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Better diagnostic accuracy for GERD observed with the new MNBI cutoff: an observational study in Vietnam

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Abstract

Background Mean nocturnal baseline impedance (MNBI) is a novel metric for multichannel ambulatory impedance and pH (MI-pH) monitoring used to diagnose gastroesophageal reflux disease (GERD); however, its thresholds vary among different geographic areas and measuring systems. This study analyzed MI-pH data from Vietnamese patients to assess the diagnostic utility of novel MNBI thresholds in identifying GERD.

Methods This retrospective study included 133 patients suspected of having GERD who underwent upper gastrointestinal endoscopy, esophageal high-resolution manometry (HRM) and 24-hour MI-pH monitoring (Laborie). The subjects were divided into 3 groups based on the acid exposure time (AET) index (abnormal, inconclusive and normal AET). The mean MNBI and the prevalence of abnormal MNBI values were compared within groups, and the diagnostic accuracy of this index for diagnosing GERD was evaluated via receiver operating characteristic (ROC) curves and their area under the curve (AUC).

Results MNBI was significantly lower in patients with abnormal AET. The prevalence of MNBI < 2292 Ohms and MNBI < 1500 Ohms were greater in patients with abnormal AET (91.2% and 79.4%, respectively). The percentage of MNBI > 2500 Ohms was 44.4% in patients with normal AET but only 2.9% in patients with abnormal AET. MNBI had the highest AUC in discriminating abnormal AET (0.90, $p < 0.001$) in comparison with other metrics on MI-pH monitoring. The new cutoff value of 1500 Ohms had lower sensitivity but higher specificity than the previous threshold of 2292 Ohms. A multivariable regression analysis revealed that an MNBI < 1500 Ohms and total number of reflux events > 80/day were significantly associated with abnormal AET (> 6%).

Conclusions Among Vietnamese patients with suspected GERD, the new MNBI cutoff of > 1500 Ohms had high sensitivity and specificity in diagnosing GERD, while the cutoff of 2500 Ohms could rule out this disease.

Keywords Mean nocturnal baseline impedance, Esophageal pH monitoring, Gastroesophageal reflux disease

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Introduction

Gastroesophageal reflux disease (GERD) represents a significant public health issue, affecting approximately 20% of populations in Western countries and 2.5–6.7% in Asia [1, 2]. In Vietnam, the prevalence of GERD in the general population is lacking, and most GERD studies have been conducted on inpatients or outpatients via clinical questionnaires and/or upper gastrointestinal endoscopy. In the very first study using 24-hour esophageal pH-impedance monitoring among Vietnamese patients, only 30.4% of those with refractory reflux symptoms, unknown chest pain and/or extraesophageal reflux symptoms had a conclusive diagnosis of GERD [3].

Multichannel ambulatory impedance and pH monitoring (MI-pH) is a widely utilized diagnostic tool in high-income countries but remains less accessible in developing nations, such as Vietnam. A conclusive diagnosis of GERD often requires the assessment of acid exposure time (AET) and/or the total number of reflux episodes. In recent years, novel diagnostic parameters, including the mean nocturnal baseline impedance (MNBI) and the post-reflux swallow-induced peristaltic wave (PSPW) index, have been suggested as potential tools for diagnosing GERD and identifying GERD phenotypes [4–6].

MNBI serves as an indicator of esophageal mucosal integrity, reflecting alterations in the esophageal lining due to reflux, even in the absence of macroscopic damage [4]. However, the normative MNBI thresholds vary across studies [7]. In the updated version of the Lyon consensus in 2023, an MNBI value of less than 1500 Ohms has been proposed to be indicative of GERD, whereas a value exceeding 2500 Ohms could effectively exclude the condition [8]. Several studies conducted in Asia have investigated the appropriate cutoff value of the MNBI, which is thought to be lower than that in Western countries [9, 10]. In this study, we analyzed MI-pH data from Vietnamese patients to assess the diagnostic utility of the novel MNBI thresholds in identifying GERD.

Materials and methods

Study design and population

Our patients were adults (≥18 years old) who underwent 24-hour pH-impedance monitoring, upper gastrointestinal endoscopy, and high-resolution esophageal manometry (HRM) at the Hoang Long Clinic/Institute of Gastroenterology and Hepatology (Hanoi, Vietnam) between December 2020 and August 2024.

There were two periods of data collection. The first period was during the national project "*Evaluate esophageal motility and secretion disorders in some gastroesophageal diseases*" funded by the Vietnam Ministry of Science and Technology. This study was conducted between 2020 and 2022 and evaluated the accuracy of several conventional and novel techniques for diagnosing GERD and other esophageal motility disorders. Indications for 24-hour pH-impedance monitoring included patients who had a previous diagnosis of GERD but were partially or completely unresponsive to proton pump inhibitor therapy or those who had extraesophageal symptoms (such as chronic cough, laryngitis, globus, and unexplained chest pain) suspected to be due to reflux disease.

In the second period, we collected data from the medical records of those who had FSSG (The Frequency Scale for the Symptoms of GERD) and GerdQ (GERD questionnaire) scores. In both periods, we excluded those with esophagogastric outflow obstruction disorders, distal esophageal spasm and hypercontractile esophagus determined by HRM based on the Chicago classification version 3.0 [11]. This observational study utilized ethics approval of the mentioned-above national project by the Institutional Review Board of Dinh Tien Hoang Institute of Medicine (Approval No.IRB-1909). The study was performed in accordance with the Declaration of Helsinki principles. All participants provided written informed consent in the first period of the study's data collection. During the second period, no study procedures were conducted and all patients followed routine procedures at our clinic. Therefore, the data collected from this period was of retrospective nature and informed consent is not required.

GERD questionnaires

To evaluate the frequency and severity of symptoms, we used FSSG (The Frequency Scale for the Symptoms of GERD) and GERD questionnaire (GerdQ) scores. The structure and psychometric properties of the scales have been described in detail elsewhere [12, 13].

Endoscopy

The endoscopy was performed when PPI usage was discontinued for at least 7 days. The severity of erosive esophagitis was evaluated using the Los Angeles (LA) classification. Barrett's esophagus was categorized as either a short segment (<3 cm in length) or a long segment (≥3 cm in length), and no biopsy samples were taken [14, 15]. We classified patients into erosive reflux disease (ERD) or non-erosive reflux disease (NERD) based on the presence of esophagitis (LA grade A and above).

High-resolution manometry (HRM)

HRM study was performed with water-perfused catheters on Laborie system. Esophageal hypomotility disorders included ineffective esophageal motility (IEM) and absent contractility diagnosed following Chicago classification 3.0. Esophagogastric junction (EGJ) morphology

was divided into 3 types based on the LES-crucial diaphragm separation (type I: complete overlap, type II: a separation of 1–2 cm and type III: a separation > 2 cm) [11].

24-hour multichannel ambulatory impedance and pH monitoring (MI-pH)

We used single-used catheters connected to an Omega device (Laborie, Poland). The catheters included one pH channel, and 6 impedance channels (Z1-Z6) located 17, 15, 9, 7, 5, and 3 cm above the lower esophageal sphincter (LES). PPI usage was discontinued for at least 7 days prior to the test. Patients were instructed to record their activity and symptom diary during the test. According to the Lyon 2.0, acid exposure time (AET) is the major parameter in diagnosing GERD, which is measured by the time the esophageal mucosa is exposed to pH < 4 over the total monitoring time [8]. The diagnosis was categorized into three groups based on AET: abnormal (AET > 6%), inconclusive (AET 4–6%) and normal (AET < 4%). Additionally, the PSPW index was calculated by dividing the number of post-reflux swallow-induced peristaltic waves (defined as a swallow occurring within 30 s after the end of a reflux episode) by the total number of reflux events [16]. MNBI was manually calculated as the mean impedance of the channels at 5 cm and 3 cm above the LES in three stable 10-minute periods (no signs of swallows, reflux events, artifacts, or pH drops) at approximately 1 AM, 2 AM, and 3 AM [6].

Table 1 Clinical, endoscopic, and manometric characteristics of the study population

Characteristics	Abnormal AET	Inconclusive AET	Normal AET	p
	(n = 34)	(n = 9)	(n = 90)	
Clinical symptoms, n (%)				
Regurgitation	26 (76.5)	7 (77.8)	70 (77.8)	0.99
Heartburn	18 (52.9)	7 (77.8)	49 (54.4)	0.38
Chest pain	10 (29.4)	1 (11.1)	26 (28.9)	0.51
Dysphagia	7 (20.6)	4 (44.4)	20 (22.2)	0.29
Pharyngeal symptoms	24 (70.6)	4 (44.4)	62 (68.9)	0.3
Clinical questionnaire score, mean ± SD				
FSSG	12.3 ± 8.1	14.7 ± 6.4	11.4 ± 6.9	0.4
GerdQ	7.9 ± 2.7	8.4 ± 1.9	7.8 ± 3.1	0.82
Upper endoscopy, n(%)				
Reflux Esophagitis				0.61
No	8 (23.5)	3 (33.3)	30 (33.3)	
LA grade A	24 (70.6)	6 (66.7)	56 (62.2)	
LA grade B-C	2 (5.8)	0	4 (4.4)	
High-resolution manometry (HRM), n(%)				
Hypomotility	23 (67.6)	6 (66.7)	48 (53.3)	0.3
EGJ hypotonia	10 (29.4)	2 (22.2)	13 (14.4)	0.16
EGJ morphology				0.68
Type I	29 (85.3)	9 (100)	76 (84.4)	
Type II	4 (11.8)	0	13 (14.4)	
Type III	1 (2.9)	0	1 (1.1)	

AET: acid exposure time; **EGJ**: esophagogastric junction.; **FSSG**: The Frequency Scale for the Symptoms of GERD); **GerdQ**: GERD questionnaire, **LA**: Los Angeles; **SD**: standard deviation

Statistical analysis

The data were analyzed via IBM SPSS Statistics for Windows, Version 20.0 (IBM Corp. Released 2011. Armonk, NY, USA). The chi-square test (χ^2) was used to test the differences in categorical variables between groups. Analysis of variance (ANOVA) was used to test the difference in means between > 2 groups; least significant difference (LSD) post hoc analysis was performed to identify the specific groups with significant differences. The ability of MNBI and other 24-hour MI-pH metrics to distinguish GERD was evaluated by the receiver operating characteristic (ROC) curves and their area under the curve (AUC). The optimal cutoff value was determined by Youden's index. P values of < 0.05 were considered statistically significant.

Results

A total of 133 patients were included in this study, among whom 56.4% were female. The mean age was 46.5 ± 12.3 years (range 20–76 years). The mean BMI was 21.7 ± 2.6 (kg/m2), 19.2% of patients were overweight (BMI 23–24.9 kg/m^2), and 10.4% were obese (BMI ≥ 25 kg/m2). On endoscopy, 41 patients (30.8%) had no reflux-related abnormalities (NERD); 92 patients (60.2%) had erosive esophagitis (ERD), predominantly LA grade A (93.5%). On HRM, the prevalence of esophageal hypomotility disorders and EGJ hypotonia were not significantly different among the 3 groups (Table 1). The mean MNBI was significantly lower in patients with EGJ hypotonia (1620 ± 814 Ohms) than those with normal EGJ pressure (2048 ± 911 Ohms) ($p = 0.03$), but not significantly different between ERD and NERD and between hypomotility disorders and normal esophageal motility.

Patients with abnormal AET, inconclusive AET, and normal AET had no difference in the total number of refluxes per 24 h. The PSPW index and MNBI were significantly lower in patients with abnormal AET. The prevalence of MNBI < 2292 Ohms and MNBI < 1500 Ohms were higher in patients with abnormal AET (91.2% and 79.4%, respectively). The percentage of MNBI > 2500 Ohms was 44.4% in patients with normal AET but only 2.9% in patients with abnormal AET (Table 2).

ROC analysis showed the diagnostic value of MNBI and other parameters in discriminating abnormal AET from others (Fig. 1a) and ERD from NERD on endoscopy (Fig. 1b). All the parameters (AET, TRs, MNBI, PSPW index) did not discriminate ERD from NERD better than random guesses did. MNBI had the highest AUC in discriminating abnormal AET (0.90, $p < 0.001$). The optimal

Table 2 24-hour MI-pH characteristics in the study population

Characteristics	Abnormal AET (*n* = 34)	Inconclusive AET (*n* = 9)	Normal AET (*n* = 90)	*p*
24-hour MI-pH				
Total refluxes (TRs)/day, mean ± SD	70 ± 37	92 ± 46	62 ± 39	0.07
TRs < 40/day, n(%)	10 (29.4)	2 (22.2)	29 (32.2)	0.81
TRs > 80/day, n(%)	16 (47.1)	2 (22.2)	36 (40.0)	0.39
PSPW index (%), mean ± SD	23 ± 10	24 ± 6	32 ± 12	0.001**
PSPW index < 50%, n(%)	34 (100)	9 (100)	84 (94.4)	0.29
MNBI (Ohms), mean ± SD	1005 ± 661	1489 ± 436	2379 ± 700	< 0.001*
MNBI < 2292 (Ohms), n(%)	31 (91.2)	9 (100)	35 (38.9)	< 0.001
MNBI < 1500 (Ohms), n(%)	27 (79.4)	4 (44.4)	10 (11.1)	< 0.001
MNBI > 2500 (Ohms), n(%)	1 (2.9)	0	40 (44.4)	< 0.001

AET: acid exposure time; **MNBI**: mean nocturnal baseline impedance, **PSPW**: post-swallow reflux-induced peristalsis wave; **TRs**: total refluxes; **SD**: standard deviation

*post hoc analysis showed significances between abnormal AET and inconclusive AET group, between abnormal AET and normal AET group, and between an inconclusive AET and normal AET group. **post hoc analysis showed significances between normal AET and inconclusive AET group, and between abnormal AET and normal AET group

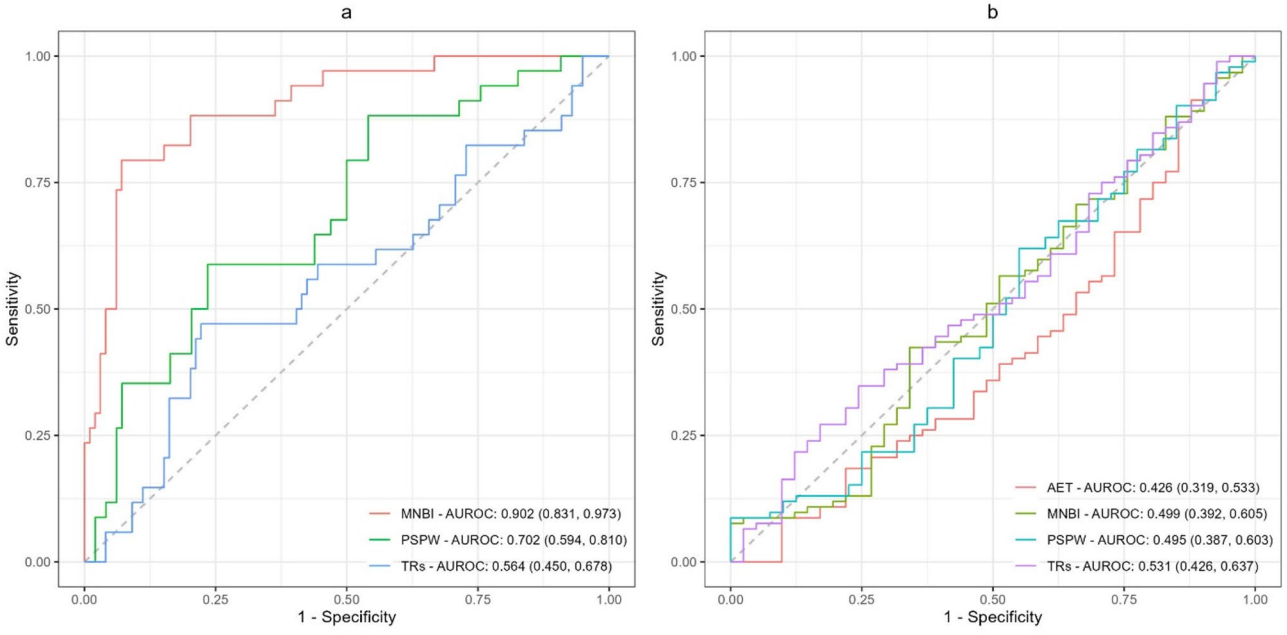

Fig. 1 Diagnostic accuracy of MNBI for diagnosing GERD: (**a**) ROC curves of MNBI, PSPW index, and TRs for differentiating abnormal AET from inconclusive AET from normal AET; (**b**) ROC curves of AET, MNBI, PSPW index, and TRs for differentiating ERD from NERD on endoscopy

Table 3 Binary logistic regression between several variables and GERD diagnosis defined by AET > 6%

Variables	OR	95%CI
MNBI < 1500 Ohms	30.5	8.9–104.1
TRs > 80/day	3.7	1.1–12.2
PSPW index < 22.5%	2.6	0.8–7.8
ERD	3.1	0.8–11.5
Esophageal hypomotility	2.2	0.7–7.0
EGJ hypotonia	2.3	0.7–8.1

EGJ: esophagogastric junction; **ERD**: erosive reflux disease; **MNBI**: mean nocturnal baseline impedance, **PSPW**: post-swallow reflux-induced peristalsis wave; **TRs**: total refluxes

cutoff value of 1243 Ohms had a sensitivity of 79.4% and a specificity of 92.9% in diagnosing GERD based on abnormal AET. The sensitivity and specificity of 1500 Ohms were 79.4% and 85.9%, respectively. The sensitivity and specificity of 2292 Ohms were 91.2% and 55.6%, respectively. PSPW index cutoff value of 22.5% had a sensitivity of 58.8% and a specificity of 76.5%.

A multivariable logistic regression analysis showed MNBI < 1500 Ohms and TRs > 80/day were significantly associated with abnormal AET (> 6%) (Table 3).

Discussion

In this study, we found that with the new threshold of 1500 Ohms, MNBI had a lower sensitivity but higher specificity in diagnosing GERD compared to the previous value of 2292 Ohms. We also found that only 2.9% of patients diagnosed with GERD by abnormal AET had an MNBI > 2500 Ohms, which could support that this threshold can be used to rule out GERD.

In recent updated guidelines and consensus, GERD is endoscopically diagnosed when having esophagitis LA grade B or higher, biopsy-proven Barrett's esophagus or other reflux-induced complications [8, 17]. Our study reported a very low prevalence of esophagitis B and higher (4.5%), but this finding was in line with other studies in Vietnam previously (2.2–18.1%) [18–20]. The Asia-Pacific consensus also agreed that GERD is mostly a mild disease in the Southeast Asia region with predominantly NERD [21]. Besides mucosal injuries, esophageal motility disorders are important factors in the pathogenesis of GERD. Hypotensive EGJ and ineffective esophageal peristalsis are reported to have a link with the development of GERD [22–24]. However, the prevalence of esophageal hypomotility disorders and EGJ hypotonia in our study were not significantly higher in patients with abnormal AET compared to those with inconclusive and normal AET. Because of this low specificity for GERD, hypomotility disorders and hypotensive EGJ are only supportive evidence for pathologic reflux [8].

MNBI adds evidence to other main metrics, including AET and total refluxes on MI-pH monitoring, which can help physicians correctly diagnose GERD. Compared with those of functional heartburn patients and healthy controls, lower MNBI values have been reported in patients with erosive esophagitis, nonerosive esophagitis, and reflux hypersensitivity [7]. Although endoscopy is widely used in clinical practice for patients with gastrointestinal complaints, the application of this technique in the diagnosis of GERD is still limited [25]. A study defining ERD as the presence of esophagitis LA C and D showed a very good performance of MNBI and PSPW indices in separating ERD from NERD [26]. However, the prevalence of these abnormalities is quite low among GERD populations in Asian countries [1, 21]. Our study showed only 6 out of 133 patients had reflux esophagitis of LA grade B or higher. This is the reason why MNBI and other metrics for 24-hour MI-pH could not differentiate ERD (defined by patients with esophagitis LA grade A and above) from NERD via ROC curve analysis.

In 2018, the cutoff of MNBI at 2292 Ohms with an AUC of 0.876 was supposed in Lyon consensus 1.0 according to the study of Franzzoni [27]. By 2022, the second version of this consensus lowered this threshold based on a new multicenter international study of healthy asymptomatic subjects underperforming pH-impedance monitoring. In this study, the fifth percentile of MNBI among healthy individuals was 1500 Ohms, implying that subjects with MNBI below this value were likely to have impaired mucosal integrity. However, the cutoff value of MNBI varies across studies and may be lower in Asia than in Europe [7]. Normal values of MI-pH monitoring demonstrate both regional and system-related differences, including higher PSPW scores in Western countries, higher MNBI in Asia using Diversatek, and higher acid exposure in the Netherlands, higher MNBI in Asia and South Africa, and lower MNBI in Turkey using Laborie [28]. A cutoff of 1785 Ohms could discriminate patients with GERD and other phenotypes on MI-pH monitoring in a Japanese study [9]. Another study in China reported that a cutoff value of 1764 Ohms was used to distinguish GERD patients from healthy individuals [10]. In Vietnam, data on asymptomatic and healthy individuals undergoing MI-pH monitoring are scarce. Our study resulted in a cutoff value of 1243 Ohms when using MNBI to diagnose GERD based on an abnormal AET higher than 6%.

Our study was the very first study in Vietnam in which 24-hour esophageal pH monitoring was used to diagnose GERD among patients who presented with reflux-like symptoms. These findings provide additional evidence for the use of MI-pH monitoring in Asian populations. Our study has several limitations. This was a cross-sectional study using retrospective data from a single center, which may have resulted in selection bias. The small number of patients with each GERD phenotype and the lack of healthy controls restricted the ability to analyze the value of MNBI in distinguishing between these groups.

Conclusion

Among Vietnamese patients with suspected GERD, the new MNBI cutoff of < 1500 Ohms had high sensitivity and specificity in diagnosing GERD, and the cutoff of 2500 Ohms could rule out GERD.

Abbreviations

AET	Acid exposure time
EGJ	Esophagogastric junction
ERD	Erosive reflux disease
GERD	Gastroesophageal reflux disease
LA	Los Angeles
MI-pH	Multichannel impedance - pH
MNBI	Mean nocturnal baseline impedance
PSPW	Post-swallow reflux-induced wave
ROC	Receiver operating characteristic
TR	Total reflux events

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Not applicable.

Author contributions

Hang Dao Viet and Long Dao Van: planning and conducting the study, final approval of the version to be published. Hue Luu Thi Minh: collecting, analyzing, and interpreting data, drafting the manuscript, Phuong Do Nhat: collecting data, drafting the manuscript. Long Hoang Bao: analyzing and

interpreting data and revising the manuscript. All authors read and approved the final manuscript.

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Data availability
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This observational study utilized ethics approval of the mentioned-above national project by the Institutional Review Board of Dinh Tien Hoang Institute of Medicine (Approval No.IRB-1909). The study was performed in accordance with the Declaration of Helsinki principles. All participants provided written informed consent in the first period of the study's data collection. During the second period, no study procedures were conducted and all patients followed routine procedures at our clinic. Therefore, the data collected from this period was of retrospective nature and informed consent is not required.

Consent for publication
All participants provided written informed consent for the use of data in research activities in the first period of the study's data collection. During the second period, no study procedures were conducted and all patients followed routine procedures at our clinic. Therefore, the data collected from this period was of retrospective nature and informed consent is not required.

Competing interests
The authors declare no competing interests.

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