

# Counterclockwise Rotation of Roux-En-Y Limb Significantly Reduces Internal Herniation in Laparoscopic Roux-En-Y Gastric Bypass (LRYGB)

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## Abstract

**Introduction** Internal hernias continue to be a significant source of morbidity after LRYGB. Literature addressing the technique of Roux limb construction as a predisposing factor is sparse. The objective of this study is to evaluate the impact of Roux limb construction technique on the development of internal hernias.

**Methods** In this study, we included 444 (367 (82.7%) were females and 77 (17.3%) were males, two deaths excluded from the analysis) consecutive patients from our institutional bariatric database who underwent LRYGB. Variables collected include demographics, body mass index (BMI) before and after the procedure, and postoperative small bowel obstruction secondary to internal herniation. Technical details collected include: type of Roux-en-Y limb construction, Peterson's defect closure at initial operation, and reoperative findings. Roux limbs were constructed in 291 patients by a clockwise rotation of the bowel and jejunojejunostomy performed on the right side of the axis of the mesentery (group 1). In 151 patients, the Roux limb was constructed by a counterclockwise rotation of the Roux limb resulting in the jejunojejunostomy on the left side of the axis of the mesentery (group 2). We also analyzed the impact of Peterson's space closure on internal hernias. Fisher's exact test and Chi-square test were used for the analysis.

**Results** Of a total 442 (mean age, 43.7±10.3 years; mean BMI pre-op was 46.4±5.1; and BMI after median follow-up of 12 months was 34.5±6.98) patients included in the study, 21 (4.7%) internal hernias were identified. Of 21 internal hernias, 17 (81%) were through Peterson's space and four (19%) were through the mesenteric defect. Group 1 patients had significantly higher overall internal hernias (20/291, 6.9% vs. 1/151, 0.7%;  $P=0.0018$ ) and Peterson's hernias (16/291, 5.5% vs. 1/151, 0.7%;  $P=0.0089$ ) compared with group 2. In addition, no significant difference was noted in the incidence of Peterson's hernia whether the defect was closed or not closed (closed group, 4/117 and 3.4% vs. not closed, 13/325, 4%;  $P=1.00$ ). Within the group where Peterson's defect was closed, clockwise rotation and anastomosis on the right side of the axis of the mesentery was associated with significantly higher incidence of Peterson's hernias compared with counterclockwise rotation (4/54 vs. 0/63;  $P=0.043$ ). In the group where Peterson's defect was not closed, clockwise rotation was associated with higher incidence of internal hernias that did not reach statistical significance (12/237, 5.1% vs. 1/88, 1.1%;  $P=0.12$ ).

**Summary** This study demonstrates that the technique for construction of the Roux limb is a major factor in the development of internal hernias. Construction of the Roux limb with a counterclockwise rotation of the bowel, such that both jejunojejunostomy anastomosis and ligament of Treitz are to the left of the axis of the mesentery significantly reduces the incidence of internal hernias.

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## Introduction

Laparoscopic Roux-en-Y gastric bypass (LRYGB) has been the most commonly performed surgical weight loss proce-

ture in USA. LRYGB is associated with a shorter hospital stay, decreased postoperative pain, and fewer wound complications compared with the open procedure.<sup>1–3</sup> However, the laparoscopic approach is also associated with a higher incidence of small bowel obstruction most frequently resulting from internal herniation.<sup>4,5</sup> The reported incidence of internal hernias varies widely from 0.2% to 9%.<sup>6</sup> Increasing evidence suggests that technical factors related to construction of the Roux limb might play an important role.<sup>7</sup>

In the past decade, the technique of LRYGB has gone through several modifications. In order to eliminate internal hernias through the mesocolon resulting from a retrocolic approach, surgeons advocated switching to an antecolic approach for the gastrojejunostomy.<sup>8</sup> Subsequently, the importance of closing the mesentery at the jejunojejunostomy and Peterson's defect has also been addressed in the literature.<sup>7,9</sup> An antecolic approach with closure of the mesenteric defect at the jejunojejunal anastomosis was reported to reduce the rates of internal hernias.<sup>10</sup> Several initial studies also reported that closure of Peterson's defect decreases the incidence of internal hernias.<sup>11,12</sup> However, recent evidence suggests that closure of the Peterson's defect may not necessarily reduce the incidence of internal herniation.<sup>13</sup> Quebeman et al. reported that placing the Roux limb mesentery on the right side of the patient with cut end of limb pointing towards the greater curvature of the stomach at the gastrojejunostomy is associated with lesser incidence of internal herniation.<sup>7</sup> Even with several technical modifications, the reported long-term internal hernia rate still ranges from 1% to 3%.<sup>5</sup>

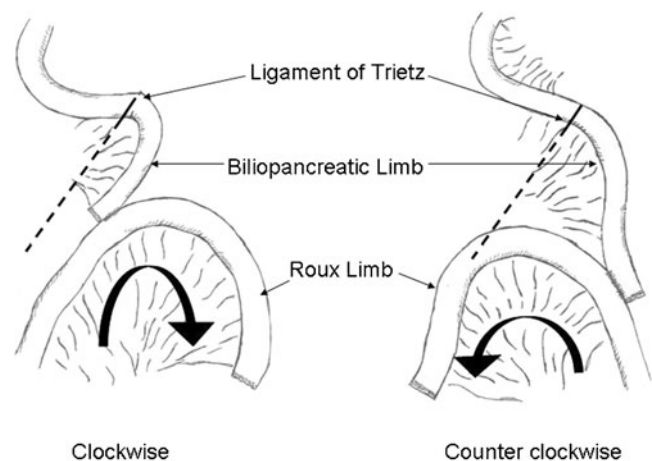
The impact of rotation of the Roux limb after initial staple division, and creation of the jejunojejunal anastomosis and its relation to the biliopancreatic limb on the development of internal herniation has not been adequately addressed. It is probable, due to the wide range of reported incidences, that there are details to the construction of the limb that play a vital role in the propensity for development of internal hernias. The objective of current study was to investigate whether direction of rotation of the Roux limb to create the jejunojejunostomy has any influence on rates of internal herniation. We hypothesized that counterclockwise rotation of Roux limb with the jejunojejunostomy performed on the left side of the axis of the mesentery with biliopancreatic limb remaining on the left side of the axis, is associated with better orientation and decreased incidence of internal herniation.

## Methods

The study population comprised of 444 consecutive patients from the bariatric database who underwent LRYGB

at our Institution between 2005 and 2010. During this period, all procedures were performed by three surgeons. Two patients expired in the early postoperative period and were excluded from the analysis. Variables collected included patient demographics, body mass index (BMI) before and after the procedure, and postoperative small bowel obstruction secondary to internal herniation. Technical details collected include: type of Roux-en-Y limb construction, Peterson's defect closure at initial operation, and reoperative findings.

During this period, the Roux limb was constructed using two different techniques. After the jejunum was divided, the Roux limb was marked with a penrose drain. The jejunal mesentery was divided up to the root of the mesentery to increase length. After division, the Roux limb can be rotated in a clockwise rotation or counterclockwise rotation (Fig. 1) in order to perform the jejunojejunostomy. With a clockwise rotation, the jejunojejunostomy is performed on the patient's right side of the axis of the mesentery and biliopancreatic limb crosses across the axis (Fig. 1). When the Roux limb was rotated counterclockwise, the anastomosis was performed on the patient's left side of the axis of the mesentery and biliopancreatic limb remains on the left side of the axis (Fig. 1). The mesenteric defect was closed in all patients. In 291 patients, the Roux limb was constructed by clockwise rotation of the bowel with the anastomosis performed on the patient's right side of the axis of the mesentery (group 1). These cases were done primarily by one surgeon. The other technical details for construction of the enteroenterostomy (creation of anastomosis, closure of mesenteric defect, and closure of Peterson's when done, were standardized). When the study findings were observed, this surgeon altered the direction of rotation of the bowel to counterclockwise. In 151 patients, the Roux limb



**Fig. 1** Showing clockwise and counterclockwise rotation of the Roux limb

was constructed utilizing counterclockwise rotation resulting in the jejunojejunostomy on the patient’s left side of the axis of the mesentery (group 2). During the case series, we also began to close the Peterson’s defect using non-absorbable sutures infra colically (cut edge of small bowel mesentery to large bowel mesentery, from base of mesocolon to the first tinea coli), and we analyzed the impact of this on internal hernia formation. In all of the patients, mesentery of jejunojejunostomy is closed with running non-absorbable suture. Gastrojejunostomy is performed antecolic antegastric technique in all of the patients.

The data were represented as mean±standard deviation. Fisher’s exact and Chi-square tests were used for the analysis. *P* value of <0.05 is considered significant. Graph Pad and Statistical Package for the Social Sciences software was used for statistical analysis. Univariate analysis was performed initially to identify the factors that had significant association. Multivariate analysis was not performed as only one factor showed a significant association with internal herniation. A separate analysis for patients in whom the internal herniation occurred at the mesenteric defect was not performed, as only four patients were identified in this group. Multivariate logistic regression analysis is performed to assess the factors associated with development of Peterson’s hernias.

**Results**

Of the total 444 (excluding two mortalities from the analysis; mean age, 43.7±10.3; mean BMI pre-op was 46.4±5.1 and post-op was 34.2±6.98; mean weight in pre-op was 127±18.96 and post-op 96.4±24.81; and mean total body weight loss percentage is 51.3±24.81) patients included in the study, 21 (4.7%) internal hernias were identified after median follow-up of 12 months at the time of operation. Of the 21 internal hernias, 17 (81%) were through Peterson’s space and four (19%) were through the mesenteric defect. Two of the four mesenteric defects were incidental findings during laparoscopic procedures for other disease. During the study period, two mortalities were

noted; one from a postoperative leak and other from aspiration pneumonia after initial operation. Two patients had small bowel ischemia requiring partial small bowel resection.

Group 1 (clockwise rotation) patients had significantly higher overall internal hernias (20/291, 6.9% vs. 1/151, 0.6%; *P*=0.0018) and Peterson’s hernias (16/291, 5.5% vs. 1/151, 0.6%; *P*=0.0089) compared with group 2 (counterclockwise; Table 1 shows characteristics of each group). The mean duration to internal hernia occurrence in group 1 was 13.7±8.5 with 14 of 16 hernias occurring within first 24 months and eight of 14 occurring within the first year. No significant difference was noted in the incidence of Peterson’s hernias whether the defect was closed or not closed (closed group, 4/117, 3.4% vs. not closed, 13/325, 4%; *P*=1.00). Within the group of Peterson’s defect closure, clockwise rotation and anastomosis on the patient’s right side of axis of mesentery was associated with significantly higher incidence of Peterson’s hernias compared with the counterclockwise rotation (4/54 vs. 0/63; *P*=0.043). When the Peterson’s defect was not closed, clockwise rotation was again associated with higher incidence of internal hernias but this did not reach statistical significance (12/237, 5.1% vs. 1/88, 1.1%; *P*=0.12).

On multivariate analysis, clockwise rotation and low postoperative weight are the only two factors shown to have significant association with Peterson’s hernias.

**Discussion**

Internal hernia has been the most common cause of small bowel obstruction after LRYGB.<sup>5</sup> The possible explanations for high incidence of internal herniation with LRYGB compared with open procedure include less adhesion formation and lack of proper closure of all created potential defects. The incidence of internal herniation reported in the literature varies widely from 1% to 9%.<sup>5</sup> The published literature is lacking in specific details regarding the construction of the Roux limb, making interpretations of

**Table 1** Patient characteristics in either group

	Number	Clockwise (group 1; 291)	Counterclockwise (group 2; 151)	<i>P</i> value
		43.2±10.2	44.7±10.6	0.45
	Age at surgery	46.4±5.3	46.6±5.1	0.95
	BMI (pre-op)	33.1±6.6	36.4±7.2	0.07
	BMI (recent)	126±19	129.1±18.4	0.41
	Pre-Op weight (kg)	93.7±25.1	101±23.4	0.04
<i>P</i> value of <0.05 considered significant	Post-op weight (kg)	51.4±26.5	50.3±23.3	0.3
	TBWL %	13.2	7.6	0.03
TBWL % total body weight loss percentage	Follow-up (median (month))			

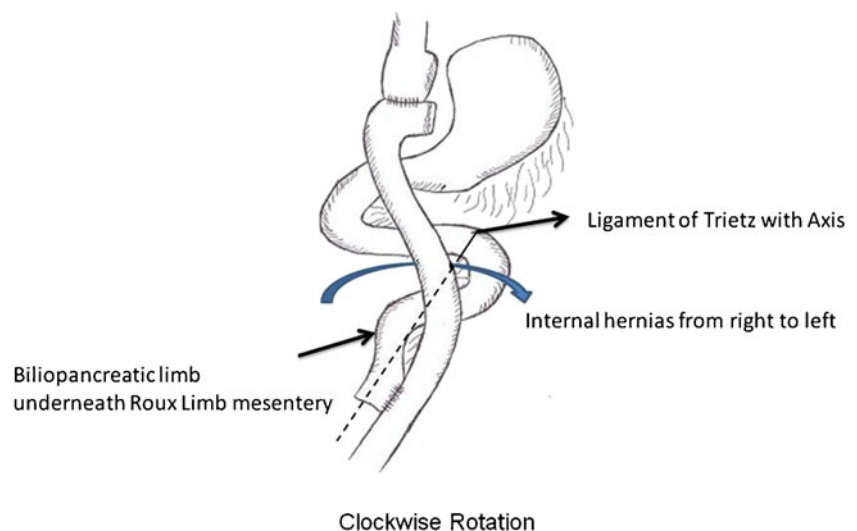
cause difficult. The incidence of internal herniation in our study was 4.7%, of which more than 80% were due to internal herniation through Peterson's space. We identified four patients with open mesenteric defect at jejunojejunal mesentery found at exploration for abdominal pain.

Spontaneous reduction of the hernias can occur, and patients might present with nonspecific or intermittent periumbilical pain, nausea, vomiting, anorexia, or abdominal distension. Internal hernias are difficult to diagnose and delay in the diagnosis is associated with significant morbidity. In extreme cases patients can suffer catastrophic loss of small bowel potentially requiring consideration for small bowel transplantation. Because of this reason it was our policy to do early diagnostic laparoscopy in patients with persistent abdominal despite of negative imaging studies. It is reported in the literature that early exploration will prevent catastrophic complications like small bowel ischemia and gangrene. This could be one explanation for high incidence of internal hernias in our study compared with the literature. In the last decade efforts have been made in improving the surgical technique to prevent this difficult complication. These improvements include details regarding the rotation of Roux limb, conversion from a retrocolic to antecolic approach and closure of the mesenteric and Peterson's defects.

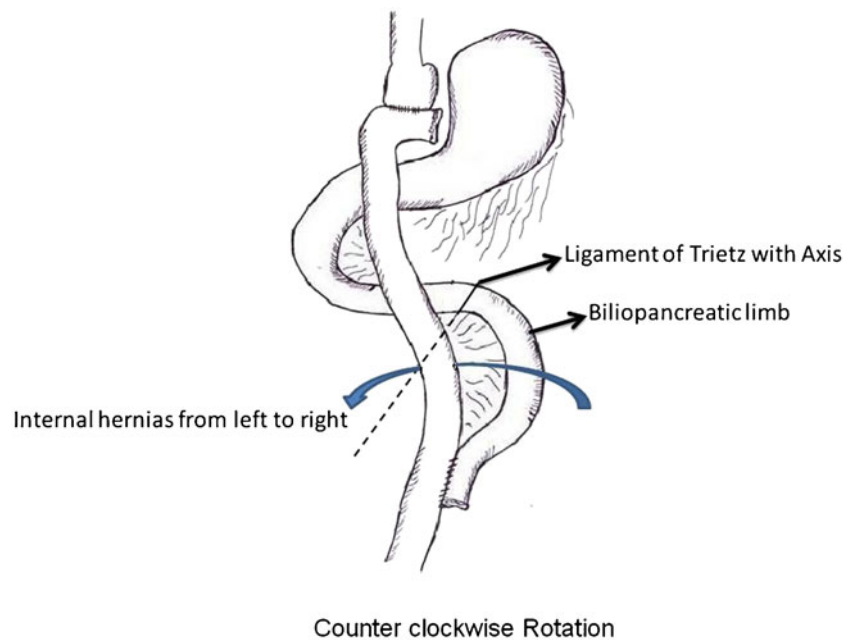
In our experience, we observed that clockwise rotation of Roux limb was associated with higher incidence of internal herniation. In addition, hernias seen tended to herniated from the right side to the left with the clockwise construction of the bowel. This was different than the left to right herniation seen in patients who underwent a counterclockwise rotation. We believe that the rotation of the Roux limb intra operatively to allow either an enteroenterostomy to the patient's right or the patient's left of the eventual location of the Roux limb is an important factor in

predisposing to internal herniation. To explain further, one must visualize the axis of the mesentery, which runs from the Ligament of Trietz towards the right lower abdomen. From this is suspended the entirety of the small bowel like a curtain. The first portion of the jejunum passes beneath the ligament of Trietz into the left upper abdomen. If the Roux limb is created with clockwise rotation (Fig. 2), the jejunojejunostomy is performed to the right side of the axis of the mesentery. This means that the biliopancreatic limb must cross the axis of the mesentery from the left to the right side during its course from the ligament of Trietz to the enteroenterostomy. Because the jejunum starts in on the left side of this axis, it acts to pull the biliopancreatic limb into the left upper quadrant, because it is traversing beneath the Roux limb from its origin on the left side, to the anastomosis on the right side. In order to close the Peterson defect in this setting, the initial stitch must be placed at the root of mesentery and include the biliopancreatic limb at the ligament of Trietz and then continue towards the top of mesentery for adequate closure. By including the jejunum at the ligament of Trietz, the surgeon is trying to fixate the Roux limb mesentery to the left side of the whole biliopancreatic limb. Even with adequate closure, we believe that because the biliopancreatic limb is traversing from one side of the axis to the other, it is pulling towards left side opening a space for potential internal herniation, and thus that attempted closure is more likely to fail. This explains the higher incidence of internal hernias in the clockwise rotation group even when Peterson's defect is closed. This hypothesis was further strengthened by the observation that all the hernias in the clockwise group noted at Peterson's space occurred over the biliopancreatic limb from right to left side. Comparatively, counterclockwise rotation of Roux limb (Fig. 3) results with the jejunojejunostomy being performed on the left side of

**Fig. 2** Showing clockwise rotation of Roux limb and its relation to mesenteric axis



**Fig. 3** Showing counterclockwise rotation of Roux limb and its relation to mesenteric axis



the mesentery. With this approach closure of Peterson's defect is simple as the entire biliopancreatic limb lies on the left side of mesentery. In addition, the biliopancreatic limb does not traverse beneath the axis of the mesentery. We noticed only one internal hernia in this group regardless of whether or not Peterson's defect was closed. In our study, group 1 patients with clockwise rotation were operated on by one surgeon, which introduces the possibility of surgeon specific factors explaining the difference in hernia rates. After this observation surgeon modified his technique began rotating the Roux limb in the counter (counterclockwise) direction, and there were no internal hernias in those patients.

The literature regarding the rotation of the Roux limb is sparse. Quebeman and Dallal reported that left side orientation of the Roux limb with cut end of limb facing lesser curvature at gastrojejunostomy is associated with higher incidence of internal herniation compared with the right side orientation with cut end facing greater curvature of the stomach.<sup>7</sup> Authors believed that with cut end of Roux limb facing towards lesser curvature of the stomach is associated with Roux limb positioned on the left side of the patient and leading increased herniation underneath the mesentery. This observation led to change in their practice during the period of study. In our experience, we had 86 patients in whom cut end of the Roux limb positioned towards the lesser curvature of the stomach and we had only 1 internal herniation in this group. Our results support that rotation of the Roux limb is more important factor than orientation of the cut end in predisposing internal herniation.

Closure of the mesenteric defects has been the standard care for several years; often resulting in vigorous debates at surgical forums. Recently, several studies in the literature reported that closure of Peterson's defect is not necessarily associated with decreased incidence of internal herniation.<sup>13,14</sup> However, these reports lack specific details about enteroenterostomy construction in order to make comparisons. We also reviewed our experience to see whether the closure of Peterson's defect is associated with decreased incidence of internal herniation. In this group, the incidence of Peterson's hernias was close to 4% in both groups with no significant association to closure of the Peterson's defect. Subgroup analysis revealed that clockwise rotation during construction of the enteroenterostomy is associated with higher incidence of Peterson's hernias even when the Peterson's defect was closed completely. This observation further strengthened our hypothesis that rotation of the bowel for construction of the enteroenterostomy is a critical and previously undiscussed factor which leads to internal hernias. Lastly, in patients that did not have Peterson's defect closed, clockwise rotation has higher number of Peterson's hernias (5%) compared with the counterclockwise rotation (1%). However, this observation did not reach significance because of smaller number of subjects in this subgroup. Overall, the incidence of internal hernia in our study was higher than recently reported series. During this period our policy was to opt for early diagnostic laparoscopy

Laparoscopic gastric bypass has become one of the commonly performed procedures in surgery and it is imperative that we limit potentially catastrophic complications associated with this procedure. This remains an unresolved debate because specific details regarding variations in individual technique of construction of the bypass

are lacking in the literature. For this reason, comparative analysis cannot adequately be done to identify the optimal techniques. The current study demonstrates that creating the enteroenterostomy using a counterclockwise rotation and orienting the jejunojejunostomy to the left of the mesenteric axis is associated with significantly less internal hernias through Peterson's defect.

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## Discussant

**Dr. Raul J. Rosenthal (Weston, FL):** I congratulate the authors for this study addressing an important subject in bariatric surgery such as prevention of internal herniation (IH) after gastric bypass. The literature reports a low incidence of this complication. However, the consequences of IH if not recognized and treated in a timely fashion are devastating. Small bowel obstruction, strangulation, ischemia, short gut syndrome requiring reversal of gastric bypass, or small bowel transplantation are some of the most feared adverse events. Suture closure of mesenteric defects has been advocated by many authors as means to prevent IH from happening. However in their reports, IH are still present. Factors that might influence IH after gastric bypass are: division of the mesentery, length and routing of the Roux Limb in an ante or retro- colic fashion and as newly suggested by the authors, the clock or counterclockwise rotation of the enteroentero anastomosis.

The authors conclude in this study that

- At 12 months follow-up, the incidence of IH is 4.7 %.
- That the counterclock way of the enteroentero anastomosis results in less internal hernias than the clockwise fashion. My comments, questions, and concerns to the above-mentioned conclusions are that the incidence of hernias in the counterclockwise group might be low because of short follow up.

## Closing Discussant

**Dr. Kalyana Nandipati:** We appreciate SSAT and Dr. Rosenthal for reviewing our study and also providing with valuable comments and suggestions. We were able to include most of the suggestions from the reviewer before submitting the final manuscript.

1. The 12 months incidence of early IH seems to be high when compared with most published series. Since IH seem to become clinically apparent at a later time, I recommend a longer follow-up to support or dispute the conclusions of the study. Can the author comment on this observation? What triggered the authors to perform laparoscopy at one year?

**Ans:** We agree with the reviewer's comments that our 12-month internal herniation was high (4.8%). We believe that the technique of Roux limb construction was the most important reason for the high incidence of internal hernias

in this particular cohort. This probably the main reason also why most our hernias were early in the follow-up. We changed our technique after this study was initiated. We will continue to follow-up on our database to see whether this change of technique reduced the incidence of internal herniation.

2. The authors should also clarify which technique was utilized in this patient cohort, (1) was the Roux limb route in an ante or retro colic fashion? (2) Was the mesentery divided? (3) What was the length of the limbs?

**Ans:** During this study period Roux limb was constructed only in antecolic fashion. Mesentery was divided in all patients. That is the reason why we also performed a subgroup analysis to see whether the closure of mesenteric defects has any impact on development of internal hernias. Roux limb length was standard in all patients.

3. Finally, my concerns are if the counterclockwise rotation of the enteroentero anastomosis can result in a higher incidence of small bowel obstruction?

**Ans:** The incidence of internal hernias after counterclockwise rotation was <1%. Which remained same since the study was performed. Our follow-up now has increased to more than 1 year but our rate internal herniation still remains low. We believe that most of the studies published

in the literature didn't provide details about the Roux limb construction. In our opinion, in the future studies reporting internal hernias should have technical details also as a part of evaluation along with other details like weight, closure of defects, length of limb, and type of Roux limb placement. Homogeneity in reporting will allow future studies to identify factors associated with the development of internal herniation.

I thank SSAT for giving me the privilege to comment on this study.

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