ムバッグ）に入れ，体外に摘出する（図 5b）。

2. ヘルニア修復術（TAPP）

Basic skill の中では非常に難易度の高い手技である。TAPP を選択したのは過去の事例で両側症例，再発症例，前立腺癌術後症例などに対して応用範囲が広いためである。これを充来法の TAPP と同等の少ない合併症率にて完遂することが重要である[6]。

コンバインド法を主に行っているが，パラレル法も可能である。臍部 2 cm の創から腹腔内に入る手技は胆嚢摘出術と同じである（図 1）。腹腔内を観察し，ヘルニアの位置とサイズから日本ヘルニア学会（JHS）による分類を行う。症例は右 JHS 分類 I -2 であるが，ヘルニア嚢の上縁に沿って腹膜前腔の剝離を進める（図 6a）。十分な剝離を行い，ヘルニア嚢は全摘除をするか，嚢周囲を剝離後，遠位側を残すようにする。ヘルニア嚢を剝離する際，とくに外鼠径ヘルニアでは精巣（卵巣）動・静脈，精索（円靱帯）からていねいに剝離することと，ヘルニア分類の境界を示す解剖学的な構築物（恥骨，Cooper 靱帯，iliopubic tract，下腹壁動・静脈など）を確認することが重要である（図 6b）。また内鼠径ヘルニア，外鼠径ヘルニア，大腿ヘルニアそれに最内側（膀胱上）ヘルニアの片側 4 カ所のヘルニア門をメッシュでしっかり被覆することが再発防止に肝要である（図 6c）。最近では縮小の少ない Parietex Anatomical Mesh などの soft mesh や，吸収性材料である Absorba-Tuck など，人体に優しい材料を選択するようにしている。

単孔式ヘルニア修復術（TAPP）でとくにむず

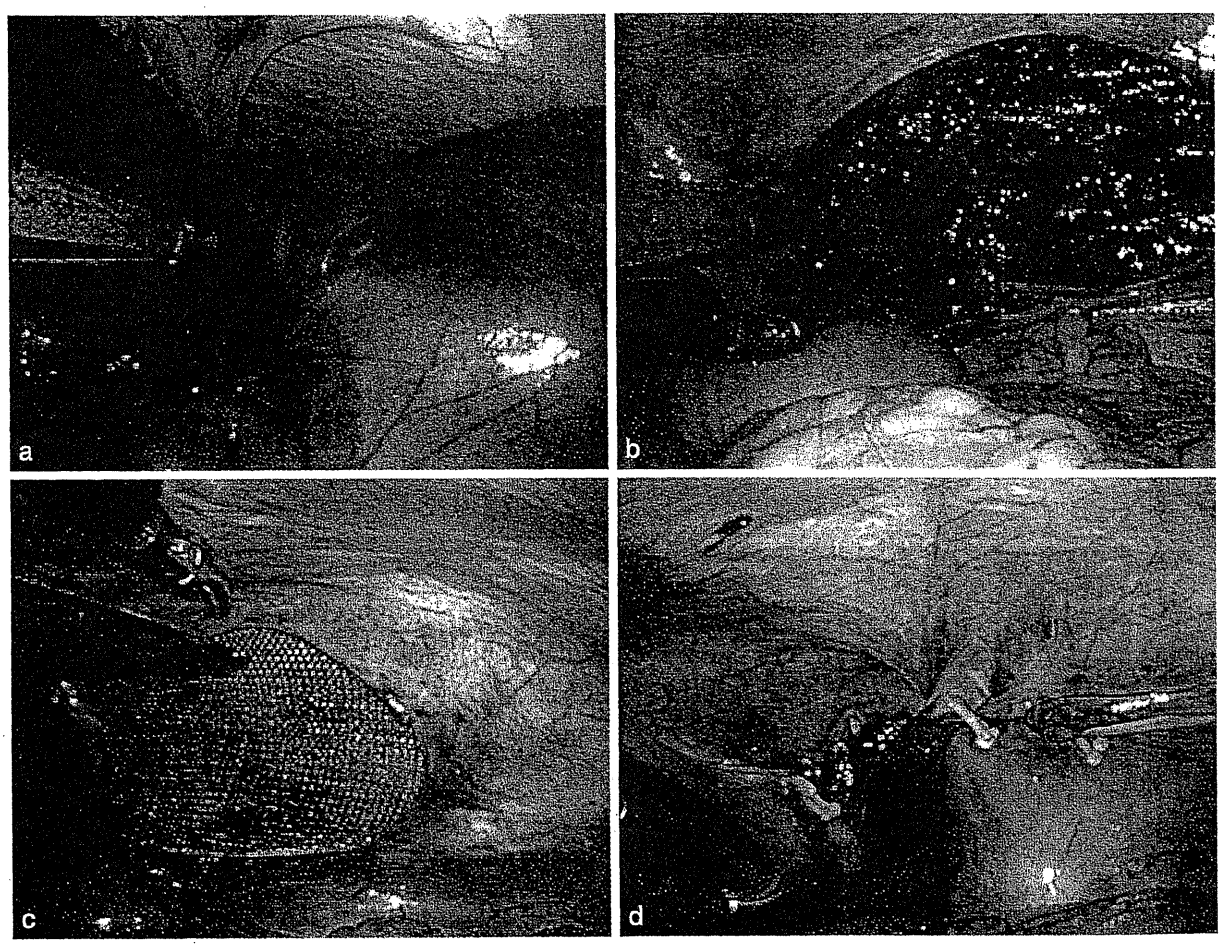

図 6　TANKO ヘルニア修復術（TAPP）

a）JHS 分類 I -2 が観察される。
b）腹膜前腔の剝離。
c）Hernia 門が被覆されるようにメッシュを入れ固定する。
d）腹膜は suturing または Endo-stitch（SILS-Stitch）にて縫合閉鎖する。

かしいのは腹膜修復である。充来法のTAPPではsuturingを基本としているが，縫合手技より結紮手技がむずかしい本法ではEndostitch（SILS Stitch）や結紮の代わりにクリップを用いることもある（図6d）。縫合のスキルは次第にアップしており，最終的には縫合結紮に帰結すると考えているが，過渡期として現在はSILS Stitchも用いている（図7）。

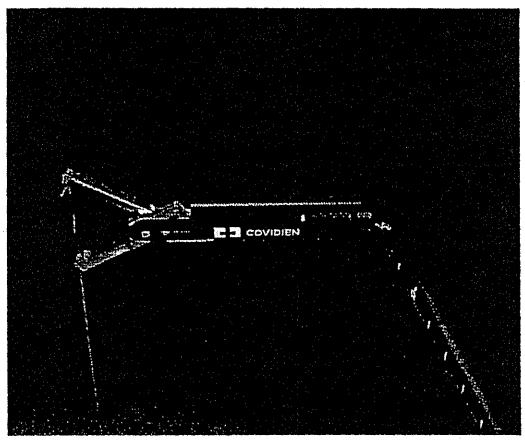

図7　SILS Stitch

3. 虫垂切除術

Basic skillの中では比較的難易度が低く施行しやすいが，緊急であることが多く，全身麻酔が必要であり，若干の時間延長など手術室や麻酔科的な問題も残されている[8]。

当院では2年目から8年目までの若手が術者となることが多いので，無理をせずにSingleポート+1を多く行っている。

症例は40歳の女性で繰り返す虫垂炎にて待機的な虫垂切除術が予定された。胆摘と同様の手技でWound Retractor XSを創部に装着し，gloveから3本のトロカールを挿入する。虫垂を右下腹部で視認し，Mini-loop retractorをかけるか，把持鉗子でそのまま虫垂間膜を把持挙上し，超音波凝固切開装置にて切離する。動・静脈があると思われる部位では十分な止血を行いつつ処理を終える（図8a）。虫垂根部にEndoloopをかけ一重または二重に結紮する（図8b）。結紮部位から5 mm程度離れた位置にて超音波凝固切開装置に

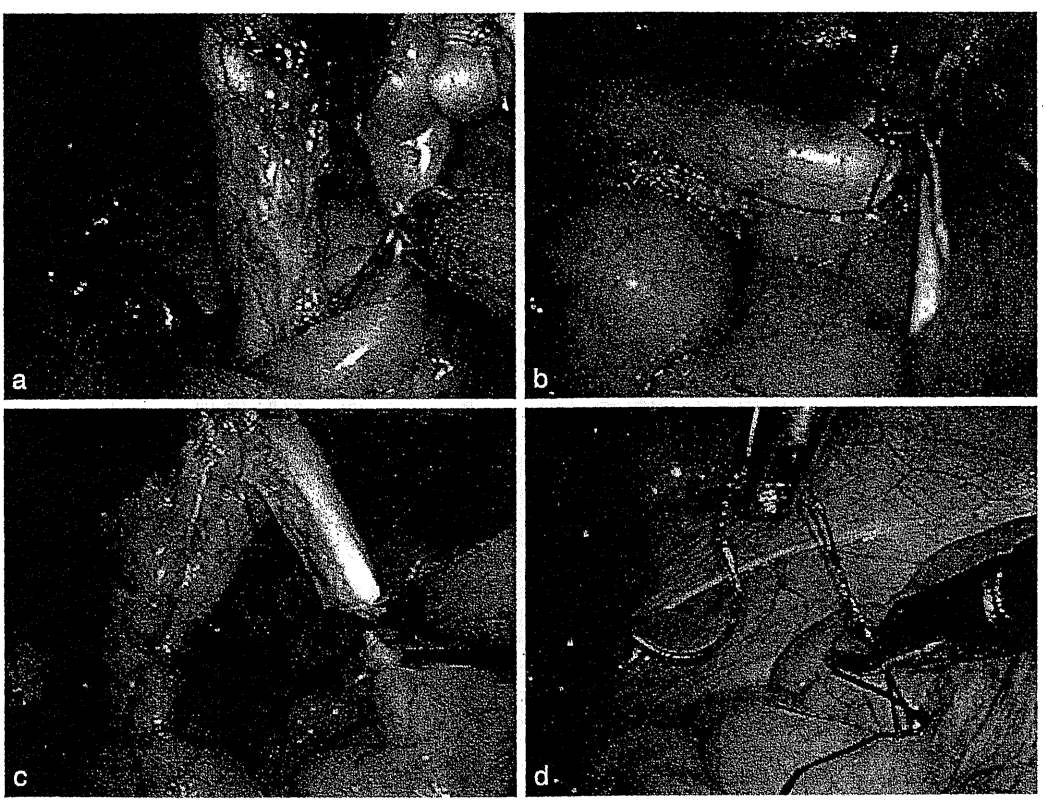

図8　TANKO虫垂切除術

a）虫垂を挙上し，虫垂間膜を切離する。
b）虫垂根部をEndoloopにて結紮する。
c）結紮部位から5〜6 mm離れてSonoSurgにて虫垂切離。
d）断端に不安のある症例では埋没縫合処理する。

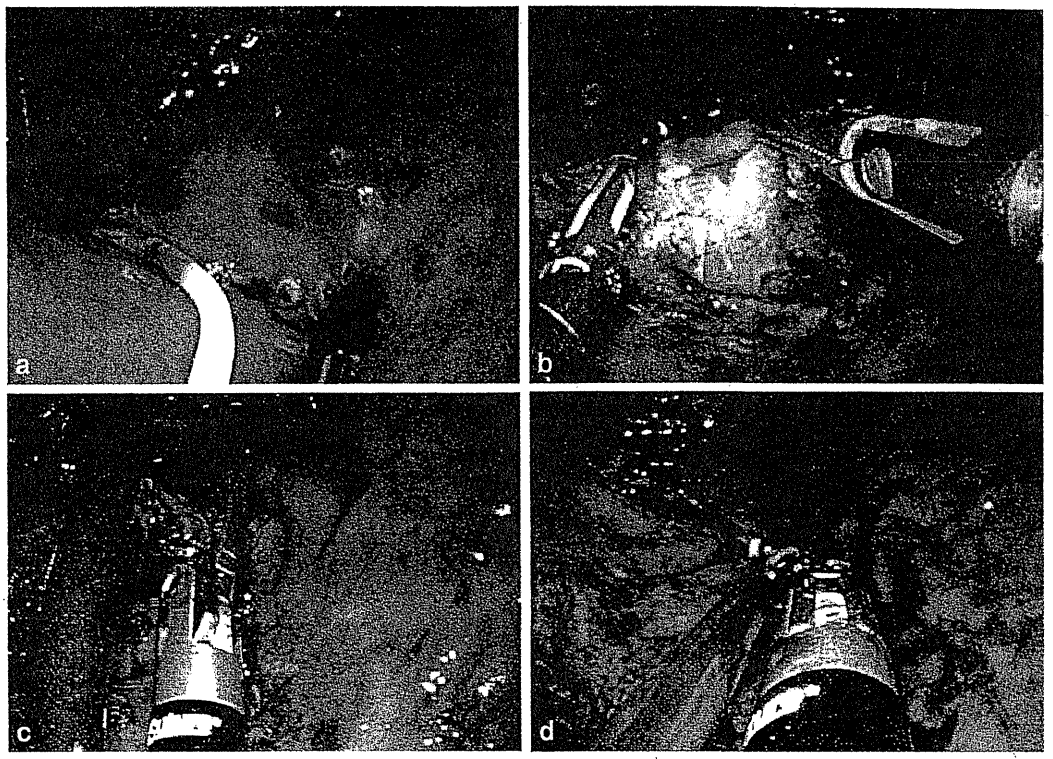

図9　TANKO 胃内手術
a）腫瘍周囲に電気メスで印をつけペチニードルでボスミン生食を注入する。
b）周囲を切離した後超音波凝固切開装置にて切離する。
c）全層切除になるが，Endostitch にて縫合開始。
d）断端をクリップ処理し，縫合終了する。

て切離する（図8c）。断端に不安のある症例では埋没縫合処理を加えることもある（図8d）。腹腔内を洗浄し，汚染腹水の貯留などがないことを確認し，洗浄吸引しドレーンは基本的に挿入せず，手術を終了する。

4. Advanced surgery

Advanced surgery としては胃部分切除術（胃内手術6例，吊り上げ法2例，LADG 2例）を胃粘膜下腫瘍および早期胃癌に施行した。

胃内手術では臍部から頭側に約2.5 cm の切開を置き，上部空腸にブルドック鉗子をかけて胃内の気腹漏れを防ぎ，胃角部対側を創部まで挙上する。以下の手技は3本法の胃内手術に準じて行った[9]。胃の漿膜筋層に4点支持糸をかけ胃大彎側前壁に約3 cm の胃瘻を作成する。Basic skill の要領で Wound Retractor XS を胃内まで装着し，glove を付け気腹する。胃の腫瘍位置を確認し，腫瘍の周囲に電気メスにて印を付ける。ペチニードルで粘膜下にボスミン生食を注入する（図9a）。胃腫瘍の肛門側粘膜を剝離し，全周に剝離を進める。切除側胃を裂かないようにていねいに挙上し，超音波凝固切開装置にて剝離を進める（図9b）。GIST の多くは術前の EUS で第4層由来ということが判明しているため，全層切除になることを想定して剝離を進める。噴門側後壁であれば全層切除となっても胃内の気腹は解除されないことが多いが，視野確保の困難な場合は腹腔内にサーフローなどで穿刺することもある。

腫瘍を摘出したら，全層一層に胃壁を縫合閉鎖する。この部位の縫合は視野が不十分で手早く行う必要が有り，Endostitch を使うことが多い（図9c）。Endostitch では針孔に組織がかみこまれることがありうるので注意を払い，全層の adaptation ができていることを確認しつつ縫合を終える（図9d）。胃瘻部は手縫い縫合かリニアステイプラーにて縫合閉鎖を行う。

LADG は Single ポート+2 で施行した2例のみであるが，肝の挙上，胃の挙上をペンローズドレーン，針糸などで工夫すれば D1+β までの標

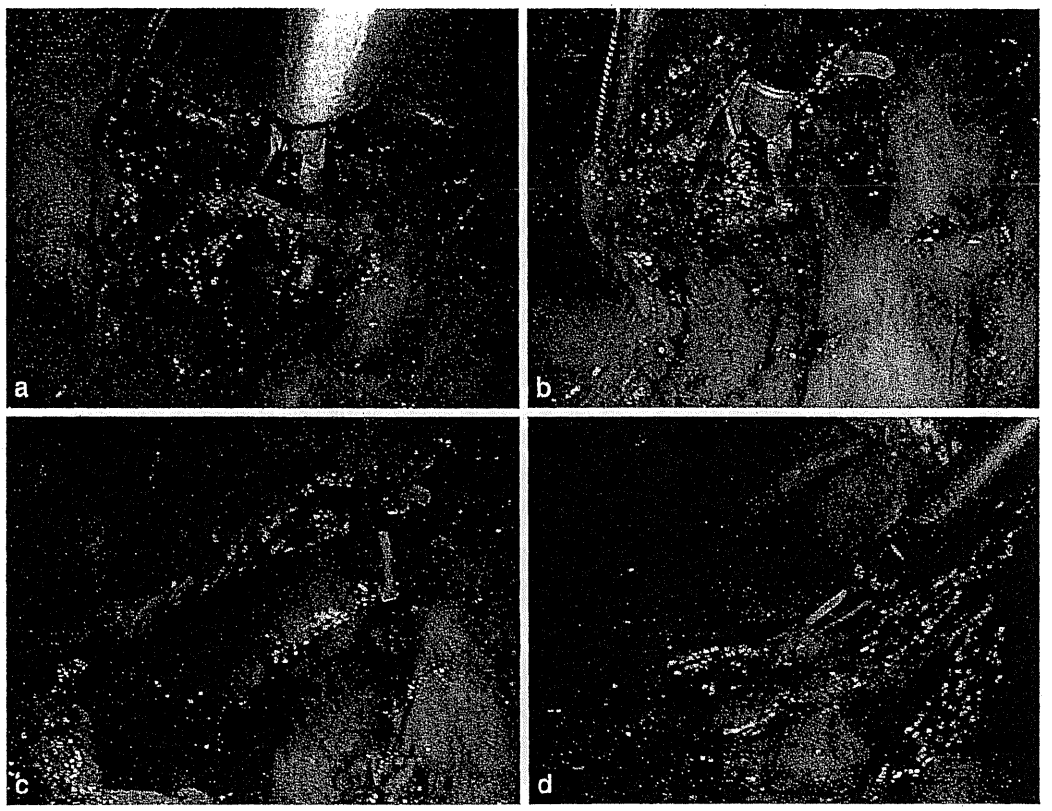

図 10　TANKO 右半結腸切除術 1

a) D3 ラインで剝離を進め，回盲動脈を根部で剝離する。
b) Surgical trunk に沿って剝離を進め，回盲静脈根部を剝離する。
c) 右結腸動脈を切離し，内側アプローチを終了する。
d) 外側アプローチを終え副右結腸静脈を確認し，本例では温存した。

準リンパ節郭清は可能である。再建は Roux-Y 再建とした。Entry hole の閉鎖を手縫いとしたため時間を要したが，創部を縮小し，根治性のある完全鏡視下 LADG は現実的なところとなってきた。

5. 大腸切除

大腸切除は advanced surgery として今後もっとも注目される分野と考えられる。よい適応としては早期癌までで，回盲部または右半結腸切除術とS状結腸切除術が比較的導入には適していると思われる。郭清が D2 または D3 まで可能であるため進行癌の一部は当然適応となりうる。

症例は上行結腸局在の T2 症例で D3 郭清を行った。臍部中心に 3.5 cm の創を設け，Wound retractor XS を装着し，glove より 5 mm のトロカール 4 本と 12 mm トロカールを誘導し固定する（図 2b）。回盲部を腸鉗子で把持挙上し，surgical trunk の左側に沿って剝離を行う。上腸間膜動・静脈に沿って剝離を進め，回盲動脈を根部で剝離同定し，クリップ処理する（図 10a）。この症例では同名静脈が頭側右側背側の上腸間膜静脈に流入することが判明したため，根部にてクリップ処理を行った（図 10b）。右結腸動脈を処理し，十二指腸，膵頭部の腹壁側を剝離し，十分剝離したところで内側アプローチを終える（図 10c）。外側の fusion fascia は虫垂，盲腸近傍から行い，上行結腸外側に至り，Gerota's fascia の前面にて内側アプローチの剝離面と連続させる。さらに横行結腸右側頭側にて大網を切離し，肝曲部を take down して尾側，内側からの剝離面と合わせる。最後に膵頭側に位置する副右結腸静脈を切離し，臍部創まで右半結腸を挙上する（図 10d）。当院では汚染防止と器具使用の観点から切除側腸管は小孔から挙上し，体外にてリニアステイプラー 2 本による functional end to end anastomosis を施行している。ステイプラーの断端および交差点を補強し腹腔内に戻し，腸の位置を確認して閉

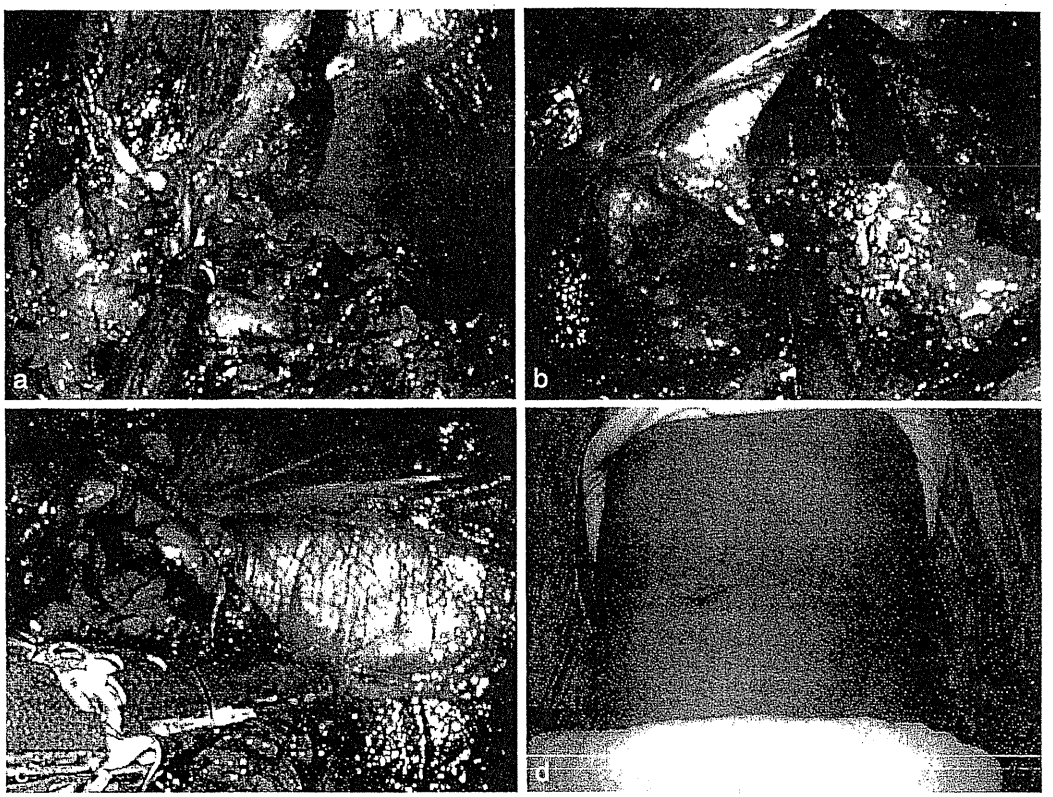

図 11　TANKO 脾臓摘出術
a）後腹膜側から超音波凝固切開装置にて剝離を進める。
b）脾門側からも剝離を行い，ステイプラーを通す準備をする。
c）ステイプラー（Gray）を用いて脾門における切離を行う。
d）TANKO 脾摘の創部。

創し手術を終える。

6. 脾臓摘出術

脾臓摘出術は疾患が限られるが，血液疾患や小児外科領域では重要な位置を占める[8]。従来の鏡視下手術では 4 本のトロカールを挿入し行っていた。

症例は 71 歳の男性で ITP の診断でステロイド，γ-グロブリンの大量投与を行ったにもかかわらず血小板減少と出血傾向が継続するため，血小板を輸血しながらの単孔式内視鏡手術となった。体位は左側臥位とし，左側腹部に 3 cm の小孔を作成し，wound retractor を装着した。Glove から 3 本の 5 mm トロカールを誘導し，脾結腸靱帯を剝離し，脾を挙上しながら，主に後腹膜側から剝離を進める（図 11a）。脾門側では脾の下極枝を切離し，上極では上極枝を切離して脾門を薄くして，ステイプラーの挿入可能な厚さまで剝離する（図 11b）。手袋の指から 13 mm トロカールを誘導し，EndoGIA（Gray）1 回にてファイアーヒ，脾臓の切離を終える（図 11c）。脾臓を大きな回収袋（キャッチパース，ラージ，ロング）に回収し，小孔まで誘導し，回収袋内の標本を細切し取り出す。脾門部の止血を確認し，ドレーンは挿入せず，層層に閉創する（図 11d）。

Ⅵ. 単孔式内視鏡手術の利点，欠点と今後の展望

単孔式内視鏡手術は NOTES の延長線として 2008 年 Cuesta らによって臍部からの傷の目立たない手術として行われ，2009 年本邦へも導入された[1]。本法の利点は傷の整容性に尽きる[2]。腹部創や肩の痛みが軽減されることや，早い回復などを挙げる論文もあるが，自験例では充来法などとの差は明らかではない[3]。

欧米における単孔式内視鏡手術の中では access devices の開発が盛んであり，SILS™ Port（コヴィ

ディエン社）ばかりでなく，TriPort™ (Advanced Surgical Concepts)，Uni-X™ Single-Port System (Pnavel Syastems, Inc.)，Airseal™ (Surgical Quest, Inc.) などが既に臨床応用されている[4]。

本邦では既に述べたように3方法があり，この中でglove法は既存の廉価な器具を組み合わせただけではあるが，利点を有する[10]。

Glove法は廉価であるばかりでなく，トロカール位置の変更が容易で，腹壁固定部分は腹壁の厚さのみと薄いので，conflictを起こしにくい形状となっている。また5本までの複数のトロカールまたは器具が誘導可能で，ステイプラーや屈曲鉗子などの使用も可能であり，応用範囲が広いという利点を有している。Basic skill的な手術における傷については，臍部皮下の剝離がなく，既存のaccess deviceは2.5 cm以上の創となるが，本方法では完全に臍部のみのもっとも小さい創となるため，整容的で，痛みも少ないと考えられる。

欠点としてのプラットフォームの欠落，トロカールの逸脱については，外科用シールの添付使用や，孔を大きくしすぎないことで疑似プラットフォームの作成が容易であり，わずかな工夫で対処しうる。本法の最大の利点はadvanced surgeryの胃，大腸，脾臓，肝などの大きな標本を回収を要する症例では創長も標本に合わせ任意に作成可能で，その3～4 cm創から生じる鉗子間距離により鉗子類やカメラとのconflictが少なくなり，精緻な手技も可能である。また創汚染が防止されているため標本回収や再建が容易で，有能なデバイスの1つと考えることができる。発展途上の内容ではあるが創意工夫によって今後とも発展性があると考えている。

本法を取り巻く医療情勢は経済的にまた安全面において厳しい局面を迎えており，とくにDPC等でのしばりの多い，本邦の医療界の中では高額医療を避け，器具を工夫して対応することは今後とも要求される事項である。単孔式内視鏡手術での臍部における創部の整容性は，充来の内視鏡手術に比較して，魅力的である。しかし，conflictの多さによる鉗子の動きの制限，視野の不安定さは，内視鏡手術の大きな利点を奪いかねない欠点と言える。われわれ次世代を担う内視鏡外科医は，この良質な視野確保を担保し，限られたコストの中で，よりよい整容性を求め，単孔式内視鏡手術の欠点を埋める努力を継続しなければならない。Glove法はその中で根治性，安全性，低侵襲性，整容性の満たされた手術であり，簡便で経済的なデバイスであると確信している。

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Original Paper

Oncological Outcomes of Laparoscopic Surgery in Elderly Patients with Colon Cancer: A Comparison of Patients 64 Years or Younger with those 75 Years or Older

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KEY WORDS: Laparoscopic colectomy; Matched case–control study; Elderly

ABBREVIATIONS: Computed Tomography (CT)

ABSTRACT

Background/Aims: We compared the results of laparoscopic resection of colon cancer between patients 75 years or older and those 64 years or younger, to confirm whether this procedure is warranted in elderly patients.

Methodology: The study group was comprised of patients with stage I to III colon cancer treated by laparoscopic surgery from 1995 through 2006. Oncologic outcomes were compared between 74 patients 75 years or older (elderly group) and 74 patients 64 years or younger (younger group) who were matched for gender, tumor location and pathological tumor-node-metastasis (TNM) stage.

Results: In patients with stage I or II disease, the disease-free survival rate and overall survival rate were similar in the elderly group (100% and 100%, respectively) and the younger group (95.6% and 95.8%, respectively). In patients with stage III disease, the disease-free survival rate and overall survival rate were also similar in the elderly group (76.7% and 88.5%, respectively) and the younger group (88.5% and 88.5%, respectively).

Conclusions: Postoperative complications and long-term oncologic outcomes were similar in elderly patients and younger patients with colon cancer who underwent laparoscopic colectomy in our hospital. These results demonstrate that laparoscopic resection of colon cancer is warranted in patients 75 years or older.

INTRODUCTION

Laparoscopic colectomy was first performed in 1990, and its indication range has been extended from early to advanced cancer. The increased use of laparoscopic surgery is attributed to several distinct advantages over open surgery, such as less postoperative pain, a lower risk of postoperative ileus, a shorter postoperative hospital stay, and earlier recovery and return to social activities, i.e. a better postoperative quality of life (1-3). Aging is generally a risk factor for surgery. In elderly patients, surgery carries increased risks of serious postoperative complications and operative mortality because of age-related declines in physical function and reserve capacity and the presence of various underlying diseases. Once complications occur, elderly patients are at risk for the development of multiple organ failure. They therefore require a careful assessment of the indications for surgery, selection of surgical procedures and close perioperative management (4). Conventional open surgery in elderly patients may prolong the hospital stay, as well as increase mortality and morbidity (5-8). We believe that elderly patients should undergo minimally invasive, laparoscopic colorectal surgery.

Since 1995, we have performed laparoscopic colorectal surgery in more than 800 patients with colorectal cancer in our hospital. To date, few studies have evaluated the safety and invasiveness of laparoscopic surgery specifically in elderly patients (9-13). Short- and long-term outcomes of laparoscopic surgery in elderly patients with colon cancer remain unclear owing to the lack of large, randomized control studies. To gain insight into these problems, we performed a matched case-control study to compare short- and long-term outcomes between patients 75 years or older (elderly group) and patients 64 years or younger (younger group) who underwent laparoscopic surgery for colon cancer. Our ultimate goal was to determine whether laparoscopic surgery is warranted in elderly patients.

METHODOLOGY

Among 344 patients who underwent laparoscopic surgery for colon cancer from April 1995 through December 2006, we studied 74 elderly patients (age, ≥75 years) and 74 younger patients (age, ≤64 years) who

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were matched for gender, tumor location, and pathological tumor-node-metastasis (TNM) stage. Patients with ileus (no response to decompression) and those who did not give informed consent for laparoscopic surgery were excluded from the study. The indications for laparoscopic surgery were assessed in all patients on the basis of the results of barium enema examination, colonoscopy, abdominal ultrasonography and computed tomography (CT) of the chest and abdomen. From 1995 through 2000, the indications for laparoscopic surgery were generally restricted to early cancer. Subsequently, the indications for laparoscopic surgery were extended to include advanced cancer without multiple-organ invasion. The technique for laparoscopic surgery is described in detail elsewhere (14). Briefly, a 12mm trocar was first placed in a small sub-abdominal incision (3-4cm), and a Lap Disc (70x70mm; Johnson and Johnson) was placed on the upper abdomen. The abdomen was insufflated with carbon dioxide at a mean pressure of 8mmHg/h. Three or four 5mm trocars were then placed using a 5mm scope. Postoperative follow-up examinations included the measurement of serum carcinoembryonic antigen levels (at 3-month to 1-year intervals), chest and abdominal CT (at 6-month intervals), and colonoscopy (at 1-year intervals), in addition to routine outpatient visits. Recurrent disease was assessed on the basis of the results of diagnostic imaging and clinical, laboratory, and histopathological examinations. Statistical analysis was performed with the use of chi-square test and Mann-Whitney U test. A p-value of less than 0.05 was considered to indicate statistical significance. Disease-free survival rates and overall survival rates were estimated according to the Kaplan-Meier method. The log-rank test was used to compare these values between the groups.

RESULTS

As for the demographic characteristics of the patients, age (p<0.001) and the American Society of Anesthesiologists (ASA) score (p=0.001) were significantly higher in the elderly group than in the younger group. The median follow-up period did not significantly differ between the elderly group (76 months) and the younger group (66 months) (**Table 1**). Conversion from laparoscopic surgery to open surgery was not necessary in either group.

Operation time and intraoperative blood loss did not significantly differ between the groups. The median hospital stay after surgery also did not significantly differ between the elderly group (10 days) and the younger group (9 days). The incidence of postoperative complications was similar in the elderly group (11% [8/74]) and the younger group (9% [7/74]) (**Table 2**).

Postoperative recurrence developed in 18% (13/74) of the patients in the elderly group, as compared 9% (7/74) of those in the younger Group (**Table 3**). This difference was not significant. In patients with stage I or II tumors, the disease-free survival rate and the overall survival rate were 100% and 100%, respectively in the elderly group and 95.6% and 95.8%, respectively in the younger group, indicating no significant difference in long-term outcomes between the groups (**Figure 1**). In patients with stage III tumors, the disease-free survival rate and the overall survival rate in the elderly group were 76.7% and 88.5%, respectively, and 88.5% and 88.5%, respectively in the younger group, indicating no significant difference in long-term outcomes between the groups (**Figure 2**).

DISCUSSION

In this single-center, matched case-control, study of patients with colon cancer who underwent

TABLE 1 Demographic Characteristics of the Patients

	Younger (n = 74)	Elderly (n = 74)	p-value
Male:Female	38:36	38:36	NS
Age (years)*	58 (35–64)	79 (75–91)	<0.001
Location			NS
Cecum	10	10	
Ascending colon	31	31	
Transverse colon	5	5	
Descending colon	3	3	
Sigmoid colon	13	13	
Rectosigmoid colon	12	12	
BMI (kg/m^2)*	22 (17–28)	22 (14–38)	NS
ASA status			<0.001
I	43	31	
II	28	51	
III	3	18	
Tumor size (cm)*	3.6 (1–9)	3.4 (1–8)	NS
Lymph nodes*	16 (2–58)	14 (4–38)	NS
pT category			NS
pT1	18	18	
pT2	13	13	
pT3	43	43	
pN category			NS
pN0	48	48	
pN1	24	24	
pN2	2	2	
p TNM			NS
I	28	28	
IIA	20	20	
IIIA	3	3	
IIIB	21	21	
IIIC	2	2	
Follow-up period (months)*	80 (10–145)[a]	66 (14–178)[b]	NS

BMI denotes body mass index; ASA status, physical status according to the American Society of Anesthesiologists classification; * Values are expressed as medians (range); a, n (alive at last visit) = 80; b, n (alive at last visit) = 66; NS, not significant.

TABLE 2 Operation Time, Blood Loss During Operation, Hospital Stay and Postoperative Complications

	Younger (n=74)	Elderly (n=74)	*p*-value
Operation time (min)	195 (120–345)	190 (85–380)	NS
Blood loss during operation (mL)	20 (0–720)	20 (0–325)	NS
Hospital stay (days)	9 (4–26)	10 (5–44)	NS
Postoperative complications			
Wound infection	2	2	NS
Ileus	2	4	NS
Postoperative bleeding	1	1	NS
Others	2	1	
Total	7 (9%)	8 (11%)	NS

Values for operation time, blood loss volume, and hospital stay are expressed as medians (range). Values for wound infection, Ileus and postoperative bleeding represent the number of events; NS, not significant.

TABLE 3 Tumor Recurrence in Patients with Colon Cancer

Recurrence site	Younger (n=74)	Elderly (n=74)	*p*-value
Liver	2	5	NS
Lung	1	3	NS
Peritoneum	3	1	NS
Lymph node	1	3	NS
Anastomosis	0	1	NS
Total	7	13	NS

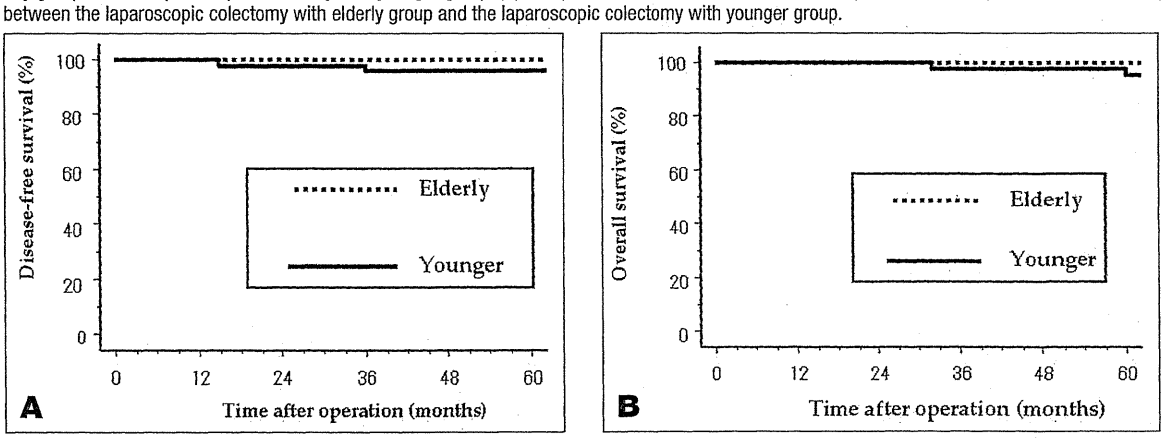
NS denotes not significant

laparoscopic surgery, the ASA score differed significantly between the elderly group and the younger group. Nonetheless, there were no significant differences between the groups in the median hospital stay, postoperative complications, the rate of postoperative recurrence, and long-term outcomes.

In elderly patients, open colorectal surgery has been linked to increased mortality due to postoperative complications, whereas overall survival rate according to disease stage was found to be similar in elderly and younger patients (15-18). Reduced surgical invasion may lead to fewer and less severe postoperative complications, as well as prompter recovery. Minimally invasive laparoscopic surgery is thus considered to offer important advantages over open surgery for elderly patients. All studies evaluating laparoscopic colectomy in elderly patients have demonstrated several advantages of this technique over open surgery (5-13). Hester *et al.* (19) studied short- and long-term outcomes after laparoscopic resection for colorectal cancer in 101 patients 80 years or older. The median age was 83 years (range, 80-95 years). There were no intraoperative complications, and the overall postoperative morbidity rate was 17%. The incidences of wound infection and cardiopulmonary complications were low. The overall postoperative mortality rate was 3%. There was no association between operative mortality the ASA score. The 5-year overall survival rate was 51%. These results are similar to our findings. Because laparoscopic surgery is associated with low postoperative morbidity and good outcomes, we believe it should be recommended for elderly patients.

Elderly patients have a high rate of mortality from cardiovascular causes and a high rate of respiratory complications after open surgery for colorectal cancer (6,7). In one study, 55% of deaths were caused by surgery-related cardiopulmonary

FIGURE 1 (**A**) Comparison of the disease–free survival rates in patients with stage I or II colon cancer between the laparoscopic colectomy with elderly group and the laparoscopic colectomy with younger group. (**B**) Comparison of the overall survival rates in patients with stage I or II colon cancer between the laparoscopic colectomy with elderly group and the laparoscopic colectomy with younger group.



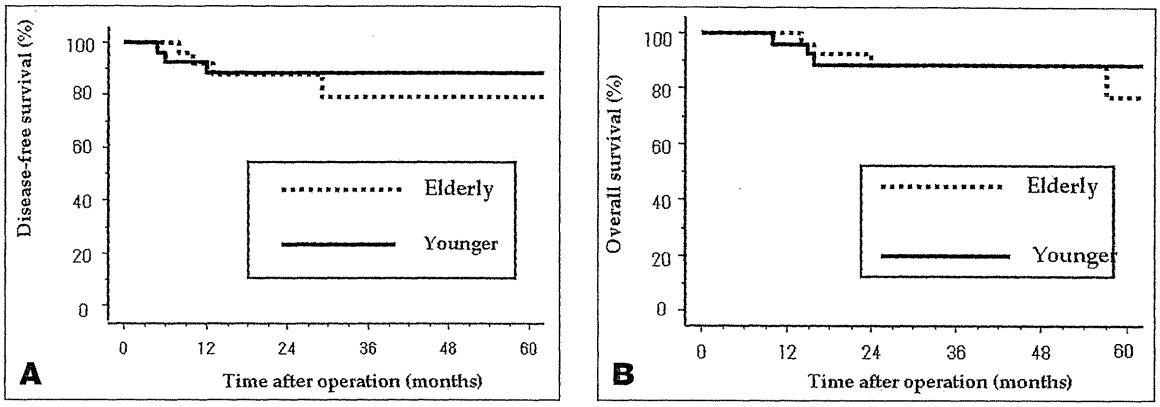


FIGURE 2 (**A**) Comparison of the disease–free survival rates in patients with stage III colon cancer between the laparoscopic colectomy with elderly group and the laparoscopic colectomy with younger group. (**B**) Comparison of the overall survival rates in patients with stage III colon cancer between the laparoscopic colectomy with elderly group and the laparoscopic colectomy with younger group.

complications (6). In our study, however, there were no cardiac complications or deaths after laparoscopic surgery in the elderly group, similar to the results of a study by Law *et al.*, which reported one death among patients who underwent laparoscopic colectomy (11).

The elderly group in our study included patients 75 years or older because the World Health Organization uses this cutoff point to define "late elderly" persons. The ASA score was class II or higher in a significantly higher proportion of patients in the elderly group (88%) than in the younger group (42%). In our study, no elderly patient died during surgery, and the ASA score was not associated with operative mortality or the length of the hospital stay. Most notably, the 5-year survival rate in the elderly group was 100% in patients with stage I or II disease and 76.7% in those with stage III disease. Their results compare favorably with those of other studies in general patients with colorectal cancer (1-3).

In elderly patients with colon cancer, accurate risk assessment before surgery requires close cooperation with internists as well as members of the surgical team, including anesthesiologists (20,21). Further technological advances in laparoscopic surgery and increased experience among surgeons will most likely promote the use of laparoscopic procedures for the treatment of colon cancer in elderly patients. The results of future, multicenter, prospective clinical trials are expected to establish laparoscopic surgery as a safe and effective procedure for elderly patients with colon cancer.

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原著

下部消化管腹腔鏡手術中呼気終末二酸化炭素濃度の検討

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内容要旨

目的:呼気終末二酸化炭素濃度(以下EtCO2)は,血中の二酸化炭素濃度を反映する.腹腔鏡下手術中,気腹に伴う血中二酸化炭素濃度の上昇からEtCO2も上昇する.術中のEtCO2上昇の危険因子としては,皮下気腫・気胸などがある.当院での大腸腹腔鏡手術時の高二酸化炭素血症とEtCO2上昇の術前および術中の危険因子について検討した.方法:2006年6月から2009年3月までの大腸腹腔鏡手術150例において,術中EtCO2が最高値45mmHg以上を示した症例(以下A群)と最高値45mmHg未満であった症例(以下B群)の2群間で,年齢,性別,BMI,術前合併症,術前呼吸機能検査,喫煙歴,手術時間,気腹時間,出血量,皮下気腫について検討した.結果:皮下気腫の発生率でA群とB群間に有意な差を認めた.考察:今回の検討からは,術前因子で高二酸化炭素血症を予測するのは困難であった.

索引用語:腹腔鏡手術,高二酸化炭素血症,EtCO2

はじめに

呼気終末二酸化炭素濃度(以下EtCO2)は,血中の二酸化炭素濃度(以下PaCO2)を反映する.肺胞死腔が大きい慢性肺疾患や肺血流量が減少する肺塞栓といった病態を除くと,EtCO2とPaCO2との差は通常5mmHg以下とされている[1].一般的にPaCO2が45mmHg以上を高二酸化炭素血症と定義されており,高二酸化炭素血症では,中枢神経が抑制されることもあり,臓器の別を問わず,外科周術期には慎重な呼吸管理が必要である.気腹を用いた腹腔鏡下手術中,稀に高二酸化炭素血症を合併し,著明なEtCO2の上昇を認めることがある.当院での腹腔鏡下大腸手術時の高二酸化炭素血症の合併について,EtCO2値を用いてretrospectiveに検討し,高二酸化炭素血症の術前および術中危険因子について検討した.

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対象と方法

対象は,2006年6月から2009年3月まで当院で施行した腹腔鏡下大腸手術150例とした.150例の性別,年齢,疾患,手術時間,気腹時間,出血量,術後入院日数,術前後の合併症を**Table 1**に示した.

Table 1で示したように,今回の検討症例の中には術前に慢性肺疾患や肺塞栓症の患者は存在しなかった.このためPaCO2とEtCO2の差はほとんどないと考え,術中EtCO2が徐々に上昇し呼吸器設定変更にも関わらず一時点でも最高値が45mmHg以上であった症例を高二酸化炭素血症群(A群)とし,EtCO2が45mmHg未満であった症例を正常群(B群)として,2群間で患者因子である年齢,性別,BMI,術前合併症,術前呼吸機能検査,喫煙歴と,また手術因子である手術時間,気腹時間,出血量,皮下気腫についてそれぞれ比較検討した.2群間の比較は,Fisherの直接法あるいはMann-WhitneyのU検定を用いて行っ

Table 1 Subject summaries (150 cases)

Gender (Male/Female)	83/67
Age (years)	63.0 (13—89)
Diagnosis	Colorectal cancer 134 (colon 104, rectum 30) Rectal prolapse 4 Appendicitis 9 Diverticulitis 3
Operating time (m)	213 (46—526)
Insufflation time (m)	144 (22—347)
Blood loss (ml)	26.0 (2—360)
Postoperative hospital stay (days)	11.7 (3—124)
Preoperative complications	Cranial disease 6 Cardiovascular disease 18 Hepatic disease 6 Endocrine/Renal disease 15 Malformation 1 Malignant tumor 10 Steroids 2
Postoperative complications	Pulmonary embolism 1 Ileus 6 Surgical site infection 7 (Organ abscess 3, leakage 4) Hemorrhage 2 Urinary infection 2 Wound separation 2

Table 2 Peak EtCO2 exceeding 45 mmHg

Case	Gender (Male/ Female)	Age (years)	Diagnosis	BMI	Smoking history (cigarettes per day)	Insufflation time (m)	Subcutaneous emphysema
1	Female	59	Adenoma	20	30	197	No
2	Female	70	Colon cancer	17.9	0	163	Yes
3	Female	58	Colon cancer	34.3	0	131	No
4	Male	77	Rectal prolapse	21.5	0	164	No
5	Female	34	Colon cancer	18.2	0	143	No
6	Female	38	Rectal cancer	21.7	0	310	No
7	Female	80	Colon cancer	16.9	0	204	Yes
8	Female	13	Appendicitis	14.9	0	78	No
9	Male	66	Rectal cancer	24.4	20	156	No
10	Male	65	Colon cancer	31.8	0	119	No
11	Male	65	Rectal cancer	19.9	12	187	No

Note : Preoperative respiratory results were within the normal range in these subjects.

た．$P<0.05$をもって有意とした．

術前呼吸機能検査については，1秒率（1秒量/努力性肺活量）が70%以下の閉塞性換気障害があるか，あるいは%肺活量が80%以下の拘束性換気障害のいずれかの場合を呼吸機能異常とした．喫煙歴は，入院前まで喫煙していた場合を喫煙歴ありとし,過去の喫煙は今回の検討では，喫煙歴なしとした．

また，麻酔中は，心電図，経皮的動脈酸素飽和度（以下SpO2），EtCO2，膀胱温を連続的にモニターし，5分ごとに非観血的動脈圧測定を行った．呼吸は，気管内挿管直後より1回換気量8～

Table 3　Preoperative factors

	Group A (n=11)	Group B (n=139)	P
Age (years)	56.8 (13−77)	63.8 (27−89)	0.09
Gender (Male/Female)	4/7	79/60	0.22
BMI	22.0 (14.9−34.3)	23.1 (16.2−41)	0.41
Preoperative complication (cases)	4 (36.4%)	54 (38.8%)	>0.99
Preoperative respiratory examination (cases)	Normal 11	Normal 119 Abnormal 20	0.36
Smoking history (cases)	3 (27.2%)	25 (18.0%)	0.43

Table 4　Operative factors

	Group A (n=11)	Group B (n=139)	P
Operating time (m)	216 (106−351)	213 (46−526)	0.88
Insufflation time (m)	168 (78−310)	142 (25−347)	0.19
Blood loss (ml)	22.3 (5−130)	26.2 (2−360)	0.79
Subcutaneous emphysema (cases)	2	0	0.005

10ml/kg，呼吸回数10～12回/分の調節呼吸として，最高気道内圧が30cmH2Oを，EtCO2が40mmHgを超えないように呼吸回数と１回換気量を増減した．動脈内留置カテーテル（以下A-line）は，通常は確保せず，術前のAmerican Society of Anesthesiologists分類が高い場合にA-line確保することを考慮した．腹腔鏡下の手技は，気腹圧8mmH2Oで二酸化炭素を用いた気腹下に行った．

結　果

150例のうち男性83例，女性67例であり，平均年齢は63.0歳（13歳～89歳）であった．疾患の内訳は大腸癌134例（結腸癌104例，直腸癌30例），直腸脱４例，虫垂炎９例，憩室炎３例であった．平均手術時間は213分（46分～526分），平均気腹時間は144分（22分～347分），平均出血量は26.0ml（２～360ml），平均術後在院日数は11.7日（３日～124日）であった．術前の合併症は，58例（38.7%）に認められ，内訳は先天疾患から悪性腫瘍，心・循環器疾患，内分泌・代謝・腎疾患などと多岐に及んだ．術後合併症は19例（12.7%）で認めた．中でもSSIが７例，腸閉塞が６例と多かったが，肺梗塞による死亡例１例を除き保存的あるいは再手術により病態改善し，退院した．

EtCO2最高値が45mmHg以上であったA群（**Table 2**）は11例で，EtCO2の平均値は49.6mmHg（45～68mmHg）であった．一方，45mmHg以下であったB群は139例であり，平均値は37.5mmHg（33～44mmHg）であった．

1．患者因子

A群とB群における平均年齢はそれぞれ56.8歳，63.9歳（p＝0.09）であった．性別はA群が男性４例，女性７例に対してB群では，男性79例，女性60例（p＝0.22）であった．BMIは，A群22.0，B群23.1（p＝0.41）であり，年齢，性別，BMIで２群間で統計学的に有意な差は認めなかった．術前合併症は，A群で４例（36.4%），B群で54例（38.8%）（p＞0.99）であった．また，術前呼吸機能検査は，A群全例で異常を認めず，B群では119例（85.6%）で異常を認めなかった（p＝0.36）．術前まで喫煙をしていたのは，A群で３例（27.2%），B群で25例（18.0%）であり（p＝0.43），術前合併症，術前呼吸機能検査，喫煙歴でも有意な差を認めなかった（**Table 3**）．

2．手術因子

A群とB群における手術時間の平均値はそれぞれ216分，212分（P＝0.88）であった．気腹時間の平均値はそれぞれ168分，142分（P＝0.19）であり

術中出血量は，A群で22.3ml，B群で26.2ml（P＝0.79）であり，手術時間，気腹時間と出血量では有意な差を認めなかった．術中の皮下気腫をA群で2例に認めた一方，B群では認めず（P＝0.005），A群，B群で統計学的に有意な差を認めた（**Table 4**）．

術後，A群全ての症例で換気不全などによる再挿管は不要であった．また，11例とも気胸，二酸化炭素塞栓，気道閉塞などの合併症は認めなかった．皮下気腫2例については，術後皮下気腫の増悪を認めなかった．

考　察

二酸化炭素を使用した気腹中は，腹腔内圧の上昇と横隔膜の挙上により全肺気量，機能的残気量，肺・胸郭コンプライアンスが低下し[2]，加えて二酸化炭素が腹膜から吸収されることにより血中の二酸化炭素濃度が上昇する．二酸化炭素を利用した気腹により，PaCO2は通常10mmHg程度上昇する[3][4]が，分時換気量の増加で通常是正が可能である．今回，EtCO2の著明な上昇を呈した11例は，調節呼吸と気腹終了により，全例EtCO2は45mmHg以下に低下し，腹腔鏡下手術を完遂することができた．是正されない二酸化炭素血症をきたした場合には，皮下気腫，気胸，二酸化炭素塞栓，気道閉塞などの合併を考えなければならず，腹腔鏡下の手技の中止や，手術そのものの中断，中止も考慮する必要もある．今回の検討では，高二酸化炭素血症をきたした11例のうち2例で皮下気腫を認めたが，その他の合併症は認めなかった．術中皮下気腫を認めた2症例については，皮下からの二酸化炭素の吸収により高二酸化炭素血症をきたしたと考えられる．また，Conettaら[5]やEveloffら[6]が，広範な皮下気腫による胸壁の圧迫により胸郭の運動が制限され，呼吸不全となった症例を報告しているように，皮下気腫による胸郭の運動制限により高二酸化炭素血症を助長させた可能性もある．

真弓ら[7]は，皮下気腫を生じる原因には，外科手技上の問題と患者側因子があると報告している．外科手技としては，トロカール刺入部からの二酸化炭素の流入および過度の腹腔内圧の上昇が考えられる．患者側因子としては，皮下組織の脆弱性，横隔膜組織の脆弱性などが挙げられ，女性，高齢者，痩せ型の人に皮下気腫の発生が多いとされる[8][9]．今回われわれが行ったA，B2群間の比較検討では，トロカールが不安定であったかどうかは不明である．腹腔内圧は，8mmHg前後で調節されているため皮下気腫の原因としては，否定的と考える．一方，患者側因子としては，2症例とも高齢の女性であり，BMIも17と18であり，いずれも痩せ型であった．以上のことから，本症例における皮下気腫を生じた2例については，患者側因子によるものである可能性が高いと考えられる．

今回の患者因子とEtCO2の関連性の検討では，年齢，性別，BMI，術前合併症，術前呼吸機能検査，喫煙歴はいずれも高二酸化炭素血症の明らかな要因とはならず，術前から高二酸化炭素血症を予測するのは困難であった．

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End-Tidal Carbon Dioxide Examination Following Laparoscopic Colorectal Surgery

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End-tidal carbon dioxide (EtCO2), reflecting the blood carbon dioxide level, rises during laparoscopic surgery as blood carbon dioxide density increases with insufflation. We studied risk factors for hypercarbia and EtCO2 increase during laparoscopic colorectal surgery. The 150 subjects, operated on between June 2006 and March 2009, were divided into those whose EtCO2 peaked during surgery at over 45 mmHg (group A, n=11) and those whose EtCO2 did not (group B, n=139). We compared the 2 groups for age, gender, body mass index (BMI), presurgical complications, presurgical respiratory function, smoking, insufflation time, bleeding volume, and subcutaneous emphysema. No significant differences were found except in subcutaneous emphysema. We concluded that hypercarbia is difficult to estimate preoperatively.

Key words: laparoscopy, end-tidal carbon dioxide, hypercarbia

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ORIGINAL ARTICLE

Diverting stoma in rectal cancer surgery. A retrospective study of 329 patients from Japanese cancer centers

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Abstract
Background A diverting stoma (DS) has been constructed for many patients with low anterior resection (LAR), but it is still controversial whether DS can prevent anastomotic leakages. The aim of this study was to investigate the risk factors of anastomotic leakage including DS construction, and to evaluate the clinical course affected by DS according to the necessity of urgent abdominal reoperation for anastomotic leakage.

Patients and methods This was a retrospective analysis of 329 middle or lower rectal cancer patients who underwent LAR with mechanical reconstruction using circular staplers. Clinical data were collected from five cancer centers in Japan.

Results The overall anastomotic leakage rate was 10.0% (33 of 329). We experienced one mortality in this series (0.3%; 1/329). Clinical factors associated with DS construction included tumor location, operation time, intraoperative bleeding, lateral lymph node dissection, simultaneous resection of other organs, and the level of anastomosis, respectively.

On univariate analysis, high ligation of the inferior mesenteric artery had a significantly high leakage rate, but not on multivariate analysis. DS construction had no connection with the overall leakage rate. Concerning the clinical course affected by DS, the frequency of urgent reoperation was significantly increased in patients without DS compared with those with DS, 11.1% and 54.2%, respectively (p=0.04).

Conclusions LAR was the safe and preferred option for rectal cancer patients with very low mortality and an acceptable leakage rate. DS did not have a relationship with overall anastomotic leakage, but did seem to mitigate its consequences and reduce the requirement for urgent abdominal reoperation.

Keywords Rectal cancer · Anastomotic leakage · Diverting stoma · Defunctioning stoma · Low anterior resection

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Introduction

Anastomotic leakage is a major problem in rectal cancer surgery, because a sphincter-preserving operation has become standard for many rectal cancer patients. A

temporary diverting stoma (DS) has been constructed for many patients in low anterior resection (LAR). But the indication of DS construction for patients without intraoperative adverse events has not been clarified for a long time. Theoretically, DS was constructed to divert the fecal stream from anastomotic sites, and to protect fragile anastomotic sites. But it remains unproven whether diverting the fecal stream in itself directly prevents leakage. Several retrospective studies showed that the absence of DS was a risk factor for leakage in LAR, whereas others did not. Therefore, it is controversial whether DS can prevent anastomotic leakage. Although recent randomized studies [1, 2] and meta-analyses [3, 4] have shown that DS reduced the incidence of symptomatic leakage in LAR for rectal cancer, there is still limited evidence as to the impact of DS on leakage. Moreover, there have been few analyses about this issue in multicenter studies with a large number of patients from Japan.

The aim of this study was to investigate the risk factors of anastomotic leakage including DS construction, and to evaluate the clinical course affected by DS according to the necessity of urgent abdominal reoperation for such leakage using data collected from five cancer centers in Japan.

Patients and method

Patients

We reviewed the clinical data from five cancer centers in Japan which participated in the "Studies on the standardization for diagnosis, treatment, and follow-up of colorectal cancer patients", sponsored by Grant-in-Aid 18-2 for Cancer Research from the Ministry of Health, Welfare and Labor of Japan. All data on patient demographics, comorbidities, and the histological results were investigated retrospectively from the clinical records of each hospital.

From 2002 to 2004, a total of 329 consecutive patients with primary rectal cancer underwent LAR, and were investigated in this series. LAR was performed on patients with middle or lower rectal cancer, and reconstructions were done using circular staplers. Coloanal anastomosis using the hand-sewn technique was excluded from this study. Patients with subtotal colectomy, total proctocolectomy, abdominoperineal resection, Hartmann's procedure, or with pull-through procedures were also excluded.

Surgical procedure

The inferior mesenteric artery (IMA) was divided either at its origin or below the origin of the left colic artery (LCA). High ligation of IMA was defined as dividing IMA at its origin, while low ligation was defined as dividing IMA below the origin of LCA. For oncological lymph node dissection, we classify regional lymph nodes into three groups: perirectal, intermediate, and main lymph nodes. Perirectal nodes are lymph nodes in the mesorectum along the superior rectal artery. Intermediate nodes are lymph nodes along IMA between the origin of the left colic artery and the origin of the terminal sigmoid artery. Main nodes mean the lymph nodes along the IMA proximal to the origin of the LCA [5]. Lymph node dissection for UICC stage I is complete dissection of perirectal and intermediate lymph nodes, that is, low ligation without lymph node dissection around the root of IMA. Lymph node dissection for stage II, III, and IV is complete dissection of all regional lymph nodes, that is, high or low ligation with lymph node dissection around the root of IMA [6].

After total mesorectal excision or tumor-specific mesorectal excision [7], we performed rectal irrigation, while clamping the anal side of the tumor. The rectum was then divided transversely or vertically [8]. After that, we usually added lateral lymph node dissection for patients diagnosed with stage II, III, and IV [9]. Although the extent of lymphadenectomy for stage IV is still debatable, in the case that every distant metastasis (stage IV) was resectable, we perform full lymph node dissection.

Reconstruction was done using a circular stapler. Most anastomoses were straight, and colonic J pouch or transverse coloplasty pouch was sometimes used at the discretion of the operating surgeon. Intraoperative leakage test by transanal instillation of fluid or air was performed depending on the surgeon. Pelvic drain was used routinely.

Indication of DS construction

No clear applicable criteria for DS construction were stipulated in the present study. The DS construction decision was made by the individual surgeon in each case.

Definition of anastomotic leakage

Anastomotic leakage was defined clinically by the presence of the following: discharge of gas, pus, or feces from the drain or wound; discharge of pus per rectum; or rectovaginal fistula. All clinically suspicious anastomotic leakages were confirmed by one or more of the following image diagnoses: contrast study; CT scan; rectoscopy. If these cases were proven not to show anastomotic insufficiency by these imaging studies, they were defined as pelvic abscess

and not as anastomotic leakage. We did not perform routine diagnostic imaging after LAR to detect anastomotic dehiscence in clinically stable patients.

Variables analyzed

Variables included in this analysis were age, gender, body mass index (BMI), bowel obstruction, tumor location, tumor invasion, adjuvant therapy, level of IMA ligation, lateral lymph node dissection, type of anastomosis (single stapling technique, SST; or double stapling technique, DST), pouch surgery, intraoperative blood loss, operating time, DS construction, synchronous resections of other organs (hepatectomies for simultaneous liver metastasis or extended surgery to adherent organs, or additional cancer resections for double cancers), tumor size, and distal resection margin of specimen.

Bowel obstruction was defined as stenosis preventing the passage of a colon fiberscope. Tumor location was classified into middle or lower rectum according to the main part of the tumor. Tumors in the lower rectum were defined as those in which the main part was located below the peritoneal reflection. Tumor location in relation to the anal verge was preoperatively measured using rigid scope or digital examination. Tumor invasion was classified according to the UICC-TNM classification (6th edition [10]) preoperatively. Tumor size and distal resection margin were measured on the specimen before fixation with formalin. The level of anastomosis from the anal verge was measured with a digital examination. But due to the retrospective nature of this study, when the data were not available, the distance was calculated from the tumor location and distal resection margin.

Statistical analysis

In the univariate analysis, the chi-squared test and Mann–Whitney test were used. After univariate analysis, variables with a p value$\leq$0.1 were selected for multivariate analysis. A multivariate analysis was performed using a binary logistic regression model. All p values <0.05 were considered statistically significant.

Table 1 Patient characteristics

Gender	
Male	215
Female	114
Age(years)	59.0±10.5 (23–87)
Tumor location (cm)	6.1±1.7 (4.0–12.0)
Bowel obstruction	
No	305
Yes	18
Missing	6
Tumor invasion	
T1,T2	108
T3,T4	215
Missing	6
Neoadjuvant chemo Tx	
No	324
Yes	5
Anastomosis	
SST	15
DST	314
High ligation	
No	142
Yes	183
Missing	4
LLND	
No	197
Yes	132
Level of anastomosis (cm)	4.1±1.4 (1.0–9.5)
Intraoperative bleeding (ml)	598±590 (10–3723)
Operating time (min)	240±104.1 (90–620)
BMI (k/m^2)	22.6±3.1 (14.1–31.2)
Tumor size (cm)	4.4±2.3 (0–12.0)
Simultaneous resection	
No	292
Yes	37
DS construction	
No	209
Yes	120

Values are number or mean±standard deviation (ranges)

DS diverting stoma, *BMI* body mass index, *SST* single stapling technique, *DST* double stapling technique, *LLND* lateral lymph node dissection

Results

Patient characteristics

From 2002 to 2004, a total of 329 consecutive patients underwent LAR. Patient characteristics were shown in Table 1. One hundred and eighteen middle rectal cancer patients and 211 low rectal cancer patients were investigated in this series. Average distance from the lower edge of the tumor to the anal verge was 6.1 cm (4.0–12.0 cm). Average distance from anastomosis to the anal verge was 4.1 cm (1.0–9.5 cm).

Neoadjuvant chemotherapy was performed for five patients, but others were treated by surgery alone. Neo-

adjuvant radiotherapy or chemoradiotherapy was not performed in this series, because preoperative therapy for resectable rectal cancer was not standard in Japan.

Synchronous resections included 20 extended resections for direct invasion of adjacent organs, 13 hepatectomies for liver metastasis, and five resections of double primary cancers.

Morbidity and mortality

The overall rate of anastomotic leakage was 10.0% (33 of 329). We experienced only one mortality in this series (0.3%; 1/329). This patient died from a septic complication caused by anastomotic leakage in the case of LAR with DS 6 days after initial surgery.

Diverting stoma

A DS was constructed in 120 patients (36.5%; 120 of 329) in initial LAR, respectively. Among the colorectal surgeons participating in this study, ileostomy was major and chosen for 92 (76.7%) patients, while transverse colostomy was done for 28 (23.3%) patients.

The DS construction rate had a significant association with tumor location. DS was constructed in only 12.7% of middle rectal cancer patients, but in 48.3% of low rectal cancer patients who experienced temporary stoma at initial LAR, respectively.

Other factors found to be significantly associated with DS construction included tumor location, operation time, intraoperative bleeding, lateral lymph node dissection,

Table 2 Univariate analysis of factors related with DS construction

	Diverting stoma		Rate	*p*-value
	DS(−)	DS(+)		
Gender				
Male	130	85	39.5	0.11
Female	79	35	30.7	
Age (years)	58.8±10.7 (23–87)	59.4±10.2 (29–75)		0.42
Tumor location (cm)	6.4±1.6 (4.0–12.0)	5.9±1.7 (4.0–12.0)		0.001
Bowel obstruction				
No	195	110	36.1	0.76
Yes	11	7	38.9	
Tumor invasion				
T1,T2	71	37	34.6	0.50
T3,T4	133	82	38.1	
Neoadjuvant chemo Tx				
No	204	120	37.0	0.10
Yes	5	0	0.0	
Anastomosis				
SST	8	7	46.7	0.40
DST	201	113	36.0	
High ligation				
No	125	58	31.7	0.12
Yes	82	60	42.3	
LLND				
No	146	51	25.9	<0.0001
Yes	63	69	52.3	
Level of anastomosis (cm)	4.2±1.4 (1.0–9.0)	3.8±1.4 (1.0–9.5)		0.002
Intraoperative bleeding (ml)	505±524 (10–2985)	760±662 (17–3723)		<0.0001
Operating time (min)	231±90.6 (90–559)	318±102.7 (130–620)		<0.0001
BMI (k/m^2)	22.9±3.0 (14.1–31.2)	22.3±3.2 (15.8–30.8)		0.07
Tumor size (cm)	4.4±2. (0–12.0)	4.4±2.3 (1.0–10.0)		0.97
Simultaneous resection				
No	192	100	34.2	0.02
Yes	17	20	54.1	

Values are number or mean± standard deviation (ranges)

BMI body mass index, *SST* single stapling technique, *DST* double stapling technique, *LLND* lateral lymph node dissection