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Original Article

Radiological gastrostomy: A comparative analysis of different image-guided methods

Hong-Tao Hu, Hang Yuan, Chen-Yang Guo, Quan-Jun Yao, Xiang Geng, Hong-Tao Cheng, Jun-Li Ma, Yan Zhao, Li Jiang, Yu-Qing Zhao, and Hai-Liang Li*

A B S T R A C T

Background: Radiographic guided percutaneous gastrostomy has become a safe and effective enteral nutrition method for patients who can not eat by mouth. Fluoroscopy, computed tomography (CT) and cone-beam CT have been routinely used clinically. The aim of this study was to compare the advantages and disadvantages of percutaneous gastrostomy using different radiographic guided methods.

Methods: We retrospectively analyzed the clinical data of 538 patients undergoing percutaneous gastrostomy in our department. According to the image guidance method used in gastrostomy, the patients were divided into groups A by fluoroscopy guidance, group B by fluoroscopy combined with C-arm CT guidance, and group C with the whole process CT guidance. The gastrostomy success rate, complication rate, procedure time, and patient radiation dose were analyzed in the three groups.

Results: Among 538 patients, 534 were successful and the success rates are 94.3%, 99.3%, and 100% in group A, B, and C, respectively ($P > 0.05$). There were 3 cases occurred postoperative bleeding as serious adverse events and transferred to surgical gastrostomy. The minor complications include local infection, hyperplasia of granulation tissue, tube obstruction or prolapse, and local pain of the ostomy. The minor complication rates were 10.5%, 10.4%, and 7.7% in group A, B, and C, respectively ($P > 0.05$). The average procedure time was 25.57 ± 5.99 minutes, 29.01 ± 6.63 minutes, and 45.47 ± 8.98 minutes, respectively ($\chi^2 = 87.98$, $P < 0.001$). The average radiation dosage was 27.30 ± 19.27 mGy, 145.07 ± 106.08 mGy, and $2,590.26 \pm 1,088.22$ mGy, respectively ($\chi^2 = 204.44$, $P < 0.001$).

Conclusion: There were no significant differences in the success rates and complication rates of gastrostomy under the three guiding methods. For difficult cases, CT-guided gastrostomy may be a very useful supplemental method.

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Keywords: Complications; Computed tomography; Fluoroscopy; Gastrostomy

Introduction

Since it was first reported by Preshaw¹ in 1981, image-guided percutaneous gastrostomy has become a safe and effective enteral nutrition method, which can improve the nutritional status and quality of life of patients who cannot feed orally. Percutaneous endoscopic gastrostomy (PEG) and percutaneous radiologic gastrostomy (PRG) standard methods and are now more popular for ensuring long-term enteral food intake.^{2–4} Compared with PEG, PRG achieved a higher success rate and a lower complication rate. It can also be used as an alternative when PEG either fails or is not suitable.^{5,6} According to the development of techniques and equipment, other image-guided methods have been used clinically,

such as the computed tomography (CT) and cone-beam CT (CBCT) guidance.^{7,8} All of these three methods, including fluoroscopy, CBCT, and CT, have different advantages and disadvantages. At present, there is no consensus on how to choose the imaging guidance method for gastrostomy.

At our hospital, we managed different types of patients and performed PRG using different guidance methods according to the principle of individualized treatment. Here, we retrospectively analyzed the clinical data of 538 patients who underwent percutaneous gastrostomy under the guidance of fluoroscopy, C-arm CT, and whole process CT guidance. The aim of this study was to compare the success rate and complication rate of PRG using different image-guided methods. To provide possible evidence for a

Department of Minimal-Invasive Intervention, The Affiliated Cancer Hospital of Zhengzhou University, Zhengzhou, China
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* Corresponding author. Department of Minimal-Invasive Intervention, The Affiliated Cancer Hospital of Zhengzhou University, 127 Dongming Road, Zhengzhou, Henan Province 450003, China.

E-mail address: lihailianggy@163.com (H.-L. Li).

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rational clinical choice of image guidance methods. In this study we report two cases of esophagea benignl related esophageal strictures which were successfully treated with balloon dilation.

Methods

Clinical data

We conducted this study in accordance with the principles of the Declaration of Helsinki. The protocol of this study has been reviewed and approved by the Ethics Committee of Henan Cancer Hospital (IRB number: 2020-262-002). Informed consent has been obtained. A total of 538 patients, including 432 males and 106 females, underwent PRG in the Intervention Department of our hospital from January 2010 to December 2019, and their data were extracted from the Electronic Medical Record System, there was no patient attempted PEG before PRG. The ages of the patients ranged from 29 to 91 years, with a mean age of 64.39 ± 11.26 years. Among them, 391 had esophageal cancer, 54 had lung cancer, 58 had oropharyngeal malignant tumors, 25 had amyotrophic lateral sclerosis, 8 had thyroid cancer, and 2 had tracheal cancer. All patients were diagnosed using histopathology, and clinical examination, all patients had symptoms of dysphagia and various degrees of malnutrition. Barium upper gastrointestinal (GI) series or esophagogram showed severe pharyngeal stenosis, esophageal stricture esophagotracheal (mediastinal) fistula, or swallowing dysfunction. Based on the image guidance method used in gastrostomy, the patients were divided into three groups: group A was the fluoroscopy guidance group, group B was the fluoroscopy combined with the CBCT guidance group, and group C was the whole-process CT guidance group.

Imaging equipment and procedure equipment

(1) Germany Siemens Artis Zeego angiography machine (Siemens, Berlin, Germany); (2) American GE 16-slice CT machine (General Electric, Schenectady, NY, USA); (3) Terumo 5 Fr single-curved catheter and loach guide wire (Terumo, Tokyo, Japan); (4) Crucian gastrostomy kit, including 15 Fr gastrostomy tube, puncture stomach needle, T-shaped support sleeve, crucian-type gastric wall fixation device and lead guide, etc.; and (5) contrast agent (Fig. 1).

Procedure

Preoperative preparation

Routine blood tests, liver and kidney function tests, coagulation function test, electrocardiogram, barium upper GI series or esophagogram, upper abdominal CT, and other examinations were performed before gastrostomy. Twelve hours before the gastrostomy procedure, all patients were taken neither food nor water. For patients who were going to directly undergo PRG, a catheter was inserted into the stomach a day before the operation and 40 to 60 mL of a contrast agent was injected to visualize the colon. All patients underwent anisodamine choline and hemostatic intramuscular injection half an hour before the gastrostomy procedure.

Radiologic gastrostomy procedure

All procedures were performed by two experienced interventional radiologists with more than five years of experience. The patients lay supine and underwent topical anesthesia of the pharynx with 1% lidocaine.⁹ A 0.035-inch exchange guidewire (Terumo) and a 100-cm 5-Fr Cobra catheter (Terumo) were used

Fig. 1. Flow chart of gastrostomy.

Table 1 Comparison of Technical Success Rate among the Three Groups

Group	Success cases (n)	Failing cases (n)	Total (n)	Success rate (%)	χ^2	P
Group A	200	12	212	94.3 (200/212)	1.015	0.314
Group B	296	2	298 + 8	99.3 (304/306)	0.171	0.679
Group C	24	0	24 + 2	100 (26/26)	1.55	0.213

to catheterize the gastric cavity through the nose or mouth under fluoroscopic guidance. Approximately 5 to 10 mL of water-soluble contrast medium and 800 to 1,200 mL of air was then injected through the catheter to confirm and insufflate the gastric cavity. Under anteroposterior and lateral fluoroscopy of the abdomen, the tip of the catheter was located in an air-filled gastric cavity as a target in a section that was sufficiently close to the anterior abdominal wall. The gastric lumen was punctured with a gastropexy device with two needles inserted vertically into the gastric cavity. The position of the needle within the gastric lumen was confirmed fluoroscopically by injecting a small amount of water-soluble contrast medium through the needle. Next, the blue handle was advanced to open the retrieval loop and inserted the gastropexy suture through the retrieval loop after removing the yellow trocar. After exiting the blue handle and removing the complete gastropexy device with the gastropexy suture in the retrieval loop, the suture was then released and tied to the anterior abdominal wall. The above operations were repeated at the second puncture point. A 5-mm incision was made between the two marked points after successful gastropexy, and a trocar with a peel-away sheath was carefully used for puncture under fluoroscopy guidance. Once the proper position was attained, the trocar was removed and the balloon tube was advanced sufficiently to ensure that the balloon left the sheath into the stomach cavity. Then, 3 mL of sterile water was put into the low-profile balloon. Thereafter, we removed the peel-away sheath by bending the handles and maintaining the balloon tube location. The puncture site was cleaned, pressure was applied on the retaining plate, and the tube was moderately pulled for the well plate position.

Post gastrostomy management

After 24 hours of water fasting, the contrast agent was injected through the gastrostomy tube to confirm the tube position to find a contrast leakage from the gastric cavity. If the position is good and there is no leakage, the liquid food without residue will be inserted through the gastrostomy tube. Copies of a manual of precautions for the use of gastrostomy tubes were distributed to patients and their families. The stitches were removed after two weeks.

Observation indicators

The operation success rate, complication rate, operation time, and patient radiation dose were analyzed in the three groups.

Statistical methods

Quantitative data are expressed as mean $\pm$ standard deviation ($\bar{x} \pm s$). The Kruskal-Wallis test was used for comparison of multiple groups of data because they did not conform to the normal distribution, and the Bonferroni method was used for pairwise comparison. Comparison between rates was performed using the χ^2 test, and the two-sided $\alpha = 0.05$ was used as the test standard; IBM SPSS ver. 22.0 (IBM Corp., Armonk, NY, USA) was used for statistical analysis.

Results

Of the 538 patients recruited into this study, 534 cases of gastrostomy were successful (212 cases in group A, 298 cases in group B, and 24 cases in group C). Four cases failed; 3 cases were transferred to surgical gastrostomy due to postoperative bleeding, and one case was changed to intravenous nutrition due to the patient's intolerance during the gastropexy suture. Gastrostomy was performed 548 times; 212 times in group A, 310 times in group B, and 26 times in group C.

The success rate of 3 groups of techniques

The success rates of the 548 gastrostomy procedure are shown in Table 1. Fourteen patients experienced failure of the gastrostomy procedure the first time, including 12 patients in group A, 2 patients in group B; however, there was a 100% success rate in group C. Eight failed patients in group A successfully finished their gastrostomy by transferring to group B through fluoroscopy combined with C-arm CT guidance, 2 patients underwent whole-process CT guidance, and 2 patients underwent surgical gastrostomy in group A due to postoperative bleeding. In group B, one patient failed to undergo surgical gastrostomy, and another patient changed to intravenous nutrition due to the patient's intolerance during the gastropexy suture. All 24 patients underwent successful gastrostomy the first time in group C. Although the success rates were different between the three groups, there was no statistically significant difference between the rates.

The incidence of complications in the three groups

During the follow-up period, three serious adverse events occurred (including gastric lumen bleeding), and the patients involved were taken to the surgery department and safely treated. No other serious adverse events such as peritonitis, mediastinitis, gastric colonic fistula, or any local infection requiring surgical intervention were observed. Minor complications include local infection, hyperplasia of granulation tissue, tube obstruction or prolapse, and local pain of the ostomy. The minor complications that occurred in this retrospective study are shown in detail in Table 2.

In group A, local infection occurred in 6 patients, hyperplasia of granulation tissue in 4 patients, tube obstruction or prolapse in 4 patients, and local pain in 7 patients. In group B, 10 patients experienced local infection, 6 had hyperplasia of granulation tissue, 4 had tube obstruction or prolapse, and 11 had local pain. Local infection and hyperplasia of granulation tissue were cured by local debridement and sterilization. Tube obstruction or prolapse was cured by inserting a new balloon tube on the same day when the patient returned to the hospital. Local pain can be relieved with oral pain medication. In group C, one patient experienced severe hyperplasia of granulation tissue and was treated by local debridement. The other patients experienced tube obstruction, which was re-canalized using a guidewire.

Table 2 Minor Complication Rate among the Three Groups

Group	Minor complication cases (n)	No complication cases (n)	Total (n)	Complication rate (%)	χ^2	P
Group A	21	179	200	10.5 (21/200)	0.018	0.894
Group B	31	275	298 + 8	10.4 (31/298)	0.159	0.690
Group C	2	22 + 2	24 + 2	7.7 (2/26)	0.198	0.656

Table 3 Comparison of Operation Time and Radiation Dose between the Three Groups

Group	Cases (n)	Operation time (min)	Radiation dosage (mGy)
Group A	200	25.57 ± 5.99	27.30 ± 19.27
Group B	306	29.01 ± 6.63	145.07 ± 106.08
Group C	26	45.47 ± 8.98	2,590.26 ± 1,088.22
χ^2		87.98	204.44
P		< 0.001	< 0.001

Values are presented as number only or mean ± standard deviation. The difference in each group, including the operation time and radiation dosage, was statistically significant ($P < 0.001$).

Procedure time and radiation dosage

The average procedure time was 25.57 ± 5.99 minutes, 29.01 ± 6.63 minutes, and 45.47 ± 8.98 minutes, respectively ($\chi^2 = 87.98$, $P < 0.001$). The average radiation dosage was 27.30 ± 19.27 mGy, 145.07 ± 106.08 mGy, and 2,590.26 ± 1,088.22 mGy, respectively ($\chi^2 = 204.44$, $P < 0.001$) (Table 3).

Discussion

Enteral nutrition is recognized as the first choice for long-term nutritional support treatment.¹⁰ For more than 30 days of nutritional support, the American Gastroenterology Association recommends percutaneous gastrostomy.¹¹ Most doctors support enteral nutrition therapy for elderly patients, and percutaneous gastrostomy should be considered if there are no contraindications.^{12,13} Compared with surgical gastrostomy, percutaneous gastrostomy has a low rate of complications and a low fatality rate because it has the characteristics of being minimally invasive, simple, and tolerable by patients.¹⁴ Patients with serious esophageal strictures due to malignant esophageal tumors, in whom endoscopy tubes cannot pass through the esophageal stenosis and who cannot be fed orally, were included in this study. This means that they cannot or can hardly undergo percutaneous gastrostomy by endoscopy guidance. Therefore, we used fluoroscopy-, CBCT combined with fluoroscopy-, and a full-course CT-guided method to complete the PEG according to the patient's condition and achieved good clinical results.

Fluoroscopy-guided gastrostomy has the following advantages:^{14,15} 1) The equipment requirements are low; it can be performed under conventional fluoroscopy, and it is easy to popularize. 2) The procedure success rate is high with less trauma, low complications, quick postoperative recovery, and easy tolerance by patients. 3) The procedure time is short and the radiation dose is low for patients. For most patients, general anesthesia is not required, which reduces the incidence of aspiration pneumonia. 4) Even if endoscopic guidance fails, this method can easily succeed. Some patients with poor health conditions who cannot tolerate endoscopy or gastrostomy would still be able to undergo fluoros-

copy-guided gastrostomy successfully.

Although fluoroscopy-guided gastrostomy has many advantages and a high operation success rate, it still has the following shortcomings:^{16–18} 1) It is impossible to accurately determine the anatomical relationship between the stomach and its surrounding organs, such as the left lobe of the liver and the transverse colon. When the left lobe of the liver is hypertrophic and the transverse colon is located in front of the stomach, fluoroscopy-guided puncture may pass through the liver and colon, causing serious complications such as liver injury, gastrocolic fistula, and hemorrhage. Therefore, CT scans of the upper abdomen should be routinely performed before surgery. Another method is administering the contrast medium either orally or by feeding the tube 12 hours before gastrostomy to visualize the colon. 2) The angle and depth of the puncture needle cannot be accurately measured. Deep puncture may damage the posterior wall of the stomach and abdominal aorta. 3) The inflating gastric cavity requires the insertion of the catheter through the esophageal cannula. When catheter insertion fails or is challenging, or when the procedure of catheter insertion causes breathing difficulties, gastrostomy either cannot be performed under fluoroscopy or threatens patient safety.

CBCT is a combination of digital subtraction angiography (DSA) rotation and computer reconstruction technology. It can provide fluoroscopy and simulated CT imaging on the same working bed in the intervention room.¹⁹ Therefore, CBCT-guided gastrostomy has the advantages of both fluoroscopy and the CT scan, which can accurately determine the anatomical relationship between the stomach and its surrounding organs, measuring the needle angle and depth. In addition, a study¹⁹ reported that the radiation dose of a single rotation of C-arm CT was significantly less than that of a single CT of the same scan, and the radiation dose was reduced by 60% to 80% compared with conventional CT. Combining the above factors, C-arm CT combined with fluoroscopy guidance can provide more precise positioning without significantly increasing the operation time. Therefore, radiological gastrostomy should be recommended, especially for patients with relative contraindications for endoscopic gastrostomy. The main disadvantages of CBCT guidance⁷ are as follows: 1) C-arm CT scan images have large artifacts, poor tissue contrast, and incomplete scan fields compared with normal CT scans;¹⁹ 2) DSA machines with CBCT function are expensive, and many hospitals are not yet equipped, especially primary hospitals, making the technique difficult to popularize.

In clinical practice, a completely obstructed esophagus or complex esophagotracheal fistula will cause the failure of insertion of the catheter into the stomach by oral administration. When this type of situation is encountered, the fluoroscopy-guided gastrostomy will be difficult due to the problems of gastric inflation. In this study, the results showed a 100% technical success rate in all patients who underwent the gastrostomy procedure using the whole-process CT guidance method. Compared with C-arm CT guidance, CT has a faster scan speed and higher image resolution; it can locate and evaluate the anatomical relationship between the stomach and surrounding organs more accurately and can

accurately monitor the needle tip position of the puncture needle. Therefore, the use of fine-needle puncture and gastric cavity inflation under CT guidance can avoid the procedure of catheter insertion for gastric inflation. CT-guided gastrostomy has a wide range of applications, including failure of fluoroscopy guidance, small residual stomach after partial gastrectomy, or massive ascites. Through the whole-process CT-guided method, the indications for gastrostomy are greatly expanded, and the previously impossible or risky gastrostomy was smoothly performed without increasing the patient's risk. However, the whole-process CT guidance method has the following disadvantages: 1) Real-time monitoring of the puncture needle and the size of the gastric cavity under CT guidance cannot be performed. 2) The procedure time exceeds that of fluoroscopy, and the patient received a higher radiation dose as compared to the other methods.

Some studies^{20,21} reported that percutaneous gastrostomy could be performed under ultrasound guidance. Its advantage lies in the high success rate of gastric cavity puncture under real-time ultrasound monitoring, which can avoid important organs and large blood vessels in the abdominal cavity. In addition, the patients and operating physicians are not harmed by radiation. The disadvantage is that although the gas in the gastrointestinal tract interferes greatly, the gastric cavity cannot be expanded, which will make it difficult to insert a gastrostomy tube. In our opinion, puncture of the gastric cavity with a fine-needle under ultrasound can be used, and performing the gastrostomy procedure under fluoroscopy guidance is a good choice.

In our study, there were no significant differences in the success rates and complication rates of gastrostomy under the three guiding methods. The fluoroscopy-guided procedure had the shortest time and the smallest radiation dose for patients; it is, hence, convenient to promote and popularize. However, upper abdominal CT should be routinely performed before the operation to exclude the left liver and anterior transverse colon. For medical units equipped with DSA with CBCT function, CBCT combined with fluoroscopy guidance should be recommended for direct use. The whole-process CT-guided method takes a long time, and the patient receives a higher radiation dose. It can be used as a supplementary guidance method when fluoroscopy or CBCT combined with fluoroscopy guidance fails, especially in patients with small residual stomachs or massive ascites. Conditional units can also attempt to use ultrasound combined with DSA-guided gastrostomy.

The limitations of this study include its retrospective nature, the absence of improvement of serum albumin concentration, and the small sample size of the whole-process CT guidance method. The retrospective study design reduces the credibility of this research; however, these patients were recruited over ten years in a single institution. Considering the problem of increasing radiation dose, we just used the whole process CT guidance method in difficult cases, and this kind of cases are few, not because of technical reasons. During the CT scan, we used the low-dose scan mode to reduce patients' radiation dose as much as possible. However, for small hospitals that only have CT and are not equipped with DSA, this method could help doctors finish gastrostomy easily and reduce the complications associated with patient transfer.

In conclusion, radiological gastrostomy is a safe and effective procedure for enteral feeding. For large hospitals, we recommend using fluoroscopy combined with the CBCT-guided method to complete gastrostomy. For difficult cases, CT-guided gastrostomy may be a very useful supplemental method. The findings of our

study may be useful for healthcare providers when creating gastrostomy practice guidelines to standardize practice, potentially reducing complications and improve overall patient outcomes.

Conflicts of Interest

No potential conflict of interest relevant to this article was reported.

ORCID

Hai-Liang Li, <https://orcid.org/0000-0002-4497-5649>

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