NASPGHAN
ANNUAL EVENT
ATLANTA, GA
Hilton Atlanta
OCTOBER 23-26, 2014

Clinical Sessions : Hot Topics in GI
Saturday 10-30 -12 am

The Role of Impedance Testing in GERD.

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DISCLOSURE

IN THE PAST 12 MONTHS, I HAVE HAD NO RELEVANT FINANCIAL RELATIONSHIPS WITH THE MANUFACTURER(S) OF ANY COMMERCIAL PRODUCT(S) AND/OR PROVIDER(S) OF COMMERCIAL SERVICES DISCUSSED IN THIS CME ACTIVITY.

Learning Objectives

- Understand the principles of Esophageal Impedance measurement
- Analyze the indications and limitations of the technique.
- Discuss the advantages and disadvantages with respect to pH probe.
- Consider the clinical conditions in which impedance is recommended

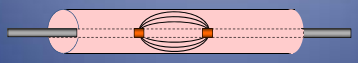
WHAT IS IMPEDANCE ?

Opposition to Current Flow

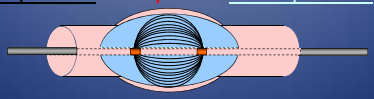
Inverse measurement of the electrical conductivity of an organ's wall & contents

WHY DOES IMPEDANCE CHANGE?

No bolus = few ions = high impedance



Bolus present = many ions = low impedance

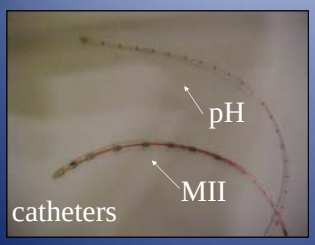


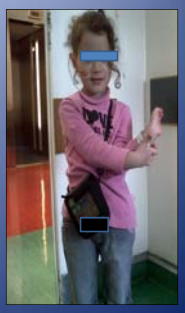
IMPEDANCE RANGE

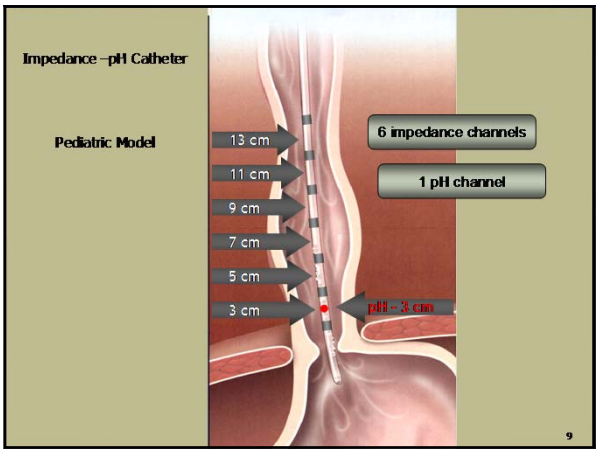
Low Conductivity = High Impedance

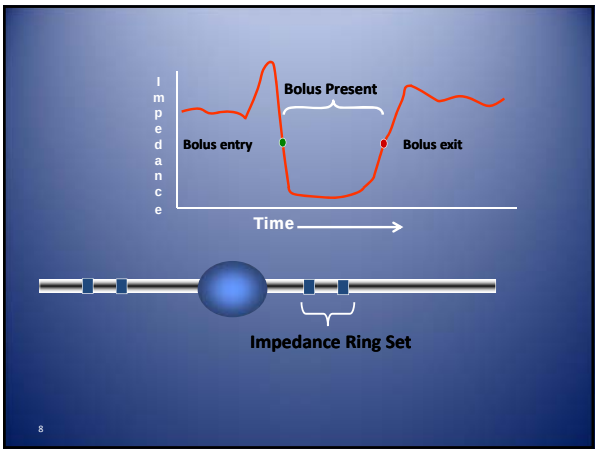
- Air (high)
- Esophageal Lining
- Saliva
- Food
- Refluxate (low)

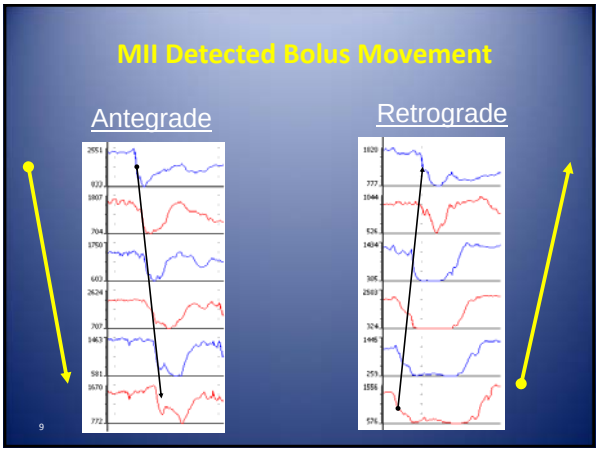
Multichannel Intraluminal Impedance device and size of Pediatric catheters

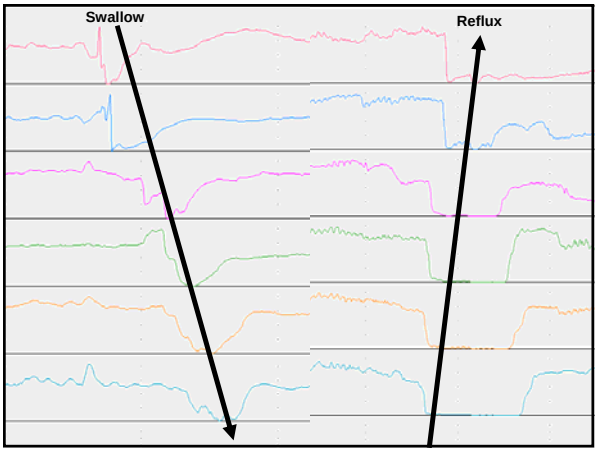


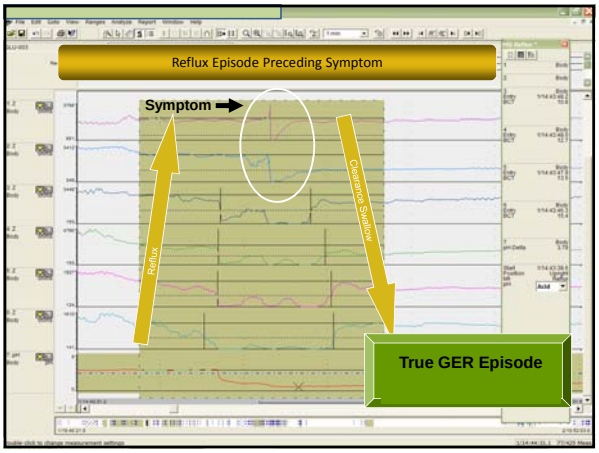


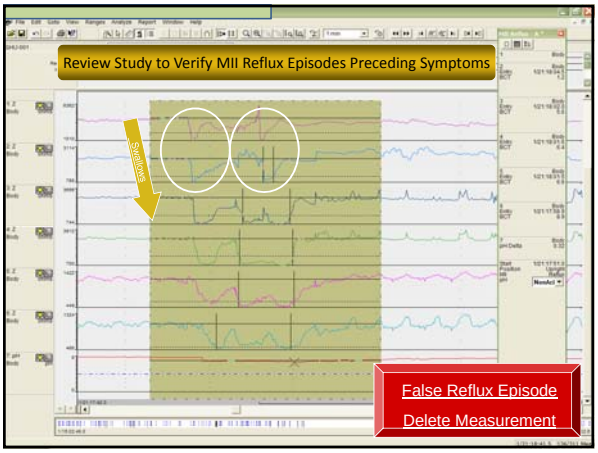

Impedance –pH Catheter
Pediatric Model
13 cm
11 cm
9 cm
7 cm
5 cm
3 cm
6 impedance channels
1 pH channel
pH – 3 cm
9

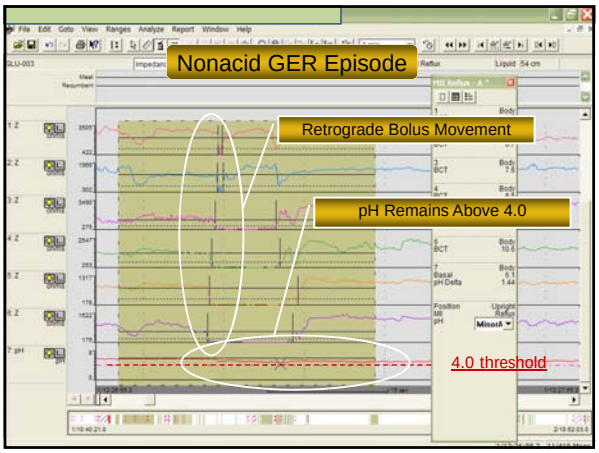

Impedance
Bolus Present
Bolus entry
Bolus exit
Time
Impedance Ring Set
8

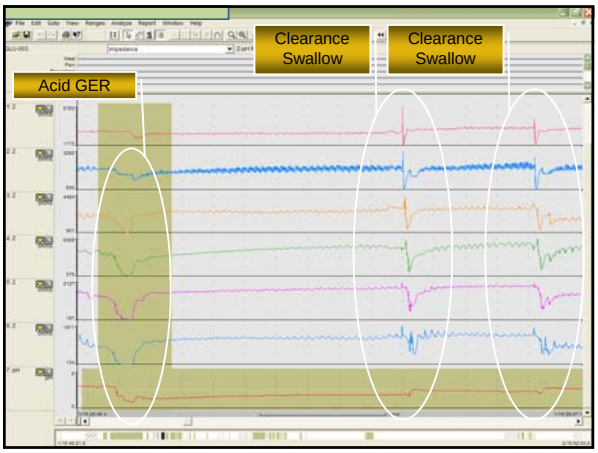

MII Detected Bolus Movement
Antegrade
Retrograde
9

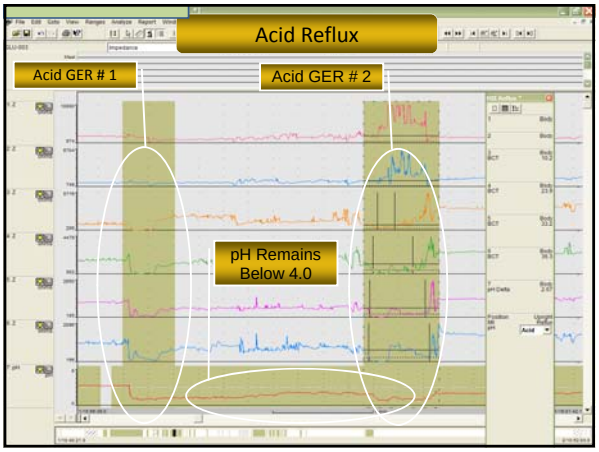

Swallow
Reflux

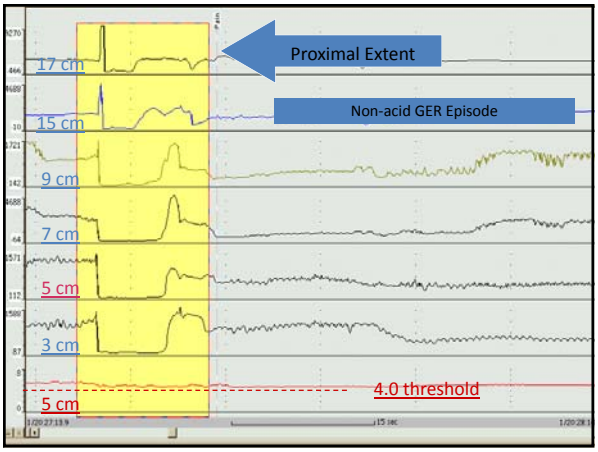

Reflux Episode Preceding Symptom
Symptom
Reflux
Clearance Swallow
True GER Episode

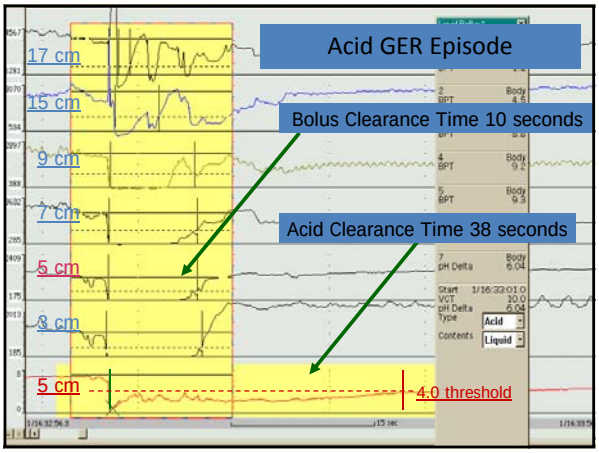

Review Study to Verify MII Reflux Episodes Preceding Symptoms
Swallows
False Reflux Episode
Delete Measurement











Background

- Infants reflux frequently
- Often, reflux cannot be detected with a pH sensor during the postprandial period due to buffering effects of the meal
- Reflux is most likely to occur in the postprandial period due to gastric distention
- Symptom correlation is not easy in infants because they do not speak.

18

What can we do with MII-pH?

- Measure acid - weakly acid and non-acid reflux
- Correlate acid and non acid reflux to symptoms
- Determine height of proximal migration
- Determine bolus clearance time (MII)
- Determine acid - non acid clearance time (pH)

Benefits of MII over pH probe

- Evaluate patient with persistent symptoms while on PPI
- Evaluate atypical GERD
  - Correlate acid & non-acid GER episodes with symptoms
  - Quantify proximal extent of GER
- Evaluate postprandial GER
  - pH is blind during early postprandial period
  - Postprandial is prime time for reflux and symptom occurrence

Clinical Benefits

- MII-pH Monitoring detects all reflux during the entire analyzed time period
- Symptom correlations are made with both acid and nonacid reflux
- MII-pH Monitoring sensitivity is not compromised during the postprandial time period.
- A true postprandial reflux study is possible

21

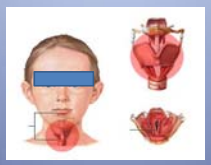
Potential MII-pH Advantages

- **Diagnosis of patient with persistent symptoms while on PPI medication**
  - **Elucidate the role of non-acid GER**
- **Evaluation of atypical GERD**
  - **Correlate acid & non-acid GER episodes to Symptoms**
  - **Quantify proximal extent of GER**
- **Evaluate Postprandial GER**
  - **pH is blind during early postprandial period**
  - **Postprandial is prime time for reflux & symptoms**



Digestive presentations




Extraesophageal Presentations





Asthma and GER

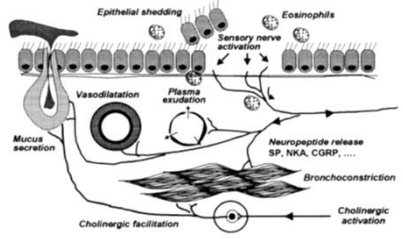


Fig. 1. Neurogenic inflammation in asthmatic airways via retrograde release of peptides from sensory nerves via an axon reflex. SP causes vasodilatation, plasma exudation and mucus secretion, whereas NKA causes bronchoconstriction and enhanced cholinergic reflexes and CGRP vasodilatation.

Respiration Physiology 125 (2001) 145–154

Clin Gastroenterol Hepatol. 2007;5:37

Diurnal variation in the chemical clearance of acid gastroesophageal reflux in infants.

Woodley FW, Fernandez S, Mousa H

- Chemical clearance is significantly prolonged during fasting in infants.
- Falling pH alone cannot explain declining chemical clearance efficiency during later postprandial periods.
- Authors speculate that inefficient chemical clearance during fasting is likely due to reduced efficiency of acid clearance mechanisms that could include salivation, swallowing, peristalsis, and/or intraluminal secretion.

Journal of Pediatric Gastroenterology and Nutrition
34:519–523 © May 2002 Lippincott Williams & Wilkins, Inc., Philadelphia

Esophageal pH Monitoring and Impedance Measurement: A Comparison of Two Diagnostic Tests for Gastroesophageal Reflux

*†Tobias G. Wenzl, *Christoph Moroder, ‡Morten Trachterna, †Mike Thomson, ‡Jiri Silny, *Gerhard Heimann, and *Heino Skopnik

*Kinderklinik and ‡Helmholtz Institut für Biomedizinische Technik, Rheinisch-Westfälische Technische Hochschule Aachen, Aachen, Germany; and †Centre for Paediatric Gastroenterology, Royal Free Hospital, University College London, London, United Kingdom

PEDIATRICS
OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

Effects of Thickened Feeding on Gastroesophageal Reflux in Infants: A Placebo-Controlled Crossover Study Using Intraluminal Impedance

Tobias G. Wenzl, Sabine Schneider, Frank Scheele, Jiri Silny, Gerhard Heimann and Heino Skopnik

Pediatrics 2003;111;e355

Journal of Pediatric Gastroenterology and Nutrition
48:2–12 © 2008 by European Society for Pediatric Gastroenterology, Hepatology, and Nutrition and the North American Society for Pediatric Gastroenterology, Hepatology, and Nutrition

Invited Review

Role of the Multichannel Intraluminal Impedance Technique in Infants and Children

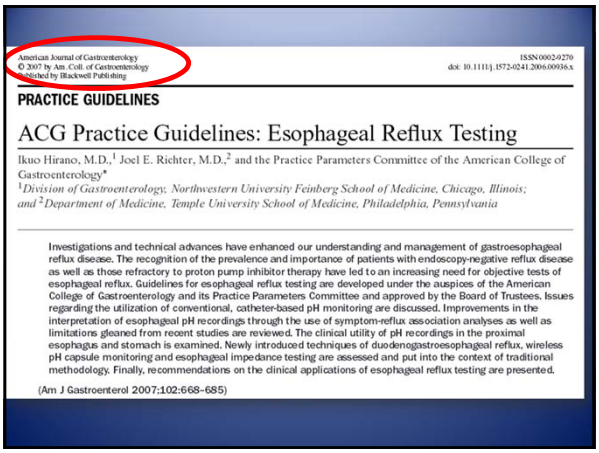
*Michiel P. van Wijk, *Marc A. Benninga, and †‡Taher I. Omari

*Department of Paediatric Gastroenterology and Nutrition, Emma Children's Hospital/Academic Medical Centre, Amsterdam, The Netherlands, †Centre for Paediatric and Adolescent Gastroenterology, and ‡Adelaide University Department of Paediatrics, Women's and Children's Hospital, Children, Youth and Women's Health Services, North Adelaide, Australia

ABSTRACT

Recently, multichannel intraluminal impedance (MII) was added to the repertoire of tests available to study esophageal (patho)physiology in children. MII has since been used in 2 major areas. First, it has been used as a diagnostic test for gastroesophageal reflux disease (GERD). The main advantage over traditional pH monitoring is its ability to detect both acid and nonacid gastroesophageal reflux (GER) and to discern between liquid and gas GER. Although feasible with multiple pH sensors, the MII technique routinely detects the proximal extent of a GER episode. When a pH sensor is added to the MII-catheter, important information about the acidity of a GER event can be gathered. The second area in which the role of MII has been investigated is that of esophageal function testing. Manometry classically reveals information about esophageal pressure patterns and sphincter function, but does not inform us about bolus flow. MII not only detects the presence of esophageal flow but also adds information on the direction of flow, duration of bolus presence, completeness of bolus clearance, and composition of a bolus. The combination of MII with manometry enables determination of the relationship between esophageal pressures and flow and, therefore, enhances evaluation of esophageal function in terms of assessment of mechanisms of esophageal volume clearance. In addition, this technique will improve our understanding of (patho)physiological mechanisms in pediatric GERD and other esophageal motility disorders.

JPGN 48:2–12, 2009. Key Words: Esophageal motor disorders—Gastroesophageal reflux—Manometry—Motility—Multichannel intraluminal impedance. © 2008 by European Society for Pediatric Gastroenterology, Hepatology, and Nutrition and North American Society for Pediatric Gastroenterology, Hepatology, and Nutrition



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PRACTICE GUIDELINES

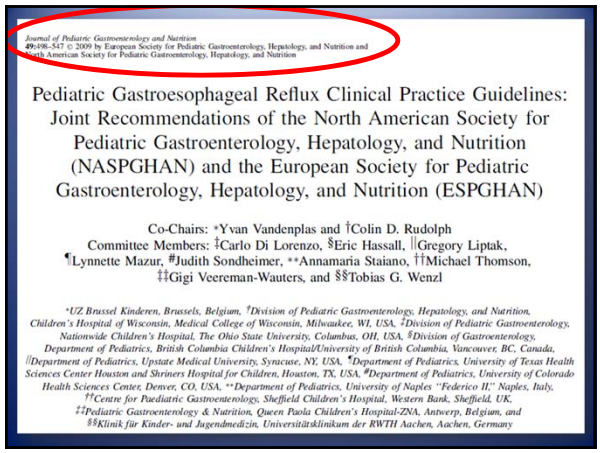
ACG Practice Guidelines: Esophageal Reflux Testing

Ikuo Hirano, M.D.,[1] Joel E. Richter, M.D.,[2] and the Practice Parameters Committee of the American College of Gastroenterology*

[1]Division of Gastroenterology, Northwestern University Feinberg School of Medicine, Chicago, Illinois; and [2]Department of Medicine, Temple University School of Medicine, Philadelphia, Pennsylvania

Investigations and technical advances have enhanced our understanding and management of gastroesophageal reflux disease. The recognition of the prevalence and importance of patients with endoscopy-negative reflux disease as well as those refractory to proton pump inhibitor therapy have led to an increasing need for objective tests of esophageal reflux. Guidelines for esophageal reflux testing are developed under the auspices of the American College of Gastroenterology and its Practice Parameters Committee and approved by the Board of Trustees. Issues regarding the utilization of conventional, catheter-based pH monitoring are discussed. Improvements in the interpretation of esophageal pH recordings through the use of symptom-reflux association analyses as well as limitations gleaned from recent studies are reviewed. The clinical utility of pH recordings in the proximal esophagus and stomach is examined. Newly introduced techniques of duodenogastroesophageal reflux, wireless pH capsule monitoring and esophageal impedance testing are assessed and put into the context of traditional methodology. Finally, recommendations on the clinical applications of esophageal reflux testing are presented.

(Am J Gastroenterol 2007;102:668–685)



Journal of Pediatric Gastroenterology and Nutrition
49:498–547 © 2009 by European Society for Pediatric Gastroenterology, Hepatology, and Nutrition and North American Society for Pediatric Gastroenterology, Hepatology, and Nutrition

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)

Co-Chairs: *Yvan Vandenplas and †Colin D. Rudolph
Committee Members: ‡Carlo Di Lorenzo, §Eric Hassall, ||Gregory Liptak, ¶Lynnette Mazur, #Judith Sondheimer, **Annamaria Staiano, ††Michael Thomson, ‡‡Gigi Veereman-Wauters, and §§Tobias G. Wenzl

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24 hr pH study

- Esophageal pH monitoring is useful for evaluating the efficacy of antisecretory therapy. It may be useful to correlate symptoms (eg, cough, chest pain) with acid reflux episodes and to select those infants and children with wheezing or respiratory symptoms in whom GER is an aggravating factor.

- The sensitivity, specificity, and clinical utility of pH monitoring for diagnosis and management of possible extraesophageal complications of GER are not well established

Journal of Pediatric Gastroenterology and Nutrition, 2009; 49:498

24 hr Impedance / pH study

- **Detects acid, weakly acid, and nonacid reflux episodes.**
- **It is superior to pH monitoring alone for evaluation of the temporal relation between symptoms and GER.**
- **The technology is especially useful in the postprandial period or at other times when gastric contents are nonacidic. The relation between weakly acid reflux and symptoms of GERD requires clarification.**

JPGN 2009; 49:498

24 hr Impedance / pH study

- Measurement of other parameters such as SI or SAP may be of additional value to prove symptom association with reflux, especially when combined with MII .
- Whether combined esophageal pH and impedance monitoring will provide useful measurements that vary directly with disease severity, prognosis, and response to therapy in pediatric patients has yet to be determined.

JPGN ; 2009;49:498

Published in final edited form as:
J Pediatr Gastroenterol Nutr. 2011 February ; 52(2): 129–139. doi:10.1097/MPG.0b013e3181ffde67.

Esophageal Impedance Monitoring for Gastroesophageal Reflux

Hayat M. Mousa*, Rachel Rosen†, Frederick W. Woodley*, Marina Orsi‡, Daneila Armas§, Christophe Faure||, John Fortunato¶, Judith O'Connor*, Beth Skaggs*, and Samuel Nurko†

*Department of Pediatric Gastroenterology, Center for Advanced Research in Neuromuscular Gastrointestinal Disorders, Nationwide Children's Hospital, Ohio State University, Columbus, OH

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J Pediatr Gastroenterol Nutr. 2011 February ; 52(2): 129–139. doi:10.1097/MPG.0b013e3181ffde67.

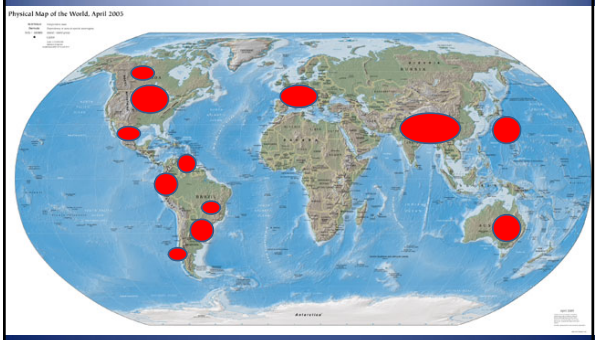
Esophageal Impedance Monitoring for Gastroesophageal Reflux

Hayat M. Mousa*, Rachel Rosen†, Frederick W. Woodley*, Marina Orsi‡, Daniela Armas§, Christophe Faure‖, John Fortunato¶, Judith O'Connor*, Beth Skaggs*, and Samuel Nurko†

Abstract

Dual pH-multichannel intraluminal impedance (pH-MII) is a sensitive tool for evaluating overall gastroesophageal reflux disease, and particularly for permitting detection of nonacid reflux events. pH-MII technology is especially useful in the postprandial period or at other times when gastric contents are nonacidic. pH-MII was recently recognized by the North American Society for Pediatric Gastroenterology, Hepatology, and Nutrition and the European Society for Pediatric Gastroenterology, Hepatology, and Nutrition as being superior to pH monitoring alone for evaluation of the temporal relation between symptoms and gastroesophageal reflux. In children, pHMII is useful to correlate symptoms with reflux (particularly nonacid reflux), to quantify reflux during tube feedings and the postprandial period, and to assess efficacy of antireflux therapy. This clinical review is simply an evidence-based overview addressing the indications, limitations, and recommended protocol for the clinical use of pH-MII in children.

Impedance groups all over the world



Evaluation of infantile acid and nonacid gastroesophageal reflux using combined pH monitoring and impedance measurement.

Condino A Sondheimer J A et al. JPGN. 2006;42:16

- MII detects more reflux events than pH monitoring alone.
- The proportion of nonacid reflux to acid reflux events in infants is more similar to adults than previously reported.
- Combined pH-MII esophageal monitoring identifies more reflux events and improves clinical correlation with symptoms.

Acid gastroesophageal reflux reports in infants: a comparison of esophageal pH monitoring and multichannel intraluminal impedance measurements.

Woodley M, Mousa H. JPGN; 2002;34:519

Detection of significant number of "pH-only" episodes raises concerns regarding possible over-estimations of acid exposure that may occur when estimates are based solely on esophageal pH monitoring.

Combined multichannel intraluminal impedance-pH monitoring to select patients with persistent gastro-oesophageal reflux for laparoscopic Nissen fundoplication

Mainie I et al. Br J Surg. 2006 ;93:1483

Patients with a positive symptom index resistant to PPIs with non-acid or acid reflux demonstrated by MII-pHmonitoring can be treated successfully by laparoscopic Nissen fundoplication

The Importance of Multichannel Intraluminal Impedance in the Evaluation of Children with Persistent RespiratorySymptoms.

Rosen R, Nurko S. Am J Gastroenterol 2004;99:2452

Nonacid reflux may be an important predictor of respiratory symptoms.

pH/MII provided important information in the evaluation of children with intractable respiratory symptoms.

Evaluation of gastroesphageal reflux with the MII- pH probe in children with respiratory symptoms.

Orsi M, Cohen Sabban J,Donato BertoldiG, D'Agostino D.

- To evaluate the proportion of acid or non acid episodes of gastroesophageal reflux in children with respiratory symptoms.
- To determine the symptom correlation and the height of the episodes.

Results

- In the 45 children studied: 1850 reflux episodes observed, 1179 (63.7%) acid and non acid : 671(36.2%).
- The pH probe detected 984 acid events.
- The proximal channel was reached in 152(62.2%) episodes; 65% acid and 35% non acid of them.
- Symptomatic correlation with cough:
- Total : 420, Acid 211(50.3%9) and Non acid 209(49.7%).

Conclusions

In respiratory patients, the 24-hour Multichannel Intraluminal Impedance-pH monitoring resulted a good method to study gastroesophageal reflux because is capable of providing a more dynamic and complete information of the different types of reflux events.

Other studies are necessary to help us understand the benefits and / or limits of this new technology.

Optimisation of the Reflux-symptom Association Statistics for Use in Infants Being Investigated by 24-hour pH Impedance

yTaher I. Omari, zAndrea Schwarzer, §Michiel P. vanWijk, §Marc A Benninga, Lisa McCall, Stamatiki Kritas, zSibylle Koletzko, and yGeoffrey P. Davidson (JPGN 2011;00: 00–00)

We conclude that the standard 2-minute time interval is appropriate for the investigation of cough and regurgitation symptoms.

The day-to-day agreement of SAP for crying was poor using standard criteria, and our results suggest increasing the reflux-symptom association time interval to 5 minutes.

(JPGN 2011;00: 00–00)

It has been postulated that the value of Impedance baseline may predict esophageal damage being lower in children with esophagitis .

Evaluation of oesophageal mucosa integrity by the intraluminal impedance technique. Ricard Farre´ , Kathleen Blondeau, Dominique Clement, Maria Vicario,Lucio, Cardozo, Michael Vieth, Veerle Mertens, Ans Pauwels, Jiri Silny,Marcel Jimenez, Jan Tack, Daniel Sifrim **Gut** (2011).

Relationship between baseline impedance levels and esophageal mucosal integrity in children with erosive and non-erosive reflux disease O.Borrelli, S. Salvatore, V. Mancini, M. Ribolsi, M. Gentile,–B. Bizzari, M. Cicala,K. J. Lindley* & G. L. De Angelis. **Neurogastroenterol Motil** (2012) 24, 828–e394.

Curr Gastroenterol Rep (2014) 16:400

Combined Multichannel Intraluminal Impedance-pH (MII-pH):Multicenter Report of Normal Values from 117 Children

Hayat Mousa & Rodrigo Machado & Marina Orsi & Catherine S. Chao & Tala Alhajj & Mark Alhajj & Courtney Port & Beth Skaggs & Frederick W. Woodley

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Division of Pediatric Gastroenterology, Nationwide Children's Hospital, 700 Children's Drive, JW 1985, Columbus, OH, USA
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The Pediatric Gastroenterology, Hepatology and Transplant Unit, Hospital Italiano, Buenos Aires, Argentina

Curr Gastroenterol Rep (2014) 16:400

Values for NAGER percent time, NAGER episode frequency, frequency of proximal NAGER, and mean NAGER duration were calculated for upright position, recumbent, and total.

Study population consisted of

46 infants (20 [F]/26 [M], median age 4.8 months [range 3 weeks–11.9 months with a median AGER index of 2.2 % (range 0.0–5.9 %) and

71 children (22 F/49 M, median age 7.2 years [range 1.3–17 years]) with a median AGER index of 1.1% (range 0–3.0 %).

Curr Gastroenterol Rep (2014) 16:400

- The results of this study provide a **range of values characteristic of infants and children** with normal AGER indices and no positive temporal associations of GER with symptoms
- **These values may be used as references for comparison to identify infants and/or children who may be at risk** of developing serious clinical manifestations due to abnormal patterns of GER.

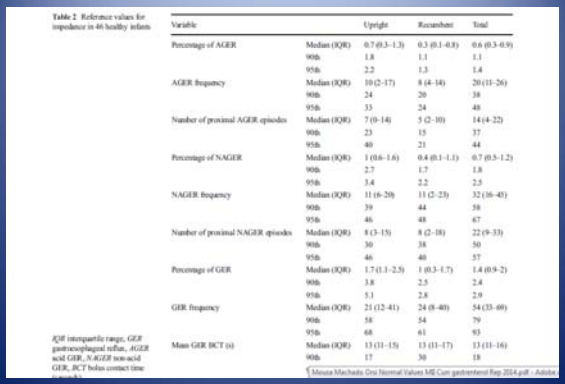

Table 2 Reference values for impedance in 46 healthy infants

Variable		Upright	Recumbent	Total
Percentage of AGER	Median (IQR)	0.7 (0.3–1.3)	0.3 (0.1–0.8)	0.6 (0.3–0.9)
	90th	1.8	1.1	1.1
	95th	2.2	1.3	1.4
AGER frequency	Median (IQR)	10 (2–17)	8 (4–14)	20 (11–26)
	90th	24	20	38
	95th	33	24	48
Number of proximal AGER episodes	Median (IQR)	7 (0–14)	5 (2–10)	14 (4–22)
	90th	23	15	37
	95th	40	21	44
Percentage of NAGER	Median (IQR)	1 (0.6–1.6)	0.4 (0.1–1.1)	0.7 (0.5–1.2)
	90th	2.7	1.7	1.8
	95th	3.4	2.2	2.5
NAGER frequency	Median (IQR)	11 (6–20)	11 (2–23)	32 (16–45)
	90th	39	44	58
	95th	46	48	67
Number of proximal NAGER episodes	Median (IQR)	8 (3–15)	8 (2–18)	22 (9–33)
	90th	30	38	50
	95th	46	40	57
Percentage of GER	Median (IQR)	1.7 (1.1–2.5)	1 (0.3–1.7)	1.4 (0.9–2)
	90th	3.8	2.5	2.4
	95th	5.1	2.8	2.9
GER frequency	Median (IQR)	21 (12–41)	24 (8–40)	54 (33–69)
	90th	58	54	79
	95th	68	61	93
Mean GER BCT (s)	Median (IQR)	13 (11–15)	13 (11–17)	13 (11–16)
	90th	17	30	18

IQR interquartile range, GER gastroesophageal reflux, AGER acid GER, NAGER non-acid GER, BCT bolus contact time (seconds)

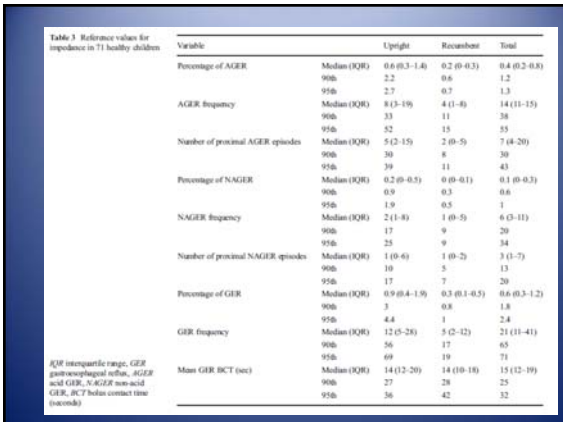

Table 3 Reference values for impedance in 71 healthy children

Variable		Upright	Recumbent	Total
Percentage of AGER	Median (IQR)	0.6 (0.3–1.4)	0.2 (0–0.3)	0.4 (0.2–0.8)
	90th	2.2	0.6	1.2
	95th	2.7	0.7	1.3
AGER frequency	Median (IQR)	8 (3–19)	4 (1–8)	14 (11–15)
	90th	33	11	38
	95th	52	15	55
Number of proximal AGER episodes	Median (IQR)	5 (2–15)	2 (0–5)	7 (4–20)
	90th	30	8	30
	95th	39	11	43
Percentage of NAGER	Median (IQR)	0.2 (0–0.5)	0 (0–0.1)	0.1 (0–0.3)
	90th	0.9	0.3	0.6
	95th	1.9	0.5	1
NAGER frequency	Median (IQR)	2 (1–8)	1 (0–5)	6 (3–11)
	90th	17	9	20
	95th	25	9	34
Number of proximal NAGER episodes	Median (IQR)	1 (0–6)	1 (0–2)	3 (1–7)
	90th	10	5	13
	95th	17	7	20
Percentage of GER	Median (IQR)	0.9 (0.4–1.9)	0.3 (0.1–0.5)	0.6 (0.3–1.2)
	90th	3	0.8	1.8
	95th	4.4	1	2.4
GER frequency	Median (IQR)	12 (5–28)	5 (2–12)	21 (11–41)
	90th	56	17	65
	95th	69	19	71
Mean GER BCT (sec)	Median (IQR)	14 (12–20)	14 (10–18)	15 (12–19)
	90th	27	28	25
	95th	36	42	32

IQR interquartile range, GER gastroesophageal reflux, AGER acid GER, NAGER non-acid GER, BCT bolus contact time (seconds)

Take home message

- **Ambulatory practice.**
- **Detects acid,weakly acid & non acid reflux**
- **Height of the episode.**
- **Study patients on PPI, refractory to treatment.**
- **Correlate symptoms to all types of GER**
- **Analyze bolus acid / non acid clearance time**
- **Is not blind in post prandial period.**
- **Differentiates if changes of pH are due to a swallow or reflux**
- **Adds information to conventional ph monitoring**
- **Helpful in extraesophageal presentations , complex patients and surgical decisions.**
- **BUT**
- **Manual Data Analysis is time consuming and there may be variability of interpretation.**

Thanks

Hospital Italiano de Buenos Aires

Pediatric Gastroenterology – Hepatology and Hepatointestinal Trasplant Unit

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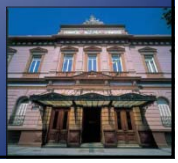


Any questions ?