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LABORATORY INVESTIGATION

Which G-Tube to Use in Pullers: Assessment of Pull Pressures on Skin Models to Determine Optimal Catheter Choice in Patients with Recurrent Pulled Gastrostomy Tubes

R. Nasirzadeh[1] · S. F. Stella[1] · O. Mironov[1] · A. Jaberi[1] · J. R. Kachura[1] · M. E. Simons[1] · J. R. Beecroft[1] · G. Annamalai[1] · K. T. Tan[1]

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Abstract
Introduction Pulled or dislodged gastrostomy catheters represent a common complication associated with percutaneous gastrostomy and are a common cause of recurrent visits in patients with altered mental status. We intended to perform an experiment to compare the pull forces required to dislodge different commonly used gastrostomy catheters.
Materials and Methods We used a digital force gauge device to measure the pull forces required to dislodge three types of 20 French gastrostomy catheters in double-layer skin models. These included the Flow 20 Pull Method (Cook Medical, Bloomington, IN, USA), Entuit Gastrostomy BR Balloon Retention feeding tube (Cook Medical, Bloomington, IN, USA), and Ponsky Non-Balloon Replacement Gastrostomy Tube (CR Bard Inc, Salt Lake City, Utah, USA). The catheters were inserted into the skin model using the same technique as would be utilized in a patient.
Results The mean forces measured to dislodge the per-oral Flow 20 Pull Method, Entuit Thrive Balloon Retention, and button-type retention Ponsky replacement catheters were 35.6, 22.8, and 20.6 Newtons, respectively. The pull method per-oral gastrostomy catheter required significantly more pull force to dislodge than both the Ponsky button-type retention catheter and the Entuit balloon retention catheters. There was no significant difference in the pull force required to dislodge the Ponsky replacement catheter and the Entuit balloon retention catheter.
Conclusions Per-oral image-guided gastrostomy with pull-method button-type retention catheters may be the ideal choice in patients at high risk of tube dislodgment.

Keywords Gastrostomy · Percutaneous · Pull force

Introduction

Percutaneous gastrostomy is a well-recognized technique for providing enteral feeding and gastric decompression. The vast majority of percutaneous gastrostomy tubes are placed for enteral feeding in patients with neurogenic dysphagia with a high risk of aspiration such as patients with cerebrovascular events, traumatic brain injury, cerebral palsy, or neurodegenerative syndromes and patients with head and neck malignancy [1, 2]. Venting percutaneous gastrostomy tubes may also be inserted for decompression of long-term small bowel obstruction due to end-stage malignancy [3, 4] or for gastric decompression to induce bowel rest in patients with gastrointestinal fistulas [5].

The most commonly used methods for gastrostomy tube insertion include radiologically inserted gastrostomy (RIG), percutaneous endoscopic gastrostomy (PEG), and per-oral image-guided gastrostomy (PIG). Due to a higher risk of wound infection from contamination by oral flora and increased need for sedation associated with per-oral routes [1, 6], RIG is the preferred method for insertion of percutaneous gastrostomy tubes. The main disadvantage of

✉ S. F. Stella
steffan.frosistella@uhn.ca

[1] Division of Vascular and Interventional Radiology, Toronto General Hospital-University Health Network/University of Toronto, Toronto, ON, Canada

RIG is the smaller size of tubes used during initial insertion, which increases the risk of blockage and requires fluoroscopic guidance to be exchanged [6].

There are different types of gastrostomy tubes commercially available, which may be selected based on the patient requirements. Loop retained tubes are the most commonly used catheters at the time of the initial insertion due to their smaller caliber. Balloon retained tubes are often of larger caliber for the same sized lumen due to the thick silicone walls and the presence of the inflation channel for the balloon [6]. Bumper retained push- or pull-type catheters may be placed from the oral route with endoscopic guidance (PEG) or purely percutaneously with fluoroscopic imaging guidance (PIG), allowing for initial insertion of larger sized tubes. Semisolid bumpers may be removed using forced traction under local anesthesia, while rigid bumpers require removal from the mouth either endoscopically or using a snare.

Tube dislodgment occurs in 1.3–4.5% of gastrostomies and is more common in patients with altered mental status such as patients with delirium or dementia [5, 7]. Reinsertion of the gastrostomy catheter depends on the age of the tract and the time elapsed since the tube was dislodged [8]. If a mature tract exists at the time of reinsertion, then the gastrostomy tract may be re-cannulated under fluoroscopic guidance. It usually takes 7–10 days for the tract to mature; however, this may be delayed up to a month in patients who are malnourished, on corticosteroid therapy or have ascites [5]. However, if a mature tract has not developed yet at the time of dislodgment or intervention is delayed, then new gastrostomy tube insertion may be required.

The purpose of this study was to devise an experiment to compare the amount of pull force required to dislodge different types of gastrostomy tubes, in order to determine which tubes would be best suited in the patient population at increased risk for tube dislodgment.

Materials and Methods

Gastrostomy Catheters

Three different 20 French gastrostomy catheters were selected for the experiment as follows: Flow 20 Pull Method (Cook Medical, Bloominton, IN, USA), Entuit Gastrostomy BR Balloon Retention feeding tube (Cook Medical, Bloominton, IN, USA), and Ponsky Non-Balloon Replacement Gastrostomy Tube (CR Bard Inc, Salt Lake City, Utah, USA) (Fig. 1). The Flow 20 Pull Method gastrostomy catheter is inserted per-orally using PIG or PEG techniques. The 20-Fr Entuit balloon retention catheter and Ponsky catheter are inserted percutaneously in patients with established gastrointestinal stoma tracts.

The Entuit catheter has a balloon retention mechanism, which was filled with 20 ml of sterile water as per the device's instructions for use. The Flow 20 per-oral gastrostomy catheter and the Ponsky catheter have semisolid bumper-type retention mechanisms and may be removed by forced traction percutaneously. Pigtail catheters were not included in our study since they have a maximum diameter of 14 French.

Experiment

Double-layer thick skin models (LifeLike Body Tissue Inc, London, Ontario, Canada) were used to simulate the patient's anterior abdominal wall. The experiment setup is displayed in Fig. 2. The skin models were secured using 4 clamps and initially punctured using an 18 Gauge needle. The tract was then dilated using a 20-Fr dilator. The gastrostomy catheters were inserted as they would in a live patient according to the respective instructions for use. A digital force gauge (model FG5000A; Efston Science, Toronto, Ontario, Canada) calibrated to an accuracy of $\pm$ 0.4% was used to measure the pull forces required to dislodge the gastrostomy tubes. The force gauge was connected to the gastrostomy tubes using two cable ties 3 cm from the skin surface. The tubes were pulled perpendicular to the plane of the skin models. The experiment was performed 6 times for each catheter type, which was done each time on different skin models in order to account for material fatigue.

Statistical Analysis

One-way ANOVA of the 3 device types with Tukey contrasts was performed. Significance was defined as $p < 0.05$. Statistical analysis performed using R 3.3.1 (Foundation for Statistical Computing, Vienna, 2016).

Results

The mean pull force required to dislodge the Flow 20 Pull Method, Entuit Gastrostomy BR Balloon Retention feeding tube, and Ponsky Non-Balloon Replacement Gastrostomy Tube were 33.2 ± 3.8, 21.2 ± 3.8, 19.2 ± 1.9 Newtons, respectively. The results are displayed in Fig. 3. There was a statistically significant difference in the force required to pull the devices (one-way ANOVA $P < 0.00001$).

The Flow 20 Pull Method per-oral gastrostomy catheter required significantly more pull force to be removed than both the percutaneously inserted Entuit gastrostomy

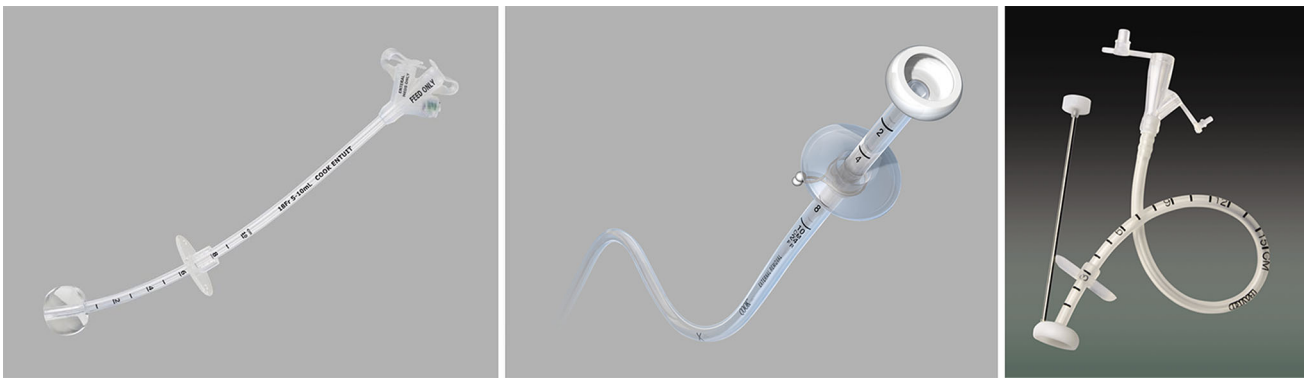

Fig. 1 From left to right, Entuit Gastrostomy BR Balloon Retention feeding tube (Cook Medical, Bloominton, IN, USA), Flow 20 Pull Method (Cook Medical, Bloominton, IN, USA), and Ponsky Non-Balloon Replacement Gastrostomy Tube (CR Bard Inc, Salt Lake City, Utah, USA)

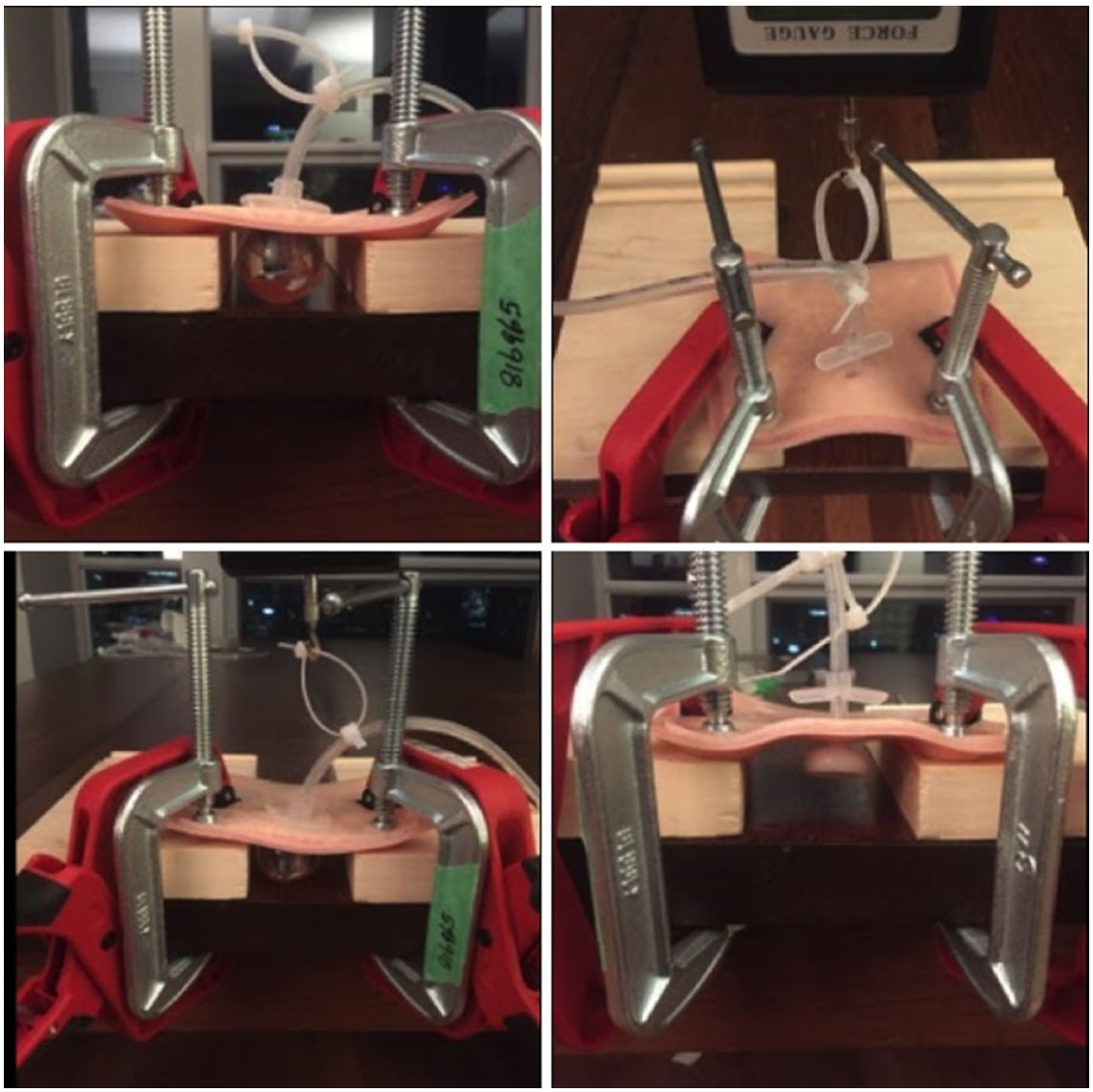

Fig. 2 Experiment setup. Double-layer thick skin models (LifeLike Body Tissue Inc, London, Ontario, Canada) secured using four clamps. A digital force gauge (model FG5000A; Efston Science, Toronto, Ontario, Canada) was connected to the gastrostomy tubes using two cable ties 3 cm from the skin surface. The tubes were pulled perpendicular to the plane of the skin models

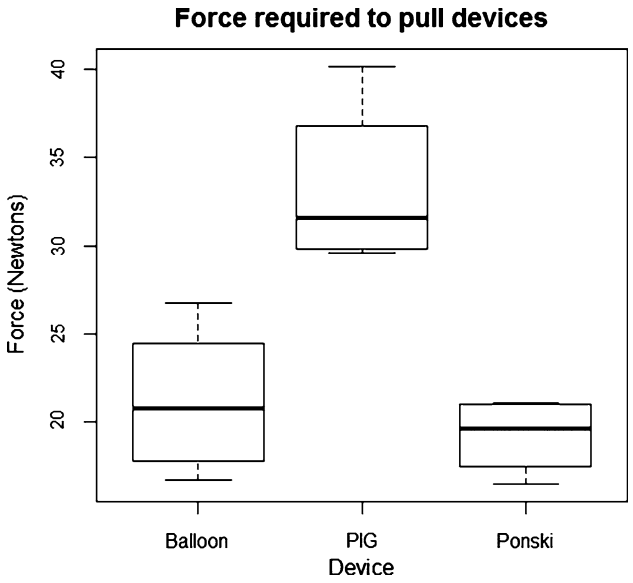

Fig. 3 Tukey boxplots of the force required to pull out percutaneous balloon retention, per-oral pull-type button retention (PIG), and Ponski button retention gastrostomy catheters. Solid line represents the median, the box represents the 25th and 75th percentiles, the whiskers represent the lowest datum still within 1.5 interquartile range (IQR) of the lower quartile, and the highest datum still within 1.5 IQR of the upper quartile

balloon retention catheter ($P < 0.0001$) and the Ponsky button-type replacement gastrostomy catheter ($P < 0.0001$). There was no significant difference in the pull forces required to dislodge the Ponsky button-type replacement gastrostomy catheter and the Entuit balloon retention catheter ($P = 0.598$).

Discussion

Dislodged gastrostomy catheters represent a common complication associated with percutaneous gastrostomy and are a common cause of recurrent visits, specially for those patients with neurological impairment. Reinsertions procedures can be onerous to the health system and as a multifactorial matter, careful choice of retention mechanism and insertion techniques in high-risk patients are crucial to avert repeated procedures.

The decision of which gastrostomy tube to use in patients at high risk of tube dislodgment is made both when a new catheter is inserted as well as when catheters have to be reinserted under fluoroscopic guidance in patients with mature tracts. The choice is often at the discretion of the interventional radiologist and is usually based on personal experience, patient history and the size of catheter required for the clinical indication.

Some techniques described to prevent tube dislodgement include placing mittens on the patient's hands to reduce the ability to pull the gastrostomy tube and reinsertion of low profile devices [5]. However, despite these measures, there are patients that present with recurrent tube dislodgment requiring frequent gastrostomy tube reinsertions under fluoroscopic guidance. The gastrostomy tube choice used during initial insertion in patient at high risk of tube dislodgment and during replacement in patients with history of previously pulled tubes can play a significant role in reducing future catheter reinsertion rates in the interventional radiology department.

Our results demonstrated that on double-layer skin models, there was significantly more force required to dislodge the per-oral route button retention pull-type gastrostomy catheter than the percutaneous balloon or bumper-type retention catheters. Even though the per-oral Flow 20 Pull Method catheter and the Ponsky Replacement catheters both utilize a bumper-type retention mechanism, we believe that the increased stiffness of the former catheter would explain its increased resistance to outward force. The retention bumper on the Ponsky Replacement catheter inherently requires to be less rigid in order to be advanced in antegrade fashion through the existing tract during tube replacement.

There was no significant difference in pull pressures required to dislodge the Ponsky percutaneous button retention replacement catheter compared to the balloon retention gastrostomy catheter of the same caliber. However, mechanical retention catheters have an advantage in requiring less frequent replacement for maintenance compared to balloon retention catheters. Our results are supported by a retrospective study comparing large bore balloon retention percutaneous gastrostomy catheters and button-type retention catheters inserted per-orally, demonstrating significantly more tube-related complications associated with balloon retention catheters including tube dislodgement [9]. This was hypothesized in the study to be related to balloon rupture or accidental deflation, however, our experiment shows that the balloon retention catheters are inherently easier to remove with direct pull pressure compared to per-oral button retention-type gastrostomy catheters.

A prospective study comparing RIG, PIG, and PEG, demonstrated no significant difference in the rates of dislodgment between the three types of catheters [1]. However, this was thought to be due to selection bias as the RIG group had a significantly larger proportion of head and neck cancer patients (50% vs 18% vs 18%) whom would be more aware of their tubes than patients with neurogenic dysphagia or stroke. This is supported by another retrospective study comparing pigtail retained gastrostomy catheters and large bore button retention-type catheters [10], which demonstrated significantly improved long-term performance for button-type retention catheters. In this

study pig tail catheters had a 20-fold increase in tube obstruction, leakage and dislodgement when compared to button-type retention catheters.

There are limitations associated with our study. The double-layer skin models used are meant for practicing surgical skills and do not replicate the mechanical properties associated with the anterior abdominal and gastric walls. However, since the same skin models were used for all three catheter types, we felt that this would serve as a good replica for inter-catheter comparisons. Also, there is inherently some variability in the tensile strength between the individual skin models. To account for this, we repeated the experiment several times for each catheter on different skin patches. Lastly, only one catheter diameter size was used to compare the large bore gastrostomy tubes. This was primarily due to limited sizes of catheters available for button-type Ponski Replacement catheter and the per-oral Flow 20 Pull method catheter.

In conclusion, based on increased pull pressures required to dislodge the PIG button-type retention catheters, compared to RIG balloon and button-type retention catheters, per-oral pull-type button retention catheters may be the ideal choice in patients at increased risk for recurrent tube dislodgment. Retrospective or prospective studies in this specific patient population may be helpful to confirm the findings in our experiment.

Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical Approval This article does not contain any studies with human participants or animals performed by any of the authors.

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