Snakeskin Appearance of Gastric Mucosa Compressed by Adjustable Gastric Bands: A Novel Diagnostic Marker of Band Migration

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Purpose: The aim of this retrospective study is to describe changes of gastric mucosa in patients with adjustable gastric band migration, and to evaluate the diagnostic value of these changes. Materials and Methods: The postoperative endoscopies of all patients that underwent adjustable gastric band surgery at a single tertiary center were retrospectively reviewed. Gastric mucosal patterns were classified based on the appearance of gastric mucosae compressed by adjustable gastric bands, as follows; Group A: normal appearance, Group B: snakeskin (reticular) appearance without band migration, Group C: snakeskin appearance with band migration, and Group D: recuperated gastric mucosa with advanced band migration. Results: Postoperative endoscopic findings of 109 patients obtained from Jan 2012 to Oct 2018 were available, and these patients were assigned to the four groups, as follows; 82 to group A, 5 to group B, 14 to group C, and 8 to group D. Times (months) between AGB implantation and initial postoperative endoscopy evaluations were 45.2±22.3, 40.0±28.2, 36.2±18.6, and 42.1±17.0, respectively (P=0.531). Of the five patients in Group B, 3 underwent band explantation due to band migration (P=0.000). Conclusion: A snakeskin pattern of gastric mucosa compressed by adjustable gastric band is strongly associated with adjustable band migration. The presence of this pattern might predict band migration before endoscopic confirmation and its identification might prevent complications associated with long-standing band migration.

Key Words: Adjustable gastric band, Complication, Endoscopy, Infection

INTRODUCTION

Obesity is associated with type 2 diabetes mellitus, hypertension, hyperlipidemia, and non-alcoholic fatty liver disease and even malignancies like colon and breast cancer. The prevalence of obesity is increasing worldwide and this increasing trend also has been observed in Asian countries. Furthermore, according to the Korea National Health and Nutritional Examination Survey (KNHANES) conducted in 2016, the prevalence of obesity in Korea had increased to 42.3% for men and 26.4% for women. Bariatric surgical procedures are known to achieve substantial weight loss and provide major secondary health benefits, and because of its ease, safety, and adjustability, laparoscopic adjustable gastric band (AGB) surgery is one of the most popular bariatric procedures. However, AGB has lost favor in recent years due to major long-term complications, such as slippage, migration, and intolerance, requiring explanation [1]. Thus, endoscopic surveillance of patients with an AGB is an integral part of postoperative management [2-4],
because patients may have abnormal symptoms such as epigastric pain, nausea, frequent vomiting, and gastroesophageal reflux, all of which might be attributable to AGB complications. Occasionally, we have noted by postoperative endoscopy a mosaic or snakeskin appearance of gastric mucosa around bands in patients with band migration. In this study, we postoperatively reviewed the endoscopic findings of our AGB patients and investigated the clinical significance of this novel finding.

MATERIALS AND METHODS

This retrospective review was conducted using the endoscopic findings of patients that underwent AGB implantation at a single tertiary center. The study was approved beforehand by our institutional review board (GCIRB2018-409). All work was carried out in compliance with the Ethical Principles for Medical Research Involving Human Subjects outlined in the Helsinki Declaration in 1975 (revised in 2000). AGB was performed according to international criteria for body mass Index (BMI) that is, a BMI of \( \geq 30 \) with comorbidity or a BMI of \( > 35 \) with or without comorbidity [5]. AGB surgery was performed by a single surgeon (S.M.K) as previously described [6] and after surgery, patients were recommended to undergo an endoscopic examination whenever there was clinical suspicion of a complication, such as slippage, erosion, or incapacitating vomiting, reflux, or epigastric pain. In addition, asymptomatic patients were recommended to undergo biannual endoscopy for screening purposes. The exclusion criteria applied were; the performance of endoscopy at another hospital and endoscopic images too poor to interpret. Endoscopies in the study subjects were performed by one of five authors of this study. After removing saline from the band balloon, patients were transferred to our endoscopic suite. Initially, the distal esophagus was observed in forward view followed by the esophagogastroduodenal (EGJ) junction for pouch formation, prolapse, esophagitis, then observed down to the antrum, and a J-turn to evaluate band migration (Fig. 1). A snakeskin appearance (SSA) was defined as a mosaic or reticulated appearance of gastric mucosa compressed by gastric band with magnified view, only in case of the normal background gastric mucosa of fundus or cardia; similar findings have been reported in portal hypertensive gastropathy [7,8], eosinophilic gastritis [9], and *H. pylori* [10]. However, we observed this effect exclusively in the fundus of involved gastric bands, and rarely in any other part of the stomach, even in nearby fundus or cardia. Gastric mucosal patterns were categorized based on the appearance of gastric mucosa compressed by bands, as follows: Group A: normal appearance, Group B: SSA without band migration, Group C: SSA with band migration, and Group D: recuperated gastric mucosa with advanced band migration.

![Fig. 1.](image_url)

(A) Laparoscopic view of a normally implanted adjustable gastric band (AGB) positioned just below the esophagogastric junction (EGJ). (B) Forward endoscopic view of normal EGJ after AGB implantation. (C) Retroflexion view of normal gastric mucosa (empty arrow) around a band. Photographs showing: (D) snakeskin appearance of gastric mucosa (white arrow) without band migration. (E) Snake-skin appearance of gastric mucosa (white arrow) with band migration. (F) Recuperated gastric mucosa (empty arrow) with advanced band migration. MB = migrated band.
migration. Preoperative demographic and anthropometric data and symptoms at postoperative endoscopy were analyzed in each group. We further evaluate the clinical consequences of the additional follow-ups of patients after initial endoscopic evaluation. Data were analyzed using SPSS Ver. 11.5 (SPSS Inc., Chicago, IL, USA). Continuous variables are presented as means±standard deviations, and were compared using one-way ANOVA for independent samples, whereas categorical variables are presented as percentages (%). Categorical variables were compared using Pearson’s Chi-squared or Fisher’s exact test, as appropriate. All tests were two-tailed, and statistical significance was accepted for P values of <0.05.

RESULTS

A total of 109 patients that underwent postoperative gastroscopy from Jan 2012 to Oct 2018 were prospectively enrolled. There were 82 patients in Group A, 5 in group B, 14 in group C, and 8 in group D. Female to male ratios (% females) in these groups were 73:9 (89.0%), 4:1 (80.0%), 13:1 (92.9%), and 8:0 (100.0%), respectively (P=0.650); ages (years) at AGB implantation were 33.9±9.0, 27.6±6.1, 34.2±8.5, and 34.8±10.4, respectively (P=0.477); BMIs (kg/m²) at AGB implantation were 35.5±5.0, 38.4±7.0, 37.7±4.4, and 38.0±4.8, respectively (P=0.214); and times (month) between AGB implantation and first postoperative endoscopy were 45.2±22.3, 40.0±28.2, 36.2±18.6, and 42.1±17.0, respectively (P=0.531). The dominant symptom at time of endoscopy in group A was gastroesophageal reflux (28/82, 34.1%), but in groups B to D, the dominant symptom was abdominal pain (3/5 [60.0%], 8/14 [57.1%], and 5/8 [62.5%], respectively) (Table 1).

Immediate AGB explantation was performed laparoscopically on all 22 patients in groups C or D, while additional follow-ups, that is, follow-ups after initial endoscopic evaluations, were performed in the 87 patients in groups A or B. Of the 82 patients in Group A, during a mean additional follow-up period of 28.4±21.6 months, 49 (59.8%) maintained the band in situ; simple AGB explantation was performed in 19 (23.2%), and concurrent AGB explantation and sleeve gastrectomy (SG) was performed in 14 (17.1%). No patient in group A underwent AGB explantation due to band migration. However, none of the five patients in Group B maintained the AGB in situ, during an additional follow-up period of 21.2±13.6 months. In Group B, simple AGB explantation was performed in one patient (20.0%), concurrent AGB explantation and SG in one, and 3 (60.0%) underwent AGB explantation due to band migration (P=0.000) (Table 2).

Table 1. Demographic, anthropometric, and clinical data of each group of patients that underwent postoperative gastroscopy from Jan 2012 to Oct 2018 (N=109)

| Group | Gender, F:M (% female) | Age (y) at AGB | Height (cm) at AGB | Body weight (kg) at AGB | BMI (kg/m²) at AGB | Interval (month)* | Symptom† |
|-------|------------------------|----------------|-------------------|------------------------|-------------------|-----------------|---------|
| A     | 73:9 (89.0%)           | 33.9±9.0       | 163.8±6.5         | 95.7±17.5             | 35.5±5.0          | 45.2±22.3       | Abdominal pain, n (%) |
|       | 4:1 (80.0%)            | 27.6±6.1       | 163.6±8.7         | 103.0±22.2            | 38.4±7.0          | 40.0±28.2       | 3 (60.0%) |
|       | 13:1 (92.9%)           | 34.2±8.5       | 162.5±7.5         | 99.4±14.0             | 37.7±4.4          | 36.2±18.6       | 0 (0%)   |
|       | 8:0 (100.0%)           | 34.8±10.4      | 162.9±5.9         | 101.2±16.4            | 38.0±4.8          | 42.1±17.0       | 8 (57.1%) |

| Group C | Gender, F:M (% female) | Age (y) at AGB | Height (cm) at AGB | Body weight (kg) at AGB | BMI (kg/m²) at AGB | Interval (month)* | Symptom† |
|---------|------------------------|----------------|-------------------|------------------------|-------------------|-----------------|---------|
|         | 13:1 (92.9%)           | 34.2±8.5       | 162.5±7.5         | 99.4±14.0             | 37.7±4.4          | 36.2±18.6       | Abdominal pain, n (%) |
|         | 8:0 (100.0%)           | 34.8±10.4      | 162.9±5.9         | 101.2±16.4            | 38.0±4.8          | 42.1±17.0       | 0 (0%)   |
| Group D | Gender, F:M (% female) | Age (y) at AGB | Height (cm) at AGB | Body weight (kg) at AGB | BMI (kg/m²) at AGB | Interval (month)* | Symptom† |
|---------|------------------------|----------------|-------------------|------------------------|-------------------|-----------------|---------|
|         | 8:0 (100.0%)           | 34.8±10.4      | 162.9±5.9         | 101.2±16.4            | 38.0±4.8          | 42.1±17.0       | Abdominal pain, n (%) |

Group A = normal appearance; Group B = SSA without migration; Group C = SSA with band migration; Group D = recuperated gastric mucosa with advanced band migration; SSA = Snake-Skin Appearance of Gastric Mucosa; BM = Band Migration; AGB = Adjustable Gastric Band; GER = Gastroesophageal Reflux.

*Time between AGB implantation and first endoscopy.
†Some patients had more than one symptom.
Table 2. Follow-ups after initial endoscopic evaluations in groups A or B (N=87)

|                      | Additional FU (mo) | Band in situ | AGB removal due to |
|----------------------|-------------------|--------------|-------------------|
|                      |                   |              | Migration     | Intolerance | Concurrent SG |
| Group A (n=82)       | 28.4±21.6         | 49* (59.8%)  | 0 (0.0%)       | 19 (23.2%)  | 14 (17.1%)    |
| Group B (n=5)        | 21.2±13.6         | 0 (0.0%)    | 3 (60.0%)      | 1 (20.0%)   | 1 (20.0%)     |
| P                    | 0.465             |              | 0.000           |             |               |

SG = sleeve gastrectomy; Group A = normal appearance; Group B = SSA without band migration; SSA = Snake-Skin Appearance of Gastric Mucosa.

*Of the 49 patients with a band in situ, 17 (34.7%) underwent follow-up endoscopy at our hospital for a mean 21.1±7.5 months (all showed grossly normal gastric mucosa compressed by band). Other 32 patients were regularly followed for band adjustment using clinico-radiologic studies (esophagograms).

Fig. 2. Schematic drawings of AGB implantation. Poor surgical technique, infection from an anchoring stitch, pouch distension, and ascending infection from connecting reservoir port all contribute to band migration through gastric mucosa around the band into gastric lumen.

**DISCUSSION**

Band migration (also termed erosion) is a well-known complication of AGB implantation. Unlike other complications such as slippage and intolerance, band migration always requires band system removal because long-standing inflammation associated with an eroded gastric band has been proven to be associated with a number of serious morbidities [11-13]. The mechanism of intragastric migration of AGB has yet to be defined. In our opinion, band migration is a consequence of a chronic infectious process initiated by infection of the AGB system caused by poor surgical technique, an abscess around an anchoring stitch or reservoir port, or tension (or ischemia) of gastric mucosa around an AGB (Fig. 2).

The clinical manifestations of band migration can range from asymptomatic to acute peritonitis and sepsis. Asymptomatic individuals often increase food intake and gain weight due to loss of restriction by the band balloon. In our series of patients, abdominal pain was the predominant symptom (60%, 13/22), which is in-line with the findings of other studies [14]. Occasionally, during screening endoscopy (many Koreans undergo screening endoscopy biannually), we observe a small stitch inside gastric lumen in some asymptomatic patients, and we have also observed friable mucosa with a SSA during endoscopy at the left inferior banding site in asymptomatic patients. Therefore, in the present study, we reviewed and analyzed all postoperative endoscopic findings of patients that underwent AGB implantation. Of the 109 patients with available postoperative endoscopy findings, 17.4% (19/109) had exhibited SSA on endoscopy and 20.2% (22/109) were diagnosed to have band migration.

In the present study, SSA was found to be strongly associated with band migration. The sensitivity of SSA for prediction of band migration is 60% (3/5) (Table 2). Interestingly, none of the five patients in Group B maintained the band in situ during an additional mean follow-up after initial endoscopy of 21.2±13.6 months, and 3 of the 5 underwent AGB explantation due to band migration. Given that band migration is a consequence of chronic inflammation, the results of present study aid decision-making, because it indicates if SSA is observed by endoscopy in AGB patients, a meticulous close examination with magnified view should be performed for any tiny-hole in gastric mucosa compressed by band or an abscess around the AGB. Even in the absence of such findings, we recommend more frequent endoscopic...
follow-up of these patients because a migrated band will require removal eventually. Although controversy exist about the optimal timing of migrated AGB removal [11,15-19], many case reports have been issued describing serious complications arising from long standing band migration, including liver abscess [20], small bowel injury [21], delayed bleeding [22,23], and peritonitis [13,24]. One Group B patient in the present study also presented with acute peritonitis at 6 months after a diagnosis of SSA. Our finding of SSA in gastric mucosa associated with band migration is reminiscent of the classic findings of portal hypertensive gastropathy (PHG) [8], that is, of pale white reticular (mosaic) pattern surrounding small polygonal areas of mucosa, with variable erythema. Decreased mucosal blood flow and passive congestion of the gastric submucosal layer appear to play roles in the development of PHG, and its endoscopic appearance is characterized by a snakeskin mucosal pattern, whereas gastric biopsies reveal vascular congestion. Likewise, given that the underlying mechanism of band migration is chronic inflammation, we postulate that SSA in gastric mucosa compressed by band is the result of edema, congestion, and fibro-inflammatory changes in mucosa and submucosal layers. In addition, no normal, healthy undulating gastric fold was observed in gastric mucosa compressed by band associated with band migration, and unlike PHG, background gastric mucosa in fundus and cardia were not grossly affected. We also speculate band migration can be detected endoscopically before symptoms develop because it seems likely that the migration process might start from a mucosal change, tiny hole, and lead to full-blown intraluminal migration. Currently, no pathognomonic sign or symptom has been identified for band migration.

Our study has several limitations. First, it is limited by its retrospective design and the relatively small number of patients with available postoperative endoscopy findings. In addition, given that band migration is a chronic process, the results of present study, including those concerning the diagnostic value of SSA might have been different had the observation period after AGB placement been longer. Second, postoperative endoscopy findings were available for only 109 of 267 patients, and during additional follow-up of group A and B patients, additional endoscopy findings were not available for more than half of the patients in group A. Although biannual screening endoscopy was recommended in all patients, typically, patients underwent endoscopy only after abnormal symptoms developed. Therefore, the results of the present study and the determined diagnostic value of SSA might have been different had all patients undergone routine endoscopic examinations after AGB. In this regards, Group D patients might be diagnosed to have SSA before full blown band migration occurs, therefore sensitivity and positive predictive value could be increased by serial postoperative endoscopy at regular intervals. Third, we did not perform any histologic examination of gastric mucosa compressed by band. Gastric mucosa compressed by the AGB is thinner than that in other regions of the gastric wall and is susceptible to injury. We consider biopsy in this situation might induce transmural injury of gastric mucosa and cause band migration, and that therefore biopsy is unethical in most cases. Further study need to be done for analysis of histologic finding of the SSA in selected cases. In conclusion, we found a SSA of gastric mucosa compressed by band was strongly associated with AGB migration. Furthermore, we believe this finding might predict band migration before endoscopic confirmation, and thus, prevent complications associated with long-standing band migration. Therefore, we recommend careful observation of the pattern of gastric mucosa compressed by gastric band as well as gross migration of gastric band.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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