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Review of Robotic-Assisted Surgical Procedures Available in Poland

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Abstract

Introduction and purpose:

Surgical robots are gaining increasing acceptance and utilization in the medical world. This trend is also notable in Poland, where both the prevalence and application of surgical robots have notably risen, establishing them as integral components of patient care. Our study aims to evaluate the current literature on robotic-assisted surgery available in Poland using the PubMed database. We aim to clarify the advantages of this approach over traditional methods and other minimally invasive techniques.

State of knowledge:

In Poland, we have three registered and widely available surgical robotic-assisted procedures intended for the treatment of prostate cancer, colorectal cancer, and endometrial cancer. Robotic surgery represents a significant advancement in the surgical treatment of cancers for both patients and surgeons. By enhancing precision and providing a more comfortable and efficient working environment, robotic surgical systems improve patient outcomes and offer substantial advantages to surgical teams.

Summary:

The major benefits of robotic surgery are short-term outcomes including reduced blood loss, shorter hospital stays, and fewer postoperative complications. When it comes to long-term outcomes differences are not such significant. What needs to be clarified is the potential advantages over conventional laparoscopic techniques in future studies to define the role of robotic surgery in different cancer treatment algorithms.

Keywords: Robotic surgery, radical prostatectomy, colorectal cancer, endometrial cancer, minimally invasive surgery

Introduction:

Modern technologies and minimally invasive surgeries allow for to reduction of the limitations associated with traditional open surgery or conventional laparoscopy, which can be beneficial to patients [1]. The past twenty years have seen critical enhancements in surgical methodologies, leading to better patient outcomes and equipping surgeons with sophisticated instruments such as surgical robots. The rapid development of technologies and the feasibility of adaptation to existing laparoscopic procedures have established robotic-assisted surgery as a leading practice in global surgical care.

With the emergence of surgical robots, their capabilities and scope of applications continue to expand substantially. Currently, surgical robots are utilized in over 200 different types of procedures. The acceleration of their adoption is influenced by demographic shifts like an aging population, the prevalence of chronic conditions, robust investment in research and technological advancements that facilitate broader use of robotics in treatment, and improved ergonomics for medical personnel [2].

Surgical robots have thus become essential tools in addressing new healthcare challenges. As with numerous other medical breakthroughs, robotic surgery has become an integral part of progress in healthcare. This study aimed to review robotic-assisted surgery widely performed in Poland. To present and evaluate its value over classical laparotomy and other minimally invasive techniques.

What is robotic-assisted surgery?

A surgical robot can be defined as a powered device with artificial sensing that can be programmed or externally controlled by a single surgeon to position and manipulate instruments

to undertake surgical tasks. Robotic-assisted surgery is a type of minimally invasive surgery and the goal is to assist rather than replace the surgeon, who always retains control over the robot. Such systems are categorized into passive, semi-active, and master-slave telemanipulators [3].

The surgeon sits at the control panel in the operating theater and remotely controls robotic arms that position and operate the camera and tools inserted into the patient through ports. The key surgical benefits of robotic technology are to tirelessly make precise repetitive movements to move, locate and hold tools and to provide tremor stabilization.

An advanced camera lens system allows three-dimensional vision and 10–15 × magnification to be transmitted to the master console. A robotic system has been built into the instruments called 'wrists' that allows one to perform six degrees of movement, which more closely approximates the range of movements possible by the human hand, rather than the more limited four degrees of freedom possible with standard laparoscopic instruments.

Studies suggest that surgeons tend to master the robotic minimally invasive technique more swiftly than conventional laparoscopy. A potentially relatively shallower learning curve can contribute to the widespread adoption and utilization of robotic platforms [4,5].

The collective benefits of these sophisticated robotic telemanipulators - increased agility in manipulating laparoscopic instruments and ergonomic design - result in tangible enhancements for the operating professional.

Range of available state-funded robotic-assisted surgical treatments

In Poland, three surgical treatments utilizing robotic systems are registered and sponsored by the National Health Fund. The beginning of robotic surgery in Poland dates back to 2009 with the first purchase of the da Vinci system by a hospital in Wrocław. Over the following years, Polish robotic surgery remained stagnant, without support in the form of reimbursement, making these procedures economically challenging for hospitals and scarcely available to patients. As a result, the private sector has largely overshadowed the public in robotic-assisted surgeries, particularly in the area of robotic radical prostatectomies.

However, the landscape has shifted dramatically over the past two years, catalyzed by modifications in the reimbursement policies. In April 2022, dedicated pricing was introduced by the National Health Insurance for prostate cancer procedures performed with robotic assistance[6]. The scope of coverage widened in August 2023, with the addition of two new remuneration categories for endometrial and colorectal cancer surgeries performed robotically[7]. These advancements have considerably broadened patient access to robotic-assisted surgeries, with 43 hospitals providing these services by January 2024. The frequency of such procedures doubled in 2023 compared to the previous year [8].

However, the widespread implementation is tempered by its substantial costs to purchase and the continued cost of equipment and maintenance of the platform [9]. Also, to upgrade the education process of surgeons because comprehensive robotic training is offered by just several international specialized centers, and none of them is located in Poland.

Prostate cancer

Prostate cancer stands as the most commonly identified malignancy in males, recording 17,832 new cases and ranking as the second leading cause of oncological mortality among men, with 5,458 fatalities reported in 2021 in Poland. Systematic reviews of autopsy studies have indicated a PCa prevalence of 5% in males under 30 years, with an increase of 1.7 times per decade, culminating in a prevalence of 59% in those over 79 years [10]. Prostate cancer is common in older men (median age 68) and diagnoses in men > 65 will result in a 70% increase in annual diagnosis rate by 2030 in Europe [11].

The optimal treatment option for many patients with localized prostate cancer is radical prostatectomy. During this operation, the surgeon eradicates the entire prostate gland and seminal vesicles, followed by vesico-urethral anastomosis. In some cases, nearby lymph nodes are removed as well. Surgical approaches have expanded from perineal and retropubic open approaches to laparoscopic and robotic-assisted techniques, enhancing the likelihood of preserving the function of pelvic organs.

The story of robotic radical prostatectomy began twenty years ago when the first operation was performed, starting a new era of minimally invasive surgery in urology. Robotic surgery is the most advanced form of minimally invasive surgery, nevertheless, as with any surgical

procedure, some complications may occur, which can be divided into short- and long-term complications.

Clinical criteria for eligibility for the provision for robotic radical prostatectomy:

1. An ICD-10 diagnosis: C61 (malignant neoplasm of the prostate)
2. In terms of disease advancement:
   a) Gleason scale: 6–10 (ISUP 1–5),
   b) Disease limited to the prostate at stage cT1-2 N0 M0,
   c) Locally advanced disease cT3a-b N0-1 M0,
   d) Absence of distant metastases M0, confirmed based on negative bone scintigraphy or whole-body magnetic resonance imaging;
3. International Index of Erectile Function (IIEF) scale >21 for erection [12]

Robotic-assisted surgery offers certain short-term benefits over open and laparoscopic radical prostatectomy. These include a reduction in bladder neck contracture, the incidence of anastomotic leaks, and occurrences of ileus. There is also a decreased risk of infection and injuries to the rectum, ureter, and bowel. Findings from Novara et al. [13] meta-analyses which selected 110 records reporting oncologic outcomes after robot-assisted radical prostatectomy and evaluated following complication rates, indicate that patients undergoing robotic-assisted surgery experience less blood loss and require fewer blood transfusions compared to those undergoing open radical prostatectomy. Whereas only the transfusion rate was lower compared to conventional laparoscopy. All the other analyzed parameters were similar, and statistically insignificant, regardless of the surgical approach.

Predictive models from the same meta-analysis show that the rates of events as per the Clavien-Dindo classification are more favorable in robotic procedures, suggesting fewer surgical complications in radical prostatectomies performed with the assistance of the robotic system [13–15].

Regarding long-term side effects commonly associated with postoperative recovery, such as urinary incontinence and erectile dysfunction, existing data do not show significant evidence of a difference between the surgical approaches. Urinary incontinence involves uncontrollable, involuntary leaking of urine, which may improve over time, even up to a year after surgery. A prospective, controlled, nonrandomized trial [16] across 14 centers compared patient outcomes

between robotic-assisted and open radical prostatectomy. The findings revealed that, after one year, 21.3% of those who underwent the robotic surgery experienced incontinence, similar to the 20.2% observed following open radical prostatectomy.

Erectile dysfunction is defined as the inability to achieve and maintain a spontaneous erection suitable for sexual intercourse. Like urinary incontinence, full recovery can take up to 12–18 months following surgery and may not be complete. Nerve-sparing prostatectomy lessens the chance of impotence but doesn't guarantee that it won't happen. During prospective controlled non-RCT by et al. [16] erectile dysfunction was reported in 1200 men (70.4%) 12 months following robotic-assisted radical prostatectomy and in 531 men (74.7%) following open radical prostatectomy. The unadjusted odds ratio was 0,81.

There also doesn’t appear to be much difference between robotic and open prostatectomy when it comes to long-term outcomes. Cumulative studies by Ra et al. [17] compared robotic to open surgery and robotic to laparoscopic surgery showed similar rates of positive surgical margins and biochemical recurrence-free survival, irrespective of the surgical technique used. The Quality-Adjusted Life Year (QALY) scores for different types of radical prostatectomy are as follows: Robotic-assisted radical prostatectomy has a QALY of 7.93, laparoscopic radical prostatectomy has a QALY of 7.69, and open radical prostatectomy has a QALY of 7.81. These findings suggest that robotic-assisted radical prostatectomy marginally surpasses both laparoscopic and open radical prostatectomy in quality-of-life metrics [18].

Colorectal cancer

Colorectal cancer stands as a pivotal challenge in cancer care, ranking among the leading causes of cancer-related mortality worldwide, with its prevalence steadily increasing. It is the third most frequently diagnosed cancer in both genders, recording 10,009 new cases in men and 7,998 in women. Additionally, it stands as the second most common cause of cancer-related deaths among men, with 6,570 deaths, and ranks third among women with 5,022 deaths in Poland in 2021[19]. The majority of colorectal cancer cases occur in individuals aged 60 to 80 years.

The primary treatment method for colorectal cancer is the resection of the colon segment with the tumor along with lymphadenectomy. Minimally invasive surgery has now become the

standard of care for benign and malignant colorectal diseases in most of the Western world [20]. The extent of the surgery varies depending on the tumor's position. In the case of rectal cancer, radiotherapy is applied preoperatively, and adjuvant chemotherapy is used to treat cancer of the rectum and colon.

Clinical criteria for eligibility for surgical treatment of colorectal cancer using a robotic system:

1. An ICD-10 diagnosis: C18 (malignant neoplasm of the colon), C19 (malignant neoplasm of the rectosigmoid junction), or C20 (malignant neoplasm of the rectum);
2. A positive evaluation by a multidisciplinary oncology council;
3. A clinical stage from I to IVA according to the 8th edition of the UICC (Union for International Cancer Control) and AJCC (American Joint Committee on Cancer) staging system;
4. No metastasis to organs outside the abdominal cavity area;
5. A single liver metastasis (confirmed by an MRI of the liver) does not constitute a contraindication for robotic-assisted surgery [7].

Recent meta-analyses have compared the efficacy of robotic surgery with laparoscopic techniques and open surgery (laparotomy). Prete et al. [21] indicated that the primary advantages of using robotic systems over traditional laparoscopy include fewer surgical conversions and enhanced functional outcomes. In their meta-analysis, seven out of nine studies found significantly reduced conversion rates to open surgery with robotic methods. However, the other two studies observed higher conversion rates with robotics, though these findings were not statistically significant. A few non-randomized studies have suggested that robotic surgery may offer better preservation of the bladder and sexual function [22]. Nevertheless, examining oncological results, studies that compare robotic and laparoscopic colorectal surgeries show comparable outcomes, with a definitive lack of evidence supporting the superiority of robotic surgery in this domain.

Furthermore, Cho et al.[23] reported comparable short- and long-term outcomes between laparoscopic and robotic resections for rectal cancer in their study and found no statistically significant difference in the 5-year overall and disease-free survival rates. Studies are inconsistent with the benefits of robot-assisted surgery in colorectal cancer. A review from 2023 [24] on robotic colorectal surgery indicates that variations in surgical outcomes could be associated with the location of the lesion. The findings suggest that while robotic surgery yields

comparable results for right hemicolectomy, it demonstrates superior outcomes for anterior resections, including reduced blood loss and lower rates of surgical conversion.

Endometrial Cancer

Endometrial cancer is the most prevalent malignancy of the female reproductive system, with its incidence on the rise, especially in developed nations [25,26]. In 2021, Poland reported 8,184 new cases and 3,008 deaths related to this cancer [19]. Endometrial cancer affects mainly post-menopausal women, with the average age at diagnosis being 60 years. A comprehensive analysis in 2016, reviewing epidemiological data from 1971 to 2014, showed that the death rate from endometrial cancer has been rising annually by an average of 1.9% [27].

Surgery is an essential step in the management of the disease. The necessity for postoperative adjuvant therapy to reduce the risk of recurrence is determined by pathological evaluation of the surgical samples. Minimally invasive surgery for early-stage endometrial cancer is favored over traditional methods because of its less invasive approach. The established treatment for early-stage endometrial cancer includes total abdominal hysterectomy and bilateral salpingo-oophorectomy, with or without pelvic lymphadenectomy and sampling of aortic lymph nodes.

Clinical criteria for eligibility for surgical treatment of endometrial cancer with robotic assist:

1. An ICD-10 diagnosis: C54 (malignant neoplasm of the corpus uteri) or C55 (malignant neoplasm of an unspecified part of the uterus),
2. Stage of advancement is determined based on imaging and clinical examination as stage I or II according to the International Federation of Gynecology and Obstetrics (FIGO) classification;
3. Tumor grade of differentiation G1, G2, G3, Gx [7].

Numerous studies have indicated that robot-assisted surgery for endometrial cancer yields similar long-term survival rates but with significantly fewer postoperative complications, lower rates of conversion to open surgery, and reduced intraoperative blood loss compared to traditional laparoscopic surgery [28,29]. Additionally, in patients undergoing robot-assisted procedures, techniques such as para-aortic lymph node dissection or sentinel lymph node sampling, which are vital for accurate staging, were conducted more frequently than in standard laparoscopy, possibly due to the advanced fluorescence imaging technology available in robotic systems like Firefly [30]. Importantly, these advantages did not compromise the thoroughness of

surgical staging, as evidenced by similar numbers of lymph nodes retrieved in robotic-assisted laparoscopy and conventional laparoscopy. These improvements substantially benefit postoperative patient well-being and potentially hasten recovery and return to normal activities [31,32].

Conclusion

The review indicates that robotic surgery represents a significant advancement in the surgical treatment of cancers. The major benefits of robotic surgery do not appear to be the oncologic and long-term outcomes but, the short-term surgical and clinical results. These advantages include reduced blood loss, shorter hospital stays, and fewer postoperative complications such as ileus and infections [29]. The outcomes from robotic surgery are superior to those of traditional open surgery and are at least equivalent to, if not slightly better than, those of laparoscopic surgery depending on the procedure. Another benefit of robotic surgery is the significant enhancements it offers surgeons, including better ergonomics and increased comfort, which may decrease the risk of occupational injuries and extend their professional careers.

It is increasingly evident that robotic surgical systems improve patient outcomes and can offer substantial advantages to the surgical workforce. What needs to be clarified is the potential advantages over conventional laparoscopic techniques. There is a very limited number of studies so future high-quality multicenter RCTs with long-term follow-up are needed to define the exact role of robotic surgery in cancer treatment algorithms.

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