Digestive and Liver Disease 44 (2012) 569–575

Contents lists available at SciVerse ScienceDirect

Digestive and Liver Disease

journal homepage: www.elsevier.com/locate/dld

Alimentary Tract

Functional aspects of distal oesophageal spasm: The role of onset velocity and contraction amplitude on bolus transit

Daniel Pohl[a,b,*], Jody Ciolino[c], Jason Roberts[a], Edoardo Savarino[d], Janice Freeman[b], Paul J. Nietert[c], Radu Tutuian[e], Donald Castell[b]

[a] Digestive Disease Center, Division of Gastroenterology and Hepatology, Medical University of South Carolina, USA
[b] University Hospital Zurich, Division of Gastroenterology and Hepatology, Zurich, Switzerland
[c] Division of Biostatistics and Epidemiology, Medical University of South Carolina, USA
[d] Division of Gastroenterology, University of Genoa, Italy
[e] Division of Gastroenterology, University Clinics for Visceral Surgery and Medicine, Bern, Switzerland

ARTICLE INFO

Article history:
Received 20 July 2011
Accepted 10 February 2012
Available online 3 April 2012

Keywords:
Bolus transit
Chest pain
DES
Diffuse oesophageal spasm
Distal oesophageal spasm
Dysphagia
GERD
Impedance manometry
MII-EM

ABSTRACT

Background: Distal oesophageal spasm is a rare and under-investigated motility abnormality. Recent studies indicate effective bolus transit in varying percentages of distal oesophageal spasm patients.
Aim: Explore functional aspects including contraction onset velocity and contraction amplitude cut-off values for simultaneous contractions to predict complete bolus transit.
Methods: We re-examined data from 107 impedance-manometry recordings with a diagnosis of distal oesophageal spasm. Receiver operating characteristic analysis was conducted, regarding effects of onset velocity on bolus transit taking into account distal oesophageal amplitude and correcting for intra-individual repeated measures.
Results: Mean area under the receiver operating characteristic curve for saline and viscous swallows were 0.84 ± 0.05 and 0.84 ± 0.04, respectively. Velocity criteria of >30 cm/s when distal oesophageal amplitude > 100 mmHg and 8 cm/s when distal oesophageal amplitude < 100 mmHg for saline and 32 cm/s when distal oesophageal amplitude > 100 mmHg and >7 cm/s when distal oesophageal amplitude < 100 mmHg for viscous had a sensitivity of 75% and specificity of 80% to identify complete bolus transit. Using these criteria, final diagnosis changed in 44.9% of patients. Abnormal bolus transit was observed in 50.9% of newly diagnosed distal oesophageal spasm patients versus 7.5% of patients classified as normal. Distal oesophageal spasm patients with distal oesophageal amplitude > 100 mmHg suffered twice as often from chest pain than those with distal oesophageal amplitude < 100 mmHg.
Conclusion: The proposed velocity cut-offs for diagnosing distal oesophageal spasm improve the ability to identify patients with spasm and abnormal bolus transit.

1. Introduction

Distal oesophageal spasm is an uncommon oesophageal motility abnormality with an estimated prevalence between 3% and 5% in patients undergoing oesophageal manometry testing [1,2]. The clinical relevance, diagnostic and therapeutic implications as well as underlying pathophysiology have been a subject of controversy since 1889, when a case series of patients with symptoms of chest pain and dysphagia attributed to oesophageal motility abnormality were described in the surgical literature [3].

Before the advent of manometry, spasm was a clinical and radiologic diagnosis. However due to limited sensitivity and specificity, radiologic exams were later shown to be primarily complimentary [4,5]. Manometry was first used to define spasm as a motor disorder incorporating simultaneous contractions and intermittent regular peristalsis in the 1960s [6,7]. Since then the definition of spasm has changed over the years with variable cut-off values used for amplitude, frequency and propagation velocity. Currently, spastic swallows are defined by a distal oesophageal propagation velocity faster than 8 cm/s with an amplitude of >30 mmHg in the distal oesophagus. If more than 20% of contractions meet these criteria a patient is diagnosed with oesophageal spasm [8,9]. As esophageal spasm is an entity almost exclusively occuring in the distal esophagus we speak of distal rather than diffuse esophageal spasm [10]. A review of the current American Gastroenterology Association (AGA) guidelines for oesophageal manometry and the available

* Corresponding author at: University Hospital Zurich, Division of Gastroenterology and Hepatology, Raemistr. 100, 8091 Zurich, Switzerland. Tel.: +41 44 2551111; fax: +41 44 2554568.
E-mail address: Daniel.Pohl@usz.ch (D. Pohl).

1590-8658/$36.00
doi:10.1016/j.dld.2012.02.003

published literature on oesophageal spasm did not allow us to clearly retrace the origin of the widely accepted 8 cm/s discriminatory value for peristaltic front wave velocity [8,9] in separating simultaneous from peristaltic swallows. It was most likely based on a study discerning bolus transit dependent on propagation velocity in a small number of patients with a variety of oesophageal motility disorders. The authors reported an excellent sensitivity and positive-predictive value in determining abnormal bolus transit as validated by video-fluoroscopy for an onset velocity of >6.25 cm/s [4]. However later studies from our group reported normal bolus transit in 33–67% of simultaneous swallows in contrast to 100% incomplete bolus transit data from the fluoroscopically viewed swallows [4,11,12]. We were therefore interested in further exploring the diagnosis of oesophageal spasm on the basis of both propagation velocity and patient symptoms in regard to both manometric and bolus transit properties.

2. Objectives

This study evaluates the physiologic properties of patients with DES focussing on the effects of propagation velocity related to bolus transit properties and patient symptoms. As the currently accepted speed cut-offs have been based on bolus transit as per barium radiography, the aim of our study was to characterize bolus transit, manometric findings and symptoms with respect to oesophageal propagation velocity using combined oesophageal multichannel impedance-manometry during saline and viscous swallows.

3. Methods

We identified patients with a diagnosis of distal oesophageal spasm from patient files analysed between June 2004 and March 2009. Clinical and demographic patient information used was age of patient and primary presenting symptoms during a standardized interview prior to each impedance-manometry study. Ethical approval was granted for the retrospective patient data analysis of our patient database by the local Institutional Review Board.

Each patient underwent oesophageal function testing using combined MII-EM with a Koenigsberg 9-channel probe (EFT-catheter; Sandhill Scientific Inc., Highlands Ranch, CO, USA). The 4.5-mm-diameter catheter generates pressure data from 5 solid-state pressure sensors placed 5 cm apart. Impedance measuring segments consisting of two metal rings placed 2 cm apart are centred at 10, 15, 20, and 25 cm from the tip. The EFT catheter was inserted transnasally into the oesophagus up to a depth of 60 cm, and collection of impedance and manometric data (30 Hz) was initiated. The lower oesophageal sphincter (LES) was identified using a station pull-through technique and the most distal sensor was placed in the high-pressure zone of the LES. Intraesophageal pressure sensors and impedance measuring segments were thus located at 5, 10, 15, and 20 cm above the LES.

Patients were given 10 swallows of 5 ml normal saline and 10 swallows of 5 ml viscous (Sandhill Scientific Inc., Highlands Ranch, CO, USA) test substance 20–30 s apart. Manometric parameters used to characterize swallows included (1) contraction amplitude at 5 and 10 cm above the LES, (2) distal oesophageal amplitude (DEA) as an average of contraction amplitude at 5 and 10 cm above the LES, (3) onset velocity of oesophageal contractions in the distal part of the oesophagus (i.e., contraction velocity between 10 and 5 cm above the LES, Fig. 1). The LES residual pressure was measured as the lowest pressure during swallow-induced LES relaxation. Manometric landmarks were identified incorporating impedance information for bolus entry to avoid misinterpreting intra-bolus pressure as peristaltic front (Fig. 1). Bolus entry at a specific level was identified by the 50% point between 3-s pre-swallow impedance baseline and impedance nadir during bolus presence. Bolus exit was determined as return to this 50% point on the impedance recovery curve as discussed in previous studies (Fig. 1) [13]. Total bolus transit time was calculated as the time elapsed from bolus entry in the proximal channel 20 cm above the LES to bolus exit in the distal channel 5 cm above the LES when bolus exit was present. For each patient, we calculated mean DEA for liquid and viscous swallows, mean LES residual pressure and mean bolus transit time.

Swallows were classified using previously published manometric criteria [9]. All patients diagnosed as DES based on criteria mentioned above had their individual swallows grouped and classified according to receiver operating characteristic (ROC) analyses results. Complete bolus transit was defined when bolus entry occurred at the most proximal site (20 cm above LES) and bolus exit points were recorded in all three distal impedance-measuring sites (i.e., 15, 10, and 5 cm above the LES). Incomplete bolus transit was diagnosed when bolus exit was not identified at any one of the three distal impedance-measuring sites. For the 10 grouped swallows oesophageal transit abnormalities overall incomplete liquid transit was defined by at least 30% of swallows showing incomplete bolus transit and incomplete viscous transit if at least 40% of swallows had incomplete bolus transit [13].

3.1. Statistics

Descriptive statistics (number and percentages) were used to describe manometric and impedance findings in this group of patients. Continuous data are presented as mean (±standard deviation) unless specified otherwise.

A series of generalized linear mixed models were fit to the data in order to determine a final predictive model for incomplete bolus transit as determined by MII with fixed effects of bolus transit velocity (cm/s) and DEA. Receiver operating characteristic (ROC) analyses were conducted for saline and viscous swallows, separately, to determine ideal velocity cut-off values for predicting incomplete bolus transit for a given DEA value.

The ROC analyses consisted of a bootstrap sampling method in which a computer algorithm randomly sampled one swallow from each subject's record, generating a sampled dataset of independent observations. A simple logistic regression model involving the DEA category variable and velocity was fit to each sampled dataset. A ROC curve was constructed based on this model for each iteration, and parameter estimates and areas under the ROC curve were captured. ROC results and parameter estimates were averaged across all iterations in order to estimate final model parameters and an overall ROC curve.

Generalized linear mixed models (GLMM) for repeated measures were constructed for outcomes of MII diagnosis (complete versus incomplete), bolus transit time, and LES residual pressure. Average DEA, LES pressure and BTT were calculated for each subject, and analysis of variance (ANOVA) was used to calculate the differences in these values among the groups of patients with chest pain, dysphagia, and GERD symptoms. Bonferroni corrections for simultaneous comparisons were used for all post hoc analyses comparing means across groups. Statistical analyses were performed using SPSS 12.0 (SPSS Inc., Chicago, IL, USA) and SAS 9.1.3 (SAS Institute Inc., Cary, NC, USA). Statistical significance level was set at 0.05.

4. Results

4.1. Patient demographics

From June 2002 to March 2009 a total of 2726 oesophageal motility exams involving combined MII-EM were performed at