

THE ROLE OF A CONTRAST STUDY  
IN THE INVESTIGATION OF  
PAEDIATRIC GASTROESOPHAGEAL REFLUX  
DISEASE

By

JANICE SEWLALL

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College of Health Sciences

University of KwaZulu-Natal

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As the candidate's supervisor I have approved this thesis for  
submission.

Signed:  Name: R. WIERSMA

Date: 26<sup>th</sup> SEPTEMBER 2018

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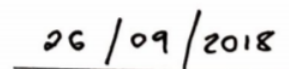
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## Overview of the thesis

Gastroesophageal reflux disease (GERD) is a common problem in the paediatric population. There are various investigations that can be used to confirm the diagnosis of GERD, however there is no single investigation or combination of clinical signs and symptoms that exist as a gold standard in making the diagnosis.

Contrast studies and oesophageal pH monitoring are two tests that are widely used in the management of GERD and these tests are readily available to our department.

The aim of this project was to identify the role of contrast radiography in the investigation of GERD, looking especially at the management of GERD in neurologically impaired (NI) children.

A retrospective departmental database search was performed for all children admitted to our department for the investigation of gastroesophageal reflux from January 2014 to December 2015. The data collected from their charts were demographic data, whether they were neurologically impaired or not, symptoms and reasons for referral, results of the contrast study performed for each child and the surgical decision making based on the contrast study results.

This project showed that contrast radiography has a low sensitivity in diagnosing GER, but is useful in diagnosing anatomical anomalies that either predispose to GER or is a consequence of GER and is also useful in the pre-operative assessment of neurologically impaired children.

In our setting, the contrast radiographic study was an investigation that was easily attainable and provided us with information that we deemed necessary prior to surgical intervention. The oesophageal pH study on its own did not provide enough information with respect to any underlying anomalies causing GER or the complications of GER eg. oesophageal stricture.

Using a combination of contrast radiography and oesophageal pH monitoring as diagnostic tools allowed us to adequately prepare the child for surgical intervention and to counsel the family appropriately.

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# **Part 1: The Review of Literature**

## **INTRODUCTION**

Gastroesophageal reflux (GER) is defined as the involuntary passage of gastric contents into the oesophagus and is a common physiological occurrence in the normal paediatric population. Most episodes of GER in healthy individuals last <3 minutes, occur in the postprandial period and cause few or no symptoms.<sup>1</sup>

Gastroesophageal reflux disease (GERD) occurs when the reflux of gastric contents is accompanied with varying degrees of complications.

The complications are numerous and can be broadly categorised into respiratory and gastrointestinal complications. Children with respiratory complications usually present with acute life threatening events (ALTE) or chronic lower respiratory tract infections. Gastrointestinal (GI) complications range from irritability, abdominal pain and persistent vomiting of milk feeds to oesophagitis, oesophageal strictures, and failure to thrive.

Gastroesophageal reflux, whilst common in infants, usually resolves by 1 year of age.<sup>2</sup> It is when these symptoms persist and complicate that intervention is warranted.

A particular subset of children that seem more predisposed to GERD are those that are neurologically impaired (NI). Contributing factors that increase reflux frequency and delay oesophageal clearance in this subset of patients are chronic supine position, abnormal swallowing, heightened gag reflex, abnormal sensory integration, delayed gastric emptying, constipation, obesity, skeletal abnormalities, abnormal muscle tone, and medication side effects.<sup>1</sup>

There are numerous investigations that can be used to confirm the diagnosis of GERD. Amongst the most commonly used are contrast radiography, oesophageal pH monitoring, combined multiple intraluminal impedance monitoring, oesophagoscopy with biopsy and nuclear scintigraphy or milk scans.

However, there is no consensus on a “gold standard” in the investigation of GERD.

The purpose of this study is to describe the role of a contrast study in the investigation of paediatric gastroesophageal reflux in children presenting to the department of Paediatric

Surgery at Inkosi Albert Luthuli Central Hospital in Durban (IALCH), KwaZulu Natal from January 2014 to December 2015.

A retrospective departmental database search was performed for all patients admitted to the Department of Paediatric Surgery at the IALCH from January 2014 to December 2015. These children were referred from peripheral hospitals in the province of KwaZulu-Natal.

All patients had a contrast study performed as their baseline investigation to detect the presence of GER. Some had a contrast swallow performed and others a contrast meal, this was done randomly. If the contrast study did not demonstrate any reflux, then a 24hr oesophageal pH monitoring study was done.

During the contrast swallow, the swallowing mechanism of the child was examined, especially looking at whether there was any aspiration during swallowing. This was of particular concern in neurologically impaired children who frequently have oropharyngeal swallowing disorders. Other factors that were documented were the presence of gastroesophageal reflux, any anatomical anomalies of the oesophagus such as oesophageal strictures, as well as anatomical anomalies of the stomach such as a hiatal hernia.

A contrast meal, in addition to the above information, also included a report on the presence of delayed gastric emptying and features of gastric outlet obstruction. If the contrast study demonstrated GER then a diagnosis of GERD was made, based on this result and clinical features, and a fundoplication was performed with or without a gastrostomy.

Due to the acknowledged rate of false negatives associated with contrast radiography in demonstrating GERD<sup>1</sup>, if the contrast study was negative for GER then a 24hr pH monitoring study was performed on these children.

The pH probe was inserted under fluoroscopy or during oesophagoscopy in theatre. The tip of the probe was placed a minimum of 2cm above the oesophago-gastric junction and the child was kept in hospital for the duration of the pH monitoring. The pH study was interpreted to be positive for reflux when the calculated De Meester score was  $> 14.72$ .<sup>3</sup>

The data captured from each child's hospital chart was gender, age at presentation, presenting signs and symptoms, neurological status, investigations performed and respective results.

## **DISCUSSION**

Gastroesophageal reflux disease is a common problem in our setting and is being diagnosed and treated more often world-wide.<sup>4</sup> Affected children usually present with respiratory or gastrointestinal symptoms and signs, with the majority of children in our cohort (85%) presenting with difficulty in feeding or vomiting. A significant percentage of the paediatric population referred to us for the investigation of GERD are neurologically impaired.

Diagnosing GERD in paediatric patients is difficult because no gold standard exists. Of the multiple methods of testing for GER and its complications, contrast radiography and oesophageal pH monitoring are two of the most readily available methods to us.

The recent NASPGHAN/ESPGHAN Paediatric Gastroesophageal Reflux Guidelines, in an attempt to summarise the diagnostic dilemma around GERD, stated that tests are useful to document the presence of pathologic reflux or its complications and to establish a causal relation between reflux and symptoms, to evaluate therapy, and to exclude other conditions. However, as no test can address all of these questions, tests must be carefully selected according to the information sought, and the limitations of each test must be recognized.<sup>1</sup>

### ***Contrast Studies***

The contrast study consists of a series of radiographs of the upper GI system using a radiopaque material, either barium or water soluble contrast. The study is captured using fluoroscopy in digitized or video format and allows detailed analysis of the oropharyngeal swallowing process, as well as anomalies of contrast transit through the oesophagus and stomach up to the duodeno-jejunal flexure.

Evaluation of the oropharyngeal swallowing process is of particular importance in neurologically impaired children. In these children that are referred for the insertion of gastrostomy tubes (GT), their ability to swallow is initially assessed by a speech therapist. The contrast study can be used as a valuable adjunct to the assessment made by the speech therapist as well as in determining the potential benefit of various treatment strategies. The study evaluates oral, pharyngeal, laryngeal and upper oesophageal anatomy, and swallow physiology. Neurologically impaired children have abnormal muscle tone, lower lip pressures, abnormal chewing and biting, delayed swallow reflex, and more than 90% of patients have oral motor dysfunction.<sup>5</sup>

The NASPGHAN/ESPGHAN group found that the contrast study is neither sensitive nor specific for diagnosing GER and the upper GI series produces false negative results. However, they also concluded that it is useful in detecting anatomical abnormalities which may be considered in the differential diagnosis of children with symptoms suggesting GERD.<sup>1</sup>

Anatomical anomalies associated with reflux include oesophageal atresia and other congenital abnormalities of the oesophagus, congenital diaphragmatic hernia, hiatal hernia, pyloric stenosis and mid-gut malrotation.<sup>2</sup> GER can either be secondary to an underlying anatomical anomaly e.g. hiatal hernia, or the anomaly seen on contrast study can be the result of GERD e.g. reflux associated oesophageal stricture.

### ***Oesophageal pH monitoring***

The glass, antimony, or ion-sensitive field electrode is inserted through the nostril and is placed a minimum of 2cm above the oesophago-gastric junction. The variables that are monitored during oesophageal pH monitoring are the position of the child i.e. supine or upright, meal times or nil per mouth, total number of reflux episodes, number of reflux episodes lasting longer than five minutes, duration of the longest reflux episode and the reflux index (RI) which is the percentage of the entire record that oesophageal pH is < 4.0. In a pH study performed with an antimony electrode, an RI >7% is considered abnormal, an RI < 3% is considered normal, and an RI between 3-7% is considered indeterminate.<sup>1</sup>

Oesophageal pH monitoring was initially introduced in 1969 and is useful because the upper limit of normal for oesophageal acid exposure (percentage time pH <4) is defined across the age spectrum, however this technique is limited because it can only detect acid reflux.<sup>6</sup> Multichannel intraluminal impedance-pH monitoring, first reported in 1991, allows for detection of liquid or gas, weakly acidic or weakly alkaline reflux as well as direction and height of flow of the reflux. However, it is expensive and limited by lack of normative values in the paediatric population.<sup>6</sup>

In 1995, the indications for paediatric oesophageal pH monitoring were established by the North American Society for Pediatric Gastroenterology and Nutrition. These included the evaluation of atypical symptoms possibly caused by GERD, assessment of the effectiveness of therapy including medication dosage and surgery, patients with unexplained recurrent pneumonia and patients prior to fundoplication.<sup>6</sup>

### *Neurologically impaired children*

Children with severe neurologic impairment often have failure to thrive due to nutritional deficiency and aspiration of pharyngoesophageal contents due to dysphagia and GER. <sup>7</sup> In these children, a GT is commonly used to optimise nutrition and reduce the risk of primary aspiration. However, these children still stand the risk of significant morbidity if they have unaddressed GER which could lead to secondary aspiration.

The decision as to whether to perform a fundoplication concurrently with a gastrostomy versus only performing a fundoplication if the patient becomes symptomatic for GERD post gastrostomy insertion, is controversial. The occurrence or worsening of underlying GER after GT placement has been identified as a possible complication. This may be due to different factors: seriousness of the underlying disease, increase in trans-diaphragmatic pressure during coughing or wheezing in chronic obstructive pulmonary illnesses, type and location of GT, and bolus or continuous feeding or malnutrition. <sup>8</sup> On the other end of the spectrum, antireflux surgery has its own potential serious complications, particularly in neurologically impaired patients. These include dumping syndrome, gas bloat syndrome and dysphagia and is therefore not a procedure to be undertaken lightly. <sup>9</sup> There are various studies that have attempted to address this dilemma.

Ponsky et al<sup>10</sup>, concluded in their study that due to the low incidence (9.1%) of subsequent fundoplication in children who undergo gastrostomy tube placement, conservative use of fundoplication in the absence of complicated reflux is justified. Those with cerebral palsy and anoxic brain injury appeared to have the greatest risk for requiring a subsequent fundoplication. A laparoscopic approach had a negative correlation with the subsequent need for fundoplication.

In a meta-analysis by Livingstone et al<sup>11</sup>, they looked at outcomes following fundoplication with gastrostomy (FG) or percutaneous gastro-jejunostomy (GJ) for GER in NI children. They concluded that there were no differences in incidence of pneumonia (17% vs 19%,  $p = 0.74$ ) or mortality (13% vs 14%,  $p = 0.76$ ). Few deaths were due to procedural complications (1%) or reflux (2%). There was a trend towards more major complications with FG (29%) compared to GJ (12%) (risk ratio = 1.70, 0.85–3.41,  $p = 0.14$ ). Minor complications were more common with GJ (70%) than FG (45%), but this difference was also not statistically significant.

Neurologic impairment was the only factor shown to be positively associated with worsening GERD and need for fundoplication. Age and undernutrition at the time of gastrostomy placement were not significantly associated with either worsening GERD or the need for fundoplication.<sup>9</sup>

The relationship between delayed gastric emptying and operative outcomes post fundoplication, is also controversial. However, it has been shown that patients who developed dysphagia post fundoplication, demonstrated a significantly slower gastric emptying time and greater dysphagia risk index preoperatively.<sup>12</sup> A contrast study demonstrating slower gastric emptying time in these patients would assist in surgical decision making and appropriate patient counselling.

We performed a contrast study in all children referred to us for the insertion of a gastrostomy tube. The study helped us to assess whether the child had pre-existing GER and would benefit from a concurrent fundoplication, as well as to detect if there was any delay in gastric emptying. Bolus feeds via a gastric tube with a missed diagnosis of either of these two conditions could significantly worsen their symptoms.

## **CONCLUSION**

Gastroesophageal reflux disease is a common problem in the paediatric population and even more so in neurologically impaired children. Contrast radiography has a low sensitivity in diagnosing GER but is useful in diagnosing anatomical anomalies that either predispose to GER or are a consequence of GER. When contrast radiography is used as a diagnostic tool, it should be a full upper GI radiographic series consisting of full analysis of the oropharyngeal swallowing process which is of particular concern in neurologically impaired children, as well as evaluation of the oesophagus, stomach, and proximal small bowel to exclude any contributing underlying anomalies. We suggest using an adjuvant study such as 24hr oesophageal pH monitoring when the diagnosis is still in doubt.

## REFERENCES

1. Vandenas Y, Rudolph CD, Di Lorenzo C, Hassal E, Liptak G, Mazur L, et al. Pediatric gastroesophageal reflux clinical practice guidelines: joint recommendations of the North American Society for Pediatric Gastroenterology, Hepatology, and Nutrition (NASPGHAN) and the European Society for Pediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN). *J Pediatr Gastroenterol Nutr.* 2009; 49(4):p498-547
2. Nel, ED. Gastro-oesophageal reflux in infants and children. *S Afr Fam Pract.* 2012; 54(5), p414-417
3. Liakakos T, Karamanolis G, Patapis P, Misiakos E.P. Gastroesophageal Reflux Disease: Medical or Surgical Treatment? *Gastroenterology Research and Practice.* 2009 Article ID 371580, 15 pages doi:10.1155/2009/371580
4. El-Serag HB, Sweet S, Winchester CC, Dent J. (2014) Update on the epidemiology of gastro-oesophageal reflux disease: a systematic review. *Gut.* 2014 **63**:871-880  
doi: 10.1136/gutjnl-2012-304269
5. Julia Gates, George G. Hartnell, Gary D. Gramigna. Videofluoroscopy and swallowing studies for neurologic disease: A primer. *Radiographics.* 2006. Vol 26  
<https://doi.org/10.1148/rg.e22>
6. Myung Seok Shin. Esophageal pH and combined impedance-pH monitoring in children. *Pediatric Gastroenterology, Hepatology & Nutrition.* 2014 Mar; 17(1):13-22  
doi: 10.5223/pghn.2014.17.1.13
7. Bryan Stone, Gabrielle Hester, Daniel Jackson, Troy Richardson, Matt Hall, Ramkiran Gou ripeddi, et al. Effectiveness of Fundoplication or Gastrojejunal Feeding in Children with Neurologic Impairment. *Hospital Pediatrics* Feb 2017, hpeds.2016-0126  
doi: 10.1542/hpeds.2016-0126
8. Gottrand F, Michaud L. Percutaneous endoscopic gastrostomy and gastroesophageal reflux: are we correctly addressing the question? *J Pediatr Gastroenterol Nutr* 2002;35:22-4.

9. Aumar M, Lalanne A, Guimber D, Coopman S, Turck D, Michaud L, et al. Influence of Percutaneous Endoscopic Gastrostomy on Gastroesophageal Reflux Disease in Children, *The Journal of Pediatrics*. 2018. Vol 197, p116-120,  
<https://doi.org/10.1016/j.jpeds.2018.02.003>.
10. Ponsky TA, Gasior AC, Parry J, Sharp SW, Boulanger S, Parry R, et al. Need for subsequent fundoplication after gastrostomy based on patient characteristics. *J Surg Res*. 2013;179:1–4.
11. Livingston, M.H, Shawyer A.C, Rosenbaum P.L, Jones S.A, Walton J.M. Fundoplication and gastrostomy versus percutaneous gastrojejunostomy for gastroesophageal reflux in children with neurologic impairment: A systematic review and meta-analysis. *Journal of Pediatric Surgery*, Vol 50 (5), p707 – 714
12. Loots C, van Herwaarden M.Y, Benninga M.A, et al (2013) Gastroesophageal Reflux, Esophageal Function, Gastric Emptying, and the Relationship to Dysphagia before and after Antireflux Surgery in Children. *J Pediatr* 162:566-73

## **Part 2: A submission ready manuscript**

**Title: The Role of a Contrast study in the Investigation of Paediatric Gastroesophageal Reflux Disease**

**Author:**

**Sewlall J, MBChB, FC Paed Surg(SA)**

Affiliation: Department of Paediatric Surgery, Inkosi Albert Luthuli Central Hospital and School of Clinical Medicine, College of Health Sciences, Nelson R Mandela School of Medicine, University of Kwazulu-Natal, Durban, South Africa

Contact details: Email: [jsewlall@gmail.com](mailto:jsewlall@gmail.com)

**Supervisor:**

**R Wiersma, BSc (Natal), MBChB(Rhod), FRCS(Glas), MMedSc(Natal), PhD(EUR)**

Affiliation: Department of Paediatric Surgery, Inkosi Albert Luthuli Central Hospital and School of Clinical Medicine, College of Health Sciences, Nelson R Mandela School of Medicine, University of Kwazulu-Natal, Durban, South Africa

Contact details: Email: [wiersma@ukzn.ac.za](mailto:wiersma@ukzn.ac.za)

**Corresponding Author: Janice Sewlall**

**Contact Details:**

Email: [jsewlall@gmail.com](mailto:jsewlall@gmail.com)

P.O. Box 455, Mt Edgecombe, Durban, 4091

Tel No: 082 373 4232

**Keywords:** Gastroesophageal reflux, Gastroesophageal reflux disease, Contrast Radiography, pH monitoring, Neurologically Impaired, Gastrostomy, Fundoplication

## ABSTRACT

**Background:** Gastroesophageal reflux (GER) is a common finding in the paediatric population. This can either be physiological reflux or established disease that may require surgical intervention. There is currently no consensus on a gold standard in the diagnosis of gastroesophageal reflux disease (GERD). The purpose of this article is to describe the role of contrast radiography in this process, looking in particular at the subset of neurologically impaired (NI) children.

**Methods:** A retrospective chart review of children admitted for the work-up of GER or for gastrostomy insertion, to the Department of Paediatric Surgery at Inkosi Albert Luthuli Central Hospital (IALCH) from January 2014-December 2015.

**Results:** 42 patients (25 male, 17 female) were admitted during this period. 27(64%) were neurologically impaired. All patients had a contrast study performed. Twenty (48%) contrast studies showed GER. Twenty-two (52%) studies were negative for GER and these children subsequently had oesophageal pH monitoring studies performed. Twelve (55%) pH monitoring studies were positive for GER. Ten (45%) pH studies were negative for GER. The sensitivity of a contrast study to show GER was 62.5%. Anatomical anomalies diagnosed on contrast radiography were hiatal hernias (3), oesophageal strictures (2), situs inversus (1) and pylorospasm (1).

**Conclusions:** Contrast radiography has a low sensitivity in diagnosing GER and adjuvant studies are sometimes necessary. However, it is useful in recognising anatomical anomalies that either predispose to GER or is a consequence of GER. It is a particularly helpful diagnostic tool in the management of neurologically impaired children who require feeding gastrostomy tubes.

## **INTRODUCTION**

Gastroesophageal reflux (GER) is defined as the involuntary passage of gastric contents into the oesophagus and is a common physiological occurrence in the normal paediatric population. Most episodes of GER in healthy individuals last <3 minutes, occur in the postprandial period and cause few or no symptoms. [1]

Gastroesophageal reflux disease (GERD) occurs when the reflux of gastric contents is accompanied with varying degrees of complications.

The complications are numerous and can be broadly categorised into respiratory and gastrointestinal complications. Children with respiratory complications usually present with acute life threatening events (ALTE) or chronic lower respiratory tract infections. Gastrointestinal (GI) complications range from irritability, abdominal pain and persistent vomiting of milk feeds to oesophagitis, oesophageal strictures and failure to thrive.

Gastroesophageal reflux, whilst common in infants, usually resolves by 1 year of age. [2] It is when these symptoms persist and complicate that intervention is warranted.

A particular subset of children that seem more predisposed to GERD are those that are neurologically impaired (NI). Contributing factors that increase reflux frequency and delay oesophageal clearance in this subset of patients are chronic supine position, abnormal swallowing, heightened gag reflex, abnormal sensory integration, delayed gastric emptying, constipation, obesity, skeletal abnormalities, abnormal muscle tone, and medication side effects. [1]

There are numerous investigations that can be used to confirm the diagnosis of GERD. Amongst the most commonly used are contrast radiography, oesophageal pH monitoring, combined multiple intraluminal impedance monitoring, oesophagoscopy with biopsy and nuclear scintigraphy or milk scans.

However, there is no consensus on a “gold standard” in the investigation of GERD.

## **AIM**

To describe the role of contrast radiography in the investigation of GERD, and in particular in neurologically impaired children.

## **METHODS**

A retrospective departmental database search was performed for all patients admitted to the Department of Paediatric Surgery at the Inkosi Albert Luthuli Central Hospital (IALCH) from January 2014 to December 2015. These children were referred from peripheral hospitals in the province of KwaZulu-Natal.

All children (birth-13yrs) admitted for the work-up of gastroesophageal reflux disease, or for insertion of a feeding gastrostomy tube, had their charts reviewed.

All patients had a contrast study performed as their baseline investigation to detect the presence of GER. Some had a contrast swallow performed and others a contrast meal, this was done randomly. If the contrast study did not demonstrate any reflux, then a 24hr oesophageal pH monitoring study was done.

During the contrast swallow, the swallowing mechanism of the child was examined especially looking at whether there was any aspiration during swallowing, this was of particular concern in neurologically impaired children who frequently have oropharyngeal swallowing disorders. Other factors that were documented were the presence of gastroesophageal reflux, any anatomical anomalies of the oesophagus such as oesophageal strictures, as well as anatomical anomalies of the stomach such as a hiatal hernia.

A contrast meal, in addition to the above information also included a report on the presence of delayed gastric emptying and features of gastric outlet obstruction.

If the contrast study demonstrated GER, then a diagnosis of GERD was made based on this result and clinical features, and we proceeded to perform a fundoplication with or without a gastrostomy.

Due to the acknowledged rate of false negatives associated with contrast radiography in demonstrating GERD [1], if the contrast study was negative for GER then we proceeded to perform a 24hr pH monitoring study on these children. If they were on a proton pump inhibitor (PPI), it was stopped at least 48 hrs prior to the study.

The pH probe was inserted under fluoroscopy or during oesophagoscopy in theatre. The tip of the probe was placed a minimum of 2cm above the oesophago-gastric junction and the child

was kept in hospital for the duration of the pH monitoring. The pH study was interpreted to be positive for reflux when the calculated De Meester score was  $> 14.72$ . [3]

The data captured from each child's hospital chart was gender, age at presentation, presenting signs and symptoms, neurological status, investigations performed and respective results.

Research ethics approval for the study was obtained from the UKZN Biomedical Research Ethics Committee (BREC) and from the KZN Department of Health.

## **RESULTS**

The charts of 42 children were evaluated. Of the 42 children, 25 were male and 17 female. Twenty-seven (64%) children were neurologically impaired. The different age groups identified were neonates (4/42), 1m-1yr (13/42), 1yr-5yr (18/42), 5yr-12yr (7/42). The majority of children presented with gastrointestinal symptoms, specifically vomiting and difficulty feeding.

Nineteen children had a contrast swallow as their baseline investigation and the other 23 had a contrast meal performed. Of these, twenty (48%) contrast studies showed GER and these children were offered surgical intervention.

The other twenty-two (52%) did not show any GER on contrast radiography and these children went on to have pH monitoring studies performed. Of the 22 pH monitoring studies, over half of them (12/22) were positive for GER (55%). Ten (45%) studies did not show any GER. The calculated specificity of a contrast study to show GER was 62.5%.

Interestingly, of the 27 neurologically impaired children referred to us, only 4 (14.8%) of them were found to not have any GER on either the contrast radiography or the pH monitoring. These four children had gastrostomy tubes placed without a current fundoplication. Two of these 4 children came back post-gastrostomy with symptoms suggestive of reflux, had GER on repeat contrast radiographic studies and had a fundoplication performed thereafter.

The remaining six children whose combined studies did not show any GER, did not have any surgical intervention performed.

The anatomical anomalies seen on the contrast radiography were hiatal hernias (3), oesophageal strictures (2), situs inversus (1) and pylorospasm (1).

**Results Table 1. n = 42**

Gender	Male	25 (60%)
	Female	17 (40%)
Neurologically impaired		27 (64%)

**Results table 2. Age Groups**

Age	Neonate	04 (10%)
	1m-1y	13 (31%)
	1y-5y	18 (43%)
	5y-12y	07 (17%)

**Table 3. Signs and Symptoms**

Respiratory	Acute life threatening events	2 (5%)
	Lower respiratory tract infections	5 (12%)
Gastrointestinal	Vomiting	12 (29%)
	Failure to Thrive	4 (10%)
	Difficulty feeding	17 (40%)
	Abdominal pain	1 (2%)
	Oesophageal Stricture	2 (5%)

**Table 4. Investigation Results**

Contrast Radiography n = 42	Reflux Positive	20 (48%)
	Reflux Negative	22 (52%)
pH monitoring n = 22	Reflux Positive	12 (55%)
	Reflux Negative	10 (45%)

**Table 5. Anatomical Anomalies**

Anatomical Abnormalities	Hiatus hernia	3
	Oesophageal stricture	1
	Situs inversus	1
	Pylorospasm	1

## **DISCUSSION**

Gastroesophageal reflux disease is a common problem in our setting and is being diagnosed and treated more often world-wide. [4] Affected children usually present with respiratory or gastrointestinal symptoms and signs, with the majority of children in our cohort (85%) presenting with difficulty in feeding or vomiting. A significant percentage of the paediatric population that is referred to us for the investigation of GERD are neurologically impaired.

Diagnosing GERD in paediatric patients is difficult because no gold standard exists. Of the multiple methods of testing for GER and its complications, contrast radiography and oesophageal pH monitoring are two of the most readily available methods to us.

The recent NASPGHAN/ESPGHAN Paediatric Gastroesophageal Reflux Guidelines, in an attempt to summarise the diagnostic dilemma around GERD stated that tests are useful to document the presence of pathologic reflux or its complications and to establish a causal relation between reflux and symptoms, to evaluate therapy, and to exclude other conditions. However, as no test can address all of these questions, tests must be carefully selected according to the information sought, and the limitations of each test must be recognized. [1]

### ***Contrast studies***

The contrast study consists of a series of radiographs of the upper GI system using a radiopaque material, either barium or water soluble. The study is captured using fluoroscopy in digitized or video format and allows detailed analysis of the oropharyngeal swallowing process, as well as anomalies of contrast transit through the oesophagus and stomach up to the duodeno-jejunal flexure.

Evaluation of the oropharyngeal swallowing process is of particular importance in neurologically impaired children. In these children that are referred for the insertion of gastrostomy tubes (GT), their ability to swallow is initially assessed by a speech therapist. The contrast study can be used as a valuable adjunct to the assessment made by the speech therapist as well as in determining the potential benefit of various treatment strategies. The study evaluates oral, pharyngeal, laryngeal and upper oesophageal anatomy, and swallow physiology. Neurologically impaired children have abnormal muscle tone, lower lip pressures, abnormal chewing and biting, delayed swallow reflex, and more than 90% of patients have oral motor dysfunction. [5]

The NASPGHAN/ESPGHAN group found that the contrast study is neither sensitive nor specific for diagnosing GER and the upper GI series produces false negative results. However, they also concluded that it is useful in detecting anatomical abnormalities which may be considered in the differential diagnosis of children with symptoms suggesting GERD. [1]

Anatomical anomalies associated with reflux include oesophageal atresia and other congenital abnormalities of the oesophagus, congenital diaphragmatic hernia, hiatal hernia, pyloric stenosis and mid-gut malrotation. [2]

GER can either be secondary to an underlying anatomical anomaly e.g. hiatal hernia, or the anomaly seen on contrast study can be the result of GERD e.g. reflux associated oesophageal stricture.

### ***Oesophageal pH monitoring***

The glass, antimony, or ion-sensitive field electrode is inserted through the nostril and is placed a minimum of 2cm above the oesophago-gastric junction. The variables that are monitored during oesophageal pH monitoring are the position of the child i.e. supine or upright, meal times or nil per mouth, total number of reflux episodes, number of reflux episodes lasting longer than 5 minutes, duration of the longest reflux episode and the reflux index (RI) which is the percentage of the entire record that oesophageal pH is < 4.0. In a pH study performed with an antimony electrode, an RI >7% is considered abnormal, an RI < 3% is considered normal, and an RI between 3-7% is considered indeterminate. [1]

Oesophageal pH monitoring was initially introduced in 1969 and is useful because the upper limit of normal for oesophageal acid exposure (percentage time pH <4) is defined across the age spectrum, however this technique is limited because it can only detect acid reflux. [6]

Multichannel intraluminal impedance-pH monitoring, first reported in 1991, allows for detection of liquid or gas, weakly acidic or weakly alkaline reflux as well as direction and height of flow of the reflux. However, it is expensive and limited by lack of normative values in the paediatric population. [6]

In 1995, the indications for paediatric oesophageal pH monitoring were established by the North American Society for Pediatric Gastroenterology and Nutrition. These included the evaluation of atypical symptoms possibly caused by GERD, assessment of the effectiveness of therapy including medication dosage and surgery, patients with unexplained recurrent pneumonia and patients prior to fundoplication. [6]

### ***Neurologically impaired children***

A significant number of our cohort were NI children (64%). These children were either referred to us for symptomatic GER or for insertion of gastrostomy tubes or both.

Children with severe neurologic impairment often have failure to thrive due to nutritional deficiency and aspiration of pharyngoesophageal contents due to dysphagia and GER. [7] In these children, a GT is commonly used to optimise nutrition and reduce the risk of primary aspiration. However, these children still stand the risk of significant mortality and morbidity if they have unaddressed GER which could lead to secondary aspiration.

The decision as to whether to perform a fundoplication concurrently at the time of gastrostomy insertion versus only performing a fundoplication if the patient becomes symptomatic for GERD post gastrostomy insertion, is controversial. The occurrence or worsening of underlying GER after GT placement has been identified as a possible complication. This may be due to different factors: seriousness of the underlying disease, increase in trans-diaphragmatic pressure during coughing or wheezing in chronic obstructive pulmonary illnesses, type and location of GT, and bolus or continuous feeding or malnutrition. [8] On the other end of the spectrum, antireflux surgery can have serious complications, particularly in neurologically impaired patients including dumping syndrome, gas bloat syndrome and dysphagia and should therefore not be undertaken lightly. [9] There are various studies that have attempted to address this dilemma.

Ponsky et al [10], concluded in their study that due to the low incidence (9.1%) of subsequent fundoplication in children who undergo gastrostomy tube placement, conservative use of fundoplication in the absence of complicated reflux is justified. Those with cerebral palsy and

anoxic brain injury appeared to have the greatest risk of the need for subsequent fundoplication. A laparoscopic approach had a negative correlation with the subsequent need for fundoplication.

In a meta-analysis by Livingstone et al [11], they looked at outcomes following fundoplication and gastrostomy (FG) or percutaneous gastro-jejunostomy (GJ) for GER in NI children. They concluded that there were no differences in rates of pneumonia (17% vs 19%,  $p = 0.74$ ) or mortality (13% vs 14%,  $p = 0.76$ ). Few deaths were due to procedural complications (1%) or reflux (2%). There was a trend towards more major complications with FG (29%) compared to GJ (12%) (risk ratio = 1.70, 0.85–3.41,  $p = 0.14$ ). Minor complications were more common with GJ (70%) than FG (45%), but this difference was also not statistically significant.

Neurologic impairment was the only factor shown to be positively associated with both worsening GERD and need for fundoplication. Age and undernutrition at gastrostomy placement were not significantly associated with either worsening GERD or the need for fundoplication. [9]

The relationship between delayed gastric emptying and operative outcomes post fundoplication, is also controversial. However, it has been shown that patients who developed dysphagia post fundoplication, demonstrated a significantly slower gastric emptying time and greater dysphagia risk index preoperatively. [12] A contrast study demonstrating slower gastric emptying time in these patients would assist in surgical decision making and appropriate patient counselling.

We performed a contrast study in all children referred to us for the insertion of a gastrostomy tube. The study helped us to assess whether the child had pre-existing GER and would benefit from a fundoplication at the same sitting, as well as to detect if there was any delay in gastric emptying. Bolus feeds via a gastric tube with a missed diagnosis of either of these two conditions could significantly worsen their symptoms.

Of the four NI children that had gastrostomy tubes placed without a concurrent fundoplication, two of them became symptomatic for GER and had a fundoplication performed as a subsequent procedure.

Our findings correlated with that of the NASPGHAN/ESPGHAN Paediatric GER guidelines and showed that contrast radiography had a low sensitivity (62.5%) as a diagnostic test for

gastroesophageal reflux. However, these were non-invasive tests that were useful in diagnosing anatomical anomalies and in the pre-operative assessment of neurologically impaired children.

In our setting, the contrast radiographic study was an investigation that was easily attainable and provided us with information that we deemed necessary prior to surgical intervention. The oesophageal pH study on its own did not provide enough information with respect to any underlying anomalies causing GER or the complications of GER eg. oesophageal stricture.

Using a combination of contrast radiography and oesophageal pH monitoring as diagnostic tools allowed us to adequately prepare the child for surgical intervention and counsel the family appropriately.

## **CONCLUSION**

Gastroesophageal reflux disease is a common problem in the paediatric population and even more so in neurologically impaired children. Contrast radiography has a low sensitivity in diagnosing GER but is useful in diagnosing anatomical anomalies that either predispose to GER or is a consequence of GER. When contrast radiography is used as a diagnostic tool, it should be a full upper GI radiographic series consisting of full analysis of the oropharyngeal swallowing process which is of particular concern in neurologically impaired children, as well as evaluation of the oesophagus, stomach, and proximal small bowel to exclude any contributing underlying anomalies. We suggest using an adjuvant study such as 24hr oesophageal pH monitoring when the diagnosis is still in doubt.

## REFERENCES

1. Vandenas Y, Rudolph CD, Di Lorenzo C, Hassal E, Liptak G, Mazur L, et al. Pediatric gastroesophageal reflux clinical practice guidelines: joint recommendations of the North American Society for Pediatric Gastroenterology, Hepatology, and Nutrition (NASPGHAN) and the European Society for Pediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN). *J Pediatr Gastroenterol Nutr.* 2009; 49(4):p498-547
2. Nel, ED. Gastro-oesophageal reflux in infants and children. *S Afr Fam Pract.* 2012; 54(5), p414-417
3. Liakakos T, Karamanolis G, Patapis P, Misiakos E.P. Gastroesophageal Reflux Disease: Medical or Surgical Treatment? *Gastroenterology Research and Practice.* 2009 Article ID 371580, 15 pages doi:10.1155/2009/371580
4. El-Serag HB, Sweet S, Winchester CC, Dent J. (2014) Update on the epidemiology of gastro-oesophageal reflux disease: a systematic review. *Gut.* 2014 **63**:871-880  
doi: 10.1136/gutjnl-2012-304269
5. Julia Gates, George G. Hartnell, Gary D. Gramigna. Videofluoroscopy and swallowing studies for neurologic disease: A primer. *Radiographics.* 2006. Vol 26  
<https://doi.org/10.1148/rg.e22>
6. Myung Seok Shin. Esophageal pH and combined impedance-pH monitoring in children. *Pediatric Gastroenterology, Hepatology & Nutrition.* 2014 Mar; 17(1):13-22  
doi: 10.5223/pghn.2014.17.1.13
7. Bryan Stone, Gabrielle Hester, Daniel Jackson, Troy Richardson, Matt Hall, Ramkiran Gou ripeddi, et al. Effectiveness of Fundoplication or Gastrojejunal Feeding in Children with Neurologic Impairment. *Hospital Pediatrics* Feb 2017, hpeds.2016-0126  
doi: 10.1542/hpeds.2016-0126
8. Gottrand F, Michaud L. Percutaneous endoscopic gastrostomy and gastroesophageal reflux: are we correctly addressing the question? *J Pediatr Gastroenterol Nutr* 2002;35:22-4.

9. Aumar M, Lalanne A, Guimber D, Coopman S, Turck D, Michaud L, et al. Influence of Percutaneous Endoscopic Gastrostomy on Gastroesophageal Reflux Disease in Children, *The Journal of Pediatrics*. 2018. Vol 197, p116-120,  
<https://doi.org/10.1016/j.jpeds.2018.02.003>.
10. Ponsky TA, Gasior AC, Parry J, Sharp SW, Boulanger S, Parry R, et al. Need for subsequent fundoplication after gastrostomy based on patient characteristics. *J Surg Res*. 2013;179:1–4.
11. Livingston, M.H, Shawyer A.C, Rosenbaum P.L, Jones S.A, Walton J.M. Fundoplication and gastrostomy versus percutaneous gastrojejunostomy for gastroesophageal reflux in children with neurologic impairment: A systematic review and meta-analysis. *Journal of Pediatric Surgery*, Vol 50 (5), p707 – 714
12. Loots C, van Herwaarden M.Y, Benninga M.A, et al (2013) Gastroesophageal Reflux, Esophageal Function, Gastric Emptying, and the Relationship to Dysphagia before and after Antireflux Surgery in Children. *J Pediatr* 162:566-73

## **List of Abbreviations**

UKZN: University of KwaZulu Natal

IALCH: Inkosi Albert Luthuli Central Hospital

GER: Gastroesophageal reflux

GERD: Gastroesophageal reflux disease

ALTE: Acute life threatening events

NI: Neurologically impaired

GT: Gastrostomy tube

GI: Gastrointestinal

RI: Reflux index

PPI: Proton pump inhibitor

**Appendix 1: The final Study Protocol**

**THE ROLE OF A CONTRAST STUDY  
IN THE INVESTIGATION OF PAEDIATRIC  
GASTROESOPHAGEAL REFLUX DISEASE**

**JANICE SEWLALL**

**DEPT OF PAEDIATRIC SURGERY**

**IALCH, UKZN**

**STUDENT No: 200306396**

**SUPERVISOR: MR RINUS WIERSMA**

**CO-SUPERVISOR: MR ASHWINI MAHARAJ**

**List of Abbreviations**

UKZN: University of KwaZulu Natal

IALCH: Inkosi Albert Luthuli Central Hospital

GER: Gastroesophageal reflux

GERD: Gastroesophageal reflux disease

## INTRODUCTION

Gastroesophageal reflux is defined as the involuntary passage of gastric contents into the oesophagus and is a common physiological occurrence in the normal paediatric population. Most episodes of GER in healthy individuals last <3 minutes, occur in the postprandial period, and cause few or no symptoms.<sup>1</sup>

Gastroesophageal reflux disease occurs when the reflux of gastric contents is accompanied with varying degrees of complications.

The complications seen at our unit are numerous and range from irritability with abdominal pain, persistent vomiting of milk feeds, oesophagitis and oesophageal strictures to the more serious failure to thrive, chronic lower respiratory tract infections, and acute life threatening events.

Gastroesophageal reflux whilst common in infants, usually resolves by 1 year of age.<sup>2</sup> It is when these symptoms persist and complicate that intervention is warranted.

Lifestyle changes are emphasized as first-line therapy in both GER and GERD, whereas medication is indicated only for patients with GERD.<sup>4</sup>

It is common practice for treatment to be initiated based solely upon thorough history taking and physical examination, or rather the lack of any clinical findings on physical examination to suggest an alternate diagnosis. These patients are generally managed successfully by the paediatrician.

However, should conservative management prove to be ineffective or complications worsen, these children are often referred to the paediatric surgeon for further investigation prior to surgical intervention.

At this stage in management, it is necessary to have investigations that show that not only does gastroesophageal reflux occur but is also the cause of the problem.

There are numerous investigations that can be used to confirm the diagnosis of GERD. Amongst the most commonly used are contrast studies, oesophageal pH monitoring, Combined Multiple Intraluminal Impedance monitoring, oesophagoscopy and biopsy and Nuclear Scintigraphy or Milk Scans.

However, there is no consensus on a “gold standard” in the investigation of GERD, and therefore institutions either use what is most practical, available to them, or refer these children elsewhere.

The purpose of this article serves to describe the role of a contrast study in the investigation of GERD.

### **Aim**

To describe the role of a contrast study in the investigation of GERD, and in particular in neurologically impaired children.

### **Study design**

A retrospective descriptive study.

### **Study location**

The study will be conducted at the Department of Paediatric Surgery at IALCH (tertiary level health care facility). This department serves the public health care sector of the Province of Kwa-Zulu Natal and a part of the Eastern Cape.

### **Study population**

All children, ages 0-13years, referred to the department of Paediatric Surgery at IALCH, between January 2014 - December 2015, for the investigation of GERD.

### **Inclusion / Exclusion criteria**

Patient files with incomplete data were excluded.

### **Method**

Department database search from January 2014 to December 2015.

Patient charts were analysed for all children (ages: birth – 13years) referred for the work up of gastroesophageal reflux disease.

## Declaration

This research protocol is my original work submitted to The University of KwaZulu-Natal as part of the requirements to fulfil the degree MMed (Paediatric Surgery).

## REFERENCES

1. Vandenas Y, Rudolph CD, Di Lorenzo C, et al. Pediatric gastroesophageal reflux clinical practice guidelines: joint recommendations of the North American Society for Pediatric Gastroenterology, Hepatology, and Nutrition (NASPGHAN) and the European Society for Pediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN). *J Pediatr Gastroenterol Nutr.* 2009;49(4):498-547.
2. Nel, ED. (2012). Gastro-oesophageal reflux in infants and children. *S Afr Fam Pract* . 54 (5), p414-417.
3. Terblanche, Alta. (2011). Gastro-oesophageal reflux disease in paediatric patients. *S Afr Pharm J.* 78 (7), p24-26.
4. Jenifer R. Lightdale, MD, MPH, David A. Gremse, MD. (2013). Gastroesophageal Reflux: Management Guidance for the Pediatrician. *Paediatrics.* 131 (5), e1684-1695.
5. Macharia (2012). Comparison of upper gastrointestinal contrast studies and pH/impedance tests for the diagnosis of childhood gastro-oesophageal reflux, *Pediatr Radiol.* 42:946–951.
6. Steven J. Czinn, Samra Blanchard. (2013). Gastroesophageal Reflux Disease in Neonates and Infants. When and How to Treat. *Pediatr Drugs.* 15:19–27.
7. Frankie B. Fike, Vincent E. Mortellaro et al (2011). Diagnosis of gastroesophageal reflux disease in infants, *Pediatr Surg Int* 27:791–797.

## **Appendix 2: The Guidelines for Authorship for the Journal selected for submission of the manuscript**

### Instructions for Authors

#### MANUSCRIPT SUBMISSION

#### Manuscript Submission

Submission of a manuscript implies: that the work described has not been published before; that it is not under consideration for publication anywhere else; that its publication has been approved by all co-authors, if any, as well as by the responsible authorities – tacitly or explicitly – at the institute where the work has been carried out. The publisher will not be held legally responsible should there be any claims for compensation.

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Please follow the hyperlink “Submit online” on the right and upload all of your manuscript files following the instructions given on the screen.

#### Title Page

The title page should include:

- The name(s) of the author(s)
- A concise and informative title
- The affiliation(s) and address(es) of the author(s)
- The e-mail address, telephone and fax numbers of the corresponding author

#### Abstract

An abstract should precede the main text of each Review Article, Original Article, Technical Innovation, and Case Report. For an Original Article (max. 200 words) the abstract should be structured, i.e. divided into four paragraphs headed Purpose, Methods, Results, and Conclusion. For a Review Article (max. 200 words), Technical Innovation (max. 50 words), or Case Report (approx. 50 words), the abstract should be unstructured, i.e. in one paragraph without subheadings.

#### Keywords

Please provide 4 to 6 keywords which can be used for indexing purposes.

#### Text Formatting

Manuscripts should be submitted in Word.

- Use a normal, plain font (e.g., 10-point Times Roman) for text.
- Use italics for emphasis.
- Use the automatic page numbering function to number the pages.
- Do not use field functions.
- Use tab stops or other commands for indents, not the space bar.
- Use the table function, not spreadsheets, to make tables.

- Use the equation editor or MathType for equations.
- Save your file in docx format (Word 2007 or higher) or doc format (older Word versions).

Manuscripts with mathematical content can also be submitted in LaTeX.

- [LaTeX macro package \(zip, 182 kB\)](#)

## Headings

Please use no more than three levels of displayed headings.

## Abbreviations

Abbreviations should be defined at first mention and used consistently thereafter.

## Footnotes

Footnotes can be used to give additional information, which may include the citation of a reference included in the reference list. They should not consist solely of a reference citation, and they should never include the bibliographic details of a reference. They should also not contain any figures or tables.

Footnotes to the text are numbered consecutively; those to tables should be indicated by superscript lower-case letters (or asterisks for significance values and other statistical data). Footnotes to the title or the authors of the article are not given reference symbols.

Always use footnotes instead of endnotes.

## Acknowledgments

Acknowledgments of people, grants, funds, etc. should be placed in a separate section on the title page. The names of funding organizations should be written in full.

## Citation

Reference citations in the text should be identified by numbers in square brackets. Some examples:

1. Negotiation research spans many disciplines [3].
2. This result was later contradicted by Becker and Seligman [5].
3. This effect has been widely studied [1-3, 7].

## Reference list

The list of references should only include works that are cited in the text and that have been published or accepted for publication. Personal communications and unpublished works should only be mentioned in the text. Do not use footnotes or endnotes as a substitute for a reference list.

The entries in the list should be numbered consecutively.

### TABLES

- All tables are to be numbered using Arabic numerals.
- Tables should always be cited in text in consecutive numerical order.
- For each table, please supply a table caption (title) explaining the components of the table.
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## COMPLIANCE WITH ETHICAL STANDARDS

To ensure objectivity and transparency in research and to ensure that accepted principles of ethical and professional conduct have been followed, authors should include information regarding sources of funding, potential conflicts of interest (financial or non-financial), informed consent if the research involved human participants, and a statement on welfare of animals if the research involved animals.

Authors should include the following statements (if applicable) in a separate section entitled “Compliance with Ethical Standards” when submitting a paper:

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- Research involving Human Participants and/or Animals
- Informed consent

Please note that standards could vary slightly per journal dependent on their peer review policies (i.e. single or double blind peer review) as well as per journal subject discipline. Before submitting your article check the instructions following this section carefully.

The corresponding author should be prepared to collect documentation of compliance with ethical standards and send if requested during peer review or after publication.

The Editors reserve the right to reject manuscripts that do not comply with the above-mentioned guidelines. The author will be held responsible for false statements or failure to fulfill the above-mentioned guidelines.

## DISCLOSURE OF POTENTIAL CONFLICTS OF INTEREST

Authors must disclose all relationships or interests that could have direct or potential influence or impart bias on the work. Although an author may not feel there is any conflict, disclosure of relationships and interests provides a more complete and transparent process, leading to an accurate and objective assessment of the work. Awareness of a real or perceived conflicts of interest is a perspective to which the readers are entitled. This is not meant to imply that a financial relationship with an organization that sponsored the research or compensation received for consultancy work is inappropriate. Examples of potential conflicts of interests **that are directly or indirectly related to the research** may include but are not limited to the following:

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- Support from a project sponsor
- Position on advisory board or board of directors or other type of management relationships
- Multiple affiliations
- Financial relationships, for example equity ownership or investment interest
- Intellectual property rights (e.g. patents, copyrights and royalties from such rights)
- Holdings of spouse and/or children that may have financial interest in the work

In addition, interests that go beyond financial interests and compensation (non-financial interests) that may be important to readers should be disclosed. These may include but are not limited to personal relationships or competing interests directly or indirectly tied to this research, or professional interests or personal beliefs that may influence your research.

The corresponding author collects the conflict of interest disclosure forms from all authors. In author collaborations where formal agreements for representation allow it, it is sufficient for the corresponding author to sign the disclosure form on behalf of all authors.

The corresponding author will include a summary statement in the text of the manuscript in a separate section before the reference list, that reflects what is recorded in the potential conflict of interest disclosure form(s).

See below examples of disclosures:

**Funding:** This study was funded by X (grant number X).

**Conflict of Interest:** Author A has received research grants from Company A. Author B has received a speaker honorarium from Company X and owns stock in Company Y. Author C is a member of committee Z.

If no conflict exists, the authors should state:

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

## Appendix 3: Ethical approval



20 September 2018

Dr J Sewlall (200306396)  
School of Clinical Medicine  
College of Health Sciences  
[jsewfall@gmail.com](mailto:jsewfall@gmail.com)

Protocol: "The role of contrast study in the investigation of paediatric gastroesophageal reflux disease"  
BREC Ref No: BE594/17 Degree: MMed

### EXPEDITED APPLICATION: APPROVAL LETTER

A sub-committee of the Biomedical Research Ethics Committee has considered and noted your application received on 05 October 2017.

The study was provisionally approved pending appropriate responses to queries raised. Your response received on 10 September 2018 to BREC letter dated 15 November 2017 have been noted by a sub-committee of the Biomedical Research Ethics Committee. The conditions have now been met and the study is given full ethics approval and may begin as from 20 September 2018. Please ensure that site permissions are obtained and forwarded to BREC for approval before commencing research at a site.

This approval is valid for one year from **20 September 2018**. To ensure uninterrupted approval of this study beyond the approval expiry date, an application for recertification must be submitted to BREC on the appropriate BREC form 2-3 months before the expiry date.

Any amendments to this study, unless urgently required to ensure safety of participants, must be approved by BREC prior to implementation.

Your acceptance of this approval denotes your compliance with South African National Research Ethics Guidelines (2015), South African National Good Clinical Practice Guidelines (2006) (if applicable) and with UKZN BREC ethics requirements as contained in the UKZN BREC Terms of Reference and Standard Operating Procedures, all available at <http://research.ukzn.ac.za/Research-Ethics/Biomedical-Research-Ethics.aspx>.

BREC is registered with the South African National Health Research Ethics Council (REC-290408-009). BREC has US Office for Human Research Protections (OHRP) Federal-wide Assurance (FWA 678).

The sub-committee's decision will be noted by a full Committee at its next meeting taking place on **09 October 2018**.

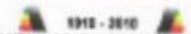





We wish you well with this study. We would appreciate receiving copies of all publications arising out of this study.

Yours sincerely

  
Prof V Rambiritch  
Chair, Biomedical Research Ethics Committee

cc: [janip@ukzn.ac.za](mailto:janip@ukzn.ac.za) [stecma@ukzn.ac.za](mailto:stecma@ukzn.ac.za) [ashw@imh@ukzn.ac.za](mailto:ashw@imh@ukzn.ac.za)

Biomedical Research Ethics Committee  
Professor V Rambiritch (Chair)  
Westville Campus, Govan Mbeki Building  
Postal Address: Private Bag X54001, Durban 4000  
Telephone: +27 (0) 31 260 2406 Facsimile: +27 (0) 31 260 4809 Email: [imes@ukzn.ac.za](mailto:imes@ukzn.ac.za)  
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## Appendix 4: Data collection tools

### DATA SHEET

NAME:

AGE:

SEX:

HOSPITAL NO:

DATE OF ADMISSION:

DIAGNOSIS:

CONTRAST STUDY DONE: Y/N

IF YES, RESULT:

PH MONITORING DONE: Y/N

IF YES, RESULT:

OUTCOME:

## Appendix 5: Raw data

Name	DOB	Sex	KZ No	Age at Sx	DOA	S+S	Diagnosis	Swallow + MEAL	Result	pH Monitor	Result	Operation	Date of OP	Outcome
	08/08/2012	M		1y4m			vomiting Neurologically impaired with GERD	Swallow only: 14/02/2014	Minimal reflux. No comment on GOO	No	N/A	Thal fundoplication	13/12/2013	Nissen fundoplication
	28/08/2011	F		3y5m	28/01/2015	malnourished	Neurologically impaired with GERD	Sw + Meal : Base	Reflux up to cervical oesophagus, good emptying of stomach	NO	N/A	Laparoscopic Nissen Fundoplication + Gi	29/01/2015	1m F/U: Nil compl
	24/05/2012	F		2y5m			Vomiting Severe Acute Malnutrition	Sw + Meal : 09/02/2015	NO GER. Good emptying, Normal C loop	yes	DM 12.1	Nil		D/C to paed's GI
	05/08/2010	M		5y5m			DA, Situs inversus. Abdominal pain	sw + M: 10/02/2015	Situs inversus, with normal oesophagus and stomach. Good gas	Yes	DM 13.5	Nil		
	30/12/2014	M		2m	27/02/2015		vomiting ? Pyloric stenosis	Sw + M: 28/02/2015	Reflux present. No malrotation. No features of pyloric stenosis.	No	N/A	Nil		Treated with omepr
	15/05/2013	M		1y10m	02/03/2015		recurrent aspiration NI with feeding difficulty	Sw+M: 20/02/2015	No GER. Aspiration on swallowing, Normal duodenal loop.	Yes	DM 11.4	Percutaneous Endoscopic Gastrostomy	02/04/2015	
	28/02/2012	M		3y	12/03/2015		Difficulty feeding Moebius Sx with Bulbar palsy	Swallow: 04/02/2014	No gastro-oesophageal reflux	Yes	DM 21.9	Nissen fundoplication and gastrostomy	12/03/2015	
	02/07/2014	F		8m	19/03/2015		Vomiting post gastrostomy insertion NI with Feeding difficulty / GER post gastrostomy insertion	S+M: 08/12/2014	Contrast via gastrostomy. Good gastric emptying, + GER	No	N/A	Nissen fundoplication + Gastrostomy	11/12/2014	Leaking gastrostomy
	28/02/2015	M		<1m	23/03/2015		Acute life threatening aspirations GER with ALTE's	S+M: 25/03/2015	GER. No malrotation ? Pylorospasm	No	N/A	Thal Fundoplication	31/03/2015	
	02/02/2015	F		1m	23/03/2015		Apnoeic spells Conelia de Lange Sx with GERD	Sw + M : 25/03/2015	GER. No malrotation	No	N/A	Laparoscopic Nissen fundoplication & gastrostomy	26/03/2015	Feeding well orally
	12/03/2014	F			27/03/2015		Incomplete data							
	04/12/2014	F		3m	30/03/2015		Feeding difficulties NI Requiring gastrostomy	S+M: 31/03/2015	No GER. Normal Duodenal loop.	Yes	DM 18.5	Fundoplication + gastrostomy	Referred to Grey's	
	08/04/2012	M		3y	14/04/2015		Feeding difficulties with recurrent aspiration NI Requiring gastrostomy	Swallow only @ Base	Confirmed GER	No	N/A	Laparoscopic Nissen fundoplication and gastrostomy	17/04/2015	
	25/04/2005	M		10y	20/04/2015		Difficulty feeding NI Requiring gastrostomy	Sw only: 17/10/2014	No Reflux. Normal stomach.	Yes	92.6	Nissen fundoplication + Gastrostomy	18/06/2015	feeding well with gastrostomy
	22/06/2010	F		4y	22/06/2015		Difficulty feeding NI Requiring gastrostomy	Swallow, at base	GER	No	N/A	Nissen fundoplication + Gastrostomy	23/06/2015	Leaking gastrostomy
	18/12/2010	M		4y	23/06/2015		FTT NI Requiring gastrostomy		0 Marked reflux with aspiration.	No	N/A	Nissen fundoplication + Gastrostomy	25/06/2015	feeding well
	19/02/2015	F		4m	25/06/2015		Dysphagia + FTT NI with GERD	Sw only : At base	GER up to level T9	No	N/A	Nissen fundoplication + Gastrostomy	26/06/2015	Leaking gastrostomy
	31/10/2013	F		1y3m	14/07/2015		Incoordinate swallowing NI Requiring gastrostomy	Sw only: 06/07/2015	The pt has incoordinate dswallowing with reflux of contrast noted into the nasopharynx. Further the patient is noted to aspirate. The study was aborted due to excessive aspiration. No obvious reflux was noted.	No	n/a	Nissen Fundoplication & Gastrostomy	21/07/2015	Lost to F/U
	27/02/2008	M		7y	20/07/2015		Failure to thrive NI Requiring gastrostomy	Yes: At base 26/05/2015	NO GER	yes	DM 15.3			
	28/10/2011	M		3y	10/09/2015		Vomiting Oesophageal Atresia TOF	Sw + M: 14/09/2015	A HIATUS HERNIA IS NOTED AND REFLUX WAS DEMONSTRATED DURING THE STUDY.	NO	N/A	Nil	Nil	Mom declined Surgery
	19/07/2013	M		2y	04/11/2015		Failure to thrive NI with GERD	Sw only: 24/07/2015	Severe GER. Normal anatomy	No	N/A	Thal fundoplication	Nov-15	Lost to F/U
	17/10/2014	M		1yr	20/11/2015		Neurologically impaired. Vomiting feeds. UAO NI for feeding gastrostomy	Sw + M : 16/09/2015	NO GER. Normal anatomy. Good gastric emptying.	Yes	DM 165. Tube dislodged	Nissen + Gastrostomy	F/U ny paed's Neuro	Good weight gain
	14/06/2004	F		11y	09/12/2015		Dysphagia + Oesophageal stricture Prev OA + TOF. With GERD	Sw+M: 09/11/2015	Comment: -Relative narrowing in the proximal thoracic oesophagus noted ? previous site of surgery. -Significant oesophageal reflux	NO	N/A	Nil	Nil	Responded to medical rx
	28/03/2015	M	KZ00358934	7m	28/12/2015		Persistent lower airway obstruction Bronchiolitis Obliterans	Sw + M: 24/12/2015	Delayed oesophageal emptying with aspiration. No evidence of GE reflux. Normal anatomy	yes	DM 31.9	Oesophageal Biopsy + pH monitor inse	31/12/2015	Mix by paed's Resp. on omeprazole.

## Appendix 5: Raw data

Name	DOB	Sex	KZ No	Age at Sx	DOA	S+S	Diagnosis	Swallow + MEAL	Result	pH Monitor	Result	Operation	Date of OP	Outcome
	17/02/2013	M		1y9m	13/11/2014	Feeding difficulty	NI with GERD	Swallow + Meal - 27/11/2013	No GER. no evidence of gastric outlet obstruction.	Yes	DM 44	Nissen + gastrostomy	16/01/2014	
	13/07/2013	F		6m	21/01/2014	Feeding difficulty	NI with GERD	Swallow only @ Base. Dec 2013	+ GER	No	N/A	Nissen + gastrostomy	23/01/2014	
	31/12/2013	F		23d	23/01/2014	Vomiting since birth	Hiatal hernia with	Swallow + Meal: 23/01/2014	Hiatal hernia	No	N/A	Awaiting fundoplication		
	06/03/2007	M		7y	03/03/2014	HIV encephalopathy		Yes-	No GERD	Yes	3.1	Nil		
	28/01/2014	M		<1m	04/02/2014	Post prandial vomiting	GER	Yes: 04/02/2014	No malrotation	No		Nil		
	02/11/2008	M		6y		Difficulty with feeding and has lost weight.	NI with GERD	Swallow + Meal : 04/02/2014	No gastro-oesophageal reflux or evidence of distal obstruction	Yes	DM 16.5			
	04/05/2014	F		1m		Vomitings since birth	GER	Swallow+Meal: 09/06/2014	Reflux noted to the distal third of the oesophagus. The duodenal loop is normal and is seen to cross the midline. No features of malrotation noted	No	N/A	Nil	N/a	Med Mx for GER
	05/02/2014	M		4m	19/06/2014	vomiting post feeds	GERD with failure to thrive	Swallow + Meal: 16/06/2014	Severe reflux. No GOO	No	N/A	Lap Thal fundoplication	20/06/2014	Persistent reflux post-op. Needed repeat nissen fundoplication.
	25/05/2014	M		5m	29/10/2014	Difficulty feeding	Neurologically impaired	Swallow + Meal:	No GER. Good gastric emptying was noted.	Yes	DM 36	Laparoscopic Nissen Fundoplication + Gastrostomy	30/10/2014	Gaining wt. However recurrent problems with GT
	10/06/2014	M		5m	05/11/2014	Difficulty feeding	Bulbar/ Pseudobulbar palsy with UMN lesio	Swallow: 17/09/2014	Gastro oesophageal reflux to a level above the carina.	NO	N/A	Laparoscopic Nissen Fundoplication and gastrostomy	06/11/2014	Tolerating feeds via gastrostomy + gaining wt
	02/07/2014	F		2m	08/09/2014	Difficulty feeding	Pseudobulbar palsy	Swallow+Meal: 30/09/2014	NO GER demonstrated. No evidence of malrotation noted.	Yes	DM 7.7	Laparoscopic gastrostomy insertion		Child develop vomiting post-op. Repeat contrast study showed GER. Proceeded to Laparoscopic Nissen fundoplication and revision of gastrostomy
	20/05/2010	F		4y	18/01/2014	Unable to swallow post TOF repair	Oesophageal stricture	Swallow: At base.	Proximal dilation of oesophagus with Complete stricture.	Yes	DM 14.73	Oesophagoscopy + Biopsy: Showed GER changes.		Proceeded to Laparoscopic Thal fundoplication in view of histology findings.
	25/05/2014	M		4m	15/09/2014	difficulty feeding	Severe encephalopathy with recurrent seizures	Swallow + Meal: 19/08/2014	The distal oesophagus and OGI are normal. The stomach shows normal distensibility and the rugal folds are normal. Good gastric emptying was noted.	Yes	DM 36	Laparoscopic Nissen Fundoplication + Gastrostomy	30/10/2014	
	17/11/2014	M		1m	19/12/2014	distended abdomen and vomiting after feeds	Previous NEC	Meal + F/T: 20/12/2014	GER to just above the level of the carina (Note:presence of NG tube affect normal physiology). There good gastric distension and emptying. No features of malrotation	No	N/A	Nil	N/A	Med Mx for GER
	05/04/2007	F		7y	13/10/2014	Frequent low respiratory chest infections	Spastic Quadriplegia cerebral palsy	swallow: 13/10/2014	Stomach grossly normal. Reflux noted within the oesophagus and there was some holdup within the oesophagus however this had emptied once the patient had sat up. No evidence of GER	yes	DM18.4	Laparoscopic Nissen Fundoplication + Gastrostomy	26/11/2014	Improvement in symptoms and gaining weight
	13/03/2007	M		4y	Jul-11	difficulty feeding	NI with Difficulty feeding	Yes at base	Minimal GER	No	N/A	Lap Nissen + Gastrostomy	14/01/2014	LOW on review
	06/02/2005	F		8y	25/11/2013	Difficulty feeding	Traumatic Brain Injury with diffuse cerebral injury and encephalopathy with feeding difficulty	Swallow: 15/01/2014	OGI normal. No hiatal hernia. No GER. oesophageal dysmotility is noted. The spot film of stomach is normal.	yes: 13/02/2014	DM 5.6	PEG Insertion	14/02/2014	Had removal of PEG 24/10/2014
	03/04/2013	F		1y1m	13/05/2014	vomiting + LRTI	hiatal hernia	swallow: 14/05/2014	Hiatus hernia. Duodenal loop could not be assessed Gastroesophageal reflux demonstrated	No	N/A	Laparoscopic Thal Fundoplication with hiatoplasty	15/05/2014	Normal post-op CR.
	06/03/2009	M		5y	04/03/2014	Feeding difficulty.	Spastic CP with feeding difficulties	Swallow - 11/02/14	No GER demonstrated. But there is oesophageal dysmotility with reflux within the oesophagus is noted. Stomach normal.	YES- 04/03/2014	DM 0.3	PEG	17/04/2014	

