Detection and Patterns of Pharyngeal Reflux Events With Two Ambulatory Pharyngeal Impedance-pH Monitoring Systems: A Comparative Study☆

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SUMMARY: Objective. To investigate the detection and patterns of pharyngeal reflux events in laryngopharyngeal reflux disease (LPRD) patients according to the type of ambulatory hypopharyngeal-esophageal multichannel intraluminal impedance-pH monitoring (HEMII-pH) system used and assessed whether potential HEMII-pH differences impact the pretreatment to post treatment findings.

Methods. Patients with laryngopharyngeal symptoms and findings and an objective LPRD diagnosis were prospectively recruited from the European Reflux Clinic from January 2017 to December 2024. The objective diagnosis was supported by two different HEMII-pH systems (Medtronic and Sandhill). The profiles of LPRD on the objective testing devices (acid, weakly acid, and alkaline LPRD) of patients from the same clinic were prospectively compared. Reflux symptom scores (RSS) and reflux sign assessment (RSA) were used to document prepersonalized to postpersonalized treatment symptoms and findings. A study of the correlation between HEMII-pH features, symptoms, and signs was conducted.

Results. The study included gender- and age-matched 101 patients with a Sandhill HEMII-pH and 102 patients with a Medtronic HEMII-pH. Both systems detected distal esophageal reflux events similarly, but Medtronic detected significantly more pharyngeal reflux events. The Sandhill group showed higher proportions of acid and weakly acid LPRD, while Medtronic patients predominantly had alkaline reflux. Patients of both groups demonstrated significant RSS reduction after treatment ($P = 0.001$), with a trend toward higher response rates in the Sandhill group ($P = 0.067$). Symptom scores were better correlated to the Sandhill pharyngeal reflux event features than the Medtronic one.

Conclusion. The patterns of LPRD can substantially vary according to the type and catheter configuration of ambulatory HEMII-pH systems used. The differences between HEMII-pH devices support the need for revising consensus statements defining the thresholds of pharyngeal reflux events for confirming the LPRD diagnosis.

Key Words: Laryngeal–Laryngopharyngeal reflux–Gastroesophageal–Impedance–Otolaryngology–Head neck surgery.

INTRODUCTION

Laryngopharyngeal reflux disease (LPRD) is defined as a disease of the upper aerodigestive tract resulting from the direct and/or indirect effects of gastroduodenal content reflux, inducing morphological and/or neurological changes in the upper aerodigestive tract.[1] Based on several normative data studies, the recent international[1] and European[2] consensus for otolaryngological practice (Dubai consensus) proposed confirming the diagnosis when more than one pharyngeal reflux event is detected during 24-hour hypopharyngeal-esophageal multichannel intraluminal impedance-pH testing (HEMII-pH). This statement is based on the conclusion of a systematic review including 720 healthy individuals undergoing ambulatory esophago-pharyngeal reflux monitoring.[3] In this paper, the 95th percentile thresholds were 10 to 73 events for proximal esophageal reflux events on 24-hour multichannel intraluminal impedance-pH testing (MII-pH) and 0 to 10 events for pharyngeal reflux events on 24-hour HEMII-pH.[3] The current guideline recommendations pooled the data of HEMII-pH studies into a single group, regardless the HEMII-pH device/system. However, from a technical point of view, HEMII-pH probes from several manufacturers could vary in terms of sensor configuration, spacing, and sensitivity to detect proximal esophago-pharyngeal reflux event, impedance detection algorithms, signal processing and filtering, event definition parameters, and software analysis configuration.[4–6]

The present study investigated the detection and patterns of pharyngeal reflux events in LPRD patients according to the type of HEMII-pH system used and assessed whether potential HEMII-pH differences impact the pretreatment to post treatment findings.

METHODS

Subjects and setting

Patients with LPRD symptoms and findings were recruited from the European Reflux Clinic between July 2022 and November 2024. The European Reflux Clinic is a multi-site consultation center for LPRD patients, including Poitiers

Accepted for publication July 3, 2025.
☆ Vesale and Roi Baudouin Foundations.
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Journal of Voice, Vol xx, No xx, pp. xxx–xxx
0892-1997

https://doi.org/10.1016/j.jvoice.2025.07.003

Hospital (Elsan, Poitiers, France), Foch Hospital (Paris, France), and consider University Hospital (CHU) Saint-Pierre (Brussels, Belgium).[7] The author of this paper and a retired laryngologist conducted this study. Consistent with the Dubai[1] and European[2] Consensus criteria for diagnosing LPRD and normative data publications,[3] the diagnosis was confirmed through the documentation of more than one pharyngeal reflux events on 24-hour HEMII-pH. Depending on the recruitment site, patients underwent 24-hour HEMII-pH testing using Medtronic probes (Foch Hospital, Poitiers Hospital) or Sandhill probes (CHU Saint-Pierre). Gastrointestinal endoscopy was performed in patients with gastroesophageal reflux disease (GERD) symptoms and findings, history of Barrett metaplasia, and in elderly patients (> 60 years). Patients were excluded if they had severe neurological or psychiatric disorders, head and neck malignancies, asthma, chronic rhinosinusitis, drug-induced laryngitis, chronic obstructive pulmonary disease, or a history of neck radiotherapy or fundoplicature. Patients with an ongoing reflux treatment were not included.

The institutional review board approved the study protocol (CHU Saint-Pierre Ethics, n°BE076201837630). Patients consented to participate. This study adhered to the STROBE guidelines to ensure transparency and replicability of our findings.[8]

Ambulator pharyngeal reflux monitoring systems

The HEMII-pH probes used were from Medtronic (Versaflex Z®, LPR ZNID22+8R FGS 9000-19; Hauts-de-France, France) and Sandhill (Diversatek Healthcare®, ComforTEC Z/pH ZAI-BL-55probe, Highlands Ranch, USA). The length of the probe was based on the patient height and estimated esophageal length. Both catheter systems were composed of 8 impedance ring pairs and 2 pH electrodes. Six impedance segments were positioned along the esophagus zones (Z1 to Z6) below the upper esophageal sphincter (UES). Two pharyngeal impedance segments were positioned 1 and 2 cm above the UES. Probe placement was standardized across both clinical settings, with placement in the morning (8:00 AM) under fasting conditions, followed by verification of proper positioning through either chest radiography or nasofiberscopy. The settings of both probes followed the recommendations of the manufacturer. Note that the Medtronic catheter design includes only one impedance ring above the upper pH sensor; therefore, when positioning two impedance rings above the LES, the upper pH sensor is in the pharynx. In contrast, the Sandhill catheter features two impedance rings above its pH sensor, which typically positions this sensor in the UES or very deep hypopharynx/post-cricoid area.

The LPRD was diagnosed for more than one acid, weakly acid, or alkaline pharyngeal reflux event at the 24-hour HEMII-pH. A pharyngeal reflux event was defined as an episode reaching the pharyngeal sensors. Acid and alkaline pharyngeal reflux events consisted of events with pH ≤ 4.0 and pH > 4.0, respectively.

A ratio between the number of acid/alkaline pharyngeal reflux event was calculated. LPRD was defined as acid when the ratio of number of acid pharyngeal reflux episodes/number of alkaline reflux episodes was > 2. LPRD was defined as nonacid when the ratio of number of acid reflux episodes/number of nonacid reflux episodes < 0.5. Mixed reflux consisted of a ratio ranged from 0.51 to 2.0.

Consistent with the Dubai recommendations,[1] the analysis of the 24-hour recordings adhered to the following parameters: exclusion of reflux events occurring during meals; diagnosis of pharyngeal reflux events only when reflux originating from the distal-most impedance channel reached the pharyngeal channels in a retrograde fashion (full esophageal column to pharynx); and implementation of manual computer analysis for accurate identification of reflux events. Patients continued their daily diet during the 24-hour pH testing, and they were off proton pump inhibitors (PPIs), alginate, or antacids for at least 7 days.

GERD diagnosis was based on the Lyon guidelines, which consisted of Los Angeles grade C and D esophagitis, long segment Barrett's mucosa, peptic esophageal stricture, and acid exposure time in the distal esophagus > 6% of 24 hours.[9]

Symptoms, findings, and treatments

Reflux Symptom Score (RSS)[10] and Reflux Sign Assessment (RSA)[11] were used to document symptoms and signs. The RSA was evaluated by the two investigators (JRL and the retired laryngologist) in a blinded manner; both reporting an adequate interclass coefficient (r_s = 0.663) regarding previous studies.[11]

According to the European clinical practice guidelines for treating LPRD,[2] the therapeutic regimen consisted of a 3-month diet and standardized therapy combining PPI (pantoprazole 40 mg/day) with postmeal antacids (Riopan® 3/day, Takeda, Zaventem, Belgium) or alginates (Gaviscon® 3/day, Reckitt Benckiser, Slough, UK).

The treatment was based on HEMII-pH features. Patients with acid LPRD received PPI and postmeal alginate. Patients with weakly acid LPRD received postmeal alginates, while those with alkaline LPRD were treated with postmeal antacids (magaldrate). A standardized anti-reflux dietary and lifestyle protocol was recommended for all patients.[12]

The therapeutic response was evaluated according to the pretreatment to post treatment RSS changes. Non-responders were defined as subjects with increased, unchanged, or 1% to 20% reduced RSS after 3 months of treatment.[13] A reduction of 20.1% to 40% of the baseline RSS was defined as a mild therapeutic response. A moderate therapeutic response consisted of a reduced RSS of 40.1% to 60% of its pretherapeutic value. A reduction of 60.1% to 80% was considered a high response, while a reduction of more than 80.1% was defined as a complete response.[13]

Statistical methods

Statistical Package for the Social Sciences for Windows (SPSS version 30.0; IBM Corp, Armonk, NY, USA) was used for statistical analyses. According to the types of variables, Mann-Whitney *U* test and Chi-square were used to compare demographics, clinical, and ambulatory pharyngeal reflux monitoring system (number of upright/daytime acid, weakly acid, or alkaline reflux events, and GERD proportion) outcomes across patients with a Medtronic HEMII-pH and those with a Sandhill HEMII-pH. A Spearman correlation analysis was carried out between ambulatory pharyngeal reflux monitoring system outcomes RSS and RSA sub- and total scores for each HEMII-pH system. Correlation coefficient was considered as low ($k < 0.40$), moderate ($k = 0.40$-0.60), and strong ($k > 0.60$). A level of significance of $P < 0.05$ was used.

RESULTS

The study included 101 patients with a Sandhill HEMII-pH and 102 patients with a Medtronic HEMII-pH, with comparable mean ages, gender ratio, body mass index, and symptom presentation (Tables 1 and 2). Gastrointestinal endoscopy findings demonstrated a significantly higher number of normal examinations in the Medtronic group compared to Sandhill, while the Sandhill group reported a higher proportion of esophagitis and gastritis than the Medtronic one.

The HEMII-pH analysis showed that both systems detected distal esophageal reflux events similarly. Regarding pharyngeal reflux events, the Sandhill system detected more acid events and fewer nonacid events compared to the Medtronic one, leading to a significantly higher number of pharyngeal reflux events for the Medtronic system compared to the Sandhill system (Table 1). The number of detected upright pharyngeal reflux events was consequently higher in the Medtronic group versus Sandhill, while the proportion of upright/daytime pharyngeal reflux events was comparable across groups. According to our classification of acid, weakly acid, and alkaline LPRD, the proportion of types of LPRD significantly varied between

TABLE 1.
Demographics and Impedance pH Monitoring Features

	Sandhill	Medtronic	
Characteristics	*n* = 101	*n* = 102	*P* value
Mean age (range, years)	51.0 ± 14.9	51.0 ± 15.1	NS
Gender (*N*, %)			
Females	55 (54.4)	55 (53.9)	NS
Males	45 (44.6)	47 (46.1)	
Body mass index	24.6 ± 3.7	24.3 ± 5.2	NS
Gastrointestinal endoscopy	*N* = 61	*N* = 58	
Normal	10 (16.4)	31 (53.4)	0.001
Esophagitis	28 (45.9)	11 (19.0)	0.019
Hiatal hernia	19 (31.1)	12 (20.7)	NS
Lower esophageal sphincter insufficiency	23 (37.7)	16 (27.6)	NS
Gastritis	23 (37.7)	9 (15.5)	0.005
Helicobacter Pylori infection	4 (6.6)	2 (3.4)	NS
HEMII-pH feature (mean, SD)			
Distal esophageal reflux events			
Acid distal reflux events	40.7 ± 44.5	26.3 ± 15.0	NS
Nonacid distal reflux events	26.5 ± 21.9	30.5 ± 18.7	NS
Total number of distal events	63.0 ± 46.3	56.8 ± 24.1	NS
Pharyngeal events			
Pharyngeal acid reflux events	10.3 ± 15.0	2.0 ± 3.7	0.001
Pharyngeal nonacid reflux events	9.9 ± 11.2	43.3 ± 66.6	0.001
Total number of pharyngeal events	20.2 ± 20.8	45.0 ± 66.8	0.001
Position events			
Pharyngeal event upright	21.0 ± 21.5	44.9 ± 64.6	0.001
Pharyngeal event supine	3.3 ± 5.2	4.1 ± 8.2	NS
Types of LPRD (*N*, %)			
Acid LPRD	23 (228)	0 (0)	
Weakly acid LPRD	12 (11.9)	3 (2.9)	0.001
Alkaline LPRD	66 (65.3)	99 (97.1)	
Gastroesophageal reflux disease			
DeMeester score	25.8 ± 53.0	60.9 ± 83.1	0.001
Percentage of time with distal pH < 4	7.1 ± 16.1	19.5 ± 27.1	0.001

Abbreviations: HEMII-pH, hypopharyngeal-esophageal multichannel intraluminal impedance-pH monitoring; LPRD, laryngopharyngeal reflux disease; NS, non-significant; SD, standard deviation.

TABLE 2.
Symptoms and Findings

Clinical Scores	Sandhill				Medtronic				Between group comparison
	Baseline	3 months	Z	*P* value	Baseline	3 months	Z	*P* value	*P* value
Otolaryngological Reflux Symptom Score	53.8 ± 40.6	31.7 ± 33.7	−4.35	0.001	52.3 ± 39.4	32.1 ± 29.5	−4.76	0.001	NS
Digestive Reflux Symptom Score	41.6 ± 33.9	24.9 ± 30.2	−3.76	0.001	34.7 ± 31.1	25.3 ± 27.5	−4.17	0.001	NS
Respiratory Reflux Symptom Score	17.6 ± 24.5	9.7 ± 18.2	−3.21	0.001	13.2 ± 14.4	8.8 ± 14.2	−2.61	0.009	NS
QoL Reflux Symptom Score	32.5 ± 19.6	20.3 ± 17.4	−5.05	0.001	29.9 ± 16.6	23.4 ± 21.0	−3.78	0.001	NS
Total Reflux Symptom Score	113.0 ± 80.8	66.2 ± 67.7	−4.69	0.001	100.2 ± 65.7	66.3 ± 54.0	−4.74	0.001	NS
Oral Reflux Sign Assessment	5.3 ± 1.9	4.5 ± 2.2	−1.46	NS	5.8 ± 2.2	5.2 ± 2.1	−1.32	NS	0.033
Pharyngeal Reflux Sign Assessment	8.5 ± 4.0	7.3 ± 4.2	−1.63	NS	9.8 ± 3.8	7.2 ± 3.8	−2.83	0.005	0.024
Laryngeal Reflux Sign Assessment	13.1 ± 5.1	8.7 ± 5.4	−4.37	0.001	13.8 ± 5.0	9.8 ± 5.1	−4.39	0.001	NS
Total Reflux Sign Assessment	27.0 ± 7.3	20.4 ± 8.5	−4.32	0.001	29.4 ± 7.8	22.0 ± 7.3	−4.57	0.001	NS

Abbreviations: NS, non-significant; QoL, quality of life.

TABLE 3.
Therapeutic Responses

Therapeutic responses (%)	Sandhill	Medtronic	*P* value
No response	24.0	38.2	
Mild response	12.0	10.3	
Moderate response	30.0	13.2	0.067
High response	12.0	23.5	
Complete response	22.0	14.7	

Percentage of responders across groups.

groups, with higher proportions of acid and weakly acid LPRD in the Sandhill group compared to the Medtronic group. The Medtronic group was primarily composed of patients with alkaline reflux events (Table 1).

The pretreatment to post treatment RSS and RSA sub- and total scores are described in Table 2. Patients from the Medtronic group had significantly higher oral and pharyngeal RSA scores compared to those from the Sandhill group. However, both groups were comparable in terms of clinical symptom and laryngeal sign presentation. RSS scores, including otolaryngological, digestive, and respiratory sub-scores, significantly improved throughout treatment in both groups. The proportion of responders and non-responders is described in Table 3. A statistical trend was found for having a higher response rate in the Sandhill group versus Medtronic ($P = 0.067$).

The study of clinical association between HEMII-pH systems, symptoms, and findings is reported in Table 4. There were no moderate or high correlations in both groups. However, the nonacid pharyngeal reflux events documented by the Sandhill system were significantly correlated with otolaryngological, respiratory RSS, and total RSS (Table 4).

DISCUSSION

The HEMII-pH is the gold standard ambulatory examination for confirming the LPRD diagnosis.[1,2] Depending on the profile of LPRD in terms of pH (acid, weakly acid, or alkaline) or position (upright/supine), practitioners can prescribe a personalized treatment combining several medications, such as PPIs, alginates, or antacids, which is associated with a substantial higher therapeutic success rate and shorter treatment duration compared to standardized PPI-therapy.[13,14] The personalized approach in treating LPRD makes sense regarding the substantial rate of adverse events,[15,16] and the cost burden related to the management of LPRD in the United States[17] and Europe.[18]

The findings of the present study suggest that the HEMII-pH system used can significantly influence diagnosis-making and the profile of LPRD features despite similar methods for analyzing the tracings. To the best of our knowledge, this study is the first demonstrating such results for HEMII-pH systems in LPRD.

TABLE 4.
Correlation Study Between Pharyngeal Reflux Events, Symptom, and Finding Scores

	Sandhill Pharyngeal Reflux Event					Medtronic Pharyngeal Reflux Event				
	Acid	Nonacid	Total	Upright	Supine	Acid	Nonacid	Total	Upright	Supine
Otolaryngological Reflux Symptom Score	0.118	0.285*	0.228	0.124	0.074	0.011	0.090	0.095	0.075	0.088
Digestive Reflux Symptom Score	0.087	0.053	0.058	0.115	−0.191	0.011	−0.135	−0.110	−0.106	−0.067
Respiratory Reflux Symptom Score	0.066	0.244*	0.167	0.063	0.208	0.203*	0.084	0.118	0.054	0.187
Total Reflux Symptom Score	0.126	0.257*	0.204	0.126	0.021	0.060	0.025	0.050	0.026	0.087
Oral Reflux Sign Assessment	−0.166	−0.142	−0.222	−0.267	−0.104	−0.096	0.118	0.099	0.123	0.081
Pharyngeal Reflux Sign Assessment	0.210	−0.016	0.119	0.121	−0.055	0.071	−0.045	−0.023	0.015	−0.005
Laryngeal Reflux Sign Assessment	−0.168	−0.039	−0.145	−0.094	0.147	−0.032	0.058	0.054	0.094	−0.091
Total Reflux Sign Assessment	−0.071	−0.046	−0.098	−0.079	0.076	−0.050	0.043	0.042	0.080	−0.050

*$P < 0.05$.

Different pH catheter configurations may support this primary observation of this study. Because the Medtronic catheter has only one impedance ring above the upper pH sensor, the upper pH sensor is located in the pharynx where it would dry out, which may explain why fewer acid events are detected through the Versaflex analysis. Moreover, the proximal two impedance rings of this catheter are 3 cm apart, which would make the likelihood of a liquid pharyngeal event connecting those two electrodes in the pharynx less likely than with the 2 cm spacing of the Sandhill catheter. Due to its configuration, the Medtronic catheter may under-call acidic pharyngeal events in general. The significant impact of the ambulatory proximal/pharyngeal reflux event monitoring system was suggested by Becker et al, who compared Dx-pH measurement with classical MII-pH in the same cohort of patients.[19] Interestingly, Becker et al described considerable differences between MII-pH and Dx-pH results with low agreement for pharyngeal reflux event detection (kappa = 0.137).[19] Note that the Sandhill probe used by Becker et al did not include pharyngeal sensors; authors considered esophageal proximal reflux events as pharyngeal ones, which can be considered a major flaw regarding the role of the UES in stopping the progression of esophageal reflux events to the pharynx.[20]

Vance et al performed simultaneous 24-hour HEMII-pH (Medtronic) and Dx-pH measurement testing on 87 patients with LPRD symptoms.[21] Authors demonstrated that the Dx-pH system detected more percent time in reflux for total reflux, supine reflux, and upright reflux, as well as longer event times than the HEMII-pH system.[21] The observation of significant differences across HEMII-pH and Dx-pH measurement is not surprising regarding their technological differences. Dx-pH measurement uses a single antimony pH sensor, which measures pH changes in aerosolized droplets within the pharyngeal environment.[22] HEMII-pH systems are based on multiple impedance ring pairs and pH sensors detecting liquid or gas reflux events through changes in electrical conductivity between adjacent impedance rings.[23] In HEMII-pH, the pharyngeal reflux event is confirmed after the documentation of a full column reflux through the esophagus to reach pharyngeal sensors, which prevents the risk of false positive events.[23] Moreover, the Dx-pH system algorithm used for calibrating the pharyngeal environment with different pH thresholds for upright and supine positions is different from the algorithm used in HEMII-pH tracing. Currently, the Dx-pH measurement is not considered the gold standard for LPRD diagnosis due to the risk of dryness of the pH sensor, as well as the risk of detecting oropharyngeal mucosal pH changes related to confounding factors, rather than actual reflux events. While our investigation cannot confirm this hypothesis, the differences between Medtronic and Sandhill HEMII-pH systems for detecting pharyngeal reflux events could be related to the above-mentioned catheter configurations, potential dryness of the upper pH sensor (Medtronic), and related sensitivity for detecting gaseous

pharyngeal reflux events; the inclusion of gaseous pharyngeal reflux events being considered in the IFOS criteria. The findings of this study are important considering the current guidelines and consensus papers in otolaryngology for defining LPRD and confirming the diagnosis. The consideration of > 1 pharyngeal reflux event was based on a systematic review combining all studies investigating the HEMII-pH in asymptomatic individuals. In this study, most studies (n = 6) used Sandhill probes, while only one study used the HEMII-pH Medtronic system in asymptomatic subjects with no calculation of the mean number of pharyngeal reflux events in asymptomatic individuals.[24] Moreover, a few details are provided by authors for the manual analysis of tracings, especially the consideration of gaseous or liquid or both events in the analysis. In addition to diagnosis-making, these differences across both HEMII-pH systems could theoretically influence therapeutic outcomes when considering personalized medicine.[13] This hypothesis can be supported by the significant differences found in the present paper for the types of LPRD at the pharyngeal reflux event ratio calculation. For comparable clinical and demographic populations, a significantly higher number of patients were categorized as acid and weakly acid LPRD in the Sandhill group, while the Medtronic group reported a higher proportion of alkaline LPRD. These differences, underlying different therapeutic strategies across groups, may, however, lead to minimal differences in therapeutic response rate with a statistical trend (P = 0.067) in favor of the Sandhill group versus the Medtronic one. Although this trend cannot support significant differences, it strengthens the need to conduct future studies investigating the therapeutic impact of the variability across HEMII-pH systems.

The impact of the HEMII-pH system on the study of the correlation between pharyngeal reflux events, symptoms, and findings was investigated through a correlation analysis. It is commonly supported that contrary to GERD, LPRD is poorly associated with symptoms and findings, which can be attributed to the gaseous nature of most pharyngeal reflux events and the potential delay between events and the development of substantial inflammation and related symptoms.[1,25,26] Despite mild correlation coefficients, significant associations were found between weakly acid pharyngeal reflux events detected by the Sandhill system and otolaryngological and respiratory RSS sub- and total scores. The low correlation between HEMII-pH features and signs corroborates the observations of Vance et al, who did not find significant correlation between the reflux finding score and the number or percent time of reflux events, the longest event, total number of events, or the percent of time at alkaline pH for either the HEMII-pH or Dx-pH test.[21] Concerning symptoms, the authors observed a significant correlation between the reflux symptom index and the HEMII-pH test for percent time spent in both upright and supine position.

The primary limitation of this study was the lack of comparison of both HEMII-pH systems on the same patients throughout the same 24-hour period with each probe introduced in each nasal cavity. This approach was not considered due to the potential poor tolerance for patients having two probes in the upper aerodigestive tract and esophagus and the associated costs; only one HEMII-pH testing is reimbursed by the healthcare system.

The lack of randomization of patients and the recruitment from three different hospitals are the primary limitations of the study, despite the hospital location in the same European region and the similarities in patient habits (diet, lifestyle, genetic patterns). Moreover, both groups shared significant differences in terms of distal acid exposure time and prevalence of esophagitis, which may introduce heterogeneity in term of clinical presentation (GERD symptoms) and group comparability. Future randomized studies are needed to investigate the potential differences across probes from different manufacturers for detecting and measuring distal reflux events and acid exposure time, while determining standardized approaches for both catheters (eg, placement of sensor) to have the most reliable results.

The nature of the reflux events (gaseous, mixed, or liquid) was not investigated in this study due to limitations in the Sandhill software for differentiating reflux events according to their nature. Future studies need to consider this point to understand the origin of differences between Medtronic and Sandhill systems in the detection and characterization of pharyngeal reflux events in LPRD patients.

CONCLUSION

The patterns of LPRD (acid, weakly acid, and alkaline LPRD) can substantially vary according to the type and catheter configurations of ambulatory HEMII-pH systems used. Differences between HEMII-pH systems in detecting pharyngeal reflux events significantly impact personalized treatment protocols and is associated with a significant variability in correlation study between symptoms and HEMII-pH features. The differences between HEMII-pH devices support the need for revising consensus statements defining the thresholds of pharyngeal reflux events for confirming the LPRD diagnosis.

Author Contributions

Jerome R. Lechien: Patients were recruited from the Reflux Consultation of the author of the paper. Contributions: design, acquisition of data, data analysis and interpretation, drafting, final approval, and accountability for the work; final approval of the version to be published; agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Declaration of Competing Interest

The author has no financial interest in the subject under discussion. All authors have read and approved the manuscript.

Acknowledgments

Dr. Francois Bobin (retired laryngologist) for the blinded finding assessment. Alexandra Rodriguez, Mihaela Horoi, Marie-Paule Thill, Stephane Hans, Didier Dequanter, and Sven Saussez for having addressed patients to the European Reflux Clinic and the consultation of the author of the paper.

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