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A comparative analysis of transhepatic cardia-gastric fundus puncture vs. gastric body puncture for insufflation for CT-guided percutaneous gastrostomy

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Abstract

Objectives To evaluate the safety and efficacy of transhepatic cardia-gastric fundus puncture (TCFP) for insufflation for CT-guided percutaneous gastrostomy (CPG).

Methods The clinical data of 38 patients who underwent TCFP for insufflation and 161 patients who underwent percutaneous gastric body for insufflation at a single center were retrospectively analyzed. The operative time, success rate, complication rate, overall procedure time, and incidence of complications within 3 months were collected.

Results The success rate of insufflation was 100%, and no serious complications occurred during percutaneous gastric insufflation. The average time for insufflation via TCFP was 9.60 ± 6.62 min, and that via gastric body puncture was 8.71 ± 71.8 min, with no significant difference between the two ($p = 0.485$). The overall duration of gastrostomy in the TCFP group was 32.16 ± 10.27 min and 33.94 ± 13.82 min in the gastric body group, with no significant difference ($p = 0.456$). The incidence of submucosal air spread was 0% in the TCFP group and 9.9% in the gastric body group, with significant difference ($p = 0.045$). The complication rates following insufflation via TCFP and via gastric body puncture were 18.4% and 21.7%, respectively, with no significant difference between the two groups (p = 0.652). The perioperative pain score was 2 after insufflation via TCFP and via gastric body puncture, with no significant difference ($p = 0.119$). The overall mortality rate was 0 in the first postoperative month, with a 3-month mortality rate of 5% (10/199). The surviving patients showed a significant increase in weight from 51.81 ± 8.52 kg to 52.52 ± 9.39 kg at 3 months postoperatively ($p = 0.009$).

Conclusions TCFP for insufflation is safe and effective, with a 100% success rate and no increased risk of complications. The choice of procedure should be based on the patient's specific condition and the physician's experience.

Keywords Gastrostomy, CT guided, Cardia-gastric fundus

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Introduction

Gastrostomy surgery allows the creation of an excellent nutritional supplement pathway for patients suffering from oropharyngeal or esophageal diseases who cannot eat via normal means. Currently, there are three main types of gastrostomy surgery: traditional surgical gastrostomy, percutaneous endoscopic gastrostomy, and percutaneous radiology gastrostomy (PRG), the latter including CT-guided percutaneous gastrostomy (CPG). Apart from traditional surgical gastrostomy, all other gastrostomies require gastric insufflation prior to surgery. Gastric insufflation is most commonly performed via a nasogastric or orogastric tube [1–3]. However, patients who are unable or unwilling to undergo gastric insufflation via these tubes must undergo percutaneous fine needle puncture of the gastric cavity.

At present, the main percutaneous puncture methods for gastric insufflation are percutaneous fine needle puncture of the gastric cavity or catheter insertion after successful fine needle puncture under CT or ultrasound guidance, both boasting a success rate of 100%[2, 4–6]. These puncture methods for insufflation do not involve high-risk organs, such as the liver and intestines, thereby averting related complications. However, there are reports of transhepatic puncture for insufflation of the gastric cavity [7].

In clinical practice, we sometimes encounter patients with small amounts of gastric fluid, remarkable gastric cavity mobility, and good gastric compliance. These factors make percutaneous gastric body puncture difficult to a certain extent. To address this difficulty, we choose a relatively fixed area, namely, the transhepatic cardiagastric fundus, for gastric cavity puncture. However, this method may increase the risk of liver bleeding. Therefore, we conducted a retrospective analysis of this method to understand its safety and effectiveness with the aim of recommending it as an alternative percutaneous gastric cavity insufflation method for patients who are prone to difficulties associated with gastric body puncture.

Patients and methods

Patients

A total of 226 patients who underwent CPG between January 2019 and January 2023 were included in the study. Among them, 27 patients were excluded, because they did not undergo gastric insufflation but rather proceeded directly to gastrostomy. Ultimately, 199 patients who were unable or unwilling to undergo gastric insufflation via nasogastric or orogastric tubes were included for analysis. All patients provided informed consent prior to the surgery. Because the study was retrospective and patient data were anonymized, the IRB waived the requirement for informed consent for participation. There were no patients lost to follow-up among those included in the analysis.

Of the included patients (Table 1), 163 were male and 36 were female, with a mean age of 65.56 ± 10.62 years. The patient population consisted of 156 patients with esophageal tumors, 17 patients with head and neck tumors, 5 patients with esophagobronchial fistula, 10 patients with amyotrophic lateral sclerosis, 7 patients with lung cancer and esophageal obstruction, 2 patients with swallowing dysfunction after cerebral infarction, and 1 patient each with esophageal chemical burn and dysphagia due to severe traumatic brain injury.

Preoperative evaluation and equipment

Before the procedure, several critical evaluations should be conducted, including electrocardiography and determination of the platelet count ($\geq 50 \times 109$/L), international normalized ratio (INR, corrected to 0.8–1.6), and activated partial thromboplastin time (APTT, must not exceed the normal limit by more than onefold). Electrocardiography should show no evidence of acute

Table 1 Clinical Data, Surgical Results, and Complications in CPG Patients

	TCFP	Gastric body	*p*
Sex			0.682
Male	32	131	
Female	6	30	
Age	67.42 ± 9.94	65.12 ± 10.76	0.232
Clinical Diagnoses			0.478
Esophageal Tumor	31	125	
HNT	2	15	
Esophagobronchial Fistula	1	4	
ALS	1	9	
LCEO	2	5	
ECB	1	0	
Cerebral Infarction	0	2	
STBI	0	1	
Gastric insufflation time	9.60 ± 6.62	8.71 ± 7.18	0.485
CPG time	32.16 ± 10.27	33.94 ± 13.82	0.456
NRS	2(IQR:1,5)	2(IQR:1,3)	0.119
Perioperative complications			0.652
Yes	7	35	
No	31	126	
Submucosal air spread			0.045
Yes	0	16	
No	38	145	

CPG: CT-guided percutaneous gastrostomy;HNT: Head and neck tumor;ALS: Amyotrophic lateral sclerosis;LCEO: Lung cancer with esophageal obstruction;ECB: Esophageal chemical burn;STBI: Severe traumatic brain injury;IQR:Interquartile Range

myocardial ischemia. All anticoagulant and antiplatelet medication therapies should be suspended before the surgery, and heparin bridging therapy should be adjusted according to the patient's medication profile. Heparin was discontinued 24 h prior to surgery.

An enhanced CT scan was performed preoperatively to examine the gastrostomy area for vascular abnormalities, such as varices. A UCT510 (United Imaging Healthcare Co., Ltd, China) system was employed for CPG, with the following scanning parameters: tube voltage, 120 kV; tube current, 200 mA; and slice thickness, 1.5–5 mm. Multiplanar reconstruction (MPR) was carried out based on the patients' intraoperative conditions.

Before surgery, sedation and analgesia were induced through injections of 0.1 g of sodium phenobarbital (Min Dong Li-jie-Xun Pharmaceutical Co., Ltd., China) and 0.1 g of pentazocine (Northeast Pharmaceutical Group Shenyang First Pharmaceutical Co., Ltd., China), respectively. Local anesthesia was induced using 0.1 g of lidocaine hydrochloride (Tian-sheng Pharmaceutical Co., Ltd., China). The surgical area was disinfected with povidone–iodine solution (Hua-tian Technology Industrial Co., Ltd., China). The procedure should be performed by experienced physicians who are skilled in interventional diagnosis and treatment under CT guidance.

Principles for gastric insufflation

The principles for selecting the puncture site for percutaneous gastric insufflation are as follows: 1) gastric insufflation via oral or nasogastric tubes remains the safest and most convenient method. If the patients is unable or unwilling to undergo gastric insufflation via these tubes, percutaneous puncture and insufflation of the gastric cavity can be considered. 2) Select the puncture site in the gastric body region to avoid causing injury to high-risk organs, such as the liver and intestines, as well as overlap with the stoma site. 3) If there was liver or intestinal obstruction during percutaneous gastric body puncture or difficulty accessing the gastric cavity, insufflation via the TCFP was considered (Fig. 1). 4) Be cautious when designing the transhepatic puncture pathway to avoid damaging hepatic blood vessels or areas with vascular lesions. Patients with esophageal varices should not undergo gastric insufflation via TCFP. 5) Before TCFP, ensure the absence of tumor lesions in the liver pathway area to prevent injury or tumor spread. 6) Avoid transhepatic puncture in patients with severe coagulation disorders to minimize excessive bleeding. 7) Patients with severe liver diseases, such as cirrhosis or liver failure, have an increased risk of bleeding during liver puncture and should not undergo TCFP. 8) Patients with severe cardiovascular diseases, such as heart failure or unstable arrhythmias, may have an increased risk of cardiovascular events during TCFP. 9) TCFP should not be performed in patients with abdominal or abdominal wall infections or trauma to prevent the spread of infection. 10) Respect the patient's wishes if they refuse to undergo TCFP after being fully informed about the risks and benefits. Explore alternative methods to achieve the treatment goal.

Gastric insufflation process

The percutaneous gastric insufflation procedure involves the utilization of an 18G soft tissue puncture needle (Argon Medical Devices, Inc.) and a 22G single-use sterile injection needle (Zhejiang Concorde Medical Equipment Co., Ltd.).

Confirmation of successful entry into the gastric cavity with the puncture needle can be ascertained through the following indicators: (1) aspiration of gastric fluid upon needle withdrawal; (2) introduction of 3–10 ml of gas to evaluate the puncture needle's position within the gastric cavity; and (3) after achieving access, a continuous inflow of 300–500 ml of air is administered, with adjustments made to the depth of the puncture needle to mitigate inadvertent dislodgement resulting from gastric cavity distension.

Following the completion of the insufflation process, a CT scan can be performed to evaluate the relationship between the gastric wall and abdominal wall. Then, once the stoma has been created, the puncture needle used for gastric insufflation is removed.

Gastrostomy

After insufflation, a 20 G gastric wall fixator was inserted into the gastric cavity. CT was used to confirm the correct placement of the puncture needles for both wire holding and wire insertion. The stainless-steel ring of the former was opened to grasp the nylon thread inserted from the latter. Upon successful grasping, the fixator was removed, and the thread was tied to fix the gastric wall. This was repeated 1–2 cm away from the initial fixation point. After fixation, CT was used to ensure proper fixation and gas filling. A 16 Fr support sheath was then used for fistula creation, and a 15 Fr gastric catheter was inserted through the opening. The distal end of the balloon was filled with 3 ml of sterile distilled water, and then the catheter was withdrawn; however, any resistance prompts verification of the balloon position under CT.

Post-gastrostomy

Following the removal of the gastric puncture needle and completion of the CPG procedure, a postprocedural CT scan was conducted to assess the presence of bleeding or other complications near the liver, cardia-gastric fundus region, and abdominal cavity.

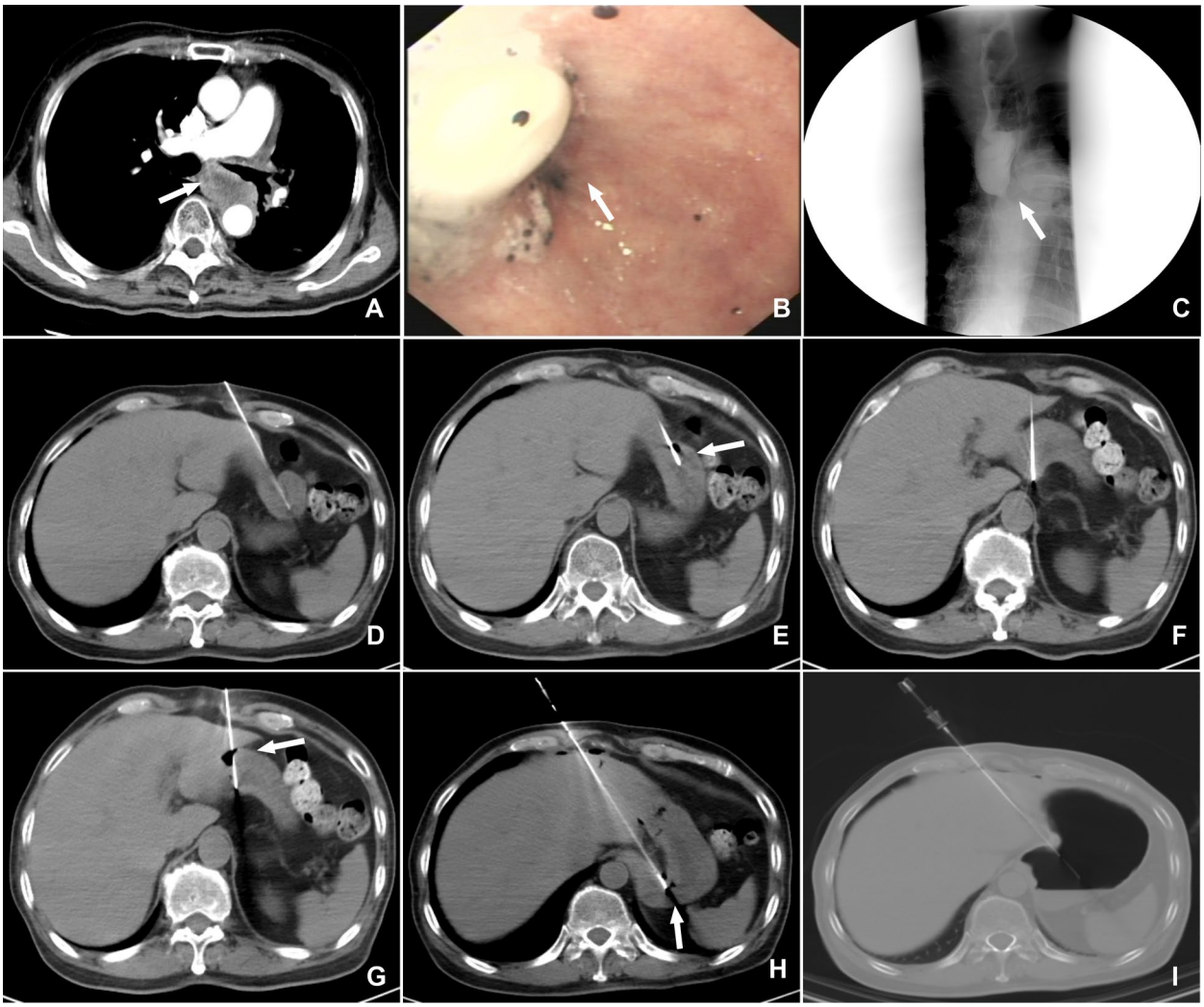

Fig. 1 A 71-year-old male patient diagnosed with esophageal cancer. CT, endoscopic, and esophagogram examinations revealed complete obstruction of the esophageal lumen due to esophageal tumor (**A, B, C**). The first attempt to perform transpercutaneous gastric puncture (**D**) and inject a small amount of gas failed to access the stomach (**E**). Subsequent attempts at the same puncture site using the same method also failed to gain access to the stomach (**F**). Finally, transgastric–gastroesophageal puncture, bypassing the liver, was successfully performed to access the stomach and inflate it with gas

Follow-up

In this study, the follow-up period was set at 3 months after the fistula creation procedure, during which trained nurses provided care for the fistula site. Standardized enteral feeding began 24 h after CPG. After discharge, trained nurses monitored the patients continuously and guided their families in administering home care through a video communication platform, including the replacement of accessories, cleaning of the fistula site, and routine maintenance of the gastric fistula catheter. Any symptoms, signs, and catheter-related complications that occurred during the follow-up process were documented accurately.

Definition

Perioperative period: this period includes the preoperative, intraoperative, and postoperative phases until the patient is discharged. Perioperative numerical rating scale (NRS) score: the highest score recorded after CPG. Perioperative complications: these are assessed by the surgeon and promptly entered into the database by trained nursing staff, including intra-abdominal gas, peritoneal reaction, and bleeding. Inflation time: the time from the first imaging scan to the completion of insufflation during CT scanning. Surgical time: the time difference between the first imaging scan and the last imaging scan after surgery, including the insufflation time.

Statistical analysis

All data are described as the mean ± standard deviation for continuous variables and numerical values (percentages) for categorical variables. Data were subjected to univariate analysis using *t* tests or one-way ANOVA for continuous variables and Pearson's $\chi 2$ test, likelihood ratio, or Fisher's exact test for categorical variables for comparison. All reported *P* values are two-sided and have not been adjusted for multiple testing, and $P < 0.05$ was considered indicative of a statistically significant difference. Statistical analysis was performed using SPSS Statistics (version 26, IBM).

Results

This study included 163 male patients and 36 female patients, with an average age of 65.56 ± 10.62 years. Among them, 38 patients underwent TCFP for gastric insufflation, and 161 patients underwent percutaneous gastric body puncture for gastric insufflation. The success rate of gastric insufflation was 100% for both methods. The incidence of submucosal gas diffusion due to TCFP was 0% (0/38) and 9.9% (16/161) for gastric body puncture, with no significant difference between the two ($p = 0.045$). The average time for TCFP puncture and gastric body puncture for gastric insufflation was 9.60 ± 6.62 min and 8.71 ± 71.8 min, respectively, with no significant difference between them ($t = 0.700$, $p = 0.485$). The overall duration of the gastric fistula surgery was 32.16 ± 10.27 min and 33.94 ± 13.82 min, respectively, with no significant difference between them ($t = -0.746$, $p = 0.456$).

No signs of bleeding or infection were observed after TCFP or gastric body puncture for gastric insufflation. The incidences of perioperative complications (including pneumoperitoneum and minor bleeding) after CPG with insufflation via TCFP and gastric body puncture were 18.4% and 21.7%, respectively, with no significant difference between them ($Z = 0.203$, $p = 0.652$). The NRS scores during the perioperative period of gastric fistula surgery after insufflation via TCFP and gastric body puncture were 2 (IQR: 1, 5) and 2 (IQR: 1, 3), respectively, with no significant difference between them ($Z = -1.559$, $p = 0.119$).

There were no cases of mortality associated with puncture for gastric insufflation or after CPG in either region in this study. The overall mortality rate within 1 month after surgery was 0%. At 3 months postoperatively, the overall mortality rate was 5% (10/199). The weight of the surviving patients increased from 51.81 ± 8.52 kg to 52.52 ± 9.39 kg, with a significant difference ($t = -2.637$, $p = 0.009$).

Discussion

Effective gastric insufflation is crucial for the success of PRG. Typically, gastric insufflation is performed using nasogastric or orogastric tubes. However, in certain situations, patients may be unwilling or unable to undergo gastric insufflation through these tubes, or the insertion procedure may be unsuccessful. As a result, an alternative method of percutaneous puncture of the gastric cavity for insufflation has been proven to be feasible [8, 9], including techniques, such as the single-needle approach, Seldinger technique, and central venous catheterization [5, 8, 10]. The most notable feature of these methods is the accurate placement of a fine needle into the gastric cavity. Although reports suggest a 100% success rate for these methods, research on the puncture site for gastric insufflation remains limited [3, 5–9, 11].

The findings of this study suggest that there is no significant difference between the two gastric insufflation techniques in terms of surgical success rate and occurrence of complications. Although there is limited research literature on transhepatic gastric puncture for insufflation, it has been found to be feasible in specific special cases [9]. Due to the influence of gastroesophageal traction, the transhepatic puncture allows for smoother insertion of the needle into the gastric cavity. Therefore, patients who are suitable for TCFP will be selected based on predefined criteria. However, insufflation via transhepatic puncture is prolonged, possibly because the transhepatic puncture procedure requires a more careful approach. In addition, the insufflation time does not fully reflect the advantage of TCFP or gastric cavity puncture, but it is worth noting that the success rate of gastric insufflation for all puncture methods was 100%.

Although theoretically, there may be complications with TCFP, we did not observe any cases of intra-abdominal hemorrhage in this study. In patients, where gastric fluid could not be aspirated, we injected a small amount of gas to determine whether the puncture needle had entered the stomach. This may cause submucosal gas spread. However, the incidence of submucosal gas spread in this study was significantly lower than that reported in the study by Petsas et al. [7], and such minor complications are not clinically significant and do not affect the overall gastrotomy process. Notably, the submucosal gas spread rate for TCFP is significantly lower than that for gastric body puncture. However, regardless of the region for insufflation, the complication rate of CPG is similar, and good clinical results can be achieved.

Furthermore, regardless of the chosen method for insufflation for CPG, there was no report of patient mortality due to any particular method, which is consistent with the reported results in many studies [2–6, 8–10, 12–14]. For this patient population, it is crucial to approach

each surgery from multiple perspectives to ensure successful outcomes, as this is their most important energy supply pathway. This study provides new evidence for CPG, demonstrating the safety of TCFP for gastric insufflation.

Limitations

This study presents a retrospective data analysis, but there are some inherent design flaws that should be acknowledged. First, there was no prospective, randomization of gastric body puncture and TCFP in this study. Second, due to the retrospective nature of the study, the assessment of puncture time for the stomach is inaccurate. Moreover, including the insufflation time in the evaluation might affect the accuracy of the TCFP time assessment. Third, it is worth noting that sterile gas was not used for gastric insufflation, thus potentially increasing the risk of infection. Last, the study did not analyze the radiation doses received by patients. These limitations and deficiencies are important factors to consider, as they may influence the interpretation and application of the results. Future research should aim to address these limitations to enhance the accuracy and reliability of the study results.

Conclusion

TCFP for insufflation is a safe and efficacious therapeutic approach, featuring a 100% success rate. When encountering challenges in gastric body puncture for insufflation, this technique can serve as a viable alternative. To ensure optimal therapeutic outcomes, the decision to employ this method should be based on a comprehensive assessment of the patient's individual circumstances and the physician's expertise.

Competing interests

The authors declare no competing interests.

Author contributions

HC: substantial contributions to conception and design, analysis and interpretation of data. HC, QXM, HCM, LL, LQH: drafting the article or revis- ing it critically for important intellectual content. HCM, QXM, LL, LQH, XJR, LLS, DLY, TGY,HXQ: approval of the version to be published and all subsequent versions.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

This study received approval from the Institutional Review Board of the First Affiliated Hospital of Army Medical University (IRB: BIIT2024011). All procedures adhered to the ethical guidelines of the Declaration of Helsinki.

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