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REVIEW ARTICLE

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Obesity as a surgical risk factor

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Abstract

In recent years, both the actual number of overweight/obese individuals and their proportion of the population have steadily been rising worldwide and obesity-related diseases have become major health concerns. In addition, as obesity is associated with an increased incidence of gastroenterological cancer, the number of obese patients has also been increasing in the field of gastroenterological surgery. While the influence of obesity on gastroenterological surgery has been widely studied, very few reports have focused on individual organs or surgical procedures, using a cross-sectional study design. In the present review, we aimed to summarize the impacts of obesity on surgeries for the esophagus, stomach, colorectum, liver and pancreas. In general, obesity prolongs operative time. As to short-term postoperative outcomes, obesity might be a risk for certain complications, depending on the procedure carried out. In contrast, it is possible that obesity doesn't adversely impact long-term surgical outcomes. The influences of obesity on surgery are made even more complex by various categories of operative outcomes, surgical procedures, and differences in obesity among races. Therefore, it is important to appropriately evaluate perioperative risk factors, including obesity.

KEYWORDS
body mass index, gastroenterological surgery, obesity, operative outcome

1 | INTRODUCTION

The overweight/obese population has been steadily increasing worldwide. According to the WHO, with 1.3 billion overweight (25 < body mass index [BMI] < 30) people and 600 million obese (BMI > 30) people in the world,[1] the obesity rate exceeds 10% for both genders and has more than doubled during the past 40 years.[2] Furthermore, as seven of the top 10 causes of death/physical disability are chronic disorders such as cancer and diabetes, which are closely related to obesity,[3] it can be said that obesity is among the world's major health concerns at present. According to "Food, Nutrition, Physical Activity, and the Prevention of Cancer: a Global Perspective" by the World Cancer Research Fund and American Cancer Society, gastroenterological cancer is known to be closely related to obesity as, in obese patients, the incidences of esophageal adenocarcinoma, colorectal cancer, and pancreatic cancer are clearly increased, while there is also a strong association with gallbladder cancer, and a possible association with liver cancer.[4]

In contrast, there are a number of reports describing the influences of obesity on gastroenterological surgery worldwide. However, the results are often difficult to pool because of differences among surgical procedures, surgical approaches, complications associated with specific organs/surgical methods, and obesity classifications. In addition, the events evaluated, such as short-term outcomes (eg complications), long-term outcomes (eg overall survival), and surgical outcomes (eg operative time, hemorrhage volume), often vary markedly among studies. The present review aims to provide an overview of how obesity affects gastroenterological

surgery based on the recent literature. For this review, we organized recently reported surgical procedures according to anatomical/surgical techniques as the influences of obesity on surgery might differ among organs or surgical procedures.

2 | GENERAL REMARKS: OBESITY PARADOX

Regarding gastroenterological cancer surgery, Shimada et al,[5] conducting a systematic review, noted high BMI to be associated with postoperative morbidity rate, but not with poor oncological outcomes, whereas low BMI was significantly associated with inferior oncological outcomes. Mullen et al[6] obtained similar results in a large-scale review, showing the complication rate to be higher in obese than in normal weight patients, whereas 30-day mortality was lower for overweight and obese patients than for those of normal weight, undergoing general surgeries other than vascular and bariatric operations (n = 118 707). According to the literature, BMI < 18.5 (underweight) is associated with particularly high rates of both complications and death.

As mentioned previously, the phenomenon wherein obesity provides an advantage against postoperative mortality is called the "Obesity paradox" and has been extensively described. In 2258 cases undergoing gastroenterological surgery (eg esophagectomy, gastrectomy, hepatectomy, pancreatectomy, low anterior resection (LAR)/proctectomy), morbidity was higher in those with BMI > 30, but mortality was still significantly better in this group than in the patients with normal BMI undergoing the same procedures.[7] In contrast, mortality was higher in patients with BMI < 18.5 or BMI > 40.[7] Benjamin et al[8] indicated that both morbidity and mortality were more favorable in the obese than in the normal weight group receiving emergency abdominal surgery. A similar obesity paradox was indicated, by organ, for colorectal cancer surgery[9,10] and for gastric cancer surgery.[11]

This obesity paradox phenomenon has not, however, been confirmed for all surgical procedures in the field of gastroenterological surgery. A cross-sectional analysis of the influences of obesity on surgery, examining multiple organs/surgical procedures, by our research group,[12] indicated that operative time was prolonged as the BMI category rose for eight principal gastroenterological surgical procedures (n = 232 199) and mortality was also higher in patients with BMI > 30. Our prior study revealed that the overweight group tended to have the lowest mortality rate, an observation consistent with those made in cases undergoing colorectal cancer surgery/gastric cancer surgery. This was attributed to Asian populations having a higher percentage of body fat and a greater risk of obesity-related comorbidities as compared to non-Asians with similar BMI.[13] By contrast, this phenomenon was not recognized in patients undergoing hepatectomy or pancreaticoduodenectomy (PD). In addition, Anazawa et al[14] examined a risk model of 30-day mortality for three gastroenterological surgery procedures (right hemicolectomy, LAR, PD) using a database from Japan and the USA. However, as mortality is significantly higher with LAR and PD for patients with BMI > 30 in Japan and the USA, respectively, the influences of obesity may vary not only among surgical procedures but also according to race.

3 | ESOPHAGEAL CANCER SURGERY

The incidence of esophageal cancer is particularly high in the area from the east coast of the Caspian Sea to Northeast China via Central Asia, the so-called Asian belt, and this cancer tends to be squamous cell carcinoma (SCC).[15] In contrast, esophageal adenocarcinoma is frequently found in Western countries such as the UK/USA and the frequency has been increasing in recent years.[16] Furthermore, the WHO concluded that the esophageal adenocarcinoma risk is clearly increased by obesity. As mentioned above, the characteristics of esophageal cancer differ markedly depending on histological features, allowing discrimination from other gastrointestinal malignant tumors. Thus, the influence of obesity on esophageal surgery should also be examined by focusing on histological type.

In examinations of the influences of obesity on esophageal surgery, the survival rate is often used as perioperative mortality is high compared to other gastrointestinal surgeries. As previously described in the systematic review by Shimada et al,[5] it is often reported that outcomes are improved by high BMI and are, at least, not worsened by high BMI, according to meta-analyses.[17–20] Furthermore, the influences of obesity on outcomes might reportedly differ depending on histological differences between adenocarcinoma or SCC.[17,21] In contrast, a number of studies focusing on the survival rate of underweight patients have demonstrated unfavorable outcomes.[18,22,23] The reasons for obesity influencing outcomes may differ depending on whether BMI is high or low, in association with certain oncological background factors, such as tumor invasion which tends to be more aggressive in the underweight.[18,24] Table 1 shows a summary of past studies on the effects of obesity on outcomes of esophageal cancer surgery.

A high BMI may increase the risk of postoperative leakage, which is an important postoperative complication,[24–26] but being underweight may increase the risk of postoperative chylothorax.[18,19] Many studies have demonstrated that operative times become increasingly prolonged as BMI increases.[18,19,21,24]

4 | GASTRIC CANCER SURGERY

East Asia is the source of several reviews on the influences of obesity on gastric cancer surgery, reflecting the high morbidity associated with this cancer in the region.[15,27]

Chen et al[11] reported an obesity paradox wherein overall survival was significantly better in patients with BMI > 25 than in those with normal BMI. Nonetheless, other than the aforementioned report, many studies failed to demonstrate any influence of obesity on long-term survival.[28–31] By contrast, Struecker et al[28] described short-term survival (postoperative death) as being significantly poorer in

TABLE 1 Summary of past studies on the effects of obesity on outcomes of esophageal cancer surgery

Year	Author	Country	n	BMI stratification	Operation	Disease	Outcome
2015	Pan et al[17]	China	4823	<25, 25< or <24, 24< or 18.5-25, 25<	Eso	EC	High BMI is a potential predictor for better outcomes in EC patients overall, and particularly in EAC patients treated with curative esophagectomy. However, in ESCC patients, high BMI is a potential predictor of worse postoperative survival.
2015	Miao et al[18]	China	1342	<18.5, 18.5-25, 25<	ILE	EC	Incidence of pneumonia was higher in high BMI than in normal BMI subjects. However, chylothorax was less frequent in those with higher BMI. The better overall survival in high BMI compared with low BMI patients might be as a result of a relatively low pathological stage in the former.
2013	Zhang et al[19]	China	2031	<18.5, 18.5-23, 23<	Eso	EC	Patients with higher BMI had more postoperative complications, such as anastomotic leakage, but a lower incidence of chylothorax. They had a longer operative time than those of normal weight. High BMI was associated with significantly improved overall survival.
2013	Hong et al[20]	China	1988	<25, 25-30, 30<	Eso	EAC	Excess bodyweight did not predict the survival of patients with esophageal adenocarcinoma.
2017	Duan et al[21]	China	291	18.5-23, 23-27.5, 27.5<	Eso	ESCC	High BMI is a potential predictor of worse outcomes in ESCC patients.
2016	Kamachi et al[22]	Japan	340	<18.5, 18.5<	Right TTE	ESCC	Overall survival and disease-free survival rates were significantly lower in the BMI < 18.5 than in the BMI > 18.5 group.
2015	Hasegawa et al[25]	Japan	304	<18.5, 18.5-25, 25<	TTE	ESCC	On multivariate analysis, high BMI was a significant risk factor for anastomotic leakage.
2012	Blom et al[26]	Netherlands	736	<25, 25-30, 30<	TTE or THE	EC	Anastomotic leakage occurred more frequently in obese patients.

BMI, body mass index; EAC, esophageal squamous cell carcinoma; EC, esophageal cancer; ESCC, esophageal squamous cell carcinoma; Eso, esophagectomy; ILE, Ivor-Lewis esophagectomy; THE, transhiatal esophagectomy; TTE, transthoracic esophagectomy.

patients with BMI > 30, whereas Kurita et al[29] described survival as tending to be less favorable in those with BMI > 25. Obesity may have a negative influence on the short-term survival of patients who have undergone gastrectomy.

The conclusion has often been reached, based on relatively large-scale reports, that obesity negatively influences the postoperative complication rate. This negative influence might account for the high risks of complications such as incision infection, leakage, postoperative pneumonia, and intra-abdominal abscess.[30–32] In contrast, although BMI routinely serves as an obesity index, the visceral fat area (VFA) is reportedly a more appropriate predictor of complications.[33,34] Notably, VFA is often used as an obesity index for patients developing pancreatic fistula as a specific complication after gastrectomy, and an increase in VFA can serve as an important indicator of pancreatic fluid leakage risk.[34–36]

Reviews limited to laparoscopic surgery noted that obesity may prolong the operative time, without influencing either the complication rate or the survival rate.[37,38] These reviews suggest the safety and effectiveness of highly difficult laparoscopic surgery as compared to laparotomy. In addition, robotic surgery for gastric cancer has recently been conducted as a form of advanced medical care. Only a few studies have shown the superiority of robotic surgery in obese cases, but robotic surgery may not outperform laparoscopic surgery, in terms of complications. Furthermore, operative time is prolonged with robotic surgery as compared to laparoscopic surgery.[39,40] Table 2 shows a summary of past studies on the effects of obesity on outcomes of gastric cancer surgery.

5 | COLORECTAL SURGERY

More reviews of the impact of obesity on surgery have focused on the colon than any other organ. From an oncological viewpoint, obesity is widely regarded as being related to the morbidity of colorectal cancer.

As described previously, postoperative morbidity appears to be increased by obesity in patients undergoing colon surgery. However, the obesity paradox phenomenon is reflected by the mildly obese having the lowest operative mortality, whereas the highest operative mortality is associated with extreme obesity.[9,10] Similarly, Hussan et al[41] and Matsubara et al[42] reported that BMI > 40 in patients undergoing colorectal cancer surgery and BMI > 30 in those receiving LAR are independently associated with higher operative mortality. The difference in BMI categories is regarded as a difference in

TABLE 2 Summary of past studies on the effects of obesity on outcomes of gastric cancer surgery

Year	Author	Country	n	BMI stratification	Operation	Disease	Outcome
2015	Chen et al[11]	China	1249	<18.5, 18.5-25, 25<	DG, TG, PG	GC	Despite a higher risk of postoperative complications, high BMI patients exhibited paradoxically superior overall survival as compared with normal BMI patients. Operative time was longer and blood loss was greater with higher BMI.
2017	Struecker et al[28]	Germany	249	<30, 30<	Gastrectomy	GC	BMI > 30 was significantly associated with longer operative time, longer hospital stay, increased postoperative morbidity, and increased postoperative mortality. There was no significant difference in overall survival between the two groups.
2015	Kurita et al[29]	Japan	33 917	<18.5, 18.5-25, 25<	DG	GC	Operative mortality rate tended to be higher in the BMI > 25 than in the BMI < 25 group.
2017	Kikuchi et al[30]	Japan	39 253	<25, 25-30, 30-35, 35<	TG	GC	BMI > 25 was identified as a risk factor for SSI, pancreatic fistula, pneumonia, prolonged ventilation over 48 h, and renal failure.
2013	Bickenbach et al[31]	USA	1853	<25, 25<	Gastrectomy	GC	Higher BMI was associated with increased rates of wound infection and anastomotic leakage. There was no difference in overall survival or disease-specific survival between the two groups.
2017	Kunisaki et al[32]	Japan	65 906	<25, 25< or <30, 30<	DG	GC	BMI > 25 was a risk factor predicting pneumonia and anastomotic leakage, while BMI > 30 was a risk factor for unplanned intubation, renal failure and blood transfusion >5 units.
2012	Sugisawa et al[34]	Japan	206	VFA	DG, TG	GC	VFA was found to be an independent risk factor for both pancreas-related infection and anastomotic leakage.
2014	Jung et al[38]	Korea	1512	<25, 25-30, 30<	LDG	GC	BMI > 30 patients had a significantly longer operative time than those with normal BMI, but there were no significant differences in either intraoperative blood loss or other complications between the two groups. Postoperative morbidity and mortality rates in the BMI > 30 group did not differ significantly from those of the normal BMI group.
2016	Park et al[39]	Korea	434	<25, 25<	RG, LG	GC	Operative time was significantly longer in patients with BMI > 25 than in those with BMI < 25. Estimated blood loss, complication rates, open conversion rate, and length of hospital stay did not differ between the obese robotic and obese laparoscopic groups.

BMI, body mass index; DG, distal gastrectomy; GC, gastric cancer; LADG, laparoscopy-assisted distal gastrectomy; LDG, laparoscopic distal gastrectomy; LG, laparoscopic gastrectomy; PG, proximal gastrectomy; RG, robotic gastrectomy; SSI, surgical site infection; TG, total gastrectomy; VFA, visceral fat area.

body fat percentage between races, as noted above.[13] The review by Shimada et al[5] describes a low BMI as correlating with reduced survival for underweight patients.

There are other studies demonstrating obesity to have a negative influence on complications. Several studies have identified a high risk of surgical site infection (SSI) with obesity.[43,44] Similar adverse influences have been recognized for surgical procedures such as right hemicolectomy,[45] LAR,[46,47] Hartmann surgery,[48] Miles surgery,[49] and robotic surgery.[50] Moreover, obesity might reportedly be an independent risk factor for leakage.[51,52]

A meta-analysis (n = 4550) of laparoscopic surgery by Fung et al[53] found that, for colorectal cancer surgery, SSI, leakage, morbidity, and conversion rate are significantly higher in patients with BMI > 30 than in those with normal BMI. Table 3 shows a summary of past studies on the effects of obesity on outcomes of colorectal surgery. Although some studies have not found obesity to influence all of these complications, the association of obesity with prolonged operative time has consistently been recognized.[54,55] Obesity reportedly does not influence intraoperative variables or postoperative complications in patients with inflammatory bowel diseases, such as Crohn's disease and ulcerative colitis, undergoing gastrointestinal surgical resection.[56]

6 | LIVER SURGERY

There are fewer large-scale reviews focusing on the influences of obesity on liver surgery than on gastrointestinal surgery. The main

TABLE 3 Summary of past studies on the effects of obesity on outcomes of colorectal surgery

Year	Author	Country	n	BMI stratification	Operation	Disease	Outcome
2016	Alizadeh et al[9]	USA	206 360	<18.5, 18.5-25, 25-30, 30-40, 40<	Colectomy with rectal resection	Various	Obesity (30 < BMI < 40) was associated with a higher overall morbidity rate and lower in-hospital mortality rate than normal BMI. Morbidly obese (BMI > 40) subjects had higher overall morbidity and in-hospital mortality rates than those with normal BMI.
2016	Govaert et al[10]	Netherlands	8687	18.5-25, 25-30, 30-35, 35<	Colectomy with rectal resection	CRC	BMI > 30 was associated with more complications, prolonged operative times and longer hospital stays. Mortality rates were significantly lower in the 25 < BMI < 30 group and significantly higher in the BMI > 35 group than in those with normal BMI.
2016	Hussan et al[41]	USA	85 300	<30, 40<	Colectomy with rectal resection	CRC	Morbid obesity (BMI > 40) was associated with an increased perioperative mortality rate and more surgical complications.
2014	Matsubara et al[42]	Japan	16 695	<30, 30<	LAR	RC	Risk model showed BMI > 30 to be an independent risk factor for both 30-day and operative mortality.
2016	Wilson et al[43]	USA	47 868	<20, 21-25, 26-30, 30<	Colectomy	Various	Obesity was associated with a higher risk of superficial and deep SSI.
2017	Watanabe et al[46]	Japan	33 411	<26, 26<	LAR	RC	Obesity increased the risk for operative site infection but not for either leakage or renal failure.
2016	Althumairi et al[49]	USA	8449	18.5<, 18.5-25, 25-35, 35<	APR	RC	BMI > 35 was a risk factor for deep SSI and wound dehiscence.
2017	Nikolian et al[51]	USA	9192	<30, 30<	Colectomy with rectal resection	Various	Multivariable analysis showed BMI > 30 to be independently associated with anastomotic leakage.
2015	Frasson et al[52]	Spain	3193	<30, 30<	Colectomy	CC	Obesity was shown to be an independent risk factor for anastomotic leakage on multivariate analysis.
2017	Fung et al[53]	Canada	4550	<30, 30<	Laparoscopic colectomy with rectal resection	CRC	Overall survival and disease-free survival were similar in the two groups. The conversion rate, postoperative morbidity, wound infection and anastomotic leakage were all significantly increased in the obese group.

APR, abdominoperineal resection; BMI, body mass index; CC, colon cancer; CRC, colorectal cancer; LAR, low anterior resection; RC, rectal cancer; SSI, surgical site infection.

diseases studied are hepatocellular carcinoma and liver metastasis of colorectal cancer, but there are reviews actually targeting all hepatic disorders.[57–67] Table 4 shows a summary of past studies on the effects of obesity on outcomes of liver surgery. Our group conducted a large-scale review to examine the impacts of obesity on hepatic resection and found that obesity (BMI > 30) prolonged operative time by approximately 50 min as compared to surgery on non-obese patients undergoing hepatectomy of more than one segment apart from the lateral segment (n = 14 903).[12] In addition, Yokoo et al[57], studying a similar surgical group, reported BMI > 30 to potentially be a risk factor for blood transfusion and BMI > 35 to be a risk factor for unplanned intubation (n = 14 970). In a similar report, Langella et al[58] noted that resection time, blood loss, and rate of pulmonary complications tended to rise if BMI > 30, and that obesity may negatively influence all three of these factors. In another large-scale review, Mathur et al[59] found that obese patients had significantly higher odds of having a complication than normal-weight patients (n=3960). However, because obesity may reportedly not influence postoperative complications in some cases, it is hoped that such cases can be analyzed in a future meta-analysis.[60–63]

Examining the influence of obesity on mortality, Kenjo et al[64] concluded that obesity (BMI > 30) had no influence on either the 30-day mortality rate or on the 90-day in-hospital mortality rate, based on developing a risk model for mortality in patients who had received hepatectomy (n = 7732). Similar results were obtained by several other investigators.[58,61–63] Based on the aforementioned results, even in hepatectomy, obesity was considered to be associated with certain complications but did not worsen survival according to the systematic review conducted by Shimada et al[5].

As to the influence of obesity on liver transplantation recipients, Saab et al[65] conducted a meta-analysis (n = 74 487) showing that BMI does not influence either mortality or survival. However, obese patients had poorer survival in subgroup analyses of studies whose cohorts of obese and non-obese patients had similar causes of liver disease.[65] Furthermore, some studies have found that extreme obesity may increase mortality and worsen survival.[66,67]

TABLE 4 Summary of past studies on the effects of obesity on outcomes of liver surgery

Year	Author	Country	n	BMI stratification	Operation	Disease	Outcome
2016	Yokoo et al[57]	Japan	14 970	<30, 30< or <35, 35<	Hx	Various	BMI > 30 was a risk factor for blood transfusion >5 units and renal failure, while BMI > 35 was a risk factor for unplanned intubation and cardiac events, according to a risk model for morbidities.
2015	Langella et al[58]	Italy	1021	<30, 30<	Hepatectomy	Colorectal metastasis	Transection time and blood loss were greater in BMI > 30 subjects. There was no difference in postoperative mortality between the two groups. Overall morbidity was greater in BMI > 30 subjects, mainly as a result of pulmonary complications. On multivariate analysis, obesity independently predicted overall morbidity.
2010	Mathur et al[59]	USA	3960	18.5<, 18.5-25, 25-30, 30<	Hepatectomy	Various	Compared to normal-weight patients, obese patients had significantly higher odds of having a complication. Obesity was not a significant predictor of mortality.
2015	Nomi et al[61]	France	228	<25, 25-30, 30<	Laparoscopic hepatectomy	Various	There were no significant differences in rates of postoperative mortality and overall complications.
2014	Wang et al[63]	China	1543	<18.5, 18.5-24, 24-28, 28<	Hepatectomy	HBV-related HCC	Mortality and total complications differed minimally among the four groups except for underweight patients having fewer total complications. Postoperative wound complications were more common in overweight and obese patients.
2014	Kenjo et al[64]	Japan	7732	<30, 30<	Hx	Various	There were no differences in either the 30-day mortality rate or the 90-day in-hospital mortality rate between obese and non-obese patients.
2015	Saab et al[65]	USA	74 487	Various	Liver transplantation	Various	Obesity did not adversely impact patient survival.
2015	Conzen et al[67]	USA	785	<18, 18-25, 25-30, 30-35, 35-40, 40<	Liver transplantation	Various	Cox regression analysis confirmed BMI > 40 to be an independent predictor of poor survival.

BMI, body mass index; HBV, hepatitis B virus; HCC, hepatocellular carcinoma; Hx, hepatectomy of more than one segment other than the lateral segment.

7 | PANCREATIC SURGERY

In pancreatectomy including various procedures, obesity was defined as a risk factor for the occurrence of postoperative complications.[68,69] Notably, several investigations have focused on pancreatic fistula after pancreatectomy, which is among the specific complications experienced. Ramsey and Martin[70] described pooled analyses, conducted as part of a meta-analysis, as showing a significant association between pancreatic fistula and BMI (n = 2736). Given these observations, increased BMI, which correlates with soft pancreatic consistency, a known risk factor for pancreatic fistula, might be among its causes.[71,72] Obesity is frequently reported to exert no influence on operative mortality in patients with pancreatic malignancies, as is the case with surgeries on other organs.[68–70]

In pancreaticoduodenectomy, numerous reviews have also consistently described obesity as exerting a negative influence.[73–77] Aoki et al[73], applying a risk model (n = 17 564), suggested BMI > 25 to potentially be a factor predicting severe complications (Clavien Dindo Classification Grade 4 or higher) including pancreatic fistula (International Study Group Pancreatic Fistula Grade C). In addition, obesity has been identified as a risk factor for severe complications[74,75] but not operative mortality.[76,77] As with hepatectomy, obesity was found to be associated with increased intraoperative blood loss.[69,75] Even with other surgical procedures, such as distal pancreatectomy and central pancreatectomy, obesity was also identified as a risk factor for complications.[78,79] Table 5 shows a summary of past studies on the effects of obesity on outcomes of pancreatic surgery.

Pecorelli et al[76] reported VFA to be an independent risk factor for pancreatic fistula, similar to its influence as a risk factor for pancreatic fistula after gastrectomy. This suggests VFA to possibly be a more precise indicator than BMI in patients undergoing pancreatectomy because increased VFA may exert a direct effect making surgical techniques more complicated. In addition, Pecorelli et al[76] addressed the combination of visceral obesity and sarcopenia as the best predictor of postoperative death.

8 | CONCLUSIONS

Obesity is generally considered to exert an adverse effect on major gastroenterological surgeries. In particular, obesity prolongs operative

TABLE 5 Summary of past studies on the effects of obesity on outcomes of pancreatic surgery

Year	Author	Country	n	BMI stratification	Operation	Disease	Outcome
2015	Chen et al[68]	China	362	<24, 24<	Pancreatectomy	Various	Higher BMI increased the risk for postoperative complications. There were no significant differences in mortality rates.
2017	Aoki et al[73]	Italy	17 564	<25, 25<	PD	Various	Obesity was a significant risk factor for pancreatic fistula with an International Study Group of Pancreatic Fistula (ISGPF) grade C and for severe morbidity.
2016	Wiltberger et al[74]	Germany	405	<25, 25-30, 30<	PPPD	Various	On multivariate analysis, obesity was a significant predictor of major complications.
2014	El Nakeeb et al[75]	Egypt	471	<25, 25<	PD	Various	Operative time was significantly longer in overweight patients. Overall complication, pancreatic fistula and hospital mortality rates were significantly higher in overweight patients.
2016	Pecorelli et al[76]	Italy	202	VFA	PPPD	Malignancy	VFA was an independent predictor of pancreatic fistula and was associated with the 60-day postoperative mortality rate.
2011	Greenblatt et al[77]	USA	4945	<18, 18-25, 25-30, 30-35, 35-40, 40<	PD or PPPD	Various	BMI > 25 was a significant predictor of morbidity, but not of 30-day mortality.
2016	Sahakyan et al[78]	Norway	423	18-25, 25-30, 30<	Lap DP	Various	Patients with BMI > 30 had significantly longer operative times and increased blood loss as compared with the other groups. Postoperative complication and pancreatic fistula rates were significantly higher in the BMI > 30 than in the normal BMI group.
2012	Dumitrascu et al[79]	Romania	24	<30, 30<	CP	Various	On multivariate analysis, BMI > 30 correlated significantly with the development of complications.

BMI, body mass index; CP, central pancreatectomy; Lap DP, laparoscopic distal pancreatectomy; PD, pancreaticoduodenectomy; PPPD, pylorus-preserving pancreaticoduodenectomy; VFA, visceral fat area.

time and may thus be a risk factor for short-term complications. However, obesity may not adversely influence long-term surgical outcomes. The influences of obesity on surgery may vary depending on the surgical procedure, surgical outcome and/or racial differences in obesity. Preoperative assessment with consideration of not only obesity but also other operative risks is essential for all surgical procedures.

DISCLOSURE

Authors declare no conflicts of interest for this article.

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