Original article

Impact of gender and body mass index on surgical outcomes following gastrectomy: an Asia-Pacific perspective

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Keywords: *body mass index; gastrectomy; gender; obesity; stomach neoplasm*

Background Although surgeons may expect difficulties in performing gastrectomy on patients with high body mass index (BMI), it is not always the case, especially regarding patient gender. The aim of this study was to evaluate gender as a predictive factor of surgical outcomes related to obesity, as defined by the World Health Organization for the Asia-Pacific region.

Methods Data of short-term surgical outcomes were obtained from 243 patients following open curative distal subtotal gastrectomy for gastric adenocarcinoma. Patients were classified into two groups by gender, and were further classified by BMI into group A (BMI ≥25 kg/m^2) and group B (BMI <25 kg/m^2). The operation time, extent of surgical bleeding, the number of resected lymph nodes, postoperative hospital stay, serum amylase levels, white blood cell count and postoperative complications were accessed for each group.

Results Within male patients, the operation time tended to be longer in group A, albeit without statistical significance (*P*=0.075). However, the extent of surgical bleeding was significantly larger in group A (*P*=0.002). Within female patients, there were no such differences. When comparisons were made between male and female patients in group A, the operation time was significantly longer in male patients (*P*=0.019). The extent of bleeding tended to be larger in males, albeit without statistical significance (*P*=0.065). No such differences were seen when comparisons were made between male and female patients in group B.

Conclusions Disparity in surgical outcomes between male and female patients does exist, particularly in patients with high BMI. Gender adjustment of BMI must be performed when predicting surgical outcomes.

Chin Med J 2012;125(1):67-71

The risks of cardiovascular diseases, hypertension and type 2 diabetes are greater in the obese population.[1-3] For patients undergoing surgery, obesity appears to be related to longer operation time, increased extent of bleeding and increased rate of complications.[4] For patients with gastric cancer, some studies have shown poorer surgical outcomes in obese patients following curative gastrectomy,[5-8] and others did not show significant difference in surgical outcomes between obese and non-obese patients.[9,10]

The body mass index (BMI) has often been used to describe the extent of obesity because it can easily be calculated from one's height and weight. Surgeons may expect difficulties in performing gastrectomy on patients with high BMI, but it is not always the case. We have been experiencing more frequent discordance between BMI, patient gender and surgical outcomes with increasing number of obese patients in Korea. It is possible that gender, in combination with BMI, may give better prediction of surgical outcomes in obese patients. Although many surgeons may agree with it subjectively, no previous studies have documented it based on a large database from a homogenous group of patients.

The aim of this study was to evaluate gender as a predictive factor of surgical outcomes related to obesity, as defined by the World Health Organization (WHO) in the Asia-Pacific region,[11] based on a large database from a homogenous group of patients with gastric cancer.

METHODS

Eight hundred and eighty-two patients with gastric adenocarcinoma underwent curative distal subtotal gastrectomy at our institution between January 2006 and January 2010. Eligible patients were identified through retrospective reviews of patient case records. The inclusion criteria were as follows: 1) history of open distal subtotal gastrectomy; 2) stapled Billroth I gastroduodenostomy; 3) D2 or more extended lymphadenectomy; and 4) stages I or stage II disease in accordance with the seventh edition of Union for International Cancer Control classification. Patients were excluded in the presence of any of the follows: 1) past history of abdominal surgery; and 2) resection of other

DOI: 10.3760/cma.j.issn.0366-6999.2012.01.013
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The authors declare no potential conflicts of interests pertaining to the publication of this article.

organs during gastrectomy. A total of 243 patients were eligible for inclusion in this study.

Patients were classified into two groups by gender, and they were further classified into subgroups by BMI. According to the WHO's definition of obesity for the Asia-Pacific region, BMI ≥25 kg/m^2 was defined as obese.[11] Patients were classified into high BMI group (BMI ≥25 kg/m^2) and low BMI group (BMI <25 kg/m^2). In total, patients were classified into four groups: male high BMI group, male low BMI group, female high BMI group, and female low BMI group.

The following surgical outcomes were evaluated: 1) operation time as defined by the time from skin incision until the last suture was tied; 2) the extent of intraoperative bleeding; 3) the number of lymph nodes resected; 4) postoperative hospital stay; 5) the level of serum amylase on the first and third postoperative days; 6) white blood cell (WBC) count on the first and third postoperative days; and 7) postoperative complications.

All patients were diagnosed with operable gastric cancer and admitted to our institution for surgery. All patients had been managed by an institutional guideline, last edited in January 2006, and the clinical data had been collected prospectively according to the guideline. All operative records were documented by the attending surgeons immediately following surgery, and the accuracy of clinical data was monitored continually by four surgeons who were the authors of this article. This study was approved by the Institutional Review Board of Keimyung University Dongsan Hospital (IRB No.11-60).

Chi-square test and analysis of variance (ANOVA) were used to conduct comparisons between groups. A *P* value of less than 0.05 was considered statistically significant. All statistical analyses were performed using the Statistical Package for Social Science version 18.0 (SPSS, Chicago, IL, USA).

RESULTS

The mean age for all patients, comprised of 136 men and 107 women (M:F=1.27:1), was (59.7±11.1) years. The mean BMI was (23.8±3.2) kg/m^2. One hundred and ninety-three patients (79.4%) had stage I disease and 50 patients (20.6%) had stage II disease.

In the male patient group, 44 patients were classified as high BMI and 92 patients as low BMI (Table 1). The highest BMI in the male patient group was 31.2 kg/m^2 and the lowest 16.1 kg/m^2. In the female patient group, there were 42 patients with high BMI and 65 patients with low BMI. The highest BMI was 33.8 kg/m^2 and the lowest BMI was 16.6 kg/m^2. There was no significant statistical difference in age and stage between male and female patients.

Within the male patient group, the mean operation time tended to be longer in the high BMI subgroup, compared with the low BMI subgroup ((186.5±34.4) minutes and (170.2±38.4) minutes, respectively), albeit without statistical significance (*P*=0.075) (Table 2). The mean quantity of bleeding was significantly larger in the high BMI subgroup than that in the low BMI subgroup ((314.6±212.7) ml and (209.5±148.4) ml, respectively;

Table 1. Characteristics of patients with high (≥25 kg/m^2) and low (<25 kg/m^2) BMI by gender

Variables	Male (*n*=136)			Female (*n*=107)			*P* value*	*P* value†
	High BMI (*n*=44)	Low BMI (*n*=92)	*P* value	High BMI (*n*=42)	Low BMI (*n*=65)	*P* value		
Age (years)	57.9±10.1	61.1±9.6	0.388	61.4±12.0	57.8±12.9	0.352	0.467	0.241
BMI (kg/m^2)	26.9±1.5	22.1±2.1	<0.001	27.5±2.1	21.7±1.9	<0.001	0.428	0.769
Stage (*n*)			0.481			0.523	0.089	0.481
I	38	75		30	50			
II	6	17		12	15			

Stage grouping by 7th edition of Union for International Cancer Control (UICC) classification. *High BMI in males vs. high BMI in females. †Low BMI in males vs. low BMI in females. BMI: body mass index.

Table 2. Surgical outcomes of patients with high (≥25 kg/m^2) and low (<25 kg/m^2) BMI by gender

Variables	Male (*n*=136)			Female (*n*=107)			*P* value*	*P* value†
	High BMI (*n*=44)	Low BMI (*n*=92)	*P* value	High BMI (*n*=42)	Low BMI (*n*=65)	*P* value		
Operation time (minutes)	186.5±34.4	170.2±38.4	0.075	163.4±31.7	164.9±38.0	0.996	0.019	0.810
Amount of bleeding (ml)	314.6±212.7	209.5±148.4	0.002	231.3±158.0	188.0±111.2	0.495	0.065	0.828
Number of resected LNs	54.5±21.7	58.1±23.2	0.797	58.8±19.4	58.8±19.9	1.000	0.788	0.996
Hospital stays (days)	13.0±11.5	11.5±7.9	0.778	10.7±4.6	12.6±7.9	0.644	0.581	0.847
Serum amylase (U/ml)								
Postoperative 1 day	132.9±121.1	303.8±579.3	0.673	347.2±596.5	379.0±1362.1	0.997	0.635	0.944
Postoperative 3 days	95.7±98.4	143.6±140.9	0.482	145.7±116.1	187.1±245.0	0.642	0.579	0.425
WBC count (10^3/μl)								
Postoperative 1 day	11.8±3.8	10.7±3.5	0.300	11.5±2.8	11.7±3.4	0.994	0.984	0.270
Postoperative 3 days	10.4±4.3	9.0±3.0	0.651	9.2±2.2	10.0±11.7	0.948	0.844	0.813

Hospital stays defined as number of hospital stays after the surgery. *High BMI in males vs. high BMI in females. †Low BMI in males vs. low BMI in females. BMI: body mass index. LN: lymph node. WBC: white blood cell.

Table 3. Complications in patients with high (≥25 kg/m^2) and low (<25 kg/m^2) BMI by gender

Variables	Male (*n*=136)		Female (*n*=107)		*P* value
	High BMI (*n*=44)	Low BMI (*n*=92)	High BMI (*n*=42)	Low BMI (*n*=65)	
Wound infection	1 (2.3)	2 (2.2)	0 (0.0)	2 (3.1)	
Delayed emptying	1 (2.3)	4 (4.3)	2 (4.8)	5 (7.7)	
Fluid collection	0 (0.0)	2 (2.2)	0 (0.0)	1 (1.5)	
Bleeding	0 (0.0)	1 (1.1)	0 (0.0)	1 (1.5)	
Leakage	3 (6.8)	3 (3.3)	0 (0.0)	0 (0.0)	
Stenosis	0 (0.0)	2 (2.2)	0 (0.0)	0 (0.0)	
Overall	5 (11.4)	14 (15.2)	2 (4.8)	9 (13.8)	0.375

Values in parentheses are percentages unless otherwise stated. BMI: body mass index.

P=0.002). However, the high BMI and low BMI subgroups in the female patient group did not exhibit significant difference in the mean operation time and the mean quantity of bleeding.

When comparison was made between the high BMI subgroups, operation time was significantly higher in male patients than in female patients ((186.5±34.4) minutes and (163.4±31.7) minutes, respectively; *P*=0.019). The quantity of bleeding tended to be larger in male patients ((314.6±212.7) ml and (231.3±158.0) ml, respectively), but did not reach statistical significance (*P*=0.065). When comparison was made between patients in the low BMI subgroups, there was no significant difference in the operation time and quantity of bleeding between male and female patients.

The number of resected lymph nodes, postoperative hospital stay, WBC count and serum amylase levels on first and third postoperative days were not significantly different between the patient groups.

In the male patient group, the rate of postoperative complications in the high BMI and low BMI subgroups were 11.4% and 15.2%, respectively (Table 3). In the female patient group, the rates of complications in the high BMI and low BMI subgroups were 4.8% and 13.8%, respectively. However, these differences did not reach statistical significance.

While the high BMI subgroup (BMI ≥25 kg/m^2) represents obese patients as defined by WHO for the Asia-Pacific region, the low BMI subgroup includes both over-weighed patients (BMI ≥23 kg/m^2 and <25 kg/m^2) and normal patients (BMI <23 kg/m^2). The pattern of changes in mean operation time and the quantity of bleeding were further analyzed between obese, over-weighed and normal patients. Within the male patient group, obese (*n*=44), over-weighed (*n*=36) and normal (*n*=56) patients exhibited significant differences in the operation time ((186.5±34.4) minutes, (177.4±38.5) minutes and (165.6±37.9) minutes, respectively; *P*=0.021) and in the quantity of bleeding ((314.6±212.7) ml, (228.7±104.9) ml and (197.2±153.0) ml, respectively; *P*=0.003). On the other hand, obese (*n*=42), over-weighed (*n*=17) and normal (*n*=48) female patients did not exhibit significant differences in the operation time ((163.4±31.7) minutes, (168.8±39.2) minutes and (163.6±37.9) minutes, respectively; *P*=0.852) and in the quantity of bleeding ((231.3±158.0) ml, (207.9±109.9) ml and (180.9±111.9) ml, respectively; *P*=0.198).

DISCUSSION

To predict the impact of obesity on surgical outcomes, it is necessary to quantify the extent of obesity, which could be measured by performing computed tomography (CT) scanning of the whole body, and calculating the actual area of body fat. However, this method is difficult and time consuming. As an alternative to whole body CT scan, BMI, which is easily calculated from height and weight, is used to describe the extent of obesity and to predict the outcome of surgery.[12-14]

It must be emphasized that BMI is represented by a number, irrespective of ethnic group and gender. Regarding ethnic groups, a number of studies have shown discordance between BMI and the actual proportion of body fat.[15,16] Compared with Caucasians, Asians have higher percentage of body fat at a given BMI. Different cut-off values are being applied for different ethnic groups, and many Asian countries adopt a lower cut-off value for obesity at BMI ≥ 25kg/m^2 while many Western countries adopt a higher cut-off value at BMI ≥30 kg/m^2.[11]

While differences in percentage body fat by ethnic groups have been shown, it has also been suggested that differences in body fat distribution between men and women do exist. While the BMI is represented by a number irrespective of adipose tissue distribution, the development of diagnostic modalities, such as CT, renders it possible to illustrate significant difference in body fat distribution between genders on screen. Women tend to accumulate less adipose tissue in the visceral area, and have a lower ratio of abdominal visceral to mid- thigh adipose tissue than men.[17-20] Although CT scanning of the abdomen enables quantification of adipose tissue in the visceral area, incorporating this method into clinical practice is difficult, because it is time consuming, not to mention the challenges at local hospitals without CT scanners.

Some studies have investigated the impact of visceral fat volume on surgical outcomes,[21,22] and poorer surgical outcomes were seen in patients with larger volume of visceral fat. Since differences in visceral fat volume do exist by gender, and difference in surgical outcomes do

exist by visceral fat volume, we hypothesized that difference in surgical outcomes may exist by genders. Instead of conducting abdominal CT scans analysis, we added gender to BMI and evaluated its impact on surgical outcomes.

There have been studies investigating the impact of BMI on the surgical outcome of patients with gastric cancer, and concluded that the operation time was longer, and the quantity of blood loss was higher in patients with high BMI.[5-8] However, none has investigated the impact of gender on surgical outcomes.

We classified 243 patients who underwent an open curative distal subtotal gastrectomy into four groups by gender and BMI. The operation time was longer, and the quantity of bleeding was larger in the male patients with high BMI, but these outcomes were not seen in male patients with low BMI and in female patients irrespective of their BMI.

This seems to support our hypothesis that difference in surgical outcomes may exist by genders, and it may well be related to different patterns of adipose tissue distribution between male and female patients. When predicting surgical outcomes of obese patients, consideration of gender, as well as BMI, may minimize the discordance between obesity and surgical outcomes. In the operating room, more experienced hands of surgeons and assistants may be required while performing surgery on obese male patients. When interpreting or comparing surgical outcomes following abdominal surgery, patient gender, as well as BMI, must be considered.

The number of lymph nodes resected by BMI remains controversial. Some studies have reported decreased number of resected lymph nodes in patients with high BMI,[5] and others have reported no such differences seen between different patient groups.[9,10] Although all patients underwent a certain level of lymph node dissection in these studies, some differences of the extent of lymph node dissection within that certain level may still be allowed between obese and non-obese patients. We believe that this accounts for the differences in the number of resected lymph nodes in some studies. Standardized operations were performed on patients regardless of the extent of obesity, and this may explain why no difference in the number of resected lymph nodes was seen between each patient group.

Although there was no statistical difference, female patients with high BMI had a tendency to have the least number of complications in our study. This may be an incidental finding, but it would be of interest to elucidate if this tendency continues when larger number of patients is made available for analysis.

Some studies indicate that elevated levels of serum amylase are associated with gastrectomy and lymphadenectomy for gastric cancer.[23,24] The levels of serum amylase were studied on the first and third postoperative days, and they were not significantly different between the four patient groups. This result not only suggests that there is no difference in surgical outcome as measured by serum amylase levels, but also is confirmative that the same surgical procedure was performed in all patient groups, regardless of obesity and gender.

Kvist et al[18] have shown that, in females, visceral adipose tissue does not increase until the accumulation of total adipose tissue has reached a certain extent, and above which the ratio of visceral adipose tissue and total adipose tissue is similar between male and female. Our study showed divergence of surgical outcomes between male and female patients as their BMI increased. It is possible that the surgical outcomes would show convergence between male and female patients, if this study was conducted in patients with higher BMIs. The prevalence of obesity in the Asian-Pacific region is lower compared with Western countries,[11] which rendered it impossible to conduct a study in patients with higher BMIs.

One may argue that the BMIs for obese patients included in this study were low compared to patients in Western countries. We emphasize that BMI is not an absolute value, and that unique interpretation of BMI must be made for different ethnic groups. Nevertheless, this study is significant, because it indicates the need to consider gender in addition to BMI in analyzing the surgical outcomes, particularly in obese patients.

While consideration of patient gender may reduce the discordance between obesity and surgical outcomes, waist circumference may provide an actual number reflecting the amount of visceral adipose tissue. The waist circumference was not documented in this study, and it may be interesting to incorporate waist circumference to BMI in the prediction of surgical outcomes following abdominal surgery.

Although this study was based on a large database from a homogenous group of patients, the number of patients with BMI $\geq$30 kg/m^2, who might have been classified into obese II as defined by WHO for the Asia-Pacific region, was not large enough to make a statistical analysis. It may not be easy to obtain enough data of patients with BMI $\geq$ 30 kg/m^2 in the Asia-Pacific region, but it might be interesting to see the effect of extremely high BMI and patient gender on surgical outcomes from larger data of multiple institutions. After all, one may propose using a gender-adjusted BMI, or changing the BMI cut-off values for each gender in defining obesity, in the prediction of surgical outcomes following abdominal surgery.

In conclusion, disparity in short-term surgical outcomes

between high BMI male patients and high BMI female patients does exist, suggesting that the conduct of gastrectomy in obese men is more challenging than in obese women. Gender must be considered in addition to BMI in the prediction of surgical outcomes following abdominal surgery, particularly in obese patients.

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(Received May 14, 2011)
Edited by GUO Li-shao