Is the Routine Use of Impedance Analysis for the Diagnosis of Gastro-Esophageal Reflux Disease More Expensive than Conventional pH Monitoring? Cost Analysis of Two Procedures

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Abstract Conventional 24-h pH monitoring is the gold standard for the diagnosis of non-erosive, non-acidic gastro-esophageal reflux disease. Multichannel Intraluminal Impedance (MII) analysis markedly improves diagnostic accuracy of non-erosive, non-acidic gastro-esophageal reflux disease. However, MII catheters are more expensive than standard catheters. This study aimed to determine the rates of acid or non-acid reflux and by making a retrospective projection, to predict the costs of two algorithms. We retrospectively reviewed the medical data of 102 patients who presented to our hospital with suspected non-erosive GERD and underwent 24 h impedance/pH-monitoring. Demographic characteristics, Demeester scores, number of reflux episodes, and results of impedance analysis were recorded. According to these data, cost was calculated either for the scenario in which impedance measurement was performed solely or following a negative conventional pH monitoring. Thirty-seven of all 102 patients (36.3 %) had a Demeester score greater than 14.7. These patients were assigned as group 1 (acid reflux). The impedance analysis of the remaining 65 patients detected 34 patients (33.3 %) to have more than 50 reflux episodes over a period of 24 h and assigned as Group 2, and 31 patients (30.4 %) had no reflux (group 3). The cost of the single-step algorithm using MII catheter was calculated as \$15,300, while the total cost of two-step scenario would have been predicted as \$16,890. Our study showed that an initial conventional pH monitoring can make the diagnosis of GERD in only one third

of the patients with suspected non-erosive GERD. In nearly two-thirds of patients, however, repeated procedures and use of impedance catheters are needed. It is clear that this algorithm has certain drawbacks with regard to cost, patient comfort, and workforce loss

Keywords Gastro-esophageal reflux · pH monitoring · Impedance analysis · Cost

Introduction

Gastro-esophageal reflux disease (GERD) is a common disorder that poses diagnostic and therapeutic challenges for gastroenterologists and general surgeons. Endoscopy is the primary diagnostic tool used for GERD. Detection of esophagitis on endoscopy is sufficient for the diagnosis [1]. However, patients with non-erosive GERD who report reflux symptoms without any endoscopic signs of esophagitis represent the most challenging group. This group reportedly constitutes 70 % of all patients with gastro-esophageal reflux symptoms [2].

Twenty-four-hour esophageal pH monitoring is the gold standard diagnostic test for non-erosive GERD [3, 4]. Certain parameters such as the number and duration of reflux episodes, and the lowest pH level are monitored by a catheter placed 5 cm above the lower esophageal sphincter (LES) to calculate the Demeester score and make the diagnosis of GERD. However, some patients may exhibit mild acid or non-acid esophageal reflux. In such cases conventional pH monitoring conclude to a false negativity. It has been reported that Multichannel Intraluminal Impedance (MII) analysis markedly improves diagnostic accuracy in such patients [5–7]. Based on the variety of intraluminal conductivity of esophagus according to its altered content, impedance analysis

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can determine the type (solid, fluid, or gas) and flow direction of any substance within esophageal lumen and detect any gastro-esophageal reflux independently of pH of reflux content [8]. The only drawback of these catheters allowing simultaneous impedance and pH analysis is their high cost compared to standard pH catheters.

Based on the assumption that routine impedance monitoring to every suspected patient would increase the cost, an initial standard pH monitoring followed by impedance analysis in case of necessity, has been recommended in suspected non-erosive reflux disease. As the accurate rate of mild acid or non-acid reflux is not known in our region, the rate of non-erosive non-acid GERD that is likely to be missed by conventional pH monitoring alone could not be predicted. Therefore, it is unclear if such a two-step diagnostic algorithm would be cost-effective.

In our hospital, patients with suspected non-erosive GERD undergo 24 h MII/pH monitoring at the general surgery clinic. This study aimed to determine the rates of acid or non-acid reflux in these patients; by making a retrospective projection, and also to predict the percentage of patients in which a secondary procedure would be needed when a conventional pH monitoring was done as the initial test. A cost analysis was then carried out between the two algorithms in light of these findings.

Materials and Method

This is a retrospective cross-sectional descriptive study. The objective of the study is to figure out the cost effectiveness of MII/pH monitoring and conventional pH monitoring for non-erosive GERD suspected patients. Primary outcome of the study is to calculate the cost of intervention for each algorithm mentioned in the introduction section. Secondary outcome is to determine the distribution of patients with acidic reflux, non-acidic reflux, and no reflux. All non-erosive GERD suspected patients who underwent 24-h pH monitoring with impedance measurement between 2011 and 2012 were included in the study without any exclusion criteria. All patients were analyzed according to each algorithm. And total cost of intervention for any scenario were calculated and discussed. Because there is no separate group of patients we did not perform any statistical analysis or power analysis.

This study was approved by our University Institutional Review Board (Project no. KA15/79).

In our general surgery clinic, we perform 24-h esophageal impedance/pH monitoring to the patients with suspected non-erosive GERD. Non-erosive GERD suspicion means, patients with GERD symptoms without endoscopic findings of esophagitis. Among patients referred to the outpatient clinic of general surgery of our hospital, those with suspected non-erosive GERD undergo a 24-h esophageal impedance/pH monitoring.

All patients asked to discontinue PPI medication a week before examination to reestablish the acidity of gastric content. An esophageal manometry study is first performed to exclude the other esophageal pathologies and to determine the site of LES. This is followed by a 24-h Multichannel Intraluminal Impedance (MII) pH monitoring by using an Ohmega-Ambulatory Impedance-pH Recorder device (MMS, Netherlands) and Ohmega catheters with six impedance and two pH channels. The catheter is removed 24 h later and the collected data are analyzed by researchers and presented to patients and referring physicians. Demeester score of the patients calculated automatically by the MMS (Medical Measurement Systems, Netherlands) database software. Upper normal limit of Demeester score was 14.7. Patients with Demeester score greater than 14.7 accepted as reflux positive.

Impedance analysis made by the same software and number of reflux periods recorded. Patients experiencing greater than 50 reflux episode accepted as reflux positive regardless of Demeester score.

We retrospectively reviewed the medical data of 102 patients who presented to our hospital with suspected non-erosive GERD and underwent 24 h impedance/pH-monitoring. Demographic characteristics, Demeester scores, number of reflux episodes, and results of impedance analysis were recorded.

Patients first divided into two groups according to their Demeester scores. Patients with a Demeester score greater than 14.7 were enrolled as the acidic GERD group (group 1). The patients with lower Demeester score were further divided into two groups based on the impedance analysis. Patients with more than 50 reflux episodes within 24 h were grouped as the non-acid reflux group (group 2) [8, 9] while patients with less than 50 reflux episodes were grouped as the reflux-negative group (group 3) according to their impedance analysis (Table 1).

Thereafter, based on the available data, overall cost was calculated either for the scenario in which impedance measurement was performed solely or following a negative conventional pH monitoring. Our routine practice and the other scenario were compared in terms of overall cost.

Results

This study included a total of 102 patients who presented to our hospital with reflux symptoms and underwent 24-h pH monitoring with impedance measurement between 2011 and 2012. The median age of the study population was 46 years.

Thirty-seven (37/102) (36.3 %) patients had a Demeester score greater than 14.7. These patients were assigned as group 1 (acid reflux). The impedance analysis of the remaining 65 patients detected 34 patients to have more than 50 reflux

Table 1 Patients division according to conventional pH monitoring and impedance analysis

episodes over a period of 24 h. In other words, 33.3 % (34/102) of the whole study population and 52.3 % (34/65) of those with a low Demeester score were assigned as group 2 (non-acid reflux). When both the Demeester score and impedance analysis were considered, 31 (30.4 %) patients had no reflux (group 3) (Fig. 1).

During cost analysis, the cost of an impedance catheter was calculated as \$120 (USD), the cost of a standard pH monitoring catheter as \$40 (USD), and the cost of each intervention with analysis as \$30 (USD). Based on these data, the costs of these two scenarios were calculated as follows:

1. When the impedance analysis was directly done (as in our routine) in all 102 patients, the cost per case was:
 - i. Catheter cost (\$120)+procedure cost \$30=\$150; and
 - ii. The total cost was $102 \times \$150 = \$15,300$

2. If conventional pH analysis had been done as the initial test in all patients, followed by impedance analysis to 65 patients excluding group 1, the cost of the conventional pH analysis would have been:

- i. $102 \times (\text{catheter cost } (\$40) + \text{procedure cost } (\$30)) = \$7,140$; and
- ii. The cost of impedance analysis to 65 non-group 1 patients would have been:
- iii. $65 \times \$150 = \$9,750$; and
- iv. The overall cost would have been:
- v. $\$7,140 + \$9,750 = \$16,890$

In summary, the cost of the single-step algorithm using MII catheter was \$15,300, while the total cost of two-step scenario would have been \$16,890.

Discussion

In the diagnostic work-up of gastro-esophageal reflux disease, pH monitoring with or without impedance analysis is the next step after endoscopy [1, 10]. However, catheters allowing simultaneous pH and impedance analyses are more expensive than catheters making pH measurement only.

For the diagnosis of GERD, Demeester scores of the patients after pH monitoring are calculated and those having a score greater than 14.7 are diagnosed with GERD. Patients with more than 50 reflux episodes in impedance analysis are also diagnosed with GERD.

At first glance, it can be thought that proceeding directly with impedance analysis without performing standard pH monitoring is an unnecessary and costly strategy; however,

Fig. 1 Patients according to the type and presence of reflux

such a judgment is misleading without knowing the exact number of patients with mild acid or non-acid reflux among patients with an indication for esophageal pH monitoring. We may have omitted the second test if the number of patients with mild acid or non-acid reflux were negligible. However, as we show in this study, a significant proportion (one third) of our patients could be diagnosed with GERD only by impedance analysis.

In patients with reflux symptoms, the strategy of using standard pH monitoring catheters instead of impedance/pH catheters and performing impedance analysis only when conventional pH monitoring yields a negative result may either miss some non-acid reflux cases or lead to perform two procedures in two third of the patients. It is clear that such a strategy would also negatively affect patient comfort. Moreover, this study did not take other cost increasing factors associated with the two-test strategy into consideration, such as workforce and time loss.

As is known, the diagnosis of non-erosive acidic GERD can be made with standard pH analysis whereas an accurate diagnosis of non-erosive, non-acidic GERD requires impedance analysis. Our study demonstrated that patients with non-erosive, non-acidic GERD have a significant proportion among patients with reflux symptoms. In this respect, it is observed that routine application of pH monitoring with impedance measurement does not increase overall cost.

Despite not being the focus of this study, the likelihood of repeat procedures and the overall cost can be reduced by pre-test prediction of both non-erosive non-acid GER patients and acid reflux patients. At this point, the easiest and the most useful method may be questioning patients whether they benefit from proton pump inhibitors (PPI). It has been reported that patients with acidic reflux benefit from PPI whereas those with non-acidic reflux are resistant to such therapy [11]. Major limitation of our study is that we performed MII/pH analysis to all non-erosive GERD suspected patients. If we had separated PPI responder and non-responder patients before the intervention, it would be much reasonable to directly recommend pH monitoring with impedance measurement for PPI-resistant patients and conventional pH monitoring for PPI responders. Cost analysis of such an algorithm may yield different results than our suggestion. As a future direction of this study; this algorithm may be analyzed by other studies in terms of repeated procedures and overall cost.

Conclusion

Our study showed that an initial conventional pH monitoring can make the diagnosis of GERD in only one third of the patients with reflux symptoms. In nearly two-thirds of

patients, however, repeated procedures and use of impedance catheters are needed. It is clear that this algorithm has certain drawbacks with regard to cost, patient comfort, and workforce loss.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no competing interests.

Ethical Statement This study was approved by Baskent University Institutional Review Board (Project no. KA15/79).

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