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

By

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Submitted in partial fulfillment of the academic requirements for the degree of MMed in the Department of Paediatric Surgery School of Clinical Medicine College of Health Sciences University of KwaZulu-Natal Durban 2018

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

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Name: [Name]
Date: 26th September 2018
Declaration

I, Janice Sewlall, declare that

(i) The research reported in this dissertation, except where otherwise indicated, is my original work.

(ii) This dissertation has not been submitted for any degree or examination at any other university.

(iii) This dissertation does not contain other persons’ data, pictures, graphs or other information, unless specifically acknowledged as being sourced from other persons.

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Signed: [Signature]  Date: 25/09/2013
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.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.

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 gastrooesophageal 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\(^1\), 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 $> 14.72$.\(^3\)

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.
DISCUSSION

Gastroesophageal reflux disease is a common problem in our setting and is being diagnosed and treated more often world-wide. 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.  

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.  

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 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.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**

Children with severe neurologic impairment often have failure to thrive due to nutritional deficiency and aspiration of pharyngoesophageal contents due to dysphagia and GER. 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. 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. There are various studies that have attempted to address this dilemma.

Ponsky et al, 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, 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.\textsuperscript{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.\textsuperscript{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 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


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doi: 10.5223/pghn.2014.17.1.13

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Part 2: A submission ready manuscript
Title: The Role of a Contrast study in the Investigation of Paediatric Gastroesophageal Reflux Disease

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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

<table>
<thead>
<tr>
<th>Gender</th>
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<tbody>
<tr>
<td>Male</td>
<td>25 (60%)</td>
</tr>
<tr>
<td>Female</td>
<td>17 (40%)</td>
</tr>
<tr>
<td>Neurologically impaired</td>
<td>27 (64%)</td>
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Results table 2. Age Groups

<table>
<thead>
<tr>
<th>Age</th>
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<tbody>
<tr>
<td>Neonate</td>
<td>04 (10%)</td>
</tr>
<tr>
<td>1m-1y</td>
<td>13 (31%)</td>
</tr>
<tr>
<td>1y-5y</td>
<td>18 (43%)</td>
</tr>
<tr>
<td>5y-12y</td>
<td>07 (17%)</td>
</tr>
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</table>
### Table 3. Signs and Symptoms

<table>
<thead>
<tr>
<th>Respiratory</th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Acute life threatening events</td>
<td></td>
<td>2 (5%)</td>
</tr>
<tr>
<td>Lower respiratory tract infections</td>
<td></td>
<td>5 (12%)</td>
</tr>
</tbody>
</table>

| 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

<table>
<thead>
<tr>
<th>Contrast Radiography n = 42</th>
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<th></th>
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</thead>
<tbody>
<tr>
<td>Reflux Positive</td>
<td></td>
<td>20 (48%)</td>
</tr>
<tr>
<td>Reflux Negative</td>
<td></td>
<td>22 (52%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>pH monitoring n = 22</th>
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<th></th>
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<tbody>
<tr>
<td>Reflux Positive</td>
<td></td>
<td>12 (55%)</td>
</tr>
<tr>
<td>Reflux Negative</td>
<td></td>
<td>10 (45%)</td>
</tr>
</tbody>
</table>
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.

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**Table 5. Anatomical Anomalies**

<table>
<thead>
<tr>
<th>Anatomical Abnormalities</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hiatus hernia</td>
<td>3</td>
</tr>
<tr>
<td>Oesophageal stricture</td>
<td>1</td>
</tr>
<tr>
<td>Situs inversus</td>
<td>1</td>
</tr>
<tr>
<td>Pylorospasm</td>
<td>1</td>
</tr>
</tbody>
</table>
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


https://doi.org/10.1148/rg.e22

doi: 10.5223/pghn.2014.17.1.13

doi: 10.1542/hpeds.2016-0126


**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

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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.¹

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.² 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.⁴

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 0-13 years, 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 – 13 years) 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


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.
• Identify any previously published material by giving the original source in the form of a reference at the end of the table caption.
• Footnotes to tables should be indicated by superscript lower-case letters (or asterisks for significance values and other statistical data) and included beneath the table body.
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:

- Disclosure of potential conflicts of interest
- 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.

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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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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
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:

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## Appendix 5: Raw data

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