# Prevalence of gastric hypomotility after additional cryoballoon ablation of the left atrial roof through the left atrial posterior wall

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### Abstract

Introduction: Gastric hypomotility (GH) is a major complication of atrial fibrillation (AF) ablation. We aimed to clarify whether additional cryoballoon ablation (CBA) of the left atrial (LA) roof is associated with GH. Methods and Results: This study included 54 patients with non-paroxysmal AF who underwent CBA for pulmonary vein isolation and of the LA roof line. GH was defined according to the results of esophagogastroscopy performed 2 days after ablation. GH was observed in 10 patients. There were significant differences in LA diameter (LAD), right inferior pulmonary vein (RIPV) diameter, and the height of the LA roof from the point where the LA posterior wall and esophagus make contact between patients with (GH+) and without GH (GH–) (LAD: 41.0 [36.3–41.8] mm vs. 46.5 [42.8–50.0] mm, p<0.01; RIPV diameter: 19.7 [19.0–20.5] mm vs. 23.2 [21.2–24.9] mm, p<0.01; height of LA roof: 5.7 [5.1–6.1] mm vs. 8.8 [7.1–11.2] mm for, p<0.01, respectively). Multivariate analysis revealed that LA roof height was a predictor of GH. Moreover, Patient Assessment of Upper Gastrointestinal Disorders-Symptom Severity Index (PAGI-SYM) scores increased significantly 1 week after ablation (from 1.0 [0.0–2.8] to 5.0 [3.0–11.0], p=0.03) in patients with GH. Conclusion: The height of the LA roof may be a predictor of GH after CBA of the LA roof line. Additionally, GH-related symptoms may still appear 1 week after ablation.

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**Conclusion:** The height of the LA roof may be a predictor of GH after CBA of the LA roof line. Additionally, GH-related symptoms may still appear 1 week after ablation.

**Keywords:** Ablation, Atrial fibrillation, Cryoballoon, Gastric hypomotility, Roof line

## INTRODUCTION

Pulmonary vein isolation (PVI) is commonly performed to treat atrial fibrillation (AF). Cryoballoon ablation (CBA) has been established as a standard method to achieve high efficacy in terms of acute success rate or chronic durability;[1] however, arrhythmia recurrences are often experienced after PVI, especially in non-paroxysmal AF. Therefore, researchers have examined various strategies for obtaining a higher arrhythmia-free rate after ablation. Linear ablation including the left atrial (LA) roof line is among the therapeutic strategies for AF ablation, whereas CBA of the LA roof has been reported as an additional therapy after PVI in patients with non-paroxysmal AF.[2] Still, esophageal complications remain a concern during AF ablation.[3,4] In addition to atrioesophageal fistula—a rare but disastrous complication—several studies have investigated the occurrence of gastric hypomotility (GH), which may cause symptoms related to gastrointestinal function (e.g., discomfort, abdominal pain, nausea, and bloating).[5–8]However, there are no available data regarding GH after CBA of the LA roof. Therefore, we aimed to investigate GH after CBA of the LA roof, as well as factors that may be related to the occurrence of GH.

## METHODS

### Patients

Written informed consent was obtained from all patients prior to the ablation procedure, and this study was approved by the local ethics committee (Japan Red Cross Yokohama City Bay Hospital 2019-8). A total of 54 consecutive patients with non-paroxysmal AF who were advised to undergo CBA for PVI and LA roof lines were prospectively enrolled between March and December 2019. Patients who underwent additional ablation aiming at the LA posterior wall (LAPW), besides PVI including touch-up ablation with a radiofrequency (RF) catheter or LA roof line ablation, were excluded. All patients underwent three-dimensional computed tomography (3DCT) and transthoracic echocardiography (TTE) before ablation. Anatomical factors including pulmonary vein (PV) diameter and those related to the esophagus were analyzed via 3DCT using a computer workstation (Ziostation, Ziosoft Inc., Tokyo, Japan). The relationship between the LA roof and esophagus is depicted in**Figure 1** . Paroxysmal AF was defined as AF terminating within 7 days, based on a prior definition.[9] Baseline demographic characteristics, comorbidities, and medications were recorded.

### Ablation procedure

The ablation procedure, previously described in detail,[10] was performed under general anesthesia. A single transseptal puncture was created under fluoroscopic and intracardiac echocardiographic guidance (Acuson, AcuNav, Biosense Webster, Diamond Bar, CA). A 28-mm cryoballoon catheter (Arctic Front Advance, Medtronic, Minneapolis, USA) was introduced into the LA through a steerable sheath (Flexcath Advance, Medtronic) with a circular mapping catheter (Achieve, Medtronic), and cryothermal energy was applied through a cryoballoon, occluding each PV. The compound motor action potentials of the diaphragm, provoked by phrenic nerve pacing, were continuously monitored during CBA of the right PV to prevent phrenic nerve injury. PVI was confirmed using a dual-decapolar circular mapping catheter (EPstar Libero, Japan Lifeline, Tokyo, Japan). If successful PVI was not achieved solely with a cryoballoon, touch-up ablation was performed using an irrigated RF catheter (FlexAbility or TactiCath, Abbott, Illinois). After successful PVI, linear ablation of the LA roof was performed using a cryoballoon. An Achieve catheter was inserted into the left and right superior PVs; the cryoballoon was shifted along the LA roof by changing the direction of the steerable sheath and adjusting the position of the cryoballoon and sheath, ensuring that each cryoballoon location overlapped with the previous location. After CBA of the LA roof, complete conduction block was confirmed based on activation and voltage maps created via an electrical, impedance-based mapping system (Ensite NavX, Abbott, Illinois), using a duo-decapolar circular mapping catheter (EPstar Libero, Japan Lifeline, Tokyo) (**Figure 2** ). If complete conduction block was not obtained after CBA, we then performed touch-up ablation using an irrigated RF catheter. Cryothermal energy was then applied for 180–240 s at the surgeon's discretion. We performed CBA under luminal esophageal temperature (LET) monitoring using esophageal temperature probes (Esophaster, Japan Lifeline, Tokyo) with a cutoff value of 15°C. RF applications were prematurely interrupted when the LET reached 39°C.

### Assessment of GH

To investigate the influence of CBA with PVI and LA roof line ablation on esophageal or gastric function, esophagogastroscopies were performed 2 days after ablation under overnight fasting conditions. GH was defined as the retention of food in the stomach.[11] The existence of esophageal lesions, such as erythema, erosions, or ulcers, was also confirmed.

All patients reported gastrointestinal symptoms before ablation, 1 day after ablation, 1 week after ablation, 2 weeks after ablation, and 3 weeks after ablation using the 20-question Patient Assessment of Upper Gastrointestinal Disorders-Symptom Severity Index (PAGI-SYM).[12] Responses to each question are rated from 0 to 5, with a score of 5 indicating a severe symptom.

### Clinical follow-up

All patients were administered proton pump inhibitors (PPI) after ablation, and antiarrhythmic drugs were prescribed after ablation at the discretion of the attending cardiologist. Twelve-lead electrocardiograms (ECGs) were recorded at every follow-up or emergency visit due to symptoms suggesting arrhythmia recurrence, and 24-hour Holter ambulatory ECG monitoring was performed to detect paroxysmal type arrhythmia recurrence. Arrhythmia recurrence was defined as any documented atrial arrhythmia lasting longer than 30 s after an initial 90-day blanking period. TTE and blood test findings were also evaluated after ablation.

### Statistical analysis

Continuous variables are expressed as the mean ± SD or median and interquartile range, while categorical variables are reported as numbers and percentages. Comparisons were made using the Mann–Whitney U-test and Wilcoxon signed-rank tests. Logistic regression analysis was also used to evaluate GH occurrence. A P-value of 0.10 was required for entry into the model, and a stepwise method was used to detect any predictors. Statistical significance was set at $P<0.05$. All analyses were performed using EZR software (Saitama Medical Center, Jichi Medical University, Saitama, Japan), a graphical user interface for R (The R Foundation for Statistical Computing, Vienna, Austria).

## RESULTS

### Study population

Baseline patient characteristics are shown in **Table 1** . Both the minimum distance between the LA roof and esophagus and the minimum height of the LA roof from the point where the LAPW and esophagus make contact were evaluated in the sagittal plane of patients whose esophagi were located at the posterior of the LA roof. The mean distance and height measurements were 11.0 ± 4.3 mm and 8.9 ± 3.3 mm, respectively.

### Ablation results

Ablation characteristics are shown in **Table 2** . All PVs were successfully isolated, and complete conduction block at the LA roof was obtained in 52 patients (96.3%). Touch-up ablation with an irrigated RF catheter was required in 18 (33.3%) patients during PVIs (left superior PV: 3, left inferior PV: 3, right superior PV: 4, right middle PV: 1, right inferior PV: 9), and in seven (13.0%) patients during LA roof line ablations. Touch-up ablation at the LAPW was performed in eight patients (left inferior PV: 2, right superior PV: 2, right middle PV: 1, right inferior PV: 3). The mean isolated area of the LAPW, defined as the ratio of the scar area in the LAPW (voltage <0.1 mV) to the whole LAPW area, was 68.8 ± 21.0%.

LET during CBA reached 15°C in 19 patients (35.2%) (**Figure 3)** . LET reached 15°C most frequently during LIPV isolation (18 patients [33.3%]), while a drop in LET below 15°C during LA roof ablation occurred in 14 patients (25.9%). Transient phrenic nerve injury was observed in two patients (3.7%). No other procedural complications, such as stroke or cardiac tamponade, were observed.

### Esophagogastroscopy findings and PAGI-SYM scores

Esophageal lesions, including erythema and erosion, were detected in seven patients (13.0%); however, no ulcerations were observed. GH was confirmed in 10 patients (18.8%). A representative case is shown in**Figure 4A** .

PAGI-SYM scores (**Figures 4B and 4C** ) did not significantly differ between patients with and without GH before ablation. In patients with GH, scores significantly increased 1 week after ablation, compared with those before ablation (from 1.0 [0.0–2.8] to 5.0 [3.0–11.0], $p<0.01$); however, they did not significantly differ between before and 1 day after ablation. At 1 week, 2 weeks, or 3 weeks after ablation, the scores were significantly higher in patients with GH (GH+) than in those without GH (GH–) (1 week: 5.0 [3.0–11.0] vs. 0.0 [0.0–3.0], $p<0.01$; 2 weeks: 5.0 [2.0–9.0] vs. 0.0 [0.0–3.0], $p<0.01$; 3 weeks: 3.0 [0.8–5.8] vs. 0.0 [0.0–1.0], $p<0.01$, respectively). Potential GH-related symptoms resolved within 3 months after ablation in all patients. One patient transiently received a medication for improvement of GH, and no medications other than PPI were prescribed in other patients.

### Factors associated with GH

The baseline characteristics or ablation results in each group are shown in **Tables 1** and **2** . There were no significant differences in the nadir temperature of the cryballoon during ablation between the GH+ and GH– groups. Although the percentage of patients in whom LET decreased below 15°C was higher in the GH+

group, especially during CBA of the LA roof, no significant between-group differences were observed. Among these patients, nadir LET did not significantly differ between GH+ and GH–. LA roof height and the distance between the LA roof and esophagus were significantly lower among patients in whom the LET reached 15°C during CBA of the LA roof (**Figure 3B and C** ). Univariate and multivariate analyses indicated that LA roof height was a reliable predictor of GH (**Table 3** ). A receiver-operating characteristic curve for LA roof height had an area under the curve of 0.90 (confidence interval: 0.81–0.99, **Figure 5** ). The cutoff LA roof height for predicting GH after additional CBA of the LA roof was 6.1 mm, with a sensitivity of 85.0% and specificity of 83.0%.

### Clinical outcomes

Clinical follow-up was performed in 53 patients, and antiarrhythmic drugs were prescribed in 11 patients at the final follow-up. Forty-one patients (77.4%) were free from atrial arrhythmia during the median 369 (311–412) days of follow-up. Both serum BNP level (170.0 ± 127.0 pg/ml before ablation vs. 50.0 ± 54.8 pg/ml after ablation, $p<0.01$) and LA diameter (45.0 ± 6.4 mm before ablation vs. 42.9 ± 7.5 mm after ablation, $p<0.01$) decreased significantly after ablation. The A-wave velocity measured by TTE after ablation was 0.54 ± 0.13 cm/s.

## DISCUSSION

GH appeared in 18.8% of patients after CBA of the LA roof with PVI, especially in patients with a lower LA roof height. In most cases, a drop in LET below 15°C occurred during PVI, especially of the LIPV; however, the percentage of patients in whom LET reached 15°C during LA roof line ablation was higher in those with GH than in those without. Moreover, many GH-related symptoms emerged 1 week after ablation rather than immediately afterward.

### CBA of the LA roof

Although the efficacy of PVI for AF treatment is well known, knowledge regarding clinical outcomes after catheter ablation is limited, especially in patients with non-paroxysmal AF.[13] CBA is generally performed to achieve PVI; nevertheless, the isolated area may be smaller after PVI with a cryoballoon than the area achieved via the conventional method using an RF catheter.[14] As a broader area may contribute to better clinical outcomes,[15] linear ablation with a cryoballoon may in turn help to overcome this possible limitation after CBA for PVI. Several studies have demonstrated that CBA of the LA roof can be performed without any remarkable problems.[2,16] In contrast to LA roof line ablation performed using an RF catheter, CBA of the LA roof provides a wider effective area. In accordance with our findings, a previous report[16] noted that the mean isolated area of the LAPW was 68.8%. The arrhythmia recurrence-free rate (77.4%) reported herein is reasonable; additionally, the decrease in serum BNP levels after ablation is favorable, and the results regarding A-wave velocity after ablation seem comparable to previous findings.[17]

### GH after ablation

GH occurs as an adverse event of catheter ablation for AF due to thermal injury of the periesophageal nerves close to the LAPW.[7] Yamasaki et al.[18] reported excessive transmural injury in 5.8% of patients who underwent AF ablation using an RF catheter with additional LA roof line ablation, noting that body mass index may be a predictor of excessive transmural injury after ablation.

The prevalence of GH after CBA is reported to be 10.3–17.5%.[7,11] Aksu et al.[7] found that the prevalence of GH was higher in the CBA group; however, GH was generally reversible after CBA, compared with RF ablation, and the nadir temperature during CBA for inferior PVs and smaller LAD was associated with GH in the CBA group. Miyazaki et al.[11]demonstrated that GH after CBA occurred in cases in which the esophagus was located between the LAPW and thoracic spine, or in those in which the distance between the RIPV and esophagus was short. In our study, CBA of the LA roof was performed in addition to PVI; however, the prevalence of GH after ablation was not as high as previously reported. This result may be attributed to the therapeutic strategy of avoiding the ablation of the LAPW such as the LAPW bottom line. In our study, LAD was significantly smaller in patients with GH, as previously reported. Given that

RIPV diameter was also smaller in those with GH, a cryoballoon may be apt to contact the broader area of the LAPW during PVI, which may cause periesophageal nerve injury. However, our multivariate analysis indicated that LA roof height from the point of contact between the LAPW and esophagus can predict GH after CBA. During CBA of the LA roof, the cryoballoon contacts both the LA roof and part of the LAPW; namely, cryothermal energy conducts the LAPW close to the esophagus, especially in patients with lower LA roof height. This may explain the findings predictive of GH in our study.

Several studies have also examined the relationship between LET and esophageal complications. Kuwahara et al.[5] reported that RF applications under LET monitoring may reduce the incidence of GH; indeed, conventional PVI using an RF catheter is generally performed under LET monitoring. Additionally, Furnkranz et al.[4]demonstrated that LET-guided CBA with a cutoff value of 15°C was associated with a lower incidence of esophageal lesions. In contrast, Miyazaki et al.[11] reported that LET monitoring was not related to the incidence of esophageal complications after CBA for PVI; instead, the incidence of esophageal lesions increased when an esophageal probe was used.

In this study, we performed CBA under LET monitoring. First, although CBA of the LA roof was additionally performed, LET reached 15°C most frequently during PVI. Second, although no significant difference was observed, the percentage of patients in whom LET reached 15°C, especially during LA roof line ablation, was higher in those with GH than in those without. Moreover, LET during CBA of the LA roof reached 15°C more frequently when LA roof height was lower, or when the distance between the LA roof and esophagus was shorter. If CBA were performed without LET monitoring, the incidence of GH may have differed.

Although GH is detected via esophagogastroscopy in patients undergoing catheter ablation for AF, not all cases are symptomatic. Hasegawa et al.[8] reported that the incidence of symptomatic GH after CBA for PVI was 3.0%; however, as the degree of symptoms associated with GH may be slight in some cases, the incidence of symptomatic GH may be underestimated.

Lakkireddy et al.[6] reported that mean PAGI-SYM scores significantly increased from 7.8% to 15.6% 24 hours after ablation, with higher scores in patients with abnormal gastrointestinal functional test results. In our study, PAGI-SYM scores did not increase 1 day after ablation; however, they significantly increased 1 week after ablation in patients with GH. Although the scores were lower in our study than previously reported, patients may suffer from mild GH-related symptoms that appear a while after ablation.

### Clinical implications

Given the comparable prevalence of GH after CBA of the LA roof in addition to PVI, our results suggest that CBA of the LA roof can be performed safely. In patients with a lower LA roof, however, clinicians should consider the risk of GH after ablation. In addition, patients with GH may still experience GH-related symptoms for a while after ablation. To reduce the incidence of GH after ablation, we recommend performing CBA of the LA roof under LET monitoring.

### Study limitations

First, this was a single-center, non-randomized study with a small population. We were unable to compare patients who underwent CBA for PVI and LA roof ablation with patients who underwent CBA for PVI alone; therefore, a larger, randomized multicenter study is required. Second, although we performed CBA under LET monitoring, data regarding the nadir LET during CBA >18°C are missing; thus, we could not sufficiently argue for the association between nadir LET and GH or the cutoff value of LET during CBA. Finally, as patients were scheduled for discharge 2 days after ablation, we could not sufficiently assess their symptoms 1 week after ablation.

## CONCLUSIONS

Rates of GH were similar in patients who underwent CBA of the LA roof and those who underwent PVI with a cryoballoon. Our multivariate analysis indicated that LA roof height from the point where the LAPW and esophagus make contact may be a reliable predictor of GH. Additionally, our results suggest that potential

GH-related symptoms can appear 1 week after ablation. Further investigation is required to obtain evidence that can aid in the prevention of GH.

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**FIGURE LEGENDS**

**Figure 1** . Anatomical analysis of the relationship between the LA roof and esophagus based on CT. The three-dimensional CT method used to examine the anatomical relationship between the LA roof and esophagus is depicted. LA roof height from the point where the LAPW and esophagus make contact (a) and the distance between the LA roof and esophagus (b) were measured in the sagittal view. The orange line in the sagittal view represents the horizontal line that passes over the point where the LAPW and esophagus make contact. The orange lines in the coronal and axial views represent the position of the plane shown in the sagittal view.

CT, computed tomography; LA, left atrial; LAPW, left atrial posterior wall.


**Figure 2** . Voltage and activation maps after CBA.

A: Posterior–anterior (PA) view of the voltage map before CBA. Local electrograms were acquired during AF.

B: PA view of the voltage map after CBA. After CBA including LA roof ablation, cardioversion was delivered, and mapping after CBA was performed during sinus rhythm. A broad scar area was observed beyond PVs in the LAPW around the LA roof.

C: PA view of the activation map after CBA. The activation map during sinus rhythm shows conduction from caudal to cranial in the LAPW. The activation propagates from red to purple.

AF, atrial fibrillation; CBA, cryoballoon ablation; LA, left atrial; LAPW, left atrial posterior wall; PV, pulmonary vein.

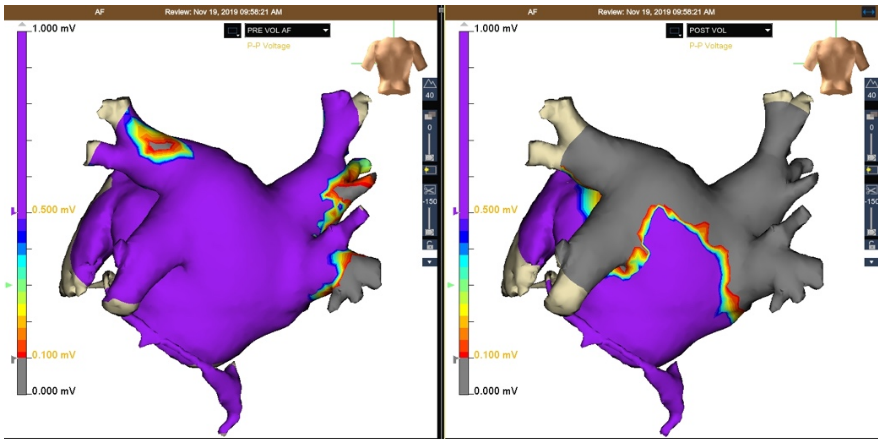


**Figure 3.** Analysis of LET during CBA.

A: Percentage of patients in whom LET reached 15°C during CBA.

B: LA roof height from the point where the LAPW and esophagus make contact were compared between patients in whom LET reached 15°C during CBA of the LA roof (Group A) and others (Group B).

C: The distance between the LA roof and esophagus was compared between Groups A and B.

The analysis described in Panels B and C was performed in patients in whom the esophagus passed the posterior of the LA roof (46 patients, including six with GH).

CBA, cryoballoon ablation; GH, gastric hypomotility; LA, left atrial; LAPW, left atrial posterior wall; LET, luminal esophageal temperature; LIPV, left inferior pulmonary vein; RIPV, right inferior pulmonary vein.

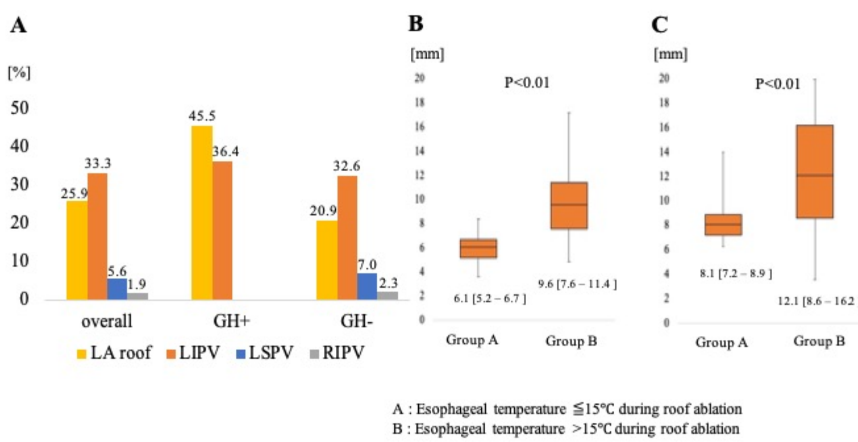

**Figure 4** . Esophagogastroscopic image of a representative GH case and changes in PAGI-SYM scores from before to 3 weeks after ablation.

A: An esophagogastroscopic view of a representative GH case. A large quantity of residue was observed in the stomach, and esophagogastroscopy was performed 2 days after ablation.

B: Median PAGI-SYM scores from before ablation to 3 weeks after ablation in patients with and without GH.

C: Changes in median PAGI-SYM scores (vs. pre-ablation scores) in patients with and without GH. Scores significantly increased 1 week after ablation in patients with GH, compared to scores in those without GH.

ABL, ablation; GH, gastric hypomotility; PAGI-SYM, patient assessment of upper gastrointestinal disorders-symptom severity index.

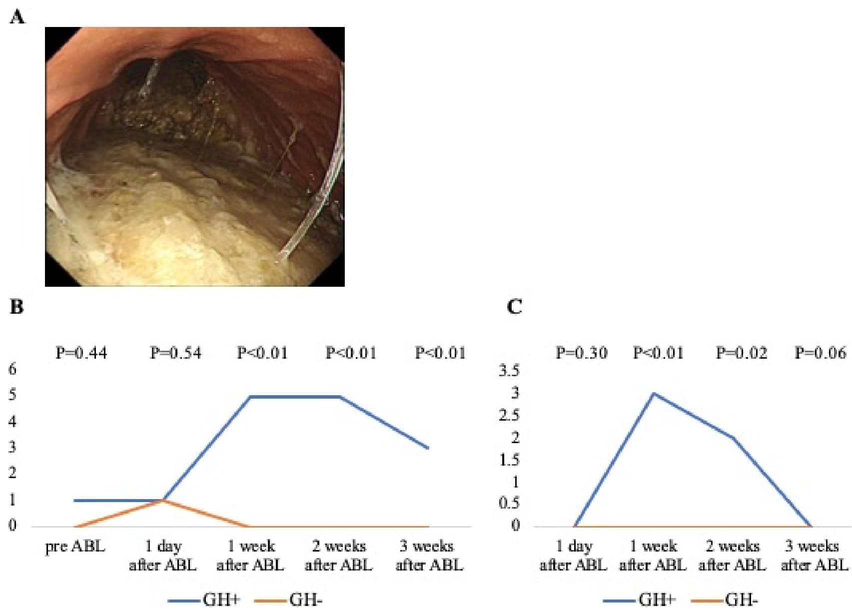


**Figure 5** . Analysis of the height of the LA roof as a predictor of GH.

A: ROC curve for predicting GH, regarding the height of the LA roof from the point where the LAPW and esophagus make contact. The cutoff value for the height of the LA roof was calculated as 6.1 mm (AUC: 0.90; sensitivity: 85.0%; specificity: 83.0%).

B: The prevalence of GH is shown according to the height of the LA roof, with the cutoff value calculated using the ROC curve. The frequency of GH occurrence was significantly higher in patients with a lower height of the LA roof.

AUC, area under the curve; GH, gastric hypomotility; LA, left atrial; LAPW, left atrial posterior wall; ROC, receiver-operating characteristic.

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### TABLES

**Table 1** . Baseline characteristics for patients with and without GH

| | **All** n=54 | **GH (+)** n=10 | **GH (-)** n=44 | **P** |
|---|---|---|---|---|
| Age | 65.1±9.4 | 66.5 (61.3-71.8) | 64.5 (59.8-72.0) | 0.59 |
| Male, n (%) | 45 (83.3) | 9 (90.0) | 36 (81.8) | 1.00 |
| Hypertension, n (%) | 26 (8.2) | 2 (20.0) | 24 (54.5) | 0.08 |
| Diabetes mellitus, n (%) | 10 (18.5) | 2 (20.0) | 8 (18.2) | 1.00 |
| Congestive heart failure, n (%) | 11 (20.4) | 1 (10.0) | 10 (22.7) | 0.67 |
| Body mass index, $kg/m^2$ | | | | |

25.1±4.8

22.0 (19.3-27.1)

25.0 (22.6-26.9)

0.14

Duration of AF, months

5.5 (2.0 - 20.8)

24.0 (10.5-34.0)

4.0 (2.0-13.0)

0.049

Left atrial diameter, mm

45.0±6.4

41.0 (36.3-41.8)

46.5 (42.8-50.0)

<0.01

Left ventricular ejection fraction, %

59.8±9.7

61.0 (58.5-67.5)

60.0 (56.0-65.3)

0.65

Distance from LIPV to esophagus, mm

3.4±4.1

1.4 (1.2 - 2.1)

1.6 (1.4-2.6)

0.48

Distance from RIPV to esophagus, mm

16.7±8.9

13.8 (10.6-18.4)

15.1 (9.8-25.2)

0.96

Distance between the LA roof and esophagus, mm

11.0±4.3

8.4 (7.4-9.5)

9.7 (8.2-15.2)

0.15

Height of the LA roof *, mm

8.9±3.3

5.7 (5.1-6.1)

8.8 (7.1-11.2)

<0.01

LSPV diameter, mm

25.3±3.3

23.4 (22.5-25.2)

25.2 (24.4-27.5)

0.06

LIPV diameter, mm

20.2±2.6

19.2 (18.3-19.5)

20.2 (18.1-22.4)

0.17

RSPV diameter, mm

27.5±3.3

27.2 (24.6-29.3)

27.3 (25.0-30.4)

0.76

RIPV diameter, mm

22.4±3.4

19.7 (19.0-20.5)

23.2 (21.2-24.9)

<0.01

* Represents the height of the LA roof from the point where the LAPW and esophagus make contact.

AF, atrial fibrillation; GH, gastric hypomotility; LA, left atrial; LAPW, left atrial posterior wall; LIPV, left inferior pulmonary vein; LSPV, left superior pulmonary vein; RIPV, right inferior pulmonary vein; RSPV, right superior pulmonary vein.

**Table 2** . Ablation characteristics for patients with and without GH

**All**

n=54

**GH (+)**

n=10

**GH (-)**

n=44

**P**

Procedure time, min

139.9±30.0

116.5 (109.5-129.0)

138.0 (126.8-150.3)

0.41

Lowest nadir temperature,

LSPV

–54.0+-5.2

–55.5 (–57.0 - –52.5)

–53.5 (–57.0 - –51.0)

0.40

LIPV

–46.9+-5.2

–46.5 (–50.3 - –44.3)

–47.0 (–49.3 - –44.0)

0.96

RSPV

–54.6+-5.7

–56.0 (–58.8 - –53.3)

–54.0 (–59.0 - –50.8)

0.38

RIPV

–49.7+-7.0

–47.5 (–53.0 - –47.0)

–49.0 (–55.0 - –45.5)

0.90

LA roof line

–49.3+-4.6

–49.0 (–51.0 - –47.3)

–49.0 (–53.3 - –45.0)

0.98

Total freezing time, s

LSPV

203.7+-65.6

180.0 (180.0-180.0)

180.0 (180.0-202.5)

<0.01

LIPV

188.2+-53.2

180.0 (180.0-192.8)

180.0 (180.0-180.0)

0.45

RSPV

220.3+-110.0

180.0 (180.0-180.0)

180.0 (180.0-224.8)

0.25

RIPV

238.3+-98.3

180.0 (180.0-229.3)

180.0 (180.0-263.0)

0.99

LA roof line

964.6+-290.2

810.0 (720.0-947.0)

914.0 (821.0-1062.0)

0.16

Isolated area of the LA posterior wall, %

68.8+-21.0

79.1 (72.5-89.3)

71.8 (58.7-82.2)

0.13

Touch up ablation for the PVI, n (%)

18 (33.3)

4 (40.0)

14 (31.8)

0.72

Touch up ablation for the LAPW roof line, n (%)

7 (13.0)

0 (0.0)

7 (15.9)

0.33

Esophageal temperature reached 15, n (%)

19 (35.2)

6 (60.0)

13 (29.5)

0.17

Esophageal temperature reached 15 during LA roof line ablation, n (%)

14 (25.9)

5 (50.0)

9 (20.5)

0.10

Nadir esophageal temperature,*

13.7+-3.0

13.8 (12.8-14.7)

14.6 (12.0-16.1)

0.66

* The analysis was performed in patients in whom LET dropped below 18degC (n=32).

GH, gastric hypomotility; LA, left atrial; LAPW, left atrial posterior wall; LET, luminal esophageal temperature; LIPV, left inferior pulmonary vein; LSPV, left superior pulmonary vein; PVI, pulmonary vein isolation; RIPV, right inferior pulmonary vein; RSPV, right superior pulmonary vein.

**Table 3** . Univariate and multivariate logistic regression analyses of factors predicting GH

| **Predictors of GH** | **Univariate** | **Univariate** | **Univariate** | **Multivaria** |
|---|---|---|---|---|
| | **OR** | **95% CI** | **P** | **OR** |
| Hypertension | 0.21 | 0.04-1.09 | 0.06 | |
| Left atrial diameter | 0.85 | 0.75-0.97 | 0.01 | |
| LSPV diameter | 0.77 | 0.59-1.01 | 0.06 | |
| RIPV diameter | 0.66 | 0.49-0.90 | 0.01 | |
| Height of the LA roof * | 0.36 | 0.15-0.84 | 0.02 | 0.33 |
| Esophageal temperature reached 15 during LA roof line ablation | 3.89 | 0.92-16.40 | 0.06 | |
| Esophageal temperature reached 15 | 3.58 | 0.86-14.80 | 0.08 | |

* Represents the height of the LA roof from the point where the LAPW and esophagus make contact.

GH, gastric hypomotility; LA, left atrial; LAPW, left atrial posterior wall; LET, luminal esophageal temperature; LSPV, left superior pulmonary vein; RIPV, right inferior pulmonary vein.