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ORIGINAL ARTICLE

Technological innovation and clinical application of direct percutaneous computed tomography–guided enterostomy vs other enterostomy techniques

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Abstract

Background: To investigate the technological innovation, safety, operational advantages, and clinical application value of direct percutaneous computed tomography (CT)–guided enterostomy.

Methods: This retrospective study included patients who underwent direct percutaneous CT-guided enterostomy (n = 52), percutaneous endoscopic gastrojejunostomy (PEG-J, n = 39), or laparoscopic jejunostomy (n = 68) at Fujian Provincial Hospital between October 2019 and July 2021. The study indices included stoma surgery success rate, operation time, complication rate, and postoperative pain score. We concurrently analyzed the technological innovation of direct percutaneous CT-guided enterostomy and the changes in body mass index (BMI), serum albumin, prealbumin, and C-reactive protein (CRP) levels and patient-generated subjective global assessment (PG-SGA) scores after patients received 2 months of nutritional support.

Results: Direct percutaneous CT-guided enterostomy had a high success rate (100%) and low postoperative complication rate (5.77%). Compared to laparoscopic jejunostomy, direct percutaneous CT-guided enterostomy had a shorter operation time (36.92 ± 10.60) minutes, lower postoperative pain score (4.06 ± 2.02), lower anesthesia risk, and lower operative cost. The anesthetic risk for direct percutaneous CT-guided enterostomy is lower than that for PEG-J and has wider applications. After 2 months of postoperative nutritional support, patients had increased BMI, serum albumin level, and serum prealbumin level and decreased PG-SGA scores and CRP level with statistically significant differences compared to the preoperative state ($p < 0.05$).

Conclusion: Direct percutaneous CT-guided enterostomy is an important method of establishing an enteral nutrition therapy pathway, especially when endoscopic jejunostomy is not possible. It has a high safety profile and few complications, has unique advantages, and deserves further promotion of its application in clinical practice.

Keywords: Computed tomography; Enteral nutrition; Enterostomy.

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1. INTRODUCTION

Malnutrition is common in hospitalized patients, negatively impacts clinical outcomes, and increases healthcare costs. Providing nutritional support to patients at nutritional risk can reduce infectious complications and shorten the hospital stay without increasing treatment costs.[1–4] Enteral nutrition emulates the normal physiological metabolic processes of the human body, features fewer complications, provides a more comprehensive nutrition supply, and helps maintain the integrity of the intestinal mucosa and barrier function compared to parenteral nutrition. Hence, enteral nutrition should be the preferred choice for patients with normal gastrointestinal function who are unable to eat fully or adequately by mouth.[5–8] When gastrointestinal feeding is not possible owing to poor gastric emptying, gastric outlet obstruction, gastroesophageal reflux, or aspiration, jejunostomy is a reasonable feeding strategy, and it is recommended when long-term (≥4 weeks) feeding is required.[9] Most surgical jejunostomies or small bowel stomas are performed incidentally due to the surgical treatment of the primary disease or complete obstruction of the gastric outlet in cases in which neither the endoscope nor the single-curved catheter can be passed.

Excluding the above cases, nonsurgical stoma techniques are considered for patients who are not undergoing abdominal surgery but require jejunostomy.[9–12] Percutaneous endoscopic gastrojejunostomy (PEG-J) and direct percutaneous endoscopic jejunostomy (DPEJ) are the most commonly used nonsurgical techniques. However, PEG-J often leads to difficulty locating the puncture site after total or subtotal gastrectomy, gastric hernia, anterior gastric wall tumor, postoperative abdominal scarring, and subcutaneous fat hypertrophy, whereas DPEJ has a lower success rate due to peristaltic displacement of the jejunum, difficulty achieving adequate inflation and expansion, and possible obstruction of the anterior bowel or viscera.[9,13,14]

For patients anticipating to undergo jejunostomy, an image-based nonsurgical procedure may be considered in cases of complete obstruction of the oropharynx or esophagus that cannot be passed by the endoscope or concern about mechanical damage from endoscopic insertion after recent oral or pharyngeal surgery.[9,15,16] Compared with the traditional imaging-based nonsurgical jejunostomy method of direct percutaneous radiologic jejunostomy, the direct percutaneous computed tomography (CT)–guided jejunostomy described in this study more clearly demonstrated the anatomical structures and allowed for more accurate localization and greater safety. This study retrospectively analyzed the clinical data of patients who underwent direct percutaneous CT-guided enterostomy and concurrent PEG-J and laparoscopic jejunostomy in our hospital to compare the safety, clinical feasibility, points of technological innovation, and surgical advantages of this technique with those of other enterostomy techniques.

2. METHODS

This study was approved by the ethics committee. Written informed consent was obtained from all patients undergoing enterostomy.

2.1. General information

Clinical data were retrospectively collected from patients who underwent enterostomy at the hospital between October 2019 and July 2021. Those who met all of the following criteria were included: a nutrition risk screening (NRS) 2002 score ≥3, nutritional risk, inability to eat by mouth for 5 to 7 days, inadequate intake by mouth for >7 days, and presence of poor gastric emptying, gastric outlet obstruction, gastroesophageal reflux, or high risk of aspiration.

2.2. Direct percutaneous CT-guided enterostomy

For preoperative preparation, routine tests such as electrocardiography and coagulation function tests were completed. The patients were then instructed to fast for 8 hours, stop warfarin 5 days before surgery, switch to subcutaneous injection of low-molecular-weight heparin, and stop low-molecular-weight heparin on the day of surgery. An intramuscular injection of anisodine 10 mg and drotaverine hydrochloride 10 or 40 mg was administered 10 minutes before surgery to inhibit gastrointestinal motility, routine intraoperative monitoring of electrocardiography and oxygen saturation, and a single-curved catheter (Johnson & Johnson CORDIS, 451-414H0[4F]) was placed nasally to the upper jejunum under preoperative X-ray guidance (Fig. 1), connected to a three-way tube device, and filled with approximately 500 to 1000 mL of gas.

2.3. Operative procedure

Axial scanning of the upper and middle abdomen was performed using spiral CT, and the upper segment of the jejunum, which was significantly dilated and closest to the abdominal wall, was selected as a suitable puncture site. The needle was punctured 1 cm from the puncture site using the fixator from a Percutaneous Gastrostomy Kit (Create Medic, Fukuoka, Japan) (Fig. 2). A sterile nylon thread was introduced, gently lifted, and knotted separately to affix the small bowel wall to

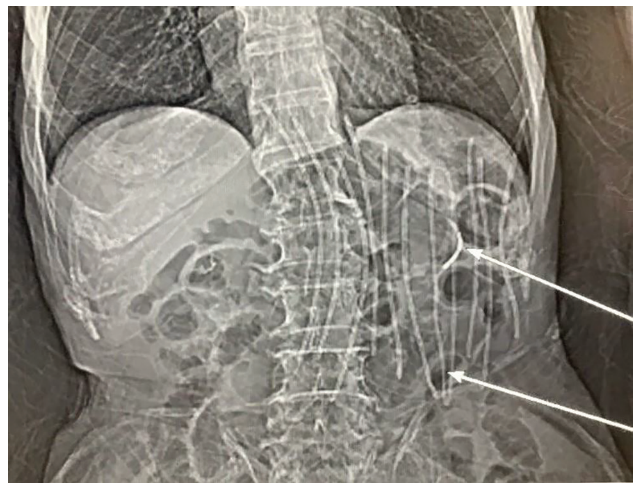

Fig. 1 X-ray–guided transnasal placement of a single-curved catheter.

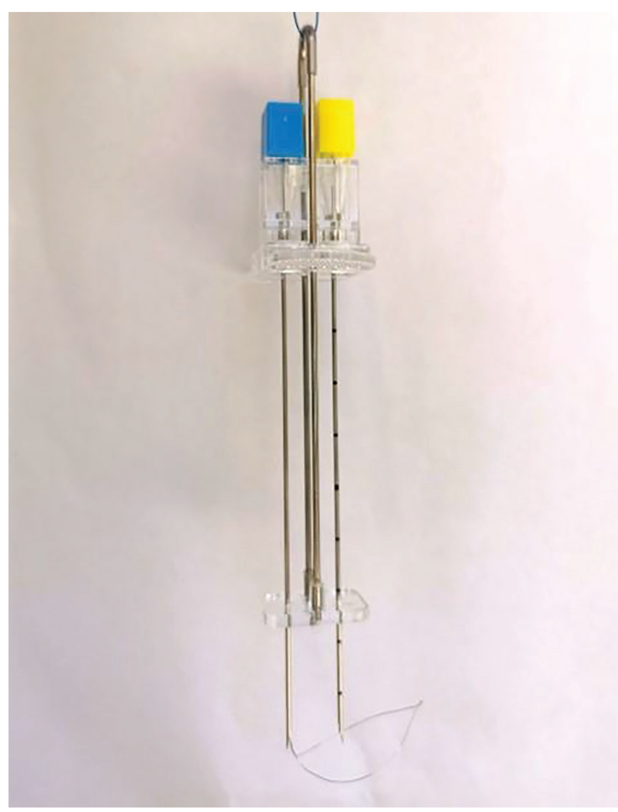

Fig. 2 Fixator (Create Medic, Fukuoka, Japan).

the abdominal wall. In the middle of the two fixation points, we reapplied 10 mL of 2% lidocaine and punctured the needle with a micro-puncture kit 21G CHIBA needle (Argon Medical Devices Inc., TX, USA) using the Seldinger technique. We then introduced a fine guidewire after gas emerged from the retraction. After the CT scan confirmed that the guidewire was in the jejunal cavity (Fig. 3), the passage was dilated step by step with different types of dilators (6F, 10F, 12F, 15F; Create Medic) (Fig. 4) and a special stoma tube was placed. Approximately 3 mL of sterile water was injected into the outer port of the balloon and pulled out gradually until resistance was felt. Gauze was spread around the stoma tube after disinfection, followed by fixation with a pressure plate. A diluted contrast agent was injected into the stoma tube and the CT scan was reviewed. The jejunointestinal canal was then visualized to confirm the accurate position of the inner port of the stoma tube and balloon. No extravasation of the contrast agent into the abdominal cavity and no signs of abdominal hemorrhage were observed abdominally or subcutaneously (Fig. 5A, B).

2.4. Percutaneous endoscopic gastrostomy

First the patients were sedated with intravenously administered propofol, then the percutaneous endoscopic gastrostomy (PEG) was performed by an endoscopist and an assistant using a standardized procedure. The gastric cavity was heavily inflated to tighten the gastric wall against the abdominal wall, and the anterior wall of the middle part of the stomach (approximately 2 cm left of the midline of the abdomen under the rib cage) was located. The anterior wall on the side of the greater curvature was located, followed by the placement of a jejunal extension tube (9F Flocare, Nutricia, China) via a PEG tube, clamping, and pushing into the gastric cavity to deliver its anterior end to the jejunum; if necessary, the correct placement position was confirmed by CT scan to avoid organ damage.[17]

2.5. Laparoscopic jejunostomy

After the induction of general anesthesia and tracheal intubation, the patients were placed in the scissor position, and the towels were routinely disinfected and catheterized. An artificial pneumoperitoneum was established, the flexor ligament was examined under lumpectomy, the jejunostomy was poked at a distance of approximately 20 cm from the flexor ligament with an ultrasonic knife, and the jejunum was dissected with a linear cutting closure device. At the distal end of the dissection, an ultrasonic knife incision was made and a jejunostomy tube was placed. The jejunum was removed from the mesenteric side approximately 5 cm from the incision end, and the spacer of the fistula was kept intact in the intestinal lumen. The jejuno-jejunal side was poked with an electric hook 30 cm distal to this incision and 10 cm distal to the flexor ligament, the jejuno-jejunal side was stabilized with a linear cutting closure, the common opening was closed with a linear cutting closure, and the fistula was led from the anterior wall and affixed.

2.6. Postoperative nutritional support plan

After routine postoperative gastrointestinal decompression, cefuroxime 0.75 g was started to prevent infection and peritonitis. Enteral nutritional support was provided through the stoma tube 48 hours after surgery; the feeding rate was gradually increased from 20 mL/h to 100 mL/h, eventually reaching a target caloric intake of 25 to 30 kcal/kg/d and 1 to 1.5 g/ kg/d of protein.

2.7. Observed indices

All information was obtained by review of the patients' medical records, imaging, and follow-up data. Observations included

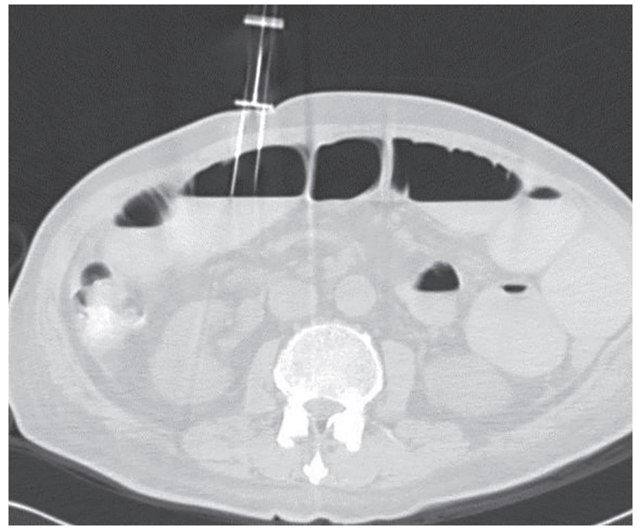

Fig. 3 Computed tomography scan confirmed that the fixator puncture needle was located in the intestinal lumen.

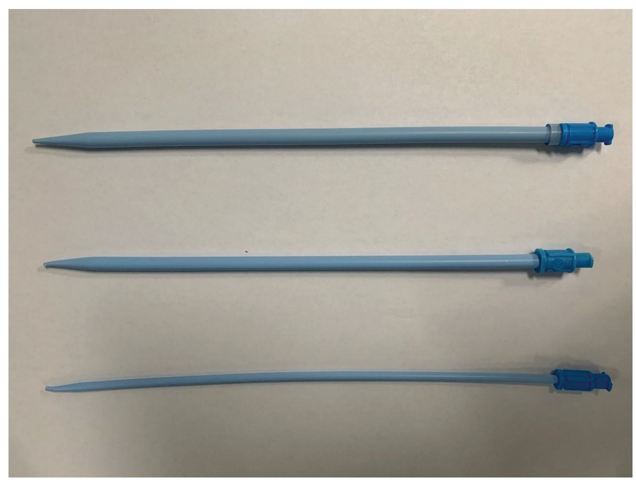

Fig. 4 Dilator (Create Medic, Fukuoka, Japan).

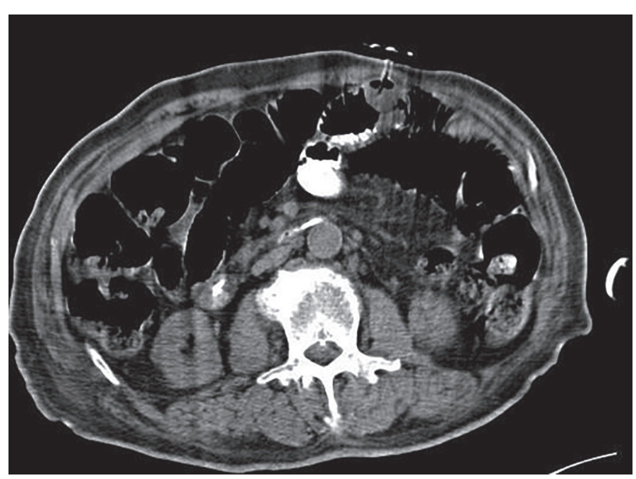

Fig. 5 Computed tomography scan review of the intestinal tube visualization confirming the accurate position of the enterostomy tube and balloon.

anesthetic modality, patient-generated subjective global assessment (PG-SGA) score, stoma surgery success rate, operation time, complication rate, postoperative pain score (visual analog scale [VAS] method), body mass index (BMI), serum albumin, serum prealbumin, and C-reactive protein (CRP) levels. The operation time of direct percutaneous CT-guided enterostomy was defined as the time from the placement of the single-curved catheter from the nasal cavity to the upper jejunum to reconfirmation of the stoma tube in place. The operation time of PEG was defined as the time from the start of sedation until reconfirmation of the stoma tube in place. The operation time for laparoscopic jejunostomy was defined as the time from the start of cutting the skin until reconfirmation of the stoma tube in place.

2.8. Statistical analysis

Microsoft Excel 2007 was used to create the database, and SPSS software (20.0) was used for the statistical analyses. Normally distributed variables are described using $\bar{x} \pm S$; intergroup comparisons were made using analysis of variance, while intragroup pairwise comparisons were made the Student-Newman-Keuls method. Non-normally distributed econometric data are described using median (P25-P75), and intergroup comparisons were made using Wilcoxon's rank-sum test. Count data are described using frequency and composition ratios, and intergroup comparisons were made using the χ^2 test. Differences were considered statistically significant at $p < 0.05$.

3. RESULTS

There were 52 patients in the direct percutaneous CT-guided enterostomy group, 39 in the PEG-J group, and 68 in the laparoscopic jejunostomy group. There were no significant intergroup differences in baseline characteristics such as age, sex, NRS 2002 score, PG-SGA score, BMI, or serum albumin, serum prealbumin, or CRP levels (Table 1) ($p > 0.05$). The success rate of direct percutaneous CT-guided enterostomy and laparoscopic jejunostomy was 100%, whereas that of PEG-J was 97.44% (one case required conversion to laparoscopic jejunostomy). There were no statistically significant intergroup differences in compared data ($p > 0.05$).

The operation time was 36.92 ± 10.60 minutes for direct percutaneous CT-guided enterostomy, 46.53 ± 11.28 minutes for the PEG-J group, and 65.58 ± 11.25 minutes for laparoscopic jejunostomy, with statistically significant data comparison (F = 105.115, $p < 0.01$). Pairwise comparison showed a difference in operation time among the three groups, with patients in the laparoscopic jejunostomy group having a longer operation time than those in the direct percutaneous CT-guided enterostomy and PEG-J groups. The mean VAS scores were 4.06 ± 2.02 points for direct percutaneous CT-guided enterostomy, 3.92 ± 1.95 points for the PEG-J group, and 6.51 ± 1.68 points for patients in the laparoscopic jejunostomy group, with a statistically significant difference (F = 35.31, $p < 0.01$) between the laparoscopic jejunostomy group and the other two groups.

The probability of postoperative complications in the direct percutaneous CT-guided enterostomy group was 5.77%. Stoma leakage occurred in one case and was relieved by adjustment of the stoma tube's position. Two patients experienced mild bleeding from the stoma that was relieved by routine disinfection. The probability of postoperative complications in patients treated with PEG-J was 5.26%. One patient had a skin infection around the stoma tube and another had mild bleeding from the stoma tube; both were relieved by routine disinfection. The probability of postoperative complications in the laparoscopic jejunostomy group was 5.88%. One dislodged jejunostomy tube was replaced under CT guidance. And three had mild bleeding from the stoma that resolved after routine disinfection. However, no serious complications such as liver or intestinal injury or hemorrhage occurred, and the difference in the data was not statistically significant (χ^2 = 9.063, p = 0.170) (Table 2). Direct percutaneous CT-guided enterostomy cases were all completed under local anesthesia only. All patients in the PEG-J group were sedated, and a combination of sedation and general anesthesia in all 68 (100%) in the laparoscopic jejunostomy group. The costs at our hospital were ¥5400 for direct percutaneous CT-guided enterostomy, ¥4800 for PEG-J, and ¥12000 for laparoscopic jejunostomy.

Table 1

Baseline information of the three patient groups

Baseline characteristics	Direct percutaneous CT-guided enterostomy group (n = 52)	PEG-J group (n = 39)	Laparoscopic jejunostomy group (n = 68)	χ^2 or F value	p
Gender, n (%)					
Male	33 (63.5)	26 (66.7)	52 (76.5)	2.467	0.291
Female	19 (36.5)	13 (33.3)	16 (23.5)		
Age, y ± s	63.29 ± 14.04	66.82 ± 16.35	60.63 ± 13.34	2.283	0.105
NRS 2002 score	5.15 ± 0.67	5.24 ± 0.71	5.07 ± 0.76	0.644	0.527
PG-SGA score	13.71 ± 6.73	11.05 ± 7.21	13.31 ± 6.50	1.924	0.149
Type of diagnosis				315.3	<0.001
Head and neck tumor (cases)	1	4	1		
Upper gastrointestinal tumor (cases)	41	6	59		
Lower gastrointestinal tumor (cases)	7	0	0		
Motor neuron disease (cases)	0	6	0		
Pneumonia	0	14	0		
Others	3	9	8		
BMI, kg/m^2	20.12 ± 4.72	18.83 ± 5.70	19.89 ± 3.23	1.020	0.363
Hb, g/L	105.57 ± 22.09	110.78 ± 27.76	119.03 ± 26.03[a]	4.292	0.015
Serum albumin, g/L	32.46 ± 5.96	32.23 ± 7.10	33.19 ± 8.23	0.262	0.770
Serum prealbumin, g/L	138.42 ± 19.61	142.63 ± 22.33	138.11 ± 20.46	0.655	0.521
C-reactive protein	55.35 ± 25.29	52.58 ± 17.01	54.72 ± 34.54	0.113	0.893

BMI = body mass index; CT = computed tomography; Hb = hemoglobin; PEG-J = percutaneous endoscopic gastrojejunostomy; PG-SGA = patient-generated subjective global assessment.

[a] $p < 0.05$ compared with the direct percutaneous CT-guided enterostomy group.

Table 2

Operation time, postoperative complications, and pain indices of the three groups

Postoperative situation	Direct percutaneous CT-guided enterostomy group (n = 52)	PEG-J group (n = 39)	Laparoscopic jejunostomy group (n = 68)	χ^2 or F value	*p*
Operation time	36.92 ± 10.60	46.53 ± 11.28[a]	65.58 ± 11.25[a,b]	105.115	<0.001
VAS score	4.06 ± 2.02	3.92 ± 1.95	6.51 ± 1.68[a,b]	35.31	<0.001
Complications (cases, %)	3 (5.77)	2(5.26)	4(5.88)	9.063	0.170
Tube prolapse	0	0	1		
Stoma leakage	1	0	0		
Bleeding	2	1	3		
Local infection	0	1	0		

CT = computed tomography; PEG-J = percutaneous endoscopic gastrojejunostomy; VAS = visual analog scale.
[a] $p < 0.05$ compared with the direct percutaneous CT-guided enterostomy group.
[b] $p < 0.05$ compared with the PEG-J group.

After 2 months of direct percutaneous CT-guided enterostomy with nutritional support, the patients' mean BMI, serum albumin level, and serum prealbumin level increased and the mean PG-SGA score and CRP level decreased, and the differences were significantly different from those before surgery ($p < 0.05$) (Table 3).

4. DISCUSSION

This study compared direct percutaneous CT-guided enterostomy with PEG-J and laparoscopic enterostomy to analyze their advantages in clinical use. We found that direct percutaneous CT-guided enterostomy had a high success rate and safety profile without serious complications. We proved that its advantages compared with PEG-J are as follows: it clearly displays the relationship between anatomical structures and avoids organ puncture injuries; residual stomach after major gastrectomy, and interstitial colon are contraindications for endoscopic jejunostomy but not direct percutaneous CT-guided enterostomy; and it can be performed under local anesthesia with a low risk of anesthetic sedation. Compared with laparoscopic enterostomy, direct percutaneous CT-guided enterostomy has the following advantages: it can be performed under local anesthesia, and it features a short operation time, low risk of anesthesia, less invasiveness, low postoperative pain score, high patient tolerance, and low cost.

To avoid organ needle injuries, the direct percutaneous CT-guided enterostomy procedure described in this study uses a dilator with blunt grade-by-stage separation and dilation followed by stoma tube placement, which is safer than the sharp separation with a peelable trocar needle previously reported in the literature.[18] This study retrospectively analyzed 52 patients who underwent direct percutaneous CT-guided enterostomy versus those who underwent PEG-J and laparoscopic enterostomy simultaneously and evaluated the patients' postoperative nutritional status. This finding suggests that appropriate postoperative nutritional support can significantly improve patients' nutritional status. Clinical studies that prove the same are warranted.

However, our study had several limitations. First, the number of patients in the PEG-J group was small. Second, direct percutaneous CT-guided enterostomy involved some radiation exposure compared to PEG-J and laparoscopic enterostomy, the dose of which received by each patient was not recorded in detail. Third, PEG-J cannot be performed if the endoscope cannot pass through the upper gastrointestinal tract and the CT-guided enterostomy cannot be performed if the single-curved catheter cannot pass through the upper gastrointestinal tract. Fourth, the follow-up time was up to 2 months after surgery, and long-term complications such as stoma tube dehiscence rate, aspiration pneumonia, and morbidity and mortality rates could not be estimated.

Although the number of cases in this study increased significantly compared to previous case studies, more prospective studies are needed in the future to validate its widespread clinical applications, and attention should be paid to issues related to the standardization of operating procedures for specialists and the development and production of standard enterostomy kits.

In conclusion, direct percutaneous CT-guided enterostomy successfully establishes enteral nutrition therapy access for patients with a high safety profile and few complications. It also has unique advantages and should be the treatment of choice in clinical practice when endoscopic jejunostomy is not possible.

Table 3

Changes in nutritional indices before versus after computed tomography–guided placement (mean ± SD)

	Preoperative	2 mo postoperative	*t*	*p*
BMI, kg/m^2	20.12 ± 4.73	21.68 ± 3.30	7.56	<0.001
PG-SGA	13.71 ± 6.73	10.65 ± 5.64	–13.87	<0.001
Hb, g/L	105.57 ± 22.09	123.62 ± 18.58	15.48	<0.001
Serum albumin, g/L	32.46 ± 5.96	39.14 ± 8.43	9.58	<0.001
Serum prealbumin, g/L	138.42 ± 19.61	184.50 ± 32.93	15.21	<0.001
C-reactive protein	54.70 ± 25.51	35.99 ± 25.79	–12.83	<0.001

BMI = body mass index; Hb = hemoglobin; PG-SGA = patient-generated subjective global assessment.

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