Indocyanine green tattooing for resection of endophytic submucosal lesions at anatomically difficult locations: Broader application of robotic platform

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INTRODUCTION

Gastrointestinal stromal tumour (GIST) is the most common mesenchymal tumour in the gastrointestinal tract.\[1\] Mutations in the cell surface KIT receptor of interstitial cells of Cajal is found in approximately 90% of cases.\[2\] GISTs >2 cm should be resected with negative margins because of their malignant potential.\[3\] GISTs arising at anatomically difficult locations such as lesser curve and gastrooesophageal junction comprise approximately 5% but are technically challenging due to their endophytic growth making them inconspicuous with minimally invasive techniques. Moreover, the surgeon may inadvertently remove a large amount of mucosa and create stenosis if the resection is not well planned. The recent introduction of da Vinci XI platform with its firefly technology has taken minimally invasive surgery to the next level advancement with excellent visualisation and safe oncologic resection of gastrointestinal cancers. We describe our technique of

**Abstract**

**Background:** Endophytic submucosal masses at anatomically difficult locations such as lesser curve of the stomach, juxta-gastroesophageal junction and duodenum are challenging to resect laparoscopically due to proximity of vital structures and difficulty to visualise them. To overcome these limitations, we describe a technique of endoscopic tattooing with indocyanine green (ICG) injection into the lesion allowing easy identification and oncological resection in a minimally invasive manner.

**Patients and Methods:** The technique of endoscopic tattooing of the lesion and robotic transgastric eversion resection technique is described in patients with gastrointestinal tumours at difficult anatomical location.

**Results:** Gastric gastrointestinal stromal tumours at the lesser curve \(n = 3\) and gastroesophageal junction \(n = 1\) were resected using this technique successfully.

**Conclusion:** The use of intraoperative ICG tattooing of endophytic submucosal lesions at difficult locations can facilitate minimally invasive oncologic resection. This technique allows the surgeon to be more comfortable to approach complex lesions safely to improve patient outcomes.

**Keywords:** Da Vinci XI®, gastroesophageal junction, gastrointestinal stromal tumour, indocyanine green, lesser curve

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Submitted: 14-Oct-2019, Revised: 04-Nov-2019, Accepted: 27-Nov-2019, Published: 17-Sep-2020

How to cite this article: Pratap A, Mungo B, McCarter M. Indocyanine green tattooing for resection of endophytic submucosal lesions at anatomically difficult locations: Broader application of robotic platform. J Min Access Surg 2020;16:438-40. This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

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Journal of Minimal Access Surgery | Volume 16 | Issue 4 | October-December 2020

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indocyanine green (ICG) tattooing of endophytic GISTs located at the lesser curve and para-gastroesophageal junction to facilitate a focused transgastric oncologic resection of the lesions.

PATIENTS AND METHODS

The operative technique of four patients with biopsy-proven GIST is described in this report. Their workup consisted of an upper endoscopy with core biopsy, an endoscopic ultrasound and computed tomography [Figure 1a and b]. All lesions were >3 cm and were located at the lesser curve (n = 3) and 2 cm distal to the gastroesophageal junction (n = 1). Operative position and port placement are shown in Figure 1c. The patient is placed in a supine position. A three-port technique is used with 8-mm robotic trocars, with a port camera 12 cm below the xiphoid process and two 8-mm robotic ports. An additional left upper assist port can be selectively placed. Next, an intraoperative endoscopy is performed after the console surgeon gently occludes the pylorus to prevent insufflation of the small bowel during endoscopy. The location of the lesion with reference to the gastroesophageal junction is carefully delineated and measured [Figure 1d]. Once the lesion is identified, under direct vision 3 cc (1.5 mg) of ICG is injected at four quadrants in the submucosal plane, as shown in Figure 1e. Next, the surgeon turns on the firefly mode and can accurately localise the lesion as a green fluorescent region of interest [Figure 1f]. A gastrotomy is made right over the fluorescent signal to prevent excessive mucosal resection which may result in gastric stenosis [Figure 1g]. The lesion can then be easily everted and resected with gross negative margins using robotic endoshears [Figure 1h]. A specimen is retrieved and the gastrotomy is closed in two layers using inner absorbable and an outer non-absorbable 3-0 suture [Figure 1i]. A leak test with endoscopic insufflation is performed at the completion of the procedure.

RESULTS

Of the four patients who underwent resection, three were male and one was female, with a mean age of 65.3 years (range: 56–72 years). The mean operative time was 110 min (range: 75–145 min). There were no conversions or intraoperative complications. Patients were discharged on post-operative day 1 on full liquids. At a mean follow-up of 6 months, none of the patients showed evidence of stenosis of the stenosis or reflux symptoms.

DISCUSSION

Minimally invasive organ-sparing surgery has become a paradigm for most GISTs in favourable locations such as the anterior wall and greater curvature of the stomach.[4] However, this approach is very challenging in difficult anatomic locations with regard to limited visualisation and dexterity of conventional laparoscopy platforms. Robotic-assisted surgery has gained popularity in allowing surgeons to perform oncological resections with confidence, dexterity and high definition three-dimensional image.[5] Of great significance in a robotic platform is the

![Figure 1: Gastrointestinal stromal tumour juxta-gastroesophageal junction visualised on upper endoscopy (a) and on computer tomography (b). (c) A patient in supine position. Standard foregut ports are placed with 8-mm camera port 12 cm below the xiphoid process and 2 cm to the left of the midline. Additional left and right 8-mm ports are placed in the respective midclavicular line under direct visualisation. (d) Intraoperative endoscopy to visually confirm the lesion with reference to its location with gastroesophageal junction or lesser curvature. (e) Under direct visualisation 3 mg of indocyanine green is injected into the lesion at four quadrants. (f) Using firefly mode, the lesion stands out as a well-demarcated green fluorescent region of interest. Targeted gastrotomy is made (g), and the lesion can then be easily everted and resected with gross negative margins using robotic endoshears (h). (i) Gastrotomy is closed in layers, first closure is approximation of the inner mucosal edges using absorbable suture, and finally, the anterior gastrotomy is closed in two layers.](image)
availability of photodynamic eye filter commonly called the firefly technology. The firefly technology uses near-infrared imaging to detect an injected tracer dye of ICG in the blood. Although most robotic surgeons utilise the firefly to evaluate blood flow characteristics of the organ of interest,\textsuperscript{[6,7]} we envisioned that ICG tattooing could be very useful to visualise deep-seated lesions at anatomically difficult locations. In our limited series of gastric GISTs at unfavourable locations, we were able to safely tattoo the lesion, identify it using firefly imaging and perform a limited oncologic resection. Besides the known benefits of robotic minimally invasive surgery – including smaller incisions, less blood loss, less post-operative pain, shorter hospital stays and earlier returns to work – the addition of intraoperative tattooing of unfavourably located submucosal lesion using the firefly system can improve patient outcomes even further and allow surgeons to approach these lesions in a safe manner.

**CONCLUSION**

The technique of intraoperative tattooing with ICG on a robotic platform is attractive to safely resect endophytic lesions at complex locations. Ease of topographic location using green fluorescence facilitates accurate planning of resection line for either eversion resection or wedge resection adhering to oncological principles at the same time offering benefits of minimally invasive surgery to the patients.

**Financial support and sponsorship**

Nil.

**Conflicts of interest**

There are no conflicts of interest.

**REFERENCES**

1. Mucciarini C, Rossi G, Bertolini F, Valli R, Cirilli C, Rashid I, \textit{et al.} Incidence and clinicopathologic features of gastrointestinal stromal tumors. A population-based study. BMC Cancer 2007;7:230.
2. de Silva CM, Reid R. Gastrointestinal stromal tumors (GIST): C-kit mutations, CD117 expression, differential diagnosis and targeted cancer therapy with Imatinib. Pathol Oncol Res 2003;9:13-9.
3. Nishida T, Hirota S, Yanagisawa A, Sugino Y, Minami M, Yamamura Y, \textit{et al.} Clinical practice guidelines for gastrointestinal stromal tumor (GIST) in Japan: English version. Int J Clin Oncol 2008;13:416-30.
4. Qiu WQ, Zhuang J, Wang M, Liu H, Shen ZY, Xue HB, \textit{et al.} Minimally invasive treatment of laparoscopic and endoscopic cooperative surgery for patients with gastric gastrointestinal stromal tumors. J Dig Dis 2013;14:469-73.
5. Buchs NC, Bucher P, Pugin F, Hagen ME, Morel P. Robot-assisted oncologic resection for large gastric gastrointestinal stromal tumor: A preliminary case series. J Laparoendosc Adv Surg Tech A 2010;20:411-5.
6. Pathak RA, Hemal AK. Intraoperative ICG-fluorescence imaging for robotic-assisted urologic surgery: Current status and review of literature. Int Urol Nephrol 2019;51:765-71.
7. Mangano A, Gheza F, Chen LL, Minerva EM, Giulianotti PC. Indocyanine green (icg)-enhanced fluorescence for intraoperative assessment of bowel microperfusion during laparoscopic and robotic colorectal surgery: The quest for evidence-based results. Surg Technol Int 2018;32:101-4.