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Robotic Gastric Cancer Surgery: What Happened Last Year?

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Abstract
Purpose of review This following review aims to evaluate the role of robotic surgery in gastric cancer, comparison with open and laparoscopic alternatives, based on the articles published last year.
Recent Findings Robotic gastric surgery is a promising and developing platform in the surgical era and its perioperative or oncological results after gastric cancer surgery are still under evaluation. Besides this, the approaches of eastern and western societies in robotic gastric surgery are also different as in open surgery, in some ways.
Summary Robotic gastric surgery seems to be more advantageous to use in early-stage gastric cancers, it causes less bleeding and provides technical advantage to the surgeon. The high cost and the long operation time are still the biggest problems. There is no difference in terms of oncological results compared to other methods. It is feasible and safe alternative to other methods.

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Keywords Gastric cancer · Robotic surgery · Minimal invasive surgery

Introduction

Minimal invasive surgery refers to the operation a surgeon performs from small incisions, using various instruments and has comparable results with open surgery. Laparoscopy comes first in mind when it comes to minimally invasive surgery. Thanks to German gynecologist Kurt Semm and another German surgeon Erich Mühe, laparoscopy which has taken a step in the modern surgical concept has been accepted all over the world in a short period of time, despite the refusal response seen at first, and today many abdominal surgical procedures are performed by laparoscopic method [1•].

The major cause of easy and quick spreading of minimal invasive surgery concept to the surgical era is its relative and absolute advantages over open surgery. Patients have decreased postoperative pain, earlier mobilization, earlier bowel movement, and shorter recovery time with smaller incisions and scars [2, 3]. In addition to these advantages, laparoscopic surgery has some disadvantages and limitations. The 2-dimensional view without the tactile feedback sense and limited angulation of instruments makes some operations technically difficult and prolongs their duration [4]. With the development of technology, robotic surgical platforms have been used to eliminate these limitations and opened a new door in the era of minimally invasive surgery. This surgical method, which provides technical superiority to the advantages of laparoscopic surgery, is one of the current research topics about in which surgical fields it can be used safely.

Gastric cancer surgery is one of these research areas of robotic surgery platform. For a long time, minimally invasive surgery has been used with caution in gastric cancer due to technical difficulties and doubts about adequate oncological outcomes. The first robot-assisted gastrectomy was performed in 2002 and thereafter a series of studies investigating the effectiveness of robotic surgery in gastric cancer have emerged [5]. It is understood from the recent studies that robotic surgery is trying to find solutions to these technical difficulties and the oncologic results are compared with open and laparoscopic surgery in many studies [6]. This review aims to evaluate the role of robotic surgery in gastric cancer today and to evaluate the open and laparoscopic surgical comparisons based on the articles published last year and to present information in terms of advantages, disadvantages, and future approaches.

Current Status of Robotic Surgery for Gastric Cancer: East or West?

It is known that the approach of eastern and western societies to gastric cancer varies in particular ways. Minimally invasive surgery seems to be taking their share from these differences at first. Numerous publications have emerged about the use of minimally invasive surgery in gastric cancer both in the east and the west.

Upper gastrointestinal system cancers are more frequent in the east and therefore there are strict screening programs. Thanks to these programs, gastric cancers are often caught in the early stages. Eastern societies recommended the use of laparoscopic gastric surgery especially in early-stage cancers [7••]. Because the number of cases is too high and because of the known advantages of laparoscopy, it has become almost the gold standard. The place of laparoscopy for advanced gastric cancer is still a debate. Retrospective analysis revealed its safety [8••, 9••] but there are still ongoing prospective randomized studies from east (KLASS02, JLSSG 0901, CLASS 01). The most important reason for this is the technical and ergonomic conditions in laparoscopic surgery and difficulties in D2 dissection but these conditions seem to be overcome by robotic surgery platforms [10]. Although the superiority of robotic surgery to laparoscopic surgery cannot be demonstrated in the east [11], it can be said that it provides three advantages theoretically. First, robotic surgery platforms provide freedom of hand movements that cannot be performed with laparoscopy under a better vision. Second, bleeding which is a major problem of dissection in gastric surgery, is lesser than laparoscopy and third, learning curve of robotic surgery can be shorter. Despite long operation time and high cost, the trend of robotic surgery in the treatment of gastric cancer for both early and advanced stages is increasing in the east. Most of the articles about this subject published last year are of eastern origin.

Differently, gastric cancer is not as common in the west as in the east. The incidence of proximal gastric cancer is higher in western societies due to higher obesity rates and increased frequency of gastroesophageal reflux. Since there are no widespread screening programs in the west, patients are usually detected at advanced stages at the time of diagnosis [12–14]. Similar to the east, due to technical difficulties in advanced-stage disease, use of minimal invasive surgery in gastric cancer has been slow in the west. Because of the rarity of the disease and the fact that they are mostly detected in advanced stage, the wide usage of robotic platforms in gastric cancer is mostly in high-volume centers [15]. This leads to a very gradual development in the field of robotic gastrectomy compared to the east and the results obtained from the studies may be partially different. After evaluation of 6427 patients in USA, Greenleaf et al. suggested that minimally invasive gastric surgery (both robotic and laparoscopic) has an impact on oncologic resection but has no significant effect on perioperative outcomes relative to open surgery [16•].This study summarizes the situation in the west very well. However, nowadays, early-stage cancer detection rates are increasing in the west and similar to the east, robotic surgery helps to overcome these technical difficulties.

Open Surgery: Do We Still Have to Be Traditional?

It is known that minimally invasive surgical procedures have different advantages over open procedures in many areas of surgery. In addition to similar oncologic outcomes in cancer surgery, earlier mobilization, less pain, fewer scars, and less hospitalization time are some of these advantages. As a new field, robotic surgery should be compared with open surgery for the treatment of gastric cancer.

In a recent meta-analysis, Kostakis et al. collected data from 18 articles that compare minimal invasive gastric surgeries (both laparoscopic and robotic) with traditional open surgery that performed in Europe [17]. They found less blood loss but higher operation time for robotic surgery group but concluded that it is a safe alternative for open surgery.

In the multicenter prospective analysis of Parisi et al. with 1026 gastrectomies, results of three different methods (robotic, laparoscopic, open) were compared and found favorable hospital stay time and less blood loss but higher operation time for robotic surgery group [18].

Similar results were obtained in several comparative studies containing different numbers of patients [19–21].The majority of these studies show that robotic surgery provides similar advantages of laparoscopic surgery for gastric cancer patients when compared with open surgery. Therefore, most of the studies compared the two minimally invasive techniques last year.

Laparoscopic Surgery: Why Robotic Surgery? Why Not?

Although both methods are minimally invasive and have inherent advantages of the procedure, the 3-dimensional and clearer view of the operation area and better angulation and flexibility of the instruments make robotic surgery technically superior and this superiority is reflected in some patient outcomes, especially in some specific areas [22–24]. In addition to the technical aspects, oncological results of the surgical technique are also important in malignancy surgeries. Besides that, the high cost of robotic surgery and an extra learning program for the surgeon make it difficult to apply robotic surgery platforms everywhere. To summarize, technical aspects, oncological results, cost, and learning curve have been the main questions to be answered for the use of robotic surgery in gastric cancer.

To clarify these issues, several studies were conducted last year. Wang et al. published a meta-analysis of 12 articles with a total of 3744 patients that compares results of laparoscopic and robotic gastric cancer surgery [25]. They revealed that both methods are same according to number of lymph nodes dissected, length of resection margins, early postoperative complications and hospital stay, and find lesser blood loss but higher operation time for robotic surgery. They concluded that robotic gastric surgery is a safe and comfortable method when compared with laparoscopic gastric surgery.

This year, Lu et al. from China compared the oncological, cost, and surgical stress results of laparoscopic versus robotic gastrectomy for gastric cancer [26]. Similar to other articles, oncological results, early postoperative complications, and hospital stay were both comparative and find lesser blood loss but higher operation time for robotic surgery. Total mean cost and total indirect cost were higher in robotic group but there was no difference in mean total direct cost. They concluded that robotic gastric cancer surgery is oncologically safe and a feasible procedure.

Hikage et al. evaluated the differences between two procedures in patients who had undergone distal gastrectomy for cT1 gastric cancer [27]. Operation time was significantly higher in robotic group but there was no difference for blood loss. Oncological and postoperative results were both similar but they concluded that potential of pancreas damage is significantly reduced in robotic surgery. Similarly, Guerra et al. showed less pancreatic complications with the use of robot in their meta-analysis with more than 2000 patients [28].

One of the largest meta-analyses was conducted by Chen et al. with 19 studies and 5953 patients [29]. This meta-analysis evaluates the feasibility, safety, and efficacy of robotic gastrectomy. Results revealed same conversion rates to open surgery, longer operation time, and lower blood loss for robotic gastrectomy and no difference for mean time to oral intake and length of hospital stay. No significant difference was identified according to postoperative complications, reoperation rates, and mortality. Similar to oncological outcomes, long-term survival was not different between groups. The cost was significantly greater in the robotic group.

Result for advanced gastric cancer or data about long-term survival or recurrence is more limited for robotic gastric cancer surgery and study designs are mostly retrospective. Recently Gao et al. revealed that 3-year overall survival and recurrence-free survival were both similar for robotic and laparoscopic gastric surgery in advanced gastric cancer [30]. Similarly, they found longer operation time and increased cost for robotic surgery. Similarly, Obama et al. showed no statistically significant differences in 5-year overall survival or relapse-free survival between two methods [31]. Similar results were observed in different studies [8, 29, 32, 33]. The prospective study of Pan et al. with 102 robotic and 61 laparoscopic gastrectomies for locally advanced gastric cancer revealed no conversion to open surgery, similar operation time, lower blood loss, higher lymph node numbers, and shorter hospital stay for robotic group and concluded that robotic gastrectomy for gastric cancer is safe and feasible and can be superior to laparoscopic gastrectomy [34].

Utopia or Dystopia?

It is obvious that the technology will facilitate surgeries and provide improvements in the surgical field, as it facilitates the daily life. Robotic surgery platforms are one of the first steps taken in this path. But is this method a precursor of utopia in gastric cancer surgery or does it include undesirable features of a dystopia?

Whether traditional or minimally invasive, there is a learning curve to be able to achieve the desired results in all surgical procedures. There are two main questions about this issue for gastric cancer surgery: Should I specialize in laparoscopic surgery before starting robotic gastric surgery? How many cases are needed to complete the learning curve in robotic gastric cancer surgery? Obviously, we

believe that the surgeon must have completed the learning curve on open gastric surgery first and should be familiar with dissection areas and anatomy. According to the evaluations made in recent years, the process of learning laparoscopic or robotic gastric surgery over open surgery is similar [35, 36]. Even in some publications, this process is shorter in robotic surgery [37, 38]. If a surgeon is experienced in the field of laparoscopic or robotic gastric surgery this practice also shortens the learning process of the other field [35, 39, 40].The meaning that can be drawn from these results is that both methods can be learned over open surgery and experience in one field shortens the learning curve of the other. An et al. evaluated a single surgeon's experience in robotic distal gastrectomy and suggested that successful robotic gastrectomy does not require experience in laparoscopic gastrectomy [41]. Most articles revealed that robotic gastrectomy provides a satisfactory postoperative outcome, especially after the 20-25 initial cases [42].

One of the superior benefits of robotic surgery is that the amount of bleeding is less than other methods [25, 26, 29]. Better image quality, 3D images, and reflection of hand movements to the robotic instruments without any tremor may have revealed this result. With the help of this superior mobility and vision, the risky areas for bleeding while dissection (especially suprapancreatic, infrapyloric, and splenic hilum) could be controlled more carefully.

Most of the articles mentioned above concluded that robotic gastric cancer surgery have an higher operation time [25–27, 30]. Preoperative preparation and docking of robotic instruments require extra time (around 30 min) and surgeon's experience in robotic surgery also effects operation period [38]. Wang et al. suggested that with higher experience and stable surgical team, operation time will reduce [25]. Maybe because of these reasons Liu et al. found no differences according to operation time for robotic gastric surgery [43]. Chen et al. showed that robotic surgery takes an average of 49 min longer and in the subgroup analysis they showed that while total gastrectomy time were similar, subtotal gastrectomy time was longer in robotic group according to laparoscopic group [29]. The reason why the operation time was longer in robotic gastrectomy was examined very recently. Liu et al. evaluated ten consecutive robotic and laparoscopic gastrectomies and measured time in every step in each operation. Robotic gastrectomy was 56.8 min longer than laparoscopic gastrectomy group for overall operation time. A large proportion of this period was for instrument setup and docking (41.5 min) and effective time was only 15.3 min longer.

Robotic surgery is still a costly technology today and this economic condition makes it difficult to apply robotic gastric surgery everywhere. As in meta-analysis of Wang et al. most of the studies have shown that robotic surgery is still expensive [26, 27, 30, 44–46].

Can robotic surgery be advantageous in the elderly? To answer this question, Liu et al. compared open and minimally invasive (laparoscopy and robotic) surgeries between patients younger than 60 years of age and older (mostly > 80 years). They concluded that minimal invasive surgery was associated with less operative blood loss, a shorter postoperative hospital stay, and has similar rates of surgical complications and mortality among older patients relative to open surgery [47]. This study showed that robotic gastric surgery could be advantageous in the elderly.

What Is Waiting for Us in the Future?

Although the instruments used in robotic surgery provide ease of movement, there are still some limitations. Current research is directed to eliminate these limitations and enhance surgical motion features. A newly developed robotic surgery platform combines the single-incision concept with robotic surgery. It allows all kinds of manipulation and traction through a single port [1]. There are also studies about reducing the number of ports and investigate its effects [48, 49].

A European project called the STIFF-FLOP (STIFFness controllable Flexible and Learnable Manipulator for surgical Operations), aims to create an articulating cognitive robotic arm that can stiffen its parts, similar to the octopus arm. Various research projects are carried out worldwide to provide surgeon ergonomics and ease of movement to be used in different kinds of operations.

Real-time vessel navigation or lymph node mapping with indocyanine green fluorescence in robotic gastric surgery is an issue that is up to date and still under investigation [50, 51]. Robotic lymph node dissection with indocyanine green fluorescence method will provide the metastatic lymph nodes other than regular dissection areas and it will contribute to the individualization of the treatment.

Conclusion

Although robotic gastric surgery is used much more in the east than in western societies, its use is increasing worldwide. It seems to be more advantageous to use in early-stage gastric cancers but it is becoming increasingly common in advanced gastric cancer with increasing experience. Although the superiority of robotic surgery for gastric cancer to laparoscopic surgery is not proven, it has the greatest advantages that it causes less bleeding and provides technical advantage to the surgeon. The high cost and the long operation time are still the biggest problems. Other

than that, there is no difference in terms of oncological results compared to other methods. Robotic gastrectomy is feasible and a safe alternative to both conventional laparoscopy and the open surgery for treating gastric cancer.

Compliance with Ethical Guidelines

Conflict of interest Muhammet Kadri Çolakoğlu, Volkan Öter, and Erdal Birol Bostancı each declare no potential conflicts of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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- •• Of major importance

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