

Effect of fundectomy, antrectomy and gastrectomy on pancreatic and brush border enzyme activity in rats

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Summary

The aim of our study was to investigate the possible effects of the removal of different parts of the stomach (fundectomy, antrectomy, gastrectomy) on the total protein content and enzyme activity in the pancreas and the brush border of the intestinal mucosa. Twenty-four 2.5-month-old male Wistar rats were divided into four groups: sham-operated animals (SHO) and those subjected to gastrectomy (Gx), fundectomy (Fx), and antrectomy (ANT). After a six-week experiment, the rats were sacrificed, and blood was collected for further gastrin analysis in serum. Samples of the pancreas, duodenum, and jejunum (proximal part in 25% of length, middle part in 50% of length, and distal part in 75% of length) were collected to determine the total protein content and enzyme activity. The rats subjected to fundectomy, antrectomy and gastrectomy showed an increased total protein content and enzyme activity (amylase, trypsin) in pancreatic tissue. They exhibited an increase in the total protein content in the homogenates of the mucosa of the proximal, middle and distal jejunum, compared to the control, and a statistical increase in maltase activity. Compared with the control group, the rats subjected to Fx and ANT showed a decreased sucrase activity in the homogenates of the mucosa of the duodenum and of the proximal, middle and distal jejunum. In the gastrectomized rats, there was a statistically significant increase in the total protein content in the homogenates of the mucosa of the jejunum, compared to the control, while the activities of lactase and sucrase were decreased. There was a statistically significant increase in the gastrin level in all experimental groups (Fx, ANT, Gx). We suggest that surgical removal of a part of the stomach radically changes the level of hormones that determine many functions of the organism. Hormonal changes may have an impact on the pancreas and the activity of brush border enzymes.

Keywords: fundectomy, antrectomy, gastrectomy, trypsin, pancreas, jejunum

Exocrine pancreas secretion is very important for digestion in the gut. This function is controlled by neuronal and hormonal pathways (4, 18). Gastric endocrine cells are a well-known source of many hormones, such as gastrin, ghrelin, obestatin, and nesfatin-1 (1, 33). These hormones take part in pancreas function, appetite control, energy regulation, and many physiological processes in the organism. Since the impact of these hormones on the body is multidirectional, procedures involving partial or total gastrectomy can have serious consequences for the physiological status and health of the organism. This should be taken into account in bariatric procedures aimed at body weight loss. As indicated by research, one of the consequences of gastrectomy may be changes in pancreatic exocrine function. Some authors report that gastrectomy results in cellular hyperplasia and hypertrophy, enzyme stor-

age, and increased *in vitro* secretory capacity (6, 16). However, discrepancies are observed between humans and animals. The exocrine pancreatic insufficiency in humans after total gastrectomy contrasts with results from rat studies (11, 20). Moreover, true pancreatic functions in terms of enzyme activity are difficult to assess in humans. Most tests used for investigation of pancreas function are indirect.

Removal of the acid-producing part of the stomach, gastric by-pass surgery, and gastrectomy resulted in decreased blood ghrelin levels (8, 10, 22). Ghrelin is found in oxyntic mucosa, as well as in the antrum and duodenum in moderate amounts (10). This hormone regulates the pituitary hormone axis, carbohydrate metabolism, and various functions of the heart, kidney, pancreas, adipose tissue, gonads, and cell proliferation (12). Data on nesfatin-1 response to gastric surgery are

ambiguous. Some authors observed decreases in the nesfatin-1 level in response to sleeve gastrectomy in patients with type 2 diabetes (32). On the other hand, reduced nesfatin-1 levels were observed in rats with a Roux-en-Y Gastric Bypass (RYGB), but this was not observed in response to sleeve gastrectomy (32). Nesfatin-1 was detected mainly within the central nervous system, in the arcuate nucleus, supraoptic nucleus, hypothalamus, and spinal cord (13). It was contained in the central part of the pancreatic islets, liver, spleen, thymus, heart, liver, muscle, pituitary glands, testes, fat tissue, and endocrine cells of the digestive tract (13, 29, 33). As an anorectic hormone, nesfatin-1 takes part in appetite regulatory processes, in regulation of body weight, fat mass, glucose levels, insulin secretion, and energy homeostasis (14, 29). Although it has been found that nesfatin-1 influences gastrointestinal motility and reduces gastric acid secretion (2, 30, 31), the functional roles of this peptide in the digestive tract are not completely understood. It is possible to assume that nesfatin-1 may be involved in the regulation of enzyme activation, nutrition absorption, and preservation of the digestive tract walls. It should therefore be assumed that elimination of hormonal factors of gastric origin may be associated with a change in digestion conditions in the gut, including not only the enzymatic activity of the pancreas, but also the brush border enzymes of the duodenum and jejunum (6). According to our knowledge, there are no data on the activity of brush border enzymes in the available literature.

Hence, the aim of the study was to investigate the possible effect of the removal of different parts of the stomach on the total protein content and enzyme activity in the pancreas and the brush border of the intestinal mucosa.

Material and methods

Animal procedures. All experimental procedures were approved by the 2nd Local Animal Welfare Committee in Lublin, Poland.

Twenty-four healthy male Wistar rats with an average initial body weight of 220-240 g were examined during the experiment. The animals were first adapted to new environmental conditions of the animal house and then housed under standard controlled conditions: temperature of 22°C ($\pm 10\%$), humidity of 55% ($\pm 10\%$), and a 12 h day/night cycle. The rats were kept separately in plastic cages with *ad libitum* access to commercial diet for laboratory animals (Agropol-Motycz, Poland) and water at all times (except for the period of overnight fasting prior to the surgery and euthanasia). After a 7-day acclimatization period, the rats were randomly divided into 4 groups, that is, one control (SHO) and three experimental (Gx, Fx, and ANT) groups.

Experimental design. On the day of surgery, after 12-h starvation, the rats were anesthetized with ketamine, 15 mg/kg b.w. *i.m.* (Biowet-Pulawy, Poland) and Rometar, 35 mg/kg b.w. *i.m.* (Leciva, Czech Republic). Six control rats underwent a sham operation by an abdominal mid-line

incision, followed by gentle manipulation of the viscera. In six rats, a modified gastrectomy procedure (Gx) was performed. This operation consisted in resection of the antrum and the glandular part of the stomach and end-to-end junction of the duodenum to the rumen, which is a nonglandular part of the stomach (26). In six rats, fundectomy (Fx) was performed. In this procedure, the fundus (oxyntic gland mucosa) of the stomach was resected along a visible borderline dividing the antrum and the fundus as well as the easily recognizable borderline between the rumen and the fundus (27). Then the antrum and the rumen were connected. In six animals, the antrum was removed (ANT), and the fundus of the stomach and the duodenum were connected. Immediately after the surgery, an antibiotic cover was applied for 3 days (Betamox L.A., Scanvet, Poland, 0.2 ml/rat).

After a 6-week experimental period, overnight-fasted rats were anesthetized in CO₂, and blood was collected by cardiac puncture. Subsequently, the rats were euthanized by cervical dislocation. Blood samples were collected into sterile tubes for and then centrifuged at 3000 rpm for 30 min. Serum samples were kept at -80°C until the analysis of gastrin levels.

Immediately after euthanasia, fragments of the gastrointestinal tract, namely, the pancreas, duodenum, and jejunum (proximal part in 25% of length, middle part in 50% of length, and distal part in 75% of length), were collected to determine the protein content and enzymatic activity.

Preparation of intestinal mucosa samples. After washing out the remaining food and mucus with cold saline and drying the duodenum and jejunum fragments by pressing a sheet of filter paper, approximately 2 g of the mucosa was gently scraped off the duodenum and 3 segments of the jejunum (25, 50, and 75% of the length) with a spatula. Samples of the scraped mucosa were immediately frozen in liquid nitrogen. Next, the samples were homogenized in a homogenizer (1 g of mucosa in 5 ml of distilled water, 2 times for 30 seconds). The samples were then centrifuged for 5 minutes at 4°C, 1000 g, and the supernatant was gently pipetted into Eppendorf tubes and frozen at -80°C for future analysis.

Determination of the enzyme activity of the intestinal brush border. The activities of lactase, maltase, and sucrase were measured according to the method described by Dalquist (7) and modified by Kotunia et al. (19). For the test, 100 μl of the intestinal mucosa homogenate was collected, 0.5 ml of a lactose, maltose, or sucrose solution was added, and the samples were incubated in a water bath at 37°C for 60 minutes. After incubation, an inhibiting solution was added. The standards were made according to the increasing glucose concentration. Subsequently, 10 μl of the test samples (for lactase and maltase) or 20 μl of the test samples (for sucrase) and 1 blank for each sample were applied in triplicate to microplates. They were made up to a volume of 255 μl with the RTU solution (Glucose RTU, bioMérieux, France) and incubated in an incubator at 37°C for 15 min. Absorbance was measured in a microplate reader spectrophotometer (Multiskan RC, ThermoLabsystems, Finland) at a wavelength of 490 nm. The results are shown in units of enzyme activity (U) per 1 g of mucosa. One unit (U) corresponds to the hydrolysis of 1 μmol of the substrate (glucose) within 1 minute (19).

Determination of the total protein content. The content of total protein was determined by the Folin method modified for the use of microplates. Fifty μl of the Folin reagent and diluted homogenate (small intestine/jejunum mucosa or pancreas) were added to each microwell (17). After a 30-min incubation period at room temperature, 200 μl of the copper reagent was added. The results were read at 450 nm.

Determination of the pancreatic enzymes activity. Pancreas was homogenized with 500 mM Tris-HCl buffer (1 : 20 w/v) containing 50 mM CaCl_2 , pH 8.0, at 4°C. The homogenate was centrifuged at $14,000 \times g$ for 30 min at 4°C. The remaining supernatant was frozen in liquid nitrogen and stored at -70°C until the activity of the other enzymes was determined. Trypsin activity was monitored by the amount of p-nitroanilide (pNA) released from a specific substrate,

measuring spectrophotometric units at 405 nm (A405) (Trypsin Activity Assay Kit, BioVision). Trypsin activity was calculated according to the formula suggested by the manufacturer. To determine the pancreatic amylase activity, ethylidene-pnitrophenol (pNP)-maltoheptaoside was used as a substrate (Amylase Activity Assay Kit, BioVision). Once the substrate is specifically cleaved by α -amylase activity, the smaller fragments produced are acted upon by α -glucosidases, which causes the release of chromophore, which is then measured at 405 nm.

Determination of the gastrin concentration. Serum gastrin levels were measured with a commercial Gastrin 1 Rat ELISA kit (Abcam Inc., Cambridge, Massachusetts, USA). The analysis of the gastrin concentration was performed by a Benchmark Plus microplate spectrophotometer equipped with MicroplateManager Software Version 5.2.1 (Bio-Rad Laboratories Inc, Hercules, CA, USA). The analysis was performed in duplicate for each sample and standard, and the tests were carried out in accordance with the manufacturer's instructions.

Tab. 1. Total protein content (mg/ml) in pancreas and in mucosa of duodenum, as well as of proximal, middle, and distal parts of jejunum in rats after fundectomy, antrectomy, and gastrectomy

Parameters	Groups			
	Control	Fundectomy (Fx)	Antrectomy (ANT)	Gastrectomy (Gx)
Pancreas	9.95 \pm 0.70 ^a	11.71 \pm 0.90 ^b	11.68 \pm 0.74 ^b	10.84 \pm 0.58
Duodenum	7.59 \pm 0.58 ^a	8.51 \pm 0.34	8.04 \pm 0.58	10.09 \pm 0.13 ^b
Jejunum				
Proximal	8.06 \pm 1.02 ^a	9.30 \pm 0.82	10.58 \pm 2.32	10.67 \pm 0.75 ^b
Middle	8.60 \pm 0.92 ^a	9.70 \pm 0.62	11.59 \pm 1.74 ^b	15.12 \pm 0.62 ^b
Distal	9.02 \pm 0.38	9.80 \pm 0.21	10.80 \pm 1.04	9.69 \pm 1.55

Explanation: a, b – values in rows with different letters differ significantly at $P \leq 0.05$

Tab. 2. Enzyme activity (U/g mucosa) in mucosa of duodenum and of proximal, middle, and distal parts of jejunum in rats after fundectomy, antrectomy, and gastrectomy

Parameters	Groups			
	Control	Fundectomy (Fx)	Antrectomy (ANT)	Gastrectomy (Gx)
Lactase				
Duodenum	0.09 \pm 0.03 ^a	0.09 \pm 0.04	0.13 \pm 0.01 ^b	0.13 \pm 0.02 ^b
Jejunum				
Proximal	0.21 \pm 0.02 ^a	0.20 \pm 0.02	0.23 \pm 0.05	0.15 \pm 0.03 ^b
Middle	0.21 \pm 0.06 ^a	0.23 \pm 0.03	0.17 \pm 0.02	0.10 \pm 0.01 ^b
Distal	0.18 \pm 0.05 ^a	0.16 \pm 0.02	0.18 \pm 0.04	0.11 \pm 0.03 ^b
Maltase				
Duodenum	7.37 \pm 0.68 ^a	9.65 \pm 0.48 ^b	7.96 \pm 0.52	10.83 \pm 2.21 ^b
Jejunum				
Proximal	2.72 \pm 0.25 ^a	4.58 \pm 0.62 ^b	6.50 \pm 1.44 ^b	6.49 \pm 1.07 ^b
Middle	3.27 \pm 1.10 ^a	3.67 \pm 0.64	8.28 \pm 0.72 ^b	5.74 \pm 1.22 ^b
Distal	2.72 \pm 0.40 ^a	6.40 \pm 0.05 ^b	4.32 \pm 0.21 ^b	4.96 \pm 1.20 ^b
Sucrase				
Duodenum	0.94 \pm 0.15 ^a	0.56 \pm 0.12 ^b	0.71 \pm 0.16	0.44 \pm 0.04 ^b
Jejunum				
Proximal	2.14 \pm 0.16 ^a	1.05 \pm 0.15 ^b	0.56 \pm 0.06 ^b	1.09 \pm 0.14 ^b
Middle	1.82 \pm 0.45 ^a	1.26 \pm 0.07 ^b	0.97 \pm 0.24 ^b	1.42 \pm 0.19
Distal	0.93 \pm 0.26 ^a	0.82 \pm 0.23	0.59 \pm 0.13 ^b	1.02 \pm 0.31

Explanation: as in Tab. 1

Statistical analysis. The results were calculated as means (\pm SEM). One-way analysis of variance for repeated measures was followed by Tukey's post-test and linear trend analysis (GraphPad Prism v.3, Graph Pad Software, San Diego, CA, USA) to investigate the relationships between the control and experimental groups. The t-test was used to analyze differences between the control and experimental groups. A value of $P \leq 0.05$ was considered statistically significant.

Results and discussion

In the present study, we observed the impact of bariatric procedures on the digestive conditions in the gut. After fundectomy, antrectomy, and gastrectomy, the rats showed a tendency toward an increase in the total protein content in the duodenum and jejunum homogenates, compared to the control (Tab. 1). A statistical increase was observed for the middle jejunum in the ANT rats ($P \leq 0.05$). The gastrectomized rats exhibited a statistically significant increase in the total protein content in the homogenates of the duodenum and proximal and middle jejunum mucosa, compared to the control ($P \leq 0.05$). A statistically significant increase in lactase activity in the duodenum was observed in the ANT and Gx rats, compared to the control animals (Tab. 2). All experimental groups were characterized by a decrease in lactase activity in the jejunum. However, a statistically significant diminution of the activity of this enzyme was noted for the proximal, middle, and distal jejunum in

the Gx rats ($P \leq 0.05$). Maltase activity in the duodenum significantly increased in the rats subjected to fundectomy and gastrectomy, compared to the control animals ($P \leq 0.05$) (Tab. 2). The activity of maltase was also significantly higher in all parts of the jejunum in the Gx, ANT, and Fx rats, except the middle part in the Fx group, in comparison to the control animals. The sucrase activity was significantly decreased in the duodenum of the Fx and Gx groups (Tab. 2). Moreover, a significant decrease in sucrase activity, in comparison to the control group, was observed in the proximal part of the jejunum in all experimental groups, in the middle part in the Fx and ANT groups, and in the distal part in the ANT group ($P \leq 0.05$).

A statistically significant increase in the total protein level in the pancreatic homogenates was observed in the rats subjected to fundectomy and antrectomy, in comparison to the control group (Tab. 1). In the gastrectomized rats, the increase in the total protein content did not show statistical significance. There was a statistically significant increase in amylase activity in the pancreatic homogenates from the rats subjected to antrectomy and gastrectomy, compared to the control group (Fig. 1). In the fundectomized rats, there was an increase in amylase activity, but without statistically significant changes. The trypsin activity in the pancreatic homogenates from the rats subjected to fundectomy and antrectomy was statistically increased, compared to the control group (Fig. 2). There were no statistically significant changes in trypsin activity after gastrectomy.

There was a statistically significant increase in the gastrin level in all experimental groups (Fx, ANT, Gx). The increase was very strong in the rats subjected to antrectomy and gastrectomy.

Many gastrectomized patients report various gastrointestinal symptoms and complications. Bariatric surgery changes the taste, meal pattern and duration, gastric emptying and intestinal transit time, gut hormone release, bile acid metabolism, and microbiota (25). Frequently reported symptoms include diarrhea, steatorrhea, loss of appetite, and increased bowel movements (3, 11, 15). Dib et al. (8) observed morphological changes in the gut manifested by a decrease in villus length, crypt depth, and mucosa thickness in the duodenum and proximal jejunum accompanied by their increase in the distal jejunum and ileum. Various hypotheses have been proposed to explain the gastrointestinal symptoms, attributing them to bacterial colonization of the gut, low-calorie intake due to changed eating habits, and pancreatic insufficiency (9, 11, 25).

After gastrectomy, intolerance and malabsorption of nutrients have been observed (24). The postprandial syndrome is a frequent symptom of intolerance. There is an abnormal absorption of nutrients, resulting from the lack of gastric lipase, which results in poor digestion of fats. Stagnation of the food content, slow gastric emptying, and lactose intolerance are observed (24).

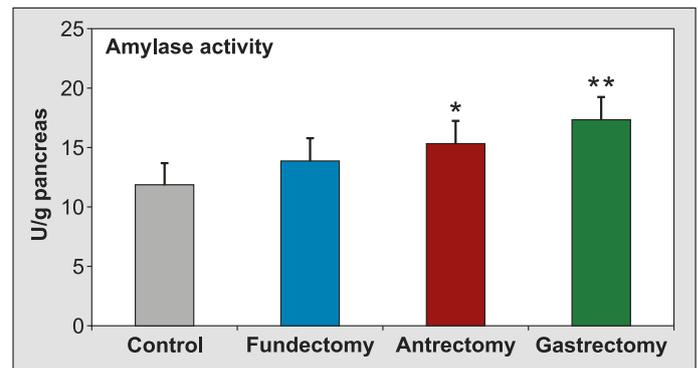


Fig. 1. Pancreatic amylase activity in rats after fundectomy, antrectomy, and gastrectomy

Explanation: The mean value is significantly different at * $P \leq 0.05$, ** $P \leq 0.01$ (one-way ANOVA for repeated measurements followed by Tukey's test)

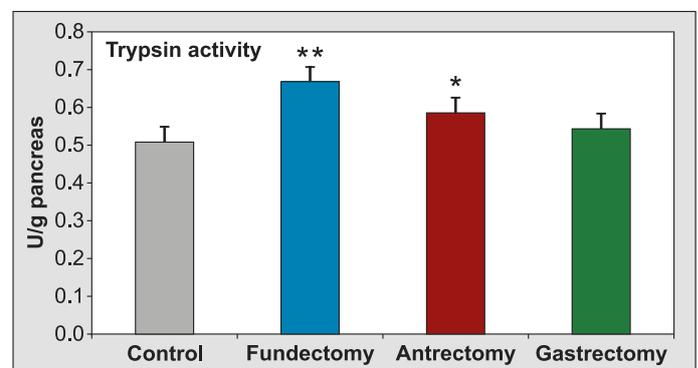


Fig. 2. Pancreatic trypsin activity in rats after fundectomy, antrectomy, and gastrectomy

Explanation: as in Fig. 1

Tab. 3. Gastrin level (pg/ml) in rats after fundectomy, antrectomy, and gastrectomy

Control	Fundectomy (Fx)	Antrectomy (ANT)	Gastrectomy (Gx)
12.2 ± 0.57 ^a	20.53 ± 6.97 ^b	1416.15 ± 302.15 ^b	2395.7 ± 999.7 ^b

Explanation: as in Tab. 1

The disturbances in digestion caused by brush border enzymes and disorders in gastrointestinal motility observed in many studies are responsible for acute postoperative weight loss in patients undergoing gastrectomy (25). In our studies, we observed differences in the enzymatic activity of the brush border of the duodenum and jejunum. An increase in lactase activity in the brush border of the duodenum by as much as 14% was observed in the ANT and Gx rats. The lactase activity in the jejunum of the rats submitted to gastrectomy decreased statistically significantly to 71.5% in the proximal part, to 48% in the middle part, and to 61% in the distal part, compared to the control rats. Intestinal lactase hydrolyzes lactose mainly in the jejunum, and its deficiency leads to disturbances in the hydrolysis of the lactose consumed and lactose intolerance. Most gastrectomized patients have an intact jejunum; therefore, lactose intolerance in these patients is considered "functional" (24).

In the rats subjected to gastrectomy and fundectomy, we observed a statistically significant increase in maltase activity (by 31% and 47%, respectively) in the duodenal brush. Similar changes were also observed for the jejunum. In the Fx, ANT and Gx rats, a higher activity of maltase was observed in each part of the jejunum, in comparison to the control rats. In the proximal part of the jejunum in the Fx, ANT, and Gx groups, maltase activity increased, respectively, by 68%, 139%, and 138%, in the middle part by 11%, 153%, and 76%, and in the distal part by 135%, 59%, and 82%.

The enzymatic activity of sucrase in the brush border of the duodenum decreased to 60% in the Fx rats, to 75% in the ANT rats, and to 48% in the Gx rats. Moreover, a statistically significant decrease in sucrase activity was observed in the jejunum. The values of this parameter were decreased in the Fx rats to 49% in the proximal part, to 70% in the middle part, and to 88% in the distal part. In the ANT rats, a decrease in sucrase activity was observed also in each part of the jejunum: to 26% in the proximal part, to 53% in the middle part, and to 60% in the distal part. In the gastrectomized rats, statistically significant changes in sucrase activity were observed only in the proximal part of the jejunum, where the enzyme activity decreased to 51%.

In our research, statistical differences were observed in the total protein content in the intestinal mucosa, depending on the procedure performed. A statistically significant increase of 32% and 76% in the total protein content in the proximal and middle parts, respectively, was observed in the homogenates of the jejunum mucosa in the Gx rats, compared to the control animals. In the ANT rats, there was a statistically significant increase (by 35%) in total protein in the intestinal mucosa homogenates of the middle part.

We also observed the influence of the surgical procedures (fundectomy, gastrectomy, and antrectomy) on the pancreas. In the rats subjected to fundectomy and antrectomy, there was an increase of 18% and 17%, respectively, in the total protein content in pancreatic tissues. In the gastrectomized rats, an increase in the total protein content was observed in the pancreatic homogenates, but it was not statistically significant. Similar results were observed in studies conducted by Chu and co-workers (6), in which the total protein content and total DNA in pancreatic tissue increased after fundectomy and after the PBD procedure (pancreaticobiliary diversion). These changes were accompanied by an increase in the pancreas weight in the Fx rats and in the BPD rats, compared to the control group. In a study reported by Matyjek et al. (23), a significant reduction in the volume of secreted pancreatic juice was observed in fundectomized rats, compared to control animals. In addition, there was a decrease in the total protein content without changes in the level of trypsin in the pancreatic juice in fundectomized rats (23). In the present study, the pancreatic homogenates

of ANT and Gx rats exhibited an increase in amylase activity by 30% and 47%, respectively. The activity of trypsin in the pancreatic homogenates of the Fx and ANT animals was increased by 31% and 13%, respectively, compared to the control rats. Our results are partly consistent with those presented by other authors (21). Malfertheiner et al. (21) found an increase in amylase and trypsin levels, while Buchler et al. (4) reported an increase in amylase, trypsin, lipase, and protein contents after gastric resection. In both animal studies, an organotrophic effect was proven as well.

On the other hand, research on humans indicates that gastrectomy causes exocrine pancreatic insufficiency with gastrointestinal symptoms. A decrease in the excretion of bicarbonate and exocrine pancreatic enzymes, such as chymotrypsin, lipase, and amylase, has been observed (11, 15). These changes were very significant. In a study by Gullo (15), gastrectomy resulted in a decrease in lipase and chymotrypsin. In a study reported by Friess (11), Gx caused a reduction in amylase and chymotrypsin activities. Moreover, in the latter study, the total amount of pancreatic secretion was decreased after exogenous stimulation by secretin and cerulein. In addition, gastrin levels were significantly reduced by 43% and pancreatic polypeptide levels were decreased by 61%.

After bariatric surgery, many authors observed different levels of gastrointestinal hormones, depending on the type of operations performed (22, 28). Bariatric surgery causes drastic changes in the anatomy and physiology of the digestive tract and changes in gut-brain communication. In the present study, we observed a statistically significant increase in gastrin levels in the blood serum of all rats subjected to surgery. The largest, 195-fold increase in the gastrin level was observed in the gastrectomized rats. In the rats after antrectomy, a 115-fold increase in the gastrin level was observed. Similarly, a 68.2% increase in the gastrin level was observed in the fundectomized rats. Opinions on the influence of hypergastrinemia on the pancreas are not conclusive. Chen et al. (5) reported that gastrin had no trophic influence on pancreatic tissue, whereas Chu et al. (6) observed that fundectomy with chronic hypergastrinemia induced pancreatic hypertrophy in the hamster, and this effect was mediated by gastrin. Furthermore, in our previous study (27) we reported a statistically significant increase in the level of nesfatin-1 in ANT, Gx and Fx animals, compared to animals from the control group. The highest increase in the level of nesfatin-1 was observed in ANT rats (27). Moreover, in the study mentioned above (27), the level of ghrelin decreased significantly in each group of the operated rats. The most intense decrease in the ghrelin level, that is, to 24% of the level observed in control animals, was found in rats subjected to gastrectomy. Ghrelin decreased to 28.5% in fundectomized rats and to 41.4% in antrectomized rats. These results are compatible with results obtained by Martins et al. (22).

In conclusion, we suggest that surgical removal of a part of the stomach radically changes the level of hormones that determine many functions of the organism. Hormonal changes may have an impact on the pancreatic and brush border enzyme activity.

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