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Rapid and safe learning of robotic gastrectomy for gastric cancer: Multidimensional analysis in a comparison with laparoscopic gastrectomy

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Abstract

Background: The learning curve of robotic gastrectomy has not yet been evaluated in comparison with the laparoscopic approach. We compared the learning curves of robotic gastrectomy and laparoscopic gastrectomy based on operation time and surgical success.
Methods: We analyzed 172 robotic and 481 laparoscopic distal gastrectomies performed by single surgeon from May 2003 to April 2009. The operation time was analyzed using a moving average and non-linear regression analysis. Surgical success was evaluated by a cumulative sum plot with a target failure rate of 10%. Surgical failure was defined as laparoscopic or open conversion, insufficient lymph node harvest for staging, resection margin involvement, postoperative morbidity, and mortality.
Results: Moving average and non-linear regression analyses indicated stable state for operation time at 95 and 121 cases in robotic gastrectomy, and 270 and 262 cases in laparoscopic gastrectomy, respectively. The cumulative sum plot identified no cut-off point for surgical success in robotic gastrectomy and 80 cases in laparoscopic gastrectomy. Excluding the initial 148 laparoscopic gastrectomies that were performed before the first robotic gastrectomy, the two groups showed similar number of cases to reach steady state in operation time, and showed no cut-off point in analysis of surgical success.
Conclusions: The experience of laparoscopic surgery could affect the learning process of robotic gastrectomy. An experienced laparoscopic surgeon requires fewer cases of robotic gastrectomy to reach steady state. Moreover, the surgical outcomes of robotic gastrectomy were satisfactory.

Keywords: Stomach neoplasms; Laparoscopy; Robotic surgery; Learning curve

Introduction

Laparoscopic gastrectomy is now regarded as oncologically safe and has become the recommended approach for early stage gastric cancer.[1,2] However, laparoscopic gastrectomy is a challenging procedure that has a steep learning curve. With its well-known advantages, robotic surgery is considered a good alternative approach to overcome the technical difficulties of laparoscopic surgery.[3] Robotic gastrectomy demonstrated satisfactory initial surgical outcomes, and its clinical application is increasing.[4–8]

Previously, it was reported that robotic surgery has a short learning period.[9–14] However, the only learning parameters investigated were operation time and postoperative morbidity; and comprehensive evaluations of the learning process of robotic surgery are still lacking. Furthermore, data comparing the learning curves of robotic and laparoscopic surgeries are not available.

Of all the parameters that evaluate the learning process, operation time is the most widely used parameter for surgical proficiency. However, the value of analyzing operation time is attenuated by patient selection for successful adaptation during the initial period.[15,16] On the other hand, in

Abbreviations: CUSUM, cumulative sum.

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evaluating the surgical success, it is essential that not only postoperative morbidity and mortality are assessed. Open conversion and oncological safety are important parameters for evaluation of surgical proficiency.[17,18]

Here we introduced multidimensional learning curve analysis to assess and compare the learning curves of robotic and laparoscopic gastrectomies. To analyze operation time, we used the moving average method as well as non-linear regression analysis to objectively identify learning parameters and to adjust for variables that affect operation time. To evaluate surgical success, we used cumulative sum (CUSUM) plot incorporating open conversion, oncological safety, postoperative morbidity, and mortality.[19]

Patients and methods

Patients

DATA of this study was based on the gastrectomies performed by a single surgeon at Yonsei University Severance Hospital, Seoul, Korea. The surgeon started his first laparoscopic gastrectomy in May 2003 and robotic gastrectomy began in July 2005 after the surgeon had performed 177 laparoscopic gastrectomies including total gastrectomy and combined resections. Since May 2003, all the minimally invasive surgeries for gastric cancer were recorded in a prospectively designed database. From the database, we found 883 consecutive minimally invasive gastrectomies including the surgeon's initial experience (247 robotic and 636 laparoscopic gastrectomies). We included 653 distal gastrectomies after excluding 186 total gastrectomies and 44 combined resection cases; specifically 20 cholecystectomies, 7 gynecologic, 6 urologic, 4 colorectal, and 7 other surgical procedures. Finally, we retrospectively analyzed those 172 robotic and 481 laparoscopic distal gastrectomies with lymphadenectomies. The patient's decision on the type of operation was made after receiving a comprehensive explanation of the surgical procedures of robotic, laparoscopic and open gastrectomies. All patients gave informed consent for surgery, including the extra cost for robotic surgery. This retrospective study was approved by Institutional Review Board of Severance Hospital, Yonsei University College of Medicine. (4-2010-0507).

Preoperative staging work-up and indications

Preoperative staging work-up was performed by esophagogastroduodenoscopy, endoscopic ultrasonography, and computed tomography. Although the initial indication for both robotic and laparoscopic gastrectomies was gastric cancer confined to the mucosa or submucosa without lymph node metastasis, the indication was extended to gastric cancers with invasion into the subserosal layer or lymph node metastasis in the perigastric area. Patients who were candidates for endoscopic treatment did not receive surgical intervention.[20]

Operative technique

The da Vinci® Surgical System was used for all robotic gastrectomies. The operation procedure for robotic gastrectomy was the same as for the laparoscopic procedure except for the use of articulating robotic instruments under three-dimensional view at the console. The rules of the Japanese Research Society for Gastric Cancer were used to determine the extent of lymph node dissection necessary, either D1 + beta or D2.[21] Detailed surgical procedures were described previously.[5,8,15] The anastomosis type (gastroduodenostomy or gastrojejunostomy) and approaches (intra-corporeal or extra-corporeal anastomosis) were selected according to tumor location and the surgeon's preference.

Postoperative management

All patients without serious comorbidities were sent to the general ward after the operation. Oral diet started with sips of water on postoperative day 2 and advanced as tolerated to a soft diet on postoperative day 4. Once soft diet was tolerated for 1 day, patients were recommended to be discharged.

Statistical analysis

All statistical results were obtained using the SAS program (Version 9.1.3, SAS Institute Inc., Cary, NC, USA). We considered $\alpha = 0.05$ for the level of significance and regarded p-values < 0.05 as statistically significant.

Comparison of clinicopathologic features

Data were expressed as mean ± standard deviation (SD) for numerical variables and as the number of cases (percentage) for categorical variables. To assess differences between the two groups (robotic vs. laparoscopic gastrectomy), we used the independent two-sample t-test for continuous variables. The Pearson chi-squared test was used to test for statistical differences in the distributions of categorical variables.

Comparison of learning curve effect

Operation time analyses

Moving average. To build a learning curve for the operation time of robotic and laparoscopic surgeries, we used the 20-patient moving average method. This average was defined as the mean of the operation time of the previous 20 cases. When the flattening of the graph was observed, we defined it as stable state.. *Non-linear regression*. We considered the following parametric non-linear regression model to estimate the stable operation time (s), reduced time by learning (r), and the number of cases for learning