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Fluoroscopy-guided jejunal extension tube placement through existing gastrostomy tubes: analysis of 391 procedures

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PURPOSE
We aimed to evaluate the safety and efficacy of fluoroscopically placed jejunal extension tubes (J-arm) in patients with existing gastrostomy tubes.

METHODS
We conducted a retrospective review of 391 J-arm placements performed in 174 patients. Indications for jejunal nutrition were aspiration risk (35%), pancreatitis (17%), gastroparesis (13%), gastric outlet obstruction (12%), and other (23%). Technical success, complications, malfunctions, and patency were assessed. Percutaneous gastrostomy (PEG) tube location, J-arm course, and fluoroscopy time were correlated with success/failure. Failure was defined as inability to exit the stomach. Procedure-related complications were defined as adverse events related to tube placement occurring within seven days. Tube malfunctions and aspiration events were recorded and assessed.

RESULTS
Technical success was achieved in 91.9% (95% CI, 86.7%–95.2%) of new tubes versus 94.2% (95% CI, 86.7%–95.2%) of replacements ($P = 0.373$). Periprocedural complications occurred in three patients (0.8%). Malfunctions occurred in 197 patients (50%). Median tube patency was 103 days (95% CI, 71–134 days). No association was found between successful J-arm placement and gastric PEG tube position ($P = 0.677$), indication for jejunal nutrition ($P = 0.349$), J-arm trajectory in the stomach and incidence of malfunction ($P = 0.365$), risk of tube migration and PEG tube position ($P = 0.173$), or J-arm length ($P = 0.987$). A fluoroscopy time of 21.3 min was identified as a threshold for failure. Malfunctions occurred more often in tubes replaced after 90 days than in tubes replaced before 90 days ($P < 0.001$). A total of 42 aspiration events occurred (OR 6.4, $P < 0.001$, compared with nonmalfunctioning tubes).

CONCLUSION
Fluoroscopy-guided J-arm placement is safe for patients requiring jejunal nutrition. Tubes indwelling for longer than 90 days have higher rates of malfunction and aspiration.

Since enteral nutrition is the preferred method of nourishment for all patients with adequate intestinal length and function, a variety of access methods to the gastrointestinal tract has been developed (1). Endoscopy-guided percutaneous gastrostomy (PEG) tubes are commonly placed in patients in whom oral intake is contraindicated. However, a PEG tube may not be preferred in mechanically ventilated or critically ill patients due to risk of aspiration; in these, administration of the nutrients directly into the jejunum through a nasojejunal tube or a percutaneously placed jejunostomy tube is recommended so that the stomach is bypassed and the risk for aspiration is decreased (2). Other indications for direct administration of nutrients into the jejunum include malfunction of the swallowing mechanism, gastric outlet obstruction, gastroparesis, pancreatitis, and the presence of esophageal fistulas or enteric foregut leaks (3–8).

Jejunal feeding tubes can be placed via the nasogastric route, but are not tolerated in the long-term as they can have irritating effects on the nostrils, nasopharynx, and esophagus, and predispose the patient to reflux (9). Hence, a wide variety of other methods for placing jejunal tubes are available, including surgical, fluoroscopy-guided, and endoscopy-guided placement (5). The conversion of an already existing PEG tube into percutaneous endoscopic gastrojejunostomy (PEGJ) tube is also available (10, 11). Another method is placement of a jejunal extension tube (J-arm) through a PEG tube; this is most commonly done endoscopically, usually at the same time that the gastrostomy tube is placed, and

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known as the gastrojejunostomy tube (12). However, endoscopic advancement of jejunal extension tube through a PEG tube can be difficult, particularly when the operator has no access to fluoroscopy to determine its exact position within the bowel (11). Furthermore, the need for jejunal tube feeds can become apparent only after placement of the PEG tube, at which point the patient may return to the endoscopic suite or to the fluoroscopic suite for jejunal extension tube placement.

At our institution, placement of a J-arm through an existing PEG tube by the radiologist under fluoroscopic guidance followed by affixation of the tube to the existing PEG tube has been a routine procedure for almost 10 years. The method does not involve removal of the PEG tube, and omits the use of endoscopy, which makes conscious sedation unnecessary and avoids the complications related to endoscopic placement. The purpose of our study was to establish the safety and efficacy of jejunal extension tube placement utilizing only fluoroscopic guidance.

Table 1. Demographic characteristics, indication for tube placement, and tube malfunction

Age, years, mean±SD	55.9±17.5
Procedures per patient, mean±SD	2.2±2.6
Gender, n (%)	
Male	94 (54)
Female	80 (46)
Tube indwell time, n (%)	
Less than 90 days	350 (89)
More than 90 days	41 (11)
Subject level indications*, n (%)	
Aspiration risk	62 (35.4)
Pancreatitis	29 (16.6)
Gastroparesis	23 (13.1)
Anatomical**	22 (12.6)
Other	41 (23.4)
Incidence of tube malfunction, n (%)	
Clogging/rupture/kinking	91 (23.3)
Migration/coiling in stomach	36 (9.2)
Inadvertent removal	69 (17.6)
None	195 (49.9)

SD, standard deviation.
*Some patients had more than one indication.
**The anatomical indication includes gastric outlet obstruction, and gastric or esophageal leaks.

Methods

Data collection

After approval by our institutional review board, a retrospective chart review was performed over a three-year period (2010–2012) in 174 patients who underwent 391 fluoroscopy-guided J-arm placements. Search terms related to the J-arm placement procedure ("FL tube placement" and "FL tube replacement") were used to mine our institution's data from the electronic medical record system (EPIC Systems). Demographic data, including age at the time of procedure and gender, were recorded in our database. Each procedure was classified as being a new placement (*de novo*) versus a replacement. Patients' radiographs obtained during tube placement were reviewed, and the position of the PEG tube was classified as being within the gastric body, antrum, prepyloric, or indeterminate. The indications for J-arm placement were recorded and summarized in Table 1. The patients' records were also reviewed for any aspiration events after tube placement, and whether the tube migrated back into the gastric lumen.

Main points

- Placement of jejunal extension tubes can be performed in a fluoroscopy suite without conversion of prior existing gastrostomies into gastrojejunostomy tubes.
- Course of the tube in the stomach, position of the gastrostomy tube, orientation with respect to the pylorus, and length of the tube did not predict technical success or incidence of tube-related complications.
- A threshold fluoroscopy time of 20 min was identified in the study, in which further attempts beyond 20 min were strongly predictive of technical failure to advance a jejunal extension tube out of the stomach. The authors therefore suggest attempts up to 20 min in difficult cases, with discontinuation of further attempts after this time.

Tube malfunction was defined as problems with the J-arm that required replacement (Table 1). The trajectory of the tube within the stomach was a straight course, a small loop (Fig. 1a), or a large loop within the gastric lumen before exiting the pylorus (Fig. 1b). Tube tip position was also recorded as shown in the postprocedural radiograph from each procedure. Technical success was defined as placement of the tube beyond the ligament of Treitz and was analyzed separately for new and replacement tubes. The position of the ligament of Treitz was defined radiologically as the segment of jejunum just distal to the acute curve of the fourth portion of the duodenum. Partial success was defined as placement of the tube anywhere within the duodenum distal to the pylorus and proximal to the ligament of Treitz (with or without a loop), or placement distal to the ligament of Treitz with looping in the stomach. Tube failure was defined as any tube that did not exit the stomach, or any aborted procedure.

For each procedure, the fluoroscopy time, tube length, and any medical complication related to the tube placement occurred within seven days of the procedure were recorded. Tube patency was calculated by measuring the number of days between each placement and replacement of the tube, or the last mention of the tube's presence in the medical record. Patency was then used to stratify two groups (group A: tubes remaining in place less than 90 days versus group B: tubes remaining more than 90 days) for analysis based on the manufacturer's recommendation for tube replacement within 90 days, as indicated in the package insert.

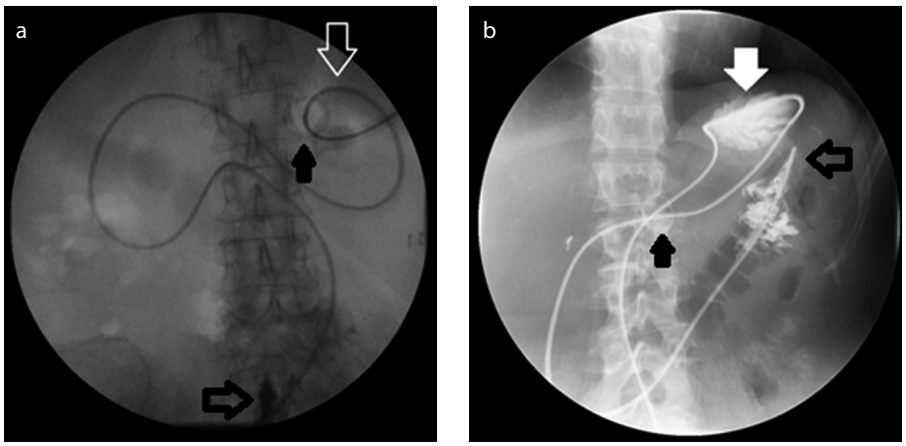

Figure 1. a, b. Digital fluoroscopy image **(a)** and spot radiograph **(b)** demonstrating looping of the J-arm in the stomach. Panel **(a)** shows an example of a small loop *(open white arrow)*. The gastrostomy tube *(solid black arrow)* is in the distal body of the stomach. Tip end *(open black arrow)* is well beyond the ligament of Treitz. Panel **(b)** shows an example of a large loop. The loop reaches the gastric fundus *(solid white arrow)*. The tip of the J-arm is at the ligament of Treitz *(open black arrow)*. Gastrostomy tube *(solid black arrow)* is in gastric antrum.

Table 2. Relationship between tube malfunction and the replacement period

	Tube malfunction n (%)	
Replacement	Yes	No
Before 90 days (group A)	156 (44.6)	194 (55.4)
After 90 days (group B)	40 (97.6)	1 (2.4)

Fisher's exact test, $P < 0.001$.

Procedure

All tubes were placed under fluoroscopic guidance in the radiology department through previously placed PEG tubes which were 24F in outer diameter (Wilson-Cook Medical) and had an inner lumen allowing insertion of a 12F J-arm. Informed consent is not obtained for this procedure at our institution. J-arms came from a single manufacturer (Flow-J/PEG-J Gastro-Jejunal Feeding Tube; Wilson-Cook Medical). In case a different type of PEG tube had been placed, the PEG was exchanged for the aforementioned J-arm-compatible PEG tube (Wilson-Cook Medical). A 5F angled-tip, Soft-Vu Hockey Stick catheter (AngioDynamics) was inserted into the PEG tube and manipulated into the duodenum and proximal jejunum under fluoroscopy (Fig. 2a), with the assistance of a 0.038 Amplatz guidewire (Boston Scientific) or a Rosen guidewire (Cook Medical) advanced through the 5F catheter (Fig. 2b). The catheter was removed, and the J-arm advanced over the wire to its desired position beyond the ligament of Treitz (Fig. 2c). Before insertion, the J-arm's outer surface was lubricated with surgical gel (Wilson-Cook Medical) to facilitate advancement through the PEG tube. A final injection of water-soluble contrast material (Iohexol 300, GE Medical) was performed to confirm the position of the tube within the jejunum (Fig. 2c) after which it was flushed with water.

Statistical analysis

Since many patients had multiple tube placements, data from repeat tube placements from the same patient could not be analyzed as independent observations. Statistical techniques designed for the analysis of correlated cluster data were utilized. Kaplan-Meier survival analyses were performed to predict tube patency for all cases, as well as for those tubes remaining in place less than or greater than 90 days. Comparisons of tube patency were carried out utilizing the generalized estimating equation (GEE) version of the Cox proportional hazard model. The GEE version of the Wald chi-square test was used as the test statistic. A two-sided $P < 0.05$ was established *a priori* decision rule as the null hypothesis rejection criterion. Wald chi-square tests were derived from binomial GEE model to test hypotheses related to dichotomous scaled outcome variables and from Gaussian GEE models to test hypotheses related to continuous scaled outcomes. The working independence GEE variance covariance structure was utilized for all GEE model and the GEE sandwich estimator was utilized to estimate the variance-covariance components.

Results

Demographic and clinical indication information of 174 patients, who underwent 391 J-arm placements, is summarized in Table 1. Sixty-six procedures had indications which could not be classified (grouped under "other"), accounting for 16.9% of procedures. One procedure had no indication in the medical record. Technical success was achieved in 91.9% (95% CI, 86.7%–95.2%) of new tube placements versus 94.2% (95% CI, 86.7%–95.2%) of replacement procedures ($P = 0.373$). Success rate was independent of clinical indication for all procedures ($P = 0.349$). The overall procedural failure rate was 6.9% (95% CI, 4.7%–10.1%). The position of the PEG tube had no bearing on procedural success for either group A or B ($P = 0.677$ and $P = 0.655$, respectively). No association was found between the trajectory of the J-tube within the stomach (presence of small or large loop), and the incidence of tube malfunction, for either group A or B ($P = 0.365$ and $P = 0.274$, respectively). The position of the tube tip within the bowel and the tube length were also not predictors of malfunction in either group A or B ($P = 0.173$, and $P = 0.366$; $P = 0.987$, and $P = 0.768$, respectively). Median overall tube patency was 103 days (95% CI, 71–134 days) following placement.

Three medical complications were directly associated with the tube placement procedure, consistent with a 0.8% procedural complication rate (95% CI, 0.16%–2.22%). One perforation occurred one day after a difficult placement in a patient in whom the J-arm penetrated through a duodenal diverticulum (Fig. 3) that was not identified at the time of the tube placement. Contrast injection at the time of tube placement showed the tip to be positioned in the duodenum. The perforation was detected in an abdominal CT performed for abdominal pain, and the patient was taken to emergent laparotomy for closure of the leak, resulting in good recovery and subsequent survival. The tube migrated proximally, and at laparotomy, it was determined that the perforation occurred during placement of the tube. The other two complications were a case of periprocedural hypotension

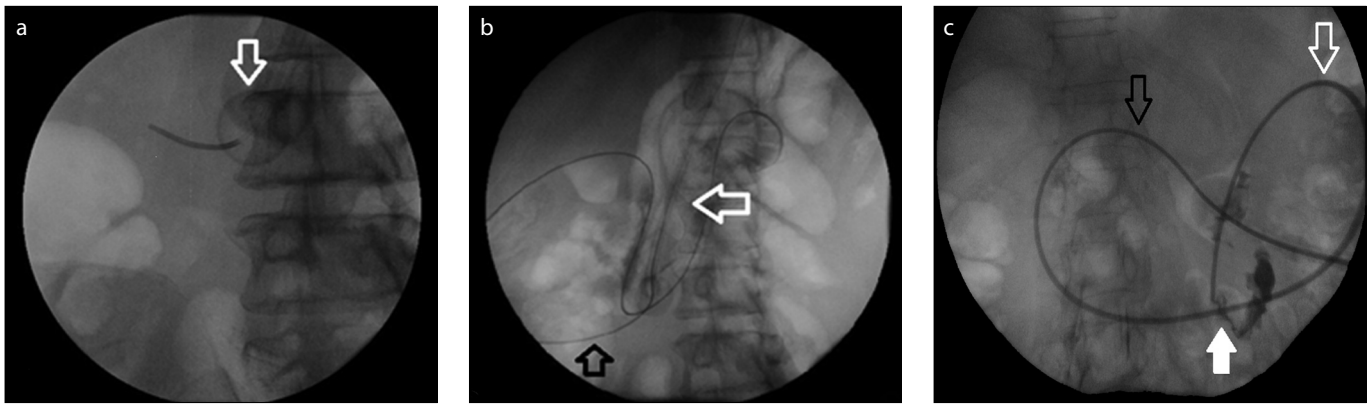

Figure 2. a–c. Digital fluoroscopy images showing placement of a J-arm through a PEG tube into the jejunum. Panel **(a)** shows a 5F angled-tip catheter advancing through the gastrostomy tube opening *(open white arrow)* with the tip directed towards the pylorus. The PEG tube is in the distal antrum of the stomach. **(b),** Under fluoroscopic guidance, the catheter is advanced through the duodenum and beyond the ligament of Treitz into the jejunum (*open black arrow*), with the assistance of a 0.035-inch guidewire . The *open white arrow* in panel **(b)** designates the location of the gastrostomy tube. The angled-tip catheter is removed while leaving the wire in place, after which the J-arm is advanced over the wire and placed in the jejunum. The wire is then removed, and a small volume of water-soluble contrast material is administered through the J-arm to confirm its position in the jejunum *(solid white arrow,* **c***)*. The tube is then flushed with water to remove any residual contrast agent (not shown) to prevent clogging. Locations of pylorus *(open black arrow)* and the ligament of Treitz *(open white arrow)* are shown. Note that the J-arm follows a straight course out of the stomach to the pylorus. The patient is slightly rotated to the right.

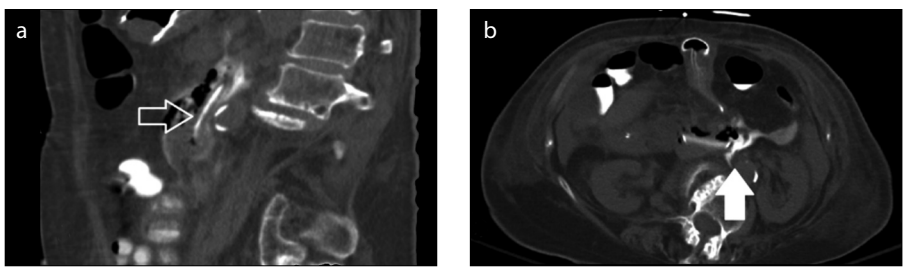

Figure 3. a, b. Sagittal **(a)** and axial **(b)** unenhanced computer tomography images demonstrate the tube exiting the duodenal lumen *(open arrow,* **a***)* with retroperitoneal leakage of orally administered water-soluble contrast material *(white arrow,* **b***)*, consistent with perforation of a duodenal ulcer by the jejunal extension tube.

in a patient who did not receive sedation, and a hematoma at the PEG tube insertion site. The case of hypotension was determined to be secondary to the patient's critical illness, and not related to the placement of the jejunal extension. The patient was a 36-year-old female motor vehicle collision trauma victim, and had a prolonged wean from the ventilator and a complicated intensive care course. The hematoma at the PEG insertion site occurred at the time of placement of gastrostomy tube. There were 45 aspiration events in the study population after J-arm placement, with 42 of these being associated with tube malfunction. Aspiration among tubes that malfunctioned showed an odds ratio of 6.4 versus tubes that did not malfunction (95% CI, 2.4–26.5; $P < 0.001$).

Table 1 summarizes the incidence of tube malfunctions. There was a significant difference in the incidence of malfunction between the tubes replaced before and after 90 days. Tube malfunctions occurred in 44.6% (95% CI, 35.6%–53.8%) of tubes replaced within 90 days, and in 97.6% (95% CI, 87.1%–99.9%) of tubes replaced after 90 days, $P < 0.001$ (Table 2). A significant association was found between fluoroscopy time and procedure outcome ($P < 0.001$). The mean fluoroscopy time for failed tube placement was 21.3 min (SD, 11.3 min), which was 11.4 min longer (95% CI, 6.7–16.1 min; $P < 0.001$) than the mean fluoroscopy time of successful procedures. PEG tubes placed in the body and antrum made up 85.7% of tube placements. For PEG tubes placed in the body, the median total fluoroscopy time was 3.7 min (95% CI, 2.0–12.4 min) for those replaced within 90 days, while 9.7 min (95% CI, 7.0–11.7 min) for those replaced after 90 days ($P = 0.0183$). For PEG tubes placed in the antrum, the median total fluoroscopy time was 8.2 min (95% CI, 3.8–14.4 min) for those replaced within 90 days, while 8.7 min (95% CI, 6.5–10.2 min) for those replaced after 90 days ($P = 0.602$).

Discussion

J-arm placement under fluoroscopic guidance is technically successful in greater than 90% of attempts in this study, and success did not appear to be associated with tube length, position of the PEG tube in the stomach, or course of the tube within the gastric lumen. The median tube patency of 103 days was longer than the intended indwell time for the tubes, which is 90 days according to the manufacturer. Interestingly, 97.6% of tubes that remained in place longer than 90 days malfunctioned, in contrast to 44.6% of tubes that were replaced before 90 days. We also identified a fluoroscopy time of 21.3 min for failed placements.

Enteral nutrition is the preferred route for nourishment in patients with a functional gastrointestinal tract (6). It is associated with improved clinical outcomes compared with total parenteral nutrition, particularly due to lower rates of sepsis and hepatotoxic effects of total parenteral nutrition (13). Placement of a PEG tube is common, and it is the second most common indication for esophagogastroduodenoscopy in the US (14). However, patients frequently require post-pyloric feeding and this need led to the development of jejunal extension tubes, which can be placed through a pre-existing gastrostomy tube or directly into the jejunum. The procedure obviates the need for endoscopy which is more invasive and adds substantial cost. J-arm placement under fluoroscopic guidance, therefore, appears to be a good alterna-

tive for establishing access to the jejunum in patients who need jejunal nutrition and have an existing gastrostomy tube. This retrospective study of fluoroscopic placement of jejunal extensions through existing PEG tubes showed that placement with only fluoroscopy was successful in 91.9% of cases, with low complication rates (0.8%). Another advantage of our procedure is that it does not require replacement of the existing PEG tube as is the case when a PEGJ tube is used in which the tube and J-arm are combined in one device that is generally more expensive than the small tube used for the J-arm extension in our study.

The analysis presented above attempted to identify variables that could assist in making the placement of J-arms safer, with reduced radiation dose, and decreased incidence of tube malfunctions, such as coiling into the gastric cavity with subsequent tube migration and aspiration. Overall success rate was similar to previously reported results of studies (3, 11, 15), which used the combined PEGJ tube for jejunal feeding, with an over-the-wire exchange technique similar to ours. Similar to Kim et al. (11), we also found that easier access to the small bowel is achieved when the position of the PEG is oriented towards the pylorus. It was anticipated that an unfavorable position of the PEG tube in the stomach could make passage of the wire and catheter more difficult, especially if the PEG was oriented away from the gastric outlet, as suggested by Kim et al. and Lu et al. (11, 12). However, our study showed that the orientation of the PEG had no effect on the likelihood of successful placement. It is possible that other factors which are difficult to analyze objectively could account for this lack of association between PEG orientation and success of placement. The position and orientation of the duodenal bulb is normally variable, and the angles with respect to the catheter and wire trajectory may be difficult even if the PEG is oriented towards the pylorus. This analysis would be difficult to perform retrospectively, as many patients may lack cross-sectional imaging providing adequate measurements of favorable versus unfavorable anatomy. The results also showed that the course of the tube in the stomach, whether it was looped or straight, did not predict the incidence of malfunction, nor did the tube length or position of the tube tip in the duodenum.

Our study demonstrated that 35.4% of patients (62/174) required a J-arm because they were at increased risk of aspiration. In a randomized controlled trial, Heyland et al. (16) showed a reduction in aspiration events with small bowel feeding, with another meta-analysis by Marik et al. (17) finding increased risk of aspiration (OR, 1.44; 95% CI, 0.84–2.46; $P = 0.19$) of gastric feeding versus jejunal feeding. Tube malfunction was a strong predictor of aspiration events. We found 45 aspiration events with 42 of these occurring in the presence of tube malfunction, making tube malfunction 6.4 times more likely to cause aspiration. In our study 9% of tubes (36/391) migrated back into the stomach, similar to the rate reported by Kim et al. (14.5%, 18/124) (11).

The extremely high incidence of tube malfunction in tubes replaced after 90 days confirms the manufacturer's recommendations (Table 2). Up to 97.6% of tubes left indwelling for more than 90 days malfunctioned. Possibly, the malfunction is caused by degradation of tube from long-term exposure to the ingredients of the tube feedings (18). It may thus be prudent to replace the tubes routinely, while the patient is clinically stable, which may help to avoid tube complications later when there is exacerbation of concomitant disease, especially given the high incidence of aspiration in the presence of tube malfunctions.

Fluoroscopy time was a predictor of procedural success. A limitation of using fluoroscopy time is the weaker relationship between time of exposure and actual dose delivered to the patient compared with dose area product (19), a metric that was not available for collection in this study. While the position of the PEG tube was not a factor in predicting procedural fluoroscopy time, the mean time for failed J-arm placements was 11.4 min longer (95% CI, 6.7–16.1 min; $P < 0.001$) than for successful procedures, with the mean time for failed tubes being 21.3 min. This suggests that, despite persistent attempts at exiting the pylorus, procedures that last over 20 min of fluoroscopy time are likely to fail, and further exposure to ionizing radiation may not be warranted. We were not able, however, to demonstrate a relationship between fluoroscopy times and the orientation of the PEG tube towards or away from the pylorus.

Another problem related to the presence of the feeding tube in the jejunum is that there is an increased risk of bowel perforation caused by pressure necrosis of the tip of the tube against the bowel wall. At our institution there were three patients who experienced perforation requiring surgical intervention. These occurred at 11, 12 and 19 days after placement of the tube, respectively, and were the subject of a separate publication (20). Although tube placements were done under fluoroscopic guidance, these were unlikely related to the procedure itself, as the risk of pressure necrosis is present with any tube that is in the bowel for some time. The only perforation we encountered in our 391 procedures that was directly related to the tube placement itself occurred when the tip of the J-arm and the guidewire lodged in a jejunal diverticulum and perforated the bowel wall. We are currently investigating the use of a J-arm that has a softer tip than the one we used in this report, and a catheter with a pig-tail shaped end to decrease the risk of pressure-related perforation over time.

The study was limited by its retrospective design, and no comparison was made to a study arm of jejunal extension tubes placed under endoscopic guidance, which would provide a better assessment of the safety and efficacy of the procedure compared with the standard endoscopic techniques.

In conclusion, this study shows that fluoroscopy-guided placement of a jejunostomy tube through an existing PEG tube is a safe procedure that obviates the need for replacing the gastrostomy tube at the time of J-arm placement, as up to 92% of tube placements were successfully performed as described above. Tubes have a higher incidence of malfunction if left indwelling for more than 90 days. Routine replacement within 90 days may therefore be beneficial, as replacement procedures are mostly successful, and there is less risk of tube malfunction occurring when episodes of exacerbated disease develop, at which time nutrition becomes even more essential for the patient's recovery. While we could not demonstrate a reliable predictor of success or failure with regards to the patient's anatomy or PEG position, J-arm procedures that require more than 20 min of fluoroscopy time are likely to fail, and continued radiation exposure may not be justified.

Conflict of interest disclosure

The authors declared no conflicts of interest.

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