The Shortest Distance from the Skin to Pancreas and the Lower Sternum Angle can Influence Short-Term Surgical Outcomes of Laparoscopy-Assisted Distal Gastrectomy for Gastric Cancer

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Research

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Abstract

Background

The surgery of laparoscopic distal gastrectomy + D2 lymph node dissection (LADG) is widely used in patients with gastric cancer, the purpose of the study is to explore the effect of abdominal shape on short-term surgical outcomes.

Methods

This was a retrospective study which included 316 patients undergoing LADG from January 2013 to June 2019 at a single clinical center. The abdominal parameters including the shortest distance of the pancreas from the anterior abdominal skin (PAAD), the lower sternum angle (LSA), the thickness of subcutaneous fat at the navel level (SFT), the anteroposterior diameters (APD) and left-right diameters(LRD) at the navel level, the distance from xiphoid process to the navel (XND), and the distance from xiphoid process to the pubis (XBD) were calculated by preoperative abdominal computed tomography (CT) image. The parameters and short-term surgical outcomes were analyzed.

Results

In males, the number of retrieved lymph nodes was significantly higher in patients with BMI <25kg/m2 (p=0.023) and APD <176.2mm (p=0.004). The time of operation was significantly shorter in male patients with BMI <25kg/m2(p=0.001), PAAD <64.6mm(p=0.000), SFT <14.9mm(p=0.017), APD <176.2mm(p=0.002) and LRD <290.0mm(p=0.036), and in female patients with XBD >370.0mm(p=0.042). The estimated blood loss was significantly lower in male patients with LSA <83.8° (p=0.009), PAAD <64.6mm(p=0.001), SFT <14.9mm(p=0.001), APD <176.2mm(p=0.009) and LRD <290.0mm(p=0.011). The complications were fewer in male patients with PAAD <64.6mm(p=0.045) and APD <176.2mm(p=0.011), and in female patients with LRD <288.5mm(p=0.047).

Conclusion

Various abdominal shapes can influence the difficulty of LADG. Lower LSA and PAAD can reduce the difficulty of LADG in male patients.

Introduction

Gastric cancer is one of the most common malignant tumors in the world, ranking fifth among all tumor incidences [1]. The incidence of gastric cancer in eastern countries is much higher than that in the west, especially in China, Japan, and South Korea [2–3]. The surgery of laparoscopic distal gastrectomy + D2 lymph node dissection (LADG) has been widely used since its first introduction [4], and the laparoscopic surgical method is widely accepted because of cosmetics and less invasive than open surgical methods [5].

There are many factors which can affect laparoscopic surgery. Obesity has always been considered as a factor that can not be ignored. Obesity may lead to a decrease in the number of retrieved lymph node, prolong hospital stay, and poor prognosis [6–8].

In addition to obesity, abdominal shape is also considered to be one of the factors that may affect laparoscopic surgery. At present, there is no certain standard for the measurement of abdominal shape. Most studies have focused on the measurement at the navel level, including the thickness of subcutaneous fat, the anteroposterior diameters and left-right diameters, and the area of visceral fat [9–11]. It was found that different abdominal shapes may affect short-term surgical outcomes of LADG.

Furthermore, abdominal shape is not only a structure at the navel level, but also a three-dimensional structure from xiphoid process to pubis. Therefore, parameters of other levels are needed. This study focused on some simple abdominal shape parameters and explored the effect on short-term surgical outcomes.

Materials And Methods

Patients

A retrospective research of gastric cancer patients who underwent LADG from January 2013 to June 2019 at a single clinical center was conducted in this study. Ethical approval from the Institutional Review Board was obtained. Patients were included by criteria as follows: 1, Patients who had undergone LADG successfully; and 2, Pathologically confirmed as gastric cancer. Totally, 418 patients were included according to the criteria. Patients were excluded by criteria as follows: 1, Neoadjuvant chemotherapy before surgery (n = 12); 2, Incomplete preoperative abdominal computed tomography (CT) image data (n = 75); 3, Absence of medical records (n = 11); and 4, palliative surgery (n = 4). A total of 316 patients were included in this study.

Surgery

All patients included in this study underwent LADG, and they were operated by two surgeons with more than 10 years of surgical experience in a same team. The surgical methods were all standard LADG, and the scope of lymph node dissection conformed to the guidelines for laparoscopic surgery of the Chinese Society of Gastric Cancer [12].

Medical records collections

Clinical data were collected from the medical record database. The baseline information included gender, age, BMI, TNM stage (according to the UICC tumor lymph node metastasis classification system definition). The surgical information included operation time, estimated blood loss, postoperative hospital stay, the number of retrieved lymph nodes. The postoperative short-term complications included

anastomotic leakage, intra-abdominal abscess, pneumonia, anastomotic bleeding, wound bleeding, wound infection, deterioration of liver function, chyle leakage, stenosis, heart disease, gastroparesis, pulmonary embolism, bowel obstruction, cerebral infarction, urinary tract infection, biliary fistula and death within 30 days after surgery according to Clavien-Dindo classification [13].

CT Image Data

All patients underwent abdomen CT examination within 14 days before the operation. The following parameters of equipment were adopted: the tube current was 150 mA; the tube voltage was 120 kVp; the section thickness was 5 mm; and the section interval was 5 mm. A 64 multi-detector scanner (LightSpeed VCT; GE Healthcare, Waukesha, WI, USA) was used for CT scanning. The scanning range was from the top of the chest to the bottom of the abdomen. An enhanced image was obtained after intravenous injection of 80–90 mL of nonionic contrast agent (320 mg/mL; iopamidol, Shanghai Braco Sinus Pharmaceutical Co., Ltd., Shanghai, China) at an injection rate of 3.0 mL/s using a 50 mL saline tracker. The contrast agent-enhanced CT images were obtained 35 and 120 s after the injection of the contrast agent in the arterial phase and the equilibrium phase, respectively.

CT images were measured by the same physician who was blind to the patient's clinical characteristics. The parameters included the shortest distance of the pancreas from the anterior abdominal skin (PAAD), the lower sternum angle (LSA), the thickness of subcutaneous fat at the navel level (SFT), the anteroposterior diameters(APD) and left-right diameters(LRD) at the navel level, the distance from xiphoid process to navel (XND), and the distance from xiphoid process to pubis (XBD).

The PAAD was composed of the shortest vertical distance between the pancreas and the skin of the anterior abdomen in the CT image. The LSA was a downward opening angle formed by the combination of the rib arches and xiphoid process on both sides. It was the apex angle of the triangle formed by the lowermost part of the sternum and the costal arches on both sides, and it could also be called the upper abdominal angle. The calculation of the LSA: Calculating the distance from the anterior midline to the midclavicular line as A, and then Calculating the distance from the level at the intersection of the midclavicular line and the costal arch to the xiphoid process as B, after that, Using the formula LSA = 2*DEGREES (ATAN (A / B)) to calculate LSA. The relevant data were entered and calculated using Microsoft Excel (2019). At the level of the navel, the distance from the anterior abdomen to the parietal peritoneum was defined as the SFT, the distance from the skin of the navel to the skin of the back was defined as the APD, and abdominal lateral diameter at the level of the anterior spine was the LRD (Fig. 1).

Statistical Analysis

The median and range was used for continuous variables that did not conform to the normal distribution. The $\chi 2$ statistics, the Fisher's exact test or the Mann–Whitney U test was used between two groups. The cutoff point of BMI was 25 kg/m2, and the cutoff point of other continuous variables was according to the median. Parameters were selected for univariate and multivariate analysis for detection of

independent risk factors for postoperative complications. Correlation between the number of retrieved lymph nodes and the parameters of abdominal shape was analyzed by Pearson's correlation test. Data were analyzed using SPSS (version 20.0) statistical software. A bilateral p value of < 0.05 was considered statistically significant.

Results

Clinical characteristics of the patients

A total of 316 patients were included in this study, including 253 males and 63 females. The median age was 61 (28–86) years. The median number of retrieved lymph nodes was 22 (6–70). The time of operation was 200.0 (90.0-435.0) minutes. The estimated blood loss was 100.0 (10.0-2000.0) milliliter. The postoperative hospital stay was 10 (4–66) days. The number of pathological stage of IA, IB, IIA, IIB, IIIA, IIIB, IIIC was 81, 37, 30, 53, 60, 41 and 14 (Table 1).

Table 1
Clinical characteristics of the patients

Characteristics	No.316
Gender	
Male	253 (80.1%)
Female	63 (19.9%)
Age, years (median, range)	61 (28–86)
TNM stage	
I (IA/ IB)	81/37
II (IIA/ IIB)	30/53
III (IIIA/ IIIB/ IIIC)	60/41/14
Retrieved lymph nodes (median, range)	22 (6–70)
Operation time, minutes (median, range)	200.0 (90.0-435.0)
Estimated blood loss, mL (median, range)	100.0 (10.0-2000.0)
Postoperative hospital stay, day (median, range)	10 (4–66)
Note: Variables are expressed as the median and range, n (%).	
Abbreviations: BMI, body mass index; TNM, Tumor Node Metastasis.	

The parameters of abdominal shape and BMI of patients

BMI and seven parameters of abdominal shape were calculated between males and females by median and range. The SFT which was 14.9 (1.0-40.5) mm in males and 21.5 (5.8–143.0) mm in females was significantly different (p = 0.000), and the APD which was 176.2 (126.0-263.0) mm in males and 167.5 (122.2–258.0) mm in females was significantly different as well (p = 0.022). There was no difference between males and females as for other parameters of BMI, LSA, PAAD, LRD, XND and XBD. Therefore, males and females were discussed separately because of the difference of abdominal shape (Table 2).

Table 2
Body shape and BMI of the patients

Parameters	All (n = 316)	Male (n = 253)	Female (n = 63)	P value
BMI (kg/m^2)	22.3(15.0-35.2)	22.5(15.0-34.5)	22.1(17.48–35.16)	0.204
LSA (°)	82.8(43.9–143.0)	83.8(43.9–143.0)	80.6(54.3-140.9)	0.122
PAAD (mm)	65.0(20.0-117.1)	64.6(20.0-107.4)	65.8(30.6-117.1)	0.851
SFT (mm)	16.0(1.0-143.0)	14.9(1.0-40.5)	21.5(5.8–143.0)	0.000*
APD (mm)	173.4(122.2–263.0)	176.2(126.0-263.0)	167.5(122.2–258.0)	0.022*
LRD (mm)	290.0(206.2-380.8)	290.0(206.2-380.8)	288.5(231.4-359.3)	0.632
XND (mm)	215.0(95.0-340.0)	215.0(95.0-340.0)	210.0(165.0-280.0)	0.966
XBD (mm)	370.0(250.0-525.0)	370.0(255.0-525.0)	370.0(250.0-445.0)	0.344
Note: Variables are expressed as the the median and range, *P-value < 0.05.				
Abbreviations: BMI, body mass index; LSA, the angle of the lower sternum angle; PAAD, the shortest distance of the pancreas from the anterior abdominal skin; SFT, the thickness of subcutaneous fat at the navel level; APD, the anteroposterior diameters at the navel level; LRD, the left-right diameters at the navel level; XND, the distance from xiphoid process to navel; XBD, the distance from xiphoid process to pubis;				

Short-term surgical outcomes in patients

The cutoff point of BMI was 25 kg/m2, and other parameters were dichotomized according to the median. The parameters were divided into higher and lower groups. Short-term surgical outcomes were compared between higher and lower groups of BMI, LSA, PAAD, SFT, APD, LRD, XND and XBD. In males, the number of retrieved lymph nodes was significantly higher in patients with BMI < 25 kg/m2(p = 0.023) and APD < 176.2 mm(p = 0.004). The time of operation was significantly shorter in male patients with BMI < 25 kg/m2(p = 0.001), PAAD < 64.6 mm(p = 0.000), SFT < 14.9 mm(p = 0.017), APD < 176.2 mm(p =

0.002) and LRD < 290.0 mm(p = 0.036), and in female patients with XBD > 370.0 mm(p = 0.042). The estimated blood loss was significantly smaller in male patients with LSA < 83.8°(p = 0.009), PAAD < 64.6 mm(p = 0.001), APD < 176.2 mm(p = 0.0092), SFT < 14.9 mm(p = 0.001) and LRD < 290.0 mm(p = 0.011). The time of postoperative hospital stay was significantly shorter in male patients with APD < 176.2 mm(p = 0.033) and PAAD < 65.8 mm(p = 0.021). The complications were lower in male patients with PAAD < 64.6 mm(p = 0.045) and APD < 176.2 mm(p = 0.011), and in female patients with LRD < 288.5 mm(p = 0.047) (Table 3) (Table 4).

Table 3
Short-term surgical outcomes in male patients (n = 253)

Parameters	Retrieved lymph nodes	Operation time (minutes)	Estimated blood loss (mL)	Postoperative hospital stay (day)	Complications
BMI (kg/m^2) ≥ 25(n = 56)	18.5(6–42)	232.5(110–435)	100(10-1800)	10(6–23)	18
BMI (kg/m^2) < 25(n = 197)	22(6–70)	197(90–395)	100(20-2000)	10(4–62)	59
P value	0.023*	0.001*	0.179	0.508	0.753
LSA (°) ≥ 83.8(126)	22(6–43)	205.5(90–435)	100(10-1800)	10(4–62)	44
LSA (°) < 83.8(n = 127)	22(6–70)	200(95–380)	100(20-2000)	10(5–33)	33
P value	0.694	0.180	0.009*	0.317	0.122
PAAD (mm) ≥ 64.6(n = 127)	20(6–45)	225(90–435)	100(10-2000)	10(5–62)	46
PAAD (mm) < 64.6(n = 126)	22(6–70)	190(95–395)	100(20–500)	10(4–50)	31
P value	0.052	0.000*	0.001*	0.302	0.045*
SFT (mm) ≥ 14.9	20(6–45)	211.5(90–435)	100(20-1800)	10(5–26)	45
SFT (mm) < 14.9(n = 127)	22(6–70)	195(95–370)	100(10-2000)	10(4–50)	32
P value	0.075	0.017*	0.001*	0.636	0.069
APD (mm) ≥ 176.2(n = 126)	19(6–42)	215(90–435)	100(10-2000)	11(4–62)	48
APD (mm) < 176.2(n = 127)	23(6–70)	190(95–395)	100(20–500)	10(6–50)	29
P value	0.004*	0.002*	0.002*	0.033*	0.011*

Note: Variables are expressed as the median and range, *P-value < 0.05.

Abbreviations: BMI, body mass index; LSA, the angle of the lower sternum angle; PAAD, the shortest distance of the pancreas from the anterior abdominal skin; SFT, the thickness of subcutaneous fat at the navel level; APD, the anteroposterior diameters at the navel level; LRD, the left-right diameters at the navel level; XND, the distance from xiphoid process to navel; XBD, the distance from xiphoid process to pubis;

Parameters	Retrieved lymph nodes	Operation time (minutes)	Estimated blood loss (mL)	Postoperative hospital stay (day)	Complications
LRD (mm) ≥ 290.0(n = 127)	20(6–42)	210(98–435)	100(10-2000)	10(4–62)	45
LRD (mm) < 290.0(n = 126)	22(6–70)	195(90–395)	100(20–800)	10(6–50)	32
P value	0.307	0.036*	0.011*	0.399	0.083
XND (mm) ≥ 215.0	20(6–47)	205(90–435)	100(10-1800)	10(4–62)	40
XND (mm) < 215.0(n = 121)	22(6–70)	195(95–348)	100(20-2000)	10(6–29)	37
P value	0.081	0.228	0.157	0.858	0.962
XBD (mm) ≥ 370.0(n = 135)	20(6–47)	205(90–435)	100(10-1800)	10(4–42)	39
XBD (mm) < 370.0(n = 118)	22(6–70)	196(95–375)	100(20-2000)	10(5–62)	38
P value	0.274	0.266	0.240	0.715	0.568
Note: Variables are expressed as the median and range, *P-value < 0.05.					
Abbreviations: BMI, body mass index; LSA, the angle of the lower sternum angle; PAAD, the shortest distance of the pancreas from the anterior abdominal skin; SFT, the thickness of subcutaneous fat at the navel level; APD, the anteroposterior diameters at the navel level; LRD, the left-right diameters at the navel level; XND, the distance from xiphoid process to navel; XBD, the distance from xiphoid process to pubis;					

Table 4
Short-term surgical outcomes in female patients (n = 63)

Parameters	Retrieved lymph nodes	Operation time (minutes)	Estimated blood loss (mL)	Postoperative hospital stay (day)	Complications
BMI (kg/m2) ≥ 25(n = 7)	27(11–33)	210(120–315)	50(40–100)	11(7–16)	1
BMI (kg/m2) < 25(n = 56)	23(7–45)	197.5(100–310)	50(10-1000)	8.5(4–66)	11
P value	0.569	0.463	0.351	0.127	1
LSA (°) ≥ 80.6(n = 33)	23(8–40)	205(100–315)	50(20-1000)	9(6–66)	5
LSA (°) < 80.6(n = 30)	24(7–45)	187.5(110–303)	50(10–300)	8.5(4–51)	7
P value	0.710	0.397	0.533	0.323	0.409
PAAD (mm) ≥ 65.8(n = 31)	22(8–45)	200(100–315)	50(20–300)	10(7–66)	6
PAAD (mm) < 65.8(n = 32)	24(7–45)	195(115–310)	50(10-1000)	8(4–51)	6
P value	0.364	0.700	0.524	0.021*	0.951
SFT (mm) ≥ 21.5(n = 31)	22(8–35)	195(110–315)	50(20–300)	10(6–66)	7
SFT (mm) < 21.5(n = 32)	24.5(7–45)	200(100–310)	75(10-1000)	8(4–35)	5
P value	0.141	0.891	0.244	0.158	0.482
APD (mm) ≥ 167.5(n = 31)	22(8–33)	195(100–315)	50(20-1000)	10(7–66)	7
APD (mm) < 167.5(n = 32)	25(7–45)	200(115–303)	75(10–400)	8(4–51)	5
P value	0.107	0.767	0.182	0.249	0.482
LRD (mm) ≥ 288.5(n = 31)	23(7–33)	210(100–315)	50(20–400)	10(4–66)	9

Note: Variables are expressed as the median and range, *P-value < 0.05.

Abbreviations: BMI, body mass index; LSA, the angle of the lower sternum angle; PAAD, the shortest distance of the pancreas from the anterior abdominal skin; SFT, the thickness of subcutaneous fat at the navel level; APD, the anteroposterior diameters at the navel level; LRD, the left-right diameters at the navel level; XND, the distance from xiphoid process to navel; XBD, the distance from xiphoid process to pubis;

Parameters	Retrieved lymph nodes	Operation time (minutes)	Estimated blood loss (mL)	Postoperative hospital stay (day)	Complications
LRD (mm) < 288.5(n = 32)	24(10–45)	178.5(115–310)	50(10-1000)	8(6–51)	3
P value	0.066	0.100	0.930	0.158	0.047*
XND (mm) ≥ 210.0(n = 37)	23(7–45)	190(100–310)	50(10-1000)	9(4–66)	9
XND (mm) < 210.0(n = 26)	24.5(8–39)	207.5(130–315)	75(20–400)	8.5(6–53)	3
P value	0.375	0.079	0.246	0.805	0.329
XBD (mm) ≥ 370.0(n = 38)	23.5(8–45)	187.5(100–310)	50(10-1000)	8(6–66)	6
XBD (mm) < 370.0(n = 25)	24(7–39)	210(135–315)	100(20–300)	10(4–53)	6
P value	0.807	0.042*	0.315	0.166	0.521
Note: Variables are expressed as the median and range, *P-value < 0.05.					
Abbreviations: BMI, body mass index; LSA, the angle of the lower sternum angle; PAAD, the shortest distance of the pancreas from the anterior abdominal skin; SFT, the thickness of subcutaneous fat at the navel level; APD, the anteroposterior diameters at the navel level; LRD, the left-right diameters at the navel level; XND, the distance from xiphoid process to navel; XBD, the distance from xiphoid process to pubis;					

Predictive factors for postoperative complications

Eighty-nine patients had postoperative complications, the highest complication was pneumonia (Table 6). Univariate analysis was used for postoperative complications, and it was found that PAAD (p = 0.046, odds ratio = 1.740, 95%CI = 1.011–2.997) and APD (p = 0.011, odds ratio = 2.032, 95%CI = 1.174–3.517) were independent factors for predicting postoperative complications in males. however, in multivariate analysis, PAAD and APD showed no difference in males. In females, there was no difference in univariate and multivariate analysis (Table 5).

Table 5
Univariate and multivariate analysis of predictive factors for postoperative complications

Risk factors	Univariate analysis				Multivariate analysis	
	Male		Female		Male	
	P value	Odds ratio (95% CI)	P value	Odds ratio (95% CI)	P value	Odds ratio (95% CI)
BMI (kg/m2)	0.753	1.108 (0.585–2.098)	0.735	0.682 (0.074–6.261)		
LSA (°)	0.123	1.528 (0.891–2.622)	0.412	0.587 (0.164–2.096)		
PAAD (mm)	0.046*	1.740 (1.011–2.997)	0.951	1.040 (0.296–3.658)	0.616	1.197 (0.594–2.413)
SFT (mm)	0.070	1.649 (0.960–2.835)	0.484	1.575 (0.441–5.623)		
APD (mm)	0.011*	2.032 (1.174–3.517)	0.484	1.575 (0.441–5.623)	0.097	1.814 (0.897–3.668)
LRD (mm)	0.084	1.612 (0.938–2.770)	0.058	3.955 (0.957–16.349)		
XND (mm)	0.962	0.987 (0.577–1.687)	0.213	2.464 (0.597–10.178)		
XBD (mm)	0.568	0.855 (0.500-1.462)	0.449	0.613 (0.173–2.177)		

Note: Variables are dichotomized according to the median, *P-value < 0.05.

Abbreviations: BMI, body mass index; LSA, the angle of the lower sternum angle; PAAD, the shortest distance of the pancreas from the anterior abdominal skin; SFT, the thickness of subcutaneous fat at the navel level; APD, the anteroposterior diameters at the navel level; LRD, the left-right diameters at the navel level; XND, the distance from xiphoid process to navel; XBD, the distance from xiphoid process to pubis; OR, odds ratio; CI, confidence interval.

Table 6
Postoperative complications

Complications	All	Male	Female
Anastomotic leakage	18	16	2
Intra-abdominal abscess	7	5	2
Pneumonia	32	31	1
Anastomotic bleeding	5	4	1
Wound bleeding	1	1	0
Wound infection	6	5	1
Deterioration of liver function	1	1	0
Chyle leakage	1	1	0
Stenosis	3	2	1
Heart disease	4	3	1
Gastroparesis	1	1	0
Pulmonary embolism	2	2	0
bowel obstruction	2	1	1
Cerebral infarction	2	1	1
Urinary tract infection	3	2	1
Biliary fistula	1	1	0
Death	0	0	0
Total	89	77	12
Note: Variables are expressed as n.			

Correlation between abdominal shape parameters and retrieved lymph nodes

There was no difference between the number of retrieved lymph nodes and the parameters of abdominal shape in females ($p > 0.05$). In males, PAAD ($p = 0.006$, $k=-0.172$), SFT ($p = 0.018$, $k=-0.149$) and APD ($p = 0.004$, $k=-0.183$) were correlated with the retrieved lymph nodes (Fig. 2).

Discussion

This study innovatively explored simple index of abdominal shape of PAAD, LSA and other parameters on short-term surgical outcomes in patients undergoing LADG. We found that abdominal shape can influence operation time, estimated blood loss, postoperative hospital stay, the number of retrieved lymph nodes and complications. Furthermore, abdominal body shape differed between two genders, males had larger APD and smaller SFT over females. Therefore, we analyzed males and females separately and found that few abdominal shape parameters had an impact on short-term surgical outcomes in females. However, in males, we found some abdominal shape parameters were crucial. The result was consistent with the previously published literature [10–11, 14].

Obesity has always been considered an independent factor in patients with gastric cancer. BMI can be a parameter to represent obesity. Some studies believed that BMI has an impact on postoperative complications and survival [15–16]. In this study, males with BMI < 25 had less operation time and larger number of retrieved lymph nodes. It can be seen that obesity has an impact on the difficulty of LADG in male patients.

The operation time and estimated blood loss can reflect the difficulty of the operation. Previous studies have found that large APD can increase the operation time and Large LRD can increase the amount of surgical bleeding [10–11]. In this study, larger PAAD, SFT, APD and LRD contributed to increase of operation time in males, and smaller XBD contributed to increase of operation time in females. As for estimated blood loss, patients with larger LSA, PAAD, APD, SFT and LRD could experience larger amount of estimated blood loss in males, but all parameters had negative relationship with females. Different distensibility of abdominal wall in men and women due to accumulation of muscle and lipid may explain why abdominal shape was more strongly associated with male patients than female patients [17]. The extra operation time and blood loss may be the large size of abdominal shape and excess fat tissues accumulated around vessels [11]. As for larger LSA resulted in larger amount of estimated blood loss in males, it remained unclear, for LSA is composed of the xiphoid and the rib arch, and it is relatively fixed. We considered, the LSA may increases the space of abdominal cavity, leading to the difficulty and resulting in extra blood loss.

Previous article reported that post-operative complications ranged from 6.1–30% [5, 11, 18–19]. These studies focused on BMI and visceral fat as for post-operative complications [20–21]. In this study, the rate of post-operative complications was 28.2% and patients with higher PAAD and APD had more complications. In univariate analysis, PAAD and APD were independent factors for predicting postoperative complications in males. It may be the large size of abdominal shape which affect the safety of LADG, so, surgeons should be cautious about patients with higher PAAD and APD.

The number of retrieved lymph nodes is related to the effectiveness of the operation. Insufficient number of retrieved lymph nodes may lead to a poor prognosis [22–23]. In this study, lower APD, PAAD and SFT had more retrieved lymph nodes in males, it seems that smaller parameters of abdominal shape can

make the surgery of LADG effective. So, much attention should be paid to patients with large parameters of abdominal shape, especially APD, PAAD and SFT.

This study has some limitations as well. First, this is a retrospective study at a single center; Second, this study included patients undergoing LADG, there may be some patients who underwent open gastrostomy because of obesity or converted to open gastrostomy caused by the large amount of bleeding or the difficulty of LADG; Third, this study used CT to estimate the LSA. Ideally, we think the rib arch is a straight line, but actually, the rib arch is a curve and some patients had asymmetrical bilateral costal arches. The calculation of the angle in this study may have some deviation. Fourth, the proportion of women in this study is obviously too small, so the results of women may be biased because of the small amount of data.

In conclusion, various abdominal shapes can influence the difficulty of LADG. Lower LSA and PAAD can reduce the difficulty of LADG in male patients. Therefore, a simple measurement of abdominal shape before surgery can predict the difficulty of surgery.

Abbreviations

LADG: The surgery of laparoscopic distal gastrectomy + D2 lymph node dissection.

PAAD: The abdominal parameters including the shortest distance of the pancreas from the anterior abdominal skin.

LSA: the lower sternum angle.

SFT: the thickness of subcutaneous fat at the navel level.

APD: the anteroposterior diameters at the navel level.

LRD: left-right diameters at the navel level.

XND: the distance from xiphoid process to the navel.

XBD: the distance from xiphoid process to the pubis.

Declarations

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Competing interests:

The authors declare that they have no competing interests.

Ethics Approval and Consent Statement:

This study was conducted in accordance with the World Medical Association Declaration of Helsinki and was approved by the Medical Ethics Committee of the First Affiliated Hospital of Chongqing Medical University (2020-430).

Consent to participate:

Informed consent was obtained from all individual participants included in the study.

Consent for publication:

Patients signed informed consent regarding publishing their data and photographs.

Data availability:

The data of this study are available upon special request to the corresponding author(s).

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Authors' contributions:

Dong Peng: Conceptualization, formal analysis, software, and writing-original draft.

Wei Tao: Data curation, formal analysis and investigation, methodology.

Yu-Xi Cheng: Data curation, formal analysis and investigation, resource.

Ying-Ying Zou: Data curation, project administration, resources.

Kun Qian: Conceptualization, project administration, supervision, writing—review and editing.

Wei Zhang: Conceptualization, supervision, writing—review and editing.

All authors read and approved the final manuscript.

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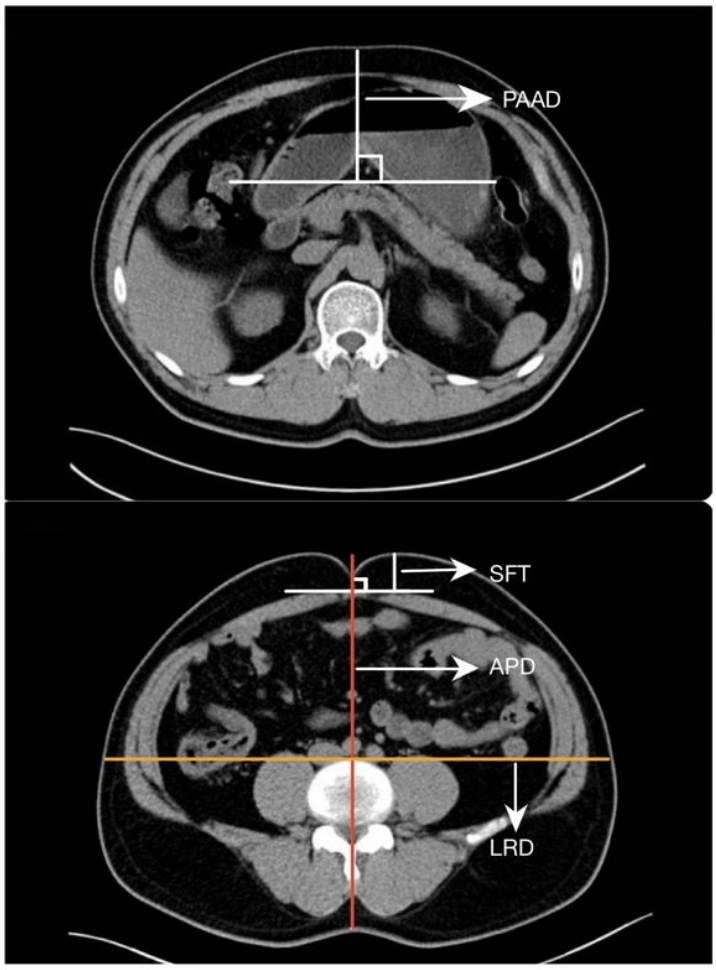
Figures



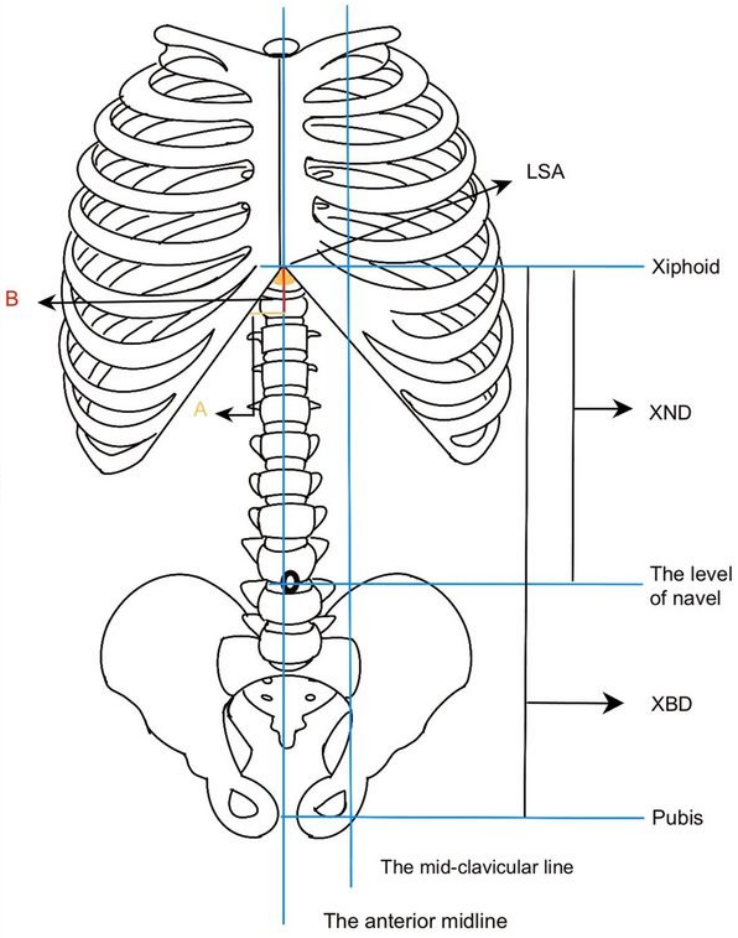


Figure 1

Parameters of abdominal shape. (a) The shortest distance of the pancreas from the anterior abdominal skin (PAAD). (b) The thickness of subcutaneous fat at the navel level (SFT), the anteroposterior diameters (APD) and left-right diameters (LRD) at the navel level. (c) The lower sternum angle (LSA), the distance from xiphoid process to navel (XND), and the distance from xiphoid process to pubis (XBD).

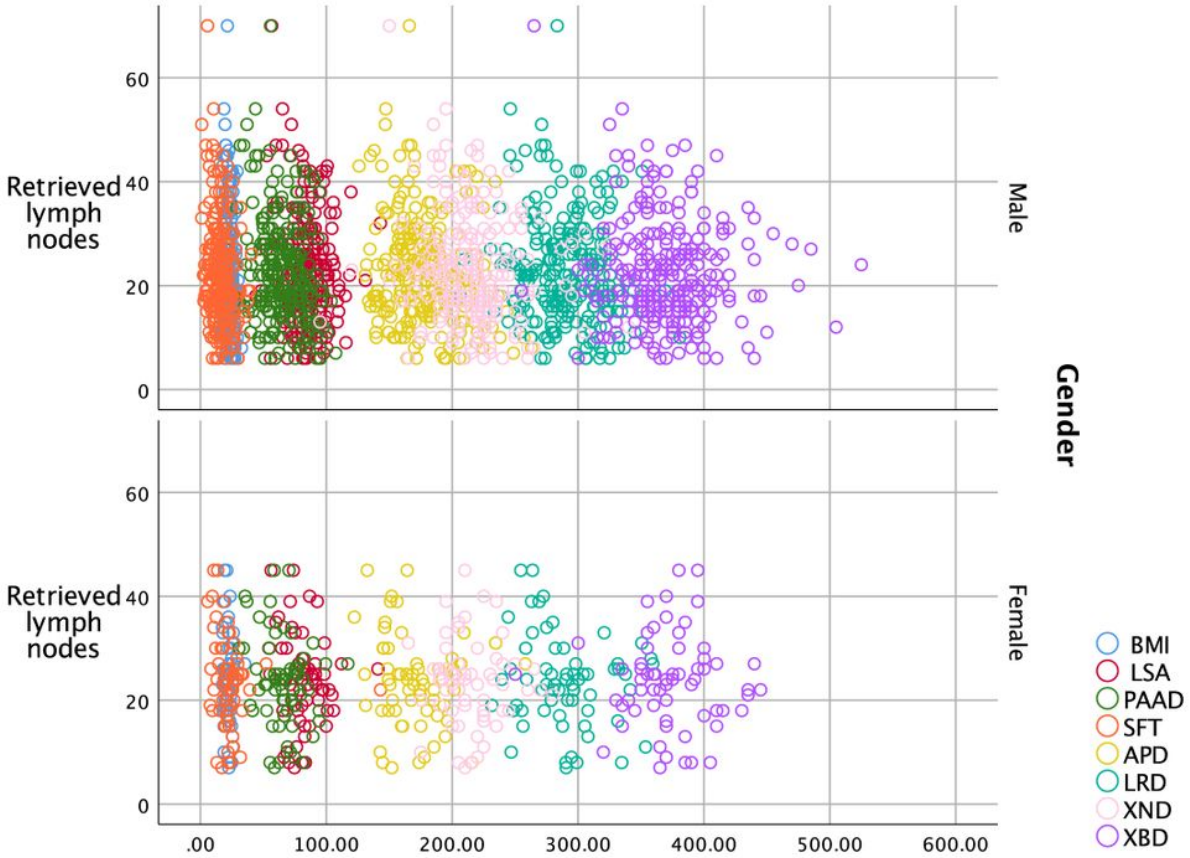


Figure 2

Correlation between abdominal shape and retrieved lymph nodes. Note: In male patients, PAAD (p=0.006, k=-0.172), SFT (p=0.018, k=-0.149) and APD (p=0.004, k=-0.183) were correlated with the retrieved lymph nodes. but in female patients, all the abdominal shape parameters were negatively correlated with the retrieved lymph nodes (p>0.05).