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Nasointestinal tube placement: Techniques that increase success

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Abstract

Background: Delayed gastric emptying (DGE) is a major cause of undernutrition that can be overcome using nasointestinal (NI) feeding, but tube placement often fails. We analyse which techniques enable successful NI tube placement.
Methods: Efficacy of tube technique was determined at each of six anatomical points: Nose, nasopharynx-oesophagus, stomach-upper and -lower, duodenum part-1 and intestine.
Results: In 913 first NI tube placements, significant associations with tube advancement were found in the pharynx (head tilt, jaw thrust, laryngoscopy), stomach_upper (air insufflation, 10 cm or 20–30 cm flexible tube tip ± reverse Seldinger manoeuvre), stomach_lower (air insufflation, possibly flexible tip and wire stiffener) and duodenum part-1 and beyond part-2 (flexible tip and combinations of micro-advance, slack removal, wire stiffener or prokinetic drugs).
Conclusion: This is the first study to show what techniques are associated with tube advancement and the alimentary tract level they are specific to.

Keywords

Delayed gastric emptying, manoeuvre, nasointestinal, nasojejunal, technique, tube advance

Introduction

Delayed gastric emptying (DGE) occurs in 30–46% of critically ill patients[1–2] and is associated with prolonged ventilation, ICU and hospital stay and increased mortality.[1,3] Although a causal link to these outcomes is not certain, DGE is associated with reduced feed and drug delivery.[1] However, early EN remains preferable to delayed nutrient intake or parenteral nutrition because it is associated with reduced mortality and infection.[4] Prokinetic drugs reduce DGE,[5] but even combined metoclopramide and erythromycin treatment is associated with tachyphylaxis.[6] Conversely, nasointestinal (NI) feeding, from duodenum part-1 to the jejunum, delivers more nutrition in patients with DGE refractory to metoclopramide treatment when compared with nasogastric (NG) feeding plus prokinetics.[7] However, aspiration risk appears to decline as NI placement becomes more distal.[8] In addition, NI feeding, rather than NG, was associated with less reflux, vomiting and ventilator-associated pneumonia [9–11]

Endoscopy and fluoroscopy are highly successful in achieving intestinal tube placement, but increase clinical risk from their invasive nature, irradiation, off-ward location and exposure to infection. Guided bedside tube placement would minimise these risks and any delay to feeding. Unfortunately, published techniques for achieving intestinal placement are mostly limited to moving the tube through the pylorus. Using prokinetic drugs, combining air insufflation + right lateral decubitus position + a weighted tube or using tube rotation with a bent guide-wire, failed to reach the intestine in 8–17% and tubes only advanced beyond duodenum part-3 in 17–22%.[12–14] Hawk and Valdivia [15] suggested operator skill as a reason for improved guided versus blind transpyloric tube placement.[16,17] However, the success associated with guidance may only be achieved if the guidance prompts the use of techniques.[18] Manufacturer guidance for Cortrak-guided placement suggests use of IV metoclopramide, laying the patient flat (upright for a distended abdomen), an air bolus and slow tube insertion to prevent coiling.[19] However, this guidance was unsubstantiated by published citations. To address the lack of systematic evidence, we analysed techniques, tried or developed in clinical practice, to achieve tube advancement. To our knowledge, this is the first analysis of multiple techniques and their efficacy at different anatomical points.

Methods

Design and data collection

In a single UK ICU we retrospectively determined the success of our techniques for clinically required NI tube placements from 22.03.07 to 31.08.21. We acquired

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demographic data, tube position attained, problems of advancement, techniques and anatomical points at which they were used from a database of contemporaneous records of bedside NI tube placement. Anatomical points were cross-referenced with digital traces of the tube path. APACHE two scores were obtained from ICNARC (Intensive Care National Audit and Research Centre). All patient ID was removed and disease transformed into a general disease category prior to export to the statistical package for anonymised publication.

Techniques

All the techniques were developed and applied to specific anatomical points as part of clinical practice (Table 1). The safety of using 'stiffener' guide-wires was discussed with Interventional Radiology who use similar practice.

Patients and equipment

Patients were referred for NI tube placement when suffering delayed gastric emptying (DGE), defined as a gastric

Table 1. Techniques, order of use and their purpose as used at different levels of the alimentary tract.

GI level		Technique order	Detail
Nose		–Nasal airway	Slit the airway along its lesser curvature, lubricate and insert into the nostril. Insert the tube through the airway. When the tube tip had reached the nasopharynx, withdraw airway, peeling the slit off the tube
Pharynx-oesophagus		1. Head tilt forward	This straightens the passage to the oesophagus, reducing both neck curvature and likelihood of tube deflection into the trachea
		2. Jaw thrust	Lower jaw displacement pulls the tongue, endotracheal tube or tracheostomy cuff forward permitting easier tube entry into the oesophagus
		3. Laryngoscopy	Direct vision to place a tube into the oesophagus
STOMACH	Upper	1. Flexible tip 10 cm	Guide-wire withdrawn 10 cm to make the tip flexible enough to navigate the gastric body flexure or folds
		2. Air insufflation	Initially 250 mL but up to 750 mL in increments to open a passage if the greater curvature or gastric folds have indented to block tube passage
		3. Flexible tip 20–30 cm ± reverse seldinger	When a tube tip has become stuck on the greater curvature or moves anti-clockwise, back towards the oesophagus, this technique facilitates tube entry into the lower stomach and orients the tip towards the pylorus. First withdraw the tube tip until just inside the stomach. Retract the guide-wire 20 cm then slowly advance the flexible tip of the tube until the guide-wire is just inside the stomach. Repeat after retracting the guide-wire another 10 cm. If the tip has dropped into the lower stomach, careful re-insertion of the guide-wire will make advance toward the pylorus possible. If the guide-wire meets resistance at the nadir of tube bulging into the lower stomach with the tip pointing towards the fundus, withdraw the tube and insert the guide-wire both in 1 cm increments, effectively pulling the tube back onto the guide-wire in a reverse seldinger manoeuvre. Repeat until the guide-wire is fully re-inserted into the tube and the tip is able to advance from within the lower stomach (see Figure 1(b) and (c)
		4. Prokinetics	1 IV dose of either 250 mg erythromycin or 10 mg metoclopramide to increase peristalsis
		5. Wire stiffener	1–3 extra 140 cm guide-wires (ie. The same type and length as the tube) were used to prevent dilation of the tube within a flaccid stomach. As the tube is advanced into the intestine the 'stiffener wire(s)' are progressively withdrawn from the tube so as to remain within the stomach
	Lower	1. Air insufflation	As above
		2. Flexible tip	
		3. Wire stiffener	
		4. Prokinetics	
		5. Patient flat	Remove any gastric folding
Duodenum part-1 or -2 and beyond		1. Flexible tip <12 cm	Incrementally withdraw the guide-wire (usually 3–7 cm) to make the tip flexible enough to go around the flexure. Alternately re-insert the guide-wire to check for when the tip has completely traversed the flexure
		Flexible tip + various combinations of	
		2. Micro-advance	Advancing in mm's, usually with an increasing length of flexible tip
and/or		3. Slack withdrawal	Gastric slack or coil reduces tube stiffness precluding forward advance. Its removal effectively stiffens the tube
		4. Wire stiffener	As above
		5. Prokinetics	As above
Last resort techniques		6. Massage abdomen	Massaging the right upper quadrant in an inwards and upwards direction to move the tube tip over the superior flexure
		7. NGT withdrawal	Pulling the NGT back into the upper stomach to reduce risk of tangling the NI tube or blocking the pylorus

residual volume ≥250 mL in a 4-h period or vomiting, that was refractory to 24-h of treatment with 10 mg IV metoclopramide or, to avoid delayed feeding, if DGE occurred on Friday. Patients who were moribund, had anatomical contraindications or refused consent were declined tube placement. Criteria for patient referral and the equipment used for tube placement remained constant. Guided placement was done using a 140 cm 10FG Cortrak™ tube (Avanos Medical Inc). Cortrak produces a real-time computer trace of the path of an electromagnet within the tube. Anatomical points were interpreted from trace characteristics, previously described.[20–22] This permitted the operator, an ICU dietitian or consultant, to guide tube placement and confirm final position. Tubes left in situ were used for feeding. There were no instances of undetected lung misplacement.

Analysis

Analysis was restricted to a patient's first tube placement to avoid over-representation by repeat placements. Using 'R Studio Version 1.1.463′ most parameters did not meet a normal distribution (Shapiro-Wilk test) so continuous data were analysed using the 2-sided Wilcox rank sum test and presented as median (inter-quartile range, IQR). Categorical variables were analysed using Fisher's exact test. Significance was taken as a $p < 0.05$. These tests were used to check for missing data bias, comparing baseline parameters for patients with versus those without 'techniques' data, and in univariate analysis of associations with tube advancement.

Difficulty in tube advancement and the techniques used to overcome it were analysed at six anatomical points:

(1) Nose,
(2) Pharynx when attempting to enter the oesophagus,
(3) Stomach_upper
(4) Stomach_lower,
(5) Duodenum part-1, particularly the superior flexure and
(6) Intestine from duodenum part-2 to jejunum, particularly the duodenuo-jejunal (DJ) flexure.

For each anatomical point, analysis:

(1) Only included difficult placements, based on operator comment and/or use of a technique to overcome difficulty and/or failure to advance;
(2) Omitted placements where an alternative technique had been used but;
(3) Coded as 'failed placement' when techniques, additional to the one being analysed, were later used.

Univariate analysis was conducted for each technique within its sub-set of placements. If a higher proportion of tube advancement was associated with use of the technique ($p < 0.05$) or the median or proportion of baseline parameters differed depending on use of the technique ($p < 0.2$) these variables were entered into a logistic regression model. Because techniques used at subsequent anatomical points might affect final tube position, these models were binary, reporting associations with advancement, or not, at a specific anatomical point. The exception was the use of ordinal logistic regression to analyse tube advancement from duodenum part-2 to parts -3, -4 or jejunum when using ≥3 techniques where further techniques would not be added. Small sample sizes and/or a zero value for an option sometimes caused logistic regression to fail to separate effects of independent variables and made statistical output unreliable. For this reason we present p-value, OR and 95%CI for univariate analysis, but note where LR failed or where the apparent association between technique and tube advance may be confounded. In all other analyses, even where baseline parameters showed a significant association to technique use, the association between technique and tube advance remained statistically significant. Co-linear variables (variance-inflation factor >5) were omitted from the model.

Baseline parameters included demography (age, estimated or actual height, weight and body mass index [BMI] and gender) and clinical parameters (APACHE two score, disease category, airway and consciousness). Analysis was done in the order techniques were used at a particular anatomical point.

Ethics

Data collection was done as part of a registered UK quality improvement project (QI71316), using standard practice, and therefore did not require ethics board approval.

Results

Study group

913 of 947 primary NI tube placements were analysed; all baseline parameters were similar to the 34 placements with missing data (Appendix 1), including tube placement day ($p = 0.5$) and operator ($p = 0.1$). The referral policy and contemporaneous records for tube placement remained constant during this period, but specific techniques were added over time. Most placements (83.7%) were undertaken for DGE refractory to 24 h of metoclopramide treatment; the remainder were placed for DGE where prokinetic drugs were contraindicated, previously failed or to permit peri-operative feeding.

Lead operator and tube position

Lead operators E and I placed most tubes: A 0.1%, B 2.9%, C 1.4%, D 0.9, E 24.0%, F 0.1%, G 2.4%, H 0.2%, I 67.9.%. Placements failed to go beyond the stomach in 9.4% and duodenum part-1 in 5.8%, but reached the late duodenum or jejunum (79%): In the table below the numbers and % columns need to be aligned for easy reading.

▪ Lung or pharynx	10	1.1%	▪ Duodenum part: 2	25	2.7%
▪ Stomach- upper	19	2.1%	▪ 3	28	3.1%
▪ Stomach- lower	57	6.2%	▪ 4	269	29.5%
▪ Duodenum part: 1	53	5.8%	▪ Jejunum	452	49.5%

Techniques

Use of single and combined techniques (Table 2) increased over time. Although no placement failed at the level of the

Table 2. Associations between technique and tube advancement beyond each anatomical point.

Anatomical point&		*N*		%			OR	95%CI		Confounders entered into LR
Technique	Used	Fail	Success	Fail	Success	*p*-value	—	2.5	97.5	—
Pharynx										
Headtilt ± jaw thrust	no	9	48	15.8	84.2	<0.0001	31.1	3.8	251.7	Conscious (-: 0.006)
±laryngoscopy	yes	1	166	0.6	99.4					
Stomach_upper										
Flexible tip 10 cm	no	177	32	84.7	15.3	<0.0001	4	2.3	7.1	cm (ns)
	yes	50	36	58.1	41.9					
Air insufflation	no	9	4	69.2	30.8	0.0003	7.8	1.9	31.4	None: All (ns)
	yes	9	31	22.5	77.5					
Flexible tip 20–30 cm ±	no	5	5	50	50	<0.0001	51	7.9	330.7	BMI (0.06)
reverse seldinger	yes	2	102	1.9	98.1					
Wire stiffener	no	3	6	33.3	66.7	0.67	1.5	0.3	8.3	Univariate ns
	yes	5	15	25	75					
Stomach_lower										
Air insufflation	no	69	3	95.8	4.2	<0.0001	34.5	10.2	116.9	APACHE 2 score (-, *p*=0.07), cm and disease (ns)
	yes	42	63	40	60					
Flexible tip	no	34	0	100	0	<0.0001	207	7.3	5888.5	LR fails
	yes	1	4	20	80					
Wire stiffener	no	9	0	100	0	<0.0004	37.1	2	701.4	LR fails: age (-:*p*=0.03). Others variables (ns)
	yes	10	20	33.3	66.7					
Lay flat	no	15	20	42.9	57.1	0.047	0.1	0	2	Only 4 interventions; unreliable analysis
	yes	4	0	100	0					
Duodenum part-1										
Slack removal	no	14	2	87.5	12.5	0.03	8.4	1.3	56.1	age and APACHE 2 score (ns)
	yes	5	6	45.5	54.5					
Flexible tip	no	14	2	87.5	12.5	<0.0001	13.3	3	59.1	age and bmi (ns), tracheostomy (*p*=0.07) and trauma (-, *p*=0.007)
	yes	214	406	34.5	65.5					
Flexible+Slack used in analyses below	yes	138								
Flexible tip +										
micro-Advance	no	10	12	45.5	54.5	0.053	4.4	1.1	17.1	Airway (ns); conditional to inclusion, the technique became significant: *p*=0.011
	yes	4	21	16	84					
slack removal	no	10	12	45.5	54.5	<0.0001	14.4	3.4	60.5	Airway (ns)
	yes	3	52	5.5	94.5					
wire stiffener	no	10	12	45.5	54.5	0.004	4.2	1.6	10.8	None: All (ns)
	yes	25	127	16.4	83.6					
Flexible tip+wire stiffener +										
micro-Advance	no	16	14	53.3	46.7	0.054	4.6	1.1	19.7	Airway (ETT), BMI, conscious, disease (ns)
	yes	3	12	20	80					
prokinetic drugs	no	12	18	40	60	0.06	4.2	1	17.4	None: All (ns)
	yes	3	19	13.6	86.4					
slack removal	no	38	14	73.1	26.9	<0.0001	10.6	4.3	26.1	Age and conscious (ns)
	yes	11	43	20.4	79.6					
prokinetic+(micro±slack)	no	19	3	86.4	13.6	<0.0001	59.1	10.8	324.5	None: All (ns)
	yes	3	28	9.7	90.3					
Duodenum part-2 and beyond										
Slack removal	no	36	0	100	0	0.07	15.9	0.7	355.8	Univariate ns
	yes	11	2	84.6	15.4					
Flexible tip	no	36	0	100	0	<0.0001	45	2.7	736.9	LR fails
	yes	362	223	61.9	38.1					
Flexible+Slack used in analyses below	yes	127								
Flexible tip +										
micro-Advance	no	139	8	94.6	5.4	<0.0001	312.8	36.9	2648.2	LR fails
	yes	1	18	5.3	94.7					
slack removal	no	139	5	96.5	3.5	<0.0001	23	8.3	63.7	Airway (0.04), conscious (-, 0.04)
	yes	35	29	54.7	45.3					
wire stiffener	no	139	5	96.5	3.5	<0.0001	38.4	15	98.6	APACHE 2 score, kg and airway (ns)
	yes	71	98	42	58					

Cells showing the total number of difficult placements.

nose or mouth, 30 (3.3%) presented difficulty with advancement. A nasal airway was used to aid advancement in only 5 (0.5%), too few to analyse. In contrast advance from pharynx to oesophagus was difficult in 224 (24.5%) and 97 (10.6%) initially deviated into the respiratory tract before being removed; 10 (1.1%) ultimately failed to advance beyond the pharynx of which 5 had entered the respiratory tract. The preferred sequence of interventions, head tilt > jaw thrust > laryngoscopy, was often precluded by clinical condition. For example, neck trauma might indicate use of a jaw thrust instead of a head tilt. Because interventions did not follow a sequence it was impossible to analyse which intervention affected tube advancement. However, use of 1–3 of these interventions appeared to improve the chance of advancing the tube ($p < 0.0001$) independent of potential confounding associations ('+' = positive, '-' = negative) from an artificial airway (+) or, separately, a conscious state (-).

Of tubes reaching the upper stomach, advancement was difficult in 295 of 903 (32.7%) of placements; 2.1% failed. Sequential use of flexible tip (10 cm) or, where that failed, air insufflation and when that failed a 20–30 cm flexible tip ± reverse Seldinger manoeuvre were all significantly associated with tube advancement ($p < 0.001$) independent of BMI (trend) and other baseline parameters. Prokinetic drugs were not used and use of a wire stiffener was of marginal benefit to tube advancement.

Tubes reaching the lower stomach presented difficulty to advancement in 177 of 884 (20%) of placements; 6.2% failed. In univariate analysis, air insufflation, a flexible tip or stiffener wire were all associated with tube advancement. However, using logistic regression, only air insufflation was independent of the negative association with APACHE two score. Logistic regression including a flexible tip or wire stiffener failed due to small samples and zero successes when not using a technique; confounding is therefore possible for these variables. There were too few interventions of laying the patient flat or prokinetic drug use to analyse these techniques of last resort.

Of tubes reaching duodenum part-1, 785 of 827 (94.9%) of placements presented some difficulty to further advancement; 5.8% failed. Independent associations with tube advancement were found for slack removal ($p = 0.03$) and use of a flexible tip ($p = 0.0001$), after accounting for tracheostomy use (+: $p = 0.07$) and trauma (-: $p = 0.007$). In placements where a flexible tip failed, adding a secondary technique was associated with tube advancement: Micro-advance only reached a trend ($p = 0.05$) but use of slack removal ($p < 0.0001$) or a wire stiffener ($p = 0.004$) were independently associated with tube advancement. When combining a flexible tip and wire stiffener failed, tube advance was independently associated with adding a third technique: Micro-advance ($p = 0.05$) or slack removal ($p < 0.0001$). Addition of prokinetic drugs (erythromycin in all but one), after failure of two or three techniques, was independently associated with tube advancement ($p < 0.0001$). It may be noteworthy that erythromycin was used as a last resort and given as a 20 min IV infusion as advancement was re-attempted 1–2 h later.

There was some difficulty in advancement from duodenum part-2 onwards in 761 of 774 (98.3%); and 2.7% failed to advance from duodenum part-2. Placements involving prokinetic drug use was analysed separately from other techniques because it was started when the tube was in duodenum part-1 in 28 of 32 placements reaching duodenum part-2 or beyond. Univariate analysis showed that slack removal ($p = 0.07$) or use of a flexible tip ($p < 0.0001$) were associated with tube advancement (Table 3), but only 15.4% and 38.1% of tubes, respectively, reached the jejunum. Logistic regression failed to compute so confounding may exist. When single techniques failed, using a second technique (micro-advance, slack removal, wire stiffener) alongside a flexible tip was significantly associated with tube advancement ($p < 0.0001$). Logistic regression failed to compute for micro-advance, so confounding may exist, but confirmed independent associations for slack removal and use of a wire stiffener. When a minimum of two techniques had failed, adding micro-advance or slack removal to use of a flexible tip and a wire stiffener or a prokinetic drug to a flexible tip + 1–3 other techniques, were all independently associated with tube advancement from duodenum part-2 (to part-3, part-4 or jejunum) ($p < 0.0001$). Finally, in the sub-group of placements where a flexible tip and wire stiffener fail, addition of two more techniques out of micro-advancement, prokinetic drug use or slack removal was independently associated with tube advancement ($p < 0.0001$).

Table 3. Association between technique and the distance the tube advances.

Technique	Used	Intestinal position[a]								p-value	OR[b]	95%CI		Confounders entered into LR
		N				%						2.5	97.5	
Flexible tip+		2	3	4	5	2	3	4	5					
wire stiffener+rmicro-advance	No	8	7	60	0	10.7	9.3	80	0	<0.0001	357.7	45.5	2811	APACHE 2 score and conscious (ns)
	Yes	0	0	1	13	0	0	7.1	92.9					
prokinetic drugs+ (micro±slack±wire)	No	9	8	114	62	4.7	4.1	59.1	32.1	<0.0001	13.7	4.6	41	general surgery (-, p=0.009)
	Yes	0	0	4	26	0	0	13.3	86.7					
wire stiffener+slack removal	No	8	7	63	1	10.1	8.9	79.7	1.3	<0.0001	112.1	14.1	891	Sex (male) (p=0.1), APACHE 2 score (ns)
	Yes	0	1	15	23	0	2.6	38.5	59					
wire stiffener+2 of: micro/ prokinetic/slack	No	8	8	83	60	5.4	5.4	56.1	33.1	<0.0001	14.9	1.8	121	APACHE 2 score (- p=0.02)
	Yes	0	0	1	9	0	0	4.8	95.2					

[a]Intestinal position: 2–4 = duodenum parts-2, three or four and 5= jejunum.
[b]OR (95%CI) is based on binary analysis of whether the technique succeeds in jejunal placement.

Discussion

Main findings

Successful tube advancement is highly associated with use of certain techniques. Baseline parameters were similar between placements analysed and the 3.6% for which data were missing. Techniques that may aid tube advancement were analysed only for placements that were difficult: Nose (3.3%), pharynx (24.5%), stomach_upper (32.7%), stomach_lower (20%), duodenum part-1 (94.9%), intestine (98.3%). There were too few techniques used and placement failures to analyse technique efficacy at the level of the nose. However, advancing from the pharynx to the oesophagus appeared to be aided by use of a head tilt, jaw thrust, laryngoscopy or combinations of these. Specific techniques were associated with tube advancement in the stomach_upper (10 cm flexible tip, air insufflation and 20–30 cm flexible tip ± reverse Seldinger manoeuvre), stomach_lower (air insufflation, possibly a flexible tip and wire stiffener) (Figure 1(a)–(d)) and for duodenum part-1 or beyond duodenum part-2 (flexible tip alone or combined with 1–3 techniques: micro-advance, slack removal, wire stiffener and prokinetic drugs when previous techniques failed) (Figure 1(e) and (f)).

Confounding variables

Baseline parameters that were associated with technique use ($p < 0.2$) in one or more analysis were BMI, and presence of an ETT or tracheostomy. Past study has shown that placement can be particularly difficult at GI flexures when a patient's BMI is low, hence a higher BMI may favour easier placement,[23] possibly because flexures are less acute. In addition, presence of an ETT or tracheostomy may be surrogates of deep sedation which improves patient tolerance during prolonged tube placement. Age, APACHE II score, being conscious and trauma were negatively associated with tube advance. APACHE II score was previously associated with advancement failure[24,25] potentially paralleling its association with DGE.[3] In DGE the fundus is typically distended and flaccid causing tube advancement to stall or move anti-clockwise towards the oesophagus. Being conscious reduced patient tolerance while age and trauma may predispose to poor gastric tone and reduced peristalsis.

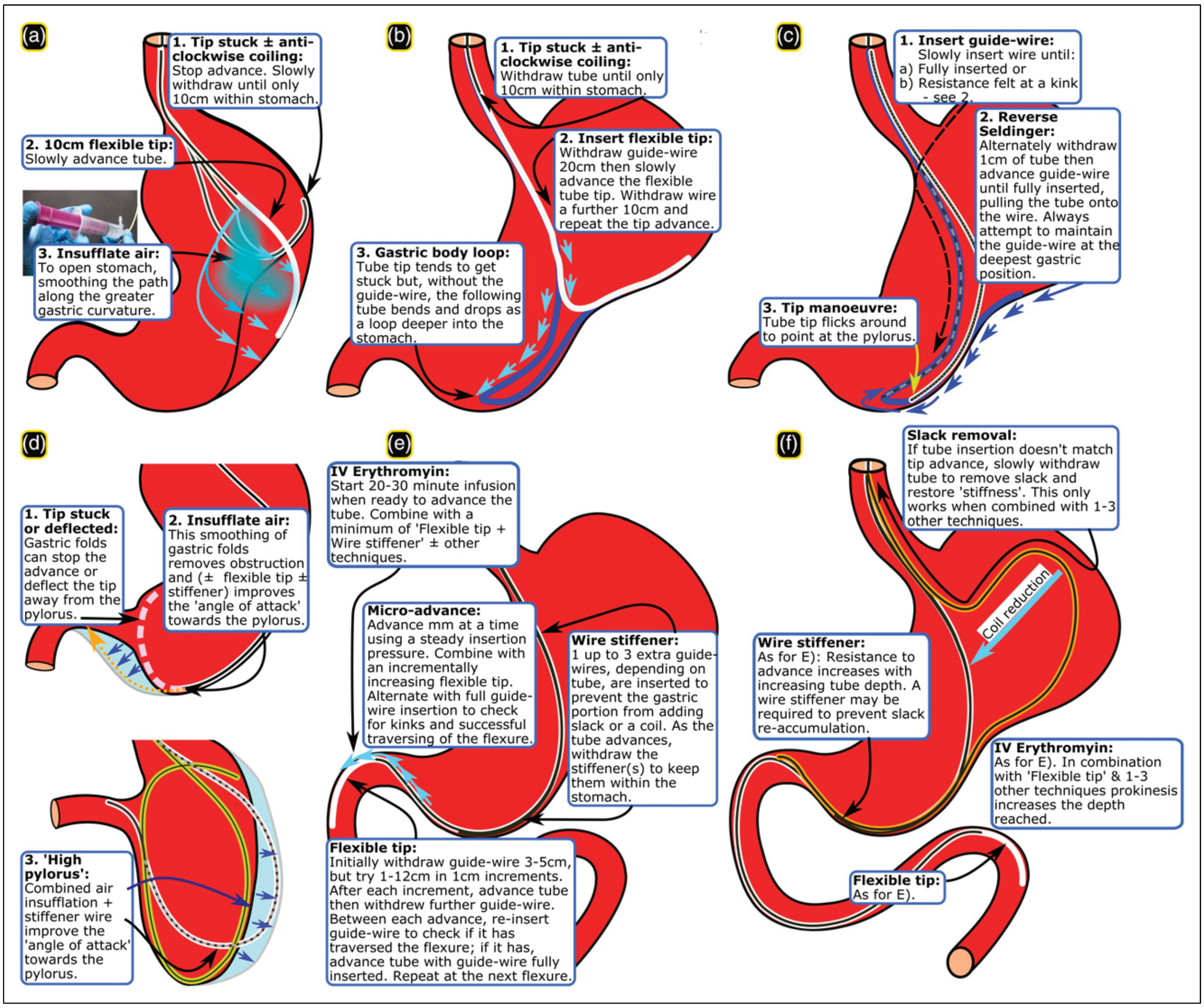

Figure 1. Techniques: (a–c) Upper stomach, (d) Lower stomach, (e) Duodenum part-1, and (f) Intestine. [© Stephen Taylor-with permission].

Technique efficacy by GI level

Stomach_upper. Air insufflation[13,26] and use of a 10 cm or 20–30 cm flexible tip with or without a reverse Seldinger manoeuvre, widen the stomach and permit the flexible tube to deflect past any gastric indentation, respectively. This facilitates movement of the tube tip into the lower stomach.

Stomach_lower

Again, air insufflation appears to help tube advancement by opening a collapsed stomach. Numbers were small, but a flexible tip or wire stiffener may aid tube advancement by deflecting past obstruction or changing the 'angle of attack' towards the pylorus, respectively. We did not employ the right lateral decubitus position or a cork-screwing (tube rotation) manoeuvre with a bent guide-wire.[13-14] This was because a Cortrak receiver unit's position would be difficult to maintain and the electro-magnetic wire easily breaks, respectively. These techniques require testing using different guidance equipment. Too few patients were lay flat or given prokinetic drugs to know their effect.

Duodenum part-1. It appears that use of a flexible tip facilitates tube advance through duodenum part-1 and specifically enabled the tube to slide over the, often acute, superior flexure. When this fails adding one or more of micro-advance, slack removal or wire stiffener appears to aid advance. Micro-advance enables the flexible tip to move around the flexure without kinking and, along with adding one or more wire stiffeners up to the level of the lower stomach, reduces the risk of accumulating a slack loop in the stomach. Removing slack restores the guide-wire rigidity to facilitate forward pressure. Erythromycin infusion started when re-attempting passage of the superior flexure initiates increased peristalsis.[27] Use of 3–4 of the above techniques appear to succeed when single or dual techniques fail. Use of abdominal massage or NG tube removal were too rare to analyse. However, when NG tube insertion was >70 cm, its withdrawal to 50 cm immediately led to NI tube advancement on a few occasions, suggesting that it was blocking duodenum part-1.

Intestine. Successful tube advancement into the jejunum appeared to be aided by the same single, dual and triple techniques as for duodenum part-1 with the exception that slack removal alone only reached a trend. The latter may be due to small numbers. In addition, resistance to advance increases the deeper the tube moves into the intestine. Hence, slack removal alone may not restore enough rigidity to the tube within the stomach to prevent repeated collapse into a coil. Combinations of 3–4 techniques or prokinetic drug use with two or more other techniques was associated with tube advance further into the intestine, regardless of whether the tube reached the jejunum.

Limitations

Tube placement results were from a single hospital, mostly by two operators, with differing experience, over different time periods. It was therefore not possible to exclude the effect of subtle operator-specific differences of technique. However, patient referral criteria and placement equipment were constant, mitigating temporal bias. Most important, except where small sample size or zero values prevented analysis, specific techniques were highly significantly associated with placement success, independent of baseline parameters. These results do not guarantee success or failure of different techniques at specific levels of the alimentary trace, even on the same patient. Rather, the associations are a 'try list' guide for operators. There will be exceptions and techniques often require several attempts even after previous failure. Most of this guidance applies to active tube advancement, not to 'peristaltic' tube placement where prokinetic use may be essential.[28] The predominant use of in-procedure IV erythromycin but not metoclopramide related to metoclopramide use and tachyphylaxis prior to tube placement; others found similar efficacy for these drugs regarding transpyloric migration.[29] Aside from patient position, all discussed techniques could be used in a prone position with two cautions: (a) Head tilt downwards and jaw thrust are more difficult when aiding tube movement into the oesophagus; (b) If using Cortrak™ electromagnetic guidance (EMG), the anterior and lateral traces must be interpreted as mirror and inverted images, respectively; ENvue® EMG doesn't require this. Lastly, the techniques were tested using a 10FG, 140 cm Cortrak tube and may require adaptation where tube characteristics differ. For example, traversing flexures may be more difficult with a wider-bore or stiffer IRIS (Kangaroo™) feeding tube but easier with the more pliant ENvue guide-wire. Conversely lack of stiffness at the level of the stomach more often necessitated stiffening with extra guide-wires. Good internal tube lubrication is essential to manoeuvre the guide-wire. Real-time guidance is needed for timely application of these techniques and has also been used with an IRIS direct vision tube[30] but ENvue is not yet available or tested within the UK.

Description of placement techniques, especially manoeuvres, is largely absent from manufacturer guidance. Operators therefore require clinical permissions to use these techniques within their healthcare settings. However, similar techniques are used during endoscopy. Substitution of the manufacturer guide-wire with a specialist guide-wire, often of different stiffness, is common during fluoroscopic feeding tube placement. Specifically, moving a 'stiffener wire' within a tube would be similar to re-tracing tube position using a near identical Cortrak guide-wire, something that is part of manufacturer guidance.

Conclusion

This is the first study to specify the anatomical level at which single or combined placement techniques may facilitate NI tube placement. Future investigation may examine the efficacy of patient position, flexible tip and wire stiffener use in lower stomach and abdominal massage close to the pyloric, superior duodenal and DJ flexures.

Impact

(1) Delayed gastric emptying (DGE) is common, can be overcome by NI feeding, but tube placement often fails.
(2) Nurses, dietitians, radiographers and medics require expertise to succeed in NI tube placement.
(3) To our knowledge, this is the first paper to determine the efficacy of NI tube placement techniques for each stage of the placement and explicitly describe them in order to disseminate expertise and encourage wider use.
(4) We identify single or combined techniques that may significantly increase the likelihood of tube advancement at each anatomical level.

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Author contributions

S.J. Taylor equally contributed to the conception and design of the research; S.J. Taylor and K. Sayer contributed to the acquisition of the data; P. White and S.J. Taylor contributed to the analysis and interpretation of the data; S.J. Taylor drafted the manuscript. All authors critically revised the manuscript, agree to be fully accountable for ensuring the integrity and accuracy of the work and read and approved the final manuscript.

Declaration of conflicting interest

ST served on a Corpak consultation committee once in 2007 and directed a lecture fee to the Tear Fund Syrian charity 2014.2. ST and KS undertook studies sponsored by Cortrak (now Avanos Medical Inc, 2012–14) and Cardinal Health (2020- current) through North Bristol NHS Trust, but these companies had no part in the planning, execution or publication of the projects.

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IMPORTANT: The UK Health Research Authority recognise this study as an audit not requiring Ethics Board approval. Their email is below and they are willing to be contacted. However, if ICCN still require IRB, please decline the submission and inform me. Because of COVID it would take many months to obtain an IRB approval.

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Appendix 1

Demography, disease, treatment characteristics and NI day: Technique data missing vs obtained.

		Technique data				
		Missing		Obtained		
Parameter	**Detail**	**Median or *n***	***IQR or %**	**Median or *n***	***IQR or %**	***p*-value**
Number	(*n*)	34	3.6	913	96.4	-
Age	Years	56	40–68	53	37–68	0.8
Sex	Male	24	75	655	72	0.5
BMI	kg/m^2	25	23–28	25	23–29	0.9
Height	Cm	174	164–180	175	167–180	0.2
Weight	Kg	76	63–84	78	68–89	0.3
APACHE 2	Score	17	9–23	15	9–21	0.5
Disease*	Medical	10	29	259	28	0.3
	Neurosurgical (non-trauma)	1	2.9	121	13	—
	Surgery (general)	9	27	223	24	—
	Trauma	14	41	310	34	—
Conscious	—	2	6.1	138	15	0.2
Airway	Normal	4	12	129	14	0.9
	Endotracheal	24	71	639	70	—
	Tracheostomy	6	18	145	16	—
NI day	—	5	4–7.3	5	3–8	0.5