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CLINICAL REPORT

Laparoscopic Gastric Greater Curvature Plication: Results and Complications in a Series of 135 Patients

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Abstract Laparoscopic gastric greater curvature plication (LGGCP) is an emerging restrictive bariatric procedure that successfully reduces the gastric volume by plication of the gastric greater curvature. Its main advantages are the reversibility of the technique as well as the lack of foreign materials or gastrectomy. We present our results, focusing on the effectiveness and complications, and on a new modification of the original technique. One hundred and thirty-five patients underwent LGGCP between April 2008 and December 2009. A five-trocar port technique was used, and following dissection of the greater gastric curvature, single plication of the latter was performed under the guidance of a 36-Fr bougie. Modification of the technique included multiple gastric plications. One hundred and four obese women and 31 obese men (mean age of 36 years) underwent LGGCP for weight reduction. Operative time was 40–50 min, and mean hospital stay was 1.9 days (range 1–6 days). After a follow-up of 8–31 months (mean 22.59), the mean percentage of excess weight loss (%EWL) was 65.29. Subgroup analyses based on BMI values showed that %EWL was significantly higher for patients with BMI<45 kg/m² (group I) compared with patients with BMI>45 kg/m² (group II) (69.86 vs 55.49, respectively, $p=0.006$). Similarly, inadequate weight loss was significantly higher for group II, while the failure of the technique and postoperative complications were comparable. On the other hand, subgroup analysis based on the technique showed that the modification of the technique did not affect the effectiveness or the operative time; however, it reduced early complications dramatically, including prolonged postoperative vomiting and late gastric obstruction, thus affecting the length of hospitalization. Overall complication rate in our series was 8.8% (12/135). Cases of prolonged postoperative vomiting, GI bleeding, and leak were treated conservatively, while one case of portomesenteric thrombosis and three cases of acute gastric obstruction were treated surgically. LGGCP is an emerging technique sparing gastric resection, the use of foreign materials and intestinal bypass. Its effectiveness is satisfactory for patients with BMI<45 kg/m², and the complication rate is acceptable.

Keywords Bariatric surgery · Laparoscopic gastric greater curvature plication · Morbid obesity

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Introduction

Obesity is a major health problem affecting over 1.7 billion people worldwide, and although it was thought to be a disease of the westernized world, it seems to have expanded to the developing world, especially in urban settings [1]. Since 1997, the World Health Organization recognized it as a global epidemic, and in 2005, over 400 million obese adults were recorded. Conservative measures, such as dieting and physical exercise have proven inadequate, as has treatment with medications [2, 3]. Bariatric surgery is an effective alternative and has become very popular in the last decade. Techniques are being performed that aim to reduce gastric capacity cause malabsorption or both.

Adjustable gastric banding and sleeve gastrectomy (SG) are the most common restrictive approaches. However, these procedures are not without significant complications, such as erosion or slippage of the gastric band or gastric leaks in SG. Laparoscopic greater curvature plication (LGGCP) is a new restrictive technique that was first reported by Wilkinson in 1981 [4]. It reduces the gastric volume successfully by plication of the greater curvature and has the advantage of a reversible restrictive procedure without the use of foreign materials or gastrectomy. In this study, we present our experience with this new bariatric technique. This is the largest series reported so far, where the primary endpoint was to evaluate the effectiveness of LGGCP on the percentage of excess weight loss (%EWL), while the secondary endpoint was the assessment of early and late complications. For the first time, we present a modification of the original technique that decreased early complications and improved recovery.

Methods and Materials

From April 2008 until December 2009, we performed a prospective study with 135 patients. The study was approved by the hospital's ethics committee, and all patients consented to participation in the trial. Global inclusion criteria were: age over 18 years old and BMI>40 or BMI>35 accompanied by at least one co-morbidity. Patients with BMI>50 were not encouraged to participate in the study. Excess weight was defined as the amount of weight above the patient's ideal body weight, based on the Metropolitan Life Insurance Company's BMI tables, published in 1983. The percentage of %EWL was defined as the percentage of the excess weight that was lost during the follow-up period. Preoperatively, all patients underwent upper GI endoscopy, blood tests, and abdominal ultrasound. Anticoagulants were given 12 h preoperatively, and chemoprophylaxis with antibiotics was given with the induction of anesthesia. In the first period of the study (April 2008–April 2009), 93 patients were treated with the original LGGCP technique (single plication) and in the second period (May 2009–December 2009), 42 patients were treated with the new multiple plications technique.

Similar to Nissen fundoplication, a five-trocar port technique was used, with the patient in a 30° reverse Trendelenburg position. Closed pneumoperitoneum of 16–18 mmHg was achieved through a 10-mm optical trocar that was placed 10 cm below the xyphoid, left paramedially. Two 12 mm trocars were placed on the midclavicular line, 5 cm subcostally, and on the anterior axillary line, 3–4 cm subcostally, respectively. On the right, one 5-mm trocar was placed 5 cm subcostally in the midclavicular line, 5 cm subcostally, and another 12 mm trocar, used for the liver retractor, was placed 3–4 cm subcostally on the anterior line. In the case of a hiatal hernia, anterior approximation of the diaphragmatic crus was performed prior to gastric dissection. Using the LigaSure™ Vessel Ligation System (Covidien), the omentum and the gastrepiploic vessels were dissected away from the greater curvature. The short gastric vessels, the posterior gastric vein, and the posterior gastric attachments were ligated, starting from the antrum towards the left crus of the diaphragm and the angle of His. The left side of the crus was carefully prepared preserving with the fat pad (reviewer #1, comment c). Following the completion of the dissection to the distal antrum (4 cm from pylorus), a 36-Fr bougie was inserted into the stomach. Under its guidance, a row of 10–12 extra-mucosal-absorbable interrupted sutures (2–0 Vicryl™) was placed along the apposed gastric walls of the dissected greater curvature starting 1 cm below the angle of His. An additional row of non-absorbable interrupted sutures (2–0 Ethibond™) was used as reinforcement, narrowing the stomach permanently. The distance between the sutures varied from 1.0 to 1.5 cm. In the second phase of the study, the technique was modified by creating a double or triple plication of the apposed gastric walls with the first row of stitches. Interrupted mattress sutures were placed on the second row (Fig. 1). No drains were used, and no leak test was performed. Patients were discharged as soon as they were able to tolerate a liquid diet and were advised to progress to a soft diet after 15 days and to solid food after 30 days. Proton pump inhibitors and anticoagulation with low molecular weight heparin were prescribed regularly for 2 months and 14 days, respectively. During the first six postoperative months, all patients were treated with multivitamins and iron supplements. Follow-up visits were scheduled at 1, 3, 6, and 12 months postoperatively with assessment of hemoglobin, liver enzymes, serum creatinine, iron, folic acid, vitamin B12, calcium, and uric acid blood

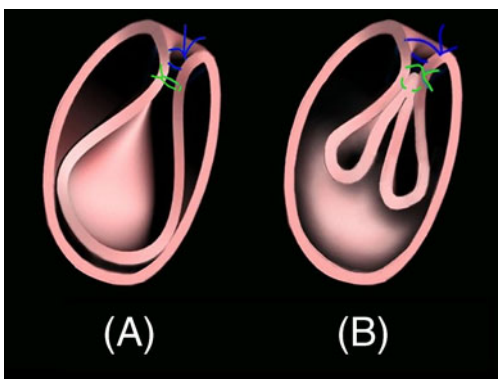

Fig. 1 **a** Single plication of gastric greater curvature-original technique. **b** Double plication of gastric greater curvature-modified technique

levels. Upper endoscopy was performed optionally after 1 year (Fig. 2).

Results

One hundred and four obese women and 31 obese men with a mean age of 36.05 years underwent LGGCP for weight reduction. Mean preoperative weight and BMI were 113.32 kg and 39.55 kg/m², respectively. Operative time was 58 min (range 45–80 min), and mean hospital stay was 1.9 days (range 1–6 days). After a follow-up of a mean of 22.59 months (range 8–31 months), the mean weight decreased to 83.48 kg and the BMI to 29.62 kg/m², with a mean %EWL of 65.29 (Table 1). The mean %EWL at 6, 12, 24 months was 51.7, 67.1, and 65.2, respectively (Table 2). Inadequate weight loss (%EWL<50) was observed in 29/135 cases (21.48%), and in 8/135 cases of these cases, the procedure failed (%EWL<30). The distribution of patients in relation to %EWL is shown in Fig. 3.

Subgroup Analysis

Subgroup analysis was performed according to preoperative BMI and the surgical technique; 110 patients had a BMI<45 kg/m², while 25 had BMI>45 kg/m². For the first group, the overall %EWL was significantly higher compared to the second group (69.86 to 55.49, $p=0.006$). In the second group, inadequate weight loss was doubled compared with the first group (36% to 18.2%, $p<0.001$). However, failure rates and postoperative complications were not associated with the patients' BMIs (Table 2).The modification of the technique to multiple plication had no impact neither on the operative time nor on the %EWL (68 min for single plication vs 64 min for multiple plication). The effectiveness of the procedure also remained unchanged, as insufficient weight loss rate was 21.4% for single vs 21.5% for multiple plications. However, some of the complications, such as prolonged postoperative vomiting and late gastric obstruction, were both eliminated with the new technique, thereby resulting in significant reductions in the length of hospitalization (2.1 days for single vs 1.4 days for multiple plications) (Table 3).

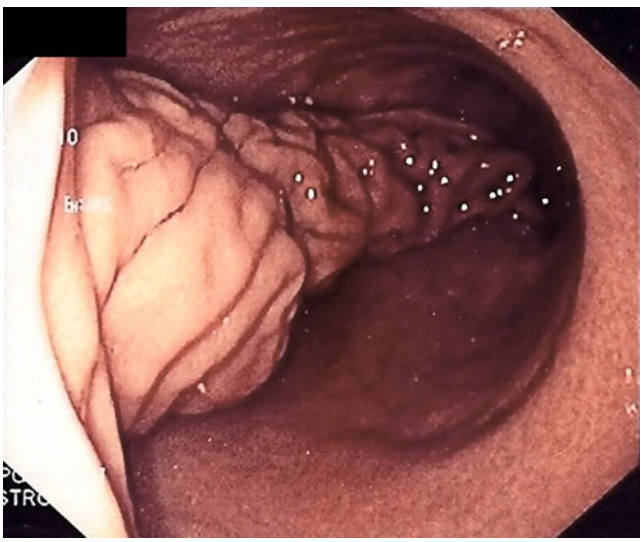

Fig. 2 Endoscopic image of plicated gastric greater curvature 1 year postoperatively

Table 1 Patients characteristics

Number	135
Female/Male	104/31
Age (years)	36.05±11.26
Pre-op weight	113.32±22.49
Pre-op BMI (kg/m²)	39.55±6.20
Follow up (months)	22.59±5.37
Follow up weight (kg)	83.48±17.32
Follow up BMI (kg/m²)	29.62±4.94
% EWL	65.29±23.53
Failure	5.9%
Inadequate weight loss	21.4%

BMI body mass index, *%EWL* percentage of excess weight loss, *Failure* %EWL<30, *Inadequate weight loss* %EWL<50

Complications

The overall complication rate in our series was 8.8% (12/135). Four patients in the single plication group had prolonged postoperative nausea and vomiting that required readmission. Two patients were readmitted on the 5th and 30th postoperative day, respectively, for GI bleeding, and two were readmitted for abdominal pain on the 7th postoperative day, which was attributed to a micro-leak from the suture line. All of them were treated conservatively. Four patients had severe complications and required reoperation. One patient was diagnosed with partial jejunal necrosis due to portomesenteric thrombosis on the 24th postoperative day and underwent small bowel resection; another one presented with acute gastric obstruction 14 months after the initial operation due to a partial

Table 2 %EWL stratification per postoperative month

Post-op month	%EWL
3	34.3±12.2
6	51.7±18.5
12	67.1±24.7
22	65.2±23.5

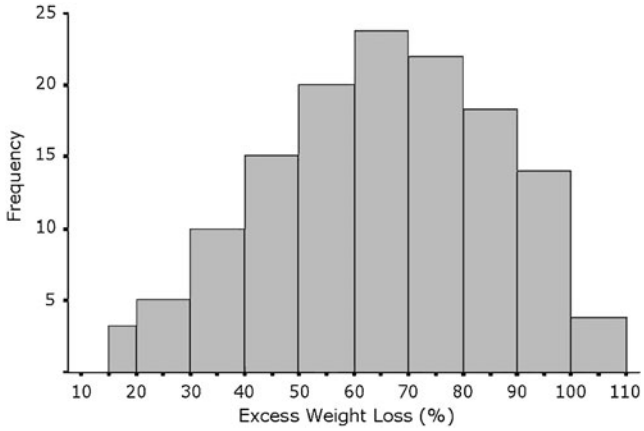

Fig. 3 Distribution of patients in relation to %EWL

prolapse of the gastric fundus between two distal fasteners of the suture line. Two other patients developed acute gastric obstruction 3 months postoperatively that was caused by accumulation of serous fluid within the cavity formed by the plicated gastric wall. Initially, they were both treated conservatively, but reversion of the plication was deemed necessary due refractory obstructive symptoms (Table 4).

Discussion

Herein, we presented our experience with the technique of LGGCP, which was notably similar to laparoscopic sleeve gastrectomy (LSG), as they both resulted in gastric tube formation and elimination of the greater curvature. However, LGGCP spared gastric resection and the use of an implant. The advantages of LGGCP that mostly influenced the patients' decision-making were the minimal invasiveness of the operation, the lack of gastric resection, the absence of foreign bodies, and the convenient follow-up program (no need for periodic adjustments). Bariatric surgery is a promising option for morbid obese patients with an average loss of two thirds of excess weight within 1.5 years. The surgical procedures performed were malabsorptive, restrictive, or a combination of the two. Gastric restriction was the preferred approach, when indicated. Laparoscopic vertical banded gastroplasty (LVBG), laparoscopic adjustable gastric banding (LAGB), and LSG are all restrictive procedures that have satisfactory results with regard to %EWL. Based on a recent update of the Cochrane Database Systematic Review of 20 randomized controlled trials, LSG was superior to LAGB and LVBG as far as weight loss was concerned and was comparable to the results of gastric bypass [4, 5]. Nevertheless, these are expensive procedures that can be accompanied by serious early or late complications. Fusco et al. originally studied the association between gastric invagination and weight loss in an experimental began in 2006. He reported that rats with gastric greater curvature invagination decreased their weight at 7 and 21 days postoperatively. Furthermore, he compared weight losses between greater curvature and anterior gastric wall invagination and concluded that greater curvature invagination resulted in statistically higher weight loss in rats at 21 days [6, 7]. Recently, Brethauer et al. published a comparative trial between laparoscopic anterior gastric wall plication in nine patients and LGGCP in six patients with a mean BMI of 43.3 [8]. During a 12-month follow-up, patients with LGGCP had a significantly higher %EWL (53.4 vs 23.3%) confirming the experimental findings of Fusco. One patient of the LGGCP group developed gastric obstruction and required reoperation for plication reduction, and another was found on a follow-up upper endoscopy to have asymptomatic partial disruption of the intraluminal fold at the distal end of the stomach due to a broken suture. Talebpour and Amoli performed laparoscopic total vertical gastric plication in

Table 3 Subgroup analysis according to BMI

	Group I (BMI<45)	Group II (BMI>45)	*p* Value
	n=110	*n*=25	
f/m	89/21	15/10	
age	37.17±11.14	31.17±10.7	
Preop weight	106.45±17.21	145.0±15.8	
Preop BMI	38.32±4.0	49.8±3.5	
Follow up (months)	22.61±4.3	22.46±5.3	ns
Mean post-op weight	81.09±13.6	105.58±18.39	
Mean pos-top BMI	28.38±3.90	35.54±5.17	
%EWL	69.86±23.66	55.49±19.29	0.006
Inadequate weight loss (%EWL<50%)	20/110 (17f, 3 m)	9/25 (6f, 3 m)	<0.001
Failure (%EWL<30%)	6/110 (4f, 2 m)	2/25 (2 m)	0.063
Complications	10/110	2/25	ns

Table 4 Subgroup analysis according to technique 5

	Single plication	Multiple plication	*p* Value
No. of patients	93	42	
Pre-op weight (kg)	113.05±22.28	113.9±23.20	ns
Pre-op BMI (kg)	39.53±6.17	39.59±6.34	ns
Operative time (min)	68.21±23.14	64.74±23.62	ns
Mean post-op weight (kg)	84.60±16.8	87.40±18.47	ns
Mean post-op BMI (kg)	29.24±4.68	30.44±5.43	ns
%EWL	68.21±23.14	64.74±23.62	ns
Inadequate weight loss (EWL<50%)	20/93 (21.5%)	9/42 (21.4%)	ns
Complications	10/93	2/42	<0.001
Length of hospitalization (days)	2.1	1.4	<0.001

two layers in a series of 100 patients with an average BMI of 47 (range 36–58). [8, 9]. Mean %EWL was 21.4 at 1 month, 54 at 6 months, 61 at 12 months, and 60 at 24 months. Operative time was 98 min (range 70–152) and length of stay 1.3 days (range 1–4). The reported early postoperative complications were prolonged vomiting and nausea in all patients for 3.1 days (range 4 h to 24 days), one case of leaking, and one case of acute perforation, while late postoperative complications included one case of liver abscess and one case of persistent vomiting and discomfort due to adhesions. The authors concluded that laparoscopic total vertical gastric plication is comparable to other restrictive methods. It presented an acceptable postoperative complications rate and offered the advantage of reversibility, lack of foreign bodies, and low cost. The same technique was reported by Ramos et al. in a series of 42 patients with a mean BMI of 41 [9, 10]. The mean %EWL was 20 at 1 month, 48 at 6 months, 60 at 12 months, and 62 at 18 months. The mean operative time was 50 min, and mean length of hospitalization was 1.5 days. Reported postoperative complications were minor, such as nausea, vomiting, and sialorrhea. Despite the low number of patients, this study had similar results to the Talebpour study and advocated LGGCP as a promising procedure. In our series, mean preoperative BMI was lower, as patients with BMI>50 kg/m^2 were not encouraged to select LGGCP. Overall, the %EWL was higher after 1 year compared to the results reported by Talebpour and Ramos (67.1 vs 61 and 60, respectively). Operative time was similar; however, the mean length of hospitalization was longer, mainly due to prolonged vomiting and liquid intolerance that was consistently present in all patients treated with the original single plication technique.

Modification of the Technique

The patients' discomfort, length of hospitalization, and postoperative vomiting were decreased substantially with the induction of the modified multiple plication technique, while the operative time and outcome remained unaffected. In essence, most of the 93 patients who underwent single gastric plication suffered from prolonged nausea and vomiting for 2–20 days. These adverse effects were attributed to mucosal edema caused by venous stasis. Four patients required readmission for intravenous antiemetics and hydration, while two others with acute gastric obstruction required reversion of the plication 3 months later, due to intragastric seroma. Interestingly, none of the 42 patients treated with multiple plications suffered from nausea or vomiting for more than a few hours. The formation of a single cavity between the juxtaposed gastric walls can potentially accommodate fluid collection resulting in postoperative obstruction. With the introduction of the modified technique, this phenomenon was eliminated.

Effectiveness According to BMI

Subgroup analysis revealed an association between preoperative BMI and %EWL. Mean %EWL was significantly higher in group I (BMI<45) compared with group II (BMI>45) (69.86 vs 55.49). The same was true for the success of the technique; the percentage of inadequate weight loss was doubled for group II compared to group I (36 vs 18), indicating that LGGCP has better results in patients with a BMI between 35 and 45. Massive obesity and hepatomegaly may hamper proper gastric fundus mobilization and subsequently proper gastric wall plication. Inadequate weight loss with LGGCP might be attributed to either insufficient gastric volume reduction or to the failure of gastric wall bonding. Although the latter was not clearly evident in our series, endoscopic findings suggest that gastric capacity was noticeably increased 6 months after LGCP in patients with inadequate weight loss. Reintervention of the plication might be indicated in such cases.

Complications

The complication rate in our series was 8.8%. Nausea, prolonged vomiting, gastric obstruction, suture rupture, and gastric leak have been reported by others as well [8–10]. Though rare, the risk of gastric leak is not absent after LGGCP and is undoubtedly attributed to causes producing excessive intra-gastric pressure in the early postoperative stages. In order to eliminate it, in our series, we used partial-thickness sutures with a 1–1.5-cm interval, partially sacrificing the more durable bonding that full-thickness suturing provides. Talebpour and Amoli reported one case of gastric leak that was attributed to excessive vomiting. In our two patients, who were later diagnosed with a leak and tried to consume solid food on the 5th postoperative day, presented with upper abdominal pain, fever, leukocytosis, and high CRP levels. Imaging revealed sub-diaphragmatic free air, but no fluid collections. Their symptoms resolved with intravenous antibiotics and food restriction, and they were discharged 5 days later. It is the first time GI bleeding, herniation of the fundus, and intragastric seroma were reported with LGGCP. Herniation of the gastric fundus was attributed to the disruption of the proximal fasteners of the second suture line. Surgical reduction of the herniated fundus and reinforcement of the suture line was performed laparoscopically. Intragastric seroma was found during an abdominal CT scan, which revealed fluid collection (seroma) inside the cavity of the inverted gastric fundus was filled with serous fluid. The latter was protruding to the duodenum thus obstructing the gastric tube (Figs. 4 and 5). Both patients with intragastric seroma were successfully treated with reversion of the plication. The most devastating complication in our series was a case of portomesenteric thrombosis on the 4th postoperative week, although the patient was on thromboprophylaxis with low-molecular-weight heparin, as usual. An abdominal CT scan revealed edema of the upper jejunum with free intra-abdominal fluid. Diagnosis of portomesenteric thrombosis was confirmed by angio-CT. During exploratory laparotomy, the patient underwent segmental small bowel resection (~100 cm) due to partial jejunum necrosis. Portomesenteric venous thrombosis (PVT) is an uncommon but potentially lethal complication. According to Ogren, the reported lifetime risk of developing PVT in the general population is approximately 1% [11]. PVT has been reported as a complication after several laparoscopic procedures, since 1991. Its presentation, treatment, and outcomes remain poorly understood, and possible etiologic factors include venous stasis due to increased intra-abdominal pressure, prolonged reverse Trendelenburg position, intraoperative manipulation, intra-abdominal inflammatory processes, and thrombophilia. In our case, coagulation studies including prothrombin time, partial thromboplastin time, platelet count, protein C activity, protein S activity, activated protein C resistance, lupus anticoagulant, and antithrombin III were all within normal ranges. Although obesity is not considered to be a predisposing factor, the results of a recent systematic review studying the relation between laparoscopy and PTV showed that seven of 18 cases with PTV were laparoscopic bariatric procedures (gastric bypass) [12].

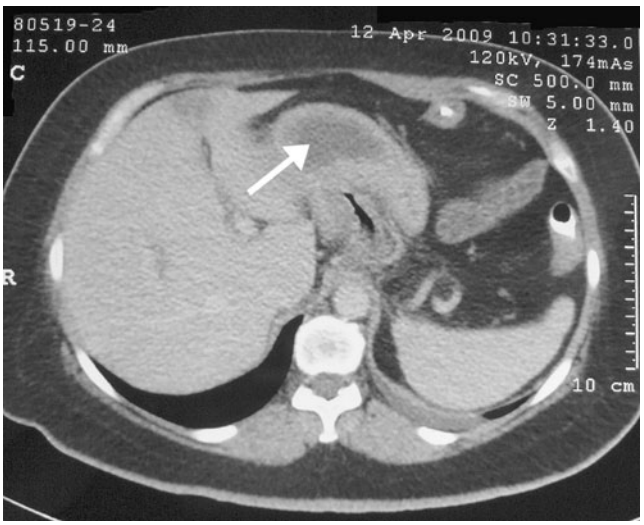

Fig. 4 CT scan: *white arrow* indicating the seroma within the plicated gastric walls

Fig. 5 CT scan: protrusion of the plicated gastric fundus (*white arrow*) into the duodenum causing complete obstruction

Conclusion

Bearing in mind the limitations of our study, such as simple study design and exclusion of super-obese patients, we advocate LGGCP as a safe and effective procedure. The

lack of gastric resection or intestinal bypass and the lack of the use of prosthetic materials are the major advantages of the technique that influenced the patients' decisions. Postoperative complications are within acceptable ranges; nevertheless, the described modification of the technique was shown to further reduce them. In order for LGGCP to become an established bariatric operation, larger trials and longer follow-ups are needed.

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

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