Original Article

Gastrointestinal stromal tumours of stomach: Robot-assisted excision with the da Vinci Surgical System regardless of size and location site

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Abstract

Aims: The role of minimally invasive surgery of gastrointestinal stromal tumours (GISTs) of the stomach remains uncertain especially for large and/or difficult located tumours. We are hereby presenting a single-centre series of robot-assisted resections using the da Vinci Surgical System (Si or Xi).

Subjects and Methods: Data of patients undergoing robot-assisted treatment of gastric GIST were retrieved from the prospectively collected institutional database and a retrospective analysis was performed. Patients were stratified according to size and location of the tumour. Difficult cases (DCs) were considered for size if tumour was >50 mm and/or for location if the tumour was Type II, III or IV sec. Privette/Al-Thani classification.

Results: Between May 2010 and February 2017, 12 consecutive patients underwent robot-assisted treatment of GIST at our institution. DCs were 10/12 cases (83.3%), of which 6/10 (50%) for location, 2/10 (25%) for size and 2/10 (25%) for both. The da Vinci Si was used in 8 patients, of which 6 (75%) were DC, and the da Vinci Xi in 4, all of which (100%) were DC. In all patients, excision was by wedge resection. All lesions had microscopically negative resection margins. There was no conversion to open surgery, no tumour ruptures or spillage and no intraoperative complications.

Conclusion: Our experience suggests a positive role of the robot da Vinci in getting gastric GIST removal with a conservative approach, regardless of size and location site. Comparative studies with a greater number of patients are necessary for a more robust assessment.

Keywords: Da Vinci Xi, gastrointestinal stromal tumour, posterior gastric wall, robot assisted, robotic surgery

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Received: 14.12.2017, **Accepted:** 19.02.2018

INTRODUCTION

Gastrointestinal stromal tumours (GISTs), although rare, are the most common mesenchymal tumours of the gastrointestinal tract,[1] with the most common site being the stomach, and complete *en bloc* surgical resection with negative margins, being the established gold standard.[2] The extent of gastric resection varies, however, from wedge resections containing the tumour to total gastrectomy, depending on GIST size and location. Nowadays, the laparoscopic approach of GISTs is favoured because of

Access this article online	
Quick Response Code:	Website: www.journalofmas.com
	DOI: 10.4103/jmas.JMAS_260_17

How to cite this article: Furbetta N, Palmeri M, Guadagni S, Di Franco G, Gianardi D, Latteri S, *et al*. Gastrointestinal stromal tumours of stomach: Robot-assisted excision with the da Vinci Surgical System regardless of size and location site. J Min Access Surg 2019;15:142-7.

the optimal results reported by several published studies,[3-5] in view of the well-document benefits of the minimally invasive approach in terms of post-operative course and accelerated recovery.[6] The National Comprehensive Cancer Network restricts the use of the laparoscopy approach for tumours <2 cm[7] and the European Society for Medical Oncology (Sarcoma Network Working Group) discourages this approach in patients harbouring large tumours, because of the risk of tumour rupture, which is associated with a very high risk of recurrence.[8] However, in recent years, several surgeons have reported optimal results with laparoscopic resection regardless of the tumour size,[3-5,9,10] with different surgical resection procedures for tumours located in difficult sites, for example, posterior wall, gastro-oesophageal junction and antrum.[11,12]

Robot-assisted surgery (RAS) was introduced to overcome the kinematic limitations of direct manual laparoscopic surgery consequent of the reduced degrees of freedom (DoF = 4). RAS provides the surgeon with a HD 3D stable view of the operative field, motion scaling with tremor filtering and enhanced dexterity, due to an internal wrist located proximal to articulated instruments, facilitating complex and difficult dissection, more delicate tissue manipulation and easier intra-corporeal suturing for surgical reconstruction. The latest version, the da Vinci Xi, is expected to overcome some of the drawbacks intrinsic to the previous platforms, due to its several innovations and technologies, thereby increasing the acceptance of its use for minimally invasive techniques in all surgical fields. Its use has been associated with a shorter operative and console time and with an improvement in allowing multi-quadrant surgery.[13-16] However, robotic surgery is more costly than conventional laparoscopy, thus underscoring the need to better define its advantages and its role in surgical practice.

Currently, there are few scan data reported in literature, only about the role of robot da Vinci Si in the GIST treatment, with a very heterogeneity of surgical choices and on a small number of patients. The aim of this study is to present our single-centre experience in robotic surgery of the gastric GISTs with the use of both the da Vinci Si and Xi.

SUBJECTS AND METHODS

Data of patients with gastric GISTs undergoing robot-assisted treatment were retrieved from a prospectively collected institutional database and were used in the present retrospective analysis. This contained patients' demographics, age, gender, body mass index (BMI), American Society of Anaesthesiologists score and comorbidities. The pre-operative workup included standard plasma biochemical analysis, abdominal ultrasonography, endoscopy and endoscopic ultrasonography, chest radiography and/or abdomen computed tomography (CT) scan and magnetic resonance imaging (MRI). Data were collected on tumour size, its location, surgical operation performed, type of robot used (Si or Xi), operative time, estimated blood loss and details of any blood transfusion in the perioperative period. Patients were stratified according to size and to the Privette classification[12] modified by Al-Thani *et al*.:[17] Type I (fundus and greater curve); Type II (antrum); Type III (lesser curvature and near the gastro-oesophageal junction) and Type IV (posterior gastric wall). Difficult cases (DCs) were considered for size if tumour was >50 mm and/or for location site if the tumour was Type II, III or IV sec. Privette/Al-Thani classification. Postoperatively, the data collected included pathological diagnosis with biomolecular analysis, length of hospital stay, post-operative morbidity according to Clavien-Dindo[18] and post-operative mortality. All patients were followed up at the outpatient clinic 2 weeks after discharge and subsequently after 6 or 12 months for oncologic follow-up. The study was approved by the institutional review board. All patients received an extensive explanation of the procedure and provided informed consent.

Statistical analysis

SPSS version 21.0 (IBM Corp., Armonk, NY, USA) and STATA version 13 (STATACorp., TX, USA) software were employed for statistical analysis. Continuous variables are given as mean ± standard deviation and compared using Student's *t*-test; $P < 0.05$ was considered statistically significant. Variables with a non-normal distribution are expressed as median and compared using the Wilcoxon Test. Statistical significance was set at 5%.

Operative technique

All the operations were performed by the same surgeon experienced in robotic surgery (>400 cases). Intraoperative ultrasound (US) scanning and/or endoscopy were performed when necessary. Patients were placed in the supine position with arms laid alongside the body. The pneumoperitoneum is achieved through a Veress needle in the umbilical pit or with an open access in patients with previous abdominal surgery. An 8 mm (da Vinci Xi) or 12 mm (da Vinci Si) trocar was placed just below the umbilicus for the 30° optic and two or three other 8 mm robotic trocars were placed as showed in Figure 1. Following port insertions, the patient was placed in a reverse Trendelenburg position, inclined 15° to the left in order to improve visualisation. During the procedure, a 12 mm extra-port was introduced for laparoscopic surgical instruments controlled by the assistant surgeon. Wedge

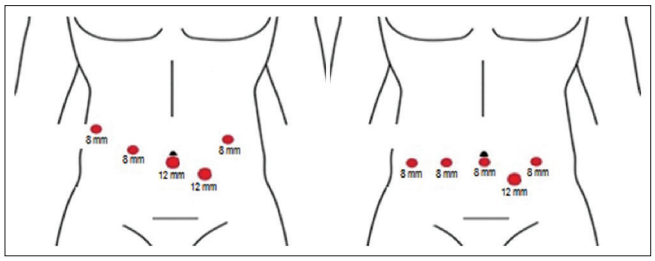

Figure 1: Trocar position with da Vinci Si and Xi

resection of the tumour was performed with monopolar scissors and bipolar coagulation. Closure of gastric wall was performed either with a two-layered running 2/0 Vicryl suture or with linear stapler reinforced with a running 2/0 Vicryl suture. All resection specimens were removed using an Endobag either through the 12 mm trocar port or through a suprapubic Pfannenstiel incision. The operative time was defined as the time between skin incision and port-site wound closure.

RESULTS

The consecutive series of 12 patients undergoing RAS of gastric GIST between May 2010 and February 2017 comprised 7 females and 5 males with a mean age was 67.4 ± 2.7 years and mean BMI was 24.9 ± 7.1. Four patients were asymptomatic, the gastric lesions being identified incidentally. Another four patients were referred for the evaluation of abdominal discomfort and dyspepsia, two with abdominal pain, one with anaemia and another presented with acute gastrointestinal bleeding with melena. Four patients had previously undergone abdominal surgery. The main medical risks were cardiopulmonary disease (3 patients), high blood pressure (6 patients) and diabetes (1 patient). Pre-operative endoscopy was performed in all patients and endoscopic ultrasonography in 7 patients. The US showed typical characteristics and pattern of growth of mesenchymal tumour. Pre-operative abdominal CT scan was performed in 10 patients and an MRI in the remaining 2.

The locations of the tumour were fundus/greater curvature (n = 4, Type I), antrum (n = 2, Type II), lesser curve (n = 3, Type III), just below the gastro-oesophageal junction (n = 1, Type III) and posterior wall (n = 2, Type IV) while 4/12 (33.3%) of tumours were >50 mm. DCs were 10/12 cases (83.3%), of which 6/10 (50%) for location, 2/10 (25%) for size and 2/10 (25%) for both. The da Vinci Si was used in 8 patients, of which 6 (75%) were DC, and the da Vinci Xi in 4, all of which (100%) were DC. The mean size in Si group was 4.4 ± 1.4 while mean size in Xi group was 2.8 ± 0.7 [Table 1].

Table 1: Distribution of cases in the Da Vinci Si and Da Vinci Xi group according to Privette

	Number of cases	Tumour size (cm)
Da Vinci Si group		
Privette Type I	4	6; 6; 3.5; 3
Privette Type II	1	4.5
Privette Type III	2	5.5; 2
Privette Type IV	1	5.1
Da Vinci Xi group		
Privette Type I	0	-
Privette Type II	1	2.9
Privette Type III	2	3; 1.8
Privette Type IV	1	3.5

In all patients, excision was by wedge resection. Robotic-assisted resection to include the tumour through normal gastric wall was performed in all cases. In the series, 8 patients (Type II, III, IV) had a two-layered closure of the gastrotomy with running suture, whereas in 4 patients (all Type I), closure was effected using a linear stapler reinforced by a running suture. During the operation, one patient underwent liver biopsy for HCV-related hepatitis and another cholecystectomy for gallstones.

The mean operative time was 149 ± 16.6 min. The operative time with the Da Vinci Xi was shorter than that incurred when the Si platform was used (107 vs. 170 min; P = 0.04).

There was no conversion to open surgery, tumour ruptures or spillage and no intraoperative complications. No blood transfusions were necessary during surgery. Blood transfusion was necessary in only one patient during the post-operative period. Histology of the resected specimens confirmed microscopically negative resection margins. Mean tumour size was 3.8 ± 1.4 cm. Mitotic index per 50 HPF was <5 in 10 cases and >5 in 2 cases. Depending on the size and mitotic index of the tumours, patients were stratified into four risk groups according to Fletcher's criteria as very low risk 1 (8%), low risk 7 (58%), intermediate risk 3 (25%) and high risk 1 (8%). Biomolecular analysis was performed in 6 patients: 4 of had GISTs with a KIT mutation on exon 11 and 2 of had GISTs with a PDGRFA mutation in exon 18.

Mean post-operative hospital stay was 4.8 ± 1.1 days. The nasogastric tube was removed after a median of 2.5 (range 1–3) days and abdominal drainage after an average of 3.3 ± 0.9 days. Only two patients were admitted to the intensive care for the first night after surgery due to the co-morbidities. No patient needed reoperation. Post-operative course and morbidity are summarised in Table 2. Only one patient had blood transfusion after surgery (Grade II Clavien-Dindo classification) and one had had an episode of atrial fibrillation

Table 2: Post-operative course

Surgical and oncologic data	Values
Mean hospitalisation length of stay, days	4.8±1.1
Median nasogastric removal, days (range)	2.5 (1-3)
Grade of complications (Clavien-Dindo), *n*	
0	10 (83)
1	1 (8)
2	1 (8)
3	0
4	0
5	0
30-day mortality	0
Adjuvant therapy	1
Follow-up	38.5±35.3 months
End result	All 12 cases are alive and had no recurrences during follow-up

(Grade I Clavien-Dindo classification.). The only patient, with high-risk pathology, received adjuvant imatinib therapy after surgery. Mean follow-up time was 38.5 months, range 3–90, and all patients were confirmed well and free of recurrence to date.

DISCUSSION

The current consensus is that all GISTs require surgical resection in view of the variable biological behaviour of these tumours and all have the potential of malignancy irrespective of size and low mitotic index.[8,19] In contrast to solid cancers which exhibit an infiltrating pattern with lymphatic submucosal spread, GISTs tend to spread locally along the gastric submucosa. Hence, resection requires complete excision with surrounding normal gastric wall with the aim of achieving complete excision (R0 resection) with 1–2 cm margin with care to avoid tumour rupture. This objective is nowadays eminently achievable with used of linear stapler, which enables complete wedge resection, currently the standard surgical procedure for excision of these gastric tumours, in preference to major gastrectomies as lymph node involvement is rare, obviating the need for regional lymphadenectomy.[20]

Although the safety and feasibility of laparoscopic resection for gastric GISTs is well documented, some concerns have been raised on the long-term outcome after localised laparoscopic resections. The most important risk factors are related characteristics of the tumour including tumour size and its location. The initial tumour size threshold of 2 cm precluding localised laparoscopic resection was subsequently reviewed in view of the effectiveness and safety reported by several studies of laparoscopic resection of larger gastric GIST.[3-5,9,21,22] For lesions situated in difficult locations, the role of laparoscopic surgical approach remains unresolved. In this respect, Privette proposes stapler resection for lesions along the greater curvature or anterior fundus as the optimal method whereas resection in other locations is usually more challenging with the use of stapler.[12] Along the same line, Seong Ho Kong reviewed several laparoscopic/endoscopic approaches in relation to GIST location and considered the gastroesophageal junction the most demanding area concluding that the open methods remain the preferred ones in this location site.[23] Only one paper reported good results with pure laparoscopy in this location, but having the bias of including in the series also tumors located in the nearby (upper edge within 5 cm), but not exactly of the gastroesophageal junction, and so including several cases manageable through applications of linear staplers.[11]

The published literature of RAS resection of gastric GISTs is limited consisting of a report of four cases of wedge resections and one total gastrectomy performed with the da Vinci Si, published by Buchs *et al*.[24] in 2010, with satisfactory oncologic result and without any recurrence. Desiderio *et al*.[25] reported another series of five GISTs located in the pyloric region, all treated with large gastric resection because they considered risk of gastric stenosis too high in this location following wedge resection. Subsequently, the literature review published by Vicente *et al*.[26] in 2016 on RAS resection for GISTs achieves a favourable perioperative outcome and does not compromise the patients' outcome and oncologic safety. More important Moriyama *et al*.[27] and more recently Al-Thani[17] reported only five cases, all located in the gastric posterior wall and suggested, based on their experience that the robotic approach could have an important role in tumour located at the oesophago-gastric junction as well as the posterior gastric wall, which usually pose technical difficulties and are thus challenging to treat laparoscopically because of the risk of narrowing of the gastric outlet or access to target anatomical site [Table 3].

The results of the current series resected by the RAS with the da Vinci platform indicate that GISTs located in any gastric region were followed by a good clinical outcome in all patients. Our intra- and post-operative results are encouraging, especially in view of the prevalence in our series of DC in 83.3% of the patients treated.[12,17] We did not encounter any adverse event: tumour rupture, R1 resection, leaks, stenosis or other major complications, even with big tumours, confirming that robot can facilitate this type of surgery, regardless tumour size and location, without compromising safety and oncologic outcomes. In our opinion, the main advantages provided by the robot in these DCs included the increased ability to expose the posterior wall in Type IV and to dissect and suture for reconstruction after resection of Type II and III and IV

Table 3: Comparative summary between literature review and present series

Author (year)	Number of patients	Type of resection	R0	Operative time, min Mean (range)	Tumour localisation	Tumour size, cm Mean (range)	Privette/ Al Thani classification	Da Vinci system	Length of stay, days Mean (range)
Buchs N (2010)	5	4 WR 1 TG (conversion to open surgery)	5	192 (132-285)	2 cardia 3 antrum	5.6 (4.2-7)	Type II, III	Si	7.2 (5-10)
Desiderio J (2013)	5	5 DG	5	240 (210-300)	2 antrum 3 prepyloric	5 (4-7)	Type II	Si	4.2 (3-5)
Vicente (2015)	6	1 WR 2 DG 3 DE	6	245 (150-540)	1 cardia 2 antrum 3 duodenum	3.9 (2.4-5.5)	Type II, III	Si	10.5 (6-24)
Al Thaani (2016)	4	4 WR	4	360	4 posterior gastric wall	6 (3.5-10)	Type IV	Si	8 (5-8)
Present series (2017)	12	12 WR	12	150 (75-240)	4 anterior gastric wall 2 antrum 3 lesser curvature 1 cardia 2 posterior gastric wall	3.9 (1.8-6)	Type I, II, III, IV	Si, Xi	4.8 (3-7)

WR: Wedge resection, TG: Total gastrectomy, DG: Distal gastrectomy, DE: Duodenal enucleation

tumours. Specifically, in Type II and III, we avoided the use the staplers because of risk of stenosis, which is the main reason for partial or total gastrectomy in reported literature.

Furthermore, since January 2015, when the institution acquired the new da Vinci Xi, we noted that this version provides additional technical advantages over the previous Si platform and have observed a trend towards a reduced operative time despite the high rate of DC in this subgroup (100% vs. 75% of the Si group). The rapid docking and the targeting system explain faster execution whereas the manoeuvrability of the chart and the reduced instrument collisions facilitates complex surgical tasks requiring a wide range of motion. A limitation of this comparison, which is not the main aim of the present manuscript, aside from its retrospective nature, the small and heterogeneous sample size, may be related to a 'proficiency-gain effect' that may create a bias in favour of one or other group. However, we think that because 'the proficiency gain effect' is related only to the use of the new robotic technology and not to the surgical operation itself (wedge gastric resection), the same 'new proficiency-gain curve' should be considered also for the Xi and so should balance this possible bias. In fact, changing from Si to Xi, the surgeon must deal with new trocar dispositions, robotic cart position, new functions (pointing, targeting, camera hopping, etc.), new docking system and robotic arm regulation. For this reasons for the first Xi cases as well as for the first Si cases, the surgeon underwent a similar proficiency-gain phase which is difficult. On this basis, as the proficiency-gain learning curve affected both groups, it is unlikely that it influenced the results.

Main limitations of the present study are the small sample size and the absence of a comparison between RAS and conventional laparoscopy, in particular, in the era of 3D and 4K HD camera and monitors that offer better vision and more careful handling of the tumour in respect to the past. However, we think that the reported good results of our experience should amplify the need of comparative studies in the same setting between the da Vinci surgical robots over conventional laparoscopy, in view of documenting any benefits from the more expensive robotic approach.

To our knowledge, the present manuscript is the largest series reported to date of robotic conservative treatment of gastric GIST located in any gastric area as well as the first to report on the initial experience with the use of the Xi da Vinci for localised resection of gastric GISTs. The availability of robotic staplers with direct control by the operating surgeon will make possible further improvements in this surgery.

CONCLUSION

Our experience suggests a positive role of the robot da Vinci in getting gastric GIST removal with a conservative approach, regardless of size and location site. The da Vinci Xi could further improve the results, but comparative studies between conventional laparoscopy and both the da Vinci Si and Xi, with a greater number of patients, are necessary for a more robust assessment.

Acknowledgements

None.

Financial support and sponsorship

This study was financially supported by the Arpa foundation (www.fondazionearpa.it).

Conflicts of interest

There are no conflicts of interest.

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