

Original

Association of Subtle Bowel-Like/Fluid-Like Sounds on Chest Auscultation with Advanced Hiatal Hernia

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Background: Hiatal hernia is a common condition associated with gastroesophageal reflux disease, yet no reliable physical examination findings have been established. This study investigated the association of subtle bowel-like/fluid-like sounds detected during chest auscultation with the presence and severity of hiatal hernia (HH).

Methods: This retrospective observational study analyzed prospectively recorded auscultatory findings in patients undergoing routine examinations at a general outpatient clinic between 2011 and 2024. Patients with and without chest bowel-like sounds (CBS) were compared. Hiatal hernia presence and severity were determined retrospectively by reviewing endoscopy, barium esophagography, or computed tomography findings in medical records and classified into five grades (HH0–HH4). Diagnostic performance indices of CBS and their associations with hernia severity were also analyzed.

Results: Among 117 patients with CBS, 72 had a hiatal hernia, as compared with 170 of 879 patients without CBS. CBS showed low sensitivity (29.8%) but high specificity (94.0%), with a positive predictive value of 61.5%, a positive likelihood ratio of 5.0, and an odds ratio (OR) of 6.7 (95% confidence interval [CI], 4.4–10.0; $p < 0.001$). The association between CBS and hiatal hernia was stronger in women than in men (OR 13.7 vs. 4.9; interaction $p = 0.031$). CBS prevalence increased from 6.0% in HH0 to 75.0% in HH4 (p for trend < 0.001). When advanced hiatal hernia (HH3–HH4) was compared with HH0–HH2, CBS yielded substantially better diagnostic performance, with a sensitivity of 64.3%, specificity of 90.6%, LR+ of 6.8, LR– of 0.4, and OR of 17.3 (95% CI, 8.8–33.8; $p < 0.001$), regardless of sex.

Conclusions: Subtle bowel-like/fluid-like sounds on chest auscultation are highly specific for hiatal hernia and increase with disease severity, suggesting that CBS is particularly useful as a clinical indicator of advanced hiatal hernia in primary care.

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Introduction

The presence of hiatal hernia (HH) in conjunction with physiological dysfunction of the lower esophageal sphincter is recognized as a major etiological factor of gastroesophageal reflux disease (GERD)^{1,2}. GERD may lead to reflux esophagitis, Barrett's esophagus, and ultimately, increased risk of esophageal adenocarcinoma^{1,2}. Therefore, early identification of HH is clinically impor-

tant in general outpatient practice. However, no physical examination findings specific to HH have been established, and diagnosis currently relies mainly on imaging modalities such as upper gastrointestinal endoscopy, barium esophagography, and computed tomography (CT)¹. Consequently, HH may be overlooked in patients with mild or nonspecific symptoms.

The author has evaluated patients in whom faint

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peristaltic-like sounds were detected during routine chest auscultation and were incidentally diagnosed with HH, as indicated in unpublished clinical observations. Although advanced HH accompanied by obvious bowel sounds in the chest has been sporadically reported in case reports³⁻⁶, the frequency of HH remains unclear among patients in whom only subtle bowel-like/fluid-like sounds are detected during routine physical examination. However, this finding has not been systematically investigated. If physical examination, particularly chest auscultation, could increase the pre-test probability of identifying HH, it would improve diagnostic efficiency and reduce unnecessary examinations, thereby offering clinical and economic benefits in daily practice.

This study retrospectively evaluated data from patients in whom peristaltic-like sounds were detected on chest auscultation and examined the association of these sounds with the presence and severity of HH.

Materials and Methods

Study Population

This study was conducted at a primary care outpatient clinic at which a wide range of patients undergo routine physical examinations, including health checkups and evaluation of various medical conditions. During routine outpatient examination, chest auscultation is performed as part of the standard physical assessment.

This study was designed as a retrospective observational analysis of prospectively documented auscultatory findings obtained during routine outpatient examinations. Chest auscultation findings were prospectively recorded during routine clinical practice, and patients were identified retrospectively from these contemporaneously documented records. Between January 2011 and December 2024, 145 patients were identified as having subtle bowel-like/fluid-like sounds on chest auscultation (CBS: chest bowel-like sounds) during routine physical examination, regardless of the reason for the hospital visit. Of these, 117 patients (79 men and 38 women) in whom the presence or absence of HH could be retrospectively confirmed were included in the analysis (**Figure 1**). The remaining 28 patients were excluded because HH status could not be confirmed in 23 cases, one patient had undergone total esophagectomy for esophageal cancer, and four patients had left diaphragmatic elevation conditions that could potentially interfere with the interpretation of chest auscultation findings.

During the same study period, 879 patients without CBS on routine physical examination whose HH status

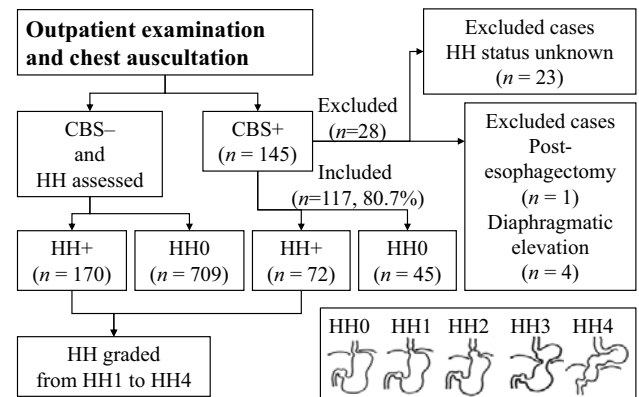


Figure 1 Flowchart of participant enrollment and classification according to CBS and hiatal hernia status, with schematic illustrations of gastric position corresponding to HH0–HH4

could be retrospectively confirmed were included in the control group. Patients in the control group were selected from the same outpatient population during the study period.

Data on potential confounding factors, including body mass index, gastrointestinal symptoms, and pulmonary diseases, were not uniformly available because of the retrospective design and therefore could not be adjusted for in the analysis.

HH Assessment and Severity Classification

The presence or absence of HH was determined retrospectively by reviewing available findings from upper gastrointestinal endoscopy, barium esophagography, or CT documented in each patient's medical records. These examinations had been performed as part of routine health checkups or for evaluation of various clinical conditions, rather than specifically for the purpose of this study. HH severity was classified into five categories as follows (**Figure 1**):

HH0: No HH

HH1: Herniation limited to part of the gastric cardia above the diaphragmatic hiatus

HH2: Herniation involving the entire cardia and proximal gastric body

HH3: Herniation extending to the gastric fundus

HH4: Herniation with intrathoracic stomach.

For the additional analysis of clinically advanced disease, HH3 and HH4 were collectively defined as advanced HH, whereas HH0–HH2 were classified as absent or mild-to-moderate HH.

Definition of CBS

In this study, CBS was broadly defined to include not

Table 1 Diagnostic accuracy of CBS for hiatal hernia

	Total n = 996	Male n = 549	Female n = 447
Mean age, years (SD)	69.9 (15.7)	71.4 (14.6)	68.1 (16.8)
CBS+ and HH+ (n)	72	43	29
CBS+ and HH- (n)	45	36	9
CBS- and HH+ (n)	170	92	78
CBS- and HH- (n)	709	378	331
Sensitivity (%)	29.8	31.9	27.1
Specificity (%)	94.0	91.3	97.4
PPV (%)	61.5	54.4	76.3
NPV (%)	80.7	80.4	80.9
LR+	5.0	3.7	10.4
LR-	0.8	0.8	0.8
OR (95%CI)	6.7 (4.4–10.0)	4.9 (3.0–8.1) *	13.7 (6.2–30.0) *
Yates-corrected χ^2 test	p < 0.001	p < 0.001	p < 0.001

* Interaction between CBS and sex: p = 0.031

CBS, chest bowel-like or fluid-like sounds; HH, hiatal hernia; PPV, positive predictive value; NPV, negative predictive value; LR, likelihood ratio; OR, odds ratio; CI, confidence interval.

only clearly audible bowel sounds, but also brief, faint peristaltic-like sounds and subtle fluid-shifting sounds detected during chest auscultation. The auscultation site was standardized to Erb's point, a fundamental location for cardiac auscultation. This site was selected to minimize the possibility of detecting transmitted abdominal bowel sounds that may be heard when auscultating more caudal areas. It is also a standard auscultation position in routine clinical practice. Given that transient bowel-like/fluid-like sounds may be heard immediately after the ingestion of food or liquids, auscultation was performed only after confirming that the patient had not recently swallowed food or fluids. Thus, emphasis was placed on identifying subtle bowel-like or fluid-like sounds detected in the absence of swallowing.

Statistical Analysis

The diagnostic performance of CBS was evaluated using Fisher's exact test and the chi-square test with Yates' correction. Sex differences in diagnostic performance were assessed using logistic regression models, including an interaction term. The association between HH severity and CBS detection was evaluated using the Cochran-Armitage trend test. All statistical analyses were performed using EZR (Saitama Medical Center, Jichi Medical University; Prof. Yoshinobu Kanda). Statistical significance was defined as a two-sided p-value < 0.05.

Ethics Committee Approval

This study was approved by the Maebashi Primary Clinic Ethics Committee (approval number: I-2024-4). Because of the retrospective observational design, written informed consent was not obtained. Instead, an opt-out process was implemented through notices displayed in the clinic and on the clinic website. The study was performed in accordance with the principles of the Declaration of Helsinki.

Results

Among the 117 patients with positive CBS results, 72 had HH and 45 did not, yielding a positive predictive value of 61.5%. Among the 879 patients without CBS, 170 had HH and 709 did not, yielding a negative predictive value of 80.7% (**Table 1**). The sensitivity and specificity of the CBS for detecting HH were 29.8% and 94.0%, respectively. The positive likelihood ratio (LR+) was 5.0 and the negative likelihood ratio (LR-) was 0.8. The odds ratio (OR) for HH in CBS-positive patients was 6.7 (95% confidence interval [CI], 4.4–10.0). The association was statistically significant according to the chi-square test with Yates' correction (p < 0.001).

Numerical differences in diagnostic performance were observed in sex-stratified analyses. In men, CBS had a sensitivity of 31.9% and a specificity of 91.3%, with an LR+ of 3.7 and an OR of 4.9 (95% CI, 3.0–8.1). In women, sensitivity was lower at 27.1%, but specificity was higher at 97.4%, resulting in an LR+ of 10.4 and an OR of 13.7

Table 2 Prevalence of CBS by HH grade

	Total	Male	Female
CBS+ : CBS- (prevalence)			
HH0 (none)	45 : 709 (6.0%)	36 : 378 (8.7%)	9 : 331 (2.6%)
HH1 (mild)	23 : 111 (17.2%)	17 : 65 (20.7%)	6 : 46 (11.5%)
HH2 (moderate)	22 : 44 (33.3%)	14 : 24 (36.8%)	8 : 20 (28.6%)
HH3 (severe)	21 : 13 (61.8%)	10 : 3 (76.9%)	11 : 10 (52.4%)
HH4 (very severe)	6 : 2 (75.0%)	2 : 0 (100.0%)	4 : 2 (66.7%)
Trend test (Z)	12.8	8.9	9.4
Cochran–Armitage trend test	p < 0.001	p < 0.001	p < 0.001
OR/grade (95% CI)	2.9 (2.3–3.5)	3.0 (2.2–4.1)	2.8 (2.0–3.9)
p value	p < 0.001	p < 0.001	p < 0.001

HH0–HH4, HH severity grades (from no HH to very severe HH with intrathoracic stomach); CBS, chest bowel- or fluid-like sounds; OR, odds ratio; CI, confidence interval.

Table 3 Diagnostic accuracy of CBS for advanced HH (HH3–4)

	Total n = 996	Male n = 549	Female n = 447
CBS+ and HH3–4 (n)	27	12	15
CBS+ and HH0–2 (n)	90	67	23
CBS- and HH3–4 (n)	15	3	12
CBS- and HH0–2 (n)	864	467	397
Sensitivity (%)	64.3	80.0	55.6
Specificity (%)	90.6	87.5	94.5
PPV (%)	23.1	15.2	39.5
NPV (%)	98.3	99.4	97.1
LR+	6.8	6.4	10.1
LR-	0.4	0.2	0.5
OR (95%CI)	17.3 (8.8–33.8)	27.9 (7.7–101.4) *	21.6 (9.1–51.0) *
Yates-corrected χ^2 test	p < 0.001	p < 0.001	p < 0.001

* Interaction between CBS and sex: p = 0.75

Advanced HH was defined as HH3–4, with HH0–2 serving as the reference category. CBS, chest bowel- or fluid-like sounds; HH, hiatal hernia; PPV, positive predictive value; NPV, negative predictive value; LR, likelihood ratio; OR, odds ratio; CI, confidence interval.

(95% CI, 6.2–30.0). Logistic regression analysis showed a significant interaction between CBS positivity and sex (interaction p = 0.031), indicating that the association between CBS and HH was stronger in women than in men.

The detection rate of CBS increased progressively with HH severity from 6.0% in HH0 to 75.0% in HH4 (**Table 2**). The Cochran–Armitage trend test demonstrated a strong positive linear trend between HH severity and CBS detection (Z = 12.8, p < 0.001). Logistic regression analysis showed that each one-grade increase in HH severity was associated with a 2.9-fold increase in the odds of CBS positivity (OR per grade = 2.9; 95% CI, 2.3–3.5). Sex-stratified analyses revealed similar increases per grade in men (OR = 3.0) and women (OR = 2.8), with no

significant sex differences (p = 0.485). CBS detected during routine chest auscultation was significantly associated with both the presence and severity of HH in the general outpatient population.

When patients were classified as those with advanced HH (HH grades 3–4) and those without advanced HH (HH grades 0–2), the sensitivity and specificity of CBS for detecting advanced HH were 64.3% and 90.6%, respectively (**Table 3**). The LR+ was 6.8, and the LR- was 0.4. The OR for advanced HH in CBS-positive patients was 17.3 (95% CI, 8.8–33.8). This association was significant according to the chi-square test (p < 0.001). The negative predictive value was very high at 98.3%, reflecting the low prevalence of advanced HH (4.2%; 42/996)

in the study population. In sex-stratified analyses, CBS showed a tendency toward higher sensitivity in men (80.0%) and higher specificity in women (94.5%). However, the strength of the association between CBS and advanced HH was similar in both sexes, with ORs of 27.9 (95% CI, 7.7–101.4) in men and 21.6 (95% CI, 9.1–51.0) in women. No significant interaction between CBS positivity and sex was observed (interaction $p = 0.75$).

Discussion

This study is the first to find an association between subtle CBS detected on chest auscultation during routine outpatient examination and the presence of HH, particularly more advanced disease. Although the sensitivity of CBS was modest, its high specificity and the clear severity-dependent increase in the detection rate suggest meaningful clinical relevance.

The prevalence of HH was reported to be approximately 40–60% in GERD-focused diagnostic cohorts and 30% in the general screening population^{7,8}. The present prevalence (24.3%) is consistent with values for the general outpatient population and supports the external validity of the present cohort. Although HH is closely associated with GERD, reflux esophagitis, and Barrett's esophagus, many patients remain asymptomatic, particularly those with mild-to-moderate HH^{1,9,10}. In contrast, multiple studies have reported that GERD symptoms and reflux esophagitis become more prevalent as hernia size and severity increase^{9–11}. Similarly, in erosive reflux disease, the prevalence of HH increases with advancing Los Angeles classification grade¹².

Despite these associations, no reliable physical examination findings that predict HH have been established. Existing reviews and clinical guidelines emphasize that diagnosis relies primarily on endoscopy, contrast studies, or CT, and physical examination is generally considered unremarkable¹. Although case reports have described obvious bowel sounds in the chests of patients with advanced HH or intrathoracic stomach^{3–6}, these reports were limited to severe cases and were retrospective in nature. No previous studies have systematically evaluated the diagnostic significance of the subtle auscultatory findings encountered during routine physical examinations.

This study is novel because it focuses on faint auscultatory findings detected during standard chest examinations and demonstrates that these sounds are not incidental but are associated with clinically significant advanced HH. CT-based studies have shown that larger HH opening areas and greater intrathoracic gastric vol-

umes are associated with more severe HH and increased GERD symptoms^{13,14}. In advanced HH, the migration of the stomach and gastroesophageal junction into the thoracic cavity facilitates retention of gastric contents, including liquid and gas¹⁵. These anatomical changes may allow sounds generated by gastric filling, reflux, or upper gastric peristalsis to be directly transmitted to the chest wall, resulting in CBS. This observation supports the hypothesis that subtle CBS primarily reflect larger or more advanced HH rather than minimal displacement of the gastric cardia. Therefore, the observed correlation between CBS and HH severity in this study is consistent with existing anatomic and pathophysiological evidence.

The diagnostic performance of CBS was higher in women than in men, mainly because specificity and positive predictive value were higher in women. The reason for this sex difference remains unclear. Possible explanations include sex-related differences in GERD epidemiology as well as anatomical differences in the chest wall, such as variations in fat distribution and breast tissue that may affect acoustic transmission during auscultation¹⁶. However, these interpretations are speculative. In analyses restricted to advanced hiatal hernia (HH3–HH4), negative predictive value was higher for men than for women (99.4% vs. 97.1%) and LR– was lower (0.2 vs. 0.5). At first glance, these findings suggest that the absence of CBS has greater exclusionary value for advanced hiatal hernia in men. However, the prevalence of advanced hiatal hernia in the present cohort was substantially lower in men than in women (2.7% [15/549] vs. 6.0% [27/447]). Because negative predictive values are strongly influenced by disease prevalence, the apparent sex difference should be interpreted with caution. Therefore, the clinical significance of this observation remains uncertain and warrants further investigation in larger cohorts with a higher prevalence of advanced disease.

Importantly, CBS should not be used as a screening tool for detecting all HH. Rather, CBS positivity indicates a higher probability of underlying HH. Although the positive predictive value of CBS was approximately 60%, suggesting a clinically meaningful association with occult HH, its sensitivity was only approximately 30%, indicating that many patients with HH would not be identified by this finding alone. Additional analyses demonstrated substantially better diagnostic performance for advanced HH (HH3–HH4), indicating that CBS may be more useful when seen as suggestive of clinically significant HH rather than as a screening sign for all grades of HH. Conversely, the absence of CBS may indicate a relatively

low probability of advanced HH, although it does not completely exclude HH.

Chest auscultation is a fundamental component of routine physical examinations. Awareness of CBS, combined with targeted symptom inquiry, may substantially increase the pre-test probability of diagnosing HH and contribute to more efficient and clinically meaningful diagnostic strategies in general practice.

Limitations

This study has some limitations. First, it was a single-center retrospective study based on observations by a single clinician, and interobserver agreement for CBS detection was not evaluated. Therefore, some degree of observer dependence in identifying CBS cannot be excluded. Second, the qualitative and quantitative characteristics of CBS, such as sound intensity, frequency, and duration, were not systematically assessed. Clinically, more distinct and persistent sounds appear to be associated with more advanced HH; however, this observation was not quantitatively analyzed. Third, potential selection bias and verification bias cannot be excluded because only patients whose hiatal hernia status could be retrospectively confirmed were included in the analysis.

Future multicenter studies involving multiple examiners, as well as quantitative acoustic analysis and assessment of interobserver reproducibility, are warranted to establish CBS detection as a more standardized and generalizable physical examination finding in primary care settings.

Conclusion

Subtle CBS detected during chest auscultation are strongly associated with the presence and severity of HH. Although this finding has limited sensitivity, its high specificity suggests that CBS may increase clinical suspicion of underlying HH when present. Additional analyses demonstrated improved diagnostic performance for advanced HH, indicating that CBS may be particularly useful as a diagnostic factor indicating clinically significant disease. Furthermore, the absence of CBS may indicate a relatively low probability of advanced HH, although it does not exclude HH overall. Recognition of this subtle auscultatory sign during routine physical examination may therefore facilitate earlier suspicion and more targeted evaluation of HH in primary care settings.

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approved the final manuscript.

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Data Availability: The datasets analyzed during the current study are not publicly available but are available from the corresponding author on reasonable request.

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