June 15, 2020 ● Volume 2 ● Number 2

Online ISSN 2704-8284 ● Print ISSN 2704-9108

JGS Journal of Gastric Surgery

Designed for practictioners involved in oncology, obesity, metabolic, and other abdominal diseases

IN THIS ISSUE

- Analysis of a large database of patients diagnosed with perforated peptic ulcer, including a comparison between laparoscopy and open surgery.
- Prof. Chang-Ming Huang and his team report the results from the largest single-center experience of laparoscopic treatment of gastric GISTs.
- Prof. Nicola Di Lorenzo presents the current evidence on ICG use during bariatric surgery for assessment of tissue perfusion at the anastomotic site.
- Dr. Domenico Di Nardo provides an overview of technological perspectives, from virtual reality to 5G networking.
- Dr. Piatto demonstrates how to correctly face up a severe bariatric surgery complication.
- *Sarcina ventriculi* is implicated in gastric ulcers, emphysematous gastritis, and gastric perforation, but the literature contains few related articles; Dr. Qing Wei reports detailed pathology findings from two patients.
- The video selected for this number depicts use of a hybrid laparoscopic–robotic approach for a completion total gastrectomy.

Published by ED Marketing & Communication - Edoardo Desiderio

www.journalofgastricsurgery.com

ABOUT THE JOURNAL

Name of Journal	*Journal of Gastric Surgery*
Title Abbreviation	*J Gastric Surg* *JGS*
Launch Date	*December 16, 2019*
Frequency	*Quarterly*
Publication Date	*June 15, 2020*
Aims and Scope	*Journal of Gastric Surgery is a peer-reviewed, open-access journal devoted to publishing papers in the area of surgical and medical oncology, obesity and metabolic disease, emergency surgery, endoscopic procedures, and other abdominal diseases. Types of articles include original articles, reviews, meta-analysis, basic science, case reports, technical notes, videos, commentary, controversy, letters to the editor and surveys.*
Indexing	*Index Copernicus, Google Scholar, BASE, Crossref, PKP index, Dimensions, Ulrichsweb, Proquest*
Founders	*Prof. Vito D'Andrea, Prof. Chang-Ming Huang, Prof. Amilcare Parisi*
Co-Founders	*Jacopo Desiderio, Jian-Xian Lin, Stefano Trastulli, Roberto Cirocchi, Domenico Di Nardo, Chao-Hui Zheng, Edoardo Desiderio, Valentina Betti*
Editors-in-Chief	*Prof. Vito D'Andrea, Prof. Chang-Ming Huang, Prof. Amilcare Parisi*
Managing Editors	*Dr. Jian-Xian Lin, Dr. Jacopo Desiderio*
Publisher	*ED Marketing & Communication - Edoardo Desiderio*
Research Domain	*Oncology, Bariatric and Metabolic Surgery, Endoscopy, Emergency Surgery, Abdominal Surgery*
Copyright	
Contact	*Editorial office* *Via Tristano di Joannuccio, 1* *05100 Terni, Italy* *Tel. +39-3497531121* *E-mail: editorialoffice@journalofgastricsurgery.com* *Publisher* *ED Marketing & Communication* *Via Benedetto Faustini, 22* *05100 Terni, Italy* *Tel. +39-3493991427* *E-mail: info@journalofgastricsurgery.com*

EDITORIAL BOARD

June 15, 2020 • Volume 2 • Number 2

JGS

CONTENTS

June 15, 2020 • Volume 2 • Number 2

JGS

COMPARATIVE STUDY

OPEN ACCESS

Laparoscopic repair for perforated peptic ulcer: our experience, a comparison with the open approach and a review of the literature.

Samuele Vaccari[1], Vito D'Andrea[1], Augusto Lauro[2], Roberto d'Intino[2], Eliana Gulotta[1], Maurizio Cervellera[2], Valeria Tonini[2]*

[1]Department of Surgical Sciences, Umberto I University Hospital - La Sapienza - Rome, Italy
[2]Emergency Surgery, St. Orsola University Hospital, Alma Mater Studiorum, Bologna, Italy

To Cite
Vaccari S, D'Andrea V, Lauro A, D'Intino R, Gulotta E, Cervellara M, Tonini V. Laparoscopic repair for perforated peptic ulcer: our experience, a comparison with the open approach and a review of the literature. J Gastric Surg 2020; 2(2): 26-32

Publication history
Received: May 02, 2020
Accepted: May 10,2020
Article in press: May 11, 2020
Published on line: May 12, 2020

***Correspondence to**
Dr. Augusto Lauro
Emergency Surgery
St. Orsola University Hospital
Alma Mater Studiorum
Via Giuseppe Massarenti, 9
40138 Bologna, Italy
augustola@yahoo.com

ABSTRACT

Background:
The incidence of perforated peptic ulcers has decreased during the last decades but the optimal treatment for these patients remains controversial. At the same time, a laparoscopic approach to this condition has been adopted by an increased number of surgeons.
Therefore, this study wants to evaluate the postoperative results of the laparoscopic treatment of perforated peptic ulcer performed in one Italian center with extensive experience in laparoscopic surgery.

Methods:
This retrospective study includes 94 patients who were operated for perforated peptic ulcer peritonitis at "St. Orsola Hospital - Emergency Surgery Unit - University of Bologna" from May 2014 to December 2019. The patients' charts were reviewed for demographics, surgical procedure, complications, and short-term outcomes.

Results:
The diagnosis was made clinically and confirmed by the presence of gas under diaphragm on abdominal X-ray. All patients underwent primary suture repair with or without omentopexy. Boey score 0 or 1 was found in 66 (70%) patients, Boey 2 or 3 in 28 (30%) patients. The operative time was between 35 and 255 minutes, with a mean of 93 minutes. The overall median hospital stay was 9.5 (1-60) days. Post-operative complications occurred in 19 (20%) patients and 18 (19%) patients died.

Conclusions:
Perforated peptic ulcer is a severe condition that requires early hospital admission and immediate surgery. Laparoscopy in experienced centers and for selected patients is safe, associated with optimal outcomes and should be the preferred approach.

Keywords:
peptic ulcer, gastric perforation, peritonitis, laparoscopy, minimally invasive surgery, emergency surgery.

Background:

Treatment outcomes for peptic ulcer disease (PUD) have been substantially improved over the past few decades, first of all in the 1970s with the introduction of H2-blockers followed by proton pump inhibitors in the 1980s and the introduction of antibacterial therapy to eradicate Helicobacter pylori, leading to a decrease in elective surgical procedures for this disease[1].

However, there are discordant results in the literature, while the Scandinavian groups[2, 3] reported a reduced incidence of perforated peptic ulcer due to these treatments, several studies reported no change or even an increase in the incidence of perforated peptic ulcer[4, 5].

Improved medical management of PUD has virtually eradicated the need for acid-reducing surgery, such as proximal selective vagotomy, gastric resection and surgery performed for benign gastric outlet obstruction[6, 7].

However gastric or duodenal perforation remains a life threatening complication of PUD; it is one of the commonest causes of emergency hospitalization and surgery in PUD and develops in 2-14% of patients[8, 9].

Most authors consider perforated gastric and duodenal ulcer as a single disease entity. However, Hodnett et al.[10] reported that perforated gastric ulcer has a higher morbidity and mortality than perforated duodenal ulcer. Moreover, perforated gastric ulcer is more commonly associated with older patients, larger ulcer size, and more severe intraperitoneal contamination than duodenal one[11, 12].

Although predominantly benign nature of peptic ulcer, underlying gastric cancer can occasionally present with perforation, as reported in over 13% of patients in one series[13].

The incidence of perforated peptic ulcer is approximately 7-10 per 10.000 population per year[5, 14]. An estimated 2% to 10% of patients with PUD will present with perforation of the stomach or the duodenum in their lifetimes, with a high risk for mortality in the elderly[15, 16]. Acute perforations of the duodenum are estimated to occur in 2–10% of patients with PUD[17, 18].

In addition, most patients with a perforated peptic ulcer are elderly with considerable comorbidity[19], among those patients a higher mortality rate (up to 25%) and a morbidity rate of up to 50% have been reported, even in recent studies[20-22]. In particular, for patient ≥ 60 years, the incidence increased over 10-fold, and mortality more than 50-fold, compared to younger ages[17, 23]. Overall prevalence of perforation is about 5% with mortality ranging from 8.5% to 25%[9, 24].

Consequently, perforated peptic ulcer remains a frequent challenge to surgeons and optimal treatment strategies are needed.

The aim of this study is to analyze the post-operative outcomes of our series from a single center comparing open and laparoscopic repair.

Methods:

Study design

The present study was designed as a retrospective cohort evaluation. All data, patient demographics and outcomes were identified from a prospectively maintained database established at "St. Orsola Hospital - Emergency Surgery Unit - University of Bologna". Data were collected between May 2014 to December 2019 and included 109 patients with diagnosis of PUD. The diagnostic criteria were as follows: (1) pneumoperitoneum detected by abdominal x-ray and/or abdominal computed tomography performed at the Emergency Room, and/or (2) gastric or duodenal ulcer confirmed by the endoscopy before the initial treatment or during the emergency surgical procedure. Preoperative endoscopy or intraoperative frozen sectioning was not routinely performed because of the emergency setting. Patients who underwent gastrectomy were excluded from the study, enrolling only those who underwent laparoscopic and open repairs. Overall, 94 patients were enrolled.

A retrospective analysis of preoperative, operative, and postoperative data was performed. Collected data included patient's demographics, clinical characteristics, operative details, and post-operative outcomes. Patients were divided into two groups to investigate the effect of the surgical approach: 53 patients in the laparoscopic group (LG), 41 patients in the open group (OG).

Data collection

Details of age, sex, history of PUD, ulcerogenic drugs (including non-steroidal anti-inflammatory drugs NSAIDs, systemic steroids, and low-dose aspirin) taken within 2 weeks before presentation, comorbidities (including cardiopulmonary disease, diabetes mellitus, and renal insufficiency) requiring treatment, American Society of Anesthesiologists (ASA) classification, were recorded. For each patient, the Boey score was retrospectively calculated for assessing the postoperative risks[25]. The score is calculated based on 3 factors: the presence of major medical illness, shock at the time of admission, estimated onset of perforation >24h. Of note, in the original paper of this score, level 3 had a 100% mortality.

Post-operative complications and 30-days postoperative outcomes were recorded prospectively. Follow-up was based on inpatient and outpatient data. Postoperative complications were classified according to the Dindo–Clavien classification[26]. According to the aforementioned classification, Grade I includes minor complications that do not require any intervention and that can be treated with routine medications like antipyretics, analgesics, diuretics, or physiotherapy; Grade II includes conditions that require major pharmacological intervention, like respiratory infections, ascites, blood transfusions, and asymptomatic pulmonary embolism; Grade III includes any complication requiring a surgical, endoscopic, or radiological intervention, like a respiratory infection requiring bronchoscopy, a pleural effusion requiring drainage, ascites or an abdominal collection requiring percutaneous drainage, and reoperation for abdominal collection, bleeding, or other reasons; Grade IV includes patients with life-threatening complications requiring Intensive Care Unit; Grade V includes death in the postoperative period.

Statistical analysis

Results are expressed as median (range) unless otherwise stated. Comparisons between categorical variables were determined using the chi-square or Fisher's exact test, as appropriate. Continuous variables were assessed with the Mann–Whitney U-test. Logistic backward regression was undertaken to determine factors independently associated with mortality, morbidity and discharge at home including all factors where the P-value was less than 0.05 on univariate analysis. A statistical software package (SPSS Version XX.0; IBM Co, Armonk, NY, USA) was used for the analysis, with $p < 0.05$ considered statistically significant.

Results:

Ninety-four patients met inclusion criteria. Preoperative characteristics, surgical procedures and postoperative outcomes of the patients included in this study are listed in *Table 1, Table 2, Table 3.*

	Overall *(n=94)*	**Laparoscopic Group** *(n=53)*	**Open Group** *(n=41)*	**p-Value**
Age (years)*	61.1±20.3	51.9±18.5	72.8±15.5	**<0.01**
Age >80 years	20 (21%)	3 (6%)	17 (41%)	**<0.01**
Male Sex	58 (62%)	35 (66%)	23 (56%)	0.39
BMI (Kg/m^2)*	24.3±4.9	23.5±4.1	25.8±5.6	**0.02**
ASA Class				**<0.01**
I-II	*41 (44%)*	*34 (64%)*	*7 (17%)*	
III-IV	*53 (56%)*	*19 (36%)*	*34 (83%)*	
Comorbidity	62 (66%)	26 (49%)	36 (88%)	**<0.01**
Cardio-Vascular	*39 (41%)*	*12 (23%)*	*26 (63%)*	**<0.01**
Diabetes	*8 (9%)*	*2 (4%)*	*6 (15%)*	**<0.01**
COPD	*7 (7%)*	*1 (2%)*	*6 (15%)*	**<0.01**
CRF	*4 (4%)*	-	*4 (10%)*	**<0.01**
Obesity	*6 (6%)*	*3 (6%)*	*3 (7%)*	1.00
Previous Abdominal Surgery	40 (43%)	20 (38%)	20 (49%)	0.30
Previous history of PUD	6 (6%)	5 (9%)	1 (2%)	0.23
Alchool abuse	10 (11%)	6 (11%)	4 (10%)	1.00
Cigarette smoking	15 (16%)	8 (15%)	7 (17%)	1.00
Use of NSAIDs	26 (28%)	11 (21%)	15 (37%)	0.11
Symptoms				
Pain in abdomen	*68 (72%)*	*41 (77%)*	*27 (66%)*	0.25
Vomiting/Nausea	*24 (26%)*	*17 (32%)*	*7 (17%)*	0.16
Hyporexia	*8 (9%)*	*5 (9%)*	*3 (7%)*	1.00
Fever (>38.0°)	*2 (2%)*	*1 (2%)*	*1 (2%)*	1.00
Abdominal distention	*17 (18%)*	*8 (15%)*	*9 (22%)*	0.43
Costipation	*17 (18%)*	*10 (19%)*	*7 (17%)*	1.00
Laboratory Tests				
*WBC (x10^9/L)**	*14.70±7.76*	*14.35±6.10*	*15.12±9.44*	0.63
*Hemoglobin (gr/dL)**	*13.70±2.62*	*14.15±2.33*	*13.11±2.88*	0.06
*CRP (mg/dL)**	*5.34±8.48*	*4.15±8.31*	*7.06±8.57*	0.10
*Creatinine (microMol/L)**	*1.49±2.06*	*1.26±2.44*	*1.79±1.41*	0.22
CRP >0.5 (mg/dL)	62 (66%)	27 (51%)	35 (85%)	**<0.01**
WBC >10 (x10^9/L)	63 (67%)	37 (70%)	26 (63%)	0.66
Boey Score				**<0.01**
0-1	66 (70%)	43 (81%)	21 (51%)	
2-3	28 (30%)	8 (19%)	20 (49%)	
Radiological Imaging				
RX Abdomen	41 (44%)	25 (47%)	16 (39%)	0.53
TC scan	11 (12%)	9 (17%)	2 (5%)	0.11
RX + TC	39 (41%)	18 (34%)	21 (51%)	0.14
Endoscopy	3 (3%)	1 (2%)	2 (5%)	0.58

Table 1: Pre-operative characteristics of patients.
*CRF: chronic renal failure; COPD: chronic obstructive pulmonary disease; CRP: c-reactive protein; WBC: white blood cell count. Values in parentheses are percentages unless indicated otherwise; *values are mean±SD.*

	Overall (n=94)	Laparoscopic Group (n=53)	Open Group (n=41)	p-Value
Surgical Procedure				-
Open	*41 (44%)*	-	*41 (100%)*	
Laparoscopic	*53 (56%)*	*53 (100%)*	-	
Conversion to Open	-	*12 (22%)*	-	
Intra-operative Endoscopy	10 (11%)	4 (8%)	6 (15%)	0.32
First flatus (days)*	4.01±1.49	3.46±1.54	4.79±1.55	**<0.01**
NG tube removal (days)*	4.48±3.72	2.31±1.19	4.09±2.30	**<0.01**
Re-Feeding (days)*	3.04±1.93	3.46±1.17	5.97±5.22	**<0.01**
Surgical drainage removal (days)*	5.28±3.94	4.40±1.22	6.59±5.85	**<0.01**
Duration of Procedure (min)*	92.93±34.37	93.33±31.54	92.46±37.87	0.90
Duration of Procedure (>90min)	36 (38%)	19 (38%)	17 (41%)	0.67

Table 2: Surgical and peri-operative characteristics of population.
*NG: nasogastric. Values in parentheses are percentages unless indicated otherwise; *values are mean±SD.*

	Overall (n=94)	Laparoscopic Group (n=53)	Open Group (n=41)	p-Value
Death in Hospital	18 (19%)	2 (4%)	16 (39%)	**<0.01**
30-day Mortality	18 (19%)	2 (4%)	16 (39%)	**<0.01**
Complication (Clavien-Dindo)	19 (20%)	10 (19%)	9 (22%)	0.80
Grade I-II	*15 (16%)*	*8 (15%)*	*7 (17%)*	1.00
Grade III-IV	*4 (4%)*	*2 (4%)*	*2 (5%)*	
Re-Operation	5 (5%)	1 (2%)	4 (10%)	0.16
Hospital Stay (days)*	9.49±8.72	6.51±3.37	13.20±11.55	**<0.01**
Discharge at Home	73 (78%)	49 (92%)	24 (59%)	**<0.01**

Table 3: Postoperative outcomes.
*Values in parentheses are percentages unless indicated otherwise; *values are mean±SD.*

		Unadjusted Model		Adjusted for co-variables	
	No. of patients	**Odds ratio [CI 95%]**	**P-value**	**Odds ratio [CI 95%]**	**P-value**
Complications					
Laparoscopic Group	10 (19%)	1.00	-	1.00	-
Open Group	9 (22%)	2.309 [0.791-6.737]	0.126	1-952 [0.551-6.916]	0.300
In-Hospital Mortality					
Laparoscopic Group	2 (4%)	1.00	-	1.00	-
Open Group	16 (39%)	**21.649 [1.212-386.817]**	**0.037**	17.211 [0.120-2478.11]	0.262
Discharge at Home					
Laparoscopic Group	49 (92%)	1.00	-	1.00	-
Open Group	24 (59%)	1.058 [0.087-12.856]	0.965	2.467 [0.023-261.013]	0.704

Table 4: Logistic regression model exploring the relationship between two group and complications, in-hospital mortality and 30-day mortality.
The adjusted model accounts for the possible impact of the co-variables: age <80 years, Boey Score 2-3, presence of cardio-vascular disease, presence of CRF, presence of COPD, presence of Diabetes, ASA score 3 or 4. Laparoscopic procedure and grade of cholecystitis. Patients of Laparoscopic Group represented the reference group.

Clinical data

The average age of two groups ranged from 51.9 years in LG to 72.8 years in OG (p<0.01). When comparing two groups, the gender distribution was not significantly different (p=0.39), male patient was more frequent in LG with 66% percentage.

The overall comorbidity rate differed significantly between the two groups (p<0.01): in particular the distribution of cardio-vascular risk factor, diabetes, chronic renal failure (CRF) and chronic obstructive pulmonary disease were more frequent in OG. Not surprisingly, ASA classification differed significantly (p<0.01) between the groups.

The two groups did not present significant differences in terms of previous abdominal surgery, history of previous peptic ulcer disease, cigarette smoking, abuse of Alcohol and use of non-steroidal anti-inflammatory drugs (NSAIDs) (p=NS).

Blood tests and radiological investigation were performed at the admission in Emergency Department in every patient, and were summarized in Table 1.

Seventy-eight percent of patient had clinical signs of peritonitis at presentation. The abdomen x-ray depicted free air in abdomen in 41 patients (44%), a CT scan after a negative radiography was required in 39 patients. In 3 patients the diagnosis of PUD was made during an endoscopy performed on suspicion of gastrointestinal bleeding.

Intraoperative and perioperative data

The overall median operative time was 92.9±34.4 [35-255] minutes, no significant difference was shown between the two groups (p=0.90). In all cases warm saline was used for intraoperative peritoneal lavage until clear fluid was obtained and the overall average amount of it was 1798.8±1213.9 ml.

The reintroduction of oral diet varied across the groups and was dependent on the first bowel movement and the severity of peritonitis. The naso-gastric tube and surgical drainage were removed earlier in the LG than OG with statistically significant differences (p<0.01).

Postoperative data

Eighteen patients (19.1%) died in hospital after surgery: 2 in LG and 16 in OG, respectively (p=<0.01). In particular, 15 patients had a Boey score 2 and one patient had a Boey score 3. Among these patients, in two cases the death occurred after a re-operation; in one patient due to a gastric suture leakage, in the other one due to an evisceration.

Post-operative complications occurred in 19 patients (20%) of our study cohort. In particular, mild complications (Clavien grade I-II) were more prevalent than severe complications (Clavien grade III-IV). However, no significant differences were recorded between the two groups. Five patients had a re-operation. In two patients the reoperation was due to a gastric suture leakage, in the remaining three cases due to an evisceration.

The overall median hospital stay was 9.49±8.72 [1-60] days and was significantly affected by surgical procedure; not surprisingly the median hospital stay was longer in OG compared to LG, with a difference of about 7 days (p<0.01).

The impact of laparoscopic procedure on the overall occurrence of complications, postoperative death and discharge at home in relation to other variables considered in the logistic regression model is shown in Table 4.

Mortality showed to be more favourable in LG in the unadjusted model. However, after adjusting for co-variables, this difference was not found to be statistically significant.

Discussion:

The first recorded description of a peptic ulcer perforation was by the Princess Anne Henriette of England, the daughter of King Charles I of England and Princess Marie Henriette of France[27].

Since that description, peptic perforation was a serious complication of PUD affected by worse outcome. The overall mortality due to perforation peritonitis ranges between 6% and 27%. One of the most important factors responsible for mortality is septicemia[28].

Perforated peptic ulcer can mimic acute cholecystitis, acute pancreatitis, or appendicitis when gastroduodenal contents spread out causing pain in abdomen[29].

The perforation leads to chemical peritonitis, with or without contamination with micro-organisms. Spillage of gastroduodenal contents is usually diffuse but may be localized in the upper abdomen. After 6 to 12 hours many patients may obtain some spontaneous relief of the pain due to dilution of the irritating gastroduodenal contents by the ensuing peritoneal exudate. The intra-abdominal infection appears after 12 to 24 hours[30].

Definitive surgical procedures have been routinely performed for decades in Japan, other Asian countries, and Eastern Europe; nowadays, non-definitive surgical procedures like simple closure with or without omentoplasty and drainage are the most popular in case of perforation[31].

Notwithstanding aggressive surgical procedures such as gastric disconnection, antrectomy, gastrostomy, lateral duodenostomy and feeding jejunostomy with restoration of intestinal continuity were described in literature; nowadays the surgical options are suture of the perforation with or without omentoplasty[32].

However, it is controversial whether laparoscopic approach or conventional open surgery should be chosen.

In literature, negative factors for the laparoscopic approach are shock at the diagnosis, delayed presentation (> 24 h), confounding medical conditions, age > 70 years, ASA (American Society of Anesthesiologists) score 3–4 and Boey score of ≥ 2, ulcer location or large perforation size (> 6–10 mm). The most accepted but discussed contraindication is signs of shock due to the negative impact of increase duration of surgery and negative influence of pneumoperitoneum on renal function[33]. For the laparoscopic approach the concern is the CO2 pneumoperitoneum who leads to increased intra-abdominal pressure intraoperatively: it is related to growing risk of bacteremia and sepsis due to the increased chance of bacterial translocation from peritoneal cavity into the bloodstream, increasing the occurrence of pneumonia in patients selected for this

approach[34].
In our cohort of patients, the OG presented more fragile patients with more severe ASA score and a greater number of Boey 2-3 than the LG.
The most common cause of conversion to open surgery was an inability to repair the ulcer due to either technical difficulties or size of perforation. The conversion rates are directly influenced by the laparoscopic skills and experience of the surgeon. In the literature it ranges between 2.6% to 7.7%[35].
Overall complications rate in our series was 20% which is comparable to other reports[36, 37].
A recent study by Teoh et al.[38] found that a laparoscopic approach in high-risk patients was not associated with increased morbidity and mortality when compared to an open approach, particularly if the ASA grading was below 3.
A Cochrane meta-analysis[32] showed a trend in reducing intra-abdominal septic complications, wound infections, postoperative ileus, pulmonary complications, and mortality with laparoscopy.
A previous meta-analysis by Lau[39] showed a lower incidence of post-operative complications in the laparoscopic group but even a higher rate of reoperation. In our cohort of patients, there were 5 reoperations in the 2 groups. One patient in the LG and 4 patients in the OG, respectively (p=0.16).
The main limitation of the present study is the relatively low sample of patients. However, all our data were prospectively collected, and all surgical procedures were performed by the same group of surgeons.

Conclusion:
Gastric perforation is a severe complication of PUD. Early diagnosis and surgical treatment are mandatory to avoid peritonitis progression with consequent high mortality risk. Laparoscopy is a valid alternative to open surgery in selected patients and in centers with experience in minimally invasive surgery.

Acknowledgements
None.

Contributors
SV, VDA, AL, MC, VT conceptualized and designed the study, acquired, and analyzed data, interpreted the study results, drafted the manuscript, and critically revised the manuscript for important intellectual content. RDI, EG, acquired, and analyzed data, interpreted the study results.

Funding
No funding was received for this study.

Competing interests
No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

Availability of data and materials
Further information is available from the corresponding author on reasonable request.

Ethics approval
all procedures performed by the participants of our study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The study received approval from the hospital's institutional review board (156/2018/Oss/AOUBo, 18/04/18).

Provenance and peer review
Not commissioned; externally peer reviewed.

References
[1] Bae S, Shim KN, Kim N, Kang JM, Kim DS, Kim KM, et al. Incidence and short-term mortality from perforated peptic ulcer in Korea: a population-based study. J Epidemiol. 2012;22:508-16.
[2] Hermansson M, Ekedahl A, Ranstam J, Zilling T. Decreasing incidence of peptic ulcer complications after the introduction of the proton pump inhibitors, a study of the Swedish population from 1974-2002. BMC Gastroenterol. 2009;9:25.
[3] Lassen A, Hallas J, Schaffalitzky de Muckadell OB. Complicated and uncomplicated peptic ulcers in a Danish county 1993-2002: a population-based cohort study. Am J Gastroenterol. 2006;101:945-53.
[4] Svanes C. Trends in perforated peptic ulcer: incidence, etiology, treatment, and prognosis. World J Surg. 2000;24:277-83.
[5] Bertleff MJ, Lange JF. Perforated peptic ulcer disease: a review of history and treatment. Dig Surg. 2010;27:161-9.
[6] Wang YR, Richter JE, Dempsey DT. Trends and outcomes of hospitalizations for peptic ulcer disease in the United States, 1993 to 2006. Ann Surg. 2010;251:51-8.
[7] Soreide K, Sarr MG, Soreide JA. Pyloroplasty for benign gastric outlet obstruction--indications and techniques. Scand J Surg. 2006;95:11-6.
[8] Dongo AE, Uhunmwagho O, Kesieme EB, Eluehike SU, Alufohai EF. A Five-Year Review of Perforated Peptic Ulcer Disease in Irrua, Nigeria. Int Sch Res Notices. 2017;2017:8375398.
[9] Thorsen K, Soreide JA, Kvaloy JT, Glomsaker T, Soreide K. Epidemiology of perforated peptic ulcer: age- and gender-adjusted analysis of incidence and mortality. World J Gastroenterol. 2013;19:347-54.
[10] Hodnett RM, Gonzalez F, Lee WC, Nance FC, Deboisblanc R. The need for definitive therapy in the management of perforated gastric ulcers. Review of 202 cases. Ann Surg. 1989;209:36-9.
[11] Horowitz J, Kukora JS, Ritchie WP, Jr. All perforated ulcers are not alike. Ann Surg. 1989;209:693-6; discussion 6-7.
[12] Lanng C, Palnaes Hansen C, Christensen A, Thagaard CS, Lassen M, Klaerke A, et al. Perforated gastric ulcer. Br J Surg. 1988;75:758-9.
[13] Ergul E, Gozetlik EO. Emergency spontaneous gastric perforations: ulcus versus cancer. Langenbecks Arch Surg. 2009;394:643-6.
[14] Muller MK, Wrann S, Widmer J, Klasen J, Weber M, Hahnloser D. Perforated Peptic Ulcer Repair: Factors Predicting Conversion in Laparoscopy and Postoperative Septic Complications. World J Surg. 2016;40:2186-93.
[15] Chung KT, Shelat VG. Perforated peptic ulcer - an update. World J Gastrointest Surg. 2017;9:1-12.
[16] Schulte-Hermes M, Klein-Wiele O, Vorpahl M, Seyfarth M. Acute tension pneumopericardium due to perforated gastric ulcer without diagnostic radiographic findings 72 h before perforation. J Cardiol Cases. 2018;18:201-3.
[17] Bhattacharjee HK, Misra MC, Kumar S, Bansal VK. Duodenal perforation following blunt abdominal trauma. J Emerg Trauma Shock. 2011;4:514-7.
[18] Milosavljevic T, Kostic-Milosavljevic M, Jovanovic I, Krstic M. Complications of peptic ulcer disease. Dig Dis. 2011;29:491-3.
[19] Sarosi GA, Jr., Jaiswal KR, Nwariaku FE, Asolati M, Fleming JB,

Anthony T. Surgical therapy of peptic ulcers in the 21st century: more common than you think. Am J Surg. 2005;190:775-9.
[20] Moller MH, Adamsen S, Thomsen RW, Moller AM, Peptic Ulcer Perforation trial g. Multicentre trial of a perioperative protocol to reduce mortality in patients with peptic ulcer perforation. Br J Surg. 2011;98:802-10.
[21] Nakano A, Bendix J, Adamsen S, Buck D, Mainz J, Bartels P, et al. 30-days mortality in patients with perforated peptic ulcer: A national audit. Risk Manag Healthc Policy. 2008;1:31-8.
[22] Towfigh S, Chandler C, Hines OJ, McFadden DW. Outcomes from peptic ulcer surgery have not benefited from advances in medical therapy. Am Surg. 2002;68:385-9.
[23] Lee CW, Sarosi GA, Jr. Emergency ulcer surgery. Surg Clin North Am. 2011;91:1001-13.
[24] Byrge N, Barton RG, Enniss TM, Nirula R. Laparoscopic versus open repair of perforated gastroduodenal ulcer: a National Surgical Quality Improvement Program analysis. Am J Surg. 2013;206:957-62; discussion 62-3.
[25] Boey J, Choi SK, Poon A, Alagaratnam TT. Risk stratification in perforated duodenal ulcers. A prospective validation of predictive factors. Ann Surg. 1987;205:22-6.
[26] Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg. 2004;240:205-13.
[27] Baron JH. Paintress, princess and physician's paramour: poison or perforation? J R Soc Med. 1998;91:213-6.
[28] Gupta S, Kaushik R, Sharma R, Attri A. The management of large perforations of duodenal ulcers. BMC Surg. 2005;5:15.
[29] Bali RS, Verma S, Agarwal PN, Singh R, Talwar N. Perforation peritonitis and the developing world. ISRN Surg. 2014;2014:105492.
[30] Kutlu OC, Garcia S, Dissanaike S. The successful use of simple tube duodenostomy in large duodenal perforations from varied etiologies. Int J Surg Case Rep. 2013;4:279-82.
[31] Gurusamy KS, Pallari E. Medical versus surgical treatment for refractory or recurrent peptic ulcer. Cochrane Database Syst Rev. 2016;3:CD011523.
[32] Sanabria A, Villegas MI, Morales Uribe CH. Laparoscopic repair for perforated peptic ulcer disease. Cochrane Database Syst Rev. 2013:CD004778.
[33] Camera L, Calabrese M, Romeo V, Scordino F, Mainenti PP, Clemente M, et al. Perforated duodenal ulcer presenting with a subphrenic abscess revealed by plain abdominal X-ray films and confirmed by multi-detector computed tomography: a case report. J Med Case Rep. 2013;7:257.
[34] Pohl D, Schmutz G, Plitzko G, Kroll D, Nett P, Borbely Y. Perforated duodenal ulcers after Roux-Y Gastric Bypass. Am J Emerg Med. 2018;36:1525 e1- e3.
[35] Tan S, Wu G, Zhuang Q, Xi Q, Meng Q, Jiang Y, et al. Laparoscopic versus open repair for perforated peptic ulcer: A meta analysis of randomized controlled trials. Int J Surg. 2016;33 Pt A:124-32.
[36] Khan SH, Aziz SH, Ul-Haq MI. Perforated peptic ulcer: a review of 36 cases. Professional Med J. 2011:124-7.
[37] Lee FY, Leung KL, Lai BS, Ng SS, Dexter S, Lau WY. Predicting mortality and morbidity of patients operated on for perforated peptic ulcers. Arch Surg. 2001;136:90-4.
[38] Teoh AY, Chiu PW, Kok AS, Wong SK, Ng EK. The selective use of laparoscopic repair is safe in high-risk patients suffering from perforated peptic ulcer. World J Surg. 2015;39:740-5.
[39] Lau H. Laparoscopic repair of perforated peptic ulcer: a meta-analysis. Surg Endosc. 2004;18:1013-21.

JGS

RETROSPECTIVE STUDY OPEN ACCESS

Laparoscopic resection for gastric GISTs: surgical and long-term outcomes of 133 cases.

Jian-Xian Lin[1,#], Qian Yu[1,#], Mi Lin[1], Chao-Hui Zheng[1], Ping Li[1], Jian-Wei Xie[1], Jun Lu[1], Qi-Yue Chen[1], Long-long Cao[1], Ju-li Lin[1], Chang-Ming Huang[1,]*

[1] Department of Gastric Surgery, Fujian Medical University Union Hospital, No.29 Xinquan Road, Fuzhou, Fujian Province,China, 350001.
[#] These authors contributed equally to this work and should be considered co-first authors.

To Cite
Lin J-X, Yu Q, Lin M, Zheng C-H, Li P, Xie J-W, Lu J, Chen Q-Y, Cao L-L, Lin J-L, Huang C-M . Laparoscopic resection for gastric GISTs: surgical and long-term outcomes of 133 cases. J Gastric Surg 2020; 2(2): 33-40

Publication history
Received: April 8, 2020
Accepted: April 15, 2020
Article in press: April 15, 2020
Published online: April 15, 2020

***Correspondence to**
Prof. Chang-Ming Huang
Department of Gastric Surgery, Fujian Medical University Union Hospital, No.29 Xinquan Road, Fuzhou 350001 Fujian Province, China.
hcmlr2002@163.com
Telephone: +86-591-83363366
Fax: +86-591-83320319

ABSTRACT

Background:
It aims to evaluate the surgical efficacy and long-term survival of different laparoscopic surgeries for gastric GISTs.

Methods:
From a prospectively collected database, 133 patients with primary gastric GISTs undergoing laparoscopic surgery were selected from January 2008 to December 2014. They were divided into three groups according to the different operations that were performed, including laparoscopic gastric wedge resection (LWR Group, n=103), laparoscopic subtotal gastrectomy (LSG Group, n=18) and laparoscopic total gastrectomy (LTG group, n=12). Clinicopathological features and short- and long-term outcomes were analyzed retrospectively.

Results:
All patients had received R0 resection. There were no differences among the three groups in age, BMI or NIH risk classification. Compared with the LSG group and LTG group, the LWR group had a shorter operative time, less blood loss, fewer operative complications and shorter time to ground activities, semi-liquid diet and hospital stay ($P<0.05$). There was no statistically significant difference in time to first flatus and liquid diet or in the rate of postoperative complications ($P<0.05$). In the patients with a large tumor (size≥5 cm), LWR was significantly associated with shorter operative time, less blood loss and shorter hospital stay compared with the laparoscopic gastric non-wedge resection (N-LWR) ($P<0.05$). The median follow-up was 30 months, with 4 cases of recurrence and 3 deaths. The 5-year cumulative survival rate was similar among the three groups ($P>0.05$).

Conclusions:
Compared with LSG and LTG, more favorable minimally invasive results can be achieved from LWR for gastric GISTs, which may be the optimal surgical procedure.

Keywords:
Stomach, gastrointestinal stromal tumors (GISTs), laparoscopic surgery, clinical outcomes.

Background:

Gastrointestinal stromal tumor (GIST) is a common mesenchymal neoplasm of the gastrointestinal (GI) tract with an annual incidence estimated to be 10–15 per million [1-2]. The majority of GISTs are found in the stomach (60%) and small intestine (30%) [3]. Complete surgical resection is the primary treatment for local gastric GISTs. Compared with open resection, laparoscopic resection for gastric GIST has advantages such as shorter operative time, less blood loss and quicker recovery [4-6]. Therefore, more and more scholars have preferred laparoscopic resection for gastric GIST in recent years. There are many controversies about the choice of laparoscopic resection for gastric GIST. The commonly used surgical methods include laparoscopic gastric wedge resection (LWR), laparoscopic subtotal gastrectomy (LSG), laparoscopic total gastrectomy (LTG), laparoscopic transgastric resection and laparoscopy endoscopic resection [7-9]. In this study, we retrospectively reviewed detailed data for patients who underwent laparoscopic resection of gastric GIST at our center from January 2008 to December 2014 and evaluated the surgical efficacy and long-term survival of different laparoscopic surgeries for gastric GIST.

Materials and methods:

Materials

From January 2008 to December 2014, 324 patients with primary gastric GISTs were treated with radical resection at the Department of Gastric Surgery, Fujian Medical University Union Hospital. A retrospective analysis was performed, using a prospectively maintained comprehensive database, to determine the technical pitfalls of the procedure. In this series, we included only patients with gastric GISTs, as confirmed by pathological examination. We excluded patients who presented with a malignant tumor (n=106); patients who underwent open surgery (n=82); and patients who underwent endoscopic excision (n=3). Finally, 133 patients were eligible for inclusion in this study. Patients were classified into three groups according to the different operations: laparoscopic gastric wedge resection (LWR Group, n=103), laparoscopic subtotal gastrectomy (LSG Group, n=18) or laparoscopic total gastrectomy (LTG group, n=12) (*Figure 1*). All patients underwent abdominal CT, endoscopy or EUS to initially assess tumor size and location and to determine whether there was distant metastasis.

Surgical procedure

Tumors were classified according to tumor location, as demonstrated in *Figure 2*. Area A is the cardia junction, area B is the fundus and body of the stomach, and area C is the antrum. Tumors were treated with LWR, LTG, laparoscopic proximal subtotal gastrectomy (LPSG), laparoscopic distal subtotal gastrectomy (LDSG) according to location of the different tumors.

The patient was placed in the reverse Trendelenburg and supine position with his or her legs spread apart. After the induction of general anesthesia, pneumoperitoneum was established at a pressure of 12 to 15 mm Hg. A 10-mm trocar for 30°telescope was inserted below the umbilicus. A 12-mm port was inserted percutaneously in the left upper quadrant as the dominant hand port. A 5-mm trocar was placed in the contralateral side. Another two 5-mm trocars were placed in the left and right lower quadrants, respectively. The surgeon stood to the left side of the patient, with the first assistant on the patient's right side and the laparoscopist between

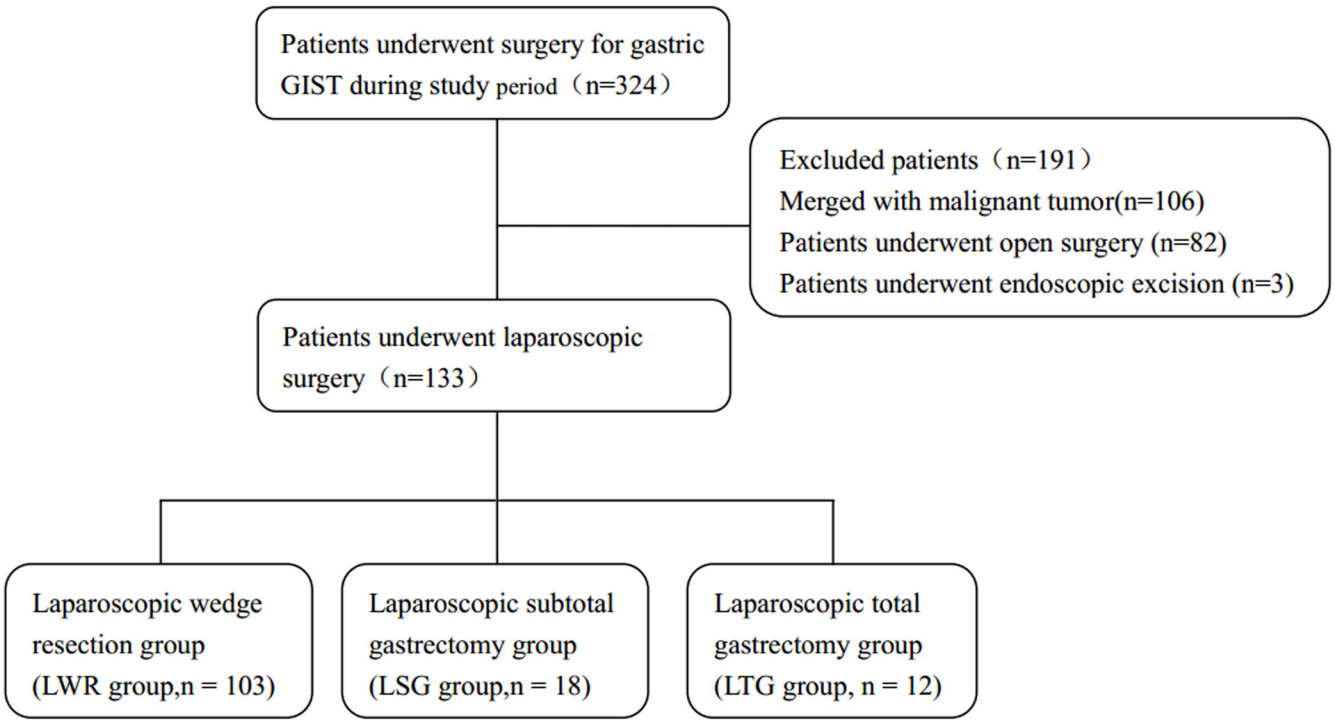

Figure 1: Patient selection flowchart

the patient's legs. Occasionally, gastroscopy was used to assist with identifying the tumor. The tumor specimen was extracted using a bag via a 6-10 cm epigastric incision. The stomach and peritoneal cavity were inspected to rule out invasion of adjacent organs and peritoneal seeding.

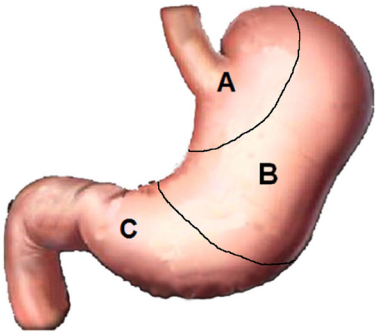

Figure 2: Anatomic classification of the gastric GIST (area A: gastroesophageal junction; area B: fundus and body of the stomach; area C: antrum)

Follow-up methods and treatment

Postoperative follow-up assessments consisted of physical examination, laboratory tests, chest radiography, abdominopelvic ultrasonography (USG) or computed tomography (CT) and an annual endoscopic examination. Survival periods were calculated from the time of surgery until death or right-censored at final follow-up.

Statistics

Continuous variables were compared using the Mann–Whitney U or Kruskal-Wallis tests, as appropriate, and categorical variables were compared using the Pearson X 2 or Fisher exact test. Total survival curves were calculated with the Kaplan–Meier method. All statistical analyses were performed using SPSS version 20 (IBM Corp., Armonk, NY).A p value<0.05 was considered statistically significant.

Results:

Patient characteristics

The LSG group had a higher proportion of male patients; the tumors of the LWR group were mostly located in the fundus and body of the stomach, and the mitotic count was lower. There was no significant difference among the three groups in age, Body Mass Index (BMI), NIH

	LSG（n=18）	LTG(n=12）	LWR(n=103)	p
Age（years）	56（45-72）	58（35-82）	59（27-80）	0.450
Gender				0.006※
Male	15（83.3%）	8（66.7%）	47（45.6%）	
Female	3（16.7%）	4（33.3%）	56（54.4%）	
BMI（kg/m2）	21.9（19.1-26.8）	21.8（18.3-26.9）	22.5（16.2-29.4）	0.724
Tumor size(cm)	4.2（1.6-8.0）	6.0（2.8-11.0）	4（0.5-11.3）	0.062
Location				0.000※
Area A	7（38.9%）	8（66.7%）	5（4.9%）	
Area B	2（11.1%）	4（33.3%）	98（95.1%）	
Area C	9（50%）	0（0%）	0（0%）	
Mitotic rate (/ 50 HPF)				0.004※
≤5	13（72.2%）	9（75%）	85（82.5%）	
>5, ≤10	3（16.7%）	0（0%）	17（16.5%）	
＞10	2（11.1%）	3（25%）	1（1.0%）	
Risk classification				0.169
Very low	1（5.6%）	0（0%）	5（4.9%）	
Low	6（33.3%）	3（25%）	54（52.4%）	
Intermediate	7（38.9%）	4（33.3%）	30（29.1%）	
High	4（22.2%）	5（41.7%）	14（13.6%）	
Pre-operative IM	1（5.6%）	1（8.3%）	1（1.0%）	0.127
Postoperative IM	5（27.7%）	3（25%）	32（31.1%）	1.000

IM: imatinib

※: p<0.05

Table 1: Comparison of clinicopathological characteristics of the patients

risk classification, pre-operative imatinib (IM) treatment or postoperative IM treatment(p>0.05)(*Table 1*).

Operative outcomes

There was no tumor rupture, and all patients successfully completed R0 resection. There was one conversion to open surgery in the LWR group due to severe adhesion with surrounding tissue. Compared with the LSG group and LTG group, the LWR group had a shorter operative time, less blood loss and fewer operative complications. The overall operative complication rate was 1.5%, with one patient in the LTG group having an injured spleen and one patient in the LSG group having an injured left gastric artery.

Postoperative outcomes

The LWR group was superior to the LSG group and LTG group in time to ground activities, semi-liquid diet and postoperative hospital stay (P<0.05). There was no statistically significant difference in time to first flatus and liquid diet or in the rate of postoperative complications (P<0.05). The overall postoperative complication rate was 6.8%; the postoperative complication rates were similar among the three groups; the rates of the LSG, LTG and LWR groups were 11.0%, 8.3%, 5.8%, respectively. The overall severe postoperative complication (≥IIIa) rate was 3.0%. One patient in the LTG group had an occurrence of an adhesive intestinal obstruction and underwent open enterolysis, and one patient in the LWR group had occurrence of bleeding that required re-exploration; both patients were discharged after recovery. Two patients developed an anastomotic stricture after LTG and LWR; both received endoscopic anastomotic dilation after one month (*Table 2*).

The efficacy of laparoscopic surgery in patients with tumor diameter ≥5 cm

We further compared the laparoscopic surgery efficacy of 55 patients with a tumor diameter ≥5 cm. Thirty-nine patients underwent LWR, and sixteen patients underwent laparoscopic gastric non-wedge resection (N-LWR, including LTG and LSG). These patients were similar in age, gender, BMI, NIH risk classification, pre-operative IM treatment and post-operative IM treatment. The LWR group was significantly associated with shorter operative time, less blood loss and shorter hospital stay compared with the N-LWR group (P<0.05).

	LSG（n=18）	LTG(n=12）	LWR(n=103)	p
Operating time（min）	120（90-315）	195（120-240）	90（30-225）	0.000※
Blood lost（ml）	50（10-100）	50（20-100）	10（5-100）	0.000※
Convert to open	0	0	1（1.0%）	1.000
Operative complication	1（5.6%）	1（8.3%）	1（0%）	0.050※
Flatus (days)	3（2-6）	3（1-14）	3（1-6）	0.079
Ground activities	2（1-5）	4（2-5）	2（1-6）	0.000※
Liquid diet (days)	4（3-6）	3（2-14）	4（1-9）	0.377
Semi-liquid diet	7（6-13）	8（4-28）	6（1-27）	0.000※
Hospital stay (days)	9（9-26）	11（10-28）	7（2-40）	0.000※
Postoperative complication	2（11.1%）	1（8.3%）	6（5.8%）	0.469＋
Pneumonia	1（5.6%）	1（8.3%）	3（2.9%）	
Anastomotic stenosis	1（5.6%）	0（0%）	1（1.0%）	
Ileus	0（0%）	1（8.3%）	0（0%）	
Wound infection	1（5.6%）	0（0%）	0（0%）	
Gastrasthenia	1（5.6%）	0（0%）	1（1.0%）	
Bleeding	0（0%）	0（0%）	1（1.0%）	

＋：two patients had two or more postoperative complications.

Table 2: Comparison of operative characteristics and perioperative outcome

	N-LWR(n=16）	LWR (n=39)	p
Age（years）	56（35-82）	56（35-82）	0.925
Gender			0.236
Male	12（75%）	22（56.4%）	
Female	4（25%）	17（43.6%）	
BMI（kg/m2）	20.7（18.3-25.5）	21.6（16.2-28.1）	0.066
Tumor size(cm)	7.3（5.1-11.0）	6.0（5.0-11.3）	0.315
Location			0.000※
Area A	8（50%）	1（2.6%）	
Area B	6（37.5%）	38（97.4%）	
Area C	2（12.5%）	0（0%）	
Mitotic rate (/ 50 HPF)			0.044※
≤5	10（62.5%）	30（76.9%）	
>5, ≤10	2（12.5%）	8（20.5%）	
＞10	4（25%）	1（2.6%）	
Risk classification			0.384
Very low	0（0%）	0（0%）	
Low	0（0%）	4（10.3%）	
Intermediate	8（50%）	21（53.8%）	
High	8（50%）	14（35.9%）	
Pre-operative IM	2（12.5%）	1（2.6%）	0.200
Postoperative IM	6（37.5%）	18（46.2%）	0.765

Table 3: Comparison of clinicopathological characteristics of the patients (tumor size≥5cm)

	N-LWR (n=16）	LWR (n=39)	p
Operating time（min）	150（90-315）	120（60-225）	0.004※
Blood lost（ml）	50（10-100）	30（5-100）	0.033※
Convert to open	0（0%）	1（2.6%）	1.000
Operative complication	1（6.3%）	1（0%）	0.291
Flatus (days)	3（1-14）	3（1-5）	0.756
Ground activities(days)	2（1-5）	2（1-5）	0.420
Liquid diet (days)	3（3-14）	4（3-9）	0.181
Semi-liquid diet(days)	7（4-28）	6（1-27）	0.106
Hospital stay (days)	10（8-28）	8（5-40）	0.001※
Postoperative complication	2（12.5%）	2（5.1%）	0.571
Pneumonia	1（6.3%）	0（0%）	
Ileus	1（6.3%）	0（0%）	
Anastomotic stenosis	1（6.3%）	1（2.6%）	
Bleeding	0（0%）	1（2.6%）	

Table 4: Comparison of operative characteristics and perioperative outcome (tumor size≥5cm)

There were no statistically significant differences in time to ground activities, first flatus, liquid diet, semi-liquid diet or operative or postoperative complications (P<0.05) (*Table 3, Table 4*).

Follow-up

One hundred thirty patients (97.7%) were followed up; the median follow-up duration for the entire cohort was 30.0 months (range, 4–78 months), with 4 cases of recurrence and 3 deaths. The 5-year cumulative survival

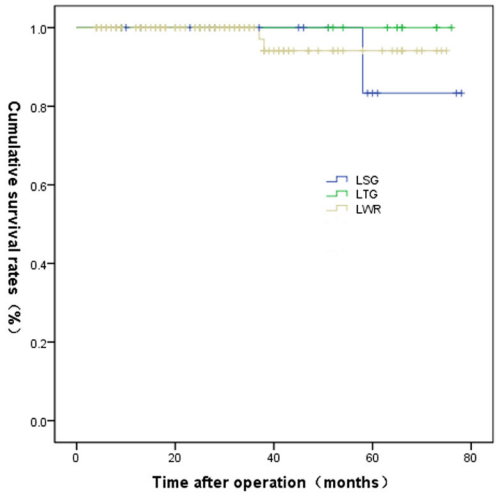

Figure 3: Total survival curve of the group LSG, group LTG and group LWR

rates of the LSG, LTG, and LWR groups were 80%, 100%, and 94.5%, respectively, which was similar among the three groups (P>0.05)(*Figure 3*). *Table 5* shows the clinicopathologic characteristics for cases of recurrence and death after resection.

Discussion:

Most GISTs are in a submucosal location and usually grow exogenously instead of diffusely infiltrating. It is generally accepted that the surgical goal should be a complete resection with negative margins. Meanwhile, extensive lymphadenectomy is not recommended because lymph node involvement is rare[10-12]. These unique growth patterns make GIST resection relatively simple and provide favorable conditions for minimally invasive surgery. A number of studies have shown the safety and feasibility of laparoscopic resection of gastric GISTs. Koh[13] et al. performed a systematic review and meta-analysis to compare the outcomes of laparoscopic gastric resection (LR) versus open gastric resection (OR) for gastric GIST. Although there was no difference in operative time, LR results in less blood loss, lower risk of minor complications, shorter time to first flatus, oral intake and a decreased postoperative hospital stay. The long-term oncological outcomes of the two groups are comparable. De Vogelaere[14] et al. considered that LR also had a similar minimally invasive effect, and the operative time of LR was significantly shorter than that of OR. In recent years, with the improvement in laparoscopic instrumentation and accumulated laparoscopic experience, an increased number of surgeons prefer laparoscopic resection of gastric GIST. Since the first laparoscopic resection for gastric GIST in 2008, our department has completed more than 100 cases with laparoscopic gastric GIST resection, and it has become the first choice for surgical treatment of gastric GIST.

There are a variety of ways for conducting a laparoscopic resection of gastric GIST, and we should determine the appropriate surgical procedures based on tumor location, tumor size and growth pattern [15-17]. The main methods of pure laparoscopic surgery contain LWR, LSG (including LPSG and LDSG) and LTG. When the tumor is located in cardia and is large enough to be involved, local resection has a high incidence of causing gastrointestinal tract stenosis. Therefore, LTG or LPSG is preferred. Meanwhile, LWR is suitable for tumors that are small or that grow exogenously with pedicle, where the digestive tract remains unobstructed. Because fundus and greater curvature are spacious, GISTs located in these areas are often removed by LWR, whereas small tumors of lesser curvature require sufficient isolation of the surrounding tissues. Large GISTs with an endogenous growth model are difficult to operate, and stenosis is a frequent outcome. In such a case, LTG or LPSG will be a safer option. For the antral GISTs, LDSG is recommended. In this study, we demonstrated that LWR had less invasiveness, faster recovery and similar long-term prognosis when compared with LTG and LSG, making it an optimal surgical approach for gastric GIST treatment.

Although the advantages of laparoscopic surgery for gastric GIST are clear, there is also the risk of intraoperative tumor rupture, especially when the tumor is large. The feasibility of laparoscopic surgery for large tumors is controversial. Because large tumors are prone to rupture during the operation and result in peritoneal spreading, laparoscopic resection of gastric GIST is mostly limited to small gastric GIST with a diameter ≤5 cm[18-19]. However, some scholars believe that laparoscopic surgery is equally applicable to large gastric GIST (≥5 cm)[20-22]. Takahashi [20] et al. suggested that laparoscopic surgery could achieve equal short- and long-term efficacy compared with

No.	gender	Age (years)	Pre-operative IM	Gastrectomy extent	Postoperative IM	Tumor size(cm)	Tumor location	Risk classification	Status	months
1	Male	56	No	LSG	No	4.0	Area B	Low	Death	37
2	Male	57	No	LWR	Yes	3.3	Area B	Medial	Death	38
3	Male	72	No	LWR	No	4.8	Area B	Low	Death	44
4	Male	35	Yes	LTG	Yes	9.0	Area A	High	Recurrent	49

Table 5: Clinicopathologic characteristics of recurrent/death cases

open surgery, which is in agreement with our previous studies [23]. In this study, 55 cases of GIST larger than 5 cm were successfully completed with laparoscopic resection except for 1 case that was converted to open due to severe adhesion to the surrounding tissue. There was no intraoperative rupture, and all cases had received R0 resection. For gastric GIST larger than 5 cm, LWR was associated with shorter operation time, less blood loss and shorter hospital stay than N-LWR was. Hence, we believe laparoscopic resection of gastric GIST with tumor diameter ≥5 cm is still feasible and safe. LWR can be a preferred surgical approach for those GISTs if conditions allow.

Conclusion:
Laparoscopic treatment of gastric GISTs is safe and feasible with satisfactory clinical efficacy. Compared with LSG and LTG, more favorable minimally invasive results can be achieved from LWR for gastric GISTs, which may be the optimal surgical procedure.

Acknowledgements
All the authors are thankful to our patients and the staffs of Fujian Medical University Union Hospital who contributed to establishing our gastric GISTs patient database.

Contributors
Jian-Xian Lin, Qian Yu and Chang-Ming Huang conceived of the study, analyzed the data, and drafted the manuscript; Mi Lin, Chao-Hui Zheng, Ping Li, Jian-Wei Xie helped revise the manuscript critically for important intellectual content; Jun Lu and Qi-Yue Chen helped collect data and design the study. All authors read and approved the final manuscript. The authors have declared no conflicts of interest.

Funding
The work was supported by the National Key Clinical Specialty Discipline Construction program of China (No. [2012]649)and Key Projects of Science and Technology Plan of Fujian Province (No. 2014Y0025). The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Competing interests
All authors declare that they have no competing interests.

Availability of data and materials
Further information is available from the corresponding author on reasonable request.

Ethics approval
Ethics Committee of Fujian Medical University Union Hospital approved this retrospective study (Approval number: 20070428). Written consent was given by the patients for their information to be stored in the hospital database and used for research. All study participants, or their legal guardian, provided informed written consent prior to study enrollment.

Provenance and peer review
Not commissioned; externally peer reviewed.

References
[1] Joensuu H. Gastrointestinal stromal tumor (GIST). Ann Oncol. 2006;17 Suppl 10:x280-6.
[2] Miettinen M, Lasota J. Gastrointestinal stromal tumors--definition, clinical, histological, immunohistochemical, and molecular genetic features and differential diagnosis. Virchows Arch. 2001;438:1-12.
[3] Miettinen M, Lasota J. Gastrointestinal stromal tumors: review on morphology, molecular pathology, prognosis, and differential diagnosis. Arch Pathol Lab Med. 2006;130:1466-78.
[4] Karakousis GC, Singer S, Zheng J, Gonen M, Coit D, DeMatteo RP, et al. Laparoscopic versus open gastric resections for primary gastrointestinal stromal tumors (GISTs): a size-matched comparison. Ann Surg Oncol. 2011;18:1599-605.
[5] Desiderio J, Trastulli S, Cirocchi R, Boselli C, Noya G, Parisi A, et al. Robotic gastric resection of large gastrointestinal stromal tumors. Int J Surg. 2013;11:191-6.
[6] Parisi A, Desiderio J, Trastulli S, Pressi E, Minicucci A, Farinacci F, et al. Laparoscopic single-stapling gastric transection for exophytic pedunculated gastrointestinal stromal tumor: is a safe procedure? Surg Laparosc Endosc Percutan Tech. 2013;23:e93-7.
[7] Privette A, McCahill L, Borrazzo E, Single RM, Zubarik R. Laparoscopic approaches to resection of suspected gastric gastrointestinal stromal tumors based on tumor location. Surg Endosc. 2008;22:487-94.
[8] Sasaki K, Fujiwara Y, Kishi K, Miyashiro I, Sugimura K, Miyoshi N, et al. [Usefulness of laparoscopy endoscopy cooperative surgery for gastric gastrointestinal stromal tumor]. Gan To Kagaku Ryoho. 2014;41:2223-5.
[9] Nguyen SQ, Divino CM, Wang JL, Dikman SH. Laparoscopic management of gastrointestinal stromal tumors. Surg Endosc. 2006;20:713-6.
[10] von Mehren M, Randall RL, Benjamin RS, Boles S, Bui MM, Casper ES, et al. Gastrointestinal stromal tumors, version 2.2014. J Natl Compr Canc Netw. 2014;12:853-62.
[11] Chernyi VV, Gul'ko ON, Simonov OM. [Treatment of gastrointestinal stromal jejunal tumor]. Klin Khir. 2014:76-7.
[12] Frankel TL, Chang AE, Wong SL. Surgical options for localized and advanced gastrointestinal stromal tumors. J Surg Oncol. 2011;104:882-7.
[13] Koh YX, Chok AY, Zheng HL, Tan CS, Chow PK, Wong WK, et al. A systematic review and meta-analysis comparing laparoscopic versus open gastric resections for gastrointestinal stromal tumors of the stomach. Ann Surg Oncol. 2013;20:3549-60.
[14] De Vogelaere K, Hoorens A, Haentjens P, Delvaux G. Laparoscopic versus open resection of gastrointestinal stromal tumors of the stomach. Surg Endosc. 2013;27:1546-54.
[15] Honda M, Hiki N, Nunobe S, Ohashi M, Kiyokawa T, Sano T, et al. Long-term and surgical outcomes of laparoscopic surgery for gastric gastrointestinal stromal tumors. Surg Endosc. 2014;28:2317-22.
[16] Pucci MJ, Berger AC, Lim PW, Chojnacki KA, Rosato EL, Palazzo F. Laparoscopic approaches to gastric gastrointestinal stromal tumors: an institutional review of 57 cases. Surg Endosc. 2012;26:3509-14.
[17] Novitsky YW, Kercher KW, Sing RF, Heniford BT. Long-term outcomes of laparoscopic resection of gastric gastrointestinal stromal tumors. Ann Surg. 2006;243:738-45; discussion 45-7.
[18] Mochizuki Y, Kodera Y, Fujiwara M, Ito S, Yamamura Y, Sawaki A, et al. Laparoscopic wedge resection for gastrointestinal stromal tumors of the stomach: initial experience. Surg Today. 2006;36:341-7.
[19] Amin AT, Kono Y, Shiraishi N, Yasuda K, Inomata M, Kitano S. Long-term outcomes of laparoscopic wedge resection for gastrointestinal stromal tumors of the stomach of less than 5 cm in diameter. Surg Laparosc Endosc Percutan Tech. 2011;21:260-3.
[20] Takahashi T, Nakajima K, Miyazaki Y, Miyazaki Y, Kurokawa Y, Yamasaki M, et al. Surgical strategy for the gastric gastrointestinal stromal tumors (GISTs) larger than 5 cm: laparoscopic surgery is feasible, safe, and oncologically acceptable. Surg Laparosc Endosc Percutan Tech. 2015;25:114-8.
[21] Hsiao CY, Yang CY, Lai IR, Chen CN, Lin MT. Laparoscopic resection for large gastric gastrointestinal stromal tumor (GIST):

intermediate follow-up results. Surg Endosc. 2015;29:868-73.
[22] Kim KH, Kim MC, Jung GJ, Kim SJ, Jang JS, Kwon HC. Long term survival results for gastric GIST: is laparoscopic surgery for large gastric GIST feasible? World J Surg Oncol. 2012;10:230.
[23] Lin J, Huang C, Zheng C, Li P, Xie J, Wang J, et al. Laparoscopic versus open gastric resection for larger than 5 cm primary gastric gastrointestinal stromal tumors (GIST): a size-matched comparison. Surg Endosc. 2014;28:2577-83.

JGS

SYSTEMATIC REVIEW OPEN ACCESS

The use of indocyanine green in bariatric surgery: A systematic review

Francesco Maria Carrano[1], *Nicola Di Lorenzo*[1*]

[1]PhD in Applied Medical-Surgical Sciences, University of Rome "Tor Vergata", 00133 Rome (RM), Italy

To Cite
Carrano FM, Di Lorenzo N. The use of indocyanine green in bariatric surgery: A systematic review. J Gastric Surg 2020; 2(2): 41-44

Publication history
Received: May 19, 2020
Accepted: May 22, 2020
Article in press: June 02, 2020
Published on line: June XX, 2020

***Correspondence to**
Prof. Nicola Di Lorenzo
Department of Surgical Sciences
University of Rome "Tor Vergata"
Viale Oxford 81
00133 Rome (RM), Italy
nicola.di.lorenzo@uniroma2.it
Telephone: +390620903854

ABSTRACT
Fluorescence-guided surgery is a recently developed technique in minimally invasive surgery in which a fluorescent dye is used to complement the surgeon's judgment in making real-time intraoperative assessment of organ vascularization and proper tissue perfusion. This technique has been adopted in several different surgical subspecialties with positive results, particularly in hepatobiliary and colorectal surgery. More recently, it has also been applied in bariatric surgery, with the aim of reducing the incidence of leaks. This paper reviews the relevant literature on the topic.

Keywords:
ICG, bariatric surgery, indocyanine green, fluorescence.

Introduction:
The alarming prevalence of obesity, with its related burden of metabolic consequences, is a well-known problem. Metabolic surgery has been recognized as the most effective treatment for achieving significant weight loss as well as tangible improvements in glycemic control and a reduction of overall cardiovascular risk.[1] Surgery for obesity is also recognized as a safe treatment, with mortality rates comparable to those of other common procedures (e.g., appendectomy, cholecystectomy, hysterectomy), ranging from 0.3% to 2%.[2] The occurrence of major adverse events at 30 days vary from 5.0% for Roux-en-Y gastric bypass to 2.6% for sleeve gastrectomy.[3] Technological improvements as well as the institution of accredited bariatric surgery programs are two of the main factors contributing to these favorable results.[4] One recently introduced technique in the field of bariatric surgery is indocyanine green (ICG) fluorescence angiography (ICG-FA). Indocyanine green, a fluorescent dye approved by the FDA and EMA for use in medical diagnostics, has been routinely used for years in ophthalmology, but recently several other fields of application have also been described in the literature, most notably colorectal, hepatobiliary, and oncologic surgery.[5] ICG absorbs near-infrared light at wavelengths between 800 to 810 nm and becomes fluorescent at 830 nm, when excited by a laser source or by a near-infrared light at 820 nm wavelength.[6] Fluorescence can be visualized by special laparoscopic cameras and rendered on screen in several different colors, depending on the proprietary filters applied by each camera maker. Our paper reviews the literature on application of ICG in obesity surgery.

Methods:
This systematic review was performed in accordance with the PRISMA guidelines.[7] The study population included patients undergoing any bariatric surgical operation. The intervention object of the analysis was intraoperative ICG-FA assessment of vascularization. Any comparison was considered. Outcome: post-operative complications. The following exclusion criteria were selected: preclinical studies, non-bariatric surgical procedures, surgeries on obese patients performed for other reasons other than weight loss, and language other than English. Duplicate studies were removed. A systematic search of the literature (*Figure 1*) was undertaken by the two authors in PubMed, Google Scholar, and Embase, current through May 5, 2020, and included additional papers identified from the references. Search terms were "indocyanine green", "ICG", "fluorescence angiography", "ICG AND bariatric surgery", "ICG AND obesity", "ICG AND leak", and "dehiscence". The following data were extracted from each study: age, preoperative BMI, length of stay, and postoperative complications.[8]

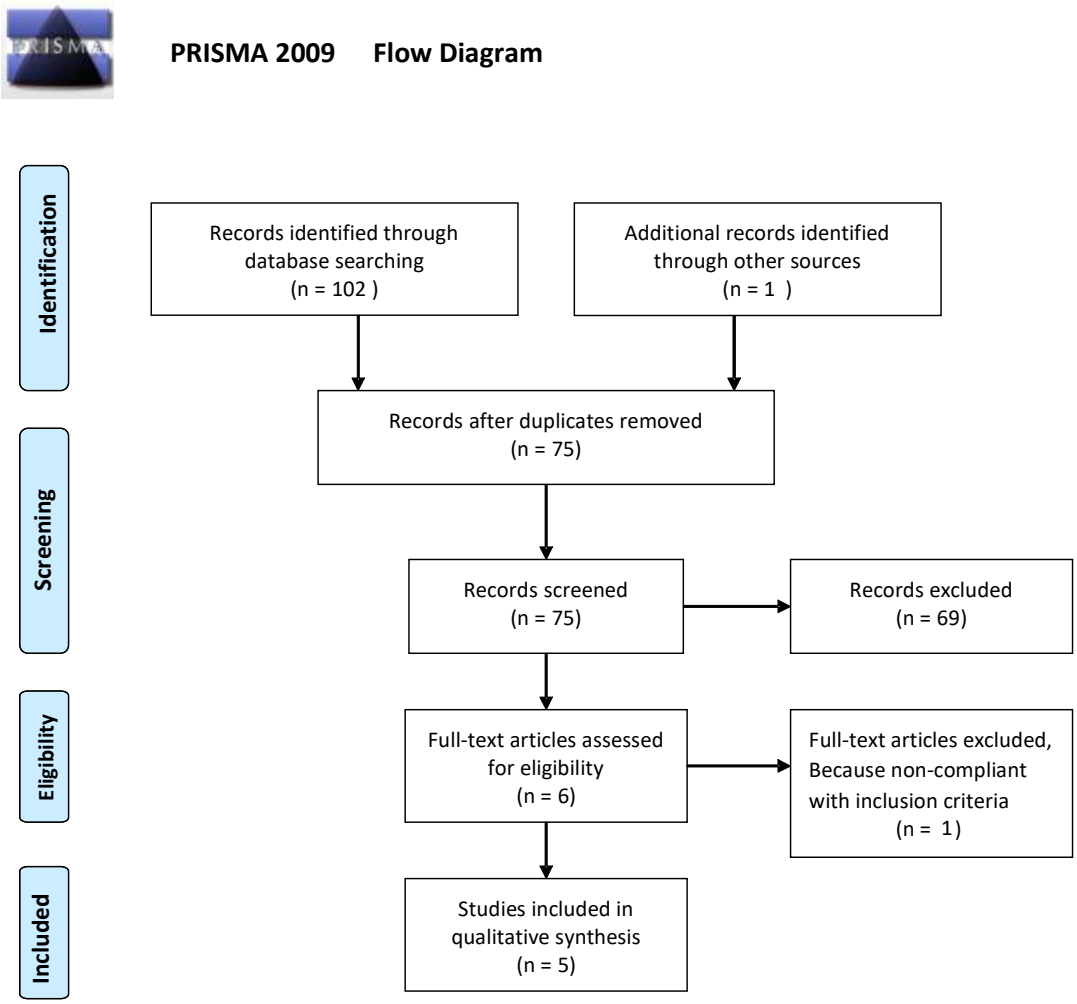

Figure 1: Flowchart of the records selection process.

Authors	Patients (N)	Age (mean ± std dev)	pre-op BMI (mean Kg/m^2± std dev)	Type of surgery	Post-op complications
Olmi et al. (2019)[9]	1	38	43	RYGB	None reported
Frattini et al. (2015)[10]	15	42	45	Sleeve	None reported
Di Furia et al. (2019)[11]	43	46.04	40.73	Sleeve	1 leak
Ortega et al. (2018)[12]	86	-	-	Sleeve	None reported
Hagen et al. (2019)[13]	95	43.9 ± 11.1	43.5 ± 6.4	R-RYGB	None reported

Table 1: Characteristics of the included studies.

Results:
A total of 103 articles were identified during the search (*Figure 1*). After removal of duplicates, 75 papers were screened, of which 69 were not pertinent to the study and thus were excluded. Six eligible studies were initially identified, one of which was removed for noncompliance with the inclusion criteria. Ultimately, five studies were included for the analysis, all published after 2008. Our search found no comparative studies.
One of the studies was a case report[9]; the remaining four included studies [10-13] from prospectively maintained databases analyzed retrospectively (*Table 1*). A total of 240 patients were included in the studies. The majority of patients (N = 144) underwent laparoscopic sleeve gastrectomy, another 95 underwent robotic Roux-en-Y gastric bypass (R-RYGB), and 1 underwent a laparoscopic RYGB combined with a Rossetti fundoplication. No demographic data were available for 86 patients, not having been reported in the study by Ortega et al.[12] No intraoperative complications were reported in any of the studies. Only one leak occurred postoperatively, in a patient who underwent a laparoscopic sleeve gastrectomy, as reported by Di Furia et al.[11] ICG was used intravenously to assess proper vascularization of the staple line in four of five studies. In the study by Hagen et al[13], however, ICG was used to assess intraoperative leaks and was administered via nasogastric tube, mixed with methylene blue dye and saline solution. No studies reported side effects following ICG administration.
Some of the studies included in our review described the effect of ICG administration on operative times, finding no significant increase. However, the lack of comparative studies prevented the drawing of any conclusions about the advantages of this technique over standard practice. Nor can any conclusion be drawn regarding the most appropriate dose and administration regimen of ICG, owing to a lack of information in some of the studies and the heterogeneity of application seen in the remainder.

Discussion:
At present, there is no gold standard method for conducting intraoperative assessment of tissue perfusion. Traditionally, visual evaluation and tactile testing of pulsating blood vessels have been most frequently adopted. The recent introduction of ICG in minimally invasive surgery has provided a potential solution to the problem, but its use is debated among the surgical community. The use of ICG in bariatric surgery was introduced only recently, with the aim of assessing adequate perfusion of the gastric tubule during sleeve gastrectomy and of bowel anastomoses in RYGB, so as to reduce leaks. However, in view of the low incidence of leaks in bariatric surgery[4], study of a large number of patients may be needed to detect any difference between standard practice and ICG, representing a potential obstacle to doing so. Consensus on optimal ICG dosage and timing of administration will also be needed. Notably, although some acute allergic reactions have been reported, the intravenous use of ICG is regarded as generally safe.[14]
Accordingly, we see revisional bariatric surgery as a potentially promising application of ICG because of the challenges provided by anatomical alterations and the need to achieve optimal perfusion in suboptimal tissues. A significant limitation of this technique is the current impossibility of providing objective quantitative assessment of fluorescence intensity, which would provide a more reliable way of demonstrating the value of this technology. In our opinion, this is an important need that should be addressed by novel studies.
Our study has several limitations. Data presented among the various studies were highly heterogeneous, preventing any comparison. All studies included were single-centered and adopted different techniques for ICG administration and imaging detection systems; indeed, some studies lacked such information altogether.

Conclusion:
ICG fluorescence is a widely adopted technique in multiple surgical specialties but has been introduced to bariatric surgery only recently. Its intravenous use allows the execution of real-time intraoperative angiography and assessment of tissue perfusion, thus potentially preventing leaks as well as perfusion-related complications. Currently no evidence suggests that its use can reduce postoperative complications in bariatric surgery. We think that ICG use may be a valuable aid to the surgeon for intraoperative real-time assessment of vascularization and tissue perfusion. More studies, particularly randomized controlled trials, comparing its application with standard vision are needed to investigate the potential advantages of ICG use in routine practice.

Acknowledgements
Not applicable.

Contributors
FMC, NDL conceptualized and designed the study, acquired and analysed data, interpreted the study results, drafted the manuscript. FMC, NDL critically

revised the manuscript for important intellectual content.

Funding
No funding was received for this study.

Competing interests
No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

Availability of data and materials
Further information is available from the corresponding author on reasonable request.

Ethics approval
Not applicable.

Provenance and peer review
Not commissioned; externally peer reviewed.

References

[1] Pareek M, Schauer PR, Kaplan LM, Leiter LA, Rubino F, Bhatt DL. Metabolic Surgery: Weight Loss, Diabetes, and Beyond. J Am Coll Cardiol. 2018;71:670-87.
[2] Aminian A, Brethauer SA, Kirwan JP, Kashyap SR, Burguera B, Schauer PR. How safe is metabolic/diabetes surgery? Diabetes Obes Metab. 2015;17:198-201.
[3] Arterburn D, Wellman R, Emiliano A, Smith SR, Odegaard AO, Murali S, et al. Comparative Effectiveness and Safety of Bariatric Procedures for Weight Loss: A PCORnet Cohort Study. Ann Intern Med. 2018;169:741-50.
[4] Ghiassi S, Morton JM. Safety and Efficacy of Bariatric and Metabolic Surgery. Curr Obes Rep. 2020;9:159-64.
[5] Purich K, Dang JT, Poonja A, Sun WYL, Bigam D, Birch D, et al. Intraoperative fluorescence imaging with indocyanine green in hepatic resection for malignancy: a systematic review and meta-analysis of diagnostic test accuracy studies. Surg Endosc. 2020.
[6] Alander JT, Kaartinen I, Laakso A, Patila T, Spillmann T, Tuchin VV, et al. A review of indocyanine green fluorescent imaging in surgery. Int J Biomed Imaging. 2012;2012:940585.
[7] Moher D, Liberati A, Tetzlaff J, Altman DG, Group P. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med. 2009;6:e1000097.
[8] Slim K, Nini E, Forestier D, Kwiatkowski F, Panis Y, Chipponi J. Methodological index for non-randomized studies (minors): development and validation of a new instrument. ANZ J Surg. 2003;73:712-6.
[9] Olmi S, David G, Cesana G, Ciccarese F, Giorgi R, De Carli S, et al. Modified Sleeve Gastrectomy Combined with Laparoscopic Rossetti Fundoplication and Vascularization Assessment with Indocyanine Green. Obes Surg. 2019;29:3086-8.
[10] Frattini F, Lavazza M, Mangano A, Amico F, Rausei S, Rovera F, et al. Indocyanine green-enhanced fluorescence in laparoscopic sleeve gastrectomy. Obes Surg. 2015;25:949-50.
[11] Di Furia M, Romano L, Salvatorelli A, Brandolin D, Lomanto D, Cianca G, et al. Indocyanine Green Fluorescent Angiography During Laparoscopic Sleeve Gastrectomy: Preliminary Results. Obes Surg. 2019;29:3786-90.
[12] Ortega CB, Guerron AD, Yoo JS. The Use of Fluorescence Angiography During Laparoscopic Sleeve Gastrectomy. JSLS. 2018;22.
[13] Hagen ME, Diaper J, Douissard J, Jung MK, Buehler L, Aldenkortt F, et al. Early Experience with Intraoperative Leak Test Using a Blend of Methylene Blue and Indocyanine Green During Robotic Gastric Bypass Surgery. Obes Surg. 2019;29:949-52.
[14] Speich R, Sasseli B, Hoffmann U, Neftel K. Letters and corrections. Ann Intern Med. 1988;109:345-6.

JGS

REVIEW

OPEN ACCESS

Technology spreading in healthcare: a novel era in medicine and surgery?

Domenico Di Nardo[1*], *Chiara Eberspacher*[1], *Giorgio Palazzini*[1]

[1]Department of Surgical Sciences, "La Sapienza" University, Rome, Italy

To Cite
Di Nardo D, Eberspacher C, Palazzini G. Technology spreading in healthcare: a novel era in medicine and surgery? J Gastric Surg 2020; 2(2): 45-48

Publication history
Received: April 08, 2020
Accepted: April 15, 2020
Article in press: April 18, 2020
Published on line: April 18, 2020

***Correspondence to**
Dr. Domenico Di Nardo
Department of Surgical Sciences
Policlinico Umberto I
"La Sapienza" University
Viale Regina Elena 324
00161 Roma (RM), Italy
domenicodinardo@outlook.it
Telephone: +393281599463

ABSTRACT

Background:

Surgery and technological innovation have begun to move at the speed of light, with innovations and discoveries such as virtual reality, robotic systems, navigation surgery, and 5G networks radically revolutionizing the surgical world as well as the medical world in general, bringing significant benefits for healthcare professionals and patients alike. Technology will increasingly be a crucial element in surgical and medical development. This new therapeutic approach aims to enhance human–computer interaction by putting a new "patient" figure at its center. Multiple studies will be needed to demonstrate new advanced technological systems' noninferiority to traditional patient approaches. Scientific societies, hospitals, and healthcare professionals cannot be found ill prepared for this revolution.

Keywords:

Telesurgery, 5G, 3D printing, immersive surgery, augmented reality.

Background:
In recent years, engineers and technology companies have striven to keep pace with rapid developments in modern surgery, including of advanced devices that allow ever quicker and more precise diagnoses and provision of therapies. This article provides an analysis of the close association between technology and surgery, with a review of the evidence from current literature. Recent technological innovations include 8K vision, 3D cameras, navigation surgery, image analysis using indocyanine green fluorescence (*Figure 1*), virtual surgical planning, 3D printing, the use of robotics systems for telesurgery, and application of 5G to surgery[1]. Surgery can thus be used to create an all-around network together with other disciplines, especially oncology, molecular biology, medicine, nutrition, engineering, and telecommunications.

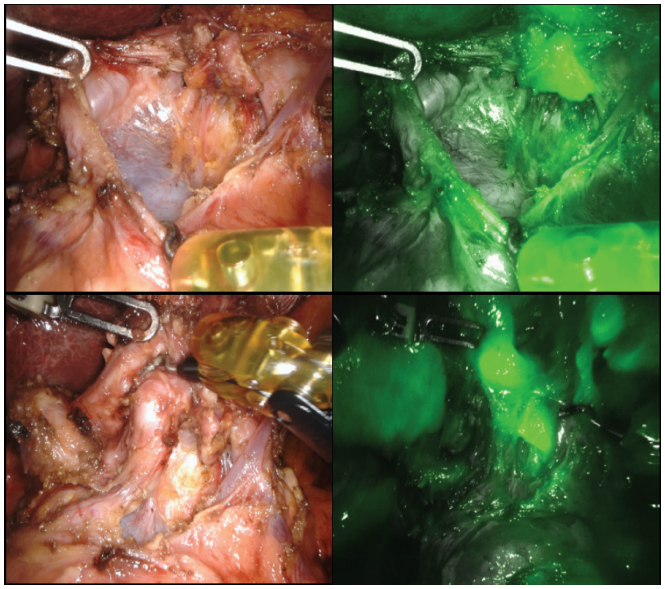

Figure 1: Fluorescence guided lymphadenectomy during total gastrectomy.

Methods:
Analysis of available published studies in the literature was performed to identify papers reporting the role of technology in medicine, robotics, 5G networks, telemedicine, and remote surgery. MEDLINE, Embase, and the Cochrane Library were searched to identify articles published through April 2020 that included reported information, details, and results concerning the medical and surgical application of advanced technological devices. Links for all search results, as well as references included in the identified articles, were reviewed to identify additional literature that was not indexed. A total of 55 potentially relevant records were identified and screened. After elimination of duplicates and exclusion of nonrelevant articles, 10 articles were read carefully and evaluated to perform a descriptive review.

Results and discussion:

3D printing
The use of 3D printing has been enjoying considerable success in the surgical field, revolutionizing medical approaches to patients both in the preoperative phase (in the study of tissues and viscera starting from axial tomography images and 2D and 3D magnetic resonance imaging) and the operating phase (using 3D-printed prostheses made of biocompatible material to repair damaged organs and tissues). 3D printing has gained increasing value in the educational field for training medical students and residents. In preoperative planning, for example, surgical simulation can help the surgeon trace the surgical steps of a procedure using a 3D-printed replica of the organ or tissue to be treated. The use of materials and specific algorithms simulates not only the patient's anatomy but even the effects of the surgical act, as described by Pugliese et al[2].

IT services: websites, social networks, videos
Thus far, IT support has been essential for general surgery development, with increasing numbers of sites, social networks, and IT tools dedicated to surgery and medicine. No scientific society, congress, or training event is possible without web support and a dedicated social platform (Facebook, Twitter, LinkedIn, and more), for such capabilities allow the rapid global spread of data. A single website can be informative and technical while containing documents (text files and videos). Both live and archived information can be made available[3]. Not only surgeons and general practitioners but also patients increasingly use the Internet and social media to search for specific information regarding diagnosis and therapy as well as information about individual specialists. Long et al.[4] reported that 65% of colorectal surgeons used the Internet from 2 to 6 h per week for clinical purposes, whether seeking for generic information or evidence-based literature (*Figure 2*). In addition, 72% of interviewed surgeons had their own website specific to their professional activity. Facebook was the preferred social media network, followed by LinkedIn and Twitter. What's more, 43% of patients searched online for information about doctors, and 75% looked for information about symptoms or conditions.

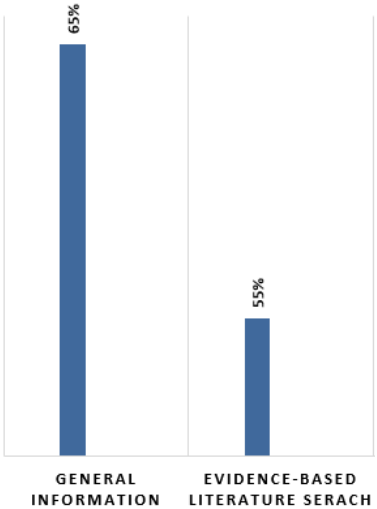

Figure 2: Use of internet among general surgeons.

5G: telemedicine and telesurgery

All the technologies thus far described have become part of everyday life, but now 5G technology is set to revolutionize the surgery–technology–communications interconnection by making huge amounts of data relating to patient diagnosis and therapy available over networks, giving an all-around view of individual patients. For example, doctors will be able to use a web platform to monitor minute chances to vital parameters, temperature, body weight, changes in lean/fat mass, metabolism, diuresis, and therapy minute by minute, day by day. Patients monitored in this way can go to the hospital only when strictly necessary, such as for surgery or urgent therapeutic reevaluation. By offering very high bandwidths at lower costs while reducing latency to a minimum, 5G overcomes the main limitation of current connections and the real obstacle to robotic telesurgery, allowing health care providers to develop a patient-based system focused on remote telemedicine diagnosis and treatments. In this way, patients can be treated and monitored worldwide using modern technologies and standardized working methods. Moreover, web-based systems can be expected to grow in accuracy and efficiency thanks to the storage of huge amounts of data for analysis by artificial intelligence, reducing bias and allowing the discovery of new diagnostic and therapeutic approaches[5]. A surgeon in one area will be able to operate on a patient in any other area of the world at any time—particularly useful for those in developing countries or war zones. Experiments have already been carried out in this field, with considerable success: on November 28, 2019, during the 30th International Congress of Digestive Surgery, held at the Auditorium del Massimo in Rome, a 5G connection was established between the congress venue and the operating room of Saint Mary's Hospital of Terni. Prof. Giorgio Palazzini, acting from Rome, used a 360-degree visor connected via a 5G network to carry out the first worldwide immersive surgery with remote consultation while Profs. Huang and Parisi performed a laparoscopic gastrectomy.

5G and education

Hospitals will be closely connected with universities, so that a trainee in Italy, for example, will be able to follow a surgery in China and vice versa—not merely through a simple monitor but rather through the eyes of the operating surgeon, who will wear a viewer capable of transmitting high-quality images in real time. Indeed, the world of training has already changed with the advents of smart working, interactive webinars, online lessons, virtual reality and 3D simulators (*Figure 3*), and

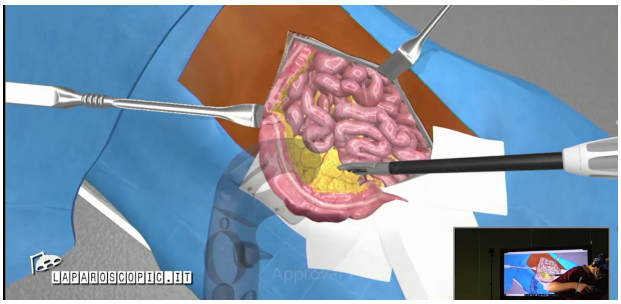

Figure 3: Virtual reality used for education of residents.

streaming conferences featuring connections from around the globe (*Figure 4*). O'Leary et al. have demonstrated the Internet's effectiveness as a training tool for doctors in training and its ability to reduce costs in favor of an effective learning curve[6]. Sheahan et al. demonstrated how video files can be used successfully in the training and teaching of individual doctors and in the evaluation of surgical skills[7].

Figure 4: Live surgery during the international congress of digestive surgery (Auditorium del Massimo, Rome, Italy). Multiple connections between operating rooms from different countries and the congress venue.

5G: the active role of the patient

Technology will increasingly lead patients to play a role that is active instead of passive, placing them at the center of the interactive hospital–doctor–patient process (*Figure 5*).

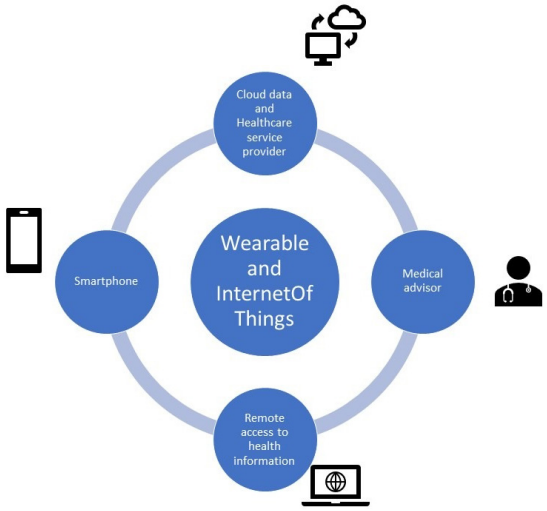

Figure 5: Integration between patient, technology and health systems.

The ever-growing market of wearable devices connected via Bluetooth (*Table 1*), which allows analysis and transmission of data at any time in real time, will transform the diagnostic process through an emphasis on screening and early diagnosis with the aim of reducing invasive therapies and complications of disease while increasing quality of life, reducing costs for healthcare facilities, and allowing the monitoring of chronic diseases[8].

Sensor	Body
Pulse	Finger
Blood oxygen	Finger or arm
ECG	Chest
EEG	Forehead or back side of head
Body temperature	Under arm seam
Stress levels	Finger
Sleeping	Wrist
Walking	Wrist
Weight and BMI	Wrist
Kcal	Wrist

Table 1: biomedical sensors and measure of physiological vital signs

Future perspectives

We now face a pandemic unrivaled in the past 100 years. The face of the scientific world has completely changed, with surgery limited to emergency surgery and nondeferrable oncology surgery. As shown by Pellino and Spinelli, the ideal time for resection of colorectal cancer has been put at 3 to 6 weeks from diagnosis—unlikely timing during the Sars-Cov2 epidemic. Such restrictions could reduce effectiveness of treatments over the short and long terms for oncological patients[9]. To overcome these issue, alternative strategies for patient management strategies should be devised and put in place. The biggest challenge associated with high-speed networks is that of increasing telemedicine through the use of advanced devices, thus enabling doctors to conduct patient visits remotely so as to reduce the possibility of viral spread among patients and health care providers. In the 5G era, moreover, it should become possible to reduce minimally invasive surgery's limits as they relate to contagion risk (pneumoperitoneum, nebulization of fumes from ultrasound or radio frequency instruments, anesthetic gases) through applications of robotic technology[10].

Conclusion:

The impact of these cutting-edge technologies is still unknown, as are their effects on the economy, on hospital infrastructures, on healthcare strategies and staff organization, and even on disease follow-up. However, social changes and the need to provide care are moving health systems inevitably toward greater integration of technology with medicine.

Acknowledgements

Not applicable.

Contributors

DDN, CE conceptualized and designed the study, acquired and analysed data, interpreted the study results, drafted the manuscript. GP critically revised the manuscript for important intellectual content.

Funding

No funding was received for this study.

Competing interests

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

Availability of data and materials

Further information is available from the corresponding author on reasonable request.

Ethics approval

Not applicable.

Provenance and peer review

Not commissioned; externally peer reviewed.

References

[1] Fang CH, Chen K, Zhang P. [The current situation and prospects of the application of intelligent diagnosis and treatment technology in the general surgery]. Zhonghua Wai Ke Za Zhi. 2019;57:1-5.
[2] Pugliese L, Marconi S, Negrello E, Mauri V, Peri A, Gallo V, et al. The clinical use of 3D printing in surgery. Updates Surg. 2018;70:381-8.
[3] Victer FC. Surgery and the internet. Rev Col Bras Cir. 2017;44:220-1.
[4] Long LE, Leung C, Hong JS, Wright C, Young CJ. Patterns of internet and social media use in colorectal surgery. BMC Surg. 2019;19:52.
[5] Stefano GB, Kream RM. The Micro-Hospital: 5G Telemedicine-Based Care. Med Sci Monit Basic Res. 2018;24:103-4.
[6] O'Leary DP, Corrigan MA, McHugh SM, Hill AD, Redmond HP. From theater to the world wide web--a new online era for surgical education. J Surg Educ. 2012;69:483-6.
[7] Sheahan G, Reznick R, Klinger D, Flynn L, Zevin B. Comparison of Personal Video Technology for Teaching and Assessment of Surgical Skills. J Grad Med Educ. 2019;11:328-31.
[8] Haghi M, Thurow K, Stoll R. Wearable Devices in Medical Internet of Things: Scientific Research and Commercially Available Devices. Healthc Inform Res. 2017;23:4-15.
[9] Pellino G, Spinelli A. How COVID-19 Outbreak Is Impacting Colorectal Cancer Patients in Italy: A Long Shadow Beyond Infection. Dis Colon Rectum. 2020.
[10] Lisi G, Campanelli M, Spoletini D, Carlini M. The possible impact of COVID-19 on colorectal surgery in Italy. Colorectal Dis. 2020.

JGS

CASE REPORT

OPEN ACCESS

Massive choleperitoneum three months after mini-gastric bypass for morbid obesity: what every emergency surgeon should be prepared to face. A case report.

Giacomo Piatto[1], Alberto Sartori[1], Maurizio De Luca[1]*

[1]UOC Chirurgia Generale, Ospedale di Montebelluna (TV), Italia

To Cite
Piatto G, Sartori A, De Luca M. Massive choleperitoneum three months after mini-gastric bypass for morbid obesity: what every emergency surgeon should be prepared to face. A case report. J Gastric Surg 2020; 2(2): 49-52

Publication history
Received: March 26, 2020
Accepted: March 28, 2020
Article in press: March 31, 2020
Published on line: April 1, 2020

***Correspondence to**
Dr. Giacomo Piatto
UOC Chirurgia Generale,
Ospedale di Montebelluna,
31044 Montebelluna (TV), Italy
giacomoplatz@gmail.com
Telephone: +393407931459

ABSTRACT

Background:

Surgery for morbid obesity has spread worldwide, to the point that more than half a million people are operated on each year. As a result, significant numbers of people are living with a new anatomical condition. A mini-gastric bypass is a relatively new bariatric procedure that has gained popularity because of its simplicity and efficacy. Leak rate after this procedure is relatively low (on the order of 1.6%), but marginal ulcer of gastrojejunal anastomosis, if undetected, may lead to leak development.

No cases of delayed massive choleperitoneum caused by an almost complete disruption of gastrojejunal anastomosis after mini-gastric bypass have yet been described.

Case presentation:

We describe here the case of a 51-year-old woman who presented at the emergency department three months after a mini-gastric bypass with acute abdomen caused by massive choleperitoneum due to an almost complete disruption of gastrojejunal anastomosis.

The patient underwent an emergency conversion to a Roux-en-Y laparoscopic gastric bypass with associated re-gastrectomy. The postoperative period was characterized by fever due to an infected left pleural effusion, which required treatment with chest tube placement. The patient was discharged three weeks after the operation, in good condition. Six-month follow-up was regular.

Conclusions:

If suspected, the possibility of marginal ulcer should be investigated as soon as possible. When possible, every obese patient who has complications should be referred to a bariatric surgery department, but each emergency surgeon must be aware of these conditions to be able to treat them optimally.

Keywords:

Mini-gastric bypass, complication, leak, marginal ulcer, emergency surgery, gastrectomy, laparoscopy, choleperitoneum.

Background:

Mini-gastric bypass (MGB) was proposed by Rutledge in 1996[1]. This technique overcame initial suspicion to gain worldwide popularity for its effectiveness and simplicity and is now considered a valid option for bariatric operation[2].

The technique involves creating a long, narrow gastric pouch by transecting the stomach below the crow's foot up to the angle of His, then attaching the pouch through an end-to-side single anastomosis with the jejunum, 200–250 cm from Treitz.

Leak rate after MGB is relatively low (O.8–1.6%), especially compared with the rates of other malabsorptive procedures such as Roux-en-Y gastric bypass (RYGB), which can reach 2.5%[3].

Leak usually develops within the first month after the operation; as reported in various studies, septic patients present symptoms within the first 10 days after MGB[4].

No cases of delayed massive choleperitoneum caused by almost complete disruption of the gastrojejunal anastomosis after this operation have thus far been described in the literature.

Bariatric procedures have gained worldwide popularity, with more than half a million performed each year[5]. However, patients may present to the emergency department, where no bariatric surgeons may be available or even on call. Although these patients should be referred to their bariatric surgery department when possible, in emergency scenarios this is not always possible.

Case Report:

A 51-year-old female patient underwent sleeve gastrectomy in March 2018 for morbid obesity (weight 106 kg, BMI 40). In May 2018 she required conversion to MGB for severe stricture of the sleeved stomach. During the initial follow-up, she was taking a full dose of lansoprazole (30 mg twice a day) and was still on a soft diet.

In June, at first-month follow-up, the patient suffered from severe intermittent abdominal pain in the left hypochondrium and epigastrium. A CT scan was performed, with an internal hernia suspected. The patient was admitted to our department and a diagnostic laparoscopy was performed. No signs of internal hernia or any pathological conditions inside the abdominal cavity were detected. The patient was prescribed additional sucralfate and was discharged the day after the operation. No endoscopy was performed during the next two months, for the patient did not complain of any symptoms.

In August 2018 the patient returned to our emergency department complaining of acute abdominal pain and fever, with reported oliguria. The patient presented with tachycardia (heart rate reaching 110 bpm), hypotension (blood pressure reaching 90/60 mmHg), fever, and abdominal rigidity, with diffuse signs of peritoneal irritation; blood tests showed significant leukocytosis (WBCs count of 24000/mcL) and raised CRP levels (13 mg/L). The patient immediately underwent a CT scan showing free gas and free fluid spread within the abdominal cavity (*Figure 1*).

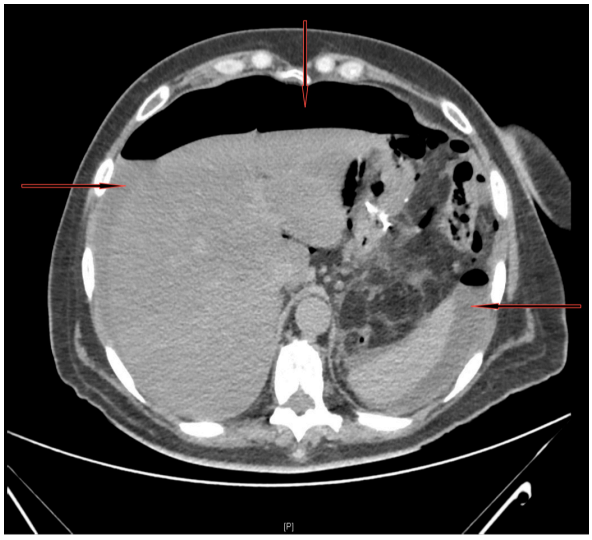

Figure 1: CT scan showing intra-abdominal free fluid and free gas (arrows).

The patient was immediately brought to the operating room, where a diagnostic laparoscopy was performed. The patient was positioned open-legged, with the first operator between the legs and the assistant to the left of the patient, holding the camera and using a 5-mm port. We induced the pneumoperitoneum with a Veress needle in the left Palmer point, then introduced a 30-degree camera through a 12-mm Visiport over the umbilicus and found a massive choleperitoneum (*Figure 2*).

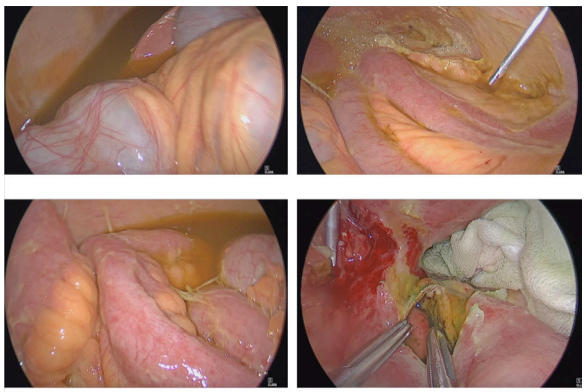

Figure 2: Massive choleperitoneum as the result of almost complete disruption of the gastrojejunal anastomosis.

There were no significant adhesions inside the abdominal cavity. Two operative 12-mm trocars were introduced into the left and right flank of the patient, and another 5-mm trocar was inserted more laterally into the left flank. The left lobe of the liver was suspended through a covered Veress needle introduced just below the xiphoid, anchored to the skin with a stitch.

After the aspiration of more than two liters of bilioenteric fluid, a thorough exploration of the bowel was carried out. Finding almost complete disruption of the gastrojejunal anastomosis (*Figure 2*), we decided to completely resect the anastomosis, conducting a re-gastrectomy and resection of both sides of the jejunum

(common and biliopancreatic limb).
Reconstruction was immediately performed through a standard laparoscopic RYGB, with a manual end-to-end gastrojejunal anastomosis and a mechanical side-to-side jejunoileal anastomosis (*Figure 3*).

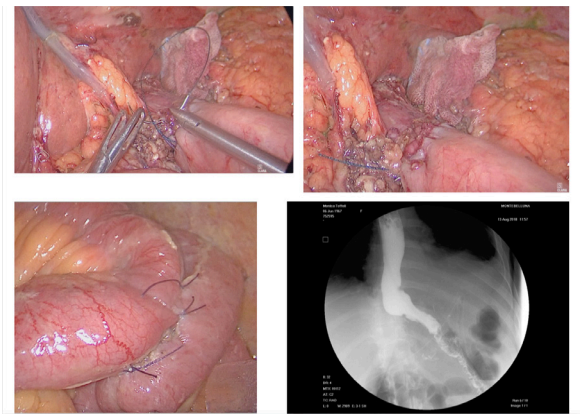

Figure 3: Emergency surgery. Laparoscopic MGB converted to laparoscopic RYGB with re-gastrectomy.

The methylene blue dye test was negative. The patient required 24-hour monitoring in the intensive care unit. She was then readmitted to our department and received total parenteral nutrition for five days.
Swallow X-ray examination on the second postoperative day was regular, and the patient began a soft diet at postoperative day 6. At postoperative day 7 she required placement of a chest tube due to an infected left pleural effusion, which was successfully resolved after three days.
The patient was discharged three weeks after the operation and at six-month follow-up had no symptoms and had reached a weight of 75 kg and a BMI of 28.6. Histopathological examination showed full-thickness ulceration and necrosis of the resected jejunum, also involving the anastomosis.

Discussion:
Leak rate after MGB, which is between 0.8% and 1.6%, can be explained by the specific features of MGB: the long narrow gastric pouch created does not suffer from inner pressure, and the gastrojejunal anastomosis is tension-free[6]. Even so, more than half of leaks develop from the single anastomosis, with the remainder arising from the gastric remnant and the pouch itself.
Although some authors regard bile reflux as a factor related to leak development[7], others show that no specific factors are related to the onset of a fistula[8]. Leak may develop from an undetected marginal ulcer, a condition related to smoking, use of nonsteroidal anti-inflammatory drugs, alcohol consumption, or presence of Helicobacter pylori[9].
A number of aspects must be taken into account when analyzing this problem: the patient's clinical condition, the leak's site and size, and the resources available (i.e., endoscopist, interventional radiologist, and bariatric surgeon).
In a 2017 survey Mahawar et al. analyzed more than 27,000 one-anastomosis (mini) gastric bypasses performed by 86 bariatric surgeons, seeking to understand the causes of marginal ulcer[9], a condition that in some cases leads to leakage of the single anastomosis. They found a 2.24% incidence of marginal ulcer, but only a few cases required surgery for perforation. They found a lack of standardization for prevention, diagnosis, and treatment of this complication.
Smoking, the use of nonsteroidal anti-inflammatory drugs, alcohol consumption, and Helicobacter pylori infection are the most important risk factors for marginal ulcers. None of these risk factors was present in our patient. In the cited survey by Mahawar, when marginal ulcer is suspected, endoscopy is routinely performed by only 58% of surgeons. We did not perform endoscopy in this case, because the patient responded well to a full dose of proton pump inhibitor added with sucralfate.
In a recent series of 2,780 patients who underwent one-anastomosis gastric bypasses, the authors tried to identify the best way of treating leaks after a MGB in relation to the clinical conditions of patients (stable vs. unstable) and the size and site of the leak, finding that with a leak rate of 1.6 % (46 patients), only 28% required surgical exploration.
Of the five septic patients, only one required conversion to RYGB for early gastrojejunal anastomotic leak; the others were treated with laparoscopic T-tube placement. All five septic patients presented at the hospital within 10 days of the operation, much sooner than in our case.
Revisional MGB was shown to be associated with a higher risk of staple line leak in the gastrojejunal anastomosis than with the primary operation[4]. Similar results in terms of leak rate and surgical approach were described in a previous survey[10]. The literature (Pubmed, Medline, Google Scholar) showed no results for delayed massive choleperitoneum after MGB, leading the authors of the present study to expand the research into the field of emergency surgery. Laparoscopy in emergency surgery, which has gained increasing popularity, represents the gold standard for treatment of appendicitis and cholecystitis and is a useful tool even in trauma, as described in a recent review[11]. Furthermore, its superiority to laparotomy in perforated peptic ulcer repair has been shown in a recent meta-analysis[12].
Merging all these considerations, we conclude that situations such as the one we encountered must be treated aggressively by emergency surgeons and can be successfully managed by using a laparoscopic approach both to identify the site of the perforation and to treat it.

Conclusion:
Through the present study we hope to raise awareness among emergency surgeons so that they can treat dramatic complications such as the one we encountered. The suspected etiology may reflect the combined effects of revisional surgery performed in a patient suffering from GERD and an undetected marginal ulcer.
After three months of bariatric surgery, the likelihood of a complicated septic patient's reaching an emergency department with no bariatric surgeons present or on call is a real one. Accordingly, every emergency surgeon must be aware of the anatomical changes that take place after bariatric procedures if he or she is to address potentially lethal complications in the quickest and most suitable way.

Acknowledgements
Not applicable.

Contributors
Each of the listed authors made a substantial contribution to the conception, design, and revision of this study. All authors read and approved the final manuscript.

Funding
No funding was received for this study.

Competing interests
No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

Availability of data and materials
Further information is available from the corresponding author on reasonable request.

Ethics approval
written informed consent was obtained from the patient for publication of this case report and any accompanying images.

Provenance and peer review
Not commissioned; externally peer reviewed.

References
[1] Rutledge R. The mini-gastric bypass: experience with the first 1,274 cases. Obes Surg. 2001;11:276-80.
[2] De Luca M, Tie T, Ooi G, Higa K, Himpens J, Carbajo MA, et al. Mini Gastric Bypass-One Anastomosis Gastric Bypass (MGB-OAGB)-IFSO Position Statement. Obes Surg. 2018;28:1188-206.
[3] Kim J, Azagury D, Eisenberg D, DeMaria E, Campos GM, American Society for M, et al. ASMBS position statement on prevention, detection, and treatment of gastrointestinal leak after gastric bypass and sleeve gastrectomy, including the roles of imaging, surgical exploration, and nonoperative management. Surg Obes Relat Dis. 2015;11:739-48.
[4] Liagre A, Queralto M, Juglard G, Anduze Y, Iannelli A, Martini F. Multidisciplinary Management of Leaks After One-Anastomosis Gastric Bypass in a Single-Center Series of 2780 Consecutive Patients. Obes Surg. 2019;29:1452-61.
[5] Angrisani L, Santonicola A, Iovino P, Vitiello A, Zundel N, Buchwald H, et al. Bariatric Surgery and Endoluminal Procedures: IFSO Worldwide Survey 2014. Obes Surg. 2017;27:2279-89.
[6] Rutledge R, Kular K, Manchanda N. The Mini-Gastric Bypass original technique. Int J Surg. 2019;61:38-41.
[7] Mahawar KK, Jennings N, Brown J, Gupta A, Balupuri S, Small PK. "Mini" gastric bypass: systematic review of a controversial procedure. Obes Surg. 2013;23:1890-8.
[8] Silecchia G, Iossa A. Complications of staple line and anastomoses following laparoscopic bariatric surgery. Ann Gastroenterol. 2018;31:56-64.
[9] Mahawar KK, Reed AN, Graham YNH. Marginal ulcers after one anastomosis (mini) gastric bypass: a survey of surgeons. Clin Obes. 2017;7:151-6.
[10] Musella M, Susa A, Manno E, De Luca M, Greco F, Raffaelli M, et al. Complications Following the Mini/One Anastomosis Gastric Bypass (MGB/OAGB): a Multi-institutional Survey on 2678 Patients with a Mid-term (5 Years) Follow-up. Obes Surg. 2017;27:2956-67.
[11] Mandrioli M, Inaba K, Piccinini A, Biscardi A, Sartelli M, Agresta F, et al. Advances in laparoscopy for acute care surgery and trauma. World J Gastroenterol. 2016;22:668-80.
[12] Tan S, Wu G, Zhuang Q, Xi Q, Meng Q, Jiang Y, et al. Laparoscopic versus open repair for perforated peptic ulcer: A meta analysis of randomized controlled trials. Int J Surg. 2016;33 Pt A:124-32.

JGS

CASE SERIES

OPEN ACCESS

Sarcina ventriculi: A Rare Case of Life-Threatening Perforated Gastric Ulcer and Review of Literature

Qing Wei[1], Sixto M. Leal Jr[1], Morad Qarmali[1], Charles Mel Wilcox[2] ,Chirag R. Patel[1], Sameer Al Diffalha[1]*

[1]Department of Pathology, University of Alabama at Birmingham School of Medicine, Birmingham, USA
[2] Department of Medicine, Division of Gastroenterology, University of Alabama at Birmingham School of Medicine, Birminghamn USA

To Cite
Wei Q, Leal SM Jr, Qarmali M, Wilcox CM, Patel CR, Al Diffalha S. *Sarcina ventriculi*: A Rare Case of Life-Threatening Perforated Gastric Ulcer and Review of Literature. J Gastric Surg 2020; 2(2): 53-56

Publication history
Received: May 10, 2020
Accepted: May 20, 2020
Article in press: May 28, 2020
Published on line: May 30, 2020

***Correspondence to**
Sameer Al Diffalha, MD
NP 3552 North Pavilion,
University of Alabama
at Birmingham Hospital
Birmingham, AL 35294-6823
saldiffalha@uab.edu
Telephone: (205) 934-5749
Fax: (205) 975-5242

ABSTRACT
Sarcina ventriculi is a gram-positive anaerobic bacterium reported rarely in patients with a history of gastrointestinal surgery and delayed gastric emptying. *Sarcina* has been implicated in the development of gastric ulcers, emphysematous gastritis, and gastric perforation. So far, less than 30 cases of *Sarcina* isolated from gastric specimens have been reported, including 3 cases associated with life-threatening illness: emphysematous gastritis and gastric perforation. Herein, we report a case of a 58-year-old woman with history of gastric surgery who presented for evaluation of persistent gastric pain and incurable ulcer. She underwent total gastrectomy, and the resected stomach demonstrated a perforated ulcer with the presence of *Sarcina* microorganisms. We also report a second case of a 56-year-old woman with history of NSAID use who presented with gastric outlet obstruction. The gastric biopsy identified concurrent *Helicobacter pylori* and *Sarcina*. Given *Sarcina*'s association with emphysematous gastritis and gastric perforation, its identification on gastric biopsies should be clearly stated in pathology reports and, depending on the clinical scenario, prompt clinicians to add adjunctive antimicrobials to anti-ulcer therapeutic regimens.

Keywords:
Sarcina ventriculi; emphysematous gastritis; gastric perforation.

Background:

Sarcina ventriculi is a gram-positive, non-motile, spore-forming, anaerobic bacterial coccus with a carbohydrate fermentative metabolism.[1] Hematoxylin and Eosin (H&E) staining of gastric biopsies reveals tetrad packets of large (3µm) basophilic cuboidal or spherical microorganisms with a refractile wall.[1, 2] Molecular diagnosis is possible by polymerase chain reaction and sequencing of the 16S ribosomal RNA and pyruvate decarboxylase genes.[3]

Sarcina was first identified as a human pathogen by Goodsir in 1843.[4, 5] It is a well-described pathogen in veterinary medicine and can cause a lethal gastric bloating-like syndrome.[6] Recently it has become increasingly implicated in human gastrointestinal disease and has been described to be associated in patients with history of GI surgery and delayed gastric emptying.[1, 3] Most patients exhibit GI symptoms, with some cases of severe disease, including emphysematous gastritis and gastric perforation.[7-9] Endoscopic findings often involve retained food residue, gastric ulcers, and inflammation or erosions.[1] Herein, we present two unique cases. One of them is the third reported case of *Sarcina* associated with gastric perforation. The other presented case is the second reported case that shows rare concurrent infections of *Sarcina* and *Helicobacter pylori*.

Case 1:

A 58-year-old Caucasian woman presented to the surgical oncology clinic for evaluation of a gastric ulcer and possible total gastrectomy. She reported epigastric pain, loss of appetite, nausea, and malnutrition. She had an open gastric bypass about 20 years prior that was taken down due to development of an internal hernia. Afterwards, the patient suffered dysphagia, gastric reflux, and chronic upper GI ulcers despite antacid and *H. pylori* treatment. Leading up to the evaluation, esophagogastroduodenoscopy (EGD) revealed an ulcer of the posterior stomach wall distal to the esophagogastric anastomosis, and ulcer biopsies showed benign fragments of gastric mucosa demonstrating marked active gastritis with focal ulceration.

The patient underwent total gastrectomy, ventral hernia repair, and associated procedures. Pathologic examination of the resected stomach showed a 2.7 cm x 2.5 cm ulcer of the proximal lesser curvature with a 1-cm thickness perforation through the serosa (*Figure 1a*). H & E staining showed multiple foci of *Sarcina ventriculi* tetrads (*Figure 1b*). *Sarcina* was also identified within the gastric lumen occasionally admixed with vegetable matter, consistent with delayed gastric emptying. Organisms were identified by the granulation tissue in the ulcer base as well as on the serosal surface, which was consistent with perforation and the presence of organisms within the peritoneal cavity.

The patient's post-operative course was complicated by an anastomotic leak and polymicrobial intra-abdominal infection that required surgical revision, antibiotics (metronidazole, vancomycin, cefepime and piperacillin-tazobactam), and antifungal treatment. She recovered after an approximately one-month hospitalization and was discharged.

Figure 1a: Gross picture of the perforated stomach.

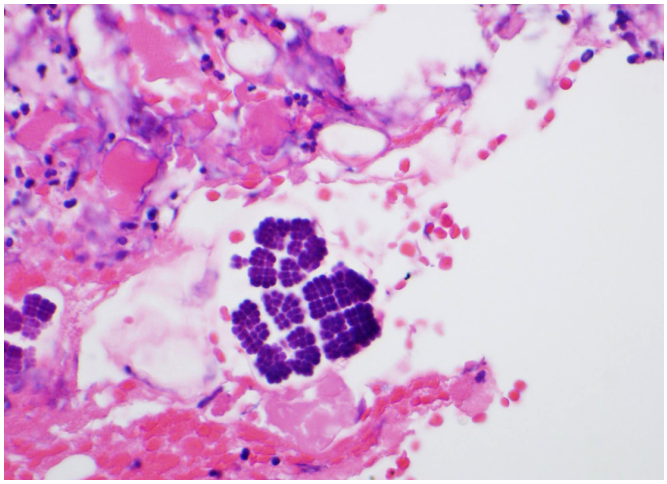

Figure 1b: The cuboid-shaped organisms were tightly packed in a tetrad formation surrounding the ulcer bed. Hematoxylin and Eosin, 40x magnification.

Case 2:

A 56-year-old woman presented with gastric outlet obstruction. She underwent four consecutive outpatient upper endoscopies at a frequency of approximately once per month. The EGDs showed an ulcer at the pre-pyloric area and a pyloric stricture, which was dilated each time. Random biopsies of the stomach during the first EGD showed chronic active gastritis, and *H. pylori* was negative by immunostaining. She started proton pump inhibitor (omeprazole 40 mg). Biopsies of the antrum taken during her second EGD showed chronic active gastritis. *Sarcina* and rare *H. pylori* microorganisms were identified on routine H&E stain (*Figure 2a and Figure 2b*). Similar to Case 1, *Sarcina* species were noted in the gastric lumen admixed with vegetable matter consistent with delayed gastric emptying. By the third EGD, the ulcer had healed after the treatment. By the fourth EGD, the patient was eating better without nausea or weight loss, and there was no further follow-up.

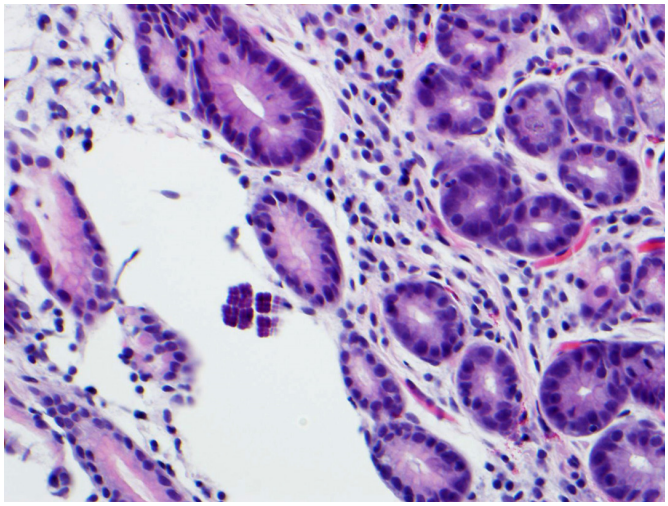

Figure 2a: H. pylori and Sarcina organisms co-exist in a gastric biopsy. The cuboid-shaped organisms were tightly packed in a tetrad formation. Hematoxylin and Eosin, 40x magnification

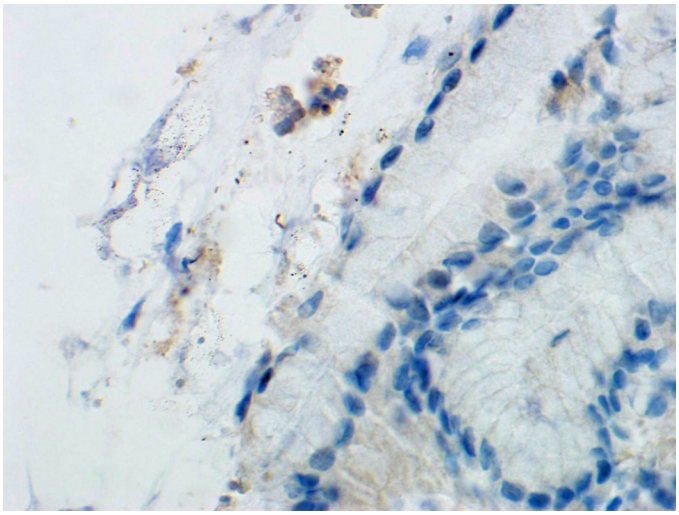

Figure 2b: H. pylori and Sarcina organisms co-exist in a gastric biopsy. H. pylori were detected by anti-H pylori immunostain (60x magnification).

Discussion:

Sarcina is a gram-positive, anaerobic, acid-tolerant coccus. It is associated with GI surgery and exhibits a 2:1 female-to-male ratio.[1] The patients in these cases were both female; the first had a history of GI surgery, and the second had a pyloric stricture.

The pathogenic role of *Sarcina* in humans remains unclear and can be an incidental finding in gastric biopsies.[3, 10] In patients with delayed gastric emptying, retained carbohydrates and other nutrients provide a fermentative substrate for *Sarcina* overgrowth.[1] In livestock, fermentative byproducts can cause deadly emphysematous gastric bloating. In humans, fermentation byproducts may increase the risk of developing life-threatening complications, such as emphysematous gastritis and gastric perforation.

Our first case supports the idea that *Sarcina* contributes to the development of gastric ulcer perforation. The only other two reported cases of perforation were a 14-year-old male with a history of bowel reduction due to malrotation of the small intestine [8] and a 76-year-old male with acute abdominal pain who presented in the ER and died after surgery.[9] Our patient had a history of gastric surgery and an ulcer resistant to *H. pylori* therapy. The pre-existing ulcer and delayed gastric emptying might have provided a nidus for *Sarcina* overgrowth. Morphologic findings of *Sarcina* microorganisms in both the gastric lumen and the serosa are consistent with clinically, macroscopically, and microscopically confirmed perforated gastric ulcer. As *Sarcina* can cause deadly emphysematous bloating in animals, it is possible that their association with human GI pathology is not due to direct tissue invasion but rather fermentation byproducts produced by the organism in the carbohydrate-rich gastric lumen.

Our second case demonstrates a rare example of *Sarcina* co-occurring with *H. pylori*. Only Sauter and colleagues have previously shown co-existence of *Sarcina* with *H. pylori* in two siblings.[11] Both *H. pylori* and *Sarcina* can survive in an acidic environment, and *H. pylori* infection can cause delayed gastric emptying via smooth muscle relaxation from release of leukotrienes or nitric oxide.[12] Although *H. pylori* could, in theory, be a predisposing factor in *Sarcina* infection, their rare co-occurrence may be due to eradication of *Sarcina* by anti *H. pylori* treatment.

Currently, there is no consensus on treatment regimens for *Sarcina*.[13] Published regimens leading to successful outcomes include anti-ulcer therapy and adjunctive use of metronidazole with a second antibiotic (most commonly ciprofloxacin).

It is very helpful if clinicians provide clinical information about any history of delayed gastric emptying along with the tissue that been submitted for pathology. This clinical history will alert GI pathologists to rule out the presence of *Sarcina* which is usually located near the gastric mucosal surface and has a pathognomonic tetrad morphology. To increase awareness of *Sarcina*'s association with severe disease, pathologists may include the following statement in their reports: "*Sarcina* has been reported to be present in association with emphysematous gastritis and gastric perforation."

Acknowledgements

None

Contributors

Each of the listed authors made a substantial contribution to the conception, design, and revision of this study. All authors read and approved the final manuscript.

Funding

No funding was received for this study.

Competing interests

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

Availability of data and materials

Further information is available from the corresponding author on reasonable request.

Ethics approval
Not applicable

Provenance and peer review
Not commissioned; externally peer reviewed.

References
[1] Al Rasheed MR, Senseng CG. Sarcina ventriculi: Review of the Literature. Arch Pathol Lab Med. 2016;140:1441-5.
[2] Behzadi J, Modi RM, Goyal K, Chen W, Pfeil S. Sarcina ventriculi as an Unknown Culprit for Esophageal Stricturing. ACG Case Rep J. 2017;4:e118.
[3] Lam-Himlin D, Tsiatis AC, Montgomery E, Pai RK, Brown JA, Razavi M, et al. Sarcina organisms in the gastrointestinal tract: a clinicopathologic and molecular study. Am J Surg Pathol. 2011;35:1700-5.
[4] Goodsir J. XXIII: History of a case in which a fluid periodically ejected from the stomach contained vegetable organisms of an undescribed form. J Nat Hist. 1843;11:125-6.
[5] Beijerinck M. An experiment with Sarcina ventriculi. Huygens Institute-Royal Netherlands Academy of Arts and Sciences (KNAW), Proceedings. 1911;13:1910-1.
[6] DeBey BM, Blanchard PC, Durfee PT. Abomasal bloat associated with Sarcina-like bacteria in goat kids. J Am Vet Med Assoc. 1996;209:1468-9.
[7] Laass MW, Pargac N, Fischer R, Bernhardt H, Knoke M, Henker J. Emphysematous gastritis caused by Sarcina ventriculi. Gastrointest Endosc. 2010;72:1101-3.
[8] Tolentino LF, Kallichanda N, Javier B, Yoshimori R, French SW. A case report of gastric perforation and peritonitis associated with opportunistic infection by Sarcina ventriculi. Laboratory Medicine. 2003;34:535-7.
[9] Dumitru A, Aliuș C, Nica AE, Antoniac I, Gheorghiță D, Grădinaru S. Fatal outcome of gastric perforation due to infection with Sarcina spp. A case report. IDCases. 2020;19:e00711.
[10] Haroon Al Rasheed MR, Kim GJ, Senseng C. A Rare Case of Sarcina ventriculi of the Stomach in an Asymptomatic Patient. Int J Surg Pathol. 2016;24:142-5.
[11] Sauter JL, Nayar SK, Anders PD, D'Amico M, Butnor KJ, Wilcox RL. Co-existence of Sarcina Organisms and Helicobacter pylori Gastritis/Duodenitis in Pediatric Siblings. J Clin Anat Pathol (JCAP). 2013;1.
[12] Zhang CL, Geng CH, Yang ZW, Li YL, Tong LQ, Gao P, et al. Changes in patients' symptoms and gastric emptying after Helicobacter pylori treatment. World J Gastroenterol. 2016;22:4585-93.
[13] Medlicott SAC. Sarcina ventricularis complicating a patient status post vertical banded gastroplasty, a case. Journal of Gastroenterology and Hepatology Research. 2015;4:1481-4.

JGS

VIDEO

OPEN ACCESS

Completion total gastrectomy with intracorporeal robot-sewn esophago-jejunal anastomosis

Francesco Carafa[1], Immacolata Della Valle[2], Riccardo Memeo[3], Giorgio Palazzini[4], Domenico Di Nardo[4]*

[1]General and Upper GI Surgery Division, University of Verona, Verona, Italy
[2]Department of General and Emergency Surgery, "P. Giaccone" University Hospital, Palermo, Italy
[3]Division of Hepato-Pancreato-Biliary Surgery, Department of Surgery, "F. Miulli" General Hospital, Acquaviva delle Fonti, Bari, Italy
[4]Department of Surgical Sciences, "La Sapienza" University, Rome, Italy

To Cite
Carafa F, Della Valle I, Memeo R, Palazzini G, Di Nardo D. Completion total gastrectomy with intracorporeal robot-sewn esophago-jejunal anastomosis. J Gastric Surg 2020; 2(2): 57-59

Publication history
Received: May 2, 2020
Accepted: May 3, 2020
Article in press: May 4, 2020
Published on line: May 5, 2020

***Correspondence to**
Dr. Domenico Di Nardo
Department of Surgical Sciences
Policlinico Umberto I
"La Sapienza" University
Viale Regina Elena 324
00161 Roma (RM), Italy
domenicodinardo@outlook.it
Telephone: +393281599463

ABSTRACT
Many technical reports concern minimally invasive surgery for stomach cancer; however, there is poor evidence about employing this approach for gastric stump cancer, which can arise at the anastomotic site in patients who have undergone previous partial gastrectomy for benign diseases such as gastric ulcer. Such surgery was quite common before the introduction of proton pump inhibitors (PPIs), and so today, according to different statistics, gastric stump cancer can be revealed in up to 8% of these patients. This report seeks to highlight the possibility of employing a minimally invasive approach in patients who already had an operation for gastric resection.
The video shows technical notes about the hybrid laparoscopic-robotic approach performed in a patient who previously underwent open distal gastrectomy. Is the previous laparotomy an absolute or relative counterindication to reperform a surgery through a minimally invasive approach?

Keywords:
Gastric cancer, gastric stump cancer, completion total gastrectomy, minimally invasive surgery, laparoscopy, robotic surgery.

Background:
After distal gastrectomy, Billroth II reconstruction is the most common reconstruction performed worldwide.
In the past, the number of gastric resections, especially for benign pathologies such as gastric ulcers, was higher, so today, we can observe a certain number of gastric carcinoma arising at the anastomotic site, that is, gastric stump cancer[1, 2].
The case reported in this article demonstrates the use of minimally invasive technology to remove a remnant stomach that is tenaciously embedded by adhesions and how to perform the reconstruction of the digestive tract.

Case presentation:
A 79-year-old man was admitted to the Department of Digestive Surgery (St. Mary's Hospital of Terni, Italy) reporting feeling abdominal pain for about 3 months, mainly localized in the upper abdominal quadrants, weight loss, microcytic anemia, and episodes of melena. The patient's history shows a previous open distal subtotal gastrectomy with gastrojejunal reconstruction (Billroth II) for a gastric perforated ulcer and a consequent peritonitis 42 years earlier. He also reported hypertension and familial hypercholesterolemia.
The patient underwent a clinical examination, blood tests, and an abdominal CT scan. The latter revealed a mass corresponding to gastro-jejunal anastomosis without evidence of a secondary disease. Therefore, the patient underwent an upper endoscopy examination that confirmed an ulcerative tumor at the level of the gastro-jejunal anastomosis on the side of the afferent loop, whose biopsies indicated the presence of a tubular adenocarcinoma.
After an anesthesiological examination to rank the operative risk, the patient was scheduled for a completion total gastrectomy via a minimally invasive approach.
Technical note
Given the previous laparotomy, the pneumoperitoneum was performed through an open access to avoid possible injuries due to expected adhesions. Then, one laparoscopic trocar for the camera (10-12 mm) was placed in the supra-umbilical position, two laparoscopic trocars (10-12 mm) were positioned along the left and right paramedian line, and two 8-mm robotic trocars were positioned in the right and left flank.
First, an exploratory laparoscopy was performed.
Multiple tight peritoneal adhesions were found involving the gastro-jejunal anastomosis, the omentum and the liver, and among the intestinal loops.
The adhesions were completely removed using the harmonic ace to gain access to the right para-anastomotic area until the right diaphragmatic pillar.
The left side of the spleen was freed from the visceral adhesions, and the dissection was completed to the left diaphragmatic pillar. The posterior wall of the esophagus was then freed, and the esophageal hiatus was completely released. A ribbon was passed around the esophagus to raise it.
The dissection continued between the gastro-jejunal anastomosis and the anterior surface of the pancreas. The biliary (afferent) and alimentary (efferent) sides of the intestinal loop were identified and mobilized.
The two intestinal tracts were sectioned through a mechanical stapler about 3 cm downstream from the anastomosis site.
Further adhesions between the gastric wall and the pancreatic capsule were removed to gain access to the left gastric artery, which is sectioned between Hem-o-Lock at its origin from the celiac trunk.
Once the proximal portion of the stomach was fully mobilized, the esophagus was fixed at the diaphragmatic pillars with two stiches and then sectioned with the linear stapler.
At this point, a mini-laparotomy was performed at the level of the previous scar for specimen extraction and for the preparation of the Roux-en-Y reconstructive step.
An extracorporeal jejuno-jejunal anastomosis was performed using the mechanical stapler followed by a hand-sewn suturing of the enterotomy (the first layer in continuous suturing in PDS 3/0 and a second layer with interrupted stiches in Vicryl 2/0).
The intestinal tract was then repositioned in the abdominal cavity, and the mini laparotomy was closed.
The Da Vinci Xi robotic system was now docked to make the esophago-jejunal anastomosis.
A first posterior layer with separated stiches in Vicryl 2/0 was done to connect the serosa of the jejunum to the muscolaris of the esophagus. Then, the esophagus end margin was opened, as was the corresponding side of the lateral wall of the jejunum, and a double continuous suturing was performed using 3/0 PDS starting from the posterior side and then closing on the anterior side. The anastomosis was completed with the second anterior layer, which was performed with separated stiches in Vicryl 2/0.
Two abdominal drainages were placed close to the esophago-jejunal and the jejuno-jejunal anastomosis.
Post-operative course
A gastrografin swallow was performed on post-operative day (POD) 2 and showed no complications; thus, the patient starting taking sips of water per os. The day after, the patient started a liquid diet, and the drainages were removed. In POD 4, a soft solid diet was regularly taken, and the patient was discharged in POD 5.

Conclusion:
The procedure described is technically demanding, and combining the laparoscopic and robotic approaches allows the surgeon to take advantage of their characteristics based on the surgical step[3, 4]. In fact, laparoscopy gives more spatiality in the lysis of adhesions, and the robotic system is unbeatable in intracorporeal suturing.

Acknowledgements
The procedure was recorded at the Department of Digestive Surgery, St. Mary's Hospital of Terni, Italy (first operator: Prof. Amilcare Parisi).

Contributors
Each of the listed authors made a substantial contribution

to the conception, design, and revision of this study. All authors read and approved the final manuscript.

Funding
No funding was received for this study.

Competing interests
No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

Availability of data and materials
The video associated with this article can be found, in the on-line version, at:
https://www.journalofgastricsurgery.com/index.php/JGS/article/view/27

Ethics approval
written informed consent was obtained from the patient for publication of this case report and any accompanying images.

Provenance and peer review
Not commissioned; externally peer reviewed.

References
1] Ma FH, Xue LY, Chen YT, Li WK, Li Y, Kang WZ, et al. Surgical resection of gastric stump cancer following proximal gastrectomy for adenocarcinoma of the esophagogastric junction. World J Gastrointest Oncol. 2019;11:416-23.
[2] Nakaji YU, Saeki H, Kudou K, Nakanishi R, Sugiyama M, Nakashima Y, et al. Short- and Long-term Outcomes of Surgical Treatment for Remnant Gastric Cancer After Distal Gastrectomy. Anticancer Res. 2019;39:1411-5.
[3] Qian F, Liu J, Liu J, Fan J, Zhao Y, Shi Y, et al. [Application of robotic surgery to treat carcinoma in the remnant stomach]. Zhonghua Wei Chang Wai Ke Za Zhi. 2018;21:546-50.
[4] Li Y, Gao Z, Zhao X, Wang B, Ye Y, Wang S, et al. [Meta-analysis of gastric stump cancer after gastrectomy for gastric cancer]. Zhonghua Wei Chang Wai Ke Za Zhi. 2018;21:569-77.