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The Role of 24-Hour Multichannel Intraluminal Impedance–pH Monitoring in Pediatric Patients: A Single-Center Experience

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ABSTRACT

Background: Laryngopharyngeal reflux in children often presents with nonspecific respiratory symptoms, and conventional pH monitoring cannot detect non-acid events. Combined 24-hour multichannel intraluminal impedance–pH (MII–pH) monitoring detects acid and non-acid reflux, assesses their composition, and determines the proximal extent. This study evaluated the diagnostic value of MII–pH monitoring in children with persistent respiratory complaints.

Methods: This research included children aged 0–18 years who underwent 24-hour MII–pH monitoring. The reflux parameters and symptom association probability (SAP) were analyzed. A study was defined as pathological if SAP ≥ 50% or reflux counts exceeded pediatric thresholds.

Main findings: The median number of reflux episodes was 50 by pH-metry and 113 by impedance, confirming that impedance detected more events. Liquid and gaseous reflux predominated, while mixed reflux was less common. The reflux index was low, and no significant difference was found between children with and without gastroesophageal reflux. Proximal migration reached the upper esophagus in over half of acid and 42% of weakly acid episodes. Gastroesophageal reflux was confirmed in 87.1% of children and treatment was started in almost all. Nineteen children with negative SAP still met pathological thresholds.

Principal conclusion: MII–pH monitoring provided higher diagnostic sensitivity than pH-metry alone and helped guide treatment in children with persistent respiratory symptoms.

Key words: pediatrics, laryngopharyngeal reflux, gastroesophageal reflux, impedance–pH monitoring, non-acid reflux, respiratory symptoms, children

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INTRODUCTION

Laryngopharyngeal reflux (LPR) is defined as the retrograde movement of gastric contents into the upper aerodigestive tract, where repeated exposure may damage the mucosa and lead to a spectrum of nonspecific respiratory manifestations (1). In children, LPR can present with a broad range of clinical problems, including hoarseness, chronic cough, and recurrent airway infections, or even pneumonia (2). Because these features are often nonspecific and overlap with other pediatric respiratory disorders, timely recognition remains challenging for clinicians. Traditional pH monitoring, long considered the gold standard for gastroesophageal reflux disease (GERD), is limited by its inability to detect non-acid events, which are now known to play an important role in pediatric reflux pathology (3). By contrast, combined 24-hour multichannel intraluminal impedance–pH (MII–pH) monitoring enables detection of acid, weakly acid, and weakly alkaline reflux episodes, while simultaneously characterizing their composition and proximal extent (4). Therefore, the present study aimed to evaluate the diagnostic value of MII–pH monitoring in children with persistent respiratory symptoms and to assess its role in identifying the relationship between reflux episodes and airway complaints.

PARTICIPANTS AND METHODS

Participants

This research included children aged 0–18 years who underwent 24-hour multichannel intraluminal impedance–pH (MII–pH) monitoring at the Department of Pediatric Pulmonology and Allergology, University Clinical Hospital Mostar, between October 2023 and October 2025. The study was approved by the Institutional Ethics Committee of the University Clinical Hospital Mostar.

Methods

Patients presented with persistent respiratory complaints such as chronic cough, wheezing, or asthma-like symptoms, or recurrent infections lasting at least three months. All consecutive referrals for MII–pH monitoring were analyzed, with no additional exclusion criteria. Before the procedure, each child underwent clinical evaluation including their history, physical examination, and allergy testing. Information on the use of proton pump inhibitors and H2-receptor antagonists was collected and considered during interpretation. Parents kept a diary during monitoring, documenting meals, body positions, activities, and respiratory symptoms. MII–pH monitoring was performed using the Digitrapper™ pH-Z system (Given Imaging/Medtronic, USA) and a VersaFlex® Z probe with one pH sensor and seven impedance rings, adjusted for age and height. The pH electrode was calibrated with pH 4.0 and 7.0 buffer solutions according to the manufacturer's protocol. The probe was placed transnasally so that the pH sensor was positioned 5 cm above the lower esophageal sphincter, verified radiographically or by standard formula. Reflux episodes were categorized as acidic (pH <4), weakly acidic (pH 4–7), or weakly alkaline (pH >7), and further classified by composition (liquid, gas, mixed) and proximal extent. A study was considered pathological if the symptom index was ≥50% or if the total number of reflux episodes exceeded 70 in children ≥1 year or 100 in infants <1 year, in line with European Society for Paediatric Gastroenterology Hepatology and Nutrition (ESPGHAN) recommendations (5). Recordings were reviewed manually using Reflux Software 6.1 (Given Imaging/Medtronic).

Statistical analysis

Descriptive statistics summarized the demographic and clinical variables. Continuous data were expressed as mean ± standard deviation or median with range, depending on distribution. Categorical

variables were presented as counts and percentages. Group comparisons used the Mann–Whitney U test for continuous data and χ^2 or Fisher's exact test for categorical. A p-value <0.05 was considered significant. Analyses were performed with IBM SPSS Statistics, version 29 (IBM Corp., Armonk, NY, USA).

RESULTS

A total of 31 children (14 girls, 45.2%) underwent 24-hour multichannel intraluminal impedance–pH (MII–pH) monitoring. The median age was 2.1 years (range 0.1–12.0 years). The median number of reflux episodes detected by pH-metry was 50 (range 0–175), whereas impedance identified a median of 113 episodes (21–366). Liquid reflux episodes were the most frequent (median 52; 13–98), followed by gaseous (68; 4–289) and mixed episodes (9; 0–20). The overall median RI was 2.2% (range 0%–13.8%). In subgroup analysis, children with gastroesophageal reflux (GER) had a median RI of 0.8% (0.2%–4.0%), compared to 0.5% (0%–1.0%) in those without GER; however, this difference was not statistically significant (Mann–Whitney U test, p=0.063). Proximal migration reached the upper third of the esophagus in a median of 56% (0%–100%) of acidic and 42.1% (0%–84.6%) of weakly acidic episodes. Gastroesophageal reflux was confirmed in 27 children (87.1%), while four (12.9%) had negative findings. Children with confirmed reflux had a higher number of episodes by pH-metry (median 58 vs. 20) and higher RI% (3.0 vs. 1.1) compared to those without reflux; however, these differences did not reach statistical significance (Mann–Whitney U test, p=0.126 for pH-metry; p=0.063 for RI%).

Therapy was initiated in 27 patients (87.1%), almost exclusively in those with confirmed reflux. Children without reflux were mostly not treated (3/4). Additional gastroenterological evaluation was performed in eight children (25.8%), but this was not statistically associated with either reflux status (p=1.0) or treatment (p=1.0). We also analyzed the relationship between symptom association probability (SAP) and the criterion of pathological reflux episode counts (>70 episodes in children older than one year, >100 in infants). Among those with negative SAP (<95%), 19 children still met the pathological threshold, compared to seven with positive SAP. Statistical testing revealed no significant association between SAP status and pathological episode counts (Fisher's exact test, p=0.296). This finding indicates that a substantial proportion of children with negative SAP can still be classified as pathological based on the overall number of reflux episodes, underlining the importance of combined parameter interpretation.

DISCUSSION

This analysis showed that 24-hour multichannel intraluminal impedance–pH monitoring was useful in children with persistent respiratory symptoms, with reflux confirmed in most patients (87.1%). Impedance detected a higher number of reflux episodes than pH-metry (median 113 vs. 50), confirming its added value in identifying both acid and non-acid events. Previous works have likewise demonstrated that impedance–pH monitoring offers more diagnostic information than conventional pH-metry, as it also captures weakly acid and non-acid reflux and assesses their temporal association with symptoms (5). The high detection rate in our group is consistent with earlier reports describing a reflux prevalence of 60%–70% in pediatric populations, particularly during infancy (6). In our cohort, 19 children with a negative SAP still had a pathological number of reflux episodes. This illustrates the limited reliability of SAP in children and supports the view that no single test can serve as a gold standard for diagnosing pediatric GERD. Similar concerns have been raised in studies of pediatric laryngopharyngeal reflux disease (LPRD) (7). The median reflux index (RI) was 2.2%, below

the pathological threshold of >7% commonly used in children. Had RI been used alone, most cases would have been missed, as the majority were classified as pathological based on impedance results. This aligns with previous findings showing that pH-metry often fails in children with predominantly non-acid reflux (8). Refluxate reached the upper third of the esophagus in a median of 56% of acid and 42% of weakly acid episodes. The extent of proximal migration has been linked to airway manifestations such as chronic cough, recurrent croup, and laryngospasm, supporting its clinical relevance in our patients (8). Liquid and gaseous reflux events were more frequent than mixed or alkaline episodes, further emphasizing the limitation of conventional pH-metry and the broader diagnostic value of impedance (6, 8). Treatment was initiated in 27 children (87.1%), almost exclusively when reflux was objectively confirmed. This demonstrates the practical impact of impedance–pH monitoring, as therapeutic decisions were directly informed by test results. Current recommendations also support a step-wise approach, starting with dietary and behavioral measures and adding pharmacologic treatment in more severe cases. By detecting both acid and non-acid reflux, impedance–pH monitoring provides a stronger rationale for initiating therapy, which was reflected in our practice (9). Our findings are in line with reports showing that interpretation restricted to pH <4 or RI underestimates the disease burden, since weakly acid reflux can also be clinically relevant (10). The low RI in our patients, the predominance of liquid and gaseous events, and the presence of pathological counts even in children with negative SAP confirm that classical pH parameters alone are insufficient. Finally, Japanese consensus guidelines emphasize that impedance–pH monitoring is indicated in children with respiratory symptoms such as cough, wheezing, or recurrent infections. They define a pathological study as RI ≥5% or an excessive number of reflux episodes, and stress that no universal pediatric cut-off values exist, with results varying between centers (11). These considerations are important when interpreting our findings. However, the retrospective design, relatively small sample size, and single-center setting limit the generalizability of our results.

CONCLUSION

This single-center experience, from the only unit in the country performing pediatric impedance–pH monitoring, highlights the clinical value of this method in children with persistent respiratory symptoms. Impedance–pH monitoring enables detection of both acid and non-acid reflux, including proximal events, and provides a more reliable basis for treatment decisions than pH-metry alone. By improving recognition of reflux-related airway problems, this approach can support more effective management of respiratory morbidity in the pediatric population. Larger multicenter studies are needed to establish standardized pediatric reference values and confirm these observations.

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CONFLICT OF INTEREST
The authors declare that there is no conflict of interest.

AUTHORS' CONTRIBUTIONS

DK: contribution to study conception and design, literature review, supervision, writing of the paper, interpretation of data, critical revision of the paper; SM: acquisition of data, contribution to study conception and design, literature review, critical revision of the paper, assistance in writing the paper; SM and AD: acquisition of data, contribution to study conception and design, literature review.

ETHICAL BACKGROUND

Institutional review board statement: The study was conducted according to the guidelines of the Declaration of

Helsinki and approved by the Ethics Committee of the School of Medicine, University of Mostar (Reg. No. 289/25).

Informed consent statement: Informed consent was obtained from all subjects involved in the study.

Data availability statement: We deny any restrictions on the availability of data, materials, and associated protocols.

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