, the question of how to best provide that (open or traditional laparoscopy) must be addressed first. In that scenario, the role of RAS must be carefully defined and implemented. Outcomes such as hospital length of stay may not be as critical in Pakistan, therefore performance indicators will need to be thoughtfully considered.

Training forms the backbone of robotic surgery. Currently, robotic surgery is being utilized in all the specialties of surgery with major stakeholders being urology, general surgery, cardiothoracic surgery, neurosurgery, and gynaecological surgery. Each specialty has gone through the adoption of various training programmes and protocols for each procedure. An intensive audit of practices has led to the training of doctors which has subsequently built the platform for future generations of surgeons to be able to replicate the training process and improve on it. This has led to the designing of robust surgical curriculums in robotic surgery for training novice surgeons. More experienced surgeons have gone on to take the role of proctorship to guide fellow surgeons. In this regard, a pathway can be made in conjunction with the CPSP for collaboration with such training centres outside the country where interested surgeons can get trained and come back to Pakistan to help establish robotic surgery at the grassroots level.

Training standards need to be defined for the easy and safe adoption of robotic surgery. In this respect, a step-up approach through increasing levels of surgical competency in robotic surgery can be followed to standardise the approach to training in robotic surgery. This will also provide reassurances to patients and the public that their surgeon has gone through structured training before taking on complex procedures. Currently, many training pathways in RAS have been led by the robotic industry and these can be used as a useful stepping stone. However, robust training pathways need to be put in place that are aligned with the principles and standards of international regulatory bodies. Also, curriculum designing for training in robotic surgery needs to take place in the centres where the robotic surgical systems are currently being utilized.

When using robotic technology for simple procedures like robotic cholecystectomy, there is considerable cost involved but it also provides a tremendous opportunity for the surgeons to train and acquire advanced skills. This can be used to build up competency for more advanced procedures through involvement in simulation, dry lab, wet lab, and didactic training.

Considering these complexities, the decision to use robotic surgery in developing countries should be guided by a careful and strategic approach. This approach should consider the following important points:

Prioritization of healthcare needs: Ensuring that the introduction of robotic surgery does not distract from fundamental healthcare priorities, such as primary care, and access to essential medications. Certainly, when considering the use of robotic surgery in a developing country, it is prudent to prioritize procedures where benefits are well-established, such as:

a) Prostate Surgery (Prostatectomy): Robotic-assisted laparoscopic prostatectomy is a widely recognized application of robotic surgery.

b) Hysterectomy: Robotic-assisted hysterectomy is often preferred for gynaecological conditions. The minimally invasive approach of robotic surgery can lead to quicker

recovery and less postoperative pain.

c) Colorectal Surgery: Robotic surgery can be beneficial in performing procedures like colectomies and pelvic exenterations, where precision and access are critical.[19]

d) Cardiac Surgery: In certain cardiac procedures, such as mitral valve repair or coronary artery bypass, robotic surgery can provide access to hard-to-reach areas with smaller incisions, potentially resulting in shorter recovery times and less scarring.

Addressing Cultural beliefs: Cultural beliefs and preferences also have an influence on the perception of technology, including robotic surgery. In the current environment, where there is a lack of basic healthcare opportunities for the wider public, backlash can occur for investment in a high-cost purchase of the robotic system. Therefore, engagement with communities through culturally sensitive communication strategies is equally important. Where appropriate, success stories, testimonials, and positive outcomes from patients who have undergone robotic surgeries need to be highlighted through the wider use of media.

Establishment of regulatory bodies: Regulatory and Policy Frameworks need to be given utmost importance in ascertaining a robotic surgery framework in the country. At present, clear regulations or policies are absent supporting the integration of robotic surgery into the healthcare system. This can be improved through collaboration with regulatory bodies to establish guidelines and standards for the safe and ethical implementation of robotic surgery. Advocation of policies is required to facilitate the adoption of advanced medical technologies. A national robotic database can be set up in this regard with oversight for clinical governance and audits of each centre undertaking robotic surgery.

Research based on local experience of RAS: Research in Robotic surgery has helped in its advancement with the use of clinical trials and reporting of patient outcomes to help demonstrate the superiority of robotic surgery over conventional surgery. Though there has been incorporation of robotic surgical systems in Pakistan for the last decade, there has been limited demonstration of their efficacy and superiority compared to traditional methods. Hence, encouragement and support of research studies and clinical trials is required that assess the outcomes, safety, and cost-effectiveness of robotic surgery in the Pakistani context. Similarly, findings need to be disseminated to build confidence in robotic surgical technology.

Conclusion

Overall, the review highlights the potential benefits and obstacles facing in implementing robot-assisted surgery in Pakistan. The entire potential of robotic surgery cannot be attained without sufficient funding for training facilities, incentives for increased research output, and supplies. By addressing these barriers, surgeons in Pakistan can work towards making robotic surgery a more common and accepted narrative in the country, improving healthcare outcomes, and providing patients with access to advanced medical technologies.

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Abbreviations

RAS - Robot-Assisted Surgery
CMR - Cambridge Medical Robotics (CMR)
SIUT - Sindh Institute of Urology and Transplantation

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