



Quality over quantity—current challenges of robotic surgery in Poland

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Abstract

Since its introduction in 2010, a dynamic growth of robotic-assisted surgery (RAS) has been observed in Poland. The number of healthcare institutions implementing RAS has tripled in the last 36 months, with 80 surgical robots currently utilized on a national scale. While urological procedures dominate RAS utilization (73%), adoption in gynecology (12.2%) and gastrointestinal surgery (8.5%) is rising, driven by recent National Health Fund reimbursement policies. However, significant fragmentation and alarmingly low numbers of individual RAS procedures were identified: 47.7% of surgeons perform less than 40 cases annually. Parallel to expanding the robotic surgery reimbursement program, several standardized actions are warranted to further facilitate and optimize modern surgical practices in Poland. Regional disparities in access and underutilization of robotic systems, followed by a lack of a centralized and standardized registry to evaluate surgical and oncological outcomes, represent the main challenges to integrating robotic surgery nationally. Addressing these, followed by implementing structured training and uniform evaluation frameworks for clinical and oncological outcomes, are critical to maximizing the potential of surgical robotic systems in Poland.

Keywords Robotic surgery · National registry · Centralized training · Regional disparities

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Introduction

The history of robotic surgery in Poland began at the end of 2010 in the city of Wrocław, over a century after the Polish School of Surgery was created by Prof. Jan Mikulicz-Radecki [1]. Prof. Wojciech Witkiewicz, along with internationally recognized experts in the field of surgery (prof. Giuseppe Spinoglio), urology (prof. Alex Motrie) and gynecology (prof. Jan Persson) played a pivotal role in building a momentum, which over the years allowed for expanding access and utilization of robotic-assisted surgery (RAS) with over 60 robotic systems in Poland today. In 2023, 10,110 robotic surgeries were performed, indicating an over two-fold increase when compared with 4,844 cases performed in 2022 [2]. It is imperative to underscore that a broad and immediate increase in robotic surgery requires continuous monitoring of the system adoption. While the utilization of RAS is associated with a decrease in traditional laparoscopic minimally invasive surgery (MIS), enthusiasm for new technology must not outshine the evidence needed to use it in the most effective clinical setting. [3]

Integrating robotic surgery and artificial intelligence (AI) into clinical practice represents a transformative shift in healthcare, offering improved precision, efficiency, and, most importantly—patient outcomes [4]. A recent systematic review and meta-analysis (COMPARE study) evaluated 30-day outcomes of RAS versus laparoscopic/

thoracoscopic (lap/VATS) or open surgery across seven oncological procedures within four surgical specialties [5]. Assessment of 34 randomized controlled trials (RCTs), 74 prospective and 122 database studies showed clinical advantages of RAS, including a lower risk of blood transfusions, length of hospital stay, 30 day complications, readmissions, and mortality when compared with lap/VATS and open surgery. While the evidence supporting the utilization of robotic surgery becomes habitual, uncertainty and personal biases can lead to innovation without rigorous evaluation, potentially decreasing patient safety [6].

Therefore, the objective of the current review was to define the current challenges of RAS in Poland with an indication of possible systemic solutions to structurize the utilization of robotic platforms nationwide.

Statistics

While robotic-assisted radical prostatectomy (RARP) continuously accounts for the vast majority of overall performed procedures in the Polish healthcare system (73%), an increasing trend in adopting robotic surgery in gynecology and gastrointestinal surgery is observed (12.2% and 8.5%, respectively) (Fig. 1). In comparison, in France, with 30,000 RAS procedures per year, 60% of robotic indications are urological, 16% are gastrointestinal and 14% are gynecological [7]. Such specific distribution partially results from the National Health Fund reimbursement program. While RARP

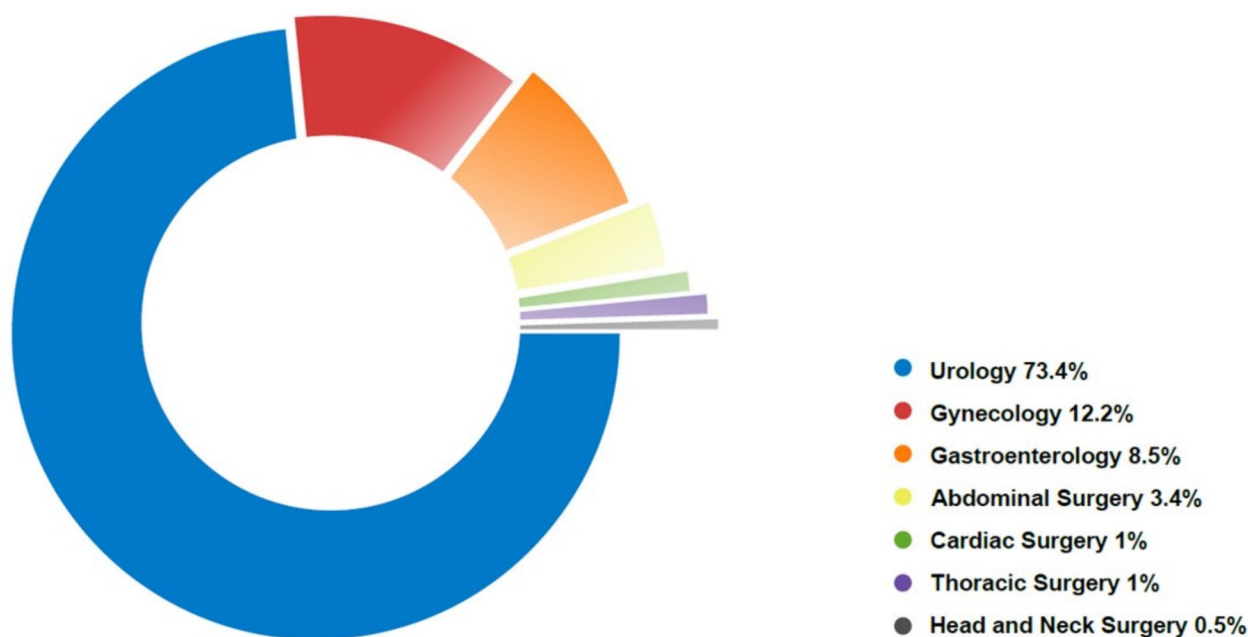


Fig. 1 Percentage of RAS performed in Poland according to surgical specialty

has been economically compensated for nearly three years (since April 2022), remaining robotic-assisted procedures (uterus, colon, and rectum resections due to cancer) have been centrally financed only since August 2023. Currently, robotic-assisted lobectomy (RL) followed by several thoracic surgery procedures is being centrally evaluated in terms of possible subsidization.

Of note, within just one year, the number of institutions performing RAS has nearly doubled, reaching 58 hospitals in 2023, indicating a 45% increase when compared with 40 institutions utilizing robotic systems in 2022 [2]. Further increase in introduction of surgical robots among national healthcare institutions reflected by 80 hospitals utilizing RAS in 2024 indicates the current trends in the market. Dynamic implementation of RAS throughout the country resulted in a minor shift towards the alignment of robotic platforms within particular regions. Currently, there is at least one healthcare institution utilizing RAS within 16 independent administrative provinces (voivodeships), with

Mazowieckie as the national leader in robotic-assisted procedures performed and Warmińsko-Mazurskie as the province with the least RAS in 2023 (2866 and 44, respectively) (Fig. 2). On a national scale, one robotic system is available for 610,000 inhabitants, indicating substantially lower access to RAS when compared with France (1 robot for 438,000 inhabitants) or USA (1 robot for 98,000 inhabitants) [7].

The increased adoption of RAS in terms of involved centers and performed surgeries is accompanied by the growth of surgeons, nurses, and other medical staff dedicated to robotic-assisted procedures. Within the last 12 months, 132 surgeons operated in 36 Polish institutions, with at least 50 RAS reported [2]. Among them, a significant fragmentation and alarmingly low numbers of individual RAS procedures performed were identified: 47.7% of surgeons performed less than 40 cases. Specifically, 33 surgeons performed less than 20 procedures, while 30 individuals operated between 21 and 39 cases.

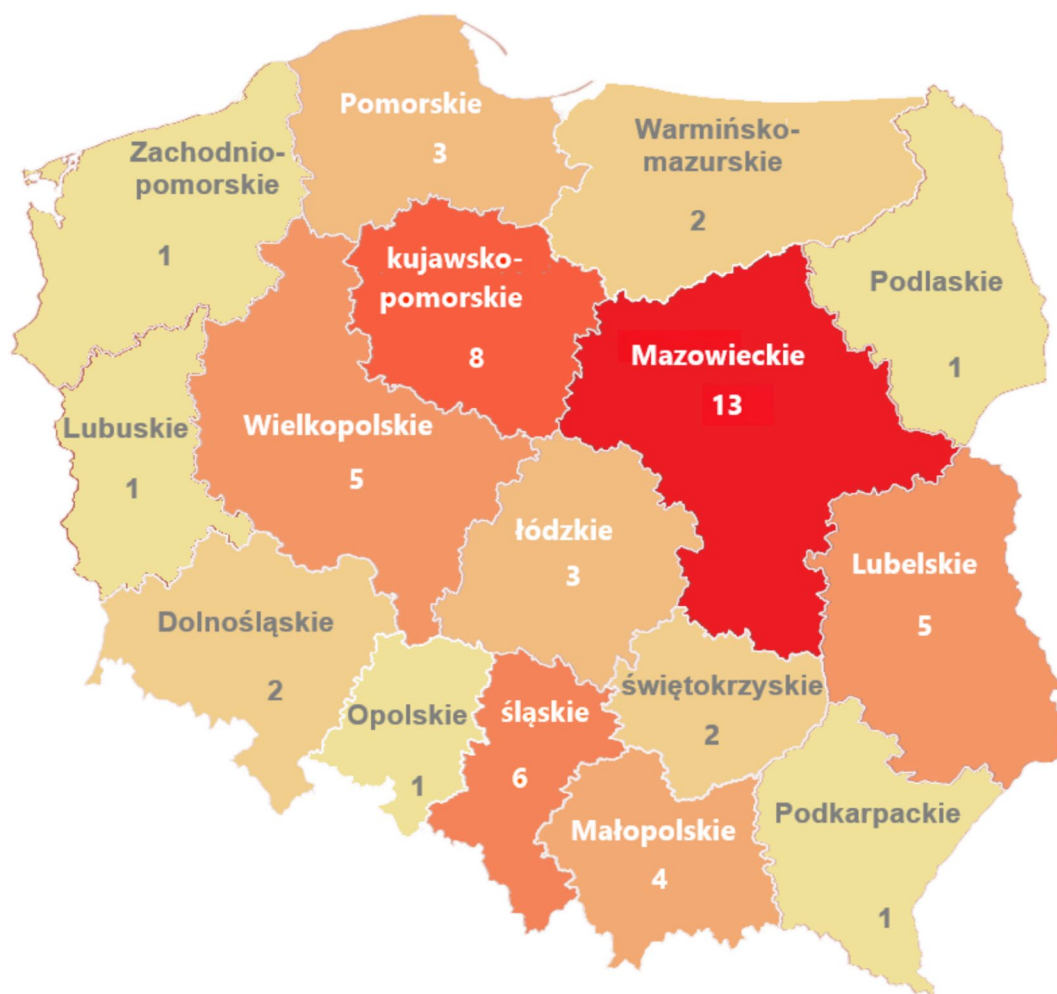


Fig. 2 Heatmap distribution of robotic platforms utilization among Poland's administrative provinces in 2023

Uterine cancer was the second most common oncological indication for RAS in 2023 in Poland. A total of 25 hospitals performed 1231 procedures, accounting for 12.2% of all RAS in Poland. Among these, robotic hysterectomy was the most prevalent procedure ($n = 921$, 74.8%). Of note, the rate of overall gynecological RAS has doubled and quadrupled within the last 12 and 24 months ($n = 622$ in 2022 and $n = 358$ in 2021, respectively). Meanwhile, colorectal cancer (CRC) was the third most common indication for RAS in 2023 in Poland. A total of 27 hospitals performed 860 procedures, accounting for 8.5% of all RAS in Poland. Of note, the rate of overall CRC RAS has nearly tripled and quadrupled within the last 12 and 24 months. ($n = 323$ in 2022 and $n = 284$ in 2021, respectively) (Fig. 3).

Assessment precedes improvement

Parallel to expanding the robotic surgery reimbursement program, several standardized actions are warranted to further facilitate and optimize modern surgical practices in Poland. Regional disparities in access and underutilization of robotic systems, followed by a lack of a centralized and standardized registry to evaluate surgical and oncological outcomes, represent the main challenges to integrating robotic surgery at a national level. Robotic platforms are versatile tools designed for multiple applications rather than a sole therapy and, therefore, should be evaluated accordingly.

Health technology assessments medical device interest group consensus

Evaluating the utility of a platform is complex and relies on the perspective of the assessment, whether at the national or local level [8]. Given the methodological challenges with health technology assessment (HTA) for RAS, a panel of 14 international experts representing relevant stakeholders discussed different approaches and produced guidance on evaluating RAS. The seven key themes were evidence inclusion and exclusion, patient- and clinician-reported outcomes, the learning curve, allocation of costs, appropriate time horizons, economic analysis methods, and robotic ecosystem benefits [8]. Of note, the group highlighted the importance of real-world evidence (RWE), as training, surgical, and organizational data collection may be more effective than in RCTs. A congenial example of a national MIS assessment is shown in a recent and first status analysis of laparoscopic liver surgery in Poland [9]. An increasing trend in the minimally invasive liver resection rates has been observed, reaching 11.7% in 2022. The authors highlight the importance of proper case selection following difficulty grade, which may already provide results within global benchmark values and textbook outcomes during the learning curve. In contrast, it has been suggested that rather than surrogate measures, future robotic studies should rigorously evaluate clinically relevant data [10], including patient-reported outcomes (PRO). While RAS may effectively relieve postoperative negative emotions and improve recovery of social function in patients undergoing major abdominal cancer surgery

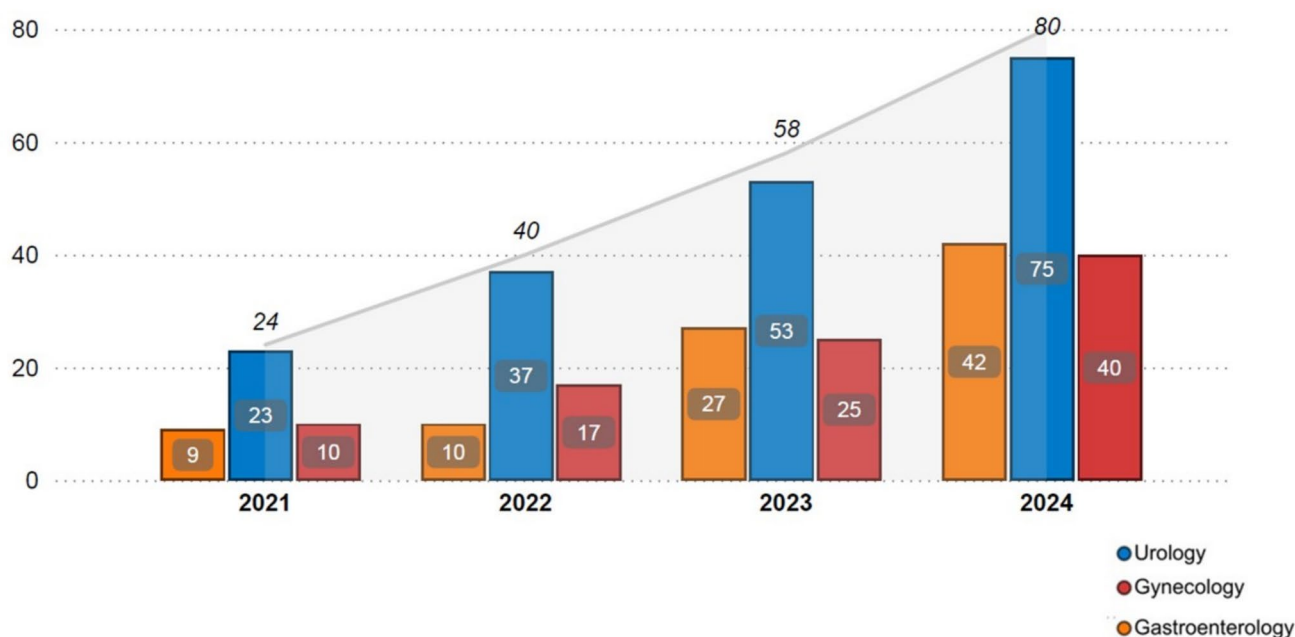


Fig. 3 Trends in utilization of RAS within Polish healthcare institutions according to the three most common surgical specialties

when compared with laparoscopic approach [11], utilization of single port robotic systems results in less severe pain and activity limitation when compared with multiportal approach among patients undergoing non-small-cell lung cancer (NSCLC) surgery. [12]

The IDEAL framework

Technological advances in RAS and AI transform the surgical landscape beyond the operating room, encompassing new challenges within healthcare. The Idea, Development, Exploration, Assessment and Long-term Monitoring (IDEAL) Robotics Colloquium proposes recommendations for evaluation during the development, comparative study, and clinical monitoring of surgical robots—providing practical recommendations for developers, clinicians, patients and healthcare systems [13]. The IDEAL framework comprises six stages: Preclinical, Idea, Development, Exploration, Assessment, and Long-term monitoring. While the initial three stages focus on the safety and feasibility of new robotic technologies, current robotic trends in the Polish medical infrastructure encourage the exploration and assessment of RAS on a larger scale, followed by long-term performance monitoring within institutions where the robotic systems have been widely adopted [6]. Clinical focus should include: (i) validated and qualitative research for perioperative and oncological outcomes, (ii) learning curve for robotic-assisted procedures in simulated and real-world environments, (iii) establishment of standardized guidelines for surgical training and performance evaluation. Concurrently, RAS acceptability must be maintained based on patient perspectives, understanding, and consent. It is essential to provide the patients with clear and objective explanations of benefits, possible risks, and gaps in knowledge about RAS in particular procedure. Lastly, comparative studies should routinely include regional and national analysis of the association between RAS, cost-effectiveness and social determinants of health (SDoH) over a substantial amount of time to ensure long-term follow up and improved access to modern surgical treatment options within low-income regions. [6, 14]

Fundamentals of robotic surgery (FRS)

In 2012, during which approximately 450,000 RAS were performed in the U.S., multiple certifying boards, professional surgical societies, and associations representing various surgical specialties established a course encompassing the cognitive, psychomotor, and team training skills required to perform safely any robotic-assisted procedure [15]. Initially, the Fundamentals of Robotic Surgery (FRS) working group identified three timeframes of minimal skills needed for a surgeon to safely perform RAS regardless of his/her specialty: (i) preoperative (e.g. ergonomic positioning,

docking, situation awareness, closed-loop communication), (ii) intraoperative (e.g. camera control, eye-hand instrument coordination, wrist articulation, needle driving, suture handling, safety of operative field) and (iii) postoperative (transition to bedside assistant and undocking). Next, as a result of two consensus conferences, a complete curriculum was established, consisting of three components: i) cognitive skills (e.g. lecture and video introduction to RAS, pre-, intra- and post-operative activity), ii) psychomotor skills (e.g. physical test device, 3D working space) and iii) team training (e.g. WHO preoperative checklist evaluation, robotic-specific communication, postoperative debriefing). Eight years later, results of a single-blinded parallel-group randomized trial from 12 international American College of Surgeons (ACS) Accredited Education Institutes (AEI), which aimed to identify an ideal training platform, were published [16]. 156 surgeons (33 experts and 123 inexperienced trainees) were randomly assigned into four simulation training groups. Since all participants demonstrated significant performance improvement after skills training, authors advocated for FRS curriculum implementation across training programs before the clinical application of RAS.

The role of medical simulation

In a constantly evolving field, providing surgical trainees with simulation-based training tailored to their clinical experience and individual attributes is critical for ensuring the safe and efficient performance of RAS. Such an approach reduces the risk of complications, thus enhancing patient safety and overall surgical outcomes [17]. Implementation of a structured robotic training program with realistic simulation techniques increases trainee and faculty awareness of robotic platforms, leading to extended RAS utilization [18]. However, virtual reality (VR) and inanimate tasks require appropriate content and scoring metrics evaluation to effectively attain basic manual skills [19]. A recent randomized crossover trial for robotic hepaticojejunostomy comparing surgical skills subjectively and objectively among surgical trainees showed improved performance among novices who had started their training with robotic simulation when compared with individuals initiating their training with suture pads [20]. While multiple benefits of robotic simulation training over dry-lab training have been outlined, including increased accessibility, cost-effectiveness, and rapid evolution of technology, suture pads can not be replaced, particularly during training programs for complex thoracic and abdominal procedures. Of note, skill assessment through the objective structured assessment of technical skills (OSATS) score demonstrated that technical scoring of surgeon's performance independently predicts patient outcomes in abdominal surgery. [21, 22] Based on the evaluation of six grading aspects (gentle tissue handling, efficient motion,

fluid use of instruments, smooth transitions between procedure steps, adequate retraction with proper tissue alignment, and overall assessment of technical skills), one of the following ratings is provided: (1) deficient/traumatic, (2) lacking finesse, (3) average, (4) skilled and (5) master. While completion of simulation-based VR training results in feasible and effective translation into a robotic environment among surgical learners [23], OSATS scores strongly correlate between simulation and OR settings. [24] Moreover, better technical skills in simulation translate to a lower incidence of organ-specific complications. While simulation techniques in Polish medical education have been successfully implemented for over a decade [25], and medical students benefit from earlier exposure to RAS regardless of clinical interest [26], there is a need for refinement and inclusion of robotics within Polish schools of medicine curricula.

One who sweats more in training bleeds less at the OR

Paraphrase of the Ancient Spartan's philosophy highlights the core values of training ethics around discipline and endurance [27]. Vast majority of current robotic programs are organ-specific. Meanwhile, establishing a structured curriculum facilitates integrating resident education into the utilization of RAS [28]. Although most U.S. surgical residents have encountered robotic platforms at their institution and have participated in RAS, very few residents received formal training before participating in a robotic case with only 18% reporting access to an operating console. [29] Development of a structured robotic program for surgical residents, based on full transparency and process flexibility, needs to address local resources and limitations due to changing financial, technical, and faculty environments. [30]

RoCS and RoSTraC — German experience

In 2020, Department of General, Visceral, Vascular and Transplant Surgery, at the University Hospital of Otto-Von-Guericke University in Magdeburg, Germany, introduced the Robotic Curriculum for Young Surgeons (RoCS). RoCS is a multimodal activity based on console training and bedside assistance during RAS. Key elements are the robotic team time-out (rTTO), perioperative process standardization, feasible personnel scheduling and applicable procedure clustering into organ systems, procedural steps, and procedural step complexity. Authors highlight the main strengths of the concept in flexibility and adaptability to internal organization processes of surgical departments [30]. Recently, the association between RoCS and patient outcomes was evaluated. The introduction of RoCS decreased surgery duration, intraoperative blood loss, conversion rate, and length of hospital stay for selected colorectal and

hepatopancreatobiliary patients compared with individuals operated before RoCS [31]. Of note, introducing RoCS follows the needs and aspirations of young trainees, taking into account individual learning curves and maintaining patient safety. Another example of a recently developed robotic program for surgical residents in visceral surgery is the Robotic Surgery Training Curriculum (RoSTraC). Initiated at the Department of Surgery, University Medical Center Schleswig–Holstein in Lübeck, Germany, RoSTraC consists of a three-step training curriculum including multimodal learning contents: (i) basics and simulation training of RAS, (ii) laboratory training on the institutional robotic system and (iii) structured on-patient training in the operating room [32]. Of note, RoSTraC training led to significantly improved performance of advanced four-hand robotic procedures, with participating surgical residents acquiring fundamental and advanced RAS skills.

NTP – British experience

The National Training Programme in Laparoscopic Colorectal Surgery (NTP, LAPCO) in England represents a pivotal initiative to standardize and improve proficiency in MIS [33]. Developed to address the steep learning curve and potential risks associated with laparoscopic colorectal surgery, the program ensures that consultant surgeons achieve competency under expert supervision before performing independently. Guided by an evidence-based framework, the LAPCO program emphasizes a blended model of hands-on inreach and outreach training, supported by continuous formative and summative evaluation [34]. The competency assessment tool (CAT) facilitates the identification of consultant surgeons within the NTP who are qualified to safely perform laparoscopic colorectal surgery before transitioning to independent practice. The content validity of the CAT was achieved through a structured process incorporating expert opinions to ensure the inclusion of all skills (exposure, pedicle control, mobilisation, resection/anastomosis) relevant for specialist-level competency assessment (instrument use, tissue handling, errors, end product). The inclusion of structured feedback and rigorous video review ensured high sensitivity (94.4%), specificity (84.6%) and positive predictive value (93.8%) in trainee evaluations [34]. Furthermore, the "Training the Trainers (Lapco TT)" curriculum was designed to improve, standardize, and benchmark the quality of training delivered within NTP [35]. Introduction of four teaching skills (learner-focused framework, skills deconstruction, trainer intervention framework, and performance enhancing feedback) was well received, improved training performance in the short- and long-term, and impacted positively on the learning curve of training. NTP structured approach has led to significant improvements in patient outcomes, with supervised trainees achieving comparable

results to seasoned experts [36]. By reducing conversion rates and complications, the program sets a benchmark for surgical education, blending tailored mentorship, robust assessments, and procedural standardization to ensure a safe and efficient transition to advanced laparoscopic practices [37]. This model of structured training offers international scalability, making it a gold standard for competency-based surgical education [38]. Development and implementation of a structured, multimodal robotic training curricula in Poland, tailored to local resources and limitations, will allow surgical trainees access to comprehensive robotic-assisted surgery (RAS) skills while ensuring patient safety and addressing modern educational needs.

Back to the future

Although the number of objective technical skills assessment tools in RAS is substantial (global rating scale tools, procedure- and task-specific tools, error tools, simulator and non-simulator automated performance metrics, artificial intelligence), a recent systematic review suggests a focus on validating and implementing existing instruments rather than seeking any further robotic surgery evaluation methods [39]. Therefore, integrating standardized assessment mechanisms into clinical practice to improve training and patient safety in Polish healthcare institutions involved in RAS will be achieved through collaboration within national surgical societies (Polish Society of Surgical Oncology—PSSO, Society of Polish Surgeons—SPS) and supported by high-quality, large-scale research. For example, our group has recently performed a comprehensive and updated assessment of National Comprehensive Cancer Network (NCCN) guideline compliance and likelihood to achieve textbook oncological outcomes (TOO) after open, laparoscopic, and robot-assisted resection of locally advanced gastric cancer (LAGC) on a national level [40]. While the overall compliance to treatment of patients with LAGC falls under 50%, RAS was associated with higher guideline adherence rates when compared with open surgery, resulting in improved short- and long-term outcomes.

While the multimodal treatment of individuals with gastrointestinal and hepatopancreatobiliary (HPB) cancers is rapidly evolving, it is important to identify potential barriers to clinical outcomes improvement, including social determinants of health (SDoH). Besides low socioeconomic status at the individual or family level, intergenerational poverty can lead to the chronic under-resourcing of particular communities, resulting in structural inequities in access to education, employment, and high-level healthcare [41]. Therefore, the continuous evolution of MIS surgery in Poland should additionally reflect on the gradually increasing role of SDoH in cancer therapy. Identifying associations between regional disparities and access to RAS on a national scale will allow

the creation and implementation of a patient-centered approach, resulting in the improvement of inequities.

Finally, as novel surgical technologies are being developed, surgical residents' educational and curriculum needs are increasing and changing [42]. While many large academic general surgery residency programs in the U.S. have developed formalized robotic educational curricula with limited guidance from the Accreditation Council for Graduate Medical Education (ACGME), a formal consensus between the national consultants in general surgery, surgical oncology, PSSO, and SPS is warranted to introduce RAS in terms of standard components, identifying differences, and serving as a resource to surgical training programs with development curricula.

Conclusion

The gradual expansion of the robotic surgery market in Poland highlights the relentless need for a structured, centralized program to ensure sustainable integration of RAS into the healthcare system. Addressing regional disparities, standardizing training, and implementing uniform evaluation frameworks for clinical and oncological outcomes are critical to maximizing the potential of robotic systems. By aligning with international best practices, fostering robust real-world evidence collection, and emphasizing patient-centered approaches, Poland can establish a comprehensive national robotic surgery strategy that promotes equitable access, cost-effectiveness, and improved healthcare delivery.

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Data availability No datasets were generated or analysed during the current study.

Declarations

Conflict of interest The authors declare no competing interests.

Ethical approval N/A.

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