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ORIGINAL CONTRIBUTIONS

Indocyanine Green Fluorescent Angiography During Laparoscopic Sleeve Gastrectomy: Preliminary Results

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Abstract

Introduction Indocyanine green (ICG) fluorescent angiography has been routinely applied for various laparoscopic procedures to evaluate the tissue blood supply. A promising branch for this technology is represented by bariatric surgery, especially to estimate the risk of gastric leak after laparoscopic sleeve gastrectomy (LSG), which seems mainly related to ischemia of the stomach.

Materials and Methods 43 consecutive patients from January 2018 to March 2019 underwent in our institution LSG with intravenous injection of 5 ml ICG after the realization of gastric tube to evaluate the blood supply of the gastric tube.

Results In all 43 cases, there have been no adverse events related to ICG. The vascular supply to stomach was estimated "satisfactory" along the stapled line in all cases. However, one patient showed signs and symptoms indicative of gastric leak in the fifth post-op day and diagnosis was confirmed by CT scan with Gastrografin.

Conclusions From our preliminary data, the intraoperative view of the blood supply of the stomach does not seem to represent a prognostic factor for the risk of gastric leak, suggesting a complex multifactorial etiology (intragastric hypertension? Abnormal inflammatory response?) which needs further data to be established.

Keywords Sleeve Gastrectomy · Indocyanine green fluorescent angiography · Obesity · Gastric leakage

Introduction

In the last two decades among the western countries, along with the increase of socioeconomic problems related to morbid obesity, the possibility to treat this pathology using bariatric surgery has been definitely evaluated and approved [1, 2].

The most common bariatric procedure nowadays is still the laparoscopic sleeve gastrectomy (LSG) [3]. Even if it is technically easier and comparable for results at middle and long term than other bariatric operations, LSG is not free from adverse events; the most concerning complication is the gastric leak, which has been described in a percentage from 0.5 to 6% of all database and commonly located near the angle of His.

The exact pathogenesis of gastric leak has not still been clarified, even if a multifactorial etiology (ischemic, mechanical, inflammatory) has been addressed [4–8].

Therefore, to avoid or at least reduce the incidence of gastric leak, bariatric surgeons has advocated variations in surgical technique to save the vascular supply and prevent the ischemia of the proximal part of the stomach [9, 10].

In the last years, the application of indocyanine green (ICG) fluorescent angiography has been extended also for bariatric surgery; it permits to evaluate the real-time tissue perfusion during laparoscopic surgery, improving the intraoperative view for surgeons.

ICG is a water-soluble anionic probe with excitation and emission wavelengths in serum at 778 and 830 nm, excreted through the liver immediately, via the first-pass effect. It binds to plasma lipoproteins and essentially travels throughout the blood flow.

Even if further investigations are needed (actually, no randomized controlled trials have been published), ICG fluorescence angiography seems a promising and feasible method to evaluate blood supply to anastomoses and is widely applied in mininvasive surgical procedures (especially, colorectal and esophageal surgery) [11–14].

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On the same side, the application of this technique to the gastroesophageal (GE) junction during LSG seems very promising, due to the low cost of the procedure and the possibility to show the real-time vascularization of the stomach.

In this contest, we described the preliminary results of the application of ICG fluorescent angiography during LSG in our center.

Materials and Methods

43 consecutive patients underwent LSG with ICG fluorescence angiography at our center (San Salvatore Hospital, L'Aquila, Italy) from January 2018 to March 2019.

In the period of interest, 13 male and 30 female patients underwent LSG from the same surgical team with the same standardized technique.

Mean age was 43.5 in the male group and 47.06 in the female group (mean 46.04).

Mean preoperative BMI was higher in the male group (42.83 vs 40.05) (mean 40.73).

In all patient, we detected at least one major comorbidity: most represented was hypertension (27 patients, 62.79%), followed by diabetes (15 patients, 34.88%), COPD and/or OSAS (11 patients, 25.58%), and arthrosis (11 patients, 25.58%).

Five patients (11.63%) had previous bariatric procedures (endoscopic placement of B.I.B.) but no bariatric surgery; none of the 43 patients had previous upper GI surgery.

No simultaneous cholecystectomy was performed even if three asymptomatic cholelithiasis were detected preoperatively.

The procedure was performed by the same surgical team with the same standardized surgical technique.

After the placing of four ports, the detachment from greater curvature with dissection of gastroepiploic and short gastric vessels was performed with an energy device.

The construction of sleeve gastrectomy was fashioned along a 36-French bougie in place using Echelon Flex™ ENDOPATH® Staplers (Ethicon); after that, 5 ml ICG was injected intravenously and a NIR/ICG camera (OPAL1® by Karl Storz) was used to identify the blood supply of the stomach, carefully evaluating the angle of His.

Adequate perfusion was defined as "the direct and clear visualization of fluorescence along the gastric tube, compared with the excised specimen, after an estimated time of 150–180 s from i.v. injection".

In case of inadequate perfusion, our expected options were re-staple (if the gastric tube was large enough on the G-E junction and the area of inadequate perfusion was confined to periferic zone) or reinforcement with omental patch and fibrin glue (if the area of inadequate perfusion was larger). Intraoperative conversion to Roux-en-Y Gastric bypass (RYGBP) was not considered an option unless the perfusion was missing in all the upper part of the gastric tube (for the unbearable risk of leakage).

A methylene blue test is routinely performed after fluorescence.

The procedure ended with the placement of an intra-abdominal drain along the stapled line.

A routine Gastrografin swallow test is performed on second post-op day.

After the Gastrografin swallow test, if negative, patients were given a liquid diet for 1 day, then a semiliquid diet, and they were discharged on the sixth post-op day; regular diet (personalized and provided by our nutritionists) was started after 2 weeks from surgery if no major complication appeared.

Our follow-up was routinely performed with blood exams at 2 weeks, Gastrografin swallow test and clinical examination at 1 month, blood exams and clinical examination at 3–6–12 months.

Results

The procedure was performed in all patients with no adverse events related to ICG.

Methylene blue test was negative in all patient.

The blood supply to GE junction was evaluated "satisfactory and adequate" in all patients (Figs. 1 and 2).

Mean operative time was 67 min. No conversion to laparotomy has been performed.

Following the Clavien-Dindo Classification of surgical complications, we had only two patients classified more than 2: one patient who needed blood transfusion (hemoglobin loss > 4 g/dL) but no reintervention for hemostasis (Clavien-Dindo 2) and another patient who was treated by endoscopists (Clavien-Dindo 3b, described as follows).

Routine Gastrografin swallow on the second post-op day was negative for leak in all patients.

Despite that, one patient (45-year-old female, affected by hypertension, no previous surgical procedures) showed signs and symptoms referable to gastric leak in the fifth post-op day, and diagnosis was confirmed by CT scan with Gastrografin; however, she needed no reintervention and the complication was treated by endoscopic placement of pigtail stent (Clavien-Dindo 3b), removed after two months. In this case, the patients showed nausea and vomit after the Gastrografin swallow test (3–4 post-op day) and was treated with medical therapy and no placement of nasogastric tube; we think that the proper cause of leakage could be related to an inappropriate and slowed gastric empty combined with the increase of intragastric pressure due to the Gastrografin.

Analyzing our database, we performed from 2012 to 2017 134 SG (7 with open approach) with no ICG test; the total number of leakage was 4 (no deaths) and our leakage rate was 2.98%.

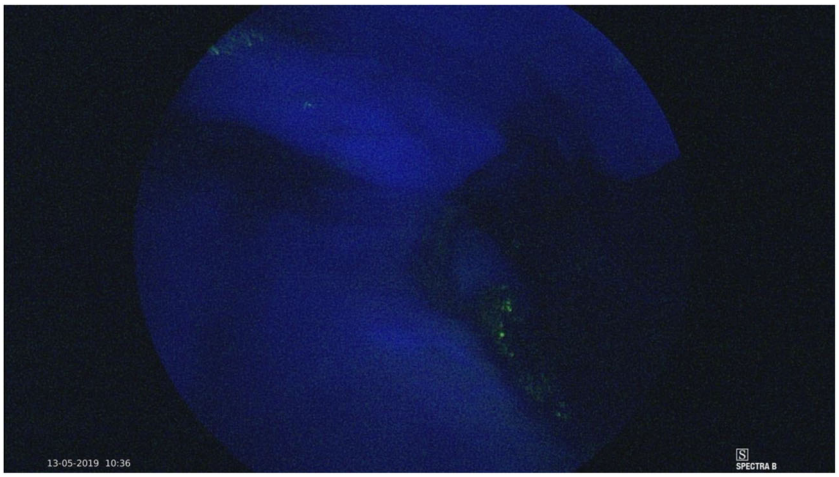

Fig. 1 Intraoperative view using ICG fluorescence with NIR/ICG camera (OPAL1® by Karl Storz), resolution SPECTRA B

In the ICG-tested LSG, we have all adequate perfusion but one leakage until now and the group leakage rate is 2.32%: this data is inferior to the non-tested patients but we need to increase the number of LSG (we expect to reach at least 80 LSG at the end of the year) and the follow-up to obtain significant values.

Moreover, our main goal was to evaluate if this method could adequately estimate the ischemia along the staple line of the stomach and help in the prevention of the gastric leakage: until now, this is not confirmed from our preliminary results (the single case in which leakage showed adequately perfused with ICG test).

No patient showed up with gastric leak at routine follow-up (currently at 3 months).

Discussion

Gastric leak after LSG is still the most dangerous complication for the patient, even if the incidence is slowly decreasing due to the standardization of surgical technique based on experts' recommendations and panels [15–17].

Most of gastric leak (up to 85%) occur near to the angle of His, at the proximal third of the stapled line [6, 18].

Timing of appearance is in the early (not immediate) postoperative period, usually starting from the fifth post-op day even if the diagnosis could be late, after hospital discharge, up to 45 days [18].

There is still uncertainty about the pathophysiology of gastric leak: it has been described that it could be related to the creation of a long, narrow tube with the maintenance of pylorus that certainly increases the intraluminal pressure (intragastric hypertension) or to the localized ischemia related to the gastroepiploic and short gastric vessel ligation during detachment of the greater curvature or even to an inadequate, abnormal inflammatory response to surgical procedure [19, 20].

Therefore, neither the great improvement in stapling technology (various stapler heights for different gastric wall tissue thickness) nor the use of biologic sealants or staple line reinforcement (SLR) or the oversewing of staple line has given the expected results in reducing the incidence of gastric leak, as confirmed by several meta-analysis and clinical trials performed during the last years [21–27].

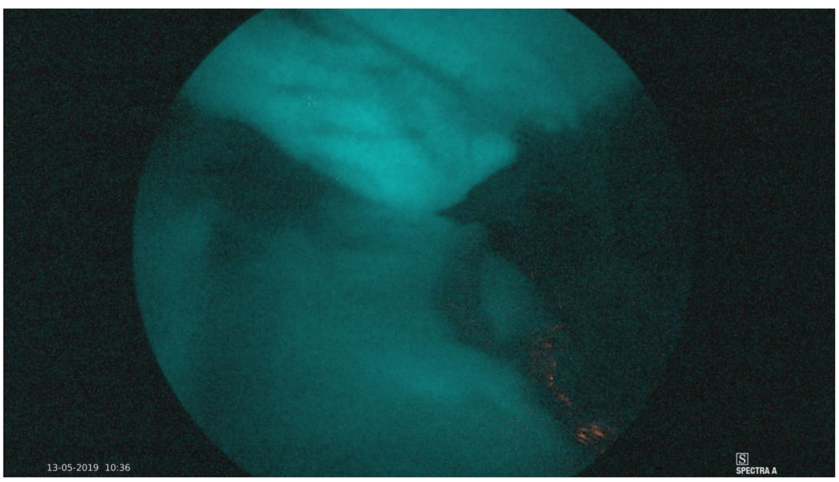

Fig. 2 Intraoperative view using ICG fluorescence with NIR/ICG camera (OPAL1® by Karl Storz), resolution SPECTRA A

At the same time, the use of routine intraoperative leak test (air, endoscopy, dye) is still discussed because it could be useful to identify staple line disruption but do not locate any area at higher risk of subsequent leak and should be performed only by surgeons' choice [27, 28].

Recently, a lot of interest has been focused on the possibility to evaluate the blood supply during the surgical procedure to estimate if localized ischemia could be a risk factor for every kind of leak, from anastomotic to staple line ones. The improvement in technology has led to the development of ICG fluorescence angiography, which is a real-time, economic, and feasible method to establish the vascularization to a target area; it has been carefully and positively approved in most laparoscopic procedures [11, 12] but there is still few literature on its utility on bariatric procedure. Frattini et al. [29], in their preliminary experience, assumed that ICG results were comparable with other tests commonly used intraoperatively (methylene blue test) and post-operatively (contrast swallow ones) along with the advantage that it allowed a real-time assessment and a direct image of gastric vascularization.

Therefore, our aim was to evaluate if the intraoperative ICG fluorescence angiography could lead to estimate ischemic area, especially in the proximal third of the stomach, and therefore to identify "patient at higher risk" to develop such complication.

At the beginning of the study, our main hope was to help clarifying the exact pathogenesis of gastric leak supporting the ischemic theory by revealing devascularized areas on the staple line that could become gastric leak in the post-operative course; this could had not only a prognostic but also (above all) a therapeutic indication, because (when detected intraoperatively) the ischemic area could be reinforced with sealants, omental patch, or oversewing.

From the first data, we have found no ischemic segmental area along the greater curvature, focusing especially on the area near the angle of His, despite one patient with gastric leak that developed on the fifth post-op day; this patient had a negative intraoperative methylene blue test, a negative Gastrografin swallow test on second post-op day, and an uneventful post-op course (except nausea and vomit on the third–fourth post-op day) until the classical presentation of this complication (pain/tenderness in left hypochondrium, high temperature, tachycardia, dyspnea, sudden increase of CRP and white blood cells, and procalcitonine). This may suggest that the main factors responsible for gastric leak arise not immediately during the procedure or in the early post-operative course, as could be for other leaks (i.e., anastomotic leak) but, as confirmed by literature, later on post-operative course and even after the hospital discharge up to 45 days [18], suggesting a poor role for an intraoperative examination like the ICG fluorescence angiography for LSG.

If this data would be suggested by our study, our surgical technique could be modified, for example, adopting a larger gastric bougie (at least 40-French instead of 36) that could avoid the increase of gastric pressure or improving the bougie itself with a system that could estimate the intraluminal pressure to perform the sleeve following no more the dimension of the tube but the values of intragastric pressure.

Conclusions

From the preliminary results of our study, we have found no relevance of the ischemia along the staple line during LSG (the single case in which leakage showed has resulted adequately in perfusion with ICG test); therefore, if our preliminary data will be confirmed at the end of our study (enlarging the sample size: our aim is to reach at least 80 patients during this year) and other trials, the significance of the ischemic factor on the pathogenesis of gastric leak could be reduced while the importance of other factors previously described (intraluminal hypertensions, abnormal systemic inflammatory response) could become predominant and will need further investigations.

Therefore, intraoperative ICG testing may be helpful in determining which patients are at an increased risk for leakage, and if adjunctive measure is needed intraoperatively. Further testing is needed to determine if ICG will predict leakage due to ischemia.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Ethical Approval All procedures performed in studies involving human participants 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.

Informed Consent Informed consent was obtained from all individual participants included in the study.

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