



## ROLE OF HIGH-RESOLUTION MANOMETRY AND X-RAY BARIUM SWALLOW IN PATIENTS WITH NON-CARDIAC CHEST PAIN: A CROSS-SECTIONAL STUDY

### Gastroenterology

|                               |                                                 |
|-------------------------------|-------------------------------------------------|
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### ABSTRACT

**Background:** Non-cardiac chest pain (NCCP) commonly arises from esophageal disorders, particularly motility abnormalities. This study evaluated the diagnostic utility of high-resolution manometry (HRM) and X-ray barium swallow in NCCP. **Methods:** In this hospital-based cross-sectional study, 30 adults with NCCP underwent cardiac exclusion using ECG, echocardiography, and cardiac biomarkers. All patients underwent upper gastrointestinal endoscopy, barium swallow, and HRM. Motility disorders were classified using the Chicago Classification, while GERD was assessed through endoscopic and reflux findings. **Results:** Mean age was  $36.4 \pm 14.4$  years, with 53.3% males. HRM abnormalities were detected in 80% of patients. Ineffective esophageal motility (36.7%) was most common, followed by EGJ outflow obstruction (23.3%), achalasia cardia (6.7%), and diffuse esophageal spasm (3.3%). GERD was identified in 36.7%. Barium swallow detected no abnormalities. Final diagnoses included motility disorders (53.3%), GERD (36.7%), mixed etiology (6.7%), and functional chest pain (10%). HRM showed superior diagnostic yield in NCCP evaluation.

### KEYWORDS

Chicago Classification, Esophageal motility disorders, High-resolution manometry, Non-cardiac chest pain

### INTRODUCTION

Chest pain is among the most common presenting complaints in emergency departments and outpatient medical settings worldwide. Because it is traditionally linked to myocardial ischemia, chest pain routinely triggers extensive cardiovascular evaluation. However, a substantial proportion of patients—estimated at 20-40%—demonstrate no evidence of coronary artery disease after thorough cardiological workup, and their symptoms are categorized as non-cardiac chest pain (NCCP).

NCCP is defined as recurrent retrosternal discomfort resembling angina pectoris in the absence of identifiable cardiac pathology. Among its many causes, disorders of the esophagus constitute the single most common aetiology. The esophagus and heart share visceral afferent pathways through the vagal and thoracic spinal segments, explaining why esophageal pain is clinically indistinguishable from cardiac pain.

Esophageal motility disorders—including ineffective esophageal motility (IEM), esophagogastric junction (EGJ) outflow obstruction, achalasia cardia, diffuse esophageal spasm (DES), and hypercontractile (jackhammer) esophagus—are increasingly recognized as major contributors to NCCP. High-resolution manometry (HRM) has emerged as the gold-standard technique for evaluating these disorders, offering detailed pressure topography of the entire esophageal column and allowing classification according to the Chicago Classification system. Simultaneously, gastroesophageal reflux disease (GERD) represents a significant functional cause of NCCP.

Despite widespread use in gastroenterology, data comparing the diagnostic utility of HRM and X-ray barium swallow specifically in patients with NCCP remain limited in the Indian context, where resource allocation and diagnostic prioritization remain ongoing challenges. This study was undertaken to evaluate and compare the yield of these two modalities in characterizing esophageal pathology among patients presenting with NCCP at a tertiary care center in North India.

### MATERIALS AND METHODS

#### Study Design and Setting

This was a hospital-based cross-sectional study conducted at the Department of General Medicine and Gastroenterology, Subharti Medical College and Chhatrapati Shivaji Subharti Hospital, Meerut, Uttar Pradesh, India, between 2023 and 2026. Ethical approval was obtained from the Institutional Ethics Committee (IEC) in accordance with the Declaration of Helsinki and Indian Council of Medical Research (ICMR) guidelines. Written informed consent was obtained from all participants.

#### Study Population

Adults aged  $\geq 18$  years presenting with symptoms suggestive of

NCCP—defined as recurrent retrosternal chest discomfort in whom cardiac causes had been excluded by clinical assessment, 12-lead electrocardiography (ECG), 2D echocardiography, and cardiac biomarkers (CK-MB and Troponin-I)—were eligible. Patients with confirmed cardiac disease, previous esophageal or gastric surgery, known esophageal malignancy, severe systemic illness, or unwillingness to participate were excluded. Thirty patients fulfilling the inclusion criteria and providing informed consent were enrolled.

#### Diagnostic Procedures

All enrolled patients underwent the following evaluations in a standardized sequence:

- Cardiac exclusion: 12-lead ECG, 2D echocardiography, serum CK-MB, and Troponin-I.
- Upper gastrointestinal endoscopy: Esophagitis graded by Los Angeles (LA) Classification; presence of hiatal hernia documented.
- X-ray Barium Swallow: Fluoroscopic examination of esophageal transit and morphology, evaluating for reflux, delayed emptying, tertiary contractions, bird-beak sign, stricture, and hiatal hernia.
- High-Resolution Manometry (HRM): Performed using a high-resolution solid-state catheter with closely spaced pressure sensors. The catheter was positioned transnasally to record resting and swallow-induced esophageal pressure activity. Ten 5 mL water swallows were analyzed. Key metrics recorded included lower esophageal sphincter (LES) pressure, integrated relaxation pressure (IRP), LES length, distal contractile integral (DCI), failed/ineffective/intact swallow proportions, and incomplete bolus clearance. Motility disorders were classified according to the Chicago Classification v4.0.
- GERD assessment: Based on endoscopic reflux findings and clinical symptom evaluation (heartburn, regurgitation).

### STATISTICAL ANALYSIS

Data were analyzed using SPSS (IBM Corp., Armonk, NY). Continuous variables were reported as mean  $\pm$  standard deviation (SD) or median (range). Categorical variables were expressed as frequency (n) and percentage (%). Associations between clinical symptoms and diagnostic findings were assessed using Pearson chi-square tests. A two-tailed p-value  $< 0.05$  was considered statistically significant.

### RESULTS

#### Demographic and Clinical Profile

Table 1: Demographic and clinical profile (n=30)

| Variable    | Category | n (%)     |
|-------------|----------|-----------|
| Age (years) | 18–30    | 13 (43.3) |
|             | 31–45    | 8 (26.7)  |
|             | 46–60    | 6 (20.0)  |

|                            |             |           |
|----------------------------|-------------|-----------|
| Mean ± SD: 36.4 ± 14.4 yrs | >60         | 3 (10.0)  |
| Gender                     | Male        | 16 (53.3) |
|                            | Female      | 14 (46.7) |
| Symptom Duration           | <6 months   | 4 (13.3)  |
|                            | 6–12 months | 15 (50.0) |
|                            | >12 months  | 11 (36.7) |
| Dysphagia                  | Present     | 17 (56.7) |
| Heartburn                  | Present     | 16 (53.3) |
| Regurgitation              | Present     | 12 (40.0) |

Thirty patients (16 male, 14 female; male:female ratio 1.14:1) with a mean age of 36.4 ± 14.4 years were enrolled. The largest age group was 18–30 years (43.3%), followed by 31–45 years (26.7%), 46–60 years (20.0%), and >60 years (10.0%). Symptom duration was 6–12 months in 50.0%, >12 months in 36.7%, and <6 months in 13.3%, indicating predominantly chronic presentation (Table 1). Dysphagia was the most frequent symptom (56.7%), followed by heartburn (53.3%) and regurgitation (40.0%).

Cardiac Biomarker Profile

Cardiac biomarkers were within low or non-diagnostic ranges in all patients (CK-MB: mean 1.01 ± 1.01 U/L; Troponin-I: mean 3.11 ± 3.78 ng/mL), confirming non-cardiac aetiology across the cohort.

Endoscopic Findings

Upper endoscopy was largely unremarkable. Esophagitis was present in only 10.0% of patients (LA Grade A, B, and C: 3.3% each), and 26.7% demonstrated small hiatal hernia. The majority (90.0%) had no mucosal abnormality.

HRM Findings

HRM identified abnormalities in 80.0% (n = 24) of patients (Table 2). Ineffective esophageal motility (IEM) was the most common diagnosis (36.7%), followed by EGJ outflow obstruction (23.3%). Normal HRM was noted in 20.0%. Mean LES pressure was 35.0 ± 7.82 mmHg and mean IRP was 20.1 ± 14.0 mmHg, with substantial inter-patient variability. Intact swallows constituted 89.9 ± 18.8% of swallows overall; however, a subset demonstrated markedly elevated failed (up to 75%) or ineffective swallow (up to 75%) proportions. Incomplete bolus clearance showed a mean of 26.3 ± 36.5%

Table 2. HRM Diagnosis Distribution (n = 30)

| HRM Diagnosis                         | n  | %     |
|---------------------------------------|----|-------|
| Ineffective esophageal motility (IEM) | 11 | 36.7  |
| EGJ outflow obstruction               | 7  | 23.3  |
| Normal HRM                            | 6  | 20.0  |
| Achalasia cardia                      | 2  | 6.7   |
| Hiatal hernia with DES                | 2  | 6.7   |
| Diffuse esophageal spasm (DES)        | 1  | 3.3   |
| Jackhammer esophagus                  | 1  | 3.3   |
| Total                                 | 30 | 100.0 |

Barium Swallow Findings

Barium swallow was uniformly normal across all evaluated parameters-including reflux, delayed emptying, tertiary contractions, bird-beak appearance, stricture, and hiatal hernia-in 100.0% (n = 30) of patients, demonstrating no structural abnormalities in the cohort.

Final Diagnostic Classification

Final diagnostic classification is presented in Table 3. Esophageal motility disorders were the predominant diagnosis (53.3%), followed by GERD (36.7%), functional chest pain (10.0%), and mixed aetiology (6.7%). A definitive diagnosis was established in all 30 patients (100%).

Table 3. Final Diagnostic Classification (n = 30)

| Diagnosis                    | Present n (%) | Absent n (%) |
|------------------------------|---------------|--------------|
| Esophageal motility disorder | 16 (53.3)     | 14 (46.7)    |
| GERD                         | 11 (36.7)     | 19 (63.3)    |
| Functional chest pain        | 3 (10.0)      | 27 (90.0)    |
| Mixed aetiology              | 2 (6.7)       | 28 (93.3)    |

Symptom–Diagnostic Correlations

Heartburn and regurgitation showed highly significant associations with GERD ( $\chi^2 = 15.2$ ,  $p < 0.001$  and  $\chi^2 = 12.7$ ,  $p < 0.001$ , respectively), while dysphagia was predominantly observed in GERD-negative patients (94.1%;  $\chi^2 = 16.0$ ,  $p < 0.001$ ). Dysphagia was more common in patients with EGJ outflow obstruction (71.4%) and IEM (63.6%),

though this association was not statistically significant ( $p = 0.634$ ). Reflux changes did not significantly correlate with individual symptoms (heartburn  $p = 0.273$ ; regurgitation  $p = 0.053$ ; dysphagia  $p = 0.400$ ). The overall clinico-physiological correlation was good in 56.7% and poor in 43.3% of patients.

Table 4. Association of Clinical Symptoms with GERD (n = 30)

| Symptom             | GERD Yes n (%) | GERD No n (%) | $\chi^2$ | p-value |
|---------------------|----------------|---------------|----------|---------|
| Heartburn (Yes)     | 11 (68.8)      | 5 (31.2)      | 15.2     | <0.001* |
| Heartburn (No)      | 0 (0.0)        | 14 (100.0)    | —        | —       |
| Regurgitation (Yes) | 9 (75.0)       | 3 (25.0)      | 12.7     | <0.001* |
| Regurgitation (No)  | 2 (11.1)       | 16 (88.9)     | —        | —       |
| Dysphagia (Yes)     | 1 (5.9)        | 16 (94.1)     | 16.0     | <0.001* |
| Dysphagia (No)      | 10 (76.9)      | 3 (23.1)      | —        | —       |

DISCUSSION

This cross-sectional study provides a systematic evaluation of the diagnostic role of HRM and X-ray barium center in North India. The principal findings are: (i) esophageal motility disorders are the leading cause of NCCP, identified by HRM in 80% of patients; (ii) IEM and EGJ outflow obstruction are the predominant HRM diagnoses; (iii) conventional barium imaging and endoscopy demonstrate minimal yield in functional NCCP; and (iv) symptom-based differentiation between GERD and motility disorders is supported by statistically significant associations.

The demographic profile-mean age 36.4 ± 14.4 years and near-equal sex distribution-is consistent with the literature. Functional esophageal disorders and visceral hypersensitivity tend to predominate in younger and middle-aged adults, as reported by Nadpara et al. (2023) and Assadian et al. (2022). The predominance of chronic symptom duration (>6 months in 86.7%) reflects the well-recognized diagnostic delay in NCCP, attributable in part to initial cardiac-focused evaluation.

The high diagnostic yield of HRM (80%) corroborates prior work by Kushwaha et al. (2025) and Zaghloul et al. (2022), who demonstrated that HRM detects clinically significant motility abnormalities in a majority of patients with unexplained esophageal symptoms. IEM was the dominant finding, aligning with multiple contemporary series, and likely reflects the contribution of disrupted peristalsis to chest pain via impaired bolus transit and elevated intraluminal pressures. EGJ outflow obstruction, the second most common diagnosis, is associated with dysphagia and chest pain and may represent incomplete or early achalasia or a distinct manometric entity.

The complete absence of radiological abnormalities on barium swallow is a key finding. It confirms that this investigation has limited value in functional NCCP and corroborates reports by Kushwaha et al. (2025) and Assadian et al. (2022), who noted that conventional modalities consistently fail to identify functional motility disorders. Barium swallow retains its role in detecting structural lesions such as strictures, large hiatal hernias, and diverticula, but should not be the primary investigation in patients with suspected functional aetiology.

The strong statistical association between heartburn/regurgitation and GERD (both  $p < 0.001$ ), and the inverse relationship of dysphagia with GERD, are consistent with established clinical practice guidelines. Dysphagia as a predictor of motility disorders-while not reaching statistical significance for specific HRM diagnoses in this sample ( $p = 0.634$ ), likely reflecting limited statistical power-aligns with the expectation that obstructive and hypomotility disorders preferentially impair bolus transport.

The moderate overall clinico-physiological correlation (good in 56.7%) highlights the recognized discordance between objective manometric findings and symptom severity in functional esophageal disorders. Mechanisms including visceral hypersensitivity, altered central processing, and psychological comorbidity contribute to this dissociation and underscore the multifactorial nature of NCCP symptom generation.

The present study is strengthened by its inclusion of all patients undergoing a standardized multi-modality diagnostic pathway achieving 100% diagnostic classification. Limitations include the cross-sectional design (precluding causal inference), small sample size limiting statistical power, single-center setting, and the absence of

ambulatory pH impedance monitoring with formal symptom association probability (SAP) calculation. Future multicentric longitudinal studies with larger cohorts and comprehensive ambulatory reflux monitoring are warranted.

## CONCLUSION

This study demonstrates that esophageal motility disorders—predominantly IEM and EGJ outflow obstruction—are the leading cause of NCCP, identified by HRM in 80% of patients. Barium swallow contributes negligibly in functional NCCP. Classical reflux symptoms (heartburn, regurgitation) reliably predict GERD, while dysphagia correlates with motility disorders. Integration of HRM into routine NCCP evaluation after cardiac exclusion enables comprehensive etiological classification and individualized, physiology-guided management—capabilities that conventional modalities cannot provide.

## KEYHOME MESSAGES

- HRM should be performed as a second-line investigation in all patients with persistent NCCP after cardiac exclusion and normal endoscopy.
- IEM and EGJ outflow obstruction are the most prevalent manometric diagnoses in tertiary care NCCP.
- Barium swallow has limited diagnostic role in functional NCCP; its use should be guided by clinical suspicion of structural pathology.
- Combined HRM and pH impedance monitoring is preferred for comprehensive differentiation between motility-related, reflux-related, and functional etiologies.
- Heartburn and regurgitation are reliable clinical predictors of GERD; dysphagia warrants primary motility evaluation.

## DECLARATIONS

### Conflict of Interest

The authors declare no conflict of interest.

### Funding

This study received no external funding. It was conducted as part of postgraduate academic research requirements at Swami Vivekanand Subharti University, Meerut.

### Ethics Approval

Ethical approval was obtained from the Institutional Ethics Committee (IEC), Subharti Medical College, Meerut. The study was conducted in accordance with the Declaration of Helsinki and ICMR ethical guidelines. Written informed consent was obtained from all participants.

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