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A Rat Gastric Banding Model for Bariatric Surgery

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Abstract

Background: Adjustable gastric banding is a surgical approach to weight reduction. In this study we created a gastric banding model in rats to better understand the mechanism of body weight loss.

Methods: Male Sprague-Dawley rats weighing 260 to 280 g were subjected to gastric banding (band group) (n=8) or to a sham operation (control group) (n=8). Body weights were monitored for 14 days, and daily food and water intake and nitrogen balance were monitored for 7 days.

Results: Two rats in the band group died of malnutrition due to gastric stomal stenosis and obstruction caused by the gastric banding. Body weight gain during the 14 days after the operation was less in the band group than in the control group ($p<0.01$). Food intake during the 7 days after the operation was significantly less in the band group than in the control group ($p<0.01$), and water intake during the 7 days after the operation was significantly less in the band group than in the control group ($p<0.01$). Cumulative nitrogen balance was significantly less in the band group than in the control group ($p<0.01$).

Conclusion: Gastric banding decreased the body weight gain of rats by decreasing the amount of food intake because of the creation of a small gastric pouch.
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Key words: food intake, rat, bariatric surgery, gastric banding, obesity

Introduction

A sedentary lifestyle and changes in living habits have increased the number of obese persons in Japan. A body mass index (BMI; weight [kg] · height^{-2}[m^{-2}]) of more than 25 is the criterion for a diagnosis of obesity[1], and the prevalence of obesity in Japanease older than 40 years was approximately 30%. Nonsurgical strategies for the treating of clinically severe obesity have included various combinations of low- or very-low-calorie diets, behavioral modification, exercise, and pharmacologic agents. However, because such strategies have generally been unsuccessful for long-term weight maintenance, surgery has become an alternative means of achieving weight reduction in patients whose obesity is classified as 'Obese IV' (BMI≧40.0) or 'Obese III' (35.5≦BMI<40.0) and who have comorbidities, such as diabetes mellitus, hypertension, and hyperlipidemia in whom less invasive weight loss methods have failed and who

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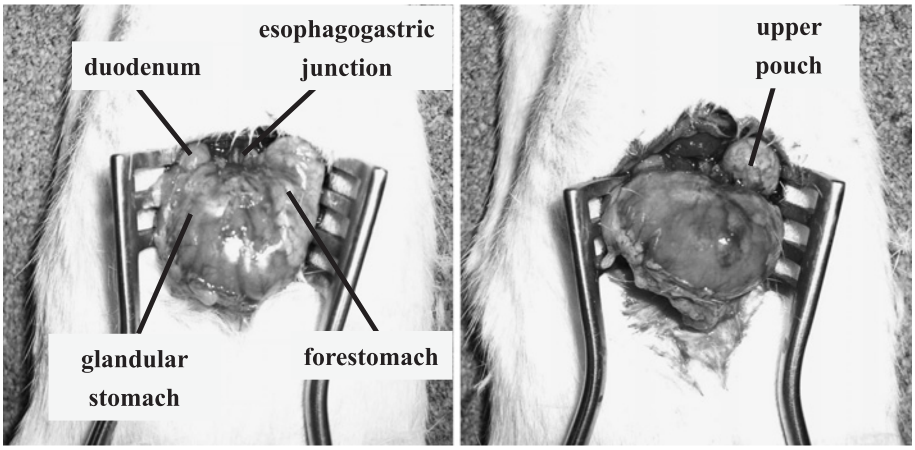

Fig. 1 Gastric banding
An upper midline abdominal incision was made, and the stomach was exposed. The gastric band was placed around the glandular portion of the gastric fundus below the esophagogastric junction, and an upper pouch and lower pouch were created, thereby reducing stomach volume.

are at high risk for obesity-associated morbidity or mortality[2].

Laparoscopic adjustable gastric banding (LAGB) is an effective treatment for obesity[3] and has been performed in Japan since 2005[4]. The stomach is divided into two pouches by placing an adjustable silicone band 2 cm below the gastroesophageal junction to create a small proximal gastric pouch having a volume of approximately 15 ml. The inner part of the band is connected to a subcutaneous port in the abdominal wall on the left side so that the diameter of the band can be adjusted. LAGB has been suggested to interfere with appetite and satiety in humans, but few experimental studies support this interpretation. To better understand the mechanism of the weight loss and amelioration of related metabolic conditions with LAGB in humans, we created a new reproducible experimental rat model of gastric banding.

Materials and Methods

Sixteen male Sprague-Dawley rats (Sankyo Labo Service Corporation, Inc., Tokyo, Japan) weighing 260 to 280 g each were acclimatized to our laboratory conditions for 7 days before being used in the experiment. The animals were housed at 21℃ under a 12-hour light and dark cycle and given free access to tap water and standard rodent chow (MF, Oriental Yeast Co., Ltd., Tokyo, Japan). The institutional Animal Care and Use Committee of Nippon Medical School approved all of the experimental protocols.

Surgical Procedure

Animals were weighed and anesthetized by intraperitoneal injection of sodium pentobarbital (50 mg/kg; Somnopentyl; Dainippon Sumitomo Pharma, Tokyo, Japan). An upper midline abdominal incision was made, and the stomach was exposed. The surgical technique for gastric banding consisted of placing a 6-mm-inside-diameter, 2-mm-wide band made from a rubber tube around the glandular portion of the gastric fundus below the esophagogastric junction to divide the stomach into an upper pouch and a lower pouch (**Fig. 1**). To keep the band from becoming dislocated, two stitches were placed in the anterior stomach wall, one near the lesser curvature and the other near the greater curvature. The abdominal wall was closed in two layers (band group).

A sham-operated group of rats was used as a control group and subjected to the same procedure as the band group except for placement of the band.

All rats were returned to metabolic cages and given free access to rodent chow, and tap water. Body weight was monitored daily through postoperative day (POD) 14. Water and chow intake

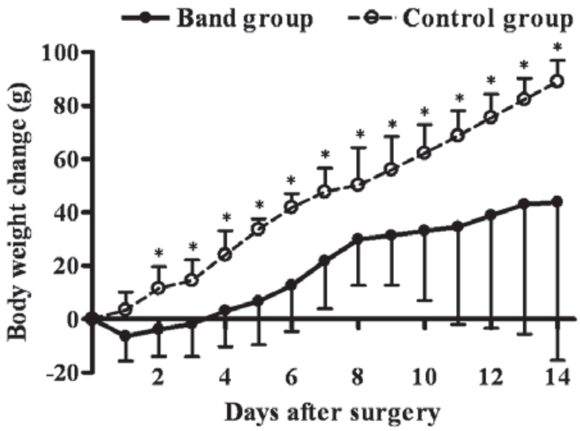

Fig. 2 Body weight changes after gastric banding. After surgery, the band group showed a lower cumulative weight gain than did the control group.
*, p<0.01 compared with the control group

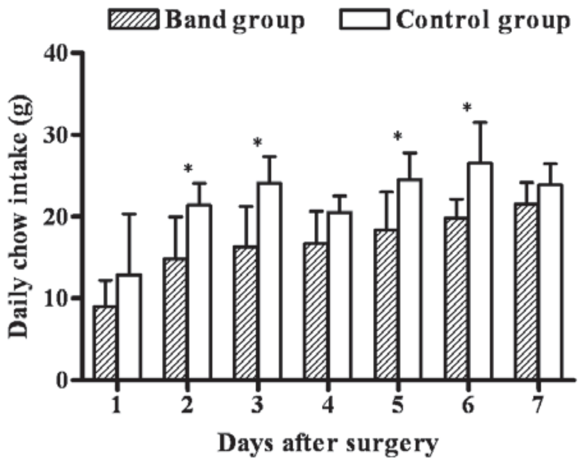

Fig. 3 Daily chow intake after gastric banding. Daily chow intake in the band group progressively increased, and was significantly less than the control group on PODs 2, 3, 5, and 6.
*, p<0.01 compared with the control group

and urine output were monitored daily through POD 7.

Nitrogen Balance

Daily nitrogen input was assumed to be the nitrogen content of the rat chow consumed. Daily nitrogen loss was assessed by collecting 24-hour urine output and measuring total urinary nitrogen by means of pyrochemiluminescence. The daily nitrogen balance was calculated by subtracting daily nitrogen output from daily nitrogen input[5].

Statistical Analysis

All data are expressed as means ± SD. One-factor analysis of variance was used for repeated measures to assess the effects of surgery, with post hoc least significant difference tests where appropriate. A *P* value less than 0.05 was considered evidence of statistical significance. All statistical analyses were performed with the StatView software package (version 5.0, SAS Institute Inc, Cary, NC).

Results

Male Sprague-Dawley rats were subjected to gastric banding (n=8) or sham-operated (n=8). Two rats in the band group died of malnutrition because of gastric stomal stenosis and obstruction by gastric banding and were excluded from analysis.

The cumulative body weight gain and the rate of body weight gain in the band group on POD 14 (43.8 ± 59.3 g and 15.1 ± 20.6%, respectively) was significantly less than those in the control group (88.9 ± 7.8 g and 30.7 ± 2.8%, respectively; p<0.01: **Fig. 2**). From the day of surgery to POD 14, the mean rate of weight gain in the band group (3.0 ± 7.6 g per day) was significantly less than that in the control group (6.6 ± 4.3 g per day; p<0.01). In the band group body weights decreased on POD 1 but began to increase POD 2 and continued to increase thereafter.

Weekly chow intake was significantly less in the band group (116.5 ± 20.2 g) than in the control group (155.0 ± 17.3 g; p<0.01). Daily chow intake in the band group progressively increased but was significantly less than that in the control group on PODs 2, 3, 5, and 6 (p<0.01; **Fig. 3**).

Weekly water intake was significantly less in the band group (171.2 ± 45.7 mL) than in the control group (219.3 ± 18.2 mL; p<0.01), and daily water intake by the band group was significantly less than by the control group on PODs 1 (p<0.01), 3, 5, and 6 (p<0.05; **Fig. 4**).

Cumulative nitrogen balance was significantly less in the band group (2,642 ± 579 mg) than in the control group (3,906 ± 593 mg; p<0.01). Daily nitrogen balance in the band group progressively

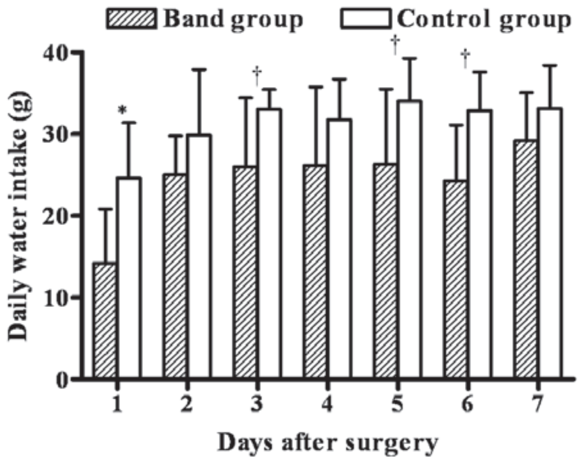

Fig. 4 Daily water intake after gastric banding. Daily water intake in the band group was significantly less than that in the control group on PODs 1, 3, 5, and 6.
*, $p<0.01$ compared with the control group; †, $p<0.05$ compared with the control group

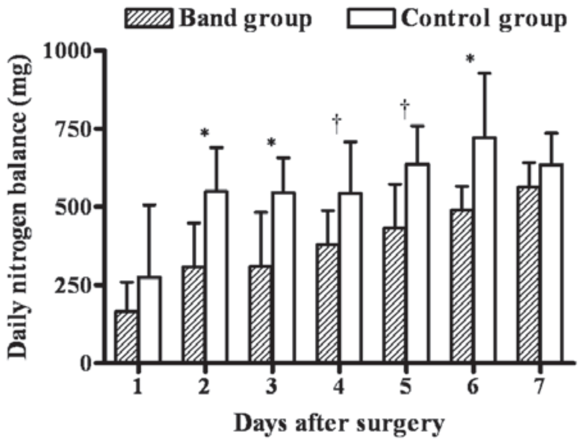

Fig. 5 Daily nitrogen balance after gastric banding. Daily nitrogen balance in the band group progressively increased after the operation, and there were no significant differences between the groups on POD 7.
*, $p<0.01$ compared with the control group; †, $p<0.05$ compared with the control group

increased after the operation, and the difference in daily nitrogen balance between the groups on POD 7 was not significant **(Fig. 5)**.

Discussion

Gastric banding decreased body weight gain in comparison with the control because of a decrease in chow intake. In other gastric banding models in rats the banding was reported[6–9] to decrease body weight gain in the growth phase of the rats[6–8]. Even when obese Zucker rats were subjected to gastric banding no decrease in absolute weight was observed, although their body weight gain and food intake was less than in those of sham-operated rats[9].

Sprague-Dawley rats were selected as the experimental model of bariatric surgery because their metabolism is well known and has been examined in detail. The establishment of a rat gastric banding model required experiments with different techniques because of anatomical differences between the human and rat stomach. This study was an attempt to establish a new rat model and we have used a small number of rats.

Vertical banded gastroplasty (VBG) is a restrictive procedure that does not allow the band to be adjusted[10]. It restricts gastric volume by creating a vertical gastric pouch along the lesser curvature and wrapping a polypropylene mesh band around the lower end of the vertical pouch, which acts as the stoma, preventing it from stretching. VBG has been almost completely abandoned because many reoperations have been required as a result of outlet stenosis and reflux and poor weight loss[11].

One of the major problems with open gastric banding was that the size of the gastric pouch was not adjustable. If the stoma is too wide, weight loss is impaired, and if the stoma is too tight, there is a risk of postoperative food intolerance. Refinement of devices has resulted in an adjustable band that can be placed laparoscopically. Therefore to prevent vomiting in the initial postoperative period[12,13], most surgeons now defer band adjustment until the first follow-up visit[14]. During the first 2 to 4 weeks following surgery, the patient is instructed to consume only fluids, and over the following 2 to 4 weeks, there is a transition phase from liquids, to soft foods, and then to solid foods. In the present study two rats died of the gastric stomal stenosis and the distention of the gastric pouch by small pieces of chow because the gastric banding was nonadjustable, and a liquid diet would be necessary for several days after gastric banding.

Rats consume the most chow during the first hour before and after dark and no significant difference in weight gain or chow intake was found between rats that eat twice a day and unrestricted nibbler rats[15]. The rats in the present study which were subjected to gastric banding consumed less chow than did the sham-operated rats. The band group, however, consumed more chow than did the control group during the daylight phase[7]. Even when chow intake was restricted by gastric banding in the present study, the daily chow intake of the band group was 72.4% of that of the sham-operated because they ate more frequently.

In conclusion, gastric banding decreased body weight gain and the amount of food intake because of the small gastric pouch. Further study is needed to reduce absolute body weight after gastric banding by considering forms of food and feeding patterns. Furthermore, the data should be reproduced in a large number of Sprague-Dawley rats and applied to adult obese Zucker rats because that model could better replicate human obesity.

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