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## Introduction

Symptomatic chronic mesenteric ischemia is well known as a clinical entity related to a stenosis of digestive arteries (1, 2). The first successful attempts to its surgical treatment date back to about 40 years ago (3-5). Since then, the revascularization of digestive arteries remains the standard therapy of this condition, which is, however, rare thus limiting the possibility of collecting a large individual experience and of conceiving prospective studies, definitely establishing which surgical option yields the best results. Currently debated issues include the opportunity of multiple or isolated revascularization of the digestive arteries, the role of transaortic endarterectomy and bypass grafting, the choice of graft material and configuration, the indication to simultaneous aorto-iliac surgery, and the role of angioplasty. The series proposing specific surgical options as superior with respect to the others, lack of sufficient inclusion numbers, in order to achieve statistical significance.

For this reason, when dealing with chronic mesenteric ischemia, rather than prospectively testing a single treatment option, we decided to flexibly apply the different techniques of revascularization as the one that best fitted each individual case. The evaluation of mid-term clinical and patency results of a so collected patients series is the purpose of the present study.

## Riassunto

### IL TRATTAMENTO DELL'ISCHEMIA INTESTINALE CRONICA

*Data la rarità della patologia mancano degli studi prospettici per la definizione del metodo di rivascolarizzazione ottimale delle arterie digestive, nel trattamento dell'ischemia intestinale cronica.*

*Lo scopo di questo studio prospettico consecutivo è quello di verificare l'ipotesi che l'applicazione di differenti metodi di rivascolarizzazione ai singoli casi, possa fornire i migliori risultati nel trattamento dell'ischemia cronica intestinale.*

*Undici pazienti con età media di 57 anni sono stati sottoposti a rivascolarizzazione di 11 arterie digestive per malattia oclusiva mesenterica cronica, sintomatica. Sono state rivascolarizzate 11 arterie mesenteriche superiori ed un tronco celiaco. Le tecniche utilizzate sono state: 7 by-pass retrogradi, 2 anterogradi, 1 angioplastica percutanea ed 1 reimpianto di arteria in un caso. L'asse donatore nei casi di reimpianto o by-pass è stata l'aorta sottorenale in 4 casi, una protesi in Dacron in altri 4, e il tronco celiaco in un caso.*

*I materiali protesici utilizzati sono stati una protesi in Politetrafluoroetilene (PTFE) in 5 casi, e una protesi in Dacron in 3. Procedure concomitanti sono state 3 by-pass aorto-iliaci ed una rivascolarizzazione di arteria renale. La durata media del follow-up è stata di 31 mesi.*

*Non c'è stata nessuna mortalità operatoria. Il tasso cumulativo di sopravvivenza è stato dell'88,9% a 36 mesi - Errore Standard (ES) 12,1%. La durata della pervietà è stata del 90% a 36 mesi (ES 11,6%). L'intervallo libero di malattia è stato del 90% a 36 mesi (ES 11,6%).*

*Il reimpianto diretto, il by-pass anterogrado e retrogrado, consentono tutti buoni risultati a medio termine, quando correttamente applicati ai singoli casi. Eventuali lesioni sottorenali o di arterie renali possono essere trattate nella stessa seduta. L'angioplastica isolata fornisce risultati mediocri e dovrebbe essere limitata a pazienti ad elevato rischio operatorio.*

*Parole chiave: Ischemia intestinale cronica, rivascolarizzazione di arterie digestive.*

## Abstract

**Background and aims:** *Due to the rarity of the condition, large and prospective series defining the optimal method of digestive arteries revascularization, for the treatment of chronic intestinal ischemia, are lacking. The aim of this consecutive sample clinical study was to test the hypothesis that flexible application of different revascularization methods, according to individual cases, will yield the best results in the management of chronic intestinal ischemia.*

**Patients and methods:** *Eleven patients, of a mean age of 57 years, underwent revascularization of 11 digestive arteries for symptomatic chronic mesenteric occlusive disease. Eleven superior mesenteric arteries and one celiac axis were revascularized. The revascularization techniques included retrograde bypass grafting in 7 cases, antegrade bypass grafting in 2, percutaneous arterial angioplasty in 1, and arterial reimplantation in one case. The donor axis for either reimplantation or bypass grafting was the infrarenal aorta in 4 cases, an infrarenal Dacron graft in 4, and the celiac aorta in one case. Grafting materials included 5 polytetrafluoroethylene (PTFE) and 3 Dacron grafts. Concomitant procedures included 3 aorto-ilio-femoral grafts and one renal artery revascularization. Mean follow-up length was 31 months.*

**Results:** *There was no operative mortality. Cumulative survival rate was 88,9% at 36 months (SE 12,1%). Primary patency rate was 90% at 36 months (SE 11,6%). The symptom free rate was 90% at 36 months (SE 11,6%).*

**Conclusions:** *Direct reimplantation, antegrade and retrograde bypass grafting, all allow good mid-term results: the choice of the optimal method depends on the anatomic and general patient's status. Associated infrarenal and renal arterial lesions can be safely treated in the same time of digestive revascularization. Angioplasty alone yields poor results and should be limited to patients at poor risk for surgery.*  
**Key words:** Chronic intestinal ischemia, digestive arteries revascularization.

## Material and Methods

Eleven consecutive patients underwent revascularization for symptomatic chronic mesenteric occlusive disease, at the Department of Surgery of the University of Rome and one affiliated hospital, from October 1<sup>st</sup>, 1999 to October 31, 2002. Patients presenting with asymptomatic stenoses of the digestive arteries, acute mesenteric ischemia, non occlusive diseases of the digestive arteries, Takayasu disease, median arcuate ligament compression syndrome, and splanchnic venous disease were excluded. Patients undergoing simultaneous surgery of the aorta for aneurysm or occlusive disease were included only if the angiographically detected lesions of the digestive arteries effectively corresponded to objective symptoms of intestinal ischemia.

The patients' population consisted of 7 men and 4 women, with a mean age of 57 years (ext. 25-88 yrs).

Demography and risk factors were as follows: 3 patients (27%) presented an extra-digestive arterial occlusive disease, 7 (63%) arterial hypertension, 6 (54%) coronary artery disease, defined as a clinical history or electric signs of myocardial ischemia, 2 (18%) a previous cholecystectomy, 1 (9%) a previous aorto-iliac revascularization, and 2 (18%) diabetes.

All the patients were symptomatic with post-prandial abdominal pain appearing about half an hour after the meals in 100% of them, a significant weight loss (about 10 kg) in 85%, and diarrhea in 57%. One patient also complained of lower limbs claudication, whereas two other patients presented an associated, pulsatile abdominal mass. Eight patients were referred after undergoing some investigations elsewhere. The mean length of symptoms before referral was 8 months, with extremes ranging from 2 to 33 months. None of the patients presented with acute symptoms. An abdominal bruit was audible in 52% of the patients, whereas 44% presented some form of discomfort or tenderness at abdominal palpation. Laboratory investigations, including enzymes were usually within the normal range.

All the patients underwent angiography before revascularization, and were considered as having a significant stenosis of a digestive axis if this was > 75%. The latest two patients in the series also underwent a Duplex-ultrasound examination with assessment of flow variations in the superior mesenteric artery and vein, before and after a test meal. As part of clinical work-up, all the patients underwent also abdominal ultrasound and CT-scan.

Angiography revealed an isolated significant stenosis of the superior mesenteric artery (SMA) in 11 (100%) patients, of the SMA and celiac axis (CA) in 2 (18%), of the SMA and inferior mesenteric artery (IMA) in one (9%), of the CA, SMA, and IMA in 4 (36%). Three patients (27%) also presented associated lesions of the infrarenal aorta and ilio-femoral axes, consisting in 2 aortic aneurysms, and one aorto-ilio-femoral obstructive lesion. This latter patient also presented a

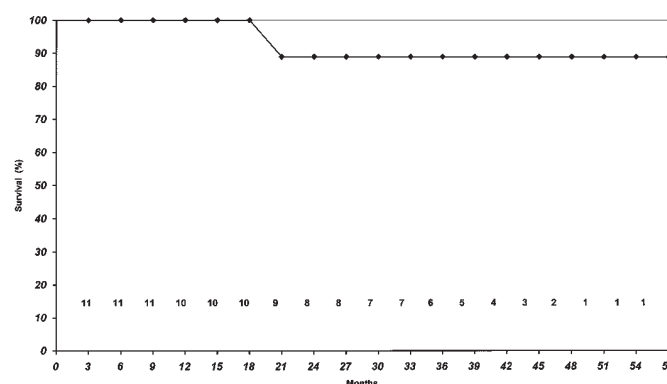


Fig. 1: Cumulative survival rate of operated patients. the numbers above the time axis indicate the number of patients at risk for each time interval.

Tab. I – CHRONIC MESENTERIC ISCHEMIA

<i>Patient</i>	<i>Sex</i>	<i>Involved Vessel</i>	<i>Revascularized Vessel/Method/Donor Axis</i>	<i>Concomitant Lesions/Procedures</i>	<i>Follow-up (Months)</i>	<i>Outcome</i>
1	M	SMA	SMA/Retrograde PTFE/Infrarenal aorta	–	43	Patent Asymptomatic
2	F	SMA + IMA	SMA/Retrograde PTFE/Infrarenal Dacron graft	AAA / Aorto-ilio-femoral Dacron graft	56	Patent Asymptomatic
3	M	CA + SMA	SMA/Retrograde Dacron/Infrarenal Dacron graft	Aorto-iliac, RRA stenosis/Aorto-bifemoral/RRA Dacron graft	19	Patent Deceased M.I.
4	M	SMA	SMA/Direct reimplantation/Infrarenal aorta	–	46	Patent Asymptomatic
5	M	CA + SMA + IMA	CA + SMA/Antegrade Dacron/Celiac aorta	–	46	Patent Asymptomatic
6	F	SMA	SMA / Angioplasty	–	19	Occluded, Recurrence of Symptoms
7	F	CA + SMA + IMA	SMA/Retrograde PTFE/Infrarenal aorta	–	36	Patent Asymptomatic
8	M	CA + SMA + IMA	SMA/Retrograde Dacron/Infrarenal Dacron graft	AA/Aorto-iliac Dacron graft	33	Patent Asymptomatic
9	F	CA + SMA	SMA/Retrograde PTFE/Infrarenal aorta	–	26	Patent Asymptomatic
10	M	CA + SMA + IMA	SMA/Retrograde PTFE/Infrarenal aorta	–	17	Patent Asymptomatic
11	M	SMA	SMA/Antegrade PTFE/Infrarenal Dacron graft	–	7	Patent Asymptomatic

Legends: SMA = superior mesenteric artery; CA = celiac axis; IMA = inferior mesenteric artery; RRA = Right Renal Artery; PTFE = polytetrafluoroethylene; AAA = aneurysm of the abdominal aorta

significant associated stenosis of the right renal artery. One more patient underwent a previous aorto-femoral bypass grafting for ilio-femoral obstructive lesions. The two patients undergoing a duplex ultrasound study of the superior mesenteric artery, both presented a significant reduction of the basal fasting flow in the superior mesenteric artery, which was not modified by meal ingestion.

Surgical revascularization techniques included arterial reimplantation, antegrade and retrograde by-pass grafting, and percutaneous arterial angioplasty. The donor axis for bypass grafts was the celiac aorta for one antegrade revascularization, the suprarenal aor-

ta for one direct reimplantation, the infrarenal aorta for 3 retrograde revascularizations, and an infrarenal Dacron graft for 4 retrograde revascularizations. One percutaneous angioplasty was performed via transfemoral Seldinger catheterization. Grafting materials included Polytetrafluoroethylene (PTFE) in 5 cases and knitted Dacron in 3.

Autologous saphenous vein was never harvested as graft material. Overall 11 SMA and 1 CA were revascularized. One SMA was revascularized by percutaneous angioplasty, 7 by retrograde and 2 by antegrade bypass grafting, and one by direct reimplantation on the abdominal aorta. The only CA was revascularized by an

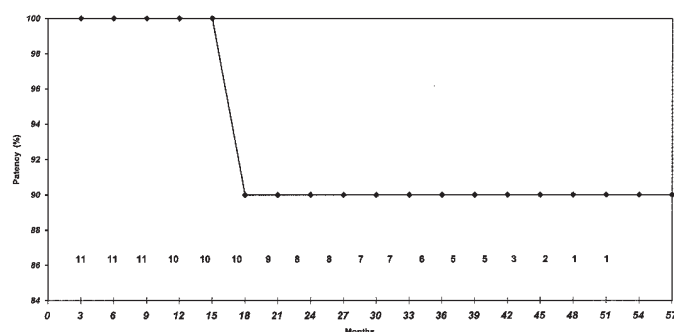


Fig. 2: Cumulative primary patency rate of revascularizations for chronic visceral ischemia.

The numbers above the time axis indicate the number of revascularizations at risk for each time interval.

antegrade graft from the celiac aorta, sequentially directed to the SMA also, in the single patient undergoing a simultaneous revascularization of the CA and SMA. All other patients underwent an isolated revascularization of the SMA, despite the eventual presence of associated lesions of the CA and/or IMA. Three patients underwent the simultaneous treatment of extradigestive arterial lesions, consisting in 2 aorto-ilio-femoral grafting for an infrarenal aortic aneurysm, and one aorto-bifemoral-right renal grafting for ilio-femoral and right renal artery obstructive lesions. The essential reported clinical data are summarized in table I.

For the evaluation of the results, the following out-

comes were considered: operative mortality and morbidity, survival rate, primary patency rate, and symptom-free rate. Operative mortality and morbidity were defined as any death or complication occurring within 30 days from operation.

For the survival rate calculation, the time elapsed from the date of surgery to the date of the last follow-up examination or death was considered.

The primary patency rate was defined as an uninterrupted patency without any adjunctive subsequent procedure, and was calculated as the interval from the date of surgery to the last follow-up examination or the first objective discovery of a restenosis or occlusion, at ultrasound scanning or angiography.

The symptom-free rate was calculated considering the time elapsed from the date of surgery to the last follow-up examination or the first recurrence of postoperative mesenteric ischemic symptoms.

The standard follow-up consisted in an outpatient clinical control together with an abdominal Duplex ultrasound every 6 months for the first postoperative years, and subsequently every 12 months. An arteriogram was performed in case of recurrence of symptoms and/or Duplex ultrasound demonstration of a failed reconstruction.

No patient was lost at follow-up, whose mean length was 31 months (ext. 7-57 months).

Overall survival, primary patency, and symptom-free rates were expressed by the actuarial method, according to Kaplan-Meier estimates of survival (6).

Tab. II - CUMULATIVE SURVIVAL RATE AFTER REVASCULARIZATION OF DIGESTIVE ARTERIES FOR CHRONIC MESENTERIC ISCHEMIA

A Interval (months)	B At risk (n)	C Deaths (n)	D Withdrawn (n)	E Interval death rate (%)	F Cumulative survival rate (%)	G Standard error (%)
0	11	0	0	0,000	100,0	0,00
3	11	0	0	0,000	100,0	0,00
6	11	0	0	0,000	100,0	0,00
9	11	0	1	0,000	100,0	0,00
12	10	0	0	0,000	100,0	0,00
15	10	0	0	0,000	100,0	0,00
18	10	0	1	0,000	100,0	0,00
21	9	1	0	0,111	88,9	9,88
24	8	0	0	0,000	88,9	10,48
27	8	0	1	0,000	88,9	10,48
30	7	0	0	0,000	88,9	11,20
33	7	0	1	0,000	88,9	11,20
36	6	0	1	0,000	88,9	12,10
39	5	0	1	0,000	88,9	13,25
42	4	0	1	0,000	88,9	14,81
45	3	0	1	0,000	88,9	17,11
48	2	0	1	0,000	88,9	20,95
51	1	0	0	0,000	88,9	29,63
54	1	0	0	0,000	88,9	29,63
57	1	0	1	0,000	88,9	29,63

## Results

No patient died in the postoperative period. Two patients (18%) presented, within the first three postoperative days, electrical signs of myocardial ischemia, regressed with appropriate medical treatment. Both of them had a previous history of coronary artery disease. A prolonged postoperative ileus, simply requiring naso-gastric aspiration was observed in 3 cases (27%). One patient, undergoing an associated infrarenal aortic and right renal artery revascularization, presented a transitory postoperative elevation of serum creatinine concentration to 280 mmol/l.

One late death occurred at 19 months for myocardial infarction, with a patent revascularization and absence of symptom recurrence. Overall late mortality was 9%. The

cumulative survival rate for the whole series was 89% at 36 months (SE 12%) (Tab. II, Fig. 1).

One revascularization (9%) consisting in percutaneous angioplasty, thrombosed at 16 months, with recurrence of symptoms. A retrograde aorto-mesenteric PTFE bypass was performed which remains patent at 43 months, with complete remission of symptoms.

The overall primary patency rate was 90% at 36 months (SE 11,62%) (Tab. III, Fig. 2).

All the patients of the series, but one, remained asymptomatic. The cumulative symptom-free rate was 90% at 36 months (SE 11.62%) (Tab. IV, Fig. 3).

## Discussion

Chronic mesenteric ischemia is a rare disease. Various surgical techniques are available for splanchnic revascularization, including transaortic endarterectomy (7), direct reimplantation on the aorta (8, 9), antegrade or retrograde bypass grafting (4, 5, 10-13), angioplasty with and without stenting (14). Each method has been followed by good results, in the experience of its proponents, nevertheless individual series are relatively small and extend over several years, which renders standardization of optimal treatment difficult. Whether multiple digestive arteries reconstruction is superior to isolated SMA revascularization, orthograde bypass is better than the retrograde configuration, and saphenous vein allows better results than other graft materials is debated. The aim of the present study was to flexibly apply the dif-

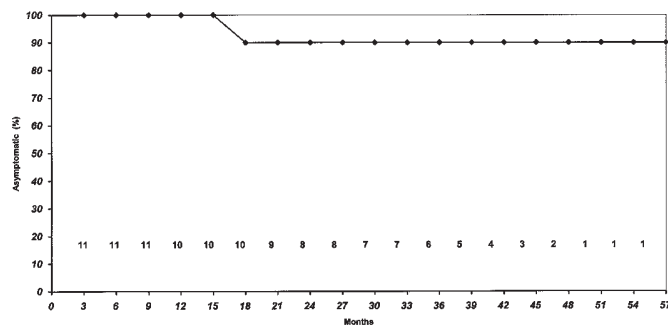


Fig. 3: Cumulative freedom from symptoms recurrence after revascularization for chronic visceral ischemia. The numbers above the time axis indicate the number of patients at risk for each time interval.

Tab. III - CUMULATIVE PRIMARY PATENCY RATE OF REVASCULARIZATIONS FOR CHRONIC VISCERAL ISCHEMIA

A Interval (months)	B At risk (n)	C Failed (n)	D Withdrawn (n)	E Interval failure (%)	F Cumulative patency rate (%)	G Standard error (%)
0	11	0	0	0,000	100,0	0,00
3	11	0	0	0,000	100,0	0,00
6	11	0	0	0,000	100,0	0,00
9	11	0	1	0,000	100,0	0,00
12	10	0	0	0,000	100,0	0,00
15	10	0	0	0,000	100,0	0,00
18	10	1	0	0,100	90,0	9,00
21	9	0	1	0,000	90,0	9,49
24	8	0	0	0,000	90,0	10,06
27	8	0	1	0,000	90,0	10,06
30	7	0	0	0,000	90,0	10,76
33	7	0	1	0,000	90,0	10,76
36	6	0	1	0,000	90,0	11,62
39	5	0	0	0,000	90,0	12,73
42	5	0	2	0,000	90,0	12,73
45	3	0	1	0,000	90,0	16,43
48	2	0	1	0,000	90,0	20,12
51	1	0	0	0,000	90,0	28,46
54	1	0	0	0,000	90,0	28,46
57	1	0	1	0,000	90,0	28,46



Tab. IV - CUMULATIVE SYMPTOM FREE RATE AFTER DIGESTIVE ARTERIES REVASCULARIZATION FOR CHRONIC VISCERAL ISCHEMIA

A Interval (months)	B At risk (n)	C Recurrence (n)	D Withdrawn (n)	E Interval recurrence rate (%)	F Cumulative recurrence freedom (%)	G Standard error (%)
0	0	0	0	0,000	100,0	0,00
3	11	0	0	0,000	100,0	0,00
6	11	0	0	0,000	100,0	0,00
9	11	0	1	0,000	100,0	0,00
12	10	0	0	0,000	100,0	0,00
15	10	0	0	0,000	100,0	0,00
18	10	1	0	0,100	90,0	9,00
21	9	0	1	0,000	90,0	9,49
24	8	0	0	0,000	90,0	10,06
27	8	0	1	0,000	90,0	10,06
30	7	0	0	0,000	90,0	10,76
33	7	0	1	0,000	90,0	10,76
36	6	0	1	0,000	90,0	11,62
39	5	0	1	0,000	90,0	12,73
42	4	0	1	0,000	90,0	14,23
45	3	0	1	0,000	90,0	16,43
48	2	0	1	0,000	90,0	20,12
51	1	0	0	0,000	90,0	28,46
54	1	0	0	0,000	90,0	28,46
57	1	0	1	0,000	90,0	28,46



Fig. 4: Antegrade Dacron bypass to the CA, and SMA from the supra-celiac aorta. Control arteriogram showing the correct morphology of the revascularization.

ferent techniques of revascularization to the different clinical background in a consecutive series, concentrated in a relatively short time interval. Transaortic endarterectomy allows the simultaneous revascularization of the CA and SMA, with good technical results. However it needs a thoraco-abdominal exposure, a supra-celiac clamping and renders the concomitant revascularization of eventually associated lesions of the infrarenal aorta and ilio-

femoral axis more complicated. Antegrade bypass has an ideal graft configuration, can be directed to both CA and SMA, and originates most often from an atheroma-spared celiac aorta, but requires a suprarenal/celiac clamping, and can hardly be associated with a concomitant infrarenal aortic reconstruction if this latter is indicated. Good results have been obtained, when performing preferentially antegrade revascularizations: postoperative mortality of 0-10%, survival rates of 73 to 86%, and primary patency rates of 68 to 86%, at 5 years (13, 15). According to some experiences, the simultaneous revascularization of the CA, SMA and IMA, in the case of trivascular lesions, allows good late results in 90% of the patients, whereas isolated SMA revascularizations are disappointing, with a patency of 0% at 5 years (13). Contradictory data, however, have been reported, based on the principle that SMA is the critical axis for digestive vascularization, and that its isolated reconstruction will allow durable results (16-18): in a recent series, isolated, retrograde SMA revascularizations yielded an operative mortality of 10%, with late survival and patency rates, respectively of 89 and 82% (17).

Good results have been reported with the autogenous saphenous vein as a graft material (12). Nevertheless, it is argued that anastomosing the saphenous vein to the aorta as a donor axis exposes it to dilation and fibrosis. Furthermore it is prone to kinking by the mesentery and abdominal viscera with consequent reduction of its patency rates. For these reasons Dacron or PTFE are usually preferred as graft materials in this setting (8, 10, 11, 17).

In the present series, transaortic endarterectomy was never performed, as we believe that, despite the aggressivity of its thoracoabdominal approach and supra-celiac clamping, its results are not superior to those yielded by less aggressive methods. Reimplantation of the SMA in the aorta was performed in one patient with excellent result. This would be the ideal technique when the quality of the aortic wall is good, and the lesion is confined to the first cm of the artery, but this favourable situation only seldom occurs.

Antegrade bypass grafting bears the theoretic advantage of a configuration which is protected from kinking and compression by the mesentery. In the present experience it was performed in two patients, and is the method of choice when a sequential revascularization of the CA and SMA is planned, in young, otherwise healthy patients, and in the absence of any associated infrarenal aortic or renal artery reconstruction (Fig. 4). Antegrade, multiple digestive revascularization is the standard technique for some authors, when multiple lesions of the digestive arteries are present (12, 13). However the superiority of multiple, orthograde revascularizations over isolated, retrograde reconstructions of the SMA is not proven by any prospective randomized trial, which is very difficult to plan, given the rarity of the condition. Furthermore, recent series of isolated, retrograde bypass grafting of the SMA have obtained results which are superposable to those of multiple antegrade revascularizations (17). Encouraged by these results and based on the rationale that infrarenal aorta is easily exposed and controlled, we have favored isolated, retrograde SMA revascularization whenever multiple, antegrade grafting was deemed too complex or risky, and when infrarenal concomitant aortic reconstruction was indicated. An infrarenal aortic Dacron graft was the donor axis for SMA revascularization in 4 cases: in three of them it was grafted in the same time of SMA reconstruction, with good results.

Concomitant infrarenal and visceral arteries reconstruction is not universally recommended, as it is claimed that it may expose to higher operative mortality and morbidity rates than two or three steps operations. In the present experience, however, this was not the case, as the results of simultaneous operations, including one combined infrarenal aortic-right renal-SMA reconstruction, were as good as those of isolated digestive trunks revascularizations. We believe that if the general status of the patients is adequate, performing infrarenal surgery together with SMA for symptomatic lesions and, eventually, renal revascularization allows to profit of the same anesthesia for optimal reconstruction at different sites, thus avoiding the necessity of iterative interventions on a scarred field of difficult exposure. The sequential aortic and retrograde visceral arteries revascularization is usually safe, as it minimizes the ischemic time of the different viscera. The simultaneous treatment of a renal lesion also reduces the risk of postoperative renal failu-

re. The direction of the retrograde SMA graft should be straight and smooth to avoid kinking and compression when peritonization of the graft is performed. The straight configuration of the graft, is usually favoured, but a curvilinear, omega-like configuration from left in order to obtain a smooth reposition of the graft at peritoneal and mesenteric covering is also employed (19).

No difference of results was observed between graft materials which were either Dacron or PTFE. An autogenous saphenous vein, for concerns on its evolution when anastomosed to the aorta, was never grafted.

The experience with transluminal angioplasty was disappointing: the only angioplasty performed, thrombosed within less than two years. It may be argued that the outcome would have been better if a stenting had been added. Nevertheless, although good results with angioplasty and angioplasty with stenting have been reported (14, 20), this method should probably be reserved for patients at poor risk for standard operations or aortic clamping, as long term durability of open surgery remains superior to that of angioplasty and stenting (20). The present experience is confined to small numbers and a mean follow-up of 31 months. However it extends over a short time interval, which bears the advantage of being homogeneous in terms of technical and indication standards. The absence of operative mortality, together with a primary patency rate of 90% and freedom from symptoms' recurrence of 90% at 3 years, validates the flexible choice of revascularization techniques according to the patients' arterial and overall clinical status. A further validation at 5 and 10 years with a larger series of patients, is necessary for more definitive conclusions. The trend towards retrograde SMA by-pass grafting simultaneously with the treatment of eventual associated aorto-iliac and renal lesions yields good results. This statement, however, is not validated by a statistical significance, again due to the limited numbers involved.

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