■ 特 集 ■ 直腸癌に対する腹腔鏡手術の問題点

直腸癌に対する腹腔鏡手術における縫合不全の危険因子
—縫合器，吻合器とその操作を中心に—

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特集

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直腸癌に対する腹腔鏡手術における縫合不全の危険因子
—縫合器，吻合器とその操作を中心に—

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Risk Factors For Anastomotic Leakage After Laparoscopically Assisted Anterior Resection in Patients with Rectal Cancer: Yamagishi S[*1], Fujii S[*1], Momiyama M[*1], Nagano Y[*1], Ota M[*2], Ichikawa Y[*2], Kunisaki C[*1], Ike H[*1], Ohki S[*2] and Shimada H[*2] ([*1]Yokohama City University Medical Center, Gastroenterological Center, [*2]Department of Gastroenterological Surgery, Yokohama City University Graduate School of Medicine, Yokohama, Japan)

Background: Anastomotic leakage is the most severe complication following rectal resection. The aim of this study was to evaluate risk factors of clinical anastomotic leakage after laparoscopically assisted anterior resection for rectal cancers.

Methods: A total of 65 consecutive operations involving anastomosis of the rectum performed from 1997 to 2006 were reviewed. The associations between clinical anastomotic leakage and 12 patient-, tumor-, surgical-, and device-related variables were studied by univariate and multivariate analysis. Result: The anastomotic leakage was seen in 12.3% (8 of 65). Univariate analysis showed that men ($p=0.046$) and a new dividing device ($p=0.046$) were significant factors of anastomotic leakage. The new dividing device remained significant after multivariate analysis (OR 7.00, p-value=0.036). In the former period, the new dividing device was the risk factor of anastomotic leakage, but not in the latter period. This study also revealed that multi-stapling was not a risk factor for anastomotic leakage.

Conclusion: In the laparoscopic surgery, because there are many types and use frequencies of the device, it is important to be well informed of the characteristic and safe directions, and to use an accustomed device.

Key words: Anastomotic leakage, Laparoscopically assisted surgery, Rectal cancer
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はじめに

大腸癌に対する腹腔鏡下手術は，1991年Jacobsの報告[1)]以来，低侵襲性や整容性から急速に普及し，わが国では1992年から導入された．当初は早期がんが適応とされてきたが，進行がんにも適応が拡大され，現在では側方郭清が不必要な下部直腸癌にも適応とされている．直腸癌に対する腹腔鏡下手術の利点は，骨盤という限られた閉鎖腔の中でも，術者，助手全員が拡大視効果により解剖の把握が可能となることにより，安全に剥離，授動が行えることである[2)]．しかし，肥満者や狭骨盤症例，8 cmを越える巨大腫瘍などでは操作性が制限される．このような症例は直腸の剥離操作は可能であるが，直腸切離前の肛門側腸管の洗浄および切離器械については，簡便で確実な腹腔鏡用器械が少なく，開腹術と比較して操作

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が困難である．本稿では直腸癌の腹腔鏡下手術における再建操作，器具の選択の観点から，縫合不全の危険因子について検討したので報告する．

1. 適 応

教室では1993年より早期癌に対する腹腔鏡下手術を導入し，2000年よりN（－），MP, 2002年よりSE, 2003年よりN1と局所再発や遠隔転移を加味して段階的に適応拡大してきた．現在の直腸癌に対する適応は，腫瘍径8 cm以下，直腸RSは進達度SE, N1とし，直腸Ra, Rbにおいては側方郭清の適応がないRaのMP, RbのSMまでとしている．狭窄が高度で術前に病変口側の情報が得られないもの，気腹が不可能な症例も適応外としている．

2. 対 象

1997年4月から2006年8月までに教室で施行した直腸RSを含む直腸癌の腹腔鏡手術症例65例を対象として，縫合不全の危険因子を検討した．

3. 手術方法

1）ポートの配置と小切開部：5ポートで，カメラポートは臍直下（開腹用腸管切離器械の使用時は臍直上に設定），術者は右側腹部上下のポート，助手は左側腹部上下のポートを使用する．2）中枢側リンパ節郭清と血管処理：D3郭清を基本とし，早期癌では下腸間膜動脈（IMA）温存のD3，進行癌ではIMA根部で処理している．自律神経は全温存．3）後腹膜剥離：内側アプローチにて後腹膜下筋膜上層を剥離し，左尿管，左精巣/卵巣動静脈を温存する．4）左側結腸授動：SD Junction付近から外側剥離し，内側からの剥離面と連続させる．5）直腸授動：自律神経を温存しながら，直腸固有筋膜を破らないように剥離を骨盤底に進める．肛門側予定切離線で直腸固有筋膜を切離し直腸の外膜を露出する．6）腸管洗浄：腸管切離直前の腸管洗浄のためのクランプ器械は，切離線が高位の症例や骨盤が広く操作性の良好な症例にはendovascular clipを使用する．低位や狭骨盤，肥満など操作性の不良な症例は，腸管クランプ前に下腹部正中に約5 cmの小切開をおき，J字型腸管クランプ鉗子を腹腔内に挿入して気密を保ち，再気腹後に通常の開腹での方法と同様に病変の肛門側をクランプし，腸管洗浄する．7）直腸切離：腸管クランプ鉗子としてendovascular clipを使用した場合は鏡視下用器械で切離し，J字型腸管クランプ鉗子の場合は開腹用器械で切離する．8）開腹操作：臍直下創部を延長して小切開創とし，直腸を体外へ誘導し口側腸管を切離して標本を摘出する．下腹部正中に小切開創がある場合は，同部から直腸を誘導する．9）再建：再気腹後に腹腔内にてdouble stapling法で吻合する．

4. 検討項目

検討1：術後縫合不全を合併した症例としなかった症例に群別し，その危険因子について単変量解析，多変量解析を用いて解析した．

検討2：開腹手術用の直腸切離器械（彎曲型一括切離縫合器）の使用経験から，症例を前期と後期に分けて解析した．

検討3：直腸切離時に同一の鏡視下用線状縫合器を使用した症例46例を対象に，複数回切離が縫合不全の危険因子となるか検討した．

共変量項目は以下とした．患者因子：性別，年齢，糖尿病の有無，栄養状態（PNI），占拠部位．手術因子：術者，IMA根部切離の有無，手術時間，出血量，肛門縁から吻合までの距離．器械因子：腸管切離器械，Circular staplerの種類．

5. 解 析

単変量解析はStudent's t-testとFisherの直接確立法を用いて解析した．多変量解析は，単変量解析で p-value＜0.8 の項目を共変量項目とし，ロジスティック回帰分析を用いて統計学的有意差検定を施行した．検定は p-value＜0.05 を有意とした．単変量解析はStatview J-5.0を用い，多

表1　**Patient characteristics**

	No. cases (n=65)
Gender	
Male : Female	44 : 21
Age	64.1±9.3
Location	
RS/Ra/Rb	38/17/10
Disease	
Carcinoma	59
Carcinoid	6
Stage	
0	6
I	40
II	5
IIIa	9
IIIb	4
Anastomotic leakage	
with/without	8(12.3%)/57

変量解析はDr. SPSS-IIを用いた．

6. 結　果

腹腔鏡手術を施行した65例の占拠部位はRSが38例，Raが17例，Rbが10例で，縫合不全合併率は12.3% (8/65) であった（表1）．縫合不全症例のうち再手術にて人工肛門を造設した症例は4例（50%）であった．

検討1：縫合不全群（n=8）と，非縫合不全群（n=57）の単変量解析による比較では，縫合不全は男性に多く（p=0.046），直腸切離器械の検討では開腹用彎曲型一括切離縫合器：Cに縫合不全が多く合併した（p=0.046）（表2）．縫合不全に対する多変量解析で独立した危険因子として選出されたのは，開腹用直腸切離器械の彎曲型一括切離縫合器：Cであった（Odds ratio 7.00, p-value=0.036）（表3）．

検討2：開腹用彎曲型一括切離縫合器について詳細に検討すると，使用開始の最初の4例中3例に連続的に縫合不全を認めた（ただし3例とも保存的に治癒）．問題点を検討すると，切離，縫合の際に腸管の緊張を解除せずにファイヤーしていたので，ファイヤーの際にはTension Freeで行うこととした．この操作を徹底し，その後の5例には縫合不全を認めなかった（表4）．そこで，開腹用彎曲型一括切離縫合器で直腸切離した症例のうち縫合不全を合併した3例が含まれる前期症例44例と，それ以降の後期症例21例に期間を分け，縫合不全群と非縫合不全群を比較検討した．前期症例での検討では，単変量，多変量解析ともに直腸切離器械で開腹用彎曲型一括切離縫合器が独立した縫合不全危険因子として選択さ

表2　**Results of univariate analysis of possible risk factors for anastomotic leakage**

	Cases with leakage (n=8)	Cases without leakage (n=57)	p value
Gender			
Male : Female	8 : 0	36 : 21	0.046
Age (≧60)	6	39	>0.999
DM	1	5	0.561
PNI (<45)	0	6	>0.999
Location			
RS/Ra/Rb	4/2/2	34/15/8	0.717
Surgeon			
A/B/C/D	6/2/0/0	38/8/5/6	0.539
IMA divided	7	40	0.427
Operation time (≧240 min)	6	40	>0.999
Blood loss (≧200 ml)	2	13	>0.999
Dividing device			
A/B/C	4/1/3	42/6/9	0.046
Circular stapler			
A/B	7/1	50/7	>0.999
Distance from AV (<70 mm)	5	20	0.243

DM, diabetes mellitus; PNI, Prognostic Nutritional Index; IMA, inferior mesenteric artery; AV, anal verge.

表3　**Odds ratio for statistically significant variables after multivariate analysis**

Variable	Odds ratio (95% CI*)	p-Value
Dividing Device		0.113
B/A	14.0 (0.69〜283.78)	0.086
C/A	7.00 (1.14〜42.97)	0.036

A：視下用線状縫合器，B：A, C以外の縫合器，C：開腹用彎曲型一括切離縫合器，95% CI*：95% Confidence interval

表4　Complication in Curved cutter cases

Gender	AGE	Location	Preope Complication	Anastomotic leakage	Anasto Site from AV (cm)	Time	Blood Loss
M	65	RS	Obesity (BMI 31)	—	70	220	20
M	58	RS	Obesity (BMI 31)	Major Leak	70	266	50
M	67	Rb	DM	Minor Leak	40	273	300
M	73	RS	Obesity (BMI 28)	Minor Leak	80	225	40
M	76	RS	Gastric ulcer	—	100	220	5
M	62	RS		—	90	240	15
M	55	RS		—	160	237	5
M	59	RS	DM	—	140	246	50
F	82	Rb		—	25	243	150

DM, diabetes mellitus; AV, anal verge.

れた(Odds ratio 40.5, p value=0.007)．しかし，後期症例の検討では，直腸切離器械は選択されず，独立した危険因子は選出できなかった．

検討3：同一の鏡視下用線状縫合器（関節機構あり）を使用した症例の検討では，術後縫合不全合併は4例（8.7%）に認め，直腸切離の際の器械使用回数が3回以上の症例は3例（75%）だった．一方，縫合不全を合併しなかった症例のうち3回以上使用したのは13例（31%）で，複数回使用した症例に術後縫合不全を合併していたが，統計学的には有意差は認めなかった（p=0.114）．

7. 考　察

開腹直腸癌手術の術後縫合不全の合併率は7.3～12%と報告され[3~8]，腹腔鏡下手術での合併率は6.4-20.0%と報告されている[9~15]．また，腹腔鏡下手術と開腹手術に関するRCTの報告では，術後縫合不全を含む合併症発生率に差はなかったと報告されている[16~19]．今回の検討では術後縫合不全合併率は12.3%であったが，後期症例21例を対象とすると合併率は9.5%だった．縫合不全症例のうち，人工肛門造設術を施行した症例は4例（50%）であった．手術関連死亡症例はなかった．

直腸癌の開腹手術における術後縫合不全の危険因子は，①下部直腸癌症例（吻合部が肛門縁から5 cm以下)，②男性，③術前放射線療法の既往，④術中に合併症を有する症例，などが報告されている[3~7]．今回の検討では，開腹用直腸切離器械の彎曲型一括切離縫合器が術後縫合不全の独立した危険因子として選択されたが，最初の連続した3例に合併しており，未熟な操作が原因の1つと考えられた．患者因子としては，3例中2例は肥満を有する男性で，1例は糖尿病を合併していた（**表4**）．合併症の経験から，以下の点を改善した．周囲臓器の巻き込みを意識して直腸に緊張をかけた状態で中間ロックするが，縫合，切離する際にもこの緊張を解除することなくファイヤーしていたので，ファイヤーの際にはTension Freeで行うこととした．これにより後期症例で開腹用彎曲型一括切離縫合器を使用した5例には縫合不全を認めず，改善点の効果と器械操作の手技が安定したためと思われた．また，開腹用彎曲型一括切離縫合器は確実に1回で切離，縫合できるという利点はあるが，本体が大きく視野が不良となり，とくに肛門側前壁の臓器(精嚢腺，膣後壁)などの挟み込みが懸念される．開腹用器械であるTL-30TM, TA-45TMなどの彎曲型一括切離縫合器より小さい器械もあるが，縫合，切離が同時でないため，口側腸管の確実なクランプが問題点として残る．一方，腹腔鏡用器械では縫合長の長いものは切離部へのアプローチが困難であり，複数回使用になる危険性が高まるが，器械本体は小さいので視野の観点からは良好であると思われる（**表5**）．教室では直腸切離器械の選択については，直腸切離部位が高位であればendovascular

表5　直腸切離器械の特徴

直腸クランプ		Endovascular clip	φ12 mm Surgical Port から挿入可能	腸管把持力が弱い 角度の調節等の操作性に難あり 斜めにかかると腸管全てをクランプできないことがある
		J字型クランプ鉗子	把持力が強く腸管の展開が可能	器械挿入時に下腹部に小切開をおき気密保持に工夫が必要
直腸切離	鏡視下用	ENDO GIA UNIVERSAL™ ENDO CUTTER™ ECHERON™	φ12 mm Surgical Port から挿入可能開腹用器械より本体が小さいので鏡視下での操作が容易	Multi stapling の可能性あり 縫合長の長い器械は操作制限あり
	開腹用	Curved Cutter™	一括切離縫合が可能	器械挿入時に下腹部に小切開をおき気密保持に工夫が必要 器械本体が大きく操作制限あり
		TL-30™ TA-45™ ACCESS 55™	一括縫合が可能	器械挿入時に下腹部に小切開をおき気密保持に工夫が必要 器械本体は Curved Cutter より小さいが切離，縫合が同時でない

clip でクランプして鏡視下用線状縫合器（関節機構あり）で切離している．低位の場合は体型，腫瘍進行度を加味してクランプ鉗子と直腸切離器械を選択している（**図1**）．

鏡視下用線状縫合器により複数回で直腸切離された症例に縫合不全が合併したという報告があり[20]，危険因子とされる．本稿では同一器械（鏡視下用線状縫合器：関節機構あり）を使用した症例を対象とし，直腸切離の際の器械使用回数が縫合不全の危険因子となるか検討した．術後縫合不全は3回以上の multi stapling 症例が75％と多く（縫合不全合併4例中3例），合併しなかった症例では31％で2倍以上の差を認めるが，統計学的には有意差は認めなかった（$p=0.114$）．複数回使用になることの問題点は，切離方向がずれて直線状の切離ラインが形成できない点であり，たとえ3回以上であっても一直線であれば縫合不全の危険因子とはならないと思われる．

術後縫合不全の危険因子とされる男性[4~7]については，今回の検討では単変量解析で有意差を認めたが，多変量解析では選択されなかった．しかし，縫合不全症例は全例男性であり，やはり危険因子と思われる．理由については解剖学的に女性より狭骨盤であること[4]，最近ではホルモンの違いで腸管の微小血管循環が影響されているとの報

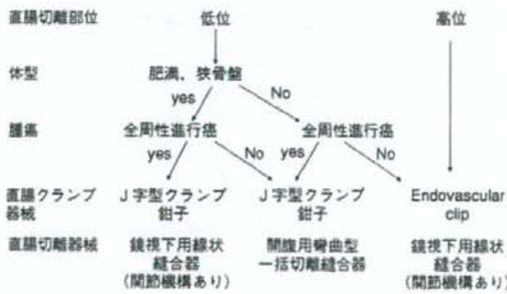

図1　教室における直腸切離器械の選択

告もある[21]．開腹手術と同様に，腹腔鏡下手術でもやはり狭骨盤は難易度が高く，とくに直腸切離器械の選択に注意が必要である．

術後縫合不全は重篤な合併症の1つであり，症状によっては緊急で一時的人工肛門造設術を施行しなければならない．合併症の発生を予防するためには，確実な解剖の把握が重要で，手術中の注意点は，口側腸管の血流の確認，肛門側腸管の十分な剥離と切離部位の設定，吻合部に緊張がかからない左側結腸の授動などが重要である．そのうえで，腹腔鏡下手術においては器械の種類や利用頻度が高いので，その特性や安全な使用法を熟知し，慣れた器械を使用することが重要であり，新規導入する器械については，操作が安定するま

では，より慎重に取り扱うべきと考える．

結　語

今回，腹腔鏡下手術における術後縫合不全の危険因子を検討したが，腹腔鏡下手術特有の縫合不全危険因子はなかった．手術器械を新規導入し，操作が安定するまでに吻合部合併症が起こっており，より慎重な使用が望まれる．自動縫合器にはそれぞれに長所・短所があり，安全な手術のためにはどの器械にも十分に慣れておくことと，症例に応じて使い分けを見極めることが重要であると思われた．

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SURGERY TODAY

Wound Infection After a Laparoscopic Resection for Colorectal Cancer

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Abstract

Purpose. The aim of this study was to investigate whether the wound infection (WI) rate in laparoscopic surgery (LS) for colorectal cancer is lower than that in open surgery (OS), and to evaluate the influence of perioperative intravenous antibiotic prophylaxis on the development of WI in LS.

Methods. We performed a meta-analysis study comparing the WI rate in patients who underwent either OS or LS in randomized controlled trials (RCTs), with a relatively large number of registered patients. Moreover, a subgroup analysis of recently reported RCTs from Japan was performed, and 290 consecutive patients who underwent LS for colorectal cancer at our institution were evaluated for the influence of perioperative intravenous antibiotic prophylaxis on the development of WI.

Results. The WI rate of the LS group was significantly lower than that of the OS group in a meta-analysis; however, no positive effect of the intra- and postoperative antibiotic prophylaxis on the development of WI was demonstrated.

Conclusions. Laparoscopic surgery for colorectal cancer is considered a surgical technique that has a lower incidence of WI in comparison to OS. Well-designed prospective, randomized controlled trials should therefore be conducted to evaluate whether intraoperative repeated dosing or postoperative repeated dosing is effective in reducing WI in LS.

Key words Laparoscopic surgery · Colorectal carcinoma · Wound infection

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Introduction

Among the many complications of colorectal cancer surgery, more attention is paid to wound infection (WI) because it is the most common complication and, even though it is rarely fatal, it does tend to increase hospital costs (length of stay, antibiotics, dressing supplies, and nursing charges) and outpatient care (outpatient follow-up, antibiotics, and self-dressing supplies). For these reasons, many parameters for risk factors of WI in colorectal cancer surgery have been examined in a number of studies with conventional open surgery (OS).[1–4] The results from these studies have demonstrated that several factors are associated with the development of WI.

In recently published randomized controlled trial (RCT) studies that compared the long-term oncological outcome after OS with that after laparoscopic surgery (LS), it was demonstrated that the outcome after LS was comparable to that after OS.[5–7] As a result, the number of candidates for LS is expected to increase in the future. On the other hand, the results from RCT studies comparing the short-term outcome after OS with that after LS in patients with colorectal cancer showed WI rates of 2%–9% for LS and 3%–17% for OS.[6–15] In half of these studies, the incidence of WI in patients treated with LS was significantly lower than that with OS. Regarding the risk factors for WI between OS and LS, there might be a difference because, in LS, the pneumoperitoneum introduced by CO_2 and the delivery of the intestine from a small incision might have some effect on the development of WI. Although several authors have conducted meta-analysis comparing short-term outcomes between LS and OS, these studies included retrospective comparative studies and RCTs with relatively low numbers of patients, and therefore, a re-evaluation is considered to be necessary.[16–18]

Recently, two interesting articles on WI with OS and LS for colorectal cancer have been reported from Japan. Fujita et al. reported that, in a multicenter RCT, in patients who underwent surgery for colorectal cancer in which oral antibiotic prophylaxis had not been used for their preoperative bowel preparation, the postoperative incidence of incisional surgical site infection (SSI) is significantly lower in patients with three doses of intravenous antibiotic prophylaxis, in comparison to those with a single dose;[19] however, in view of the surgical characteristics between LS and OS mentioned above, a subgroup analysis by surgical approach might thus be valuable. Meanwhile, Yamamoto et al. reported that in a study of 290 patients who underwent elective LS, the risk factors for the development of WI included intraoperative hypotension and stoma creation, but not the dose regimen of antibiotics.[20]

Based on these reports, to investigate whether the WI rate in LS is lower than that in OS, we performed a meta-analysis comparing the WI rate in patients who underwent OS or LS in RCTs, with a relatively large number of registered patients. Moreover, the influence of perioperative intravenous antibiotic prophylaxis on WI in patients treated with LS as the subgroup analysis reported by Fujita et al. and the influence of perioperative intravenous antibiotic prophylaxis on the development of WI at our institution were evaluated.

Patients and Methods

For the purpose of a meta-analysis, the English-language literature was searched to identify studies reporting the efficacy of LS compared with OS for colorectal carcinoma. The Medline database search was performed between 2000 and 2007 to compare LS and OS. The following text words were used: "laparoscopic," "colon or rectal," "cancer," and "randomized." The "related articles" function was used to broaden the search. Data were extracted and tabulated from the text, tables, and graphs of the relevant articles. To enter the analysis, studies had to (1) compare LS and OS in RCTs in patients undergoing colorectal cancer, (2) involve more than 100 patients for randomization, and (3) clearly document numbers of patients with WI. When more than two studies were reported by the same institution or the same study group, the best quality or the most recent publication was included in the analysis. Statistical analyses were conducted using STATA version 9.2 (STATA, College Station, TX, USA). The *P* value was calculated using the random effects model.

For the subgroup analysis of WI reported by Fujita et al., clinical data of subgroup patients who underwent LS for colorectal cancer were collected, and clinical parameters that would influence the occurrence of WI between patients with a single dose and those with three doses of intravenous antibiotic prophylaxis (cefmetazole 1 g/body) were evaluated. The study design and main results have already been published.[19] Briefly, patients aged 20 through 80 years scheduled to undergo elective colorectal surgery were eligible for enrollment into this study. The patients underwent mechanical bowel preparation with 2l of polyethylene glycol–electrolyte solution (Niflec, Ajinomoto Pharma, Tokyo, Japan) 1 day before surgery. On the basis of a block-randomized, computer-generated list balancing tumor site, the patients were randomized into one of two groups: a single-dose group given a single intravenous dose of 1 g of cefmetazole just before skin incision and a three-dose group given an intravenous dose of 1 g of cefmetazole just before skin incision and two postoperative 1-g doses at 8 and 16 h after the first administration. Incisional SSI, organ or space SSI, and other infectious diseases were checked daily by an attending surgeon until hospital discharge and then were checked again at the first postoperative hospital visit.

Regarding the influence of perioperative intravenous antibiotic prophylaxis on the development of WI, 290 consecutive patients who underwent LS for colorectal cancer at our institution between June 2001 and December 2005 were retrospectively evaluated.[20] The patients who were administered intra- and postoperative intravenous antibiotic prophylaxis using the same schedule reported by Fujita et al. were selected, and the incidence of WI was evaluated. The candidates and contraindications for LS, preoperative bowel preparations, and the LS techniques in our institution have previously been reported.[20-22] Wound infection was diagnosed within 30 days of the operation according to the criteria of the Centers for Disease Control and Prevention (CDC).[23] Briefly, superficial SSIs only involve the skin and subcutaneous tissue, whereas deep SSIs occur when the incisional wound involves the muscle and fascial layers but not the organ space. Wound infection was characterized by wound erythema, cellulitis, localized pain, swelling, tenderness, or a purulent or culture-positive wound discharge. Preoperative antimicrobial administration was given intravenously within 30 min before skin incision in all cases. The indications for postoperative and intraoperative repeated dosing differed according to the study period. Similarly, the antimicrobial agents differed according to the study period; however, the prophylactic antimicrobial agent given intraoperatively and/or postoperatively was the same antimicrobial prophylaxis given preoperatively in all patients. Superficial and deep incision SSIs were evaluated together under the umbrella term of WI. The statistical analysis was performed using Fisher's exact test. A *P* value of less than 0.05 was considered to be significant.

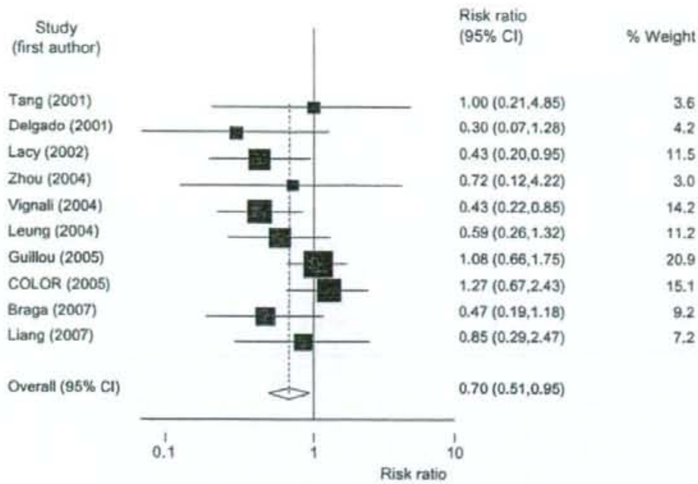

Fig. 1. Meta-analysis for wound infection between laparoscopic surgery and open surgery. Heterogeneity chi-squared = 12.12 (df = 9), P = 0.207. Estimate of between-study variance Tau-squared = 0.0631. Test of risk ratio = 1:z = 2.26, P = 0.024. *CI*, confidence interval

Table 1. Patients' characteristics

	Single-dose (n = 61)	Three-dose (n = 55)	P Value
Sex ratio (M:F)	37:24	29:26	0.4542
Mean age (years)	60.5 (34–79)	61.0 (23–77)	0.2142
Location (n)			
Colon: Rectum	51:10	42:13	0.3592
Laparoscopic colorectal procedures (n)			
Ileocecal resection	5	9	
Right hemicolectomy	7	10	
Transverse colectomy	5	1	
Left hemicolectomy	3	1	
Descending colectomy	2	0	
Sigmoid colectomy	28	21	
Partial resection	3	0	
High anterior resection	2	1	
Low anterior resection	8	12	
Operative time (min)	199.7 (73–326)	205.7 (97–640)	0.6306
Blood loss	59 (0–971)	96 (0–440)	0.1292

Results

Meta-analysis for WI Between LS and OS

The literature search identified 10 suitable studies that compared the results of LS and OS in RCTs. All patients (n = 3821) from these 10 studies were included in the meta-analysis: patients who underwent LS (n = 2022) were compared with those who underwent OS (n = 1799). The WI rate of the LS group was significantly lower than that of the OS group [OR 0.70 (0.51, 0.95); P = 0.024] (Fig. 1). Regarding the organ/space surgical site infection, the anastomotic leakage rate was 3.7% (75/2022) in the LS group and 3.4% (62/1799) in the OS group; however, the intra-abdominal abscess rate was 1.3% (10/787) in the LS group and 1.9% (15/794) in the OS group (data missing in four studies).

Subgroup Analysis for WI Between Patients with a Single Dose and Those with Three Doses of Intravenous Antibiotic Prophylaxis

The patient demographics for the subgroup analysis of WI reported by Fujita et al. are summarized in Table 1. No significant differences were observed in the baseline characteristics between the patients with a single dose and those with three doses of intravenous antibiotic prophylaxis.

Regarding the correlation between infectious disease and antibiotic prophylaxis, the WI rate in the single-dose and three-dose groups was 10% (6/61) and 2% (1/55), respectively, although the difference was not significant ($P = 0.1171$). Moreover, the occurrence of other infectious disease and antibiotic prophylaxis was not significant (Table 2).

Influence of Intra- and Postoperative Intravenous Antibiotic Prophylaxis on the Development of WI

Table 3 demonstrates the effect of intra- and postoperative antibiotic prophylaxis on the development of WI, and no advantage was demonstrated ($P = 0.7797$). Similarly, a positive effect of three doses (cefmetazole 1 g/body) on the development of WI was not demonstrated ($P = 0.4396$) (Table 4). Regarding the organ/space SSI, we experienced one patient (0.3%) with anastomotic leakage in this series.

Discussion

In the present study, our meta-analysis using data from previously-reported RCT studies comparing OS with LS for colorectal cancer showed that the incidence of WI was significantly lower in the LS group. In previously reported meta-analyses comparing OS with LS for colorectal cancer, case-series and/or case-control studies were included, and RCTs with a relatively small number of patients were also included.[16–18] This study using data only from RCTs with a large number of patients demonstrated a significantly lower incidence of WI in LS. For LS to be widely accepted as a surgical technique for colorectal cancer, it goes without saying that it is necessary for several RCTs comparing LS with OS to demonstrate that the oncological outcome of LS is not inferior to that of OS, and 98% of patients who undergo LS performed by a well-experienced laparoscopic team can be discharged from the hospital soon after surgery.[22] Even if a patient develops a WI, the patient can manage it with self-dressing, because the wound size in LS is small.[20] In addition, many researchers have reported that patients who underwent LS had a lower incidence of postoperative obstruction. In the future, therefore, LS might be recognized as a safe surgical technique with lower incidences of complications than OS.[22]

Interestingly, in our meta-analysis the total WI rate in the OS group [9.6% (95/986 patients)] was higher than in the LS group [4.9% (47/961 patients)] for single institutional RCT, but for multiple institutions, the LS group [6.3% (67/1061 patients)] was higher than in the OS group [4.7% (38/813 patients)]. The reasons for these conflicting data between single and multiple institutions might include differences in the criteria for WI, the period from the day of surgery to the patient follow-up evaluation among institutions and/or investigators, and possible biased views on LS or OS by investigators. In future studies on WI, WI should be evaluated by a third person based on uniform criteria.

As demonstrated in the present study, subgroup analysis of Fujita's trial comparing a single dose with three doses in the LS group showed an incidence of WI of 10% (6/61) and 1.8% (1/55), respectively ($P = 0.1171$). As there was no significant difference among the background factors, a significant difference might be obtained in a study with a sufficiently large number of patients. For this reason, even in a case-series study, we evaluated the relationship between the antibiotics dosing

Table 2. Correlation between infectious disease and antibiotic prophylaxis

	Single-dose ($n = 61$)	Three-dose ($n = 55$)	P Value
Incisional SSI	6 (10%)	1 (2%)	0.1171
Organ/space SSI	1 (2%)	3 (5%)	0.3440
Others	2 (3%)	2 (4%)	1.000
Total	7 (11%)	6 (11%)	1.000

SSI, surgical site infection

Table 3. Intra- and postoperative antibiotic prophylaxis on the development of wound infection

Intra- and postoperative antibiotic prophylaxis	Wound infection		Total
	Positive	Negative	
Yes	5	69	74
No	11	175	186
Total	16	244	$P = 0.7797$

Table 4. Perioperative antibiotic prophylaxis on the development of wound infection

Perioperative antibiotic prophylaxis (cefmetazole 1 g)	Wound infection		Total
	Positive	Negative	
Single dose	8	65	73
Three doses	1	28	29
Total	9	93	$P = 0.4396$

regimen and the incidence of WI in a large number of patients who underwent LS in our institution.

The results obtained by this case-series analysis using data from patients in our hospital demonstrated that multiple dosing of antibiotics was not effective in reducing the incidence of WI in LS. There were no significant differences between the patients with preoperative single dosing and with repeated dosing (preoperative single dose+intra- and/or postoperative doses) (P = 0.7797), and in another comparison under the same condition as reported by Fujita et al. (cefmetazole single dose vs three doses; $P = 0.4396$). Recently, more attention has been paid to the effect of LS in reducing the incidence of WI, but few studies have been conducted on WI with LS. In the future, well-designed prospective RCTs should be conducted to evaluate whether intraoperative repeated dosing or postoperative repeated dosing is effective in reducing WI in LS.

In conclusion, LS for colorectal cancer is considered to be a surgical technique that has a lower incidence of WI than OS. The most important challenge for surgeons is, of course, for their patients to recover early after surgery by reducing complication rates without worsening the oncological outcome for both OS and LS. In particular, laparoscopic surgeons for colorectal cancer should continue to improve their laparoscopic skills in order to conduct LS more safely.

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DISEASES OF THE COLON & RECTUM

ORIGINAL CONTRIBUTION

Visceral Obesity Predicts Surgical Outcomes after Laparoscopic Colectomy for Sigmoid Colon Cancer

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PURPOSE: This study was designed to assess whether visceral obesity is a more useful predictor of surgical outcomes compared with body mass index after laparoscopic colectomy.

METHODS: A total of 133 consecutive patients who underwent elective laparoscopic colectomy for sigmoid colon cancer between April 2001 and April 2007 were included. Obesity was defined by visceral fat area $\geq$130 cm^2 or body mass index $\geq$25 kg/m^2, and the variables were compared for obese and nonobese patients.

RESULTS: There were 68 (51.1 percent) obese patients according to visceral fat area and 27 (20.3 percent) according to body mass index. Using either definition, obese patients had a significantly longer operative time compared with nonobese patients. Patients classified as obese by visceral fat area had a significantly higher incidence of wound infection (20.6 *vs.* 4.6 percent; P=0.006) and overall complication rates (32.4 *vs.* 12.3 percent, P=0.006) compared with nonobese patients, whereas there was no significant difference when classified by body mass index. Postoperative hospital stay was significantly longer in obese patients compared with nonobese patients classified by visceral fat area (median 10.5 *vs.* 9 days; P=0.007), whereas it was not statistically different when classified by body mass index.

CONCLUSION: Visceral fat area is a more useful parameter than body mass index in predicting surgical outcomes after laparoscopic colectomy for sigmoid colon cancer.

KEY WORDS: Visceral fat; Obesity; Laparoscopic surgery; Surgical outcome; Postoperative complications.

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Body mass index (BMI) has been used as one of the most reliable anthropometric indices of obesity. BMI is simply calculated as weight in kilograms divided by height in meters squared (kg/m^2); therefore, it is an easily available, objective value. The impact of obesity on laparoscopic colorectal surgery has previously been investigated, defining obesity as BMI $\geq$30 kg/m^2, as proposed by the World Health Organization (WHO BMI cutoff line). Previous reports have shown that obese patients have unfavorable surgical outcomes, including longer operative time, increased postoperative complication rate, increased conversion rate,[1,2] and prolonged hospital stay.[1] In contrast, more recent studies have shown no significant differences between obese and nonobese patients in terms of operative time, conversion rate, and incidence of postoperative complications, and similar or shorter hospital stay in obese patients.[3–5] Laparoscopic colectomy for obese patients has been further supported by a case-matched study conducted by Delaney *et al.* [6] in which there were no statistically significant differences in operating time, complications, reoperation, readmission rate, or direct medical costs between open and laparoscopic colectomy for obese patients. Hence, laparoscopic colorectal surgery is appropriate in obese patients as well as nonobese patients.

However, the distribution of BMI may differ among various ethnic groups. Moreover, a potential disadvantage of BMI is that the value does not consistently reflect body adipose tissue accumulation. In particular, Asian populations may have greater visceral adiposity, although the average BMI is reported to be lower than in non-Asian populations.[7] This fact may underestimate the risk profile associated with visceral obesity when the WHO BMI cutoff line is used to define obesity in these populations.[7]

Metabolic syndrome is a cluster of metabolic abnormalities, including atherogenic dyslipidemia, insulin resistance and/or glucose intolerance, and elevated blood pressure.[8,9] Metabolic syndrome is recognized as a major and prevalent risk factor for developing Type 2 diabetes and cardiovascular disease.[8,9] Visceral obesity is a physical status of individuals having excessive amounts of visceral fat accumulation, and the magnitude of visceral obesity is typically assessed by anthropometric measurement and/or a quantification of the amount of visceral fat using radiologic studies. There is evidence of a substantial association between visceral obesity and the metabolic syndrome, which has been discussed in recent reviews.[8–10]

In laparoscopic surgery, the essential component of the procedure is performed within the intracorporeal field, *i.e.*, the visceral cavity. Therefore, surgical techniques may be influenced by intra-abdominal anatomic and physical conditions. It has been suggested that visceral obesity, indicating an altered intra-abdominal environment, may be more practical for the assessment of surgical outcomes compared with BMI, which corresponds to general obesity. Although this notion prompted early reports showing that visceral fat area (VFA) was associated with increased operative time[11,12] and increased surgical morbidity,[12] these preliminary results should be further evaluated in a larger study. Therefore, we undertook this study to assess whether VFA is a more useful predictor of surgical outcomes compared with BMI, or a potential determinant of the surgical indications for laparoscopic colectomy.

PATIENTS AND METHODS

After approval by the Institutional Bioethics Committee, 133 consecutive patients who underwent elective laparoscopic sigmoid colectomy for sigmoid colon cancer in our institution between April 2001 and April 2007 were included in this study. Cases with conversion to laparotomy also were included in the analysis.

All patients underwent a mechanical bowel preparation with magnesium citrate solution and oral antibiotics consisting of kanamycin sulfate and metronidazole. Patients in whom mechanical bowel preparation was not indicated because of an obstructing tumor did not undergo laparoscopic surgery and were not included in this study. Prophylactic intravenous administration of cefmetazole was performed upon induction of general anesthesia and repeated during surgery if the operative time exceeded three hours.

Low-dose heparin was given by subcutaneous injection for prophylaxis of thromboembolism until the first postoperative ambulation. Water could be taken orally on the day of surgery. Feeding began after the passage of flatus and started with a low-residue diet, progressing to a regular diet on the following day.

Surgical Procedure

Surgery was performed by a surgical team consisting of two senior colorectal surgeons and surgical residents under their supervision. Pneumoperitoneum was maintained at 10 mmHg. Dissection was performed using a medial-to-lateral approach, and the mesenteric artery was divided at the level of the root of the inferior mesenteric artery or distal to the origin of the left colic artery, according to the extent of disease. The splenic flexure was taken down if necessary to achieve an adequate resection margin and to perform a tension-free anastomosis. A plastic wound protector was applied in the left lower quadrant where the proximal bowel was exteriorized. The end-to-end anastomosis was performed by a double-stapling technique using the circular stapler. The integrity of the anastomosis was verified by an air-insufflation test, followed by placement of a pelvic drain in the vicinity of the anastomosis through the right lateral port site.

Data Collection

Patient and tumor characteristics with regard to age, sex, previous abdominal surgery excluding appendectomy, patients' concomitant disease, American Society of Anesthesiologists (ASA) physical status score, and tumor stage were collected. To assess intraoperative technical difficulty, operative time, estimated blood loss, conversion to laparotomy, and the reason for conversion were recorded. The patients' postoperative course was evaluated by postoperative complications, mortality, duration of postoperative hospital stay, and days to flatus, stool, and food (low-residue diet) intake. Wound infection and stitch abscess were defined in accordance with the Centers for Disease Control and Prevention (CDC) criteria.[13]

Quantification of Visceral Fat Area

During the last two decades, quantification of VFA has been developed to evaluate visceral adipose tissue accumulation by imaging studies, primarily with computed tomography (CT).[14–24] In this study, all patients underwent an abdominal CT scan (Aquilion™, Toshiba Medical Systems, Tochigi, Japan) for the preoperative assessment of the extent of disease. The CT scanner is linked to a networked medical imaging system through which images are electronically transferred to a centralized data system and then retrieved at a workstation (Ziostation System 1000™, Ziosoft Inc., Tokyo, Japan). Software enables multiple image rendering and geometric measurements of a specific region with a specified CT number (in Hounsfield units).

A single cross-sectional scan at the level of the umbilicus was selected for quantification (Fig. 1A).[11,15,19,23] Adipose tissue was determined by setting the attenuation level within the range of -190 to -30 Hounsfield units,[14,17,20,22] and the acquired image corresponded to the total fat region (Fig. 1B). The region of visceral fat was defined by manual tracing of its contour, and then the total fat region was divided into visceral and subcutaneous fat regions (Fig. 1C). Finally, the VFA was calculated by the software. All quantifying procedures described above were performed by a single examiner (ST) under the supervision of the

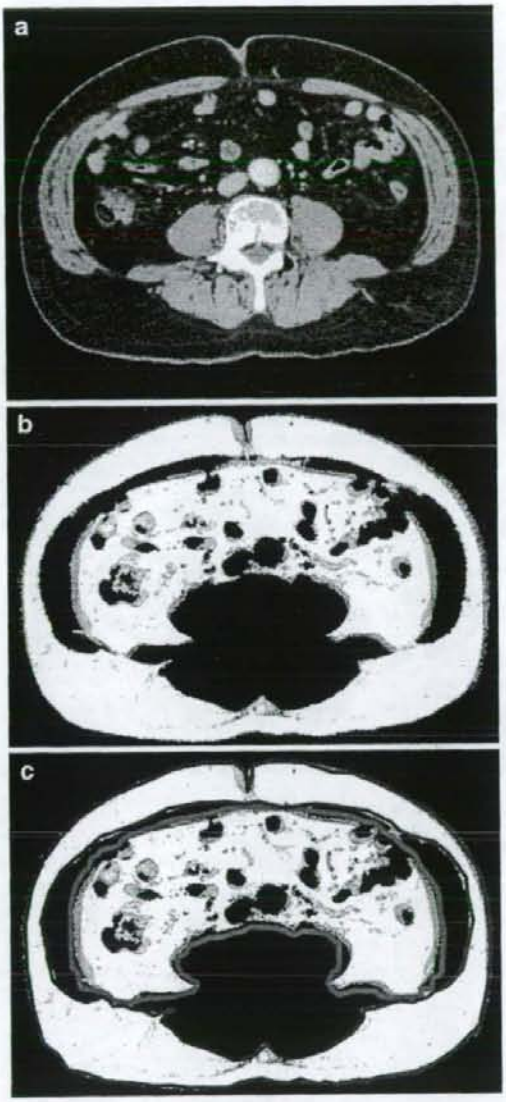


FIGURE 1. Quantification of visceral fat area (VFA) on CT scan. A. Original CT scan image at the level of the umbilicus. B. Alteration of the window width for the detection of adipose tissue. C. The visceral fat region is determined by outlining the intra-abdominal component (red line), and the remaining as the subcutaneous fat region (between the 2 blue lines).

radiologists, all of whom were blinded to the surgical outcome at the time of quantification.

Definition of Obesity

Patients were classified as obese or nonobese by using both VFA and BMI criteria. We used the definition of visceral obesity as VFA of ≥130 cm^2, because this threshold value has been previously proven to be associated with elevated cardiovascular risk[21] and with a substantial deterioration of metabolic variables predictive of the metabolic syndrome.[24] Accordingly, patients with VFA of ≥130 cm^2 were classified as obese (VFA-obese) and the remainder as nonobese (VFA-nonobese).

BMI was calculated, and obese patients were defined as those with BMI of ≥25 kg/m^2 (BMI-obese), and the remainder as nonobese (BMI-nonobese), in accordance with the criteria of the Japan Society for the Study of Obesity.[15] For both of these definitions, patient and tumor characteristics, intraoperative variables, and postoperative course were compared between obese and nonobese patients.

Statistical Analysis

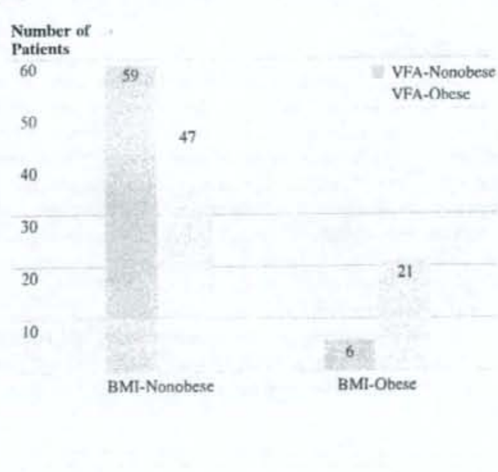
Statistical analysis was performed by using the chi-squared test or Fisher's exact test for categorical values, and the Mann-Whitney *U* test for continuous variables. All statistical analyses were performed by using SPSS® version 11.0 J software (SPSS, Inc., Chicago, IL). A difference with $P<0.05$ was considered statistically significant.

RESULTS

Distribution of VFA and BMI

There were 68 (51.1 percent) VFA-obese patients and 65 (48.9 percent) VFA-nonobese patients, whereas there were 27 (20.3 percent) BMI-obese patients and 106 (79.7 percent) BMI-nonobese patients. Figure 2 illustrates

FIGURE 2. Distribution of visceral fat area (VFA) and body mass index (BMI).



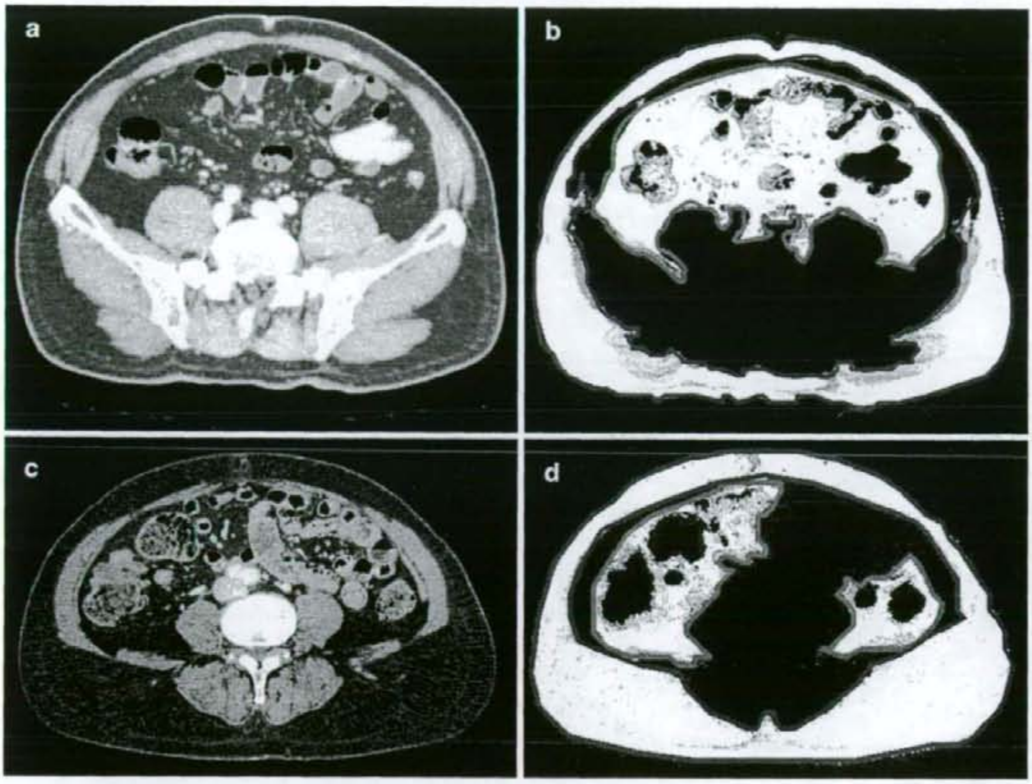


FIGURE 3. Images demonstrating a "viscerally obese" patient and a "subcutaneously obese" patient. **A.** Viscerally obese patient: original CT scan image. **B.** Viscerally obese patient: corresponding CT scan image with altered window width for the detection of adipose tissue. The visceral fat area is outlined by the red line, and the remainder is the subcutaneous fat area (between the 2 blue lines). Visceral fat area is 206.4 cm^2; body mass index is 28.4 kg/m^2. **C.** Subcutaneously obese patient: original CT scan image. **D.** Subcutaneously obese patient: corresponding CT scan image with altered window width for the detection of adipose tissue. The visceral fat area is a sum of two components outlined by the red lines, and the remainder is the subcutaneous fat area (between the 2 blue lines). Visceral fat area is 106.8 cm^2; body mass index is 28.3 kg/m^2.

the distribution of VFA and BMI in this study population. Forty-seven (44.3 percent) BMI-nonobese patients were VFA-obese, and six (22 percent) BMI-obese patients were VFA-nonobese. This variation in the distribution of VFA and BMI implies that BMI-defined obesity does not necessarily correspond to visceral obesity. Figure 3 demonstrates images of a "viscerally obese" patient and a "subcutaneously obese" patient with a nearly similar BMI value.

Patient Characteristics and Tumor Stage

Table 1 summarizes the patient characteristics and tumor stage. There was no significant difference in age or previous abdominal surgery between nonobese and obese patients defined by VFA or BMI. VFA-obese patients included a significantly higher proportion of men, whereas the gender ratio was identical in BMI-nonobese and BMI-obese patients.

VFA-obese patients had a somewhat higher ASA score compared with VFA-nonobese patients, although the difference did not reach statistical significance. This trend was not observed when obesity was defined by BMI. Details of patients' concomitant diseases using both definitions are shown in Table 2. Although individual patients may have multiple diagnoses, it seemed that VFA-obese patients were associated with more severe concomitant diseases compared with VFA-nonobese patients. In contrast, patients with severe concomitant

Table 1. Patient characteristics

Variables	VFA nonobese (n=65)	VFA obese (n=68)	P value	BMI nonobese (n=106)	BMI obese (n=27)	P value
Mean age (yr)	64 (31–84)	65.5 (41–88)	0.372	65 (31–88)	66 (41–82)	0.767
Gender			0.002			0.987
Female	35 (53.8)	19 (27.9)		43 (40.6)	11 (40.7)	
Male	30 (46.2)	49 (72.1)		63 (59.4)	16 (59.3)	
Previous abdominal surgery	16 (24.6)	10 (14.7)	0.150	22 (20.8)	4 (15)	0.487
ASA score			0.066			0.825
1	47 (72.3)	38 (55.9)		69 (65.1)	16 (59.3)	
2	16 (24.6)	22 (32.4)		29 (27.4)	9 (33)	
3	2 (3.1)	8 (12)		8 (7.5)	2 (7.4)	
Tumor stage			0.182			0.578
0	2 (3.1)	–		2 (1.9)	–	
I	25 (38.5)	16 (23.5)		35 (33)	6 (22)	
II	19 (29.2)	27 (39.7)		35 (33)	11 (40.7)	
III	18 (27.7)	23 (33.8)		31 (29.2)	10 (37)	
IV	1 (1.5)	2 (2.9)		3 (2.8)	–	

VFA = visceral fat area; BMI = body mass index; ASA = American Society of Anesthesiologists. • Data are means with ranges in parentheses or numbers with percentages in parentheses unless otherwise indicated.

diseases were distributed in the nonobese group, not the obese group, when obesity was defined by BMI.

Tumor stage was not significantly different between nonobese and obese patients using either definition of obesity.

Intraoperative Difficulties

Intraoperative variables used to assess technical difficulty are shown in Table 3. Obese patients using either definition had a significantly longer median operative time compared with nonobese patients. In contrast, neither estimated blood loss nor conversion rate differed statistically between nonobese and obese patients defined by VFA or BMI.

Table 4 details the reasons for conversion to open laparotomy. Dense adhesions were the most common reason for conversion. Although an increased visceral fat volume might have compromised instrumental manipulation during laparoscopic procedures, there was no direct reason for conversion related to visceral obesity. Other reasons seemed to be nonspecific and independent of obesity.

Postoperative Complications and Mortality

There were 33 postoperative complications in 30 patients, including wound infections in 17 patients, small-bowel obstruction in 7, stitch abscess in 5, anastomotic leakage in 1, urinary tract infection in 1, pneumonia in 1, and atelectasis in 1. Statistical comparison was made between nonobese and obese patients regarding the frequently observed postoperative complications and overall complication rate (Table 5). There was no significant difference in the incidence of small-bowel obstruction or stitch abscess, although the latter was close to statistical significance. Conversely, the incidence of wound infection and the overall complication rate was significantly higher in VFA-obese compared with VFA-nonobese patients, whereas they were not different between obese and nonobese patients defined by BMI. There was no postoperative mortality. No patient required reoperation or readmission within 30 days after discharge.

Postoperative Recovery

Table 6 shows the numeric variables associated with postoperative recovery. There was no significant difference using either definition of obesity in terms of days to flatus, stool, or dietary intake. However, the median postoperative hospital stay was significantly longer in VFA-obese com-

Table 2. Patients' concomitant disease and incidence of overall complications

Concomitant disease	VFA nonobese (n=65)	VFA obese (n=68)	BMI nonobese (n=106)	BMI obese (n=27)
Hypertension	7 (0)	21 (7)	22 (5)	6 (2)
Diabetes mellitus	3 (0)	9 (4)	8 (3)	4 (1)
Coronary heart disease	2 (1)	5 (4)	6 (4)	1 (1)
Hyperlipidemia	4 (1)	3 (2)	5 (2)	2 (1)
Cerebral arterial disease	0	3 (3)	2 (2)	1 (1)
Arrhythmia	3 (1)	0	3 (1)	0
Asthma	1 (0)	2 (1)	1 (0)	2 (1)
Thyroid disease	3 (1)	0	3 (1)	0
Rheumatoid arthritis	0	2 (0)	1 (0)	1 (0)
Aortic aneurysm	1 (1)	1 (0)	1 (1)	1 (0)
Cardiomyopathy	1 (0)	0	1 (0)	0
Valvular heart disease	0	1 (1)	1 (1)	0
Chronic renal failure	0	1 (1)	0	1 (1)
Bone marrow disease	0	1 (1)	0	1 (1)

VFA = visceral fat area; BMI = body mass index. • Data are the number of patients with each concomitant disease with the number of patients who developed overall complications shown in parentheses.

Table 3. Intraoperative technical difficulties

Variables	VFA nonobese (n=65)	VFA obese (n=68)	P value	BMI nonobese (n=106)	BMI obese (n=27)	P value
Operative time (min)	190 (115–325)	220 (125–410)	0.006	207.5 (115–410)	235 (150–335)	0.01
Estimated blood loss (ml)	10 (10–890)	42.5 (10–530)	0.109	30 (10–890)	30 (10–380)	0.63
Conversion to laparotomy	3 (4.6)	6 (8.8)	0.493	6 (5.7)	3 (11)	0.386

VFA = visceral fat area; BMI = body mass index. • Data are medians with ranges in parentheses or numbers with percentages in parentheses unless otherwise indicated.

pared with VFA-nonobese patients, whereas the values were similar in obese and nonobese patients as defined by BMI. Because wound infection was the most commonly observed postoperative complication, a comparison was made to clarify the impact of wound infection on postoperative length of stay. Patients with a wound infection (n=17) had a significantly longer postoperative length of stay compared with those without wound infection (n=116; median, 14 *vs.* 9 days; P=0.001).

DISCUSSION

This study demonstrates that patients with visceral obesity determined by increased visceral adipose tissue accumulation had a longer operative time, an increased rate of postoperative complications, and prolonged hospital stay compared with nonobese patients. The same patients also were classified into obese and nonobese groups using BMI criteria, and a longer operative time was the only significant difference in surgical outcomes between these groups. Considering that visceral adipose accumulation is regarded as a reflection of systemic alteration of the metabolic profile,[8,9] it is suggested that the unfavorable surgical outcome in VFA-obese patients may be attributed to visceral obesity.

Previous studies have investigated the feasibility of laparoscopic colorectal surgery in obese patients, with a wide variety of surgical outcomes.[1–6,11,12] Each absolute value cannot be equally compared among different studies because of the heterogeneity in study design, study population, inclusion criteria of patients and diseases, definitions of variables, physicians' clinical practice, health insurance system, and social standards. The values of postoperative length of stay in the present study are relatively longer than that in similar reports from Western populations.[1–3,6] In the current study, the average length of hospital stay in the early study period was apparently longer than that in our current practice (detailed data not shown). In addition, the most common postoperative morbidity was wound-related complications; wound care has been one of the most challenging issues in the care of our patients, and not usually amenable to ambulatory self-management. However, the principles of hospital care are changing and this is reflected in the length of stay; the shortest was five days in our study group (Table 6), and the average length of stay for patients without postoperative complications is from five to seven days in recent years (detailed data not shown).

Table 4. Reasons for conversion to laparotomy

Reason	VFA nonobese (n=65)	VFA obese (n=68)	BMI nonobese (n=106)	BMI obese (n=27)
Dense adhesions	–	4	3	1
Bowel injury	1	–	1	–
Extent of tumor	–	1	–	1
Incomplete anastomosis	–	1	–	1
Uncontrollable bleeding	1	–	1	–
Ischemia of resected proximal bowel	1	–	1	–
Total	3	6	6	3

VFA = visceral fat area; BMI = body mass index. • Data are the number of patients.

We restricted the patients included in this study to those undergoing laparoscopic colectomy for sigmoid colon cancer in an attempt to minimize the heterogeneity in surgical techniques associated with the site of colectomy (*i.e.*, right, left, or anterior resection) and in the pathophysiology of disease (*i.e.*, malignant or benign neoplastic lesions, diverticulitis, or other inflammatory bowel diseases). In addition, sigmoid colectomy has been one of the most frequently performed and technically standardized laparoscopic surgical procedures in our institution, so that diversity in surgeons' skill was not deemed to affect the results. Nevertheless, our results still have limitations because of the nature of the consecutive but retrospective study design, and are potentially biased by the methodology with regard to the definition of obesity and the method of quantifying VFA used.

The definition of general obesity in this study is BMI ≥25 kg/m^2, which may not apply in other countries, and this may raise concern regarding the applicability of our observations. Several nationwide, population-based, long-term cohort studies have shown that the prevalence of individuals with BMI ≥30 kg/m^2 is only 2 to 3 percent of the general population in Japan.[25,26] There were only four (3 percent) patients with BMI ≥30 kg/m^2 in our study; this value corresponds to the aforementioned large-scale surveys,[25,26] suggesting that the WHO BMI cutoff line may not be indicated for the evaluation of the degree of obesity actually present in our population.

Table 5. Postoperative complications and overall complication rate

Variable	VFA nonobese (n=65)	VFA obese (n=68)	P value	BMI nonobese (n=106)	BMI obese (n=27)	P value
Wound infection	3 (4.6)	14 (20.6)	0.006	12 (11.3)	5 (19)	0.338
Small bowel obstruction	4 (6.2)	3 (4.4)	0.714	7 (6.6)	–	0.344
Stitch abscess	–	5 (7.4)	0.058	2 (1.9)	3 (11)	0.057
Overall complications	8 (12)	22 (32.4)	0.006	22 (20.8)	8 (30)	0.325

VFA = visceral fat area; BMI = body mass index. · Data are number of patients with percentages in parentheses unless otherwise indicated.

Increased evidence of the high prevalence of metabolic syndrome-associated diseases, such as diabetes and/or cardiovascular disease, and the high prevalence of elevated body fat percentage with lower average BMI in a specific Asian ethnic group have been frequently reported.[7,9,15,25,26] Therefore, redefining the appropriate BMI for Asian populations has been proposed and discussed. WHO Steering Committee of the Western Pacific Region[27] has proposed the definition of obesity as BMI ≥25 kg/m^2, and the increased prevalence of metabolic syndrome in the subset with this BMI cutoff line has been subsequently verified in a number of nationwide, large-scale cohort studies.[25,26,28] Based on these studies, BMI ≥25 kg/m^2 has been validated as a population-specific definition of obesity in our population.[15]

However, establishing an ethnic specific cutoff line may lead to confusion in health promotion, disease prevention, and management, particularly in multicultural European societies.[7,29] We believe that the use of population-based anthropometric parameters is reasonable for the assessment of obesity, acknowledging the difference in standards among various world populations.

The method of quantification of regional adipose distribution may differ among institutions, resulting in variation in results and interpretations. The mainstream imaging modality is CT, whereas magnetic resonance imaging (MRI) and abdominal ultrasound can be alternatively used with adequate diagnostic concordance with the results obtained by CT.[10,16,30] Whatever diagnostic modality is used, the critical issue is the reproducibility and reliability of measurement of visceral fat area; the reported intraobserver and interobserver error using CT ranges from 1.2 to 3.9 percent in the literature.[10]

The software used for quantification of visceral fat area is a preinstalled application supplied with the imaging workstation. This system can be used by multiple specialties, through numerous image rendering functions in combination with multidetector row CT. Despite the variety of available imaging software, this difference alone does not seem to influence the results, because key confounding factors during the quantification procedure are setting of the attenuation range and selection of the planimetric location.

The attenuation range for determination of adipose tissue varies in the literature: −250 to −50,[16] −190 to −30,[14,17,20,22] or −140 to −40[18] Hounsfield units, although the obtained data with these various definitions were found to be similar to those in a previous cadaver study.[23] The longitudinal level of planimetric location may affect the results. The main suggested levels are the umbilicus[11,15,19,23] and the L4-L5 intervertebral space.[14,16,17,22] Both levels are thought to correspond to the highest percentage of body adipose tissue accumulation, and the latter is a more strictly defined location in relation to the skeleton.[10]

An insulin-resistant state with impaired nonesterified fatty acids metabolism, reduced adiponectin concentration responsible for atherogenic and diabetogenic metabolic risk, and abnormalities in the neuroendocrine system are observed in viscerally obese patients; therefore, visceral obesity is considered an important marker predictive of systemic risk with an altered metabolic profile.[8,9] In this study, as shown in Tables 1 and 2, VFA-obese patients tended to have higher ASA scores and more severe comorbid medical conditions compared with VFA-nonobese patients. The increased incidence of postoperative complications in this subgroup, mostly wound infections, may have consequently led to the prolonged postoperative hospital stay. Table 2 also supports that VFA-defined obesity can be a more sensitive

Table 6. Postoperative course

Variable	VFA nonobese (n = 65)	VFA obese (n = 68)	P value	BMI nonobese (n = 106)	BMI obese (n = 27)	P value
Days to flatus	2 (1–4)	2 (1–4)	0.177	2 (1–4)	2 (1–4)	0.622
Days to first passage of stool	3 (1–7)	3 (1–9)	0.582	3 (1–8)	3 (1–9)	0.387
Days to oral intake	3 (1–12)	3 (2–20)	0.232	3 (1–20)	3 (2–14)	0.854
Postoperative length of stay	9 (5–29)	10.5 (5–31)	0.007	9.5 (5–31)	9 (5–24)	0.8

VFA = visceral fat area; BMI = body mass index. · Data are median number of days with ranges in parentheses unless otherwise indicated.

indicator of underlying comorbid medical conditions compared with BMI-defined obesity. The increased percentage of patients with conditions, such as hypertension, diabetes, and coronary heart disease, had an increased incidence of overall postoperative complications. However, interpretable variables are limited to these frequently observed concomitant diseases. This table also reports several variables with low frequency (*i.e.*, rheumatoid arthritis, aortic aneurysm). The significance of these small numbers of concomitant diseases cannot be assessed.

Despite the significant association with an augmented risk profile, increased VFA does not necessarily mean that viscerally obese patients have an increased surgical risk. Given that the reasons for conversion did not include factors directly associated with visceral obesity, and the acceptable incidence of observed postoperative complications, we see no limitation in the indication for laparoscopic colectomy in patients who present with visceral obesity. Conventional risk factors, such as age, sex, smoking history, presence of patient-specific comorbidity, and laboratory data, including triacylglycerol and cholesterol levels, also must be considered during the preoperative evaluation. Other anthropometric measurements might be informative; waist-to-hip ratio has been shown to be more closely correlated with metabolic risk than BMI, and waist circumference is the simplest but has variability in the exact location used for determinations.[10] These indices might be useful for the estimation of regional adipose accumulation, where a direct method of quantification is not available. The efficacy of these clinical, radiologic, and anthropometric parameters must be further verified in prospective, population-based studies, to optimally assess the surgical risk and determine the indications for laparoscopic surgery in individual patients. Interestingly, several trials have shown that the depletion of visceral adipose accumulation in response to weight loss is associated with improvement in insulin sensitivity and glucose tolerance.[20,31] Therefore, it would be of interest to investigate whether depletion of visceral adipose accumulation could be a potential therapeutic target in patients with colon cancer, particularly for viscerally obese patients, with the goal of a reduction in postoperative complications.

The present study demonstrates that VFA may be a more useful parameter than BMI in predicting surgical outcomes after laparoscopic colectomy for sigmoid colon cancer. However, one potential weakness of this observation is that only 27 patients were allocated to the BMI-obese group; the small number in this subgroup may not adequately support a comparative trial of VFA *vs.* BMI. Therefore, this preliminary result must be further verified by future prospective, population-based cohort studies, with the appropriate sample size based on the results obtained in the present study. At present, our findings may not be directly applicable to the Western population; therefore, it would be worthwhile if future studies focused on the impact of VFA-obesity and BMI-obesity on surgical outcome and are conducted in populations with a higher average BMI, and possibly with different adipose tissue distributions.

Although these conclusions are somewhat limited in the study population because of the nonrandomized, retrospective nature of this single institutional study, VFA can be valuable as a predictor of longer operative time, increased postoperative complications, and prolonged postoperative hospital stay. The adverse impact of visceral obesity on surgical outcomes does not imply that laparoscopic colectomy is contraindicated in these individuals. However, the prolonged operative time in these patients may increase the risk of developing postoperative complications. Preoperatively obtained information about visceral obesity may be useful for planning the operative strategy and may alert clinicians to the increased risk of a complicated postoperative course in viscerally obese patients.

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