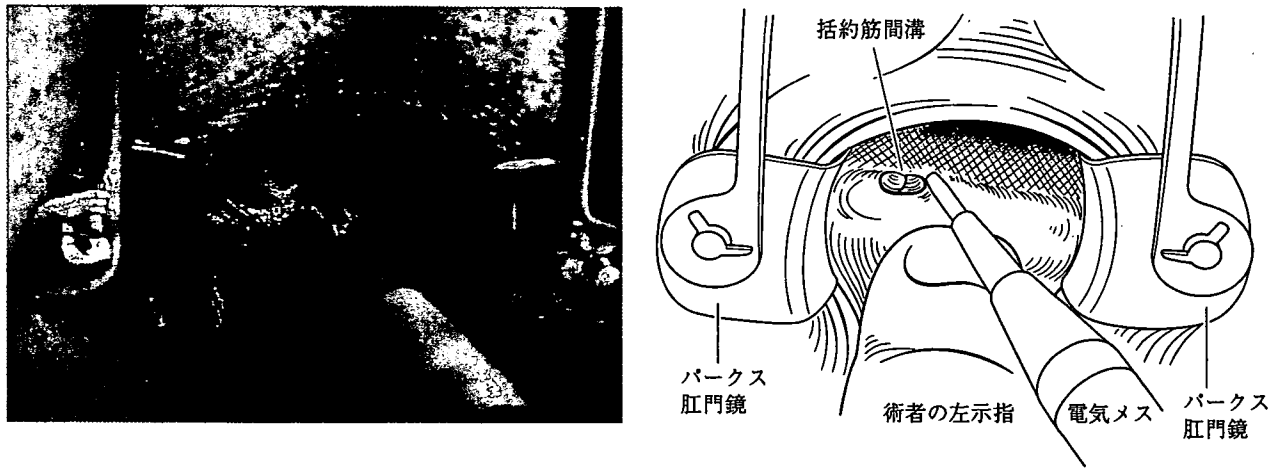


図3 括約筋間溝の切開
後壁の括約筋間溝を電気メスにて垂直に切り込む.

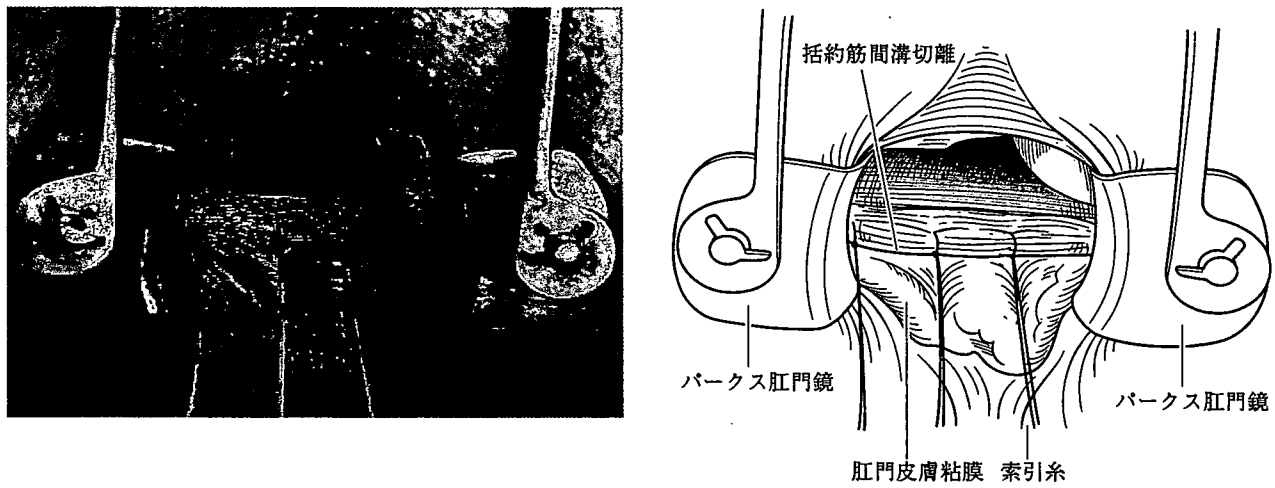


図4 肛門管切除断端の牽引
肛門管の切除断端に牽引糸をかけ，これを牽引しながら切除を進める.

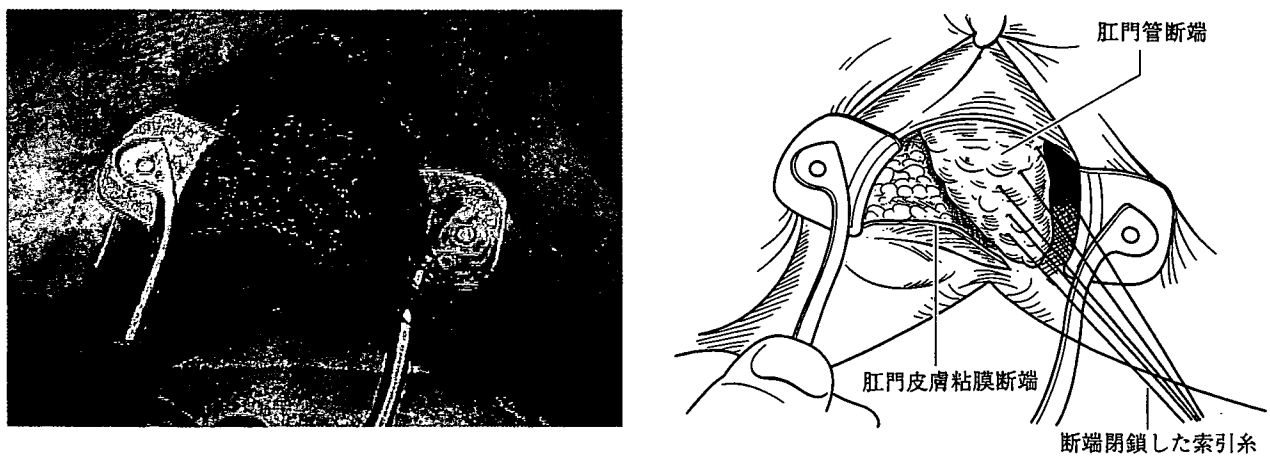


図5 肛門管断端の閉鎖
肛門管の断端を縫合閉鎖し，パークスの肛門鏡を仙骨前に挿入する.

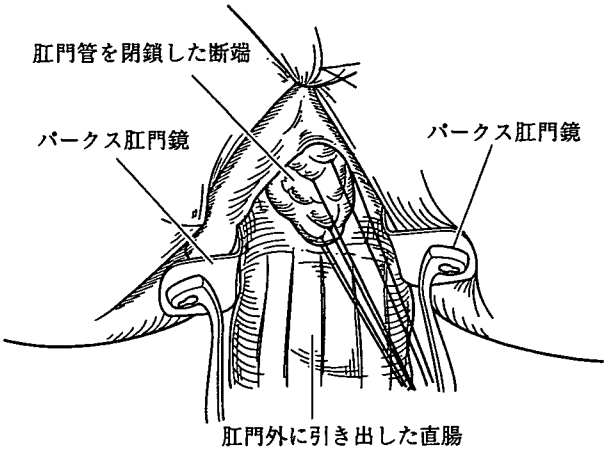


図6　肛門外直腸引き出し法
直腸の口側断端を腹会陰式直腸切断術の如く肛門外に引き出す.

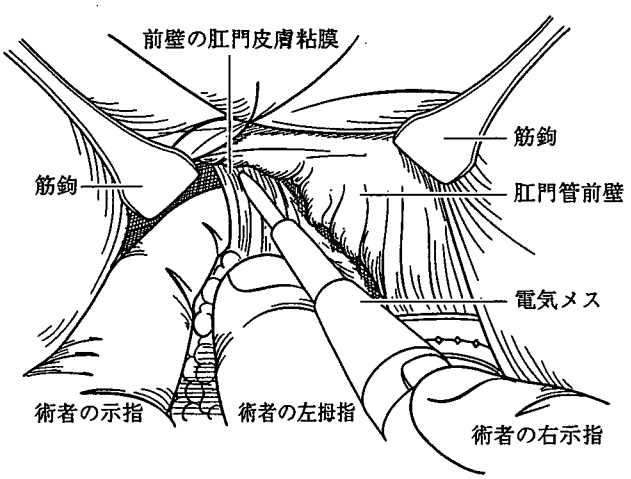
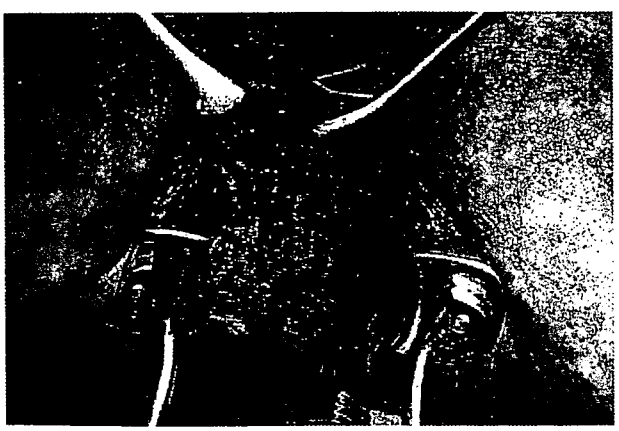


図7　肛門管前壁の切離
腹会陰式直腸切断術の要領で左の示指で直腸を圧排しながら，前壁側の恥骨直腸筋を切離する.



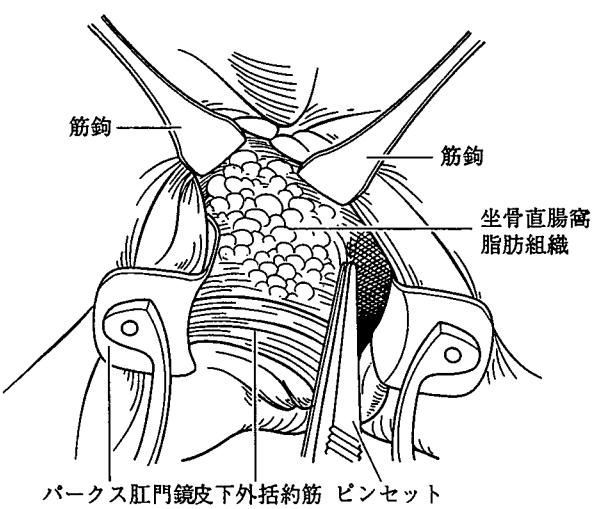


図8　直腸摘出後に仙骨前面
肛門挙筋が切離され，坐骨直腸窩の脂肪組織が露出している.

知すると，すぐ口側に内括約筋との境界に一致する括約筋間溝を確認できる．図3に示すように電気メスを後壁の括約筋間溝に沿って垂直に切り込む．浅外括約筋も一部温存しようとすれば，口側方向に斜めに切り込むとよい．さらに深く切り込んでいくと，腹腔側から剝離した坐骨直腸窩脂肪組織に到達する．図4に示すように切除断端に牽引糸をかけ，これを牽引しながら切除すると操作が容易である．左右の側壁も同様に切除した後，癌細胞の散布を防止する目的で図5に示すように肛門管の断端を縫合閉鎖し，パークスの肛門鏡を仙骨前(肛門内ではない)に挿入する．前壁の切除は肛門側切除断端が十分に縫合閉鎖できるまで行った方がよい．次いで，肛門側切除断端の牽引糸を上方に引き上げ，腸ベラにて直腸後壁を圧排する．仙骨前面が十分に見えれば，図6に示すように，直腸の口側断端を腹会陰式直腸切断術の如く肛門外に引き出すことができる．この操作を“肛門外直腸引き出し法”と名づけているが，この手術を容易ならしめる重要で簡単な操作である．肛門管が3/4周性に切除されているため直腸を十分に肛門外に引き出すことが可能で，また直腸前壁がblindにならず容易に観察できる．次いで図7に示すように，腹会陰式直腸切断術の要領で左の示指(左利きの術者は右の示指)で直腸を圧排しながら，前壁側の恥骨直腸筋を切離する．男性では前立腺後壁を，女性では膣後壁を切離すると直腸を完全に摘出できる．図8は直腸摘出後の仙骨前ならびに腹腔内の所見を示すが，肛門挙筋が切離され，坐骨直腸窩の脂肪組織が露出している．

V．経肛門的結腸肛門吻合

図9に示すように，結腸肛門吻合を施行している．以前はJ型結腸嚢を作成していたが，最近はS状結腸を用いて端々吻合を施行している．S状結腸を肛門側に引き出し，まず3時，6時，9時，12時方向の4点で肛門皮膚粘膜，皮下外肛門括約筋，結腸全層の順で3-0 Vicryl糸をかけ，折り返し結腸粘膜と肛門皮膚粘膜のマットレス縫合を行って，その都度結紮する．その後，4点縫合部の両隣を順次縫合結紮し支持糸とする．12針の縫合結紮が終了した後，支持糸を牽引し肛門全体を眺めながら，間隙のある不十分な箇所を追加縫合する．合計で16～20針程度で縫合し吻合が完了する．最後に一時的回腸人工肛門を造設し手術を終了する．人工肛門閉鎖は6～10ヵ月後を目安とする．

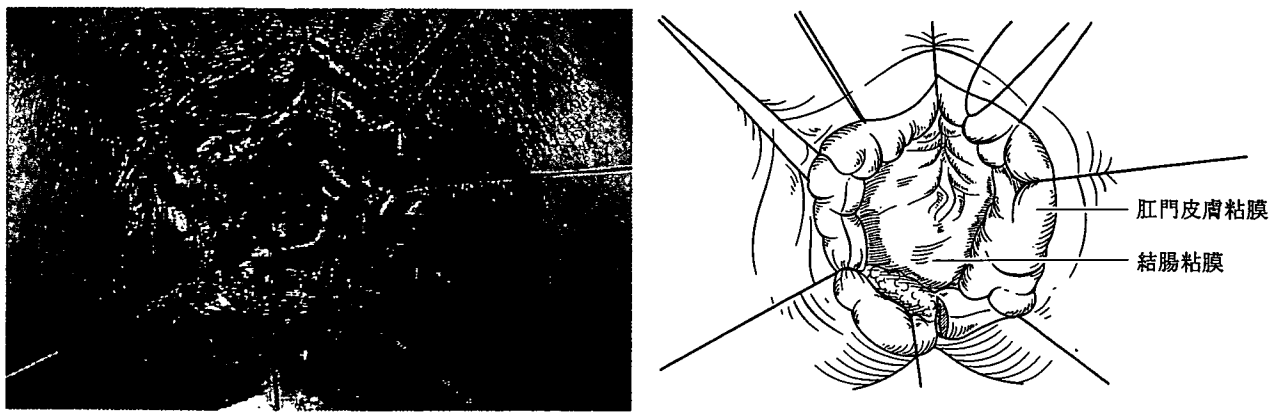


図9　結腸肛門吻合完了
結腸肛門吻合は16～20針程度で施行している．

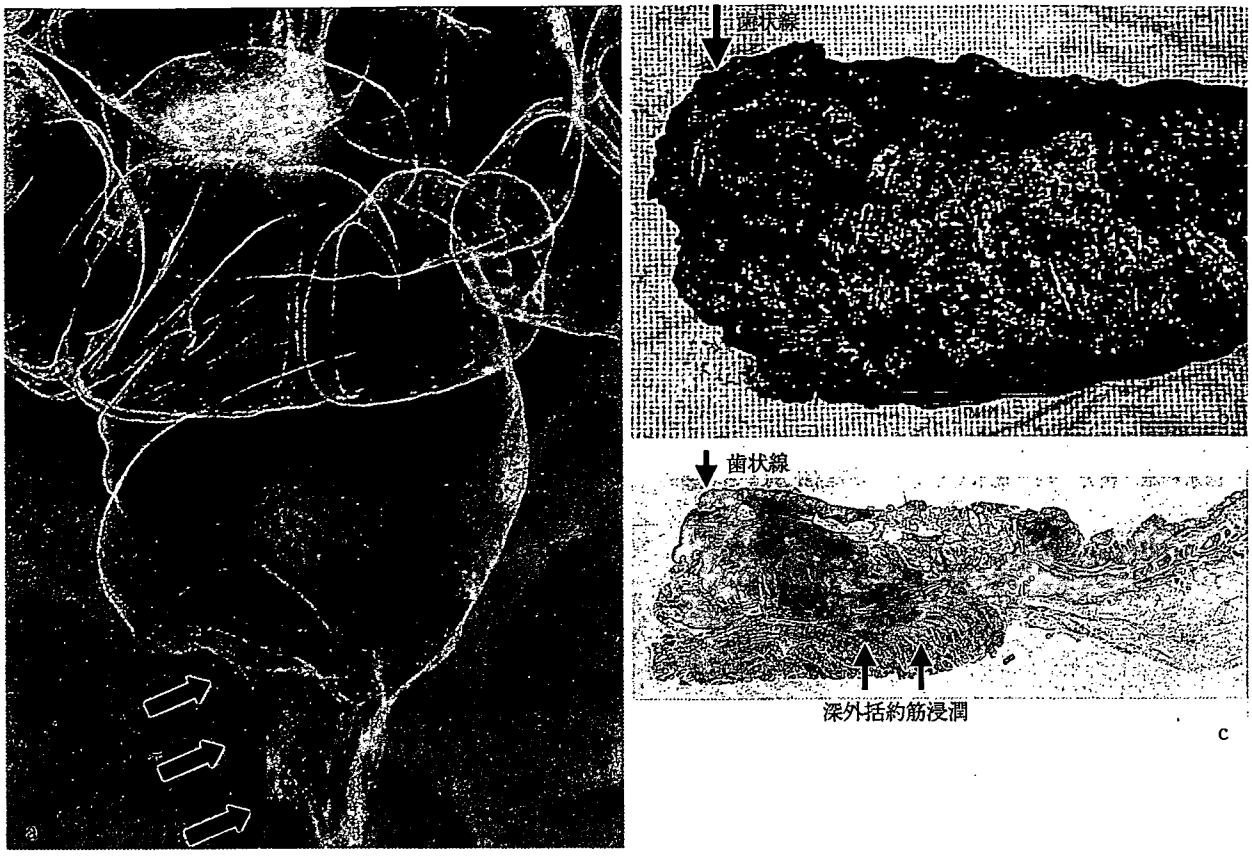


図10 外括約筋切除例

a は術前の注腸造影で下部直腸癌(Rb-P)の症例である.
b は切除標本で腫瘍下縁の一部は歯状線を越えている.
c は病理所見で腫瘍は深外括約筋に浸潤しているが, 外括約筋が十分に切除されており根治性に問題はない.

VI. 外括約筋切除症例

術前の注腸造影は, 図10a に示すように下部直腸癌(Rb-P)の症例である. 切除標本では図10b に示すように, 腫瘍の肉眼型は2型で腫瘍下縁の一部は歯状線を越えている. 肛門側断端の距離は十分に確保されている. 病理所見は, 図10c に示すように腫瘍は外括約筋に浸潤する深達度 ai の癌で, 深・浅外括約筋が十分切除されている. 外科的剝離面に問題はなかった.

おわりに

従来の経肛門吻合術が歯状線を温存して内肛門括約筋を切除する術式であるのに対し, 本術式は深・浅外肛門括約筋合併切除を伴う新しい肛門温存手術で, 言わば究極の肛門救済手術である. 内肛門括約筋合併切除の際に部分的に本術式が適用されることもあるが, 腫瘍径が大きく深達度が深い場合には, 必然的に深・浅外肛門括約筋合併切除術になるはずである. 腫瘍学的にみて十分な根治が得られることは確かであるが, いまだ予後や肛門機能を評価したものはない. 今後長期的な予後や肛門機能の評価を行い, 本術式が腹会陰式直腸切断術に代わる治療法の選択肢として, 許容される時代がくることを期待している.

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内括約筋温存超低位前方切除術

Super low anterior resection with internal sphincter preservation

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●要旨●下部直腸癌に対する肛門温存術は手術器具の発達により比較的容易に安全に施行されるようになったが，手術を成功に導くためには，繊細な技術の習得や腫瘍学の専門的な知識が必要である。本術式における器械吻合，手縫いによる経肛門吻合の適応，手術手技，手術のコツ，合併症，治療成績について述べる。本術式の成功率を高めるためには，直腸前壁の剝離操作と血流障害のない再建腸管の確保，および経肛門吻合法を会得することが重要である。

● key words：直腸癌，超低位前方切除術，括約筋温存手術

はじめに

直腸癌に対する肛門温存術は，器械吻合器の発達によりどこの施設でも誰でもが簡単に施行できる時代になった。しかしながら，下部直腸癌に対する肛門温存術，とくに内括約筋を温存する超低位前方切除術を成功させるには，十分な腫瘍学的な知識と手術技術が要求される。肛門を温存したがゆえに，局所再発や肛門機能の廃絶をきたすようなことがあってはならない。本稿では，本術式の適応，手術手技，治療成績などを中心に述べる。

概　念

超低位前方切除術の明確な定義はされていないが，一般的には図1に示すように，肛門挙筋付着部上縁（肛門直腸輪）で直腸を全切除し，結腸と外科的肛門管とを器械吻合あるいは経肛門的に吻合する術式として位置づけられている[1)2)]。この部位で直腸を切除すれば，内肛門括約筋（内括約筋）は自ずと温存される。

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適　応

適応を考える場合には，腫瘍下縁から肛門側切除断端の距離が重要なポイントとなる。大腸癌は大部分が高分化腺癌で，比較的限局した局所進展形式を呈するものがほとんどである。また，肛門側への進展は，リンパ管や静脈の流れに逆行する形式であるため，頻度も少なく，進展距離も2cm未満であるとする報告が多い[3)4)]。さらに，このような症例の予後はきわめて悪いとする報告がみられる[5)6)]。われわれの検討でも[7)]，Dukes A，Bではほとんど皆無であり，Dukes Cでも，わずか数%であった。しかも，その進展距離は2cm未満で，多くは1cm未満にとどまっていることが多かった。予後に関しては，肛門側進展をきたすものは，遠隔転移で死亡することがほとんどで，局所再発が原因で死亡することはきわめて少なかった。それゆえ，肛門側切除断端距離は1cmでも十分であろうと思われる。欧米でも切除断端距離は1～2cmでよいとする報告が多い[8)9)]。したがって，肛門挙筋付着部上縁で腫瘍を切除するならば，腫瘍下縁がこれより1～2cm，肛門縁から4cm前後，歯状線から3cm前後の下部直腸癌が超低位前方切除術の適応となる（表1）。

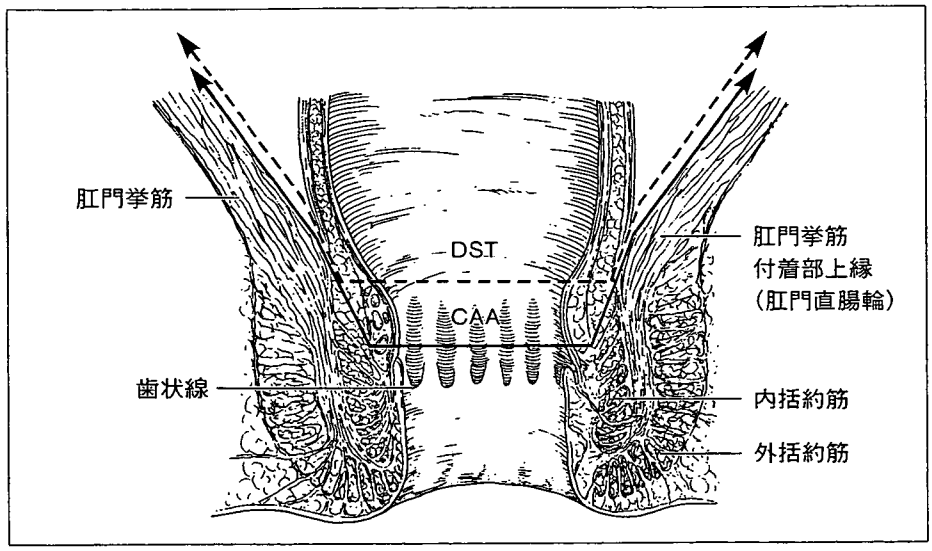

図1　超低位前方切除術の切除線

DST（double stapling technique）は肛門挙筋付着部上縁（肛門直腸輪）にて直腸を切除し，器械吻合する

CAA（coloanal anastomosis）は歯状線近傍にて粘膜抜去し，肛門直腸輪にて直腸を切除し，経肛門的に吻合する

表1　超低位前方切除術の適応，非適応

Ⅰ．適応

1. 高分化腺癌

原則として高分化腺癌

2. 肛門縁より4 cm前後の下部直腸癌

器械吻合（DST），手縫い吻合（CAA）の選択は下記の状況に依存することが多い

①進行度

早期癌では断端距離が短くてよいので，より低位のものでも器械吻合が可能

②占居部位

後壁の場合には器械吻合，前壁の場合には手縫い吻合

③環周度

可動性のよい非全周性のものでは器械吻合，全周性の場合には手縫い吻合

④大きさ

比較的小さいものでは器械吻合，大きいものでは手縫い吻合

⑤狭骨盤の有無

狭骨盤の男性では，手縫い吻合

⑥吻合トラブルで修復不可能な縫合不全や腸管損傷を起こした場合は手縫い吻合

Ⅱ．非適応

1. 肛門管浸潤

内括約筋切除や外括約筋切除による肛門温存術の適応

2. 肛門挙筋浸潤

通常，腹会陰式直腸切断術

3. 低分化腺癌，印環細胞癌

通常，器械吻合器を用いて切除・吻合操作を施行可能であるが，表1に示すように，腫瘍の進行度，占居部位，環周度，大きさ，狭骨盤の有無などの状況により，十分な切除断端を確保できず，器械吻合器を腫瘍下縁にセットできない場合には，経肛門的直腸切除と手縫い吻合を施行する標準的な経肛門吻合術の適応である[10][11]。

非適応

非適応となる場合は，肛門管に浸潤する下部直腸・肛門管癌である（表1）。この場合には，内括約筋あるいは外括約筋切除による肛門温存術の適応となる[12)-14)]。肛門挙筋に浸潤する場合にも，通常の肛門温存術は不可能で，腹会陰式直腸切断術が選択される。組織型では，スキルス型の低分化腺癌や印環細胞癌の場合には，肛門側進展の可能性が高く，肛門温存術は慎重に考慮されねばならない。

手術手技

1. 左側結腸～脾彎曲部の剝離，授動

S状結腸を上方に持ち上げながらfusion fasciaを切開し，後腹膜腔を剝離すると，尿管，精巣動静脈（女性では卵巣動静脈）を確認できるので，損傷しないように露出しながら頭側へ剝離を進める。さらに腎筋膜の前面を十分に剝離すると，腎臓と下行結腸間膜が剝離される。この切離線を脾彎曲部まで延長し，脾結腸靱帯を横行結腸付着部で切離して脾彎曲部を十分に遊離する。操作が困難な場合には，胃の網嚢を切開し，大網を横行結腸付着部で脾彎曲部に向かって切離すれば，脾臓を損傷せずに横行結腸を容易に遊離できる。超低位前方切除術では，再建腸管の十分な長さが必要であるので，脾彎曲部の剝離・授動が重要である。

2. 大動脈前面の剝離

S状結腸間膜を上方に持ち上げながら，上下腹神経叢を損傷しないように大動脈前面を剝離する。腰内臓神経は下腸間膜動脈根部の外側から背部に向かうので，この神経を十分背側に落とし込む。大動脈前面を十分に剝離した後，S状結腸間膜を下大静脈の右側で切開し，これを下腸間膜動脈根部に向かって進めると，その根部を容易に確認できる。

3. 腸間膜動静脈の結紮切離

下腸間膜動脈を根部で二重結紮切離する。下腸間膜静脈は，静脈還流の問題があるので，できるかぎり膵下縁近傍で結紮切離したほうがよい。低位で結紮切離すると，S状結腸の静脈還流障害をきたすことがある。また，下腸間膜静脈の結紮切離の際には，腰内臓神経および左尿管が背側に存在することを確認しておくことが，損傷を防ぐために大切である。

4. S状結腸の切離

下腸間膜静脈を切離した後，S状結腸間膜の血管走行を確認することが重要である。左結腸動静脈を結紮切離し，辺縁動脈を温存しながらS状結腸の切離予定線まで間膜を切離する。辺縁動静脈を結紮切離し，S状結腸をGIAやlinear cutterなどで離断する。

5. 仙骨前面の剝離

上下腹神経叢が岬角の近傍で左右の下腹神経に分岐するのを確認し，これをツッペルなどで外側に圧排しながら直腸枝のみを切離する。正中側より仙骨前腔を電気メス，鋏などで剝離し左右両側に進めると，仙骨神経，骨盤神経叢を確認できるので，これらを温存する。仙骨静脈叢を損傷しないように剝離を進め，Waldeyer筋膜を穿破すると肛門挙筋が露出される。さらに尾骨直腸靱帯を切離すると，直腸後壁の固定が解除され，直腸が十分授動される。

6. 直腸前壁と側壁の剝離

仙骨前腔の剝離が終了すれば，左右後腹膜の切開線を腹膜反転部に延長し反転部を切開する。男性では精嚢が露出するので，これを鉤にて上方に圧排しながら，精嚢の後壁を電気メス，ツッペルなどを使用し剝離する。女性の場合には子宮後壁を剝離する際，誤って子宮頸部に刺入することがある。この場合には出血をみるので剝離層を正しい層に戻す。腟の後壁を確認し，これをアリス鉗子で上方に牽引すると，後壁の剝離が出血なく容易にできる。次いで，精嚢・腟後壁の剝離層を直腸の両側に延長し，膀胱直腸間隙を鋏にて開窓する。この間隙の腹側には自律神経精嚢枝，前立腺枝，膀胱枝などの細い神経線維とともに細い血管網が存在し，神経血管束を形成しているので，剝離層を誤れば神経損傷と出血をきたす。この間隙を仙骨前面に向かってさらに鋏で押し広げると，挙筋前腔に連なり肛門挙筋が露出される。この時点で直腸側壁は側方靱帯

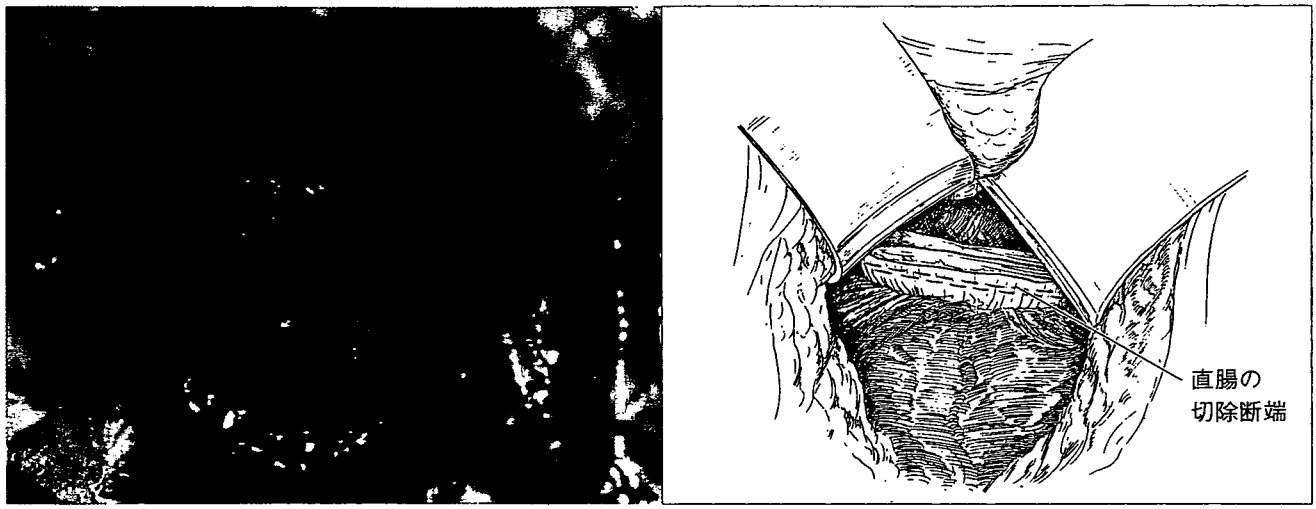

図2　直腸切除
肛門挙筋付着部上縁にて，直腸を切除する

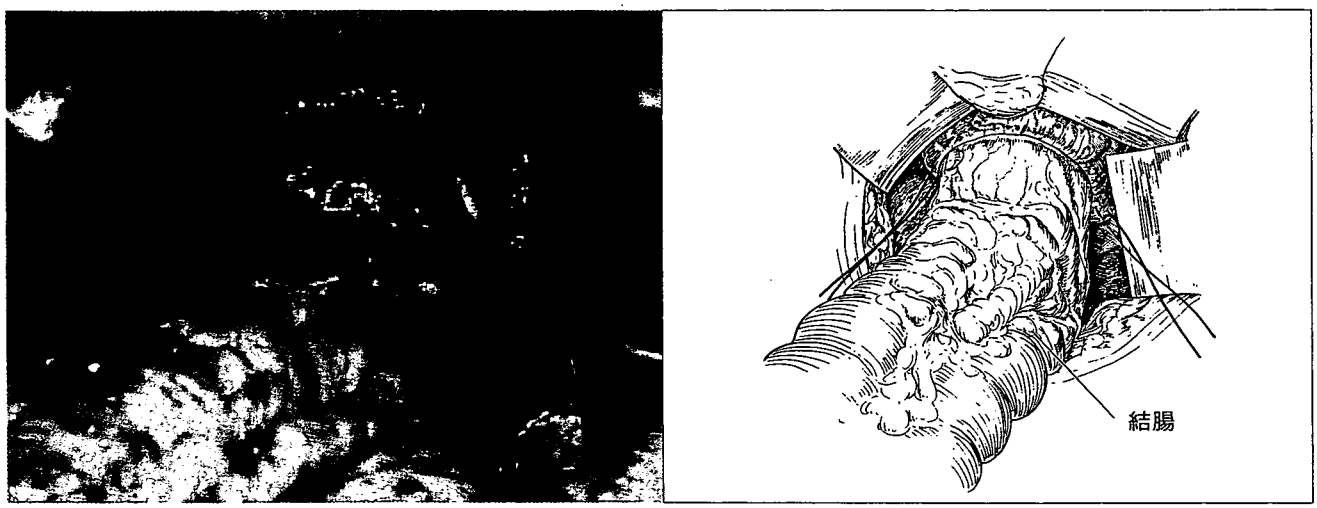

図3　器械吻合
DSTによる結腸肛門管吻合の完成

で固定された状態になり，これを切離すれば骨盤神経叢を損傷することなく，側方靱帯を切離できる。

7. 前立腺，腟後壁の剝離

側方靱帯を切離すると挙筋前腔が広く露出されるので，前立腺，腟後壁の剝離をさらに進める。前立腺や腟後壁の剝離がこの手術のポイントである。この部位は術野の確保が難しいので，直腸前壁を左手で背側に圧排しながらゆっくりと根気よくツッペルや電気メスを交互に用いて剝離することがコツである。用手的に強引に剝離すると出血をきたしやすいので注意を要する。剝離を完了すると，直腸は肛門挙筋付着部で固定されているだけの状態となる。肛門挙筋付着部の直腸後壁や前壁は直腸間膜を欠如しており，直腸を損傷しやすいので愛護的に剝離する。直腸側壁には直腸間膜が存在するので，これを肛門挙筋直上で切離すると，全直腸間膜切除術を完遂できる。もし前立腺の後壁を損傷した場合には，まずガーゼにて圧迫止血を試みる。その後ケリー鉗子などの曲がりの強い鉗子を前立腺後壁の出血部位や近傍にあてがい，電気メスをスプレー凝固に切り替えて止血する。この部の止血を根気よく行うこともこの手術を成功させる鍵となる。

8. 直腸切除

直腸を肛門管直上で全周性に剝離した後，胃全摘鉗子を腫瘍の肛門側にかけ，肛門よりイソジン加生理食塩水にて肛門管を洗浄する。直腸切除はdouble stapling techniqueが便利であり，curved cutterやTA55

図4　経肛門的直腸切除
歯状線よりやや口側にて，直腸を切除する

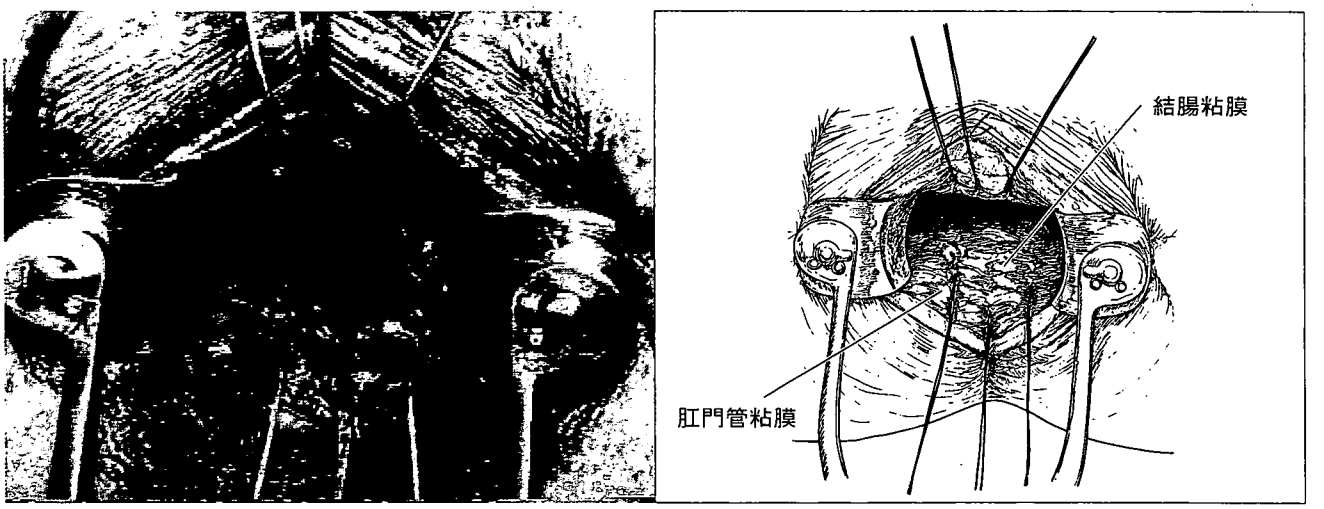

図5　経肛門的結腸肛門管吻合
経肛門的に結腸と肛門管を吻合する

などを全摘鉗子の肛門側にセットして直腸を切除する（図2）。curved cutter や他のデバイスを使用しても，肛門側にうまくセットできない場合には無理をせず，経肛門的に直腸を切除し，手縫いによる経肛門吻合を施行する。

9. 結腸・肛門管吻合

1） 器械吻合

吻合は器械吻合が簡単で，ストレート吻合，J型結腸嚢肛門管吻合などがあるが，標準的な術式という観点からすれば，必ずしも固執する必要はない。まず，吻合予定の再建腸管（S状結腸または下行結腸）の切除断端に巾着縫合を施行しアンビルを挿入する。アンビルのロッドにナイロン糸を巻きつけて緩まないように縫縮する。次に肛門を用手的に十分に広げPCEEAを挿入する。挿入のコツは必ず左手でPCEEAの本体を肛門の入り口で握り，PCEEAが勢いよく入り込むのを防ぐことである。肛門管内に挿入できれば，ロッドを断端中央部に貫通させる（前後壁どちらでもよい）。再建腸管は，仙骨前面に空間ができないように密着するように引きおろし，吻合に緊張がかからないことを確認することが重要である。その後，再建腸管のアンビルを結合させて吻合を完了する（図3）。

2） 経肛門吻合

腫瘍下縁が肛門挙筋付着部近傍にあり，十分な切除断端距離を確保できない場合には，経肛門的に直腸を切除する[10][11]。まず，Parksの肛門鏡を肛門より直腸に挿入し，約1cmの肛門側切除断端を確保しながら

表2　吻合を成功させるコツ

1. 再建腸管
   ①脾彎曲部を十分に剝離，授動し，吻合部に緊張がかからないようにする
   ②血流障害に注意する
   動脈の拍動の有無，腸管のうっ血だけでなく腸管の蠕動に注意する
2. 直腸切除
   ①直腸と前立腺，膣の間を十分に剝離する
   ②尾骨直腸靱帯を切離する
   ③肛門側切除断端を十分確保する
   ④経肛門吻合術を習得する

(図4)，粘膜抜去を歯状線近傍から肛門直腸輪（anorectal ring）のレベルまで施行する。このレベルで直腸の輪状筋を切除すると，内括約筋は自ずと温存される。全周性に切除が終了すれば，再建腸管を肛門管内に引きおろしマットレス縫合にて吻合する（図5)。

3)　吻合時のトラブルの対処

器械吻合がうまくいかない場合，例えば吻合部のリーク，腸管損傷などがあり，修復しても吻合に不安が残る場合には，一時的人工肛門（回腸または横行結腸）を造設したほうが縫合不全を予防するためにも，術後管理の面でも得策である。また，吻合部のリークや損傷が修復不可能な場合には，経肛門的吻合に変更することも考慮したほうがよい（表1)。

超低位前方切除術では，再建腸管の血流の確保がもっとも重要でストレスのかかる手術操作である。本手術では，再建腸管を長く確保する必要があるため，時として動静脈の血流障害が発生し，再建腸管の血行障害を引き起こす危険性があり注意を要する。血行障害はS状結腸を再建腸管として用いた場合や，肥満で内臓脂肪が豊富な狭骨盤の男性に起こりやすい。この場合には色調が暗赤色となり，蠕動も停止するので，色調のよい部分で再切除するのがよい。蠕動が確認できれば，まず心配はない。

吻合を成功させるコツ

表2に示すように，血流障害のない再建腸管を確保することと，直腸前壁の十分な剝離が重要である。さらに経肛門的直腸切除・吻合の技術を習得すれば，成功率が高まる。

合併症

術中に起こりやすい主な合併症は，再建腸管の血流障害や吻合部のトラブルの他，左側の尿管損傷，左側の腎静脈損傷，脾損傷，仙骨静脈叢損傷，前立腺損傷などが重要である。この他にも膣損傷，左側の精巣・卵巣動静脈損傷，左側の腰内臓神経損傷，上下腹神経損傷，下腹神経損傷，骨盤神経叢損傷などがある。予防対策としては，腹腔内や骨盤内の解剖を十分に把握することである。

治療成績

超低位前方切除術の5年生存率は70%前後と報告されている[1)15)16)]。自験例では，stage 1，2，3の再発率は，それぞれ11%，21%，33%で，局所再発は，それぞれ7%，10%，6%であった。10年健存率は，それぞれ85.4%，79.9%，63.6%であった。

排便機能に関する成績は，内括約筋が温存されるために，機能障害をきたすことはきわめて少ない。また，J型結腸嚢はストレートより排便機能に優れているという報告もあるが[17)]，差がないとする報告もある[18)]。

おわりに

超低位前方切除は決して難しい手術ではなく，ゆっくりと落ち着いて行えば必ず成功する。自分なりの手順を覚えて，経験を積めば上達も早い。上達しても，自信過剰にならず初心に返ることも忘れてはならない。

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Original article

Survival benefit of high ligation of the inferior mesenteric artery in sigmoid colon or rectal cancer surgery

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Background: The aim of this study was to assess the impact of inferior mesenteric artery (IMA) root nodal dissection before high ligation of the artery on survival in patients with sigmoid colon or rectal cancer.

Methods: Data on 1188 consecutive patients who underwent resection for sigmoid colon or rectal cancer, with high ligation of the IMA, were identified from a prospective database (April 1965 to December 1999). Survival of patients with involvement of nodes along the IMA proximal to the origin of the left colic artery (root nodes, station 253) through the bifurcation of the superior rectal artery (trunk nodes, station 252) was determined.

Results: Twenty patients (1·7 per cent) had metastatic involvement of station 253 lymph nodes and 99 (8·3 per cent) had metastases to station 252. The 5- and 10-year survival rates of patients with metastases to station 253 were 40 and 21 per cent, and those for patients with metastases to station 252 were 50 and 35 per cent, respectively.

Conclusion: High ligation of the IMA allows curative resection and long-term survival in patients with cancer of the sigmoid colon or rectum and nodal metastases at the origin of the IMA.

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Introduction

During surgery for sigmoid colon or rectal cancer, the inferior mesenteric artery (IMA) may be ligated at a point just below the origin of the left colic artery (low ligation) or at the origin of the IMA directly from the aorta (high ligation). The high-ligation technique enables *en bloc* removal of additional lymphatic drainage from cancers at and around the origin of the IMA, but it is unclear whether this confers a survival advantage.

There have been no prospective controlled or randomized studies of high *versus* low ligation. Guidelines published by Nelson *et al.*[1] recommend low ligation for rectal cancer surgery, except when metastases to lymph nodes beyond the origin of the left colic artery are suspected. However, this recommendation is based on the data from one French randomized trial in patients with left colonic cancer[2].

No study has investigated the detailed anatomical distribution of lymph node metastases along the IMA in a large series in which high ligation was performed routinely. The few studies on this issue included limited numbers of patients with colorectal cancer, ranging from 129 to 198[3–5]. Other studies have reported details of such lymph node distributions, but only in patients who underwent colorectal cancer resection and whose operative findings indicated the need for high ligation of the IMA[4,6,7]. This type of intraoperative determination is known to be unreliable[8]. At present, the true distribution of lymph node metastasis along the IMA in patients with sigmoid colon or rectal cancer who undergo potentially curative resection is unknown.

Some favourable outcomes after high ligation may be attributable to the stage migration phenomenon, which may arise as a result of more accurate staging owing to more extensive lymphadenectomy[6,9,10]. A proportion of patients will therefore be assigned to a more advanced stage than would otherwise be the case, although their prognosis is the same. If this occurs, the overall results in

each stage improve and the proportion of patients in more advanced stages increases[11].

The present study was a prospective analysis of the largest known series of curative resections for sigmoid colon or rectal cancer in which high ligation was performed routinely. The study was designed to circumvent the stage migration effect in order to provide direct information on the significance of lymph node metastases along the IMA. The aim was to evaluate whether patients with sigmoid colon or rectal cancer and metastasis in certain nodes that are left behind after low ligation would benefit from high ligation in terms of curability of resection and survival.

Patients and methods

Since the foundation of the Aichi Cancer Centre Hospital, high ligation of the IMA for proximally extended lymph node dissection in patients with sigmoid colon or rectal cancer has been adopted as a standard procedure, except when adequate exposure to allow ligation of the IMA on the aorta is considered too hazardous. Data on 1361 consecutive patients who had histologically proven adenocarcinoma of the sigmoid colon or rectum and who underwent high ligation of the IMA between April 1965 and December 1999 were documented prospectively. Dissection of all lymph nodes surrounding the root of the IMA was performed before IMA ligation and excision flush with the aorta, irrespective of the operative findings with regard to the presence or absence of lymph node metastasis (*Fig. 1*).

Eighteen patients with cancers confined to the mucosa were excluded. To examine the curative value of apparently complete resection of lymph nodes along the IMA, 155 patients in whom there was clear evidence of surgical incurability were also excluded. These patients had either macroscopic or microscopic residual tumour tissue left at operation, or underwent macroscopically complete resection of hepatic or peritoneal metastases. A total of 1188 patients remained eligible, and these formed the study population.

Rectal tumours were sited as follows: lower rectum (below the peritoneal reflection), upper rectum (above the peritoneal reflection) and rectosigmoid. Lateral pelvic lymphadenectomy was used for lower rectal cancer with T2 or deeper invasion. Twenty-nine of the patients with Dukes' C lower rectal cancer received adjuvant radiotherapy. Adjuvant chemotherapy, mainly using oral 5-fluorouracil prodrugs (uracil and tegafur, UFT), was administered to patients with Dukes' A (15 sigmoid colon, 56 rectal), Dukes' B (57 sigmoid colon, 88 rectal) or Dukes' C (57 sigmoid colon, 179 rectal) tumours deemed to be at high risk for metastasis.

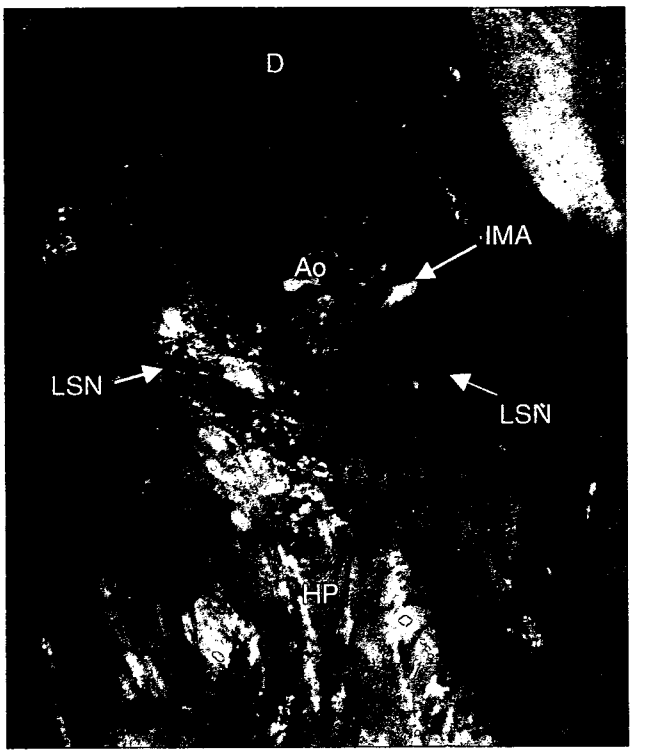


Fig. 1 High ligation of the inferior mesenteric artery at its origin from the aorta. Ao, aorta; D, duodenum, HP, hypogastric plexus; IMA, inferior mesenteric artery; LSN, lumbar splanchnic nerve

Level of ligation of inferior mesenteric artery and pathological examination of lymph nodes

The inferior mesenteric lymph nodes conglomerate around the origin of the IMA, and their location has been defined ambiguously as both the root and the periphery[12]. The Japanese criteria (Japanese Society for Cancer of the Colon and Rectum, JSCCR)[13] define the nodes at the origin of the IMA (station 253) as those nodes that lie along the IMA proximal to the origin of the left colic artery (*Fig. 2*). They define the inferior mesenteric trunk nodes (station 252) as those nodes that lie along the IMA from distal to the origin of the left colic artery to the bifurcation of the superior rectal artery. A high ligation was defined as ligation of the IMA at its root and including dissection of station 253 nodes. A low ligation was defined as ligation of the IMA at or below the level of the origin of the left colic artery and removal of the pericolic and intermediate groups of lymph nodes only, including station 252 nodes, with the primary cancer.

All regional lymph nodes were dissected individually from the adipose connective tissue of the specimen immediately after resection by the surgeons who performed the operation. Node numbers and locations were recorded on

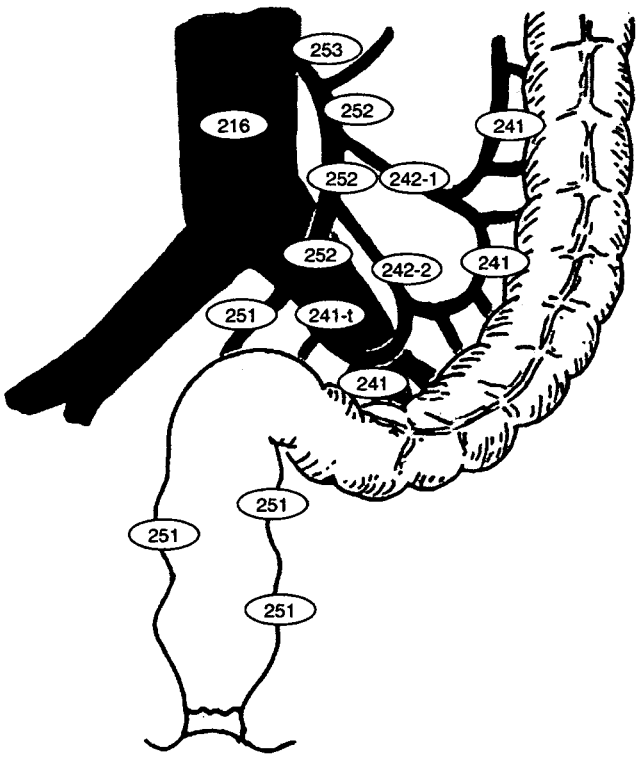


Fig. 2 Japanese Society for Cancer of the Colon and Rectum classification of lymph nodes[13] (shaded ovals denote inferior mesenteric lymph nodes)

a lymph node map (*Fig. 2*). Nodes were assigned to the appropriate station according to the classification of the JSCCR. Nodes found at each station were labelled and sent for pathological assessment. This system, which is standard practice in Japan, yields an exact topographical representation of the nodes combined with their number. Fat clearing methods were not used to collect lymph nodes from the specimen. All specimens were formalin fixed and paraffin embedded. A single section for each lymph node was routinely examined. Sections of 4 μm were cut and stained with haematoxylin and eosin for histological analysis. Special attention was paid to evaluation of the incidence of metastasis to lymph node stations 252 to 253 in relation to the tumour site, depth of invasion and survival data.

Statistical analysis

Overall and cancer-specific survival of patients with lymph node metastases along the IMA was calculated for each nodal station by the Kaplan–Meier method, irrespective of metastasis to other lymph node stations. Operative deaths were not excluded from the survival analysis. Follow-up data were documented prospectively.

Results

The characteristics of the 1188 patients who underwent potentially curative resection with high ligation are shown in *Table 1*. The overall hospital mortality rate was 0·2 per cent (three of 1188). The overall morbidity rate was 31·5 per cent (374 of 1188). Three hundred and forty-seven patients (29·2 per cent) had one or more surgical complications.

The mean number of nodes examined per patient was 28·6. A total of 107 patients had nodal involvement at stations 252 and/or 253. The incidence of metastasis to station 252 nodes was 8·3 per cent (99 of 1188). Station 252 nodal metastases occurred more frequently in patients with pT3 and pT4 lower rectal cancer (*Table 2*). The incidence of metastasis to station 253 nodes was 1·7 per cent (20 of 1188); this represented the frequency of residual metastatic nodes that would normally have been left behind in a low ligation. Of the 20 patients with station 253 nodal metastases, eight did not have cancer deposits in the station 252 nodes studied, that is they demonstrated skip metastases. There was a steady increase in the rate of

Table 1 Characteristic of 1188 patients who underwent a high ligation with curative intent

	No. of patients
Age (years)*	58·6 (59) (23–86)
Sex ratio (F : M)	482 : 706
Site of primary tumour	
Sigmoid colon	421 (35·4)
Rectosigmoid	202 (17·0)
Upper rectum	216 (18·2)
Lower rectum	349 (29·4)
Type of resection	
Sigmoidectomy	393 (33·1)
High anterior resection	141 (11·9)
Low anterior resection	329 (27·7)
Abdominoperineal resection	286 (24·1)
Hartmann's operation	15 (1·3)
Total pelvic exenteration	10 (0·8)
Other	14 (1·2)
Other surgery	
Lateral pelvic node dissection	301 (25·3)
Postoperative death	3 (0·2)
Postoperative morbidity	374 (31·5)
Urinary or sexual dysfunction	103 (8·7)
Ileus	77 (6·5)
Urinary tract infection	47 (3·9)
Wound infection	42 (3·5)
Anastomotic leakage	39 (3·3)
Intraabdominal or pelvic infection	39 (3·3)
Non-surgical (cardiac, respiratory, renal, cerebral)	27 (2·3)
No. of lymph nodes examined per patient*	28·6 (22·6) (7–115)

Values in parentheses are percentages unless otherwise indicated; *values are mean (median) (range).

Table 2 Nodal metastases to station 252

	Incidence of metastasis				
	pT1	pT2	pT3	pT4	Total
Sigmoid colon	2 of 100 (2)	0 of 67 (0)	7 of 169 (4·1)	5 of 85 (6)	14 of 421 (3·3)
Rectosigmoid	0 of 21 (0)	4 of 37 (11)	12 of 110 (10·9)	5 of 34 (15)	21 of 202 (10·4)
Upper rectum	1 of 30 (3)	0 of 51 (0)	13 of 105 (12·4)	3 of 30 (10)	17 of 216 (7·9)
Lower rectum	1 of 42 (2)	6 of 119 (5)	36 of 164 (22·0)	4 of 24 (17)	47 of 349 (13·5)
Total	4 of 193 (2·1)	10 of 274 (3·6)	68 of 548 (12·4)	17 of 173 (9·8)	99 of 1188 (8·3)

Values in parentheses are percentages. pT, pathological tumour stage.

positivity in station 253 nodes with increasing depth of invasion, irrespective of the tumour location; however, no station 253 nodal metastases occurred in patients with pT1 cancer (*Table 3*). Mean positive node yields of 2·0 from station 252 and 1·9 from station 253 were obtained from patients with nodal involvement along the IMA (*Table 4*).

Follow-up continued until January 2005 for all eligible patients. The median follow-up period for survivors was 79·3 months. Follow-up was completed in all patients with nodal metastases along the IMA. Actuarial overall survival rates were 50 (95 per cent confidence interval (c.i.) 41 to 60) per cent at 5 years and 35 (95 per cent c.i. 24 to 46) per cent at 10 years in patients with metastases to station 252, and 40 (95 per cent c.i. 19 to 62) per cent at 5 years and 21 (95 per cent c.i. 2 to 41) per cent at 10 years in patients with metastases to station 253 (*Fig. 3*). The cancer-specific survival rates were 53 (95 per cent c.i. 43 to 64) per cent at 5 years and 41 (95 per cent c.i. 30 to 53) per cent at 10 years in patients with metastases to station 252, and 42 (95 per cent c.i. 20 to 64) per cent at 5 years and 23 (95 per cent c.i. 2 to 43) per cent at 10 years in patients with metastases to station 253 (*Fig. 4*).

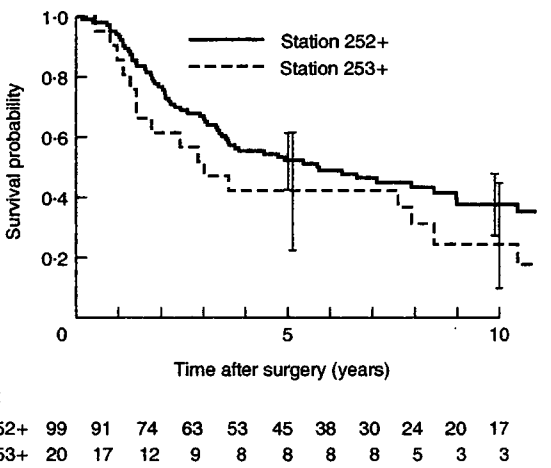


Fig. 3 Overall survival curves for patients with sigmoid colon or rectal cancer who underwent high ligation, according to inferior mesenteric lymph node status. +, Metastatic nodal disease present. Vertical bars represent 95 per cent confidence intervals

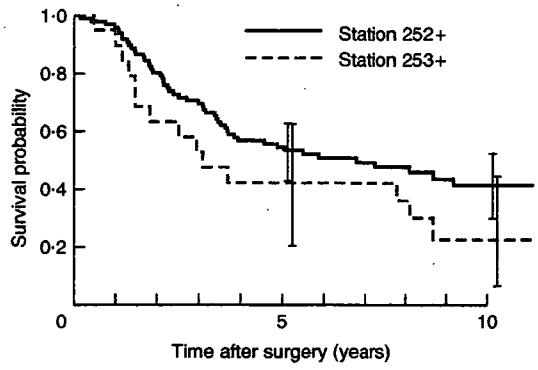
Discussion

In 1908, Moynihan[14] advised high ligation of the IMA in resections for cancer of the sigmoid colon or upper rectum. However, because the oncological effectiveness of high ligation of the IMA is not generally accepted, the level at which the IMA is ligated in operations for sigmoid colon or rectal cancer has varied greatly[3,4,7,15–20], depending largely on the surgeon[6,20]. Recent reports have shown a stage-specific survival benefit of high ligation[6,9,10]. However, these studies did not eliminate the stage migration phenomenon and failed to show a survival

Table 3 Nodal metastases to station 253

	Incidence of metastasis					
	pT1	pT2	pT3	pT4	Total	Skip Metastasis*
Sigmoid colon	0 of 100 (0)	1 of 67 (1)	2 of 169 (1·2)	3 of 85 (4)	6 of 421 (1·4)	4 of 421 (1·0)
Rectosigmoid	0 of 21 (0)	0 of 37 (0)	3 of 110 (2·7)	1 of 34 (3)	4 of 202 (2·0)	2 of 202 (1·0)
Upper rectum	0 of 30 (0)	0 of 51 (0)	2 of 105 (1·9)	0 of 30 (0)	2 of 216 (0·9)	0 of 216 (0)
Lower rectum	0 of 42 (0)	0 of 119 (0)	7 of 164 (4·3)	1 of 24 (4)	8 of 349 (2·3)	2 of 349 (0·6)
Total	0 of 193 (0)	1 of 274 (0·4)	14 of 548 (2·6)	5 of 173 (2·9)	20 of 1188 (1·7)	8 of 1188 (0·7)

Values in parentheses are percentages. *Node positive at station 253 without nodal involvement at station 252. pT, pathological tumour stage.



No. at risk

Station 252+	99	91	74	63	53	45	38	30	24	20	17
Station 253+	20	17	12	9	8	8	8	8	5	3	3

Fig. 4 Cancer-specific survival curves for patients with sigmoid colon or rectal cancer who underwent high ligation, according to inferior mesenteric lymph node status. +, Metastatic nodal disease present. Vertical bars represent 95 per cent confidence intervals

Table 4 Frequency of positive nodes in patients with nodal involvement along the inferior mesenteric artery

	Frequency of positive nodes	
	No. of positive nodes	No. of nodes harvested*
Station 252	2·0 (1·0) (1–16)	5·8 (5·0) (1–23)
Station 253	1·9 (1·0) (1–6)	3·2 (3·0) (1–10)

*Values are mean (median) (range).

advantage for patients with advanced node metastases. Furthermore, other recent series did not find any survival benefit after high ligation[4,7,19,20]. There has been no randomized or prospective study of high *versus* low ligation in patients with sigmoid colon or rectal cancer.

This prospective (but uncontrolled) study introduced a novel concept[21] for evaluation of the effectiveness of high ligation in sigmoid colon or rectal cancer surgery. The methodological approach was based on the assumption that patients who survived in the long term after resection of lymph node metastases would not have done so if the involved lymph nodes had been left *in situ*. The frequency of metastasis in nodal stations that would be left behind after low ligation of the IMA was evaluated, and the therapeutic effect of node dissection was determined by examining the incidence of metastases and the survival rates of patients with nodal deposits in those particular stations, irrespective of nodal metastases to any other lymph node station.

Potentially curative resection was achieved in 20 patients with involvement of nodal station 253, and 5-year overall and cancer-specific survival rates were 40 and 42 per cent respectively. These results demonstrate the therapeutic benefit of high ligation, because there would probably have been no long-term survivors if low ligation had been performed. However, the benefit of routine use of high ligation in patients undergoing curative resection was low (1·7 per cent, 20 of 1188) and only 0·7 per cent of patients with sigmoid colon or rectal cancer are likely be cured by high ligation of the IMA (incidence rate of metastasis 1·7 per cent, times survival rate 42 per cent). This low incidence of metastasis in the lymph nodes at the base of the IMA does not undermine the rationale behind high ligation of this artery. Surgery must always be performed for the greater good of the patient, especially if it can be carried out without adding appreciably to the risk. The negligible operative mortality and morbidity rates in this study confirm that high ligation of the IMA can be performed safely. Urinary or sexual dysfunction was the most frequent postoperative complication. Three hundred and one of the patients with lower rectal cancer also underwent lateral pelvic lymph node dissection. The autonomic nerves are intentionally sacrificed or preserved depending on whether the cancer has spread to them. This additional step is considered to be the major cause of such complications.

Five-year survival rates after low ligation in patients with involvement of middle-level lymph nodes (station 252) along the IMA of 20·5 per cent[6] and 32 per cent[22] have been reported. In the present study, patients with involvement of nodal station 252 had appreciably higher survival rates (more than 50 per cent) after high ligation, suggesting a positive effect of high ligation of the IMA on survival. Resection with curative intent could be achieved by high ligation in 107 patients with nodal involvement at stations 252 and/or 253. Because some of these nodes are left behind in a low ligation, high ligation increased the curative resection rate by 9·0 per cent (107 of 1188) at worst (assuming that low ligation would have involved ligation of the superior rectal artery at a low level). The proportion of patients with node-positive disease (Dukes' C) was 40·3 per cent (479 of 1188) in this study, which suggests that low ligation would have led to residual metastases being left in the nodes of a maximum of one-quarter of these patients. Thus, high ligation might save the occasional patient and prove helpful in those who have nodal metastases limited to below the level of the left colic artery by providing a greater margin of safety when the artery, including all the surrounding glands and lymphatics, is excised by a single block dissection; however, these data are inconclusive. The survival benefit of high ligation still remains to be investigated. Likewise, to say that high ligation of the IMA is essential to remove nodes at

station 253 is premature at the present time. Dunphy and Pikula[23] suggested a modified procedure instead of high ligation, in which fatty tissues and nodes were dissected free and excised in the angle between the IMA and aorta, and the artery was ligated below the left colic branch. Comparison of this procedure with high ligation is beyond the scope of this paper.

The results of this study suggest that high ligation of the IMA is beneficial in patients with node-positive disease. An optimal lymphadenectomy, therefore, should include the dissection of tumour-containing nodes. When the operative findings have indicated that high ligation of the IMA should be performed in patients undergoing colorectal cancer resection, several authors have reported the anatomical distribution of nodal metastases along the IMA[4,6,7]. However, intraoperative assessment for the presence of lymph node metastases is not reliable[12]. This uncertainty was demonstrated in the present study as nearly half of the patients with positive station 253 nodal metastases had no metastases in station 252 nodes. Upper lymphatic spread along the IMA was strongly related to the depth of tumour invasion. Both station 252 and 253 nodal metastases occurred more frequently in patients with pT3 and pT4 tumours. In contrast, no station 253 nodal metastases occurred in those with pT1 cancers. Therefore, low ligation may be sufficient for pT1 sigmoid colon or rectal cancers. However, there is no method of accurately assessing the depth of tumour invasion before or during operation. Indeed, by using information on the extent of lymph node involvement and the depth of tumour invasion, it is impossible to decide whether high ligation should be performed for sigmoid colon or rectal cancer. An ill chosen or poorly executed operation may increase the risk of local recurrence and adversely affect survival.

The present results show that high ligation of the IMA can be performed safely and is of therapeutic value in patients with sigmoid colon or rectal cancer who have IMA root node metastases. They also provide indirect evidence that high ligation has a possible beneficial effect on patients with middle-level node metastases along the IMA. These findings indicate that wide resection of the regional mesenteric lymphatics with high ligation of the IMA should usually be performed when operating with curative intent for sigmoid colon or rectal cancer.

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