

The technical outcomes of delta-shaped anastomosis in laparoscopic distal gastrectomy: a single-center safety and feasibility study

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Abstract

Background The indications for laparoscopic gastrectomy for early stomach cancer have spread worldwide, and the short-term outcomes have been favorable. Intraabdominal delta-shaped gastroduodenostomy using endoscopic linear staplers, a technique which was developed by Kanaya et al. is one of the feasible reconstructive procedures. Pure laparoscopic surgery is reported to be associated with several intraoperative and postoperative advantages in comparison with laparoscopy-assisted surgery. However, the clinical results remain uncertain. The present study

aimed to evaluate both the technical feasibility and safety of delta-shaped anastomosis with LDG according to the short-term outcomes.

Methods The study group was composed of 229 patients who underwent delta-shaped anastomosis with LDG at Gifu University School of Medicine from December 2004 to December 2014.

Results The median total operative blood loss and operative time were 20 ml and 277 min, respectively. Postoperative complications were detected in 20 (8.7 %) patients. The complications included: anastomotic stenosis, $n = 3$ (1.3 %); anastomotic leakage, $n = 3$ (1.3 %); pancreatic injury, $n = 8$ (3.5 %); anastomotic ulcer, $n = 1$ (0.4 %); bowel obstruction, $n = 1$ (0.4 %); abdominal abscess, $n = 1$ (0.4 %); lymphorrhea, $n = 1$ (0.4 %); cardiac failure, $n = 1$ (0.4 %); and infection, $n = 1$ (0.4 %). The complications were classified as grade 2, $n = 4$ (1.7 %); grade 3a, $n = 12$ (5.2 %); grade 3b, $n = 4$ (1.7 %); and grade 4 and 5, $n = 0$ (0 %).

Conclusion The findings of the present study indicate the safety of Kanaya's procedure and that it should provide better outcomes in patients who undergo intracorporeal gastroduodenostomy after laparoscopic distal gastrectomy.

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Keywords Delta-shaped anastomosis · Laparoscopic gastrectomy · Intracorporeal gastroduodenostomy

Laparoscopic surgery is currently accepted throughout the world as a surgical treatment for malignancies of the stomach [1–5]. Lee et al. [6] reported the advantages of laparoscopic procedures over conventional open methods. We previously reported the safe postoperative course and oncological benefits of laparoscopic gastrectomy. However, intraabdominal anastomotic procedures are

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considered to be complex and to involve a high degree of technical difficulty. In addition, endoscopic linear staplers are expensive and are associated with increased medical costs in comparison with extra-abdominal anastomotic procedures [7]. However, some surgeons have reported several intraoperative and postoperative advantages of total laparoscopic surgery in comparison with laparoscopy-assisted surgery [8, 9].

At present, Kanaya commonly selects the Billroth I reconstruction method (a delta-shaped anastomosis method) for laparoscopic operations in Japan. However, intraabdominal anastomosis is technically difficult. A method for performing Billroth I anastomosis after LDG which only uses endoscopic linear staplers was developed by Kanaya in 2002, and has been widely accepted in Asian countries, including Japan and Korea [10]. However, the clinical results of this procedure have not yet been fully evaluated. We herein report the surgical outcomes of Kanaya's delta-shaped anastomosis procedure at our institutes.

Patients and clinical evaluations

Patients

This study included a total of 229 gastric cancer patients who underwent intraabdominal anastomotic procedures and delta-shaped anastomosis in the surgical oncology department of Gifu University School of Medicine from December 2004 to December 2014. The mean body mass index (BMI) of the study population was 22.2 ± 3.1 kg/m². The patients' clinicopathological features are shown in Table 1.

Pathological examinations showed that all of the tumors were malignant, and preoperative imaging indicated that there was no spread over the muscularis propria (MP) and N0 lymph node metastasis. The preoperative imaging performed to determine invasion depth was endoscopic ultrasound used for staging. In addition, the preoperative imaging performed to determine lymph node metastasis was CT examination used for staging.

Our policy for such cancer progression has usually been to perform D1+ (Tumor confined to the submucosa)+ or D2 (Tumor invades the muscularis propria) lymph node dissection.

The operative method was converted to open surgery if serosal invasion or extensive lymphadenopathy was detected during laparoscopy. Written informed consent was obtained from all of the patients who were enrolled in the present study. The study protocol conformed to the ethical guidelines of the 1975 Declaration of Helsinki and the

Table 1 Demographic, operative, and tumor characteristics of 229 patients after laparoscopic radical gastrectomy

Patients <i>n</i> = 229	Delta anastomosis
Age, years	64.4 ± 11.2
Gender, male/female, <i>n</i>	149/80
Body mass index	22.2 ± 3.1
Operation	
Totally laparoscopic procedure,	99.6 %
Assist/no., <i>n</i>	0 (1)/229
Conversion, <i>n</i>	1 (0.4 %)
D1/D1 + α/D1 + β/D2	2/24/163/40
Lymph node yields, <i>n</i>	31.9 ± 12.4
Resection of other organ	
Yes/no. <i>n</i>	5/224
Operation time, min (MED)	277
Postoperative days	14.3 ± 11.3
Bleeding, ml (MED)	20
Tumor	
Histology	
pap/tubl/tub2/porl/por2/sig/muc/end	1/60/63/36/29/38/1/1
Tumor size, cm	3.2 ± 1.8
Stage	
IA/IB/IIA/IIB/IIIA/IIB/IIIC, <i>n</i>	174/36/11/3/3/1/1

guidelines of the regional ethical committees of Zurich and Basel, Switzerland.

Statistical analysis

All of the data are presented as mean ± SD. The data were statistically evaluated using Student's *t* test, the Wilcoxon signed-rank test, the Kaplan–Meier method, the log-rank test, and Pearson's product-moment correlation coefficient. *P* values of 0.05 were considered to indicate statistical significance.

Intracorporeal anastomosis in pure laparoscopic distal gastrectomy

In Billroth I gastroduodenostomy, the delta-shaped anastomosis procedure was termed reconstruction of intracorporeal anastomosis. The original method for this procedure was first described by Kanaya et al. [10]. We partly modified the technique for ease of use as follows. Gastrotomy was performed on the greater curve corner of the staple line on the remnant stomach; then, a small hole was made on the posterior tip of the duodenal stump. The cartridge fork of a 60-mm linear stapler (Powered ECHELON FLEX™, Ethicon Endo-Surgery, Cincinnati) was inserted into the

gastric remnant, and another fork was inserted into the duodenal stump. The stapler was then fired to form a functional end-to-end gastroduodenal anastomosis. After checking the anastomosis from the lumen to check for bleeding, common enterotomy was performed vertically using two forceps without placed stay sutures, and closed with one firing of the stapler (Figs. 1, 2, 3, 4). In this time, it is important that the both operator and assistant operator harmonize and move. Each operator should avoid working without cooperation. Delta-shaped anastomosis was satisfactorily performed using this strategy. After anastomosis, security was confirmed with an air-leak test (Fig. 5).

Our department employs an endoscopic surgical skill qualification system: Five surgeons are recognized by the Japan Society for Endoscopic Surgery as being qualified to perform endoscopic surgery. It is important that the both operator and assistant operator harmonize and move. It is our method that closedown of the entry hall performed only one stapler. It is the attention' points that closedown method of the entry hall was prevented by bloodstream incomplete and tension's free of stapling sites.

Clavien–Dindo classification

We evaluated the safety and feasibility of the procedure using the Clavien–Dindo classification, which categorizes surgical complications from grades 1 to 5 based on the invasiveness of the necessary treatment. Grade 1 requires no treatment; grade 2 requires medical therapy; grade 3a requires surgical, endoscopic, or radiological intervention but not general anesthesia; grade 3b requires general anesthesia; grade 4 represents life-threatening complications that require intensive care; and grade 5 represents the death of the patient. In the present study, we retrospectively determined the incidence of complications of grades 2–5

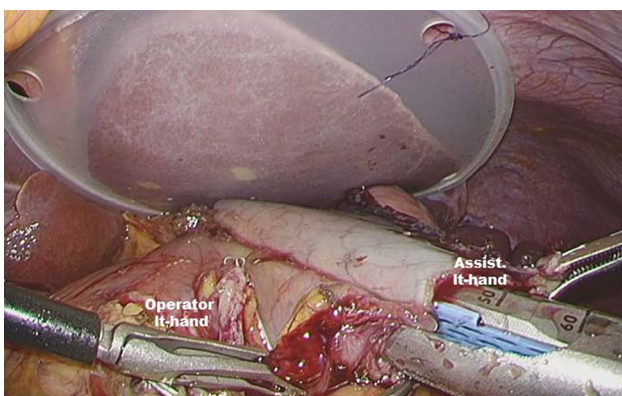


Fig. 1 Cartridge fork of 60-mm linear stapler (Powered ECHELON FLEX™; Ethicon Endo-Surgery, Cincinnati) was inserted into the gastric remnant, and another fork was inserted into the duodenal stump

during hospitalization and within 30 days after surgery from the patient's records. With the exception of surgical site infections, we did not evaluate grade 1 complications

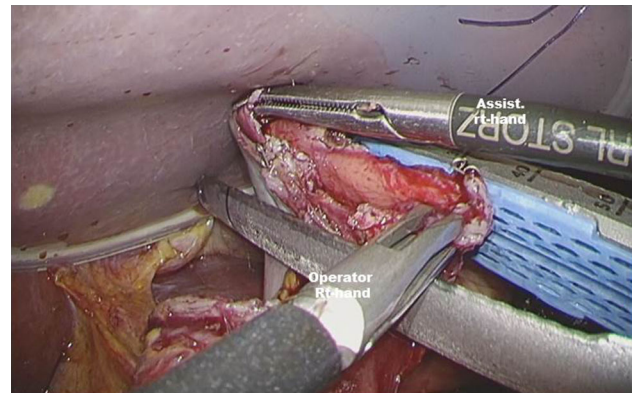


Fig. 2 Stapler was then fired to form a functional end-to-end gastroduodenal anastomosis

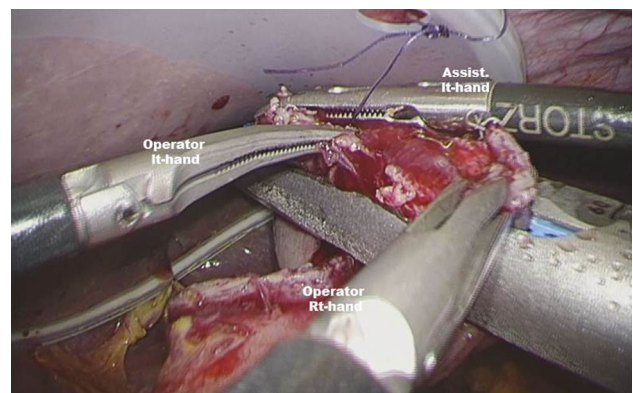
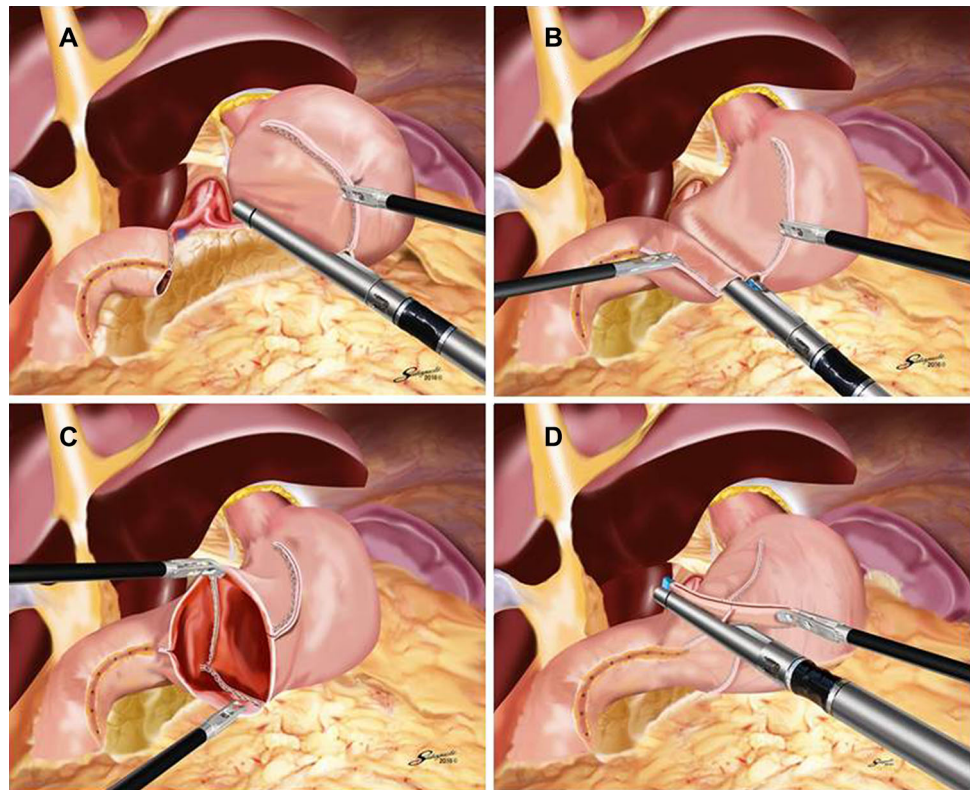


Fig. 3 After checking the anastomosis from the lumen to check for bleeding, common enterotomy was performed vertically using two forceps without placed stay sutures and closed with one firing of the stapler



Fig. 4 Delta-shaped anastomosis was satisfactorily performed using this strategy

Fig. 5 Reconstruction by delta anastomosis



so as to exclude the possibility of description bias in the patient records. Serious complications were defined as complications of grade 3a. Mortality (grade 5) was defined as hospital death due to any cause after surgery.

The results of delta-shaped anastomosis

The present study included 229 gastric cancer patients (male, $n = 149$; female, $n = 80$; and mean age: 64.4 ± 11.2 years) who underwent intraabdominal anastomotic procedures and delta-shaped anastomosis in the surgical oncology department of Gifu University School of Medicine from December 2004 to December 2014.

Concomitant resections of other organs were performed in 5 (2.2 %) cases and consisted of cholecystectomy for gallstones, $n = 3$ (1.3 %); low anterior resection for synchronous rectal cancer, $n = 1$ (0.4 %); and low anterior resection and cholecystectomy for synchronous rectal cancer and gallstones, $n = 1$ (0.4 %). Conversion to open surgery was performed in 1 (0.4 %) patient due to uncontrollable hemorrhage from the gastroduodenal artery.

The final clinical stages of the patients, according to the Union for International Cancer Control (UICC) classification were as follows: stage IA, $n = 174$ (76.0 %); stage IB, $n = 36$ (15.7 %); stage IIA, $n = 11$ (4.8 %); stage IIB, $n = 3$ (1.3 %); stage IIIA, $n = 3$ (1.3 %); stage IIIB, $n = 1$ (0.4 %); and stage IIIC, $n = 1$ (0.4 %). The average median

values for total blood loss and operation time were 20 ml and 277 min, respectively (Table 1). Postoperative complications were detected in 20 (8.7 %) patients. The complications were as follows: anastomotic stenosis, $n = 3$ (1.3 %); anastomotic leakage, $n = 3$ (1.3 %); pancreatic injury, $n = 8$ (3.5 %); anastomotic ulcer, $n = 1$ (0.4 %); bowel obstruction, $n = 1$ (0.4 %); abdominal abscess, $n = 1$ (0.4 %); lymphorrhea, $n = 1$ (0.4 %); cardiac failure, $n = 1$ (0.4 %); and infection, $n = 1$ (0.4 %). The postoperative complications that were detected for each surgical procedure are shown in Table 2. The complications were classified as follows: grade 2, $n = 4$ (1.7 %); grade 3a, $n = 12$ (5.2 %) patients; grade 3b, $n = 4$ patients (1.7 %); and grade 4 and 5, $n = 0$ (0 %) patients (Table 3). There were no significant differences in complications in relation to the clinicopathological features or operative procedures.

Discussion

Since Kitano et al. [12] first reported on laparoscopy-assisted distal gastrectomy more than two decades ago, laparoscopic surgery has been increasingly used to treat gastric cancer, especially in East Asian countries such as Japan, Korea, and China [13–15]. In general, LDG can be divided into laparoscopy-assisted and pure laparoscopic techniques. However, intraabdominal anastomosis is

Table 2 Intraoperative and postoperative complications in 229 patients who underwent laparoscopic radical gastrectomy

Complications	Delta anastomosis (<i>n</i> = 229)
Morbidity	
Intraoperative, <i>n</i> (%)	2 (0.9 %)
Bleeding, <i>n</i>	2 (0.9 %)
Organ injury, <i>n</i>	0
Postoperative, <i>n</i> (%)	20 (8.7 %)
Anastomotic leakage, <i>n</i>	3 (1.3 %)
Duodenal stump leakage, <i>n</i>	0
Anastomotic stricture, <i>n</i>	3 (1.3 %)
Anastomotic ulcer, <i>n</i>	1 (0.4 %)
Stasis, <i>n</i>	0
Pancreatic injury, <i>n</i>	8 (3.5 %)
Bleeding, <i>n</i>	0
Bowel obstruction, <i>n</i>	1 (0.4 %)
Abdominal abscess, <i>n</i>	1 (0.4 %)
Wound infection, <i>n</i>	0
Pulmonary infection, <i>n</i>	0
Urinary infection, <i>n</i>	0
Lymphorrhoea	1 (0.4 %)
Cardiac failure	1 (0.4 %)
Renal failure	0
Infection	1 (0.4 %)
Mortality	
Severe sepsis	0

technically difficult under pure laparoscopic techniques. Although some skillful surgeons have presented hand-sewn intraabdominal techniques, the extra-abdominal

approach is now popular for laparoscopic Billroth I gastroduodenostomy, while laparoscopic Roux-Y reconstruction using a circular stapler has also been reported [16, 17]. However, this technique is complicated and an extended incision of approximately 5 cm is required at the upper median area. Anastomosis is often difficult to perform in this narrow and restricted space, especially in obese patients with thick abdominal walls or in patients with a small remnant stomach. In Japan, a method for Billroth I anastomosis after LDG which uses only endoscopic linear staplers was developed by Kanaya et al. [10]; since then, this technique has been widely accepted in other Asian countries. However, the clinical results of this procedure remain to be fully documented. In fact, Noshiro et al. [18] reported that the surgical outcomes after LDG with Kanaya's procedure were associated with technical pitfalls and that postoperative complications around the anastomosis site had occurred in some patients.

In a recent study, we showed LG to have a safe postoperative course and to have oncological benefits. In the present study, to investigate the feasibility and benefits of an intracorporeal anastomosis technique, named delta-shaped anastomosis, we compared our experience of using pure LDG in a consecutive series of patients who were treated at our institution.

We found that the delta-shaped anastomosis (B-I) method was associated with significantly lower rates of anastomotic complications, including leakage, stenosis, and gastric stasis. Postoperative complications were detected in 20 (8.7 %) patients. These complications included anastomotic stenosis, *n* = 3 (1.3 %); anastomotic

Table 3 Details of patients with Clavien–Dindo classification

Complication	Grade 1	Grade 2	Grade 3a	Grade 3b	Grade 4a	Grade 4b	Grade 5
Anastomotic leakage, <i>n</i>			2	1			
Anastomotic stricture, <i>n</i>			3				
Anastomotic ulcer, <i>n</i>		1					
Pancreatic injury, <i>n</i>		1	4				
Bowel obstruction, <i>n</i>			1				
Abdominal abscess, <i>n</i>			1				
Wound infection, <i>n</i>							
Pulmonary infection, <i>n</i>							
Urinary infection, <i>n</i>							
Lymphorrhoea			1				
Cardiac failure		1					
Renal failure							
Infection		1					
Severe sepsis							
Total	0	4	12	4	0	0	0

Severe complications were defined as those graded as $\geq 3a$ 7.0 % ($\geq 3b$ 1.7 %)

leakage, $n = 3$ (1.3 %); and anastomotic ulcer, $n = 1$ (0.4 %). In addition, 2 of the cases of anastomotic leakage involved pancreatic injury.

In the bariatric surgery, Higa et al. [19] reported in 1996s that laparoscopic Roux-en-Y gastric bypass with gastrojejunal anastomosis occurred in 15.3 % (61/400) complication. The laparoscopic surgery can perform minute and correct operations in comparison with the open surgery. Patients seem willing to accept a possible complication rate to avoid the pain and/or problems associated with larger incisions [20].

Noshiro et al. reported the complications of delta-shaped anastomosis occurred in 15 of 71 patients (21.1 %), which is a relatively high incidence of complications. The complications in the study of Noshiro et al. [18] included anastomotic failure and intraabdominal abscess around the anastomosis site before the addition of a secure suture was introduced to reinforce the anastomosis. Similarly, the rate of anastomotic leakage after LADG in the current study (6.8 %) [B-I (7.1 %), R-Y (11.1 %), and B-II (0 %)] was comparable with other studies of LADG, which reported a rate of 7.8 % [B-I (7/87, 8.1 %); R-Y (0/3, 0 %)] reported by Fujiwara et al. [21], and 5.3 % (B-I, 4/76, with no cases of R-Y reconstruction) by Shimizu et al. [5]. In addition, Lee et al. reported good results with anastomotic leakage occurring in 3 of 248 (1.2 %) cases in a LAD + B-I group, 2 of 128 (1.6 %) cases in a LAD + R-Y group, and 5 of 73 (6.8 %) cases in a LADG + EC group [B-I (4/56, 7.1 %); R-Y (1/9, 11.1 %); and B-II (0/8, 0 %)]; however, Lee et al. noted that the rates of pancreatic fistula were 2/73:2.7 % in a LADG group, 12/248:4.8 % in a B-I group with LDG, and 2/128:1.6 % in an R-Y group with LDG [22].

Many retrospective studies have not defined complications. Recently, Dindo et al. [11] proposed a new classification for surgical complications called the Clavien–Dindo classification. Many retrospective studies have not mentioned the Clavien–Dindo classifications. We used the Clavien–Dindo classifications when we reported LG to have a safe postoperative course.

We suspect that many of these studies have not used the classification scheme because grade 1 complications require no treatment. In a prospective study, Jeong et al. [23] defined complications based on the identification of abnormalities on radiological imaging studies that were performed when a complication was clinically suspected, which should mean complications of grade >2 according to the Clavien–Dindo classification system. In the present study, we reported on the severity of postoperative complications after LG, with the rate of severe complications of grade 3a being 7.0 % and that of grade 3b being 1.7 %.

In our institution, we employ an endoscopic surgical skill qualification system: Five surgeons are recognized by

the Japan Society for Endoscopic Surgery as being qualified to perform endoscopic surgery (three stomach surgeons and two colorectal surgeons). It is very rare to have five qualified surgeons in a single institution. Based on this fact, we are of the opinion that it can be objectively stated that our institution is able to safely perform high-quality endoscopic surgery procedures [24–26]. At present, endoscopic surgery is undergoing a great deal of innovation as it transitions from a pioneering period to becoming standard practice. At our institution, the skills of our surgeons have been standardized and we aim to educate young surgeons. At present, intracorporeal anastomosis is performed in many institutions. However, with the exception of the original evaluation of Kanaya's procedure, there are few reports on the topic of intracorporeal anastomosis. It would be significant to evaluate the safety and feasibility of Kanaya's procedure at other institutions.

The present study, in which we examined the postoperative course of delta-shaped anastomosis with LDG showed that it was a safe and feasible procedure. The laparoscopic surgery can perform minute and correct operations in comparison with the open surgery. Therefore, we think that the laparoscopic surgery is good at oncological. A discussion is necessary about the short-term safety and feasibility of intracorporeal anastomosis. In addition, a discussion is necessary about the long-term oncologic outcome of intracorporeal anastomosis.

We expect the results from a future study to expand the evaluation of delta-shaped anastomosis with LDG.

Conclusion

In conclusion, we found that delta-shaped anastomosis with LDG followed by mechanical anastomosis to be a safe and feasible procedure that was associated with advantages, including a small wound size, reduced invasiveness, and more effective anastomosis. Although we consider pure LDG to be a useful technique for patients with early gastric cancer, a randomized, multicenter trial is necessary to evaluate the risks and benefits of performing delta-shaped anastomosis with LDG.

Compliance with ethical standards

Disclosures K. Yoshida has received honoraria for lecture from Chugai Pharmaceutical Co., Ltd., Taiho Pharmaceutical Co., Ltd., Takeda Pharmaceutical Co., Ltd., Eli Lilly and Company, Daiichi Sankyo Co., Ltd., Ono Pharmaceutical Co., Ltd., Merck Serono Co., Ltd., Novartis Pharma K.K., Sanofi K.K., and research funding from Ajinomoto Pharmaceutical Co., Ltd., Takeda Pharmaceutical Co., Ltd., Chugai Pharmaceutical Co., Ltd., Daiichi Sankyo Co., Ltd., Taiho Pharmaceutical Co., Ono Pharmaceutical Co., Yakult Honsha Co., Ltd., outside the submitted work. All remaining authors declare that they have no conflict of interest.

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