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BRIEF ARTICLE

# Percutaneous endoscopic gastrostomy and gastro-oesophageal reflux in neurologically impaired children

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## Abstract

**AIM:** To investigate the effects of percutaneous endoscopic gastrostomy (PEG) feeding on gastro-oesophageal reflux (GOR) in a group of these children using combined intraluminal pH and multiple intraluminal impedance (pH/MII).

**METHODS:** Ten neurologically impaired children underwent 12 h combined pH/MII procedures at least 1 d before and at least 12 d after PEG placement.

**METHODS:** Prior to PEG placement (pre-PEG) a total of 183 GOR episodes were detected, 156 (85.2%) were non-acidic. After PEG placement (post-PEG) a total of 355 episodes were detected, 182 (51.3%) were non-acidic. The total number of distal acid reflux events statistically significantly increased post-PEG placement (pre-PEG total 27, post-PEG total 173, $P$ = 0.028) and the mean distal pH decreased by 1.1 units. The distal reflux index therefore also significantly increased post-PEG [pre-PEG 0.25 (0-2), post-PEG 2.95 (0-40)]. Average proximal pH was lower post-PEG but the within subject difference was not statistically significant ($P$ = 0.058). Median number of non-acid GOR, average reflux height, total acid clearance time and total bolus clearance time were all lower pre-PEG, but not statistically significant.

**CONCLUSION:** PEG placement increases GOR episodes in neurologically impaired children.



**Key words:** Percutaneous endoscopic gastrostomy; Gastro-oesophageal reflux; Multiple intraluminal impedance

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## INTRODUCTION

The enteric nervous system contains more neurones than the spinal cord[1]. Insults to the central nervous system therefore may result in dysfunction of the gastro-intes-

tinal tract such as oro-motor dysfunction, rumination, gastro-oesophageal reflux (GOR), delayed gastric emptying and constipation. All these problems may contribute to feeding difficulties and ultimately sub-optimal nutrition in neurologically impaired children. In children with severe oro-motor dysfunction calorie supplementation of oral feeds is often not successful and adjunctive methods are required in order to achieve adequate nutrient intake. The long-term use of a fine bore nasogastric tube (NGT), though most widely used, has several limitations. These include nasal discomfort, laryngeal irritation and penetration, recurrent pulmonary aspiration, tube blockage, tube displacement, oral aversion and possibly impedance of the progressive maturation of the oral feeding pattern from sucking to chewing[2]. Percutaneous endoscopic gastrostomy (PEG) technique has become increasingly popular for the provision of nutrition in disabled children[3] and there are a variety of commercially available devices of variable lengths and calibres that are suitable even in young children[4].

Several studies have demonstrated the clinical advantages to patients fed *via* PEG when compared with other feeding techniques[5,6]. Randomised comparisons of feeding in patients with dysphagia secondary to neurological impairment, demonstrated that PEG-fed children achieved better weight gain than those fed *via* NGT[7,8]. Post-operative follow up however, is essential to monitor weight gain and the development of GOR[9]. Indeed nutritional rehabilitation using a feeding gastrostomy of disabled children is associated with increased mortality and morbidity secondary to GOR[10].

Oesophageal pH monitoring is regarded as the investigation of first choice in children with unusual presentations of GOR disease (GORD), such as apnoea and recurrent respiratory disease[11-14]. However pH measurements cannot detect GOR in the pH range 4.0-7.0 due to the proximity to the physiological oesophageal pH[15-17] and thus misses many episodes of postprandial reflux in young infants and intragastrically fed children due to neutralisation of gastric contents by milk formula for 1-2 h after a meal. Therefore the term acid (pH < 4) and/or non-acid (pH $\geqslant$ 4) GOR should be preferred over the term GOR. Because GOR-associated symptoms are not necessarily confined to acid GOR, a pH-independent technique, known as multiple intraluminal impedance (MII) has been established[18-21], which detects a typical decrease of electrical impedance (resistance) during the passage of a bolus through a measuring segment. The use of multiple segments along a catheter allows the analysis of movement, direction and height attained by the bolus, making it possible to distinguish antegrade and retrograde bolus movement. Simultaneous use of integrated pH sensors can help determine the pH of the reflux episodes as well.

The aim of this study was to measure GOR in neurologically impaired children before and after insertion of a PEG using the combined pH/MII procedure.

## MATERIALS AND METHODS

The study included 10 neurologically impaired patients (5 male, 5 female), nine being diagnosed with cerebral palsy and one with Down's syndrome. All had severe feeding difficulties requiring long-term nutritional support and were admitted to the Centre for Paediatric Gastroenterology, Royal Free Hospital, London, UK for insertion of a PEG. Patients underwent a daytime 12-h impedance procedure for detection of acid and non-acid GOR before (Pre-PEG) and after (Post-PEG) PEG placement.

### *Pre- and Post-PEG study*

Patients were of median age 4.9 years (range 0.5-16.8 years). Impedance procedure took place 1-79 d (median 1.5 d) prior to PEG placement. All patients were bolus fed of which four patients were fed orally and six were fed *via* NGT during the study.

Patients were of median age 5.3 years (range 0.8-17 years). The impedance procedure took place 12-384 d (median 55 d) after PEG placement, and this represented a pragmatic compromise dependent on parental instruction. All patients were receiving bolus feeds *via* their PEG during the study.

Patients were on the same medication during the pre- and post-PEG impedance procedure; eight were not on any medication influencing gastric pH or motility, one was on omeprazole and cisapride, and one was on ranitidine and Gaviscon®. There was no change in the parent/carer subjective impression of potential reflux-related events or symptoms and no change in the frequency of diagnosis of chest aspiration or infection.

The study protocol was approved by the Royal Free NHS Trust Ethical Review Committee. On the initial visit to the clinic informed consent was obtained from the parent or guardian.

An MII catheter (outer diameter 2 mm) with two pH-sensitive antimony electrodes and seven impedance electrodes (PRZ-062B00013, Sandhill Scientific, Inc., Colorado, USA) was used. Changes in intra-oesophageal impedance were measured along this catheter. The impedance was measured between seven adjacent electrodes (15 mm apart), thus enabling readings to be obtained from 6 impedance channels (6 adjacent electrode pairings). The catheter was passed transnasally and positioned by a height-derived formula[22] with total measuring segments reaching from approximately 1.5 cm above the lower oesophageal sphincter (channel 6) to the upper oesophagus (channel 1). The pH sensors were situated at the level of channel 6, approximately 2 cm above the gastro-oesophageal junction, and at the level of channel 1. The catheter was connected to a Windows 98 personal computer, *via* voltage transducers (Z-Box) that continuously recorded impedance and pH events (Sandhill Scientific, Inc). Impedance and pH signals were sampled at a rate of 50 Hz per channel, as compared to 0.25 Hz in conventional pH-metry. Impedance and pH recordings were made for 12 h.

All impedance recordings were visually analysed for

the typical MII pattern of GOR. This was defined as any retrograde-passing bolus detected by channel 4 with a duration of more than 5 s. The reflux index was calculated for both proximal and distal pH sensors by (percentage of time < pH 4.0/total study duration). The clearance time for a liquid bolus may differ from the time taken for the acid environment to neutralise at the pH sensors. Thus the height reached by each bolus, as well as the volume- and acidity-clearance, was registered for each MII-defined GOR episode. Mean values for all episodes were calculated for each patient. As data from children ($n$ = 10) in pre- and post-PEG groups was not normally distributed, medians are reported for between-group comparisons, and non-parametric tests (Wilcoxon Rank Sum) used in statistical analyses. *A priori* variables selected for comparison were: reflux index (proximal and distal pH), total reflux events, acid-reflux events, non-acid reflux events, bolus height, bolus clearance time and acid clearance time.

## RESULTS

Prior to PEG placement a total of 183 reflux events were detected by the combined pH/MII procedure. 156 (85.2%) were non-acidic and 27 (14.8%) were acidic. Post PEG placement a total of 355 reflux events were detected, of which 182 (51.3%) were non acidic and 173 (48.7%) were acidic.

The total number of reflux events and acid reflux events were significantly lower before PEG placement ($P$ = 0.047 and $P$ = 0.028, respectively) (Table 1). Individual measurements are detailed in Tables 2 and 3. The average minimum distal pH was lower by 1.1 pH units post-PEG placement ($P$ = 0.05) and the distal reflux index was significantly higher, but still within normal limits after the procedure [$P$ = 0.032, reflux index (RI) 0.25% pre-PEG and 2.95% post-PEG].

The percentage of the GOR events reaching the uppermost impedance channel (channel 1) i.e. the pharyngeal space, pre-PEG placement was 56%. Post-procedure this increased significantly to 82%.

The median number of non-acid reflux events per hour, average reflux height, total distal and proximal acid clearance time and total bolus clearance time were all lower pre-PEG placement, but were not significantly different.

The average minimum proximal pH was also lower post-PEG placement but again, this was not statistically significant.

Nutritional improvement occurred between the pre- and post-PEG insertion with a median weight gain of 2.53 kg (range 0.8-7.24 kg).

Table 1 summarises the main results before and after PEG placement.

**Table 1 Summary of pH and multiple intraluminal impedance results before and after percutaneous endoscopic gastrostomy placement**

| Parameter | Pre-PEG | Post-PEG | *P*-value |
|---|---|---|---|
| Total GOR events | 183 | 355 | |
| Median | 17.50 | 39.50 | 0.047 |
| Range | 2-54 | 3-63 | |
| Total number of GOR events reaching uppermost channel 1 | 103 | 290 | |
| Median | 9.00 | 27.00 | 0.022 |
| Range | 1-29 | 1-55 | |
| Total non-acid GOR events | 156 | 182 | |
| Median | 13.00 | 18.00 | 0.610 |
| Range | 2-49 | 3-38 | |
| Total acid GOR events | 27 | 173 | |
| Median | 1.00 | 13.00 | 0.028 |
| Range | 0-11 | 0-50 | |
| Bolus clearance time (s) | | | |
| Median | 13.45 | 13.00 | 0.445 |
| Range | 9-20 | 9-19 | |
| Height (channel) | | | |
| Median | 1.50 | 1.50 | 0.172 |
| Range | 1-3 | 1-2 | |
| Proximal pH | | | |
| Median | 5.70 | 5.15 | 0.058 |
| Range | 5-7 | 4-6 | |
| Distal pH | | | |
| Median | 5.30 | 4.20 | 0.050 |
| Range | 4-6 | 4-5 | |
| Proximal acid clearance time (s) | | | |
| Median | 17.00 | 20.10 | 0.715 |
| Range | 2-320 | 12-33 | |
| Distal acid clearance time (s) | | | |
| Median | 38.70 | 39.50 | 0.500 |
| Range | 10-130 | 26-92 | |
| Proximal reflux index (%) | | | |
| Median | 0.15 | 0.70 | 0.092 |
| Range | 0-0 | 0-11 | |
| Distal reflux index (%) | | | |
| Median | 0.25 | 2.95 | 0.032 |
| Range | 0-2 | 0-40 | |

GOR: Gastro-oesophageal reflux; PEG: Percutaneous endoscopic gastrostomy.

## DISCUSSION

We describe the effect of PEG placement on GOR events in neurologically impaired children with feeding difficulties by using a combined pH and intraluminal impedance measurement.

The use of combined pH and impedance allows detection of both acid (pH < 4) and non-acid (pH ⩾ 4) GOR episodes, as well as the height of the refluxate and the total acid clearance time. In our study 183 reflux events were detected by MII pre-PEG insertion, of which 85.2% were non-acid and would therefore have been undetected using the "gold standard" pH-metry. The total number of GOR episodes more than doubled after PEG insertion. Furthermore, the average distal oesophageal pH was significantly lower after PEG placement. This is clinically relevant as we have shown that an acid reflux event takes longer to clear than a non-acid bolus. Skopnik *et al*[17] in a study of 17 infants using MII, detected that 90% of GOR episodes were non-acid and therefore undetectable by conventional pH-metry.

**Table 2 Individual results of pH and multiple intraluminal impedance results before percutaneous endoscopic gastrostomy placement**

| Patient | Total GOR | Total GOR/h | Total non-acid GOR | Total non-acid GOR/h | Total acid GOR | Total acid GOR/h | Prox RI (%) | Dist RI (%) | Reflux events reaching ch 1 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 24 | 2.00 | 24 | 2.00 | 0 | 0.00 | 0.0 | 0.0 | 18 |
| 2 | 54 | 4.50 | 49 | 4.08 | 5 | 0.42 | 0.2 | 0.4 | 29 |
| 3 | 18 | 1.50 | 13 | 1.08 | 5 | 0.42 | 0.1 | 2.2 | 6 |
| 4 | 7 | 0.58 | 6 | 0.50 | 1 | 0.08 | 0.3 | 0.1 | 6 |
| 5 | 23 | 1.92 | 22 | 1.83 | 1 | 0.08 | 0.2 | 0.5 | 14 |
| 6 | 3 | 0.25 | 2 | 0.17 | 1 | 0.08 | 0.0 | 0.1 | 1 |
| 7 | 19 | 1.58 | 19 | 1.58 | 0 | 0.00 | 0.0 | 0.0 | 9 |
| 8 | 2 | 0.17 | 2 | 0.17 | 0 | 0.00 | 0.0 | 0.0 | 1 |
| 9 | 17 | 1.42 | 6 | 0.50 | 11 | 0.92 | 0.3 | 2.0 | 10 |
| 10 | 16 | 1.33 | 13 | 1.08 | 3 | 0.25 | 0.2 | 1.2 | 9 |

"Ch 1" refers to the most proximal impedance measurement and was located in the pharynx or most proximal 3 cm of oesophagus. GOR: Gastro-oesophageal reflux; RI: Reflux index.

**Table 3 Individual results of pH and multiple intraluminal impedance results after percutaneous endoscopic gastrostomy placement**

| Patient | Total GOR | Total GOR/h | Total non-acid GOR | Total non-acid GOR/h | Total acid GOR | Total acid GOR/h | Prox RI (%) | Dist RI (%) | Reflux events reaching ch 1 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 57 | 4.8 | 7 | 0.58 | 50 | 4.17 | 10.6 | 39.9 | 55 |
| 2 | 48 | 4.0 | 38 | 3.17 | 10 | 0.83 | 2.4 | 3.2 | 41 |
| 3 | 63 | 5.3 | 25 | 2.08 | 38 | 3.17 | 1.2 | 5.6 | 42 |
| 4 | 14 | 1.2 | 11 | 0.92 | 3 | 0.25 | 0.1 | 0.4 | 12 |
| 5 | 3 | 0.3 | 3 | 0.25 | 0 | 0.00 | 0.0 | 0.0 | 1 |
| 6 | 33 | 2.8 | 17 | 1.42 | 16 | 1.33 | 0.2 | 3.6 | 20 |
| 7 | 46 | 3.8 | 27 | 2.25 | 19 | 1.58 | 0.1 | 2.0 | 34 |
| 8 | 49 | 4.1 | 19 | 1.58 | 30 | 2.50 | 6.7 | 10.1 | 47 |
| 9 | 21 | 1.8 | 21 | 1.75 | 0 | 0.00 | 0.0 | 0.0 | 18 |
| 10 | 21 | 1.8 | 14 | 1.17 | 7 | 0.58 | 1.5 | 2.7 | 20 |

"Ch 1" refers to the most proximal impedance measurement and was located in the pharynx or most proximal 3 cm of oesophagus. GOR: Gastro-oesophageal reflux; RI: Reflux index.

Likewise, Wenzl *et al*[23] showed in 50 patients that only 14.9% of MII-determined reflux episodes were acidic, whilst non-acidic reflux events have clearly been temporally associated with unexplained respiratory phenomena[24].

The diagnosis of GOR is more difficult in children with neurological impairment as the characteristic features may be absent. Although GOR may cause pain manifesting as restlessness, abnormal movements or food refusal, these symptoms may be subtle and frequently go undetected in the disabled child. Any operative procedure is a major undertaking with potential complications, particularly in an undernourished child who has recurrent respiratory infections and may have postural deformities. Therefore accurate assessment of GORD and careful patient selection is even more important in these children before PEG insertion, particularly as patients with moderate to severe GOR are already considered unsuitable for the procedure. For this reason, operative gastrostomies are frequently performed in conjunction with a fundoplication in those children with refractory or severe GOR. It has been previously reported[24] that neurologically impaired children may have a reduction in the lower oesophageal sphincter (LOS) pressure, which may predispose not only to GOR, but also to recurrent respiratory infections. This concept was supported by Wenzl *et al*[25] who, in a study evaluating the link between reflux and respiratory phenomena in 22 infants, reported 78% of the reflux episodes causing apnoea to be non-acidic. Changes in gastric motility and lower oesophageal sphincter pressure following gastrostomy tube placement may also account for the observation that clinically significant GOR is detected in 75% of children after insertion of a gastrostomy tube[9]. Therefore the increase in GOR events entering the pharyngeal space from 56% to 82% after the placement of a PEG may have significant clinical implications, suggesting an increased risk of aspiration pneumonia in this vulnerable cohort of children.

None of the patients selected for this study had an abnormal reflux index prior to PEG-placement. Although the post-procedure median reflux index still remained < 4%, the more than 10 fold increase in RI following the procedure suggests that less careful selection of patients for such an intervention may lead to a profound deterioration in GOR. In fact three patients had a RI > 4% post procedure. The detected increase in distal reflux index and total number of acid GOR events, along with the increased height of refluxate is likely to be the result of disordered gastric motility, and hence the delayed

emptying, that arises from the anchoring of the gastric wall to the abdominal wall by the PEG.

Mollitt *et al*[9] observed that, while a gastrostomy tube can greatly improve nutritional status and facilitate care of the neurologically disabled child, postoperative follow-up for the development of GOR was essential. Rehabilitation of nutrition in children with neurological impairment can be associated with an increase in mortality and morbidity secondary to GOR. MII has potentially significant implications in the diagnosis, patient selection and follow-up of neurologically impaired, gastrostomy-fed children who have an increase risk of developing GOR. Indeed, for the first time we are now able to accurately and objectively undertake a physiologically appropriate assessment of GOR which is of particular clinical significance in children with neurological impairment. A more accurate assessment of the pathophysiology of GORD and disturbed gastro-oesophageal motility may allow us to study the effects of treatment modalities such as feed thickeners, proton pump inhibitors and prokinetic agents, which may subsequently improve the efficacy of our therapeutic approach in this complex subgroup of children.

The placement of a PEG in neurologically compromised children needs careful consideration in view of the presented findings. The number and severity of GOR events are likely to increase after the procedure and may lead to significant morbidity in this group of children.

## COMMENTS

### Background

Percutaneous endoscopic gastrostomy (PEG) technique or "non surgical opening in the stomach" has become increasingly popular for the provision of nutrition in disabled children particularly as several studies have demonstrated that PEG-fed children achieved better weight gain than those fed *via* a tube in their stomach *via* the nose (Nasogastric tubes). However, nutritional rehabilitation using a feeding gastrostomy of disabled children is associated with increased mortality and morbidity secondary to gastro-oesophageal reflux (GOR). So far, ph studies were helpful in diagnosing "acid reflux" in these children. However pH measurements cannot detect non acid reflux GOR due to the proximity to the physiological oesophageal pH and hence a pH-independent technique, known as multiple intraluminal impedance (MII) has been established.

### Research frontiers

The aim of this study was to measure GOR in neurologically impaired children before and after insertion of a PEG using the combined pH/MII procedure.

### Innovations and breakthroughs

For the first time the authors were now able to accurately and objectively undertake a physiologically appropriate assessment of acid and non-acid GOR.

### Applications

Using combined pH/MII testing the authors could undertake a physiologically appropriate assessment of gastroesophageal reflux which is of particular clinical significance in children with neurological impairment

### Terminology

MII is a technique which detects a typical decrease of electrical impedance (resistance) during the passage of a bolus through a measuring segment. The use of multiple segments along a catheter allows the analysis of movement, direction and height attained of the bolus, making it possible to distinguish antegrade and retrograde bolus movement.

### Peer review

This is a nice contribution. Subjects were bolus fed during the day of their pH/MII. It is well written paper, with a clear message that PEG feeds in this paediatric subpopulation aggravate or promote reflux.

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