# An Experimental Approach to Gastrojejunostomy on Rats for Better Gastric Emptying

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***Cite this article as:*** Karatas C, Alim A, Akıncı H, İlgün S. An experimental approach to gastrojejunostomy on rats for better gastric emptying. *Cerrahpaşa Med J.* 2021;45(3):147-151.

***Abstract***

**Objective:** Postsurgical gastroparesis is common morbidity following antecolic gastrojejunostomy. We aimed to find a solution for postsurgical gastroparesis with a modification of the operative technique using cross antecolic gastrojejunostomy.

**Methods:** Twenty adult male rats were separated into 2 groups of 10 animals (classic antecolic gastrojejunostomy—group A and cross antecolic gastrojejunostomy—group B). By using a scintigraphic method on the second postoperative day, these 2 groups were compared for their gastric emptying rates. A 5 mCi Tc-99m pertechnetate scintigraphy scan was used for measuring the gastric emptying rate with a 6 F feeding tube at the 1st, 20th, and 45th minute and compared within areas of the anastomosis, cardia, body, and pylorus. The Mann–Whitney *U*-test was used for the statistical analysis.

**Results:** When compared with group B at the 1st, 20th, and 45th minute, the radioactivity of Tc99m pertechnetate in the pylorus was significantly higher in group A. This likely suggests that gastric emptying rate was slower in group A than in group B. However, the gastric emptying rate of group B gradually decreased and was found to be more effective.

**Conclusion:** Cross antecolic gastrojejunostomy may be a solution to improve gastric emptying in patients with postsurgical gastroparesis.

**Keywords:** Postsurgical gastroparesis, gastrojejunostomy, scintigraphy

***Sıçan Modelinde Gastrojejunostomi Sonrası Daha İyi Mide Boşalımı için Deneysel Yaklaşım***

***Öz***

**Amaç:** Antekolik gastrojejunostomi (AGJ) sonrası gastroparezi nadir görülen bir morbidite değildir. Çapraz AGJ kullanarak ameliyat tekniğinin modifikasyonu ile ameliyat sonrası gastroparezi için bir çözüm bulmayı amaçladık.

**Yöntemler:** Yirmi sıçan, on hayvandan oluşan iki gruba ayrıldı (Klasik AGJ-grup A-ve Çapraz AGJ-grup B). Ameliyat sonrası ikinci gün sintigrafik yöntemler kullanılarak bu iki grup mide boşalma hızlarına göre karşılaştırıldı. 5 mCi Tc 99m perteknetat sintigrafi taraması kullanılarak 6F besleme tüpü ile 1., 20. ve 45. dakikalarda mide boşalma hızı ölçülerek anastomoz, kardiya, gövde ve pilor alanlarında karşılaştırıldı. İstatistiksel analiz için Mann-Whitney-U testi kullanıldı.

**Bulgular:** 1., 20. ve 45. dakikalarda grup B ile karşılaştırıldığında, Tc99m perteknetatın pilordaki radyoaktivitesi grup A'da anlamlı olarak daha yüksekti ve bu da grup A'da grup B'ye göre mide boşalmasının daha yavaş olduğunu düşündürmektedir. Ancak, ilerleyen sürede B grubunun mide boşalması giderek azaldı ve daha etkili olduğu gözlendi.

**Sonuç:** Ameliyat sonrası gastroparezi hastalarında çapraz antekolik gastrojejunostomi mide boşalmasını iyileştirmede bir çözüm olabilir.

**Anahtar Kelimeler:** Cerrahi sonrası gastroparezi, gastrojejunostomi, sintigrafi

Gastroparesis syndrome is a motility disorder characterized by delayed gastric emptying without any anatomical obstruction. It typically presents with nausea, vomiting, bloating, postprandial pain, and an increased number of complaints.[1] The incidence of this syndrome after gastrectomy has been reported to be between 0.4 and 5%.[2]

Weight loss, electrolyte imbalance, dehydration, and decreased quality of life are common problems in patients due to nutritional disorders, secondary to gastroparesis.[3] The consequence is that diabetes mellitus, idiopathic and previous history of gastrectomy may occur more frequently in these patients.[4] Studies have shown a decrease or damage in intestinal Cajal cells, depending on the etiology.[5]

The main neurovascular bundles of the stomach are located longitudinally through the length of the lesser and

**Received:** January 30, 2021 **Accepted:** July 6, 2021 **Available Online Date:** August 23, 2021
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**DOI:** 10.5152/cjm.2021.21003

greater curvatures of the stomach. Furthermore, these bundles split up into vertical branches. Theoretically, these tiny branches can be damaged during gastrojejunostomy.

Indeed, we hypothesized that the gastric neurovascular bundle injury that may occur with a standard horizontal incision may be prevented with a vertical incision on the gastric side of anastomosis. In our study, we evaluated the impact of this novel gastrojejunostomy technique on gastric emptying by scintigraphy. Although anamnesis, physical examination, and radiological examinations are helpful in the diagnosis of this syndrome, the gold standard diagnostic method is still the scintigraphic examination of gastric emptying.[6]

## Methods

### Animals

Twenty adult male Wistar Albino rats were used in the animal experimental unit of Taksim Training and Research Hospital, Istanbul, Turkey. All experimental procedures on animal usage were performed by the Institutional Animal Care and Use Committee of the same hospital. All the rats (175-250 g) were under standard laboratory conditions with a 12-hour dark-light cycle and a humidity-controlled environment at a room temperature of $22 \pm 2$°C. The animals were fed with dry pellet food and water ad libitum and were fasted 6 hours before surgery. The rats were randomly divided into 2 groups, with 10 animals in each group.

### Operative Technique

All the surgeries were performed via a surgical loupe with 2.5 magnification. General anesthesia was administered with diethyl ether inhalation. Disinfection of the skin was performed with a povidone-iodine solution. A routine 3 cm median laparotomy was performed in both groups (Figure 1). Group A underwent a classical antecolic gastrojejunostomy (AGJ), and group B underwent a cross-sectional AGJ.

### Classic AGJ (Group A)

A 1 cm parallel incision to the greater curvature of the antrum was made for gastrotomy. An intestinal loop distal to the duodenojejunal junction was brought to the front edge of the greater curvature of the antrum for the classic gastrojejunostomy (Figure 2). The anastomosis was performed 0.5 cm away from the pylorus in the antecolic and isoperistaltic direction with 1 layer of 6/0 polypropylene continuous sutures. The abdominal wall was closed with 2/0 polypropylene continuous sutures and surgery was completed.

**Figure 1.** Surgical image of a rat undergoing classical gastrojejunostomy.

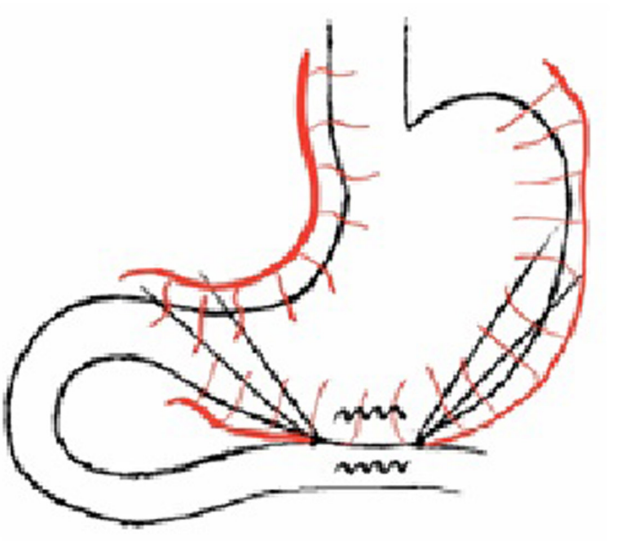

**Figure 2.** Classical gastrojejunostomy.

### Cross AGJ (Group B)

A 1 cm incision vertical to the greater curvature of the antrum was made for gastrotomy. An intestinal loop distal to the duodenojejunal junction was brought to the front edge of the greater curvature of the antrum for the diamond-shaped anastomosis (Figure 3). The anastomosis was performed 0.5 cm away from the pylorus in the antecolic and isoperistaltic direction with 1 layer of 6/0 polypropylene continuous

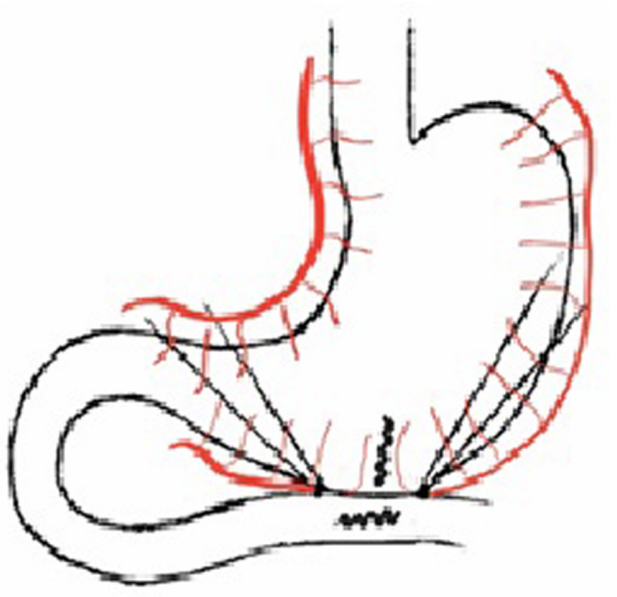

**Figure 3.** Cross gastrojejunostomy.

sutures. The abdominal wall was closed with 2/0 polypropylene continuous sutures and surgery was completed.

The rats were not given any food on the first day after surgery but were injected with 3 cc of 5% saline solution to the intraperitoneal space. On the second postoperative day, they were fed with 5% dextrose and water. After scintigraphic evaluation, they were fed with normal water and dry pellets ad libitum.

**Imaging**

On the second postoperative day, the gastric emptying rates of the operated rats were assessed with scintigraphic scanning after 6 hours of fasting. After diethyl ether inhalation for sedation, 5 mCi Tc-99m pertechnetate was administered, with the help of a 6 gauge feeding tube (1 mL at the 1st, 20th, and 45th minute). Immediately after gavage, scintigraphic images in a supine position were recorded for 1 minute with a gamma camera (Siemens, Scintiview SP, Munich, Germany). These radioisotopic exposures of the stomach (areas of the gastrojejunostomy, cardia, body, and pylorus) were taken after the 20th and 45th minute. A region of interest was drawn around the Tc-99m pertechnetate in the stomach. Radioactivity data was recorded for all the rats in the 1st, 20th, and 45th minute, counting for 1 minute. Thus, time-radioactivity curves were obtained expressing the gastric emptying rates for each part of the stomach (gastrojejunostomy, cardia, body, and pylorus) (Figure 4).

**Statistical analysis**

Statistical analysis was performed using Statistical Package for the Social Sciences for Windows version 10.0 (SPSS Inc., Chicago, IL, USA). Radionuclide data, obtained according to the times for each sub-group, was evaluated using the Mann–Whitney *U*-test. The level of statistical significance was defined as $P < .05$.

**Results**

All the rats survived until postoperative day 2, when scintigraphic assessments were made. Wound healing in abdominal wall closure was uneventful. No statistical difference was observed between the weights of the rats in the groups. The radioactivity values according to the time intervals showing the elimination of the radioactive material in the cardia, corpus, pylorus, and anastomosis region after the administration of radioactive material into the stomach with the aid of a 6 F feeding probe in all groups are shown in Table 1.

In the cardia of group A, uptake of radioactivity tended to be more than group B at the 1st and 45th minutes. On the other hand, uptake of radioactivity in the cardia of group B was found to be higher than group A at the 20th minute.

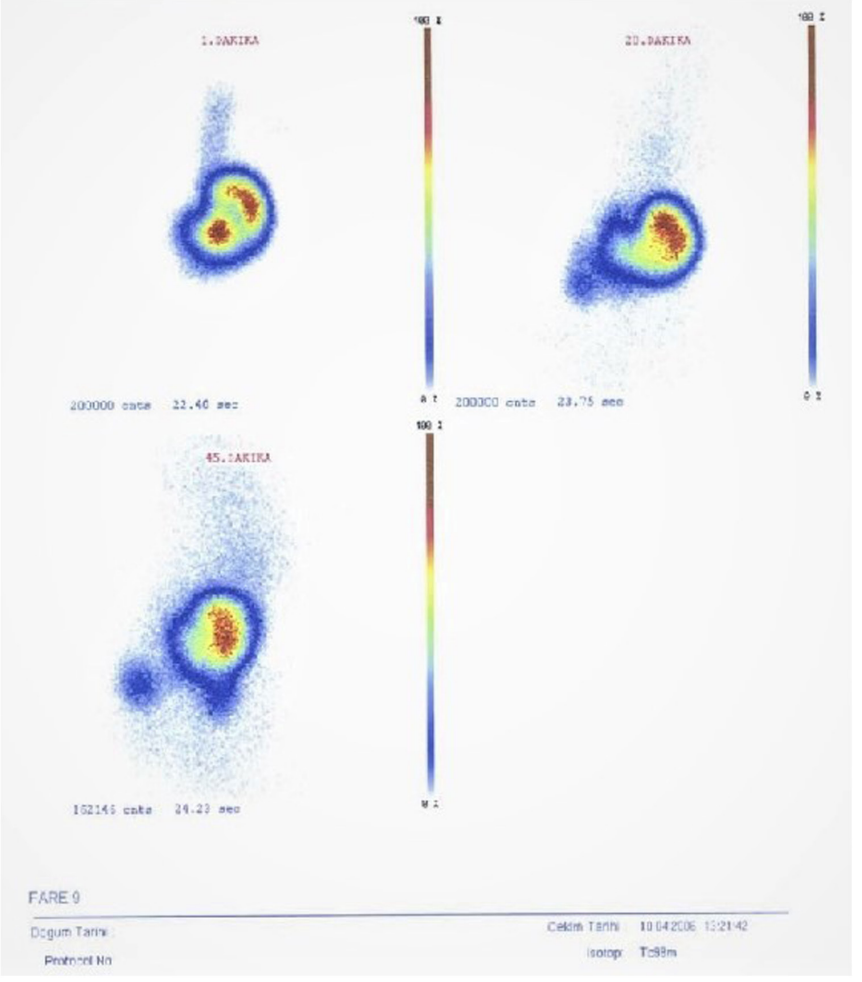


**Figure 4.** Scintigraphic image of gastric emptying of a rat in the group 2 at 1st, 20th, and 45th minute.

**Table 1.** The Average Radioactivity Measurements of the 1st, 20th, and 45th minute of the Classic (Group A) and Cross Gastrojejunostomy (Group B) Groups (*$P < .05$)

| | Group A (Mean ± SD) | | Group B (Mean ± SD) | | *P* |
|---|---|---|---|---|---|
| Cardia 1st minute | 2.167 | 0.775 | 1.648 | 0.399 | .56 |
| Cardia 20th minute | 1.538 | 0.384 | 2.264 | 0.536 | .427 |
| Cardia 45th minute | 2.285 | 0.589 | 1.978 | 0.554 | .958 |
| Body 1st minute | 93.653 | 54.582 | 80.378 | 6.754 | .56 |
| Body 20th minute | 32.81 | 4.535 | 64.613 | 6.34 | .266 |
| Body 45th minute | 31.965 | 4.961 | 57.909 | 6.097 | .315 |
| Pylorus 1st minute | 6.342 | 5.302 | 1.355 | 0.281 | .03* |
| Pylorus 20th minute | 2.693 | 0.997 | 1.919 | 0.449 | .004* |
| Pylorus 45th minute | 2.048 | 0.718 | 1.221 | 0.364 | .007* |
| Anastomosis 1st minute | 5.651 | 3.332 | 2.936 | 0.469 | .874 |
| Anastomosis 20th minute | 2.543 | 0.458 | 3.461 | 0.765 | .711 |
| Anastomosis 45th minute | 2.606 | 0.562 | 3.153 | 0.886 | .223 |

Yet these differences did not reach any statistical significance ($P > .05$).

In the body of group A, uptake of radioactivity was higher than group B at the 1st minute. However, while the decrease in radioactivity uptake from the 1st minute to the 20th minute was higher in group A, it was observed that there was more controlled emptying in group B for the body region. Similarly, no statistically significant difference was observed between these measurements ($P > .05$).

In the anastomosis area of group A, the uptake of radioactivity tended to be higher than group B at the 1st minute. At the following 20th and 45th minutes, a tendency of less uptake of radioactivity was observed in group A than group B. But there was no statistically significant difference between these values ($P > .05$).

However, when compared with group B during all time intervals, the radioactivity of Tc-99m pertechnetate in the pylorus was significantly higher in group A ($P < .05$). This likely suggests that the gastric emptying rate was slower in group A than in group B.

## Discussion

Postsurgical gastroparesis (PSG) is defined as delayed gastric emptying (DGE) in the absence of mechanical obstruction with an incidence of approximately 0.4-5%.[1,2] This disease does not cause mortality, but it can prolong hospital stays, lead to reoperations, increase costs, and affect the quality of life and nutritional status of patients.

Among the most common causes of DGE are diabetes mellitus (29%), post-abdominal surgery (13%), and idiopathic reasons (36%).[3] Postsurgical DGE often occurs after operative maneuvers that cause the loss of the organs responsible for gastric motility and emptying or kinetic muscular or neuromuscular ischemia.[4] To prevent PSG, it is vital to develop and universalize a standardized surgical technique in a way that reduces the factors that are believed to cause PSG.

Gastric emptying is a complex process and requires the coordination of various factors, such as smooth muscle cells (myogenic), enteric neurons (hormonal), and an autonomic nervous system (neural).[7] The stomach is innervated sympathetically from the splanchnic nerves and parasympathetically from the vagus nerve.[8] The parasympathetic nerves stimulate the gastric glands and musculature, which leads to slow peristaltic contractures during the passage of chime. Sympathetic nerves are responsible for the motor innervation of the pylorus and the sensory innervation of the stomach mucosa. When these nerves are damaged, the muscles of the stomach do not function properly, and PSG may occur.

Syed et al.[9] underlined that medical treatment is enough for most people with gastroparesis; however, 2 to 5% of patients with gastroparesis do not benefit from drug therapy and are hospitalized multiple times. Kung et al.[10] analyzed 955 consecutive patients who had undergone gastric surgery. They found that 23 patients had experienced DGE. In an 11-year study of 81 patients with postsurgical DGE, who have no response to drug therapy, the patients were treated with near-completion gastrectomy.[11]

In our experimental animal study, we avoided harming the gastric vasculature and innervation system by performing a 1 cm incision vertical to the major curvature of the antrum and anastomosed to the jejunum with a 1 cm enterotomy. This new anastomosis was diamond-shaped. We were inspired by Kimura's diamond-shaped anastomosis for congenital duodenal obstruction and diamond-shaped choledochoduodenostomy anastomosis for choledocholithiasis.[12,13] The effect of the new anastomosis model-cross-sectional AGJ-on the gastric emptying rate was investigated and compared with the classic AGJ by gastric emptying scintigraphy, which was introduced in 1966 by Griffith and remains the gold standard for assessing gastric emptying.[14]

In group A, emptying of the body area was less at the 1st minute but much more at the 20th minute compared to the

group B and remained at the same level at the 45th minute. In group B, a more controlled emptying was observed between these periods. In the end, gastric content in group B showed a more balanced emptying than the group A. Considering that bowel movements have not yet recovered in the early postoperative period, this method can provide the necessary time until the pacemaker activity of the intestines normalizes. Thus we can reduce problems such as postoperative nausea, vomiting, epigastric pain, and mechanical intestinal obstruction.

The reason why the radioactivity uptake is higher in the pylorus in group A can be relayed to the fact that the passage through the anastomosis is more difficult and the substance is directed to the pylorus. When the 1st, 20th, and 45th minute measurements were compared between group A and B, the uptake of radioactivity in the pyloric region of group A was higher for each timepoint. Since the uptake of radioactivity in the pyloric region is less in group B, it can be concluded that the anastomosis works more effectively.

According to the results obtained, we observed that the passage of substance was more difficult at the 1st minute in the anastomosis area in group A. In group B, we demonstrated that the radioactivity uptake was less in the anastomosis region at the same time compared to group A. The results of the 20th and 45th minutes were close to each other, but it is not easy to make a clear statement on this issue because of statistical insignificance. Considering the activity uptake in other parts of the stomach, the passage of substance in an anastomosis is more effective in group B than group A.

We believe that we caused minimal damage to the gastric neurovascular structure by a vertical incision to the stomach. We assume that the diamond shape of anastomosis may also minimize passage problems. Further studies are certainly required to identify the exact mechanism for these observations, which may help to improve the clinical management of PSG patients.

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**Ethics Committee Approval:** Ethics committee approval was received for this study from the ethics committee of Taksim Training and Research Hospital (2006-1025).

**Peer Review:** Externally peer-reviewed.

**Author Contributions:** Concept - C.K.; Design - C.K., H.A.; Supervision - C.K., H.A.; Resources - C.K., H.A.; Materials - C.K.; Data Collection and/or Processing - C.K., S.İ.; Analysis and/or Interpretation - C.K., A.A., H.A., S.İ.; Literature Search - C.K., A.A.; Writing Manuscript - C.K., A.A.;Critical Review - C.K., A.A.

**Conflict of interest:** The authors have no conflicts of interest to declare.

**Financial Disclosure:** The authors declared that this study has received no financial support.

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**Etik Komite Onayı:** Bu çalışma için etik komite onayı Taksim Eğitim ve Araştırma Hastanesi'nden (2006-1025) alınmıştır.

**Hakem Değerlendirmesi:** Dış bağımsız.

**Yazar Katkıları:** Fikir – C.K.; Tasarım – C.K., H.A.; Denetleme – C.K., H.A.; Kaynaklar – C.K., H.A.; Malzemeler – C.K.; Veri Toplanması ve/veya İşlemesi – C.K., S.İ.; Analiz ve/veya Yorum – C.K., A.A., H.A., S.İ.; Literatür Taraması – C.K., A.A.; Yazıyı Yazan – C.K., A.A.; Eleştirel İnceleme – C.K., A.A.

**Çıkar Çatışması:** Yazarlar çıkar çatışması bildirmemişlerdir.

**Finansal Destek:** Yazarlar bu çalışma için finansal destek almadıklarını beyan etmişlerdir.

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