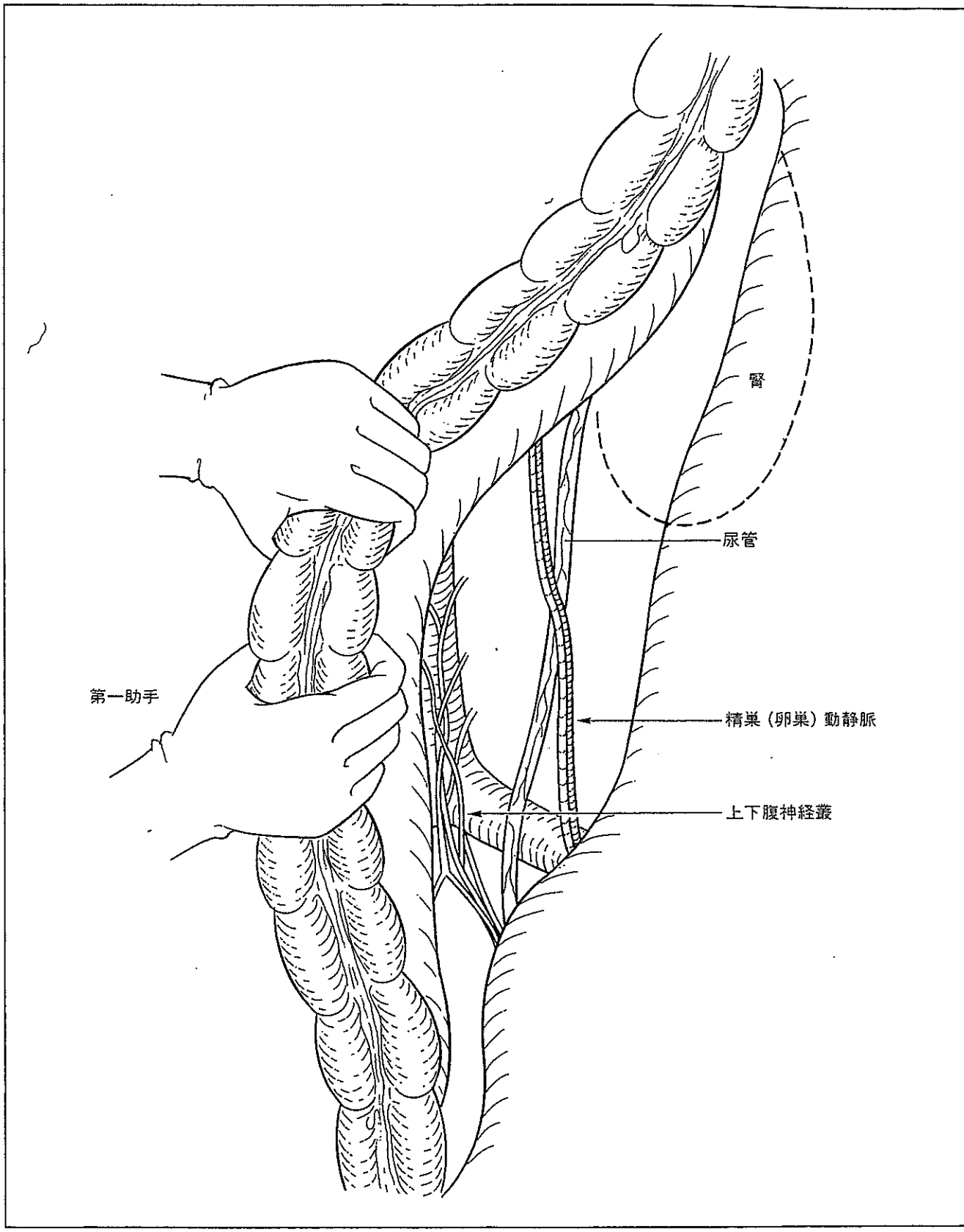

図4　剝離

Toldt's fusion fascia と腎筋膜前葉の間を電気メスにて剝離していき，左尿管，精巣（卵巣）動静脈を越え，大動脈左縁あたりまで十分に剝離しておく．剝離の層が正しければ尿管，精巣（卵巣）動静脈は腎筋膜前葉とともに後腹膜側に残り，テーピングの必要はない．下腹神経叢を確認し，温存する．

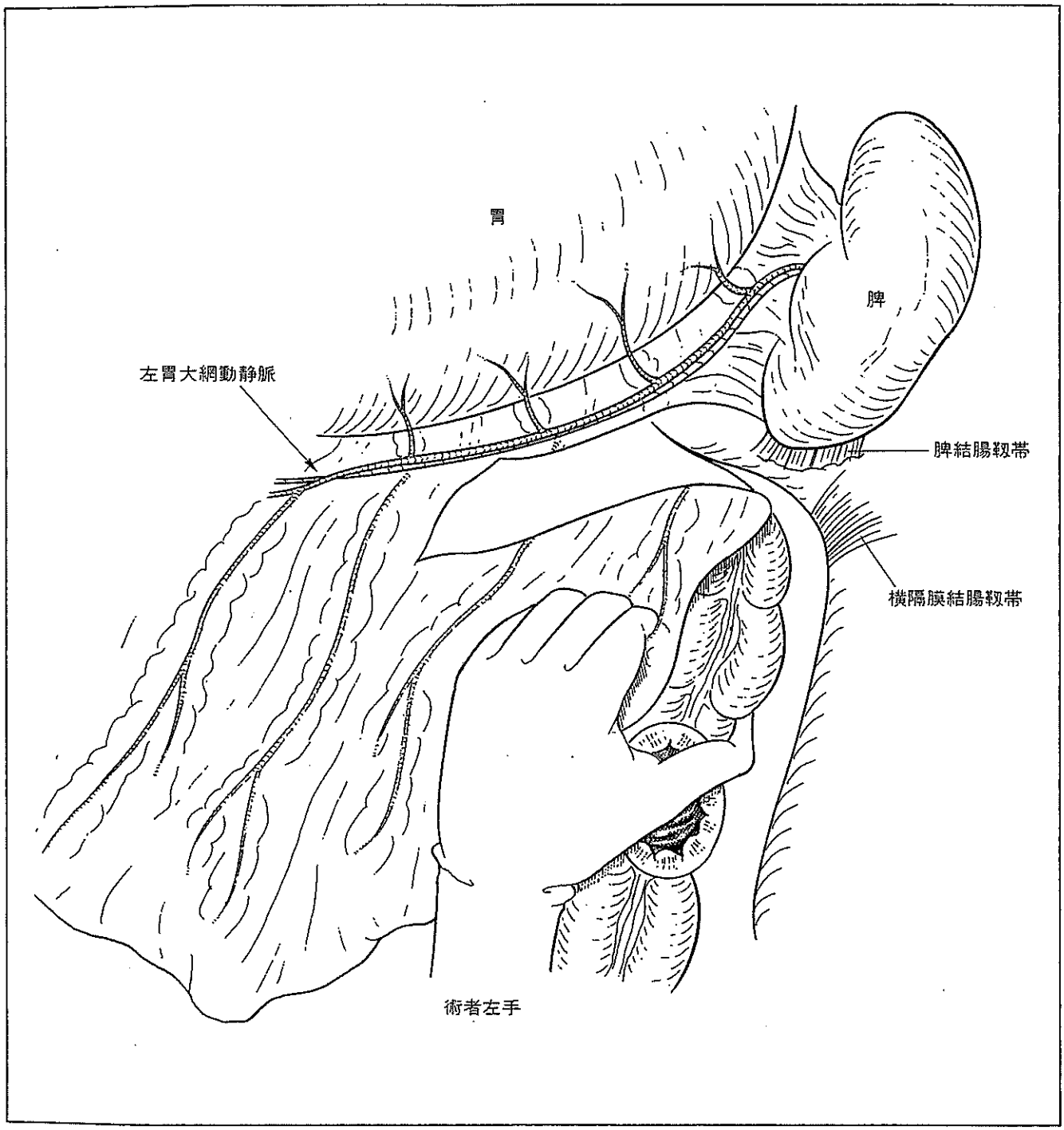

図5　授動

脾彎曲部から左横行結腸の授動を行う．術者は右側に立ったほうが操作しやすい．脾下極の被膜損傷に注意する．また漿膜浸潤陽性の腫瘍が脾彎曲部近くにある場合，その肛門側の過度の牽引によって腫瘍に亀裂を作り，癌を播種することのないよう注意する．

れれば脾臓合併切除を行う．また漿膜浸潤陽性の腫瘍が脾彎曲部近くにある場合，その肛門側の過度の牽引によって腫瘍に亀裂を作り，癌を播種することのないよう注意する．左結腸曲を後腹膜から剝離し，横行結腸間膜左方を膵下縁で切離して脾彎曲部を完全に授動する（図5）．

3．腸間膜，血管，腸管切離，標本摘出

S状結腸から下行結腸間膜を広げ，上直腸動脈右側の腹膜を切開する．尾側は上部直腸まで，頭側はIMA根部から空腸起始部の左側を回り，切り上げておく．先の授動が十分であればこの時点で容易に左側からの剝離ラインとつながる．上下腹

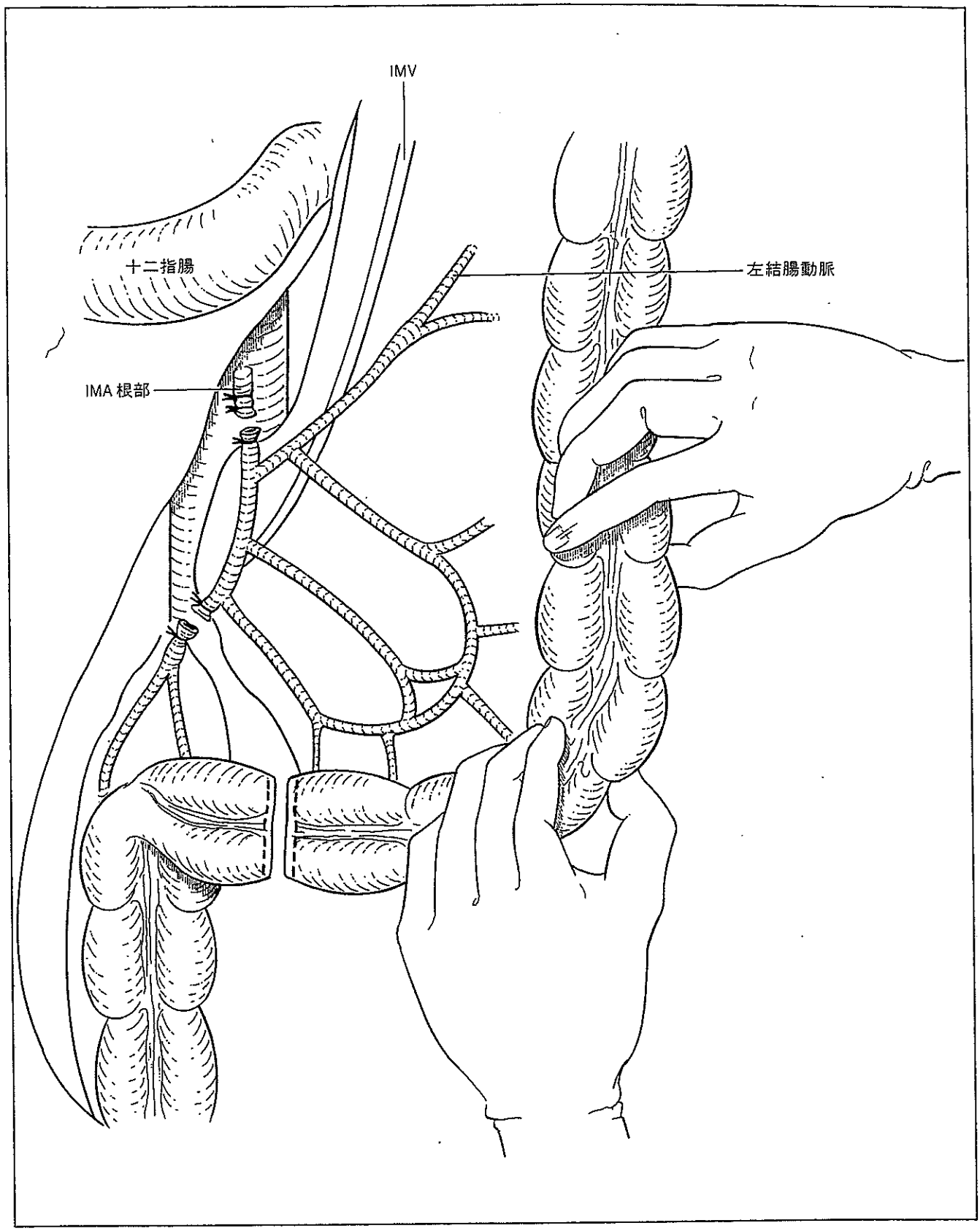

図 6　腸管の切離

上下腹神経叢を温存しながら IMA 根部を郭清し，露出，二重結紮し，切離する．IMA 根部処理後の直腸口側断端の血流は腹膜翻転部から 10～15 cm までは良好に保たれる．したがって，この範囲から口側の S 状結腸はすべて切除されることになる．切除予定線の腸間膜を処理し，linear stapler で腸管を切離する．

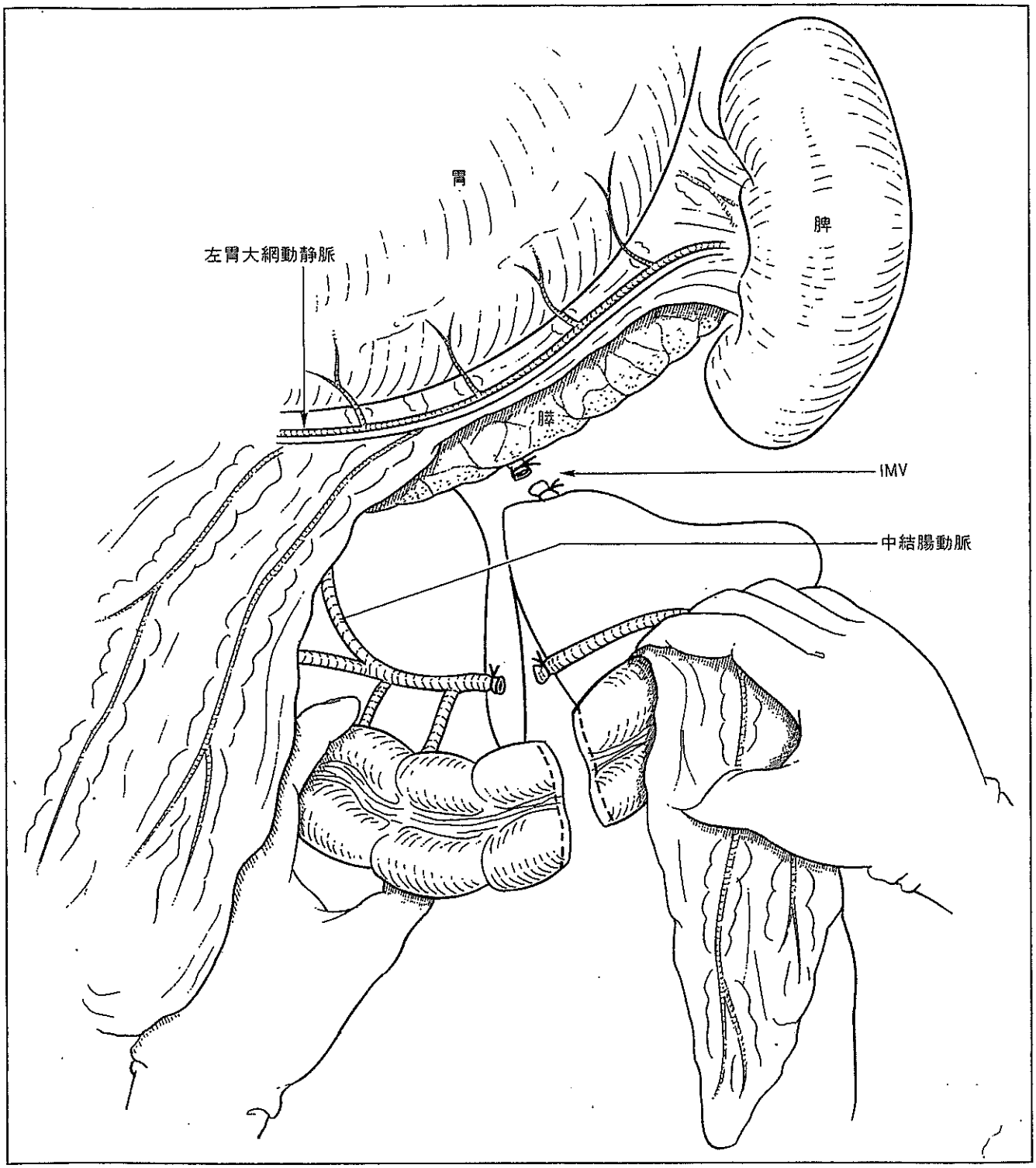

図7　横行結腸の切離

膵下縁で横行結腸間膜を吻合予定部に緊張がかからないところまで切離する．途中2，3本の間膜栄養血管を認めるが，確実に止血しておく．下腸間膜静脈を高位で切離する．口側断端を十分にとって腸間膜切離線を決め，尾側から切り上げてきた切除線とつなげる．

神経叢を温存しながらIMA根部を郭清し，露出，二重結紮し，切離する．IMA根部処理後の直腸口側断端の血流は腹膜翻転部から10～15 cmまでは良好に保たれる．したがって，この範囲から口側のS状結腸はすべて切除されることになる．切除予定線の腸間膜を処理し，linear staplerで腸管を切離する(図6)．次に横行結腸を下方に牽引し，膵下縁で横行結腸間膜を吻合予定部に緊張がかか

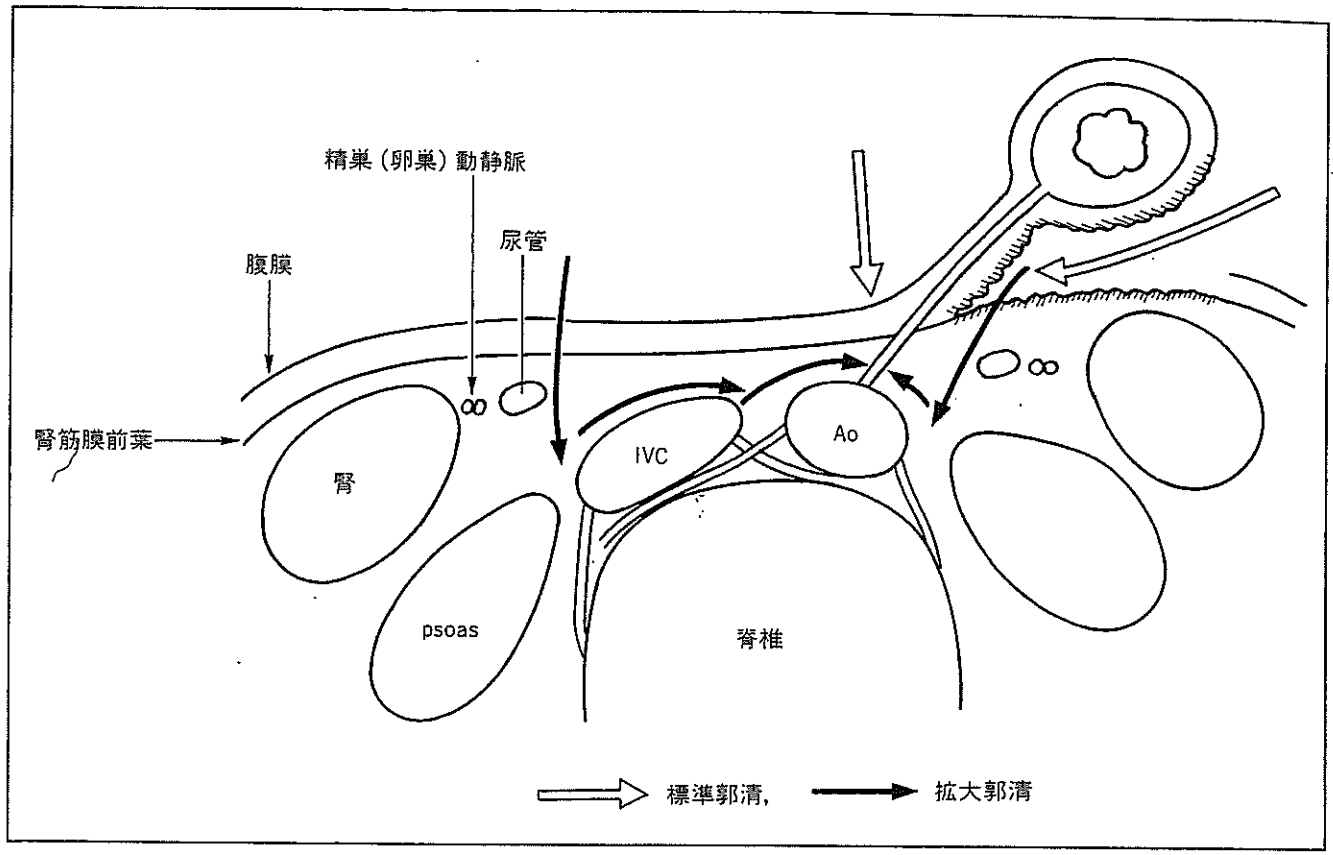

図8　郭清

拡大郭清の場合，下行結腸の授動に引き続き左尿管内側で腎筋膜前葉内に入り，大動脈外側の郭清を行う．次に右尿管内側で腹膜，腎筋膜前葉を切り，下大静脈外側，前面，大動静脈間，大動脈前面の郭清を行う．これを左腎静脈下縁から大動脈分岐部レベルまで行い，傍大動脈リンパ節を標本とともに *en bloc* に摘出する．下腹神経は当然切除側に含まれる．

らないところまで切離する．途中2，3本の間膜栄養血管を認めるが，確実に止血しておく．下腸間膜静脈を高位で切離する．口側断端を十分にとって腸間膜切離線を決め，尾側より切り上げてきた切除線とつなげる．横行結腸間膜の切離に際して Riolan 動脈弧や副中結腸動脈が認められることがあるが，必要に応じて切離する．Linear stapler で横行結腸を切離すれば摘出操作は終了する（図7）．

第二群以上のリンパ節転移が疑われ，他に非治癒因子がない症例では傍大動脈リンパ節の系統的切除を加えた拡大郭清を行う．下行結腸の授動に引き続き左尿管内側で腎筋膜前葉内に入り，大動脈外側のリンパ節郭清を行う．次に右尿管内側で腹膜，腎筋膜前葉を切り，下大静脈外側，前面，大動静脈間，大動脈前面の郭清を行う．これを左腎静脈下縁から大動脈分岐部レベルまで行い，傍大動脈リンパ節を標本とともに *en bloc* に摘出する．下腹神経は当然切除側に含まれる（図8）．高度動脈硬化や大動脈瘤などの合併症のある症例では，拡大郭清は禁忌である．

4．腸管吻合

通常は前方切除同様，径 31 mm ないし 33 mm の自動吻合器を用い，経肛門操作による端々吻合を行う．吻合部に緊張がかからないよう必要があれば右側結腸の授動，中結腸動脈根部に向けての横行結腸間膜の切離などを行う．上部直腸を剥離しておくことも効果的である．また多発癌などで横行結腸の大半を同時切除したような場合でも，回腸後結腸直腸吻合を採用することで吻合部の緊張をとることができる（図9）．

5．閉腹

腹腔内洗浄ののち，筋膜を腹膜とともに吸収糸（PDS®）にて連続縫合する．皮膚をステイプラーでとめて手術を終了する．

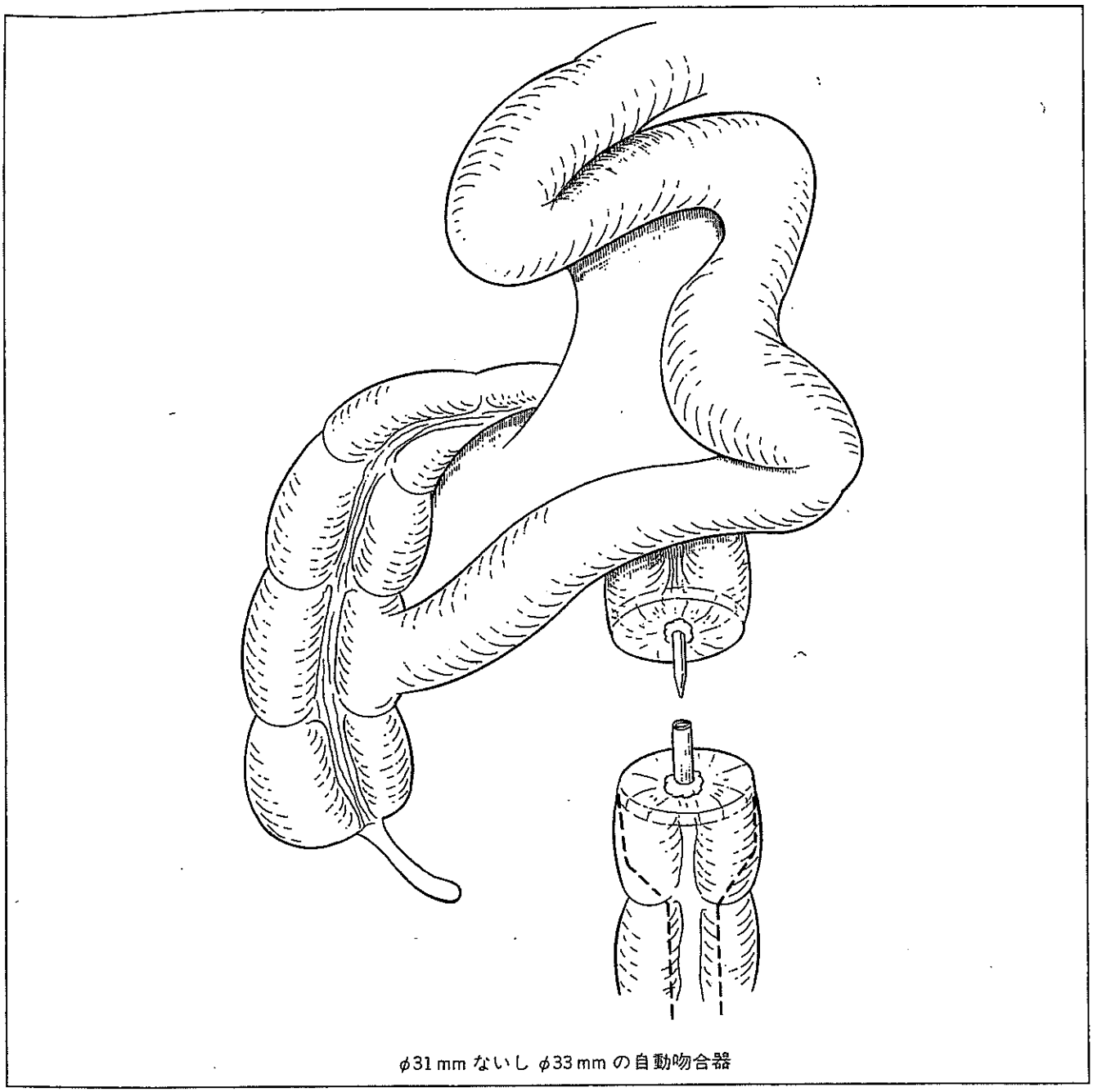

図9　腸管吻合

通常は前方切除同様，径 31 mm ないし 33 mm の自動吻合器を用い，経肛門操作による端々吻合を行う．多発癌などで横行結腸の大半を同時切除したような場合でも，回腸後結腸直腸吻合を採用することで吻合部の緊張をとることができる．

むすび

本稿で言及した左半結腸切除術における腸管切除量はかなり多いが，術後排便障害の訴えは軽度である．進行癌でもリンパ節転移や主幹動脈の走行状況によっては D_2手術，すなわち IMA の温存，腸管切除範囲の縮小を当然考慮すべきである．また傍大動脈郭清を含む拡大郭清に関しては侵襲も大きく，男性における術後の射精障害は必発するため適応は慎重になされるべきで，患者に性機能障害の内容を説明し，同意を得なければならない．

(YAMAGUCHI Takashi, et al 国立病院機構京都医療センター外科：〒 612-8555 京都市伏見区深草向畑町 1-1)

臨床報告 1

Linear stapler による functional end-to-end anastomosis 後に吻合部再発をきたした結腸癌の2例*

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* Two cases of anastomotic recurrence of colon cancer following functional end-to-end anastomosis

キーワード：結腸癌，吻合部再発，機能的端々吻合

はじめに

結腸癌切除後の linear stapler を用いた機能的端々吻合（functional end-to-end anastomosis：以下，FEEA）は Steichen[1]によって 1968 年に報告され，1990 年代には手術手技の簡便性と手術時間の短縮効果のため欧米を中心に広く普及し，現在では標準的吻合手技として確立されている．一方，わが国では直腸癌手術と異なり，結腸癌手術では吻合器の使用が保険で認められていなかったことから，手縫いによる吻合再建が一般的であった．しかし，2000 年 4 月に結腸癌手術に対しても 4 個を限度に縫合器の使用が保険で認められてから，FEEA による吻合再建は急速に普及しつつある[2]．当院でも 1999 年から結腸癌手術の吻合に FEEA を部分的に導入し，現在では主に circular stapler を用いる S 状結腸を除き，吻合再建は原則的に FEEA で行っている．

一方，結腸癌では直腸癌と比較して術後吻合部再発の頻度は低いが，近年，学会や論文での FEEA 後吻合部再発の報告が散見されるようになっている[2,3]．今回，FEEA で再建を行った結腸癌術後に吻合部再発をきたした 2 症例を経験したので報告する．

症　例

〔症例 1〕

患　者：73 歳，男性

主　訴：横行結腸癌術後 1 年目の大腸内視鏡検査で吻合部再発を指摘された．

現病歴：2004 年 10 月，横行結腸癌に対し横行結腸切除術＋2 群リンパ節郭清を施行した．吻合は縫合器（PROXIMATE, TLC75®：ジョンソン・エンド・ジョンソン）を 2 回使用し，FEEA で行った．吻合前の腸管洗浄は施行しなかった．肉眼所見は 2 型，32×28 mm，pm 10 cm，dm 11 cm で，病理組織診断は高分化腺癌，ss，ly0，v0，n0，stage II であった（図 1）．2005 年 10 月に術後 1 年目の大腸内視鏡検査で吻合部再発を指摘された．

入院時検査所見：腫瘍マーカーを含め，異常所見を認めなかった．

大腸内視鏡検査所見：吻合部に一致して，中心に陥凹を伴う扁平隆起病変を認めた．病変の表面には staple が露出していた（図 2）．

腹部 CT 検査所見：遠隔転移は認めなかった．

手術所見：2005 年 12 月，前回吻合部を含めた結腸切除術を施行した．腹膜播種や肝転移は認めなかった．再建は腸管内を生理食塩水 500 ml で洗浄したのち，FEEA で行った．

切除標本所見：前回手術の吻合線に沿って，中心に陥凹を伴う 50×35 mm の扁平隆起病変を認めた（図 3a）．

病理組織所見：病理組織診断は前回手術と同様に高分化腺癌であり，横行結腸癌吻合部再発と診断した（図 3b）．

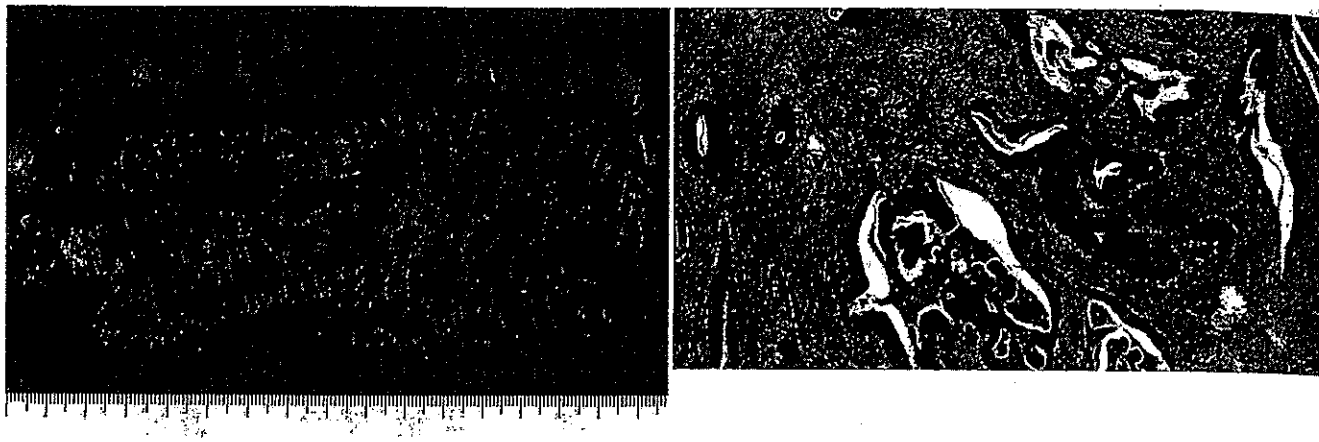

図1　症例 1①
a：初回手術の切除標本．横行結腸に 2 型病変を認めた．口側，肛門側断端は 10 cm および 11 cm と十分にとれていた．
b：病理組織所見は高分化腺癌で，ss，ly0，v0，n0 であった（HE 染色，×40）．

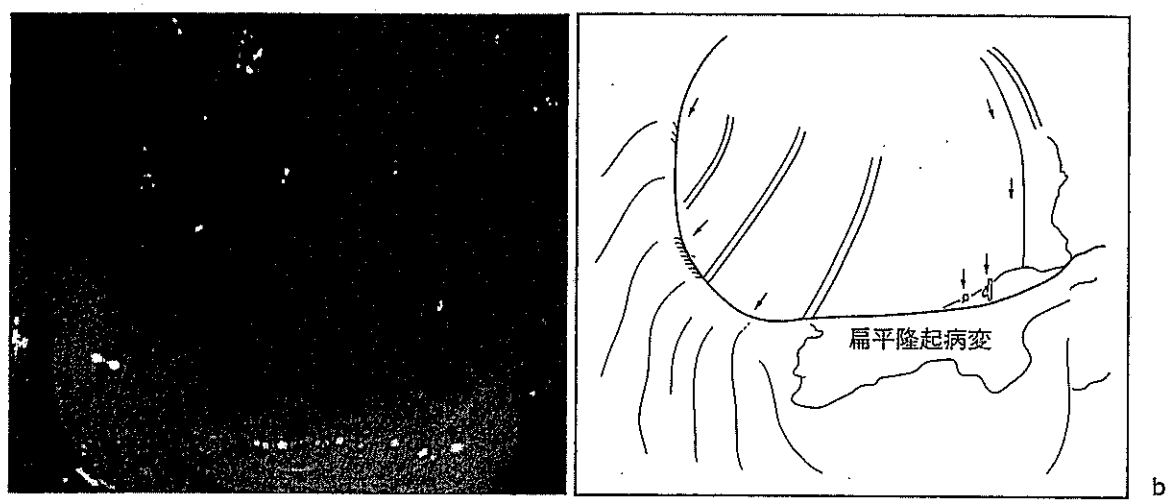

図2　症例 1②
a：大腸内視鏡検査．前回吻合部に一致して扁平隆起病変を認めた．
b：a のシェーマ．矢頭；吻合部．矢印；病変に露出する staple．

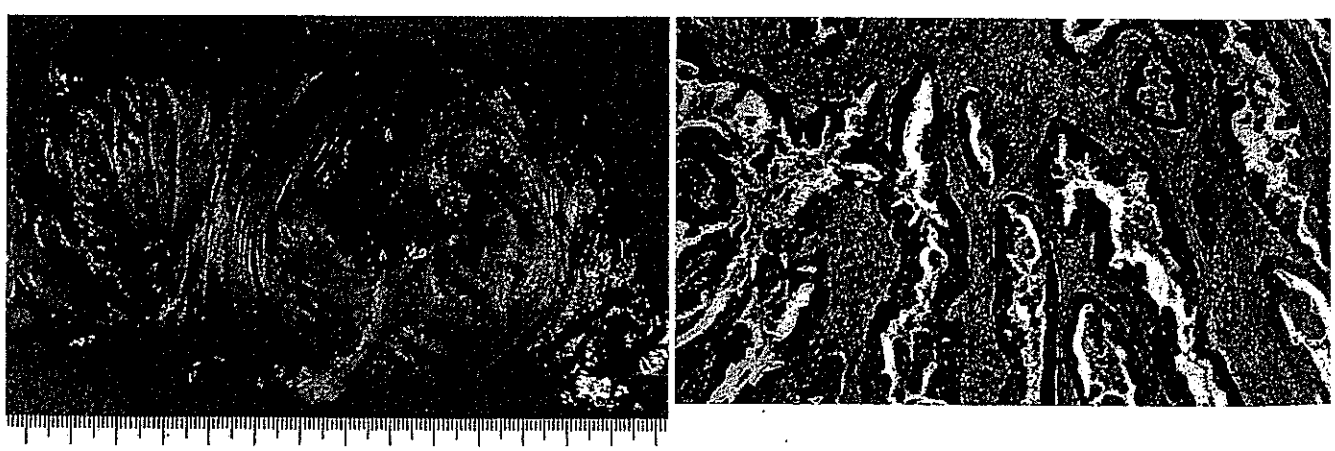

図3　症例 1③
a：再手術切除標本．前回手術の吻合線に一致して再発腫瘍を認めた．
b：病理組織所見は前回手術と同様，高分化腺癌の所見であった（HE 染色，×40）．

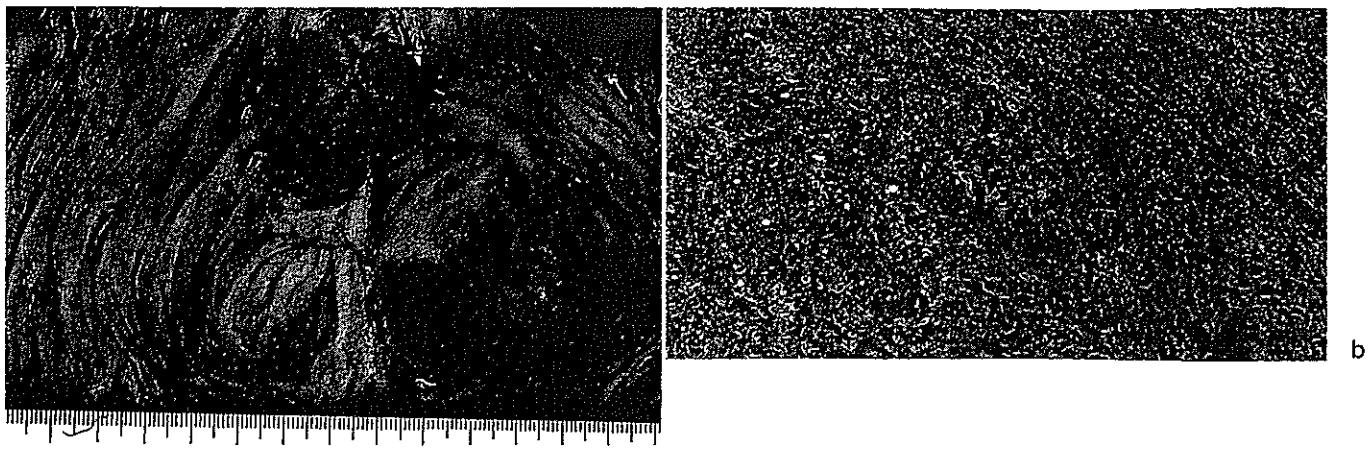

図4　症例2
a：再手術における切除標本．前回手術の吻合線に一致して潰瘍限局型腫瘍を認めた．
b：病理組織所見は他院での初回手術と同様で，低分化腺癌の所見であった（HE染色，×40）．

〔症例2〕

患　者：29歳，女性

主　訴：下血

現病歴：2002年9月，他院において横行結腸癌に対し，横行結腸切除術＋3群リンパ節郭清を施行された．吻合はFEEAで行われた．病理組織診断は低分化腺癌，ss，ly2，v1，n3（1/19），stage IIIbであった．2003年3月に下血のため当院で大腸内視鏡検査を施行され，吻合部再発を指摘されて入院となった．

入院時検査所見：腫瘍マーカーを含め，異常所見を認めなかった．

大腸内視鏡検査所見：吻合部に一致して潰瘍限局型病変を認めた．

腹部CT検査所見：明らかな遠隔転移は認めなかった．

手術所見：前回吻合部を含めた結腸切除術を施行した．腹膜播種や肝転移は認めなかった．再建は再度FEEAで行った．

切除標本所見：前回手術の吻合線に沿って，37×27 mmの2型病変を認めた（図4a）．

病理組織所見：病理組織診断は初回手術と同様に低分化腺癌であり，横行結腸癌吻合部再発と診断した（図4b）．

考　察

近年，三角吻合やFEEAなどのlinear staplerを用いた器械吻合が，手技の簡便性や手術時間の短縮，術野の汚染が少ないことから，腹腔鏡下手術のみならず開腹結腸癌手術でも急速に普及しつつある．当院においても1999年から結腸癌術後の吻合再建にFEEAを部分的に導入し，現在では結腸切除後再建の標準手技として位置づけている．結腸癌術後吻合部再発は従来の手縫い吻合症例での検討によれば比較的稀であり，その頻度は0.6～1.4%とされてきた[4,5]．このため，吻合前の腸管洗浄が必須とされる直腸癌と比較し，結腸癌吻合部再発に対する意識が乏しかったことは否めない．

しかし，近年の学会や論文ではFEEA後の吻合部再発の報告が散見され，無視できない問題となりつつある[2,3]．狭い骨盤腔内で多臓器に隣接する直腸癌と比較し，切除・剥離断端を十分に確保できる結腸癌では，吻合部再発の原因はviabilityを有する腸管内遊離癌細胞のimplantationが関与していると考えられている[6,7]．当院では，1995年以降に施行した手縫い吻合症例402例には吻合部再発例を認めておらず，FEEA症例490例では0.2%と低率である．欧米では機械吻合が手縫い吻合と同等の安全性を有すると報告される一方[8,9]，悪性腫瘍の切除後再建にFEEAを施行した135例の吻合部再発率が5.9%と高い報告もあり[10]，吻合距離が長くなるlinear staplerによる吻合が手縫い吻合と比較してimplantationを起こしやす

表1　わが国における報告例11例（自験例2例を含む）の臨床病理学的特徴

平均年齢	62歳（29～84歳）
男女比	6：5
原発部位	C：1例，T：3例，D：3例，S：4例
原発巣深達度	mp：1例，ss：10例
組織型	well：2例，mod：8例，por：1例
症状	なし：5例，下血：3例，食思不振：2例，貧血：1例
平均再発時期	11.2か月（5～24か月）

い可能性は否定できない．

わが国における自験例を含むFEEA後の吻合部再発報告例11例の検討では，全例が深達度mp以深の進行癌で，いずれの症例も術中洗浄は施行していなかった（表1）．特に遊離腫瘍細胞数が多いと考えられる進行癌症例に対しては何らかの吻合部再発防止策が必要と考えられ，最近では進行結腸癌症例に対しては吻合前に術中腸管内洗浄を試みている．直腸癌手術と異なり肛門からの洗浄が行えないため洗浄手技の工夫が必要であり，われわれは以下の手順で行っている．(1) No touch isolationを心掛け，授動後は腫瘍の口側および肛門側を絹糸で結紮する．(2) Linear staplerの挿入口から15 cm離して口側および肛門側を腸鉗子で遮断する．(3) 挿入口から尿道カテーテルを挿入し，バルーンを膨らませ，洗浄液が術野を汚染しないように十分に注意して生理食塩水で洗浄を行う．腸管洗浄による手術時間の過度の延長や術野の汚染は器械吻合の長所を失わせるため，迅速で安全な腸管洗浄が必要となる．

再発予防策と同時に早期発見も重要である．吻合部再発発見時期は平均11.2か月（5～24か月）であった（表1）．症例1を含め約半数の症例が無症状で，経過観察の大腸内視鏡検査で再発を発見されている．「大腸癌治療ガイドライン」[11]で推奨されているように，進行結腸癌症例では吻合部の観察のため，少なくとも術後1年での大腸内視鏡検査が不可欠と考えられる．

おわりに

FEEAの普及とともに今後も結腸癌術後の吻合部再発の報告の増加が予想される．特に進行結腸癌症例でのFEEAでは吻合部再発をつねに念頭に置いた予防策と経過観察が必要である．

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Hemodynamic Changes in the Liver under Balloon Occlusion of a Portal Vein Branch : Evaluation with single level dynamic computed tomography during hepatic arteriography

バルーンカテーテルによる門脈枝閉塞下の肝内血行動態の変化：single level dynamic computed tomography during hepatic arteriography による評価

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Hemodynamic Changes in the Liver under Balloon Occlusion of a Portal Vein Branch : Evaluation with single level dynamic computed tomography during hepatic arteriography

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Abstract

AIM: To assess hemodynamic changes in the liver under temporary occlusion of an intrahepatic portal vein.
MATERIALS and METHODS: Between February 2000 and October 2004, 16 patients with hepato-biliary disease underwent single level dynamic computed tomography during hepatic arteriography (SLD-CTHA) under temporary balloon occlusion of an intrahepatic portal vein. All patients needed percutaneous transhepatic portography for therapy of their disease. SLD-CTHA was taken to clarify the time-attenuation curve influenced by portal vein occlusion and it was performed continuously over a period of 30 s. The difference in absolute attenuation of the liver parenchyma in segments with occluded and non-occluded portal vein branches was determined by means of the CT number, and the difference in absolute attenuation of the occluded and non-occluded portal veins themselves were also evaluated.
RESULTS: SLD-CTHA demonstrated a demarcated hyperattenuation area in the corresponding distribution of the occluded portal vein branch. The attenuation of the liver parenchyma supplied by occluded portal vein was significantly higher than that in the non-occluded area ($p<0.01$). The balloon occluded portal branch enhancement in fifteen of 16 cases (94%) appears due to arterio-portal communications. Failure to evaluate a remaining case for portal branch enhancement was due to absence of a visualized portal branch in the scanning slice.
CONCLUSION : Under temporary occlusion of an intrahepatic portal vein, hepatic angiography produced enhancement of the occluded portal branches and their corresponding parenchymal distribution; this finding is considered consistent with the presence of arterio-portal communications.

Key words : Portal vein, stenosis or obliteration , Liver, blood supply , Liver, CT

Introduction

Transcatheter arterial chemoembolization (TACE) is known to be an effective palliative treatment for unresectable hepatocellular carcinoma (HCC) (1–5). However, histopathologic studies of HCCs resected after TACE have shown that complete necrosis occurs in less than 50% of lesions (6). Histopathologic investigations have shown that most viable tissue of HCC is located at the periphery of the tumor (6). Some researchers (7, 8) have reported that superselective TACE is useful for treatment of small HCC because it can embolize simultaneously over the subsegmental liver parenchyma around the HCC. Besides, recently introduced radio frequency ablation or percutaneous ethanol injection are also effective treatments for small liver tumors less than 3 cm in diameter. As far as treatment for large liver tumors is concerned, however, the types of therapy are limited to those that result in complete necrosis of the tumor.

Because of this problem, some researchers (9–12) have investigated the hemodynamic changes that occur in the liver and tumors under hepatic vein occlusion using computed tomography during hepatic arteriography (CTHA) and arterial portography. Murata et al. (11, 12) observed that the segmental hepatic vein occluded area is supplied with arterial blood alone. This suggests that adequate embolization may be obtained during TACE therapy with arterial control alone. However, there are a lot of complex veno-venous communications in the liver (9, 11). Therefore, it is difficult to obtain sufficient embolization in huge liver tumors using the hepatic vein balloon occlusion technique because the tumor have other draining veins, or the hepatic veins are changed to play a role as draining veins despite single hepatic vein occlusion (11, 13).

When portal venous blood flow is decreased gradually or stopped due to tumor thrombus, thromboembolus, or compression of the portal vein, the corresponding parenchyma appears as a hyperattenuated area with straight borders on CTHA (14–18), as well as hepatic vein occlusion. There is little anatomical variation in portal veins or porto-portal venous anastomosis. These facts suggest that sufficient embolization may be obtained even in huge liver tumors by TACE therapy under temporary occlusion of a portal vein branch. The purpose of this article was to assess the hemodynamic changes in the liver under acute temporary occlusion of an intrahepatic portal vein.

Materials and methods

Patients

Permission to carry out the study was granted by the Ethics Committee of our university, and all patients gave their informed consent before taking part in the study. The study population comprised 16 patients (six women, 10 men; age range, 29–73 years) with hepato-biliary disease who required percutaneous transhepatic obliteration (table 1). The study was performed between February 2000 and October 2004. Thirteen of the 16 patients had liver cirrhosis [Child-Pugh B (n=11), Child-Pugh C (n=2)] with gastric varices. The remaining three patients had cancer of the biliary duct (n=1), cancer of the gall bladder (n=1), or colon cancer with liver metastases (n=1). These three patients were scheduled to undergo extended hepatectomy. Endoscopy and ordinary angiography were performed on 13 patients with gastric varices to determine the most appropriate therapy for their disease. Ordinary angiography for hepato-biliary diseases included celiac arteriography, superior mesenteric arterio-portography and common hepatic arteriography. The intrahepatic portal veins were visualized in all patients regardless of hepatofugal portal venous flow.

【 Table 1 】 Case summary

Case No.	Age / Sex	Diagnosis	Purpose for PTP	Portal Vein Approach Site	Portal Vein Occlusion Site	Artery Infusion Site	Appearance of Portal Vein Occluded/ Non-occluded
1	46 Male	LC with varices	PTO	P8	P6+7	PHA	(+) / (-)
2	67 Male	LC with varices	PTO	P5	P2	PHA	(+) / (-)
3	29 Male	LC with varices	PTO	P5	P2	CHA	(+) / (+)
4	66 Female	LC with varices	PTO	P5	P2	PHA	(+) / (-)
5	55 Female	CBD Cancer	Preoperative PTO	P5+8	P3	PHA	(+) / (-)
6	70 Female	LC with varices	PTO	P5	P3	PHA	(+) / (-)
7	54 Male	LC with varices	PTO	P5+8	P2	PHA	(-) / (-)
8	61 Male	LC with varices	PTO	P2	P6+7	PHA	(+) / (-)
9	51 Female	Gall Bladder Cancer	Preoperative PTO	P5+8	P5+6+7+8	CHA	(+) / (+)
10	73 Male	HCC with AP shunt	PTO	P3	P5+8	PHA	(+) / (-)
11	68 Male	LC with varices	PTO	P2	P2	CHA	(+) / (+)
12	59 Female	LC with varices	PTO	P2	P2	CHA	(+) / (+)
13	64 Male	Liver Metastasis	Preoperative PTO	P5+8	P2	CHA	(+) / (+)
14	44 Male	LC with varices	PTO	P5+8	P2	CHA	(+) / (+)
15	57 Male	LC with varices	PTO	P2	P2	PHA	(+) / (-)
16	65 Female	LC with varices	PTO	P5	P2+3	PHA	(+) / (-)

LC:liver cirrhosis, AP shunt:arterioportal shunt, PTP:percutaneous transhepatic portography, PTO:percutaneous transhepatic obliteration, CHA:common hepatic artery, PHA:proper hepatic artery,
P2:superior lateral branch, P3:inferior lateral branch, P2+3:left lateral branch, P5:anterior inferior branch, P8:anterior superior branch P5+8:anterior branch, P6+7:posterior branch, P5+6+7+8:right portal vein

Angiographic procedures

Portal vein approach

An intrahepatic portal vein was punctured using the percutaneous transhepatic technique guided by ultrasonography and a 5-Fr. sheath (Medikit, Tokyo, Japan) was inserted into the portal vein trunk. A 5-Fr. pig tail catheter was then inserted into the portal vein trunk and direct portography was performed for recognition of anatomical findings. A 5-Fr. balloon catheter (35-70-CJ-H; Clinical Supply, Tokyo, Japan) was then introduced into an intrahepatic portal vein (lateral superior branch of the left portal vein (n=9), lateral inferior branch of the left portal vein (n=2), posterior branch of the right portal vein (n=2), lateral segmental branch (n=1), right portal vein (n=1), anterior branch of the right portal vein (n=1)).

Hepatic artery catheterization

After puncture of the unilateral femoral artery, a 5-Fr. long sheath (Medikit, Tokyo, Japan) was inserted. A 5-Fr. shepherd's crook-shaped catheter (Medikit, Tokyo, Japan) was introduced into the celiac artery and celiac arteriography was performed for mapping of the anatomical findings. A 4-Fr. cobra-shaped catheter (Medikit, Tokyo, Japan) was then introduced into the hepatic artery (proper hepatic artery (n=10), common hepatic artery (n=6)) and hepatic arteriography was carried out in all patients to determine the appropriate injection rate for CTHA with portal vein occlusion that would not cause backflow of contrast medium at angiography.

Single-level dynamic CTHA

A pre-contrast computed tomography scan (RADIX-1 PRIMA; Hitachi Medical System, Tokyo, Japan) was obtained of the liver with a single acquisition to determine the scanning slice for single level dynamic CTHA (SLD-CTHA). The balloon in the portal branch was inflated with contrast medium diluted in physiological saline. SLD-CTHA was then performed immediately in all patients to clarify the time attenuation curve influenced by temporary occlusion of the portal vein with a balloon catheter.

Using a 3-mm collimated beam, SLD-CTHA was

initiated simultaneously with the injection of diluted nonionic contrast medium (100 mg iodine/ml diluted with physiological saline) via the hepatic artery, and performed continuously over a period of 30 s with a single acquisition with oxygen mask. The rate of image acquisition for SLD-CTHA was one image per second. The injection rate was 1.5–2.0 ml/s when the catheter tip was located in the proper hepatic artery and 2.0–2.5 ml/s when the tip was located in the common hepatic artery; the injection was continued for 10 s.

Data analysis

Visual evaluation

Thirty images of SLD-CTHA with temporary portal vein occlusion were analyzed visually with special attention paid to the contrast enhancement of portal branches with balloon occlusion or non-occlusion, and the marginal area during occlusion and non-occlusion. Image analysis was performed by two radiologists (S.M., H.T.) with consensus who were blinded as to any of patient information.

Absolute CT number evaluation

The CT number (Hounsfield units) in the region of interest was measured in the balloon-occluded and non-occluded segments of each image, with vascular structures avoided as much as possible. As far as the non-occluded area was concerned, the CT number was determined in three different segments of each image and the average value was calculated. The difference in absolute CT number of the liver parenchyma between occluded and non-occluded portal veins in each image was evaluated. All data are shown as means ± SD. Results were compared by Tukey's range test and the Student's t-test. Differences at $P<0.05$ were considered statistically significant.

Results

Visual evaluation

1) Portal vein branches

In all 10 patients who underwent injection of contrast material via the proper hepatic artery, SLD-CTHA with temporary portal vein occlusion demonstrated contrast enhancement of the balloon-occluded portal vein branch. Portal vein parallel to scanning slice (two of 10 cases) was clearly enhanced from proximal to distal in the portal vein branch (Fig. 1, 2). Conversely, there was no enhancement of the non-occluded portal branches in any of the 10 cases. Of the six patients in whom contrast material was injected via the common hepatic artery, five showed enhancement of the balloon-occluded portal branch on SLD-CTHA with temporary portal vein occlusion (Fig. 3). In the remaining case where the occluded portal branch could not be enhanced, no portal branches could be identified in the occluded area. Therefore, it is uncertain whether they were enhanced or not. Concerning the non-occluded portal branches, these were slightly enhanced in six cases mainly because contrast material passed into the portal vein via the gastroduodenal artery.

2) The territories of the occluded and non-occluded vessels

SLD-CTHA revealed a well-demarcated area of hyperattenuation consistent with the area of portal vein occlusion in 14 of 16 patients, and a poorly demarcated area of hyperattenuation in the remaining two patients. These two patients had severe liver cirrhosis (Child-Pugh C), and the marginal area was only partly identified. The enhancement in the area of portal vein occlusion was prolonged over 30 s compared with that in the non-occluded area in all 16 patients.

Figure Legends

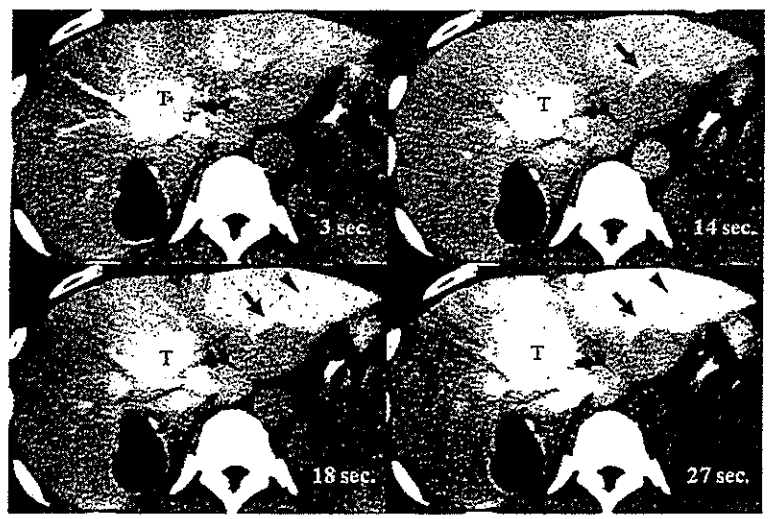

Figure 1. Fifty-five-year-old female with common bile duct cancer.
SLD-CTHA images with balloon occlusion of the inferior lateral branch of the portal vein. The catheter tip is located in the proper hepatic artery. SLD-CTHA images at 3, 14, 18 and 27 s after the onset of injection of contrast medium show that the inferior lateral subsegment is enhanced in a well-demarcated hyperattenuated area. The inferior lateral branch of the portal vein is clearly enhanced from proximal (arrows) to distal (arrow heads) in images at 18 s and 27 s in spite of occlusion of the same portal vein. Alphabet T indicates bile duct cancer.

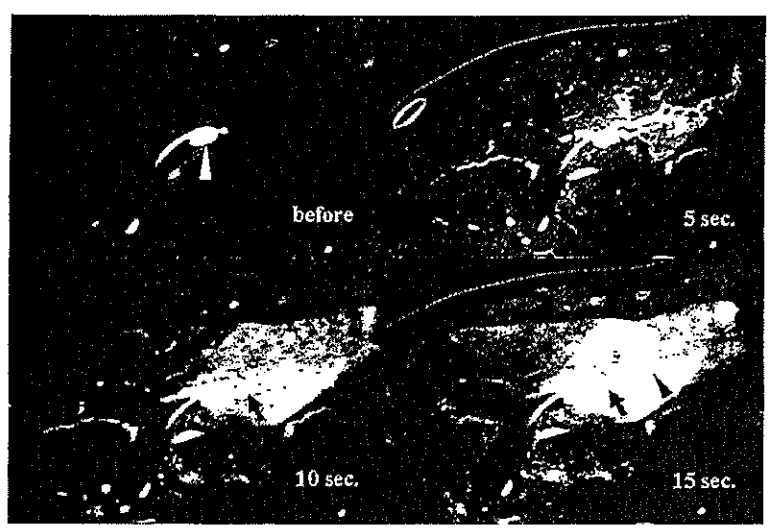

Figure 2. Sixty-five-year-old female with gastric varicose veins caused by liver cirrhosis.
SLD-CTHA images with balloon occlusion of the lateral branch of the portal vein. The catheter tip is located in the proper hepatic artery. The white arrowhead indicates an inflated balloon with contrast medium. White arrow indicates the inferior lateral branch of the left hepatic artery. SLD-CTHA images before the onset of injection of contrast medium, and 5, 10 and 15 s after the onset of injection of contrast medium show that the lateral segment is enhanced. The lateral branch of the left portal vein is obviously enhanced from proximal (black arrows) to distal (black arrowhead) in images at 5, 10 and 15 s in spite of occlusion of the same portal vein branch. In particular, the image at 10 s clearly shows that the lateral branch of the left portal vein runs in parallel with the lateral segmental artery.

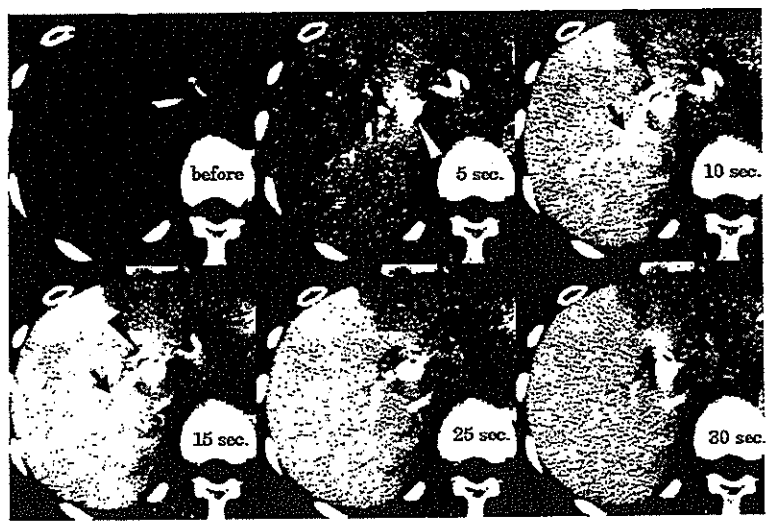

Figure 3. Fifty-one-year-old female with cancer of the gall bladder involving the liver.
SLD-CTHA images with balloon occlusion of the right portal vein. The catheter tip is located in the common hepatic artery. The white arrowhead indicates a balloon. Black arrowheads indicate the right hepatic artery. The SLD-CTHA images were taken just before the onset of injection of contrast medium, and 5, 10, 15, 20 and 30 s after the onset of injection of contrast medium. The right lobe is shown a well-demarcated, hyperattenuated area from 10 s after the onset of injection, and the enhancement continued until 30 s after injection. The right portal vein (arrows) is obviously enhanced in the images at 10 s and 15 s in spite of occlusion of the same portal vein.

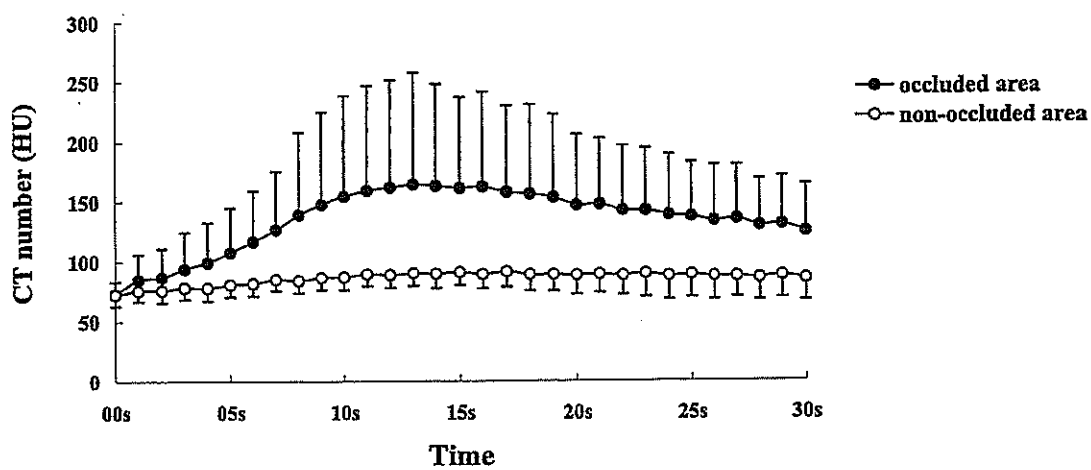

Figure 4. Time-density curve between occluded and non-occluded area

Absolute CT number evaluation (table 2)

CT number in the occluded area was significantly higher than that in the non-occluded area from 4–30 s in all cases. A time density curve (Fig. 4) showed that the peak of contrast enhancement in the occluded and non-occluded areas was 14.3 ± 4.7 s and 15.2 ± 5.6 s, respectively; this difference was not statistically significant. The difference in CT number between that

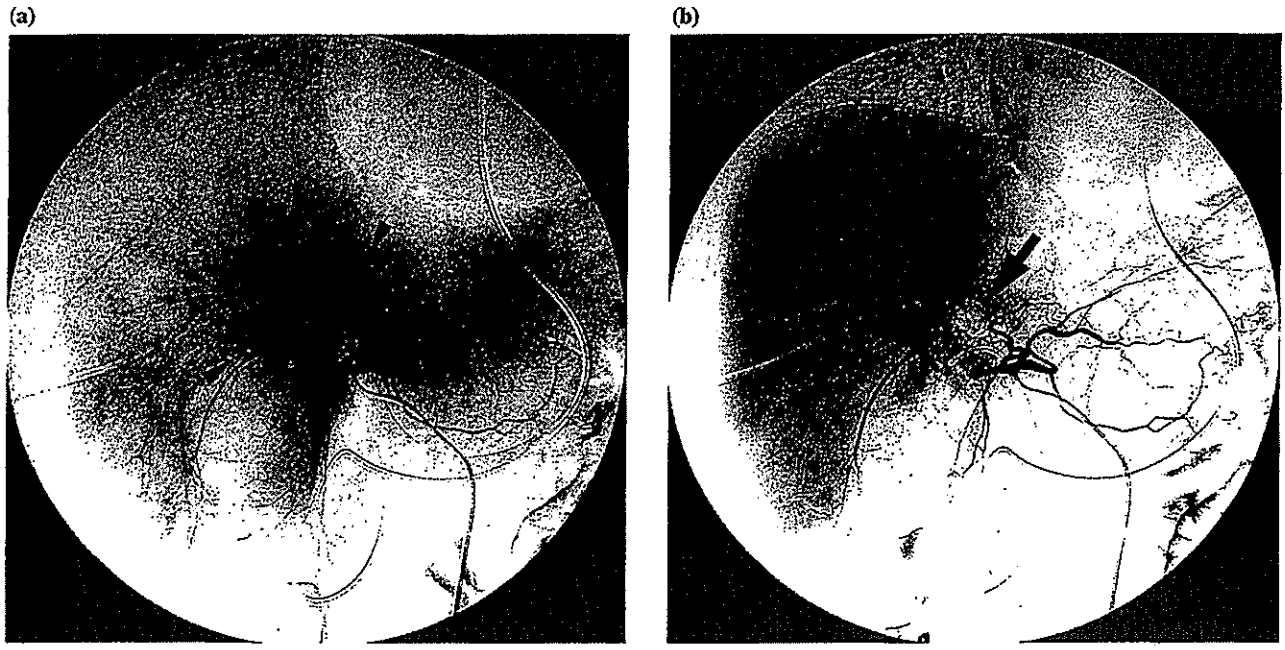

Figure 5. Fifty-five-year-old female with common bile duct cancer.
Proper hepatic arteriography without (a) and with (b) occlusion of the right portal vein branch.
Proper hepatic arteriography (b) with occlusion of the right portal vein branch shows increase opacity of the right lobe and decrease opacity of the left lobe in the liver compared with (a). Arrowheads (a) indicate bile duct cancer and arrow (b) indicates an inflated balloon with contrast medium.

at 0 s and at peak enhancement was 103.4 ± 51.0 HU in the occluded area and 21.8 ± 11.8 HU in the non-occluded area; this difference was statistically significant ($P<0.01$). The difference in CT number between that at peak and at 30 s was 49.8 ± 59.4 HU in the occluded area and 8.9 ± 5.9 HU in the non-occluded area; once again this difference was statistically significant ($P<0.05$). The contrast enhancement effect was very high in the occluded area and very low in the non-occluded area.

Therapy after SLD-CTHA

After examination, 13 of the 16 patients, who all had gastric varices, underwent embolization of the extra-hepatic hepatofugal circulation for the gastric varicose vein and balloon-occluded retrograde transvenous obliteration. Additionally, the left gastric artery was embolized using coils to decrease blood flow into the gastric vein in 10 of 13 patients. The remaining three patients with hepato-biliary cancer underwent embolization of the adequate intra-hepatic portal branch (Fig.5) in preparation for extended hepatic resection.

【 Table 2 】 The difference in CT number of the liver parenchyma

	Peak Time (Av/SD)	Maximum (Av/SD)	Difference between Minimum and Maximum	Difference between Maximum and 30 s (Av/SD)
Occluded Area	14.3 / 4.7 (s)	176.3 / 90.5 (HU)**	103.4 / 51.0 (HU)**	49.8 / 59.4 (HU)*
Non-occluded Area	15.2 / 5.6 (s)	94.4 / 17.9 (HU)	21.8 / 11.8 (HU)	8.9 / 5.9 (HU)

Av:average, SD:standard deviation, HU:Hounsfield Unit, * $p<0.05$, ** $p<0.01$,

Discussion

The liver is an unusual organ from the point of view of its blood supply because of the dual blood supply of the portal vein and hepatic artery. Knowledge of this dual blood supply plays an important role in the diagnosis and treatment of liver tumors. Many researchers have investigated the correlation between the portal vein and the hepatic artery, especially communication systems including transvasal and transplexal routes (18–20), and the hemodynamic changes of dual blood flow. There are several communication systems between both vessels. Among them, the most prominent system is transplexal via the peribiliary plexus in the normal liver. On the other hand, changes in portal venous blood flow produce inverse changes in flow in the hepatic artery. It is considered that a decrease in portal vein blood flow (less washout of adenosine) leads to an increased concentration of adenosine, which in turn causes hepatic arterial dilation and hepatic arterial blood flow increases in the corresponding area (21–23).

When portal venous flow stoppage occurs chronically in various conditions, including portal vein obstruction due to tumor thrombus and portal vein compression by intra- and extrahepatic tumors, hepatic arterial blood flow is increased mainly through the peribiliary plexus (18–20). The present study showed a corresponding hyperattenuated area with portal vein occlusion in all patients. This suggests that when portal venous flow stoppage occurs chronically or acutely, hepatic arterial blood flow is increased as well as adenosine washout (21–23).

The most interesting result of the current study was that SLD-CTHA with portal vein occlusion resulted in contrast enhancement of the balloon-occluded portal branch in all 10 cases with contrast material injection via the proper hepatic artery. While the non-occluded portal branches in these 10 cases were never enhanced. Before starting this study, it was considered that contrast enhancement of the balloon-occluded portal branch would not be demonstrated in the proximal site of the portal branch by arterio-portal communications because arterio-portal communications occur in the distal site of the portal vein, namely the terminal portal venules. Arterial blood supply in the normal liver parenchyma is provided by four different types of arterio-portal communications (24–26): the first type is the peribiliary plexus, which is the most abundant type of arterial blood supply to the liver parenchyma. These plexuses drain into the portal venules (the most common pathway) or into the periportal sinusoids. The second type is the terminal arterio-portal twigs, which also drain into the periportal sinusoids. The third is the vasa vasorum, which only has a limited contribution, and the fourth are direct arterio-portal communications, which are either few or non-existent (14). The phenomenon of contrast enhancement of the balloon-occluded portal branch in the present study could be explained as follows: first is that contrast medium flowed into the portal venules via the arterio-portal communications and then flowed backwards to the proximal site of the occluded portal vein because blood pressure in the occluded portal vein was lower than that in the non-occluded veins; second is that under special circumstances such as acute portal vein occlusion, direct arterio-portal communications, which are either few or non-existent, might be forced open. Indeed, portal vein parallel to scanning slice (three of 16 cases) was clearly enhanced from proximal to distal in the portal vein branch. This result suggested the latter explanation. In addition, experimental studies with rats using in vivo microscopy and angiography show the same phenomenon (27). To our best knowledge, this is the first report to demonstrate this phenomenon in clinical cases. However, there is currently no other evidence to support this latter explanation.

The present study revealed that arterial blood flowed into the corresponding liver parenchyma via the portal vein site as well as via the ordinary arterial site under temporary portal vein occlusion. Unlike the hepatic veins, there are few anatomical variations in the portal veins

and porto-portal venous anastomoses. This suggests that TACE under temporary occlusion of the portal vein could embolize an unresectable liver tumor in the corresponding area. With these results in mind, we have started to perform TACE under temporary occlusion of the portal vein for unresectable HCC. It consists of two procedures. First, we insert a 5-Fr. balloon catheter into the intrahapatic portal branch corresponding to localized tumor using percutanous transhepatic portography technique. Secondly, we insert a 4-Fr. Cobra-shaped catheter or a microcatheter into the feeding artery of the tumor and carry out injection of an emulsion of Lipiodol and anticancer agents, and also gelatin sponge via the feeding artery under temporary occlusion of the corresponding portal vein branch.

In conclusion, we have demonstrated significant enhancement of liver parenchyma and portal veins in the distribution of occluded portal vein branches following hepatic arteriography.

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