

# Robotic gastrectomy: the future

Moneer E. Almadani<sup>1,2,3</sup>, Donna Dy Abalajon<sup>1,2,3</sup>, Kun Yang<sup>1,2,3</sup>, Woo Jin Hyung<sup>1,2,3</sup>

<sup>1</sup>Department of Surgery, Yonsei University College of Medicine, Seoul, South Korea; <sup>2</sup>Gastric Cancer Center, Yonsei Cancer Hospital, Yonsei University Health System, Seoul, South Korea; <sup>3</sup>Robot and MIS Center, Severance Hospital, Yonsei University Health System, Seoul, South Korea

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**Correspondence to:** Woo Jin Hyung, MD, PhD. Department of Surgery, Yonsei University College of Medicine, 50-1 Yonsei-ro Seodaemun-gu, Seoul 120-752, South Korea. Email: wjhyung@yuhs.ac.

**Abstract:** In recent years, implementation of robotic surgery has been successfully introduced into clinical practice. The approach is considered as safe and feasible to overcome the current limitations of laparoscopic surgery, particularly for complicated procedures. Gastrectomy is a procedure that can highlight the potential benefits of the robotic approach. However, well-designed prospective randomized trials have not been published. In this review, we discuss the possible future benefits, and potentials for enhanced imaging and diagnostics, as well as the applications of expected new technology in surgical robot, when it used for the treatment of gastric cancer.

**Keywords:** Robotic; gastrectomy; gastric cancer; future

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## Introduction

Over the last decade, the use of robot-assisted surgery has increased dramatically, as this approach has several reported benefits (1,2). Technically, it has equipped with three-dimensional, high-definition visualization, improved dexterity, seven degrees of freedom, ability to perform scaled motions, elimination of tremors, and ergonomic positioning. Practically, it facilitates the reconstruction using intra-corporeal anastomosis. It also enables precise dissection even at the level of the most complex lymph node stations and around the major vessels. These features eventually reduce blood loss and lymphatic leakage, minimizes tissue trauma, and increases the number of retrieved lymph nodes (3,4). They may also add oncologic advantages to minimize the risk of cancer cell dissemination (5,6).

The potential expansion of robotic surgery in gastric cancer is vast. After publication of the initial large case series of the robotic radical gastrectomy, subsequent reports have shown better peri-operative outcome, proper post-operative staging information, and potential survival benefit (4).

Moreover, since the use of surgical robot has the intention to overcome the limitations of current surgical techniques, complex procedures using robotic approach would expected to be performed with less difficulty (4,7-9). However, the long-term role of robotic surgery in the treatment of gastric cancer has not been proven using well-designed randomized trials. All available meta-analyses are based on retrospective comparative study designs (10-13). Ongoing studies and multi-center registries may determine the best approach to treat gastric cancer (14).

## Indications and oncological adequacy of robotic gastrectomy

The current accepted indications for robotic gastrectomy are similar to those for the laparoscopy in treating early gastric cancer. However, minimally invasive role in advanced gastric cancer is still within the context of randomized controlled studies (15-17).

Other indications upon which surgeons are focusing are the relatively challenging and complicated procedures, such

as advanced gastric cancer with D2 lymph node dissection, total gastrectomy with or without organ-preservation, and function-preserving gastrectomy. These demanding procedures are rarely performed as they have associated with postoperative complication, and immunity disturbance (4). Also, they are not easily overcome by the surgeon's experience or current laparoscopic tools which further hindered the expansion of the indications for minimally invasive gastrectomy.

The oncological effectiveness and potential benefits of robotic gastrectomy are promising. The surgical robot provides faster recovery and better postoperative performance, which eventually facilitate more patients to receive adjuvant therapy (3). Therefore, it plays an important role in the integration of multimodal strategy especially in the management of advanced gastric cancer.

### Learning curve

There is no accurate way to assess the learning curve of robot-assisted surgery. It would be helpful if the evaluation has included non-expert laparoscopic surgeons, as available robotic training programs are mostly towards surgeons already expert in laparoscopy (4). On the other hand, studies have shown surgeon's ability to switch their practice directly from open to robotic surgery without an intermediate laparoscopic step (18). Overall, the learning curve and reproducibility of robotic surgery are shorter and easier than conventional laparoscopy even in advanced stages as this minimally invasive approach is applied to a greater number of complex procedures, including radical gastrectomy for cancer (19-21). Moreover, the growing application of preoperative simulator technology in surgical robotics may further reduce the learning curve of robot-assisted operations (22).

### Cost

The surgical robot is an expensive tool. The principal reason for the higher robotic gastrectomy-associated cost is the cost of the robotic system itself, and the depreciation reserve. However, for an accurate assessment of the robotic cost-effectiveness, its potential benefits and expenses should be balanced in details. Unfortunately, very few studies give an itemized breakdown of its costs, making accurate comparisons difficult (23). In addition, lack of long-term follow-up makes the financial assessment even more complicated. Several randomized prospective clinical

trials are currently ongoing seeking to address this point at different surgical subspecialties, such as the ROBOT trial in esophageal cancer and ROLARR trial in rectal cancer (24,25). Eventually, an impartial assessment from these studies should be performed to determine if the progress that has been identified by robotic application is really worth the higher expenses. In the future, industry competition to invent alternative robotic systems, increase in the number of specialized robotic centers, and widespread penetration of the technology can possibly change the current situation of high-cost robotic procedure.

### Limitations of robotic gastrectomy

A consensus statement regarding safety and efficacy of robotic surgery, specifically for those performed by the use of da Vinci system has recently been released by the SAGES committee (26). Despite all the reported advantages of the surgical robot, it has not fully translated into clinical practice as expected. Robotic gastrectomy is considered to have little benefit compared with laparoscopic approach, at least for the current indication of minimally invasive surgery. Its cost-effectiveness which remains the largest obstacle for its widespread adoption is yet to be verified. Examples of other barriers include the positioning time consumed, inability to reposition the docked arms, and the loss of haptic feedback. Debate regarding robotic surgery as an advanced novel technology without a distinct evidence of clinical advantage still exists in certain surgical sectors.

### Recent developments and future prospective of robotic gastrectomy

Surgical robot continues to evolve, and its application currently at its infancy (27). The future directions of surgical robot would likely incorporate a variety of innovations along with advanced computing features, which do not exist in current da Vinci surgical robotic system. Partnership between surgeons and robotic engineers is crucial for the development of both technically impressive and clinically effective features to improve surgical outcomes (28). Additionally, a collaborative effort of more than one surgeon interacting with each other at the surgical site in teleoperation could add more benefits (29,30). The primary goals of robotic advancement are generation of novel platforms, downsizing of hardware, improvement of flexible instruments, and application of diverse emerging technologies.

There are many innovations to improve robotic surgical performance through continuously generated platforms and instruments. “Endo-Wrist” is a jointed-wrist designed to allow more surgical dexterity particularly in narrow spaces (31). ‘Neuro arm’ is another robotic platform that has magnetic resonance imaging (MRI)-compatible arm, with a very high degree of precision. It can be further extended to be used in gastric surgery.

Another expected area of improvement is the incorporated facilities of surgical robot. The forced feedback has a major advantage that gives the ability to sense the force applied by instruments, and eliminates the disadvantage of “sight-only” feedback of traditional robotic system. Ongoing research is looking into how best to incorporate haptic feedback into the robotic system to enable the surgeon to feel during the procedure. The Surgeon’s Operating Force-feedback Interface Eindhoven (SOFIE) robot is a newly invented portable robot that has this facility (32). Also, a retrofitted robotic instruments are being embedded with light emitting diodes to detect tissue oxygenation and ischemia to provide feedback to operating surgeon (33,34).

Advancements in imaging system also show great promise. The combination of real-time data acquired through the robotic system with that stored in the robot offers significant advantage. Reconstructed vascular images or intraoperative endoscopic, radiologic, and pathologic images can be incorporated into the surgeon’s view of console. Organ or vascular injury during gastrectomy could potentially be prevented by practicing case-specific simulation and real-time navigation (35,36). Additionally, intra-operative combination with augmented reality navigation systems can be also used in gastric surgery as it has shown its success to provide high-resolution images and achieve greater surgical precision in endocrine procedures. StealthStation is the system used to precisely allocate the pathological areas from the robotic console. It has the ability to add three-dimensional images from a variety of radiological sources such as X-ray, computerized tomography (CT), MRI, and ultrasound. Then, fuse these images with other technologies such as histoscanning, or nanoparticles (37,38). An incorporation of fluorescent images in the console via an infrared camera in gastrointestinal surgery is another valuable tool to maximize the precision advantages of the robotic system (27). Another advanced technical tool that could be used in the future surgical robot is ‘Floshield’, which eliminates the frequent need to clean the camera. It creates a carbon dioxide (CO<sub>2</sub>) barrier over the endoscopic lens and flushes the lens with an *in situ* surfactant whenever required (39).

The feasibility of incorporating the surgical robot to single incision solo surgery for gastric cancer has been reported. However, the use of the robotic system for this subclinical models has been under-investigated.

## Summary

The advanced technology of surgical robotic system enables surgeons to challenge the new horizons of minimally invasive gastrectomy. However, it is difficult to generate specific conclusions without established objective values.

Robotic gastrectomy is a safe and feasible alternative to laparoscopic surgery in the treatment of gastric cancer. It has faced numerous obstacles, and its full potential remains to be balanced against the high cost, the longer operation time, and in the field of surgical oncology, the lack of oncologic superiority to its counterparts.

The future of robotic gastrectomy remains extremely exciting. We would expect more upcoming robotic advances, aiming to provide more accurate diagnostics, reliable treatments, increase patient benefits and surgeon’s satisfaction. These benefits should be investigated using well-designed randomized prospective studies to establish clear indications for this approach.

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## Footnote

*Conflicts of Interest:* The authors have no conflicts of interest to declare.

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