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Initial Report of Near-Infrared Fluorescence Imaging as an Intraoperative Adjunct for Lymph Node Harvesting during Robot-Assisted Laparoscopic Gastrectomy

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Keywords

Gastric cancer; robotic surgery; indocyanine green; fluorescence; lymph node

Introduction

Adequate lymphadenectomy is a fundamental aspect of oncologically sound gastric cancer operations. Increasing number of positive lymph nodes is highly congruent with higher recurrence risk and thus aids guide treatment recommendations. There has been significant debate in the literature regarding the optimal extent of lymphadenectomy (1), with recent studies suggesting a shift towards more comprehensive dissection (2), (3). Prior studies have shown that at least 16 nodes are necessary for proper staging of gastric cancer patients (4) (5), highlighting the importance of adequate sampling of relevant draining lymph node basins.

Among the surgical techniques used for gastrectomy, open surgery and laparoscopic gastrectomy have been reported to be similar in the number of lymph nodes harvested (6), (7). Recently, robot-assisted laparoscopic gastrectomy (RALG) has been used as a minimally invasive alternative to traditional laparoscopic surgery. RALG allows for high-definition, magnified, 3-D imaging and instruments with greater range of motion. These factors may mitigate the technical challenges of lymphadenectomy.

Robotic platforms allow functional imaging to be easily integrated into the surgical field. Near-infrared fluorescence imaging (NIFI) with indocyanine green (ICG) has been used to improve the visualization of vascular anatomy (8), (9) and lymph node identification in gynecologic and colorectal procedures (10), (11), in which adequate lymphadenectomy is also important for staging. NIFI-ICG has been used for the identification of sentinel lymph nodes during traditional laparoscopic resections for gastric cancer (12) (13).

To our knowledge, robot-assisted NIFI-ICG has not been reported as an adjunct for the identification of relevant lymph node basins during RALG. The purpose of this report is to describe the use of NIFI-ICG during RALG, which complements standard surgical technique by better visualizing en bloc lymph nodes to be included in the surgical specimen.

Anatomy

The lymphatic drainage of the stomach has been extensively described (14). Figure 1 shows the perigastric regional lymph node stations. The extent of lymphadenectomy is classified as D1 if the lymphadenectomy includes the perigastric lymph nodes (stations 1-6); D2 if it includes main arterial vessels such as celiac, splenic, left gastric and hepatic arteries (stations 1-14v); and D3 if it includes portal and periaortic lymph nodes.

Technique

Port Placement

After pneumoperitoneum is established, an 8-mm robotic port is placed in the midline through an umbilical incision. Additional ports are placed in a curve (Figure 2) targeting operative anatomy. Two 8-mm robotic ports are placed to the left of the umbilical port, approximately 8 cm apart (surgeon's right hand and assistant robotic arm) and an additional 8-mm port is placed to right of the umbilicus (surgeon's left hand). An additional 5-mm port is placed in the right flank for the bedside assistant. A sub-xiphoid incision is used for the liver retractor.

Tumor identification and ICG injection

After initial laparoscopic exploration of the cavity, tumor is identified endoscopically and its relationship with surface gastric anatomy marked with stitches. Five milligrams of ICG (25mg in 10mL) are injected into the sub-serosa of the four quadrants surrounding the tumor (Figure 3). Indocyanine green (ICG) is a soluble tricarbocyanine dye which is taken by hepatic parenchymal cells and is secreted into the bile. Caution should be used if patient has a history of allergy to iodine products. During injection, care is taken to ensure that ICG is not spilled, as this may obscure lymph node visualization. NIFI (SPY Imaging; Novadaq, Bonita Springs, FL USA) built into the robotic platform (Firefly Fluorescence Imaging Scope; Intuitive Surgical, Sunnyvale, CA USA) is used to verify uptake of ICG by the primary tumor site and draining lymphatics (Figure 4).

Right gastroepiploic lymphovascular bundle dissection

The procedure starts by dissecting the omentum off its insertion to the transverse colon, exposing the lesser sac. Subsequently, the left gastroepiploic artery is ligated close to the tail of the pancreas. The greater omentum is freed from the colonic attachments. The right gastroepiploic artery and vein are ligated close to its origin at the anterior surface of the pancreas (Figure 5).

Left gastric lymphovascular bundle dissection

Once the duodenum has been transected, intermittent NIFI is used to evaluate lymph nodes along the lesser curvature and the left gastric vascular bundle. The nodal packages are identified and the artery and vein are ligated proximal to them (Figure 6).

Results

We have used NIFI-ICG during robotic gastrectomy for 31 patients. Their mean age was 57 years (range, 35-83); 45% were female. Results are summarized in Table 1. NIFI-ICG allowed the surgeon to have a visual reference of lymph node packages along the main gastric vessels. No adverse effects of the ICG were noted. In all cases, at least 5 lymph nodes were seen along the main nodal basins, which provided real time intraoperative feedback regarding lymph node identification. All ICG-positive lymph nodes were included in the specimens. The average time of ICG application and intermittent NIFI evaluation was less than 10 minutes, adding little to the total operative time.

Conclusions

Adequate lymph node sampling during radical gastrectomy is key for proper staging of patients with gastric cancer. This report describes a novel technique for real-time intraoperative visualization of lymph nodes during RALG. NIFI-ICG may provide an improved method to help visualize lymph nodes intraoperatively, thus adding a potentially valuable adjunct for lymphadenectomy and overall lymph node retrieval.

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Figure 1. Typical port placement for robot-assisted gastrectomy

Figure 2. Endoscope-guided application of ICG to the tumor site

An arrowhead demonstrates the endoscope used for tumor identification. Injection site surrounding tumor marked in the gastric surface by stitches.

Figure 3. Primary tumor and draining lymph nodes and channels identified by NIFI-ICG
A white arrow head indicates the primary tumor site marked with ICG. Blue arrowheads indicate ICG uptake by draining lymph nodes and channels.

Figure 4. Right gastroepiploic lymph node bundle identified with NIFI-ICG application

A. Arrowhead shows the right gastroepiploic artery, vein and lymph node package. B. Near-infrared image. The arrowhead indicates ICG uptake by the right gastroepiploic lymph node bundle. No NIFI-ICG lymph nodes are noted below the level of ligation.

Figure 5. Left gastric lymph node bundle identified with NIFI-ICG application

A. The arrowhead shows the left gastric artery, vein and lymph node package. B. Near-infrared image. The arrowhead indicates the ICG uptake by the left gastric lymph node bundle. No NIFI-ICG lymph nodes are noted below the level of ligation.

Table 1
Demographic information and surgical outcomes of patients who underwent robot-assisted gastrectomy and ICG-NIFI

Variable	Data
N	31
Preoperative characteristics	
Age, y, median (range)	57 (35-83)
Sex, n, male:female	14:17
Body mass index, kg/m ² (range)	25.5 (16.4-42.1)
Surgical Procedure	
Total gastrectomy	11
Subtotal gastrectomy	4
Distal gastrectomy	14
Wedge resection	2
Surgical Outcomes	
Operative time, min (range)	221 (122-356)
Estimated blood loss, mL (range)	88 (10-350)
Lymph node retrieval (radical gastrectomy) (mean)	31 (17-61)
Morbidity	
Early bowel obstruction	1
Esophago-jejunostomy anastomotic leak	1
Pulmonary embolism	1