How I do it

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Robotic Surgery of Locally Advanced Gastric Cancer: A Single-Surgeon* Experience of 41 Cases

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Rezumat

Chirurgia robotică a cancerului gastric local avansat: experiența unui singur chirurg după 41 de cazuri

Pilonul principal al terapiei cu viză curativă în cancerul gastric este reprezentat de rezecția gastrică deschisă cu evidare ganglionară regională. Chirurgia minim invazivă nu constituie încă o metodă consacrată cu un rol bine definit în terapia cancerului gastric. Chirurgia robotică a depășit unele dintre limitele laparoscopiei convenționale și s-a dovedit atât sigură, cât și fezabilă. În această lucrare prezentăm experiența noastră inițială în chirurgia robotică pe un număr de 41 de pacienți cu cancer gastric. Sistemul robotic facilitează realizarea anastomozelor. Sunt descrise tehnicile realizării anastomozelor eso-jejunale termino-laterale (cu stapler circular sau sutură manuală) și latero-laterale. Am obținut rezultate bune folosind anastomozele mecanice cu stapler circular. În plus, recomandăm trecerea de la anastomoza asistată robotic la cea total intracorporeală cu beneficii în recuperarea post-operatorie, mai ales la pacienții obezi. Prezentăm trei metode pentru realizarea eso-jejunoanastomozei intracorporeale cu un stapler circular: crearea bursei prin sutură manuală, utilizarea OrVil™ și tehnica "double stapling". Tehnicile numeroase permit adaptarea la caz, mai ales în gastrectomia totală, în care eso-jejunoanastomoza reprezintă o dificultate tehnică. Considerăm că o pregătire prealabilă pentru realizarea acestei anastomoze este necesară chirurgilor care abordează gastrectomiile totale.

Cuvinte cheie: cancer gastric, gastrectomie laparoscopică, gastrectomie robotică, eso-jejunoanastomoză

Abstract

The mainstay of curative gastric cancer treatment is open gastric resection with regional lymph node dissection. Minimally invasive surgery is yet to become an established technique with a well defined role. Robotic surgery has by-passed some of the limitations of conventional laparoscopy and has proven both safe and feasible. We present our initial experience with robotic surgery based on 41 gastric cancer patients. We especially wish to underline the advantages of the robotic system when performing the digestive tract anastomoses. We present the techniques of end-to-side eso-jejunoanastomoses (using a circular stapler or manual suture) and side-to-side eso-jejunoanastomoses. In our hands, the results with circular stapled anastomoses were good and we advocate against manual suturing when performing anastomoses in robotic surgery. Moreover, we recommend performing totally intracorporeal anastomoses which have a

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better post-operative outcome, especially in obese patients. We present three methods of realising the total intracorporeal eso-jejuno-anastomosis with a circular stapler: manual purse-string suture, using the OrVil™ and the double stapling technique. The eso-jejunoanastomosis is one of the most difficult steps in performing the total gastrectomy, but these techniques allow the surgeon to choose the best option for each case. We consider that surgeons who undertake total gastrectomies must have a special training in performing these anastomoses.

Key words: gastric cancer, laparoscopic gastrectomy, robotic gastrectomy, eso-jejunostomy

Background

Except for bariatric surgery, laparoscopic gastric surgery is not a widespread technique in Europe or Romania. The interest in this subject is therefore limited, as opposed to countries in Southeast Asia where the increased incidence of early gastric carcinoma has fueled the initiation and promotion of most of the current surgical techniques, both in open and minimally invasive surgery.

The study of minimally invasive surgery in advanced gastric cancer is not largely undertaken. Clinical research is directed towards multicentric randomised controlled trials in early gastric cancer, for which it is hoped that laparoscopic surgery will prove to be an oncologically sound alternative with good long term survival.

Robotic surgery is not an accessible technique. This is largely a matter of costs and it may be settled by the disappearance of the current monopoly on the market.

Gastric cancer surgery has been the interest of our team since 1996 (1). The purchase of the robotic system by our clinic, in January 2008, allowed us to perform the first robotic gastric resection on April 8th, 2008. Our initial experience with 2 cases has already been published (2). After going through the learning curve with these first 40 cases, we report our experience concerning advanced gastric cancer resection, lymph node dissection and reconstruction techniques.

Do minimally invasive surgery and advanced gastric cancer fit together?

Laparoscopy

Minimally invasive surgery in early gastric cancer is quickly becoming an accepted approach. Since the first laparoscopic assisted distal gastrectomy for early gastric cancer, performed by Kitano in 1994 (3), the technique has disseminated worldwide. Asian countries, especially South Korea and Japan, have screening programmes that allow for the precocious discovery of gastric cancer (4,5). The small size of the tumours makes laparoscopic surgery more accesible. Adding to this are the small build of the patients who usually have a reduced BMI and a small antero-posterior diameter.

The immediate benefits of laparoscopic surgery are undeniable: diminished post-operatory pain, reduced inflammation, rapid recovery of gastrointestinal function, shorter hospital stay and a quicker social reinsertion (6,7). The long term benefits remain to be proven in studies which can overcome the limitations of the ones already published (reduced number of patients, non-multicentric, conflicting results) (6,8,9). The KLASS study is the first randomised controlled prospective multicentric study comparing distal laparoscopic gastrectomy with open surgery in early gastric cancer. According to the preliminary data, post operatory mortality rates were 1,1% and 0% respectively (p=0,497). There were also no significant differences between mortality and morbidity (10). Besides this Korean study, there is also a Japanese study underway (JCOG0912). This is a Phase III study seeking to confirm the non-inferiority of laparoscopic distal gastrectomy to open surgery for early gastric cancer (11).

Regarding laparoscopic surgery in advanced gastric cancer, there is a series of small, retrospective studies that demonstrate non-inferiority to open surgery. The results from KLASS-02, another prospective randomised controlled trial which is underway in South Korea will ascertain the long term benefits of laparoscopic surgery in advanced gastric cancer (clinicaltrials.gov NCT01456598).

The 3rd edition of the Japanese gastric cancer treatment guidelines in English classifies laparoscopic gastrectomy under investigational treatments. This is more than 15 years after the first laparoscopic gastrectomy, which comes to prove that this type of surgery needs further reasearch before establishing its definitive indications (12).

Robotics

The da Vinci Surgical System (Intuitive Surgical Inc., Sunnyvale, CA, USA) was introduced in order to compensate for the difficulties in laparoscopic surgery (13). The robotic system aims to reduce the surgeons' discomfort and the counterintuitive movements. It also offers a three dimensional view and increased maneuvrability and precision due to the EndoWrist instruments allowing 7 degrees of freedom (14,15).

The first robot-assisted gastrectomy was performed by Hashizume in 2003 (16). Since then, the papers published illustrate either robotic surgery series, or comparisons between open or laparoscopic surgery and robotic surgery (17,18,19, 20). The largest number of patients reported in such a study was 236 by Woo et al (18). The immediate benefits are obvious and the procedures are feasible. However, this field also lacks statistical evidence from studies to sustain its long term benefits in the treatment of gastric cancer.

Given our previous experience with advanced gastric cancer, we were interested in applying the robotic technique to this field. We opted here for the presentation of the cases exclusive to our team in order to reduce the heterogeny in technical approaches and patient selection. We also wanted to assess the learning curve progression. It is well known that unsatisfactory results concerning post-operatory morbidity and surgical time are compensated by the team after a number of cases. This number is greater in laparoscopic surgery than in

robotic surgery where the learning curve reaches the plateau faster (21). It is also worth mentioning that robotic surgery allows for good results from the beginning, revealing a shallower learning curve (22). There are no established standards for the learning curve in robotic surgery for gastric cancer. Its evolution depends on the surgeons' experience with minimally invasive, open and oncological surgery. Also, the importance of age and ability must not be neglected – some learn easier, some learn harder, some never – and still don't give up. Besides the console surgeon, the assistant surgeon must also be qualified. In another paper we analyzed the role of the patient-side surgeon in robotic surgery and concluded that the interventions can benefit in safety and efficacy when the assistant surgeon is at the end of the learning curve (23).

The surgical experience behind our opinions in this paper

In this paper we do not wish to present a detailed analysis of our initial cases, but rather a few observations and lessons learned after the first 41 patients. This sort of information could enable other surgeons to go through their own learning curves.

Between April 2008 and July 2012 we performed a total of 41 surgeries which were as follows:

- 19 total gastrectomies: 14 for gastric adenocarcinoma and 5 for non-Hodgkin lymphoma;
- 16 distal gastrectomies for gastric adenocarcinomas;
- 1 proximal eso-gastrectomy for an eso-gastric junction adenocarcinoma;
- 1 pylorus-preserving gastrectomy for non-Hodgkin lymphoma;
- 3 paliative anastomoses for gastric adenocarcinomas;
- 1 gastrotomy for GIST. (*Table 1*)

What are the indications of minimally invasive surgery in gastric cancer?

The decision to operate on a gastric cancer patient with either laparoscopic or robotic surgery will only be taken after a thorough exploration. The degree of invasion, if any, and the location of the tumour need to be established prior to surgery. For that computer tomography, endoscopy and sometimes endoscopic ultrasound are needed. The tumours that do not invade the pylorus or the esophagus to an extent that would make thoracic approach necessary are eligible for minimally invasive surgery.

Table 1. *Chronology of the first robotic procedures and detailed anastomoses our team has performed*

Robotic procedure	Date of first procedure
Intervention	
Robot-assisted total gastrectomy	5 May 2008
Robot-assisted distal gastrectomy	8 April 2008
Robot-assisted proximal gastrectomy	31 January 2012
Anastomoses	
Robot-assisted eso-jejunostomy	5 May 2008
Robot-assisted gastro-jejunostomy	8 April 2008
Totally intracorporeal eso-gastrostomy (OrVil™)	31 January 2012
Totally intracorporeal eso-jejunostomy (double stapling)	9 March 2012
Totally intracorporeal side-to-side eso-jejunoanastomosis (overlap technique)	17 July 2012

On the surgical technique

Gastric cancer surgery – present status

It is now well known that the gold standard in gastric cancer surgery is the total or subtotal gastrectomy with D2 lymphadenectomy (12). The latter was controversial when it was first proposed by surgeons in Southeast Asia and it was extensively disputed by European studies showing unsatisfactory results (24). Long term results, however, have proven that there is a net survival benefit for patients undergoing this type of dissection (1,25,26).

An issue to be solved when trying to accomplish a D2 lymphadenectomy is the splenectomy. On a purely theoretical ground, we might state that the dissection of lymph nodes in group 10 makes splenectomy absolutely necessary. Nonetheless, splenectomy carries with it an increased risk of infectious complications and pancreatic fistulas which needs to be taken into account before performing this procedure (27). At the moment, distal gastric cancer benefits from D2 lymphadenectomy without splenectomy, while a proximal gastric cancer, for which D2 lymphadenectomy includes the excision of groups 10 and 11 (lymph nodes in the splenic hilum and along the splenic artery, respectively) requires performing a splenectomy. A recent Japanese study has included 505 patients with advanced gastric cancer in the upper third of the stomach. This study was retrospective, comparing 254 patients with splenectomy with 251 patients without splenectomy. It demonstrated that the splenectomy bought no benefit in terms of survival for the patients that had metastases in the splenic hilum nodes (group 10) (28). Nonetheless, when looking at these results we need to take into account the fact that this was not a randomised study. The JCOG0110-MF study which is underway seeks to eliminate these shortcomings by evaluating the same endpoints under a randomised controlled design (clinicaltrials.gov NCT00112099). Preliminary results from this study show a rise in post-operatory morbidity and bleeding in patients with splenectomy, but long term results are awaited in order to truly evaluate the need for splenectomy in gastric cancer surgery.

More extensive surgery than D2, like para-aortic lymph node dissection have shown no survival benefits (29). For locally invasive gastric cancer, resections of the pancreas and duodenum may also be required. They were shown to bring a survival benefit to patients with few lymph nodes metastasis (30), however the decision to perfom such an extensive resection must take into account the experience of the surgeon and the risk of major septic complications thereafter (31).

Differences between laparoscopy and robotics

Given the extent of the procedures that need to be performed in gastric cancer surgery, the laparoscopic approach has a high degree of dificulty and requires a very good training, as well as a strict quality control. This is why, this type of surgery is only suitable for high volume centers with experienced laparoscopic surgeons.

The robotic approach makes difficult steps in laparoscopic surgery more accesible. For instance, lymph node dissection along the celiac trunk, the left gastric artery and the hepatic pedicle which are usually associated with increased bleeding, are now performed in a more precise and safe environment, owing to the robotic system.

Anastomoses in robotic surgery

The reconstruction solutions after total or subtotal gastrectomy can be grouped into two large categories:

- Extracorporeal anastomoses by the so called robot assisted surgery – require the performance of a mini-laparotomy (smaller than 6 cm) through which the ends that need to be anastomosed are brought out and continuity of the digestive tract is reestablished, usually with the aid of a circular stapler. This technique is not suitable for obese patients for whom the incision may need to be larger than 6 cm in order to perform the proximal resection and the purse-string suture on the esophageal stump.
- Intracorporeal anastomoses – avoid the laparotomy and imply sectioning the esophagus under video control followed by any of the solutions we present below.

In subtotal gastrectomy, using robot-assisted extracorporeal reconstruction will shorten the operation time by 30-40%, but we have to take into account that the incision we need to perform is larger than the one necessary for taking out the resected stomach. We may regard this fact as a compromise, as it requires less surgical effort. This is why, we strongly advise for an intracorporeal reconstruction in obese patients for whom a laparotomy that cannot be "mini" may override the other benefits that robotic surgery has to offer.

Anastomoses in robotic surgery are largely adapted from laparoscopic surgery where the experience is greater, but so is the difficulty in suturing. In our team, we have adopted anastomosis techniques used in Southeast Asia for laparos-copic (Prof. Naoki Hiki – Cancer Institute Ariake Hospital, Tokyo) and robotic surgery (Prof. Woo Jin Hyung – Department of Surgery, Yonsei University College of Medicine, Seoul).

Key moments for the anastomosis are as follows: the closing of the duodenal stump; the closing of the stomach stump in subtotal gastrectomy, or that of the esophageal stump in total gastrectomy; preparing the jejunum for the gastro-jejunoanastomosis or the eso-jejunoanastomosis. We generally opt for a Roux-en-Y anastomosis.

Types of eso-jejunoanastomoses

1. End-to-side

At the moment, the standard reconstruction method is the end-to-side eso-jejunoanastomosis done using a 24 or 25 mm circular stapler. The difficulties in performing this type of reconstruction are the anvil placement in the esophageal stump and the creation of the purse-string suture needed to close the esophagus once the anvil is inside. In open surgery, these two problems are easily solved by using a purse-string clamp for the esophagus and a circular stapler thereafter. To compensate for the lack of a purse-string clamp in robotic surgery, a number of other techniques were imagined:

Manual purse-string suture

This is not a technique our team has great experience with. After sectioning the esophagus, the suture is performed manually, the anvil is introduced in the esophagus and then the purse-string is closed. The shaft of the stapler is introduced in the jejunal limb through an incision, and then the two sides are stapled together. This technique is seldomly used in laparoscopic surgery, but it has been adapted for use in robotic surgery. The disadvantage with this method is the difficult positioning of the anvil in the esophagus, given the narrow working space. Using excessive strength for this step may lead to a tear in the esophageal mucosa and an anastomotic leak with serious consequences.

Using the OrVil™

The difficulties of introducing the anvil in the esophagus lead to the creation of a device destined to deliver the anvil trans-orally to the esophageal stump. The OrVil™ (Covidien, Mansfield, MA, USA) is a foldable anvil which forms an 170° angle with the PVC tube it is attached to. This tube may be up to 95 mm long and the anvil is fixed in the folded position by polyester yarns that attach to it *(Fig. 1A)*. The free end of this tube is called the valve tip and is the first to be introduced trans-orally. An essential moment is passing the anvil through the pharyngo-esophageal junction. To ease this passage it is recommended to position the convex portion of the anvil towards the hard palate and to lubricate the entire device. The esophageal stump is closed with a linear stapler and the valve tip is pulled inside the patients' abdomen through a small incision created by the surgeon. The tube is pulled until the center rod of the anvil passes through the incision. The polyester yarns are then cut, the anvil unfolds and is positioned appropriately and the PVC tube is detached. The anastomosis is performed using the shaft of a stapler introduced through the jejunal stump *(Fig. 1B)* and connected to the OrVil™ *(Fig. 1C)*. For this procedure, we used a 21 mm stapler and the post-operative results were good. In order to eliminate the risk of an esophageal stricture, a 25 mm device is also being marketed, but its delivery to the esophagus is difficult, especially near the tracheal bifurcation and it also carries the risk of injury to the esophageal mucosa.

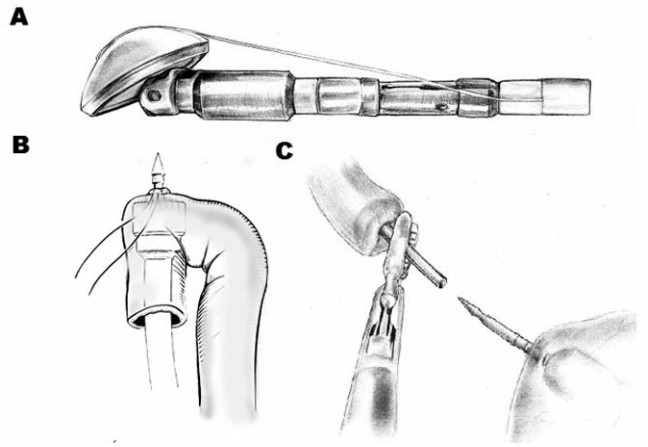

Figure 1. *Performing an end-to-side eso-jejunoanastomosis with an anvil delivered trans-orally (OrVil™). **(A)** The OrVil™ head with the foldable anvil which forms an 170° angle with the PVC tube it is attached to. The anvil is fixed in the folded position by polyester yarns which connect it to the tube. **(B)** The shaft of the stapler is passed through the Roux-en-Y jejunal limb. **(C)** The shaft of the stapler is connected to the rod of the OrVil™*

Figure 2. *End-to-side eso-jejunoanastomosis using the double stapling technique. The head of the anvil is tied to the end of a nasogastric tube which has been brought out through one of the operation ports. A 10 cm fragment from another nasogastric tube is fixed to the rod of the anvil. By drawing on the nasogastric tube previously inserted, the anvil will be introduced in the peritoneal cavity*

Double stapling technique

This was presented in 2007 by Prof. Naoki Hiki (32). This technique is conceived so as to minimize the damage inflicted to the esophagus. Before sectioning the stomach a small incision is made above the eso-gastric junction through which a nasogastric tube is passed. The tube is then brought to the exterior through one of the operation ports. The anvil of a circular stapler is attached to the nasogastric tube using sutures. Another 10 cm fragment of a nasogastric tube is attached to the rod of the anvil (*Fig. 2*). The anvil is then put back in the peritoneal cavity. Under video control, the nasogastric tube is pulled back until the anvil reaches the desired position in the esophagus *(Fig. 3)*. The esophagus is then sectioned with and EndoGIA™ stapler just below the anvil *(Fig. 4)*, the anvil rod is brought out and the anastomosis is performed as above with the jejunal limb (*Fig. 5-6*). We used this technique for two cases, neither of which had post-operatory complications.

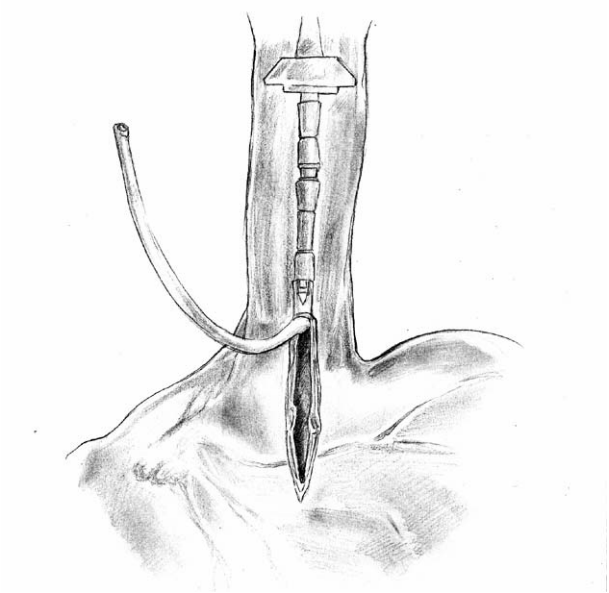

Figure 3. *End-to-side eso-jejunoanastomosis using the double stapling technique. The anvil is pulled into the desired position in the esophagus. Without severing the esophagus completely, a small vertical incision is made, through which the nasogastric tube fragment will be taken out and maintained in position for the next step. Modified after (32)*

Entirely manual suturing

The manually sutured anastomosis is not a solution that we would recommend. Although feasible, it is no longer a real option in open or minimally invasive surgery. It prolongs the operative time unnecessarily, since mechanical anastomoses have now been proven efficient and reliable.

2. Side-to-side

The side-to-side eso-jejunoanastomosis is made by closing the esophageal stump with and EndoGIA stapler. It is also called the overlap technique. After creating a Roux-en-Y jejunal limb, the proximal end of the jejunum is also stapled with EndoGIA™. 7 cm below this stapling line, a small incision is created through which a fork of a 45 mm linear stapler is

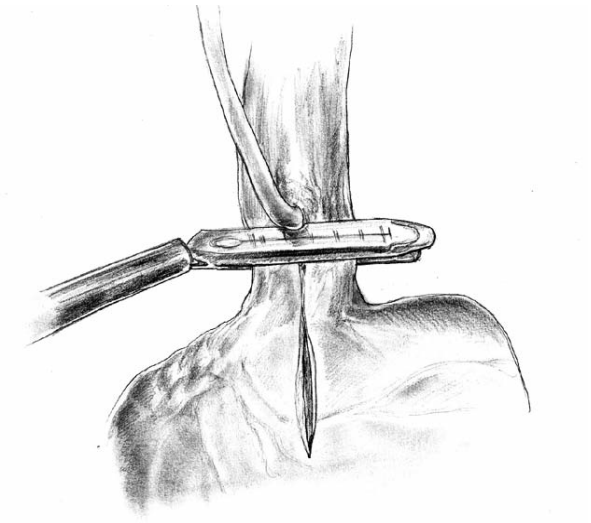

Figure 4. *End-to-side eso-jejunoanastomosis using the double stapling technique. The esophagus is sectioned with a linear stapler just below the rod of the anvil. Modified after (32)*

Figure 5. *End-to-side eso-jejunoanastomosis using the double stapling technique. Intraoperatory view. After stapling the esophagus, the nasogastric tube fragment is pulled on until the head of the anvil becomes fixed in the desired position in the esophageal stump*

Figure 6. *End-to-side eso-jejunoanastomosis using the double stapling technique. Intraoperatory view. The shaft of the stapler was introduced in the jejunal limb (lower right) and connected to the anvil rod. The stapler was fired afterwards*

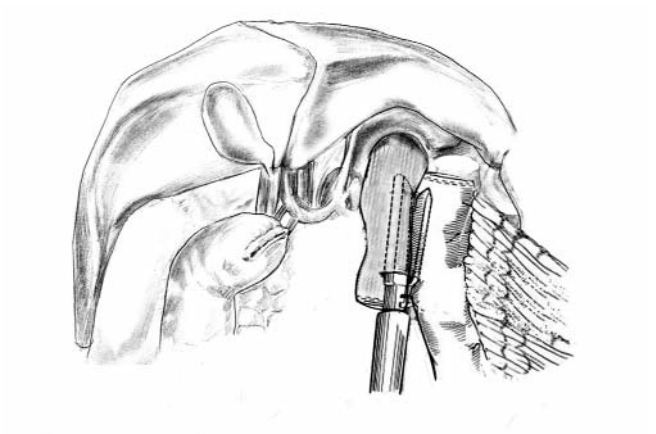

Figure 7. *Side-to-side eso-jejunoanastomosis by overlap technique. In order to perform the overlap anastomosis, the jejunal limb is brought next to the esophageal stump. One fork of the linear stapler is introduced through an incision performed 7 cm below the jejunal stapling line and the other one is inserted through the esophagus. The two ends are stapled together and the remaining orifice is sewn manually*

introduced. The jejunal limb is drawn up and positioned next to the esophagus. Another small incision is created in the esophageal wall through which the second fork of the linear stapler is introduced. The two ends are then stapled together *(Fig. 7)*. The incision through which the stapler was introduced will then be manually sutured in order to complete the anastomosis (33). This is a technique our team uses mainly in open surgery. We also performed it once using the robotic system and we are satisfied with the results.

Conclusions

The current standard of care in gastric cancer surgery is gastric resection with D2 lymph node dissection. Progress in minimally invasive surgery allows emerging techniques like laparoscopy and robotic surgery to also be considered as a therapeutic option for these patients. However, these procedures have an increased difficulty and they require a skilled, well trained surgical team. It is therefore recommended for minimally invasive surgery for gastric cancer to be performed

in centers with experience in oncologic laparoscopic or robotic surgery. Concerning the reconstruction techniques, we strongly advocate for the intracorporeal anastomoses. The option for the specific technique should be made according to the surgeons' experience and preferences. The expected long term benefits of minimally invasive techniques are still a matter of research and it remains to be seen if the good results rendered by laparoscopy and robotics so far will also be confirmed in terms of survival on large numbers of gastric cancer patients.

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