Factors affecting splanchnic haemodynamics in Crohn's disease: a prospective controlled study using Doppler ultrasound

G Maconi, F Parente, S Bollani, V Imbesi, S Ardizzone, A Russo, G Bianchi Porro

Abstract

Background—Current knowledge on splanchnic haemodynamics in Crohn's disease is limited.

Aims—To investigate which features of Crohn's disease affect splanchnic haemodynamics, and to establish whether portal vein (PV) and superior mesenteric artery (SMA) blood supply reflects clinical or biochemical activity of Crohn's disease.

Methods—Seventy nine patients with Crohn's disease and 40 controls were evaluated by Doppler ultrasound (US). The mean velocity of PV and SMA flow, the volume of blood flow of the PV and SMA, and the resistance index of SMA were studied. A series of clinical, biochemical, and US variables including Crohn's disease activity index, serum C reactive protein concentrations, disease duration and its anatomical location, smoking habits, abdominal complications, and current medical therapy, as well as the maximum bowel wall thickness as measured by US, were determined. The relation between PV and SMA blood flow and these variables was assessed by univariate and multivariate analysis.

Results—Patients with Crohn's disease had significantly higher PV and SMA flow and a lower SMA resistance index than controls. Stepwise multiple regression analysis identified bowel wall thickness and location of the disease as the main predictive variables of both PV and SMA blood flow variation, accounting for 36% and 45% of their variability, respectively. No relation was found between splanchnic haemodynamics and disease activity.

Conclusion—A hyperdynamic mesenteric circulation does exist in Crohn's disease; however splanchnic blood flow does not reflect the clinical or biochemical activity of the disease, but seems to be linked more to other Crohn's disease characteristics, such as maximum bowel thickness and anatomical location.

(Gut 1998;43:645-650)

Keywords: Crohn's disease; Doppler ultrasound; splanchnic blood flow

Vascular lesions and microvascular changes, such as granulomatous vasculitis, neovascularisation, and dilatation of feeding arteries and draining veins, are well known features of Crohn's disease and are considered to be

involved in the pathogenesis of this condition.¹⁻⁴ In particular, anatomical studies have shown that these morphological microvascular changes are associated with profound damage to mesenteric vascular blood supply and with impaired splanchnic haemodynamics.¹⁻³ However, mesenteric blood supply has not been extensively evaluated in vivo so far, owing to the difficulty of assessing splanchnic circulation in these patients.

In recent years, Doppler ultrasound (US) has been found to be increasingly useful for the investigation of splanchnic haemodynamics in several digestive and hepatic conditions. This has been mainly due to the fact that, unlike other techniques previously used to study splanchnic vessels (for example, angiography), Doppler US is not invasive, is accurate and reproducible, avoids exposure to radiation, and can be easily repeated. To date, very few studies have dealt with splanchnic haemodynamics in Crohn's disease, as evaluated by Doppler US; studies have focused exclusively on the potential relation between disease activity and blood flowmetry data and, moreover, have yielded conflicting results.⁵⁻¹⁰ In addition, none of these studies, all of which were based on very small series of patients, evaluated whether or not some important features of the disease other than activity (anatomical location, duration of disease, extent of intestinal involvement, and the presence of complications) have any effect on splanchnic haemodynamics.

Therefore, the aims of this prospective investigation were to assess the influence of important clinical, biochemical, and US features of Crohn's disease on splanchnic haemodynamics, as measured by Doppler US; and to evaluate whether there is a link between disease activity and blood flowmetry parameters in a large series of consecutive patients with quiescent or active Crohn's disease.

Patients and methods

PATIENTS

Over a 12 month period, a series of 85 consecutive inpatients with a diagnosis of Crohn's disease were evaluated by Doppler US flowmetry and abdominal ultrasound in our department. Six patients were excluded owing to the presence of bowel gas, which prevented an accurate Doppler US examination of at least one vessel. Diagnosis of Crohn's disease was ascertained according to the usual criteria¹¹ and the site, extension, and complications (presence of stenosis) of disease were established by endoscopy, histology and/or small

Gastrointestinal Unit,
L Sacco University
Hospital, Milan, Italy
G Maconi
F Parente
S Bollani
V Imbesi
S Ardizzone
G Bianchi Porro

Analytical
Epidemiology Section,
Epidemiology Unit,
CSPO, A.O. Careggi,
Florence, Italy
A Russo

Correspondence to:
Professor G Bianchi Porro,
Gastrointestinal Unit, L.
Sacco University Hospital,
Via GB Grassi 74, 20157
Milano, Italy.

Accepted for publication
16 April 1998

bowel x ray, and double contrast barium enema according to the type of bowel involvement, respectively.

Patients presenting with rectal and/or distal sigmoid colon involvement only were excluded from this study because of the well known low accuracy of US in detecting these forms of disease; furthermore, this would be mainly inferior mesenteric artery territory and therefore not expected to affect superior mesenteric artery (SMA) flow.

Forty normal subjects comparable to the patients for sex, age, height, and weight served as a control group.

CLINICAL AND BIOLOGICAL VARIABLES

The duration of disease was established in each patient as the number of months since initial diagnosis. The number of recurrences was assessed as the number of high or medium dose steroid treatment cycles and we considered steroid treated patients as those who had been receiving steroids for at least one week. Clinical activity was measured by the Crohn's disease activity index (CDAI)¹² and biochemical activity (C reactive protein, CRP) was measured by the automated nephelometric immunochemistry system.

EVALUATION OF ULTRASONOGRAPHY AND DOPPLER FLOWMETRY

Within five days of the previous evaluations, a transabdominal sonographic examination was carried out in order to evaluate bowel wall thickening, the extent of thickened bowel wall, and Doppler flowmetry of the portal vein and superior mesenteric artery. Transabdominal sonographic examinations were performed by the same physician who was unaware of the patient's clinical and biohumoral data but aware of the diagnosis of Crohn's disease. As previously described,¹³⁻¹⁵ the maximum bowel wall thickness was measured in both longitudinal and transverse sections and only those measurements that could be reproduced for at least 4 cm in length were considered. In patients with more than one lesion, the highest bowel wall thickness value was used. The extent of disease was evaluated using the mean of radiographic, endoscopic, and ultrasonographic extents in patients who underwent a radiological study (small and large bowel double contrast study) and/or endoscopic examination of the gastrointestinal tract within one month of the US measurement. These evaluations were carried out with a real time scanner device (Ecotron-Aloka SSD-680) using a convex 3.5 MHz transducer and, for detailed evaluation, a linear 7.5 MHz transducer.

Doppler US examinations were performed on each patient in a supine position, after a rest of 30 minutes, and with suspended breath in expiration with the same equipment consisting of a 3.5 MHz convex transducer, provided with a pulsed Doppler device operating at a frequency of 2.5 MHz.

The time averaged spatial mean velocity (V_{mean}) (cm/s) and the anteroposterior diameter of the portal vein (PV) and SMA, as well as the resistance index (RI) of the SMA were studied.

The V_{mean} was calculated directly by the instrument software by integrating the area under each individual velocity waveform. The portal and mesenteric flow volume were calculated from the V_{mean} and anteroposterior diameter of the vessels according to the formula: $Q = V_{\text{mean}} \times A$, where Q = volume flow, V_{mean} = time averaged mean velocity of blood flow in the vessel, and A = cross sectional area of the vessel.

The RI of the SMA was calculated as follows: $RI = (S - D)/S$, where S = peak systolic velocity and D = end peak diastolic velocity. This semiquantitative index is related to the impedance of the arterial bed, which includes the resistance, compliance, and congestion of the vascular bed.^{16, 17}

To measure these parameters the vessels were first identified at real time imaging, the transducer was placed on the longitudinal axis of the vessel, and the sample volume (5 mm and/or 10 mm sample volume, in accordance with the vessel diameter) was positioned at the centre of the vessel.

In all vessels the sample volume was positioned at least 2 cm before or after any venous or arterial confluence; the angle of incidence of the Doppler US beam was maintained between 30° and 60°, as large angles affect the accuracy of velocity calculation. Three consecutive evaluations were carried out for each parameter (V_{mean} , diameter, and IR), and the mean value calculated; each evaluation was carried out by a new Doppler US measurement.

All subjects were examined by the same investigator in the morning after an overnight fast, without any special preparation.

As previously reported the day to day variability of the measurements of PV and SMA parameters showed a Pearson correlation coefficient no lower than 0.91⁷ and the intraobserver variation had a coefficient of variation of less than 10%.

STATISTICAL ANALYSIS

Differences between the Doppler US values in patient and control groups were tested by the Wilcoxon rank sum test. Data are expressed as mean (SD).

To investigate the relation between intestinal blood flow and clinical and biochemical parameters, vascular flow values were compared for different levels of clinicopathological variables. The Wilcoxon rank sum tests for unpaired data were performed for statistical evaluation of significant difference in vascular flow distributions of two groups. The Kruskal Wallis test was used if more than two groups were compared. Analysis of variance with post Scheffé tests was done for three way comparisons among the groups.

A stepwise regression discriminant analysis was performed to identify which of the clinical and biological variables discriminated between subjects, after adjusting for age, sex, and body mass index, using flow levels as the dependent variable.

Starting from the full model with all variables included, non-significant variables

Table 1 Demographic and Doppler flowmetry data of controls and patients with Crohn's disease

Characteristics and parameters	Crohn's disease	Controls (n= 40)	p Value
Female/male	37/39	23/17	0.48
Age (y)	32.3 (10.6) (n=76)	33.6 (13.2)	0.57
Weight (kg)	60.4 (12.2) (n=76)	58.2 (9.0)	0.32
Height (cm)	169.7 (8.7) (n=76)	167.1 (8.2)	0.12
Portal vein			
Diameter (mm)	11.4 (1.1) (n=67)	10.9 (1.1)	0.025
V _{mean} (cm/sec)	23.4 (4.3) (n=67)	18.2 (2.7)	0.0001
Flow volume (ml/min)	1443 (362) (n=67)	1011 (193)	0.0001
Superior mesenteric artery			
Diameter (mm)	6.5 (0.9) (n=54)	5.7 (0.8)	0.0001
V _{mean} (cm/sec)	46.5 (11.1) (n=54)	35.3 (6.4)	0.0001
Flow volume (ml/min)	889 (354) (n=54)	534 (139)	0.0001
Resistance index	0.82 (0.05) (n=54)	0.85 (0.02)	0.0001

Results are expressed as mean (SEM).

were progressively deleted with a step down procedure based on a likelihood ratio test.

Results

PATIENTS

Of the 85 patients recruited, six were excluded because it was impossible to obtain an accurate measurement of at least one vessel. The PV was evaluated in 70 patients (82.3%), and the SMA in 56 patients (65.9%). Three more patients were excluded from the analysis as they had left colon involvement only.

Table 1 shows the demographic characteristics and Doppler flowmetry of the PV and SMA in the remaining 76 patients and the 40 controls. In patients with Crohn's disease, the V_{mean} and D of the PV and SMA were significantly higher than in normal subjects. The RI of SMA was significantly lower in patients with Crohn's disease than controls.

Among all the patients examined 62.5% had active Crohn's disease (CDAI at least 150) and six patients were treated with more than one drug. Thirty six patients had Crohn's disease limited to the small bowel only, 27 had a small bowel and colonic involvement, and 16 patients had colonic involvement only. In the latter subgroup 13 patients had either pancolitis (n=10) or involvement of the right hemicolon (n=3), whereas three patients had disease limited to the left colon only; therefore they were excluded from the analysis.

Table 2 shows the clinical, biochemical, and ultrasonographic features of patients with Crohn's disease successfully evaluated by Doppler US.

Table 2 Clinical, biochemical and ultrasonographic characteristics of patients with Crohn's disease successfully evaluated by Doppler ultrasonography

Characteristics and parameters	%	Mean (SD)	n
First attack	31.6		24
Duration of Crohn's disease (months)		54.1 (53.0)	76
Previous surgical resection	34.2		26
Number of recurrences		2.9 (3.1)	76
Intestinal location of Crohn's disease			
Small bowel only	47.4		36
Small bowel and colon	35.5		27
Colon only	17.1		13
CDAI (best)		185.4 (93.3)	69
C reactive protein		3.0 (3.6)	70
Current treatment			
None	43.4		33
Mesalazine	30.3		23
Steroids	26.3		20
Azathioprine	7.9		6
Maximum bowel wall thickness observed (mm)		7.5 (2.1)	73
Length of diseased intestinal tract (cm)		27.6 (15.5)	65

PORTAL FLOW

Univariate analysis showed a relation of portal flow with sex, current treatment, and bowel wall thickness. Subgroup analysis revealed that portal flow was higher in men than in women and that it was statistically different in patients treated with steroids versus patients treated with other drugs (mesalazine and/or immuno-suppressants). Moreover portal flow and bowel wall thickness were significantly correlated. On the contrary, no relation was found between portal flow and the clinical activity of the disease, or between portal flow and other clinical variables such as smoking habit, number of recurrences, duration of the disease, presence of stenosis or previous surgical resections, or length of diseased intestinal tract (table 3).

When stepwise multiple regression was performed with portal flow as the dependent variable, only bowel wall thickness and ileocolonic location of the disease were found to be significant predictors; they explained, according to the multiple correlation coefficient, only about 36% of the variability of the portal flow ($R^2=0.36$) (table 4).

SUPERIOR MESENTERIC ARTERY FLOW

Univariate analysis showed that SMA flow was correlated with previous surgical resection, current treatment, and bowel wall thickness. In particular, the mean of mesenteric flow was lower for patients with history of surgical treatment, and in those who were on treatment with systemic steroids; furthermore, as far as the bowel wall thickness is concerned, patients with moderate or high maximum bowel wall thickness had a mean mesenteric flow significantly higher than patients with low thickness (table 3). In contrast, there was no correlation between the SMA and any clinical or biochemical index of Crohn's disease activity, smoking habit, number of recurrences, length of disease, presence of stenosis, and length of affected intestinal tract (table 3).

The stepwise regression analysis showed that the colonic location of disease and bowel wall thickness were independent factors linked to SMA blood flow, accounting for 49% of SMA flow variation ($R^2=0.49$) (table 4).

RESISTANCE INDEX

By univariate analysis, significant results were found between the RI and the site of lesion, the RI and the presence of stenosis, and number of recurrences and duration of the disease. In particular, the RI of the SMA was lower for patients with longer disease duration or complicated by stenosis or higher number of recurrences of Crohn's disease. No relation was found between the RI and disease activity and between other clinical and ultrasonographic variables (table 3).

Stepwise multiple regression analysis of the RI versus clinical and biological variables, and age and sex showed that only the colonic location of the disease and the number of recurrences were significant in the final model, accounting for only 27% of RI variation, indicating that other unidentified factors were also involved (table 4).

Table 3 Descriptive analysis of portal flow, superior mesenteric artery (SMA) flow, and resistance index

Variable	n	Portal flow (ml/min)	p Value	SMA flow (ml/min)	p Value	Resistance index	p Value
Sex							
Male	40	1524 (330)		963 (296)		0.82 (0.04)	
Female	36	1374 (371)	0.08	827 (387)	0.2	0.82 (0.05)	0.9
Surgery							
No	50	1460 (362)		1000 (376)		0.83 (0.04)	
Yes	26	1439 (351)	0.6	716 (263)	0.02	0.80 (0.06)	0.2
Current treatment							
No	33	1443 (346)		835 (310)		0.84 (0.03)	
Steroid	20	1314 (354)		668 (275)		0.81 (0.08)	
Other	23	1641 (310)	0.06	1118 (417)	0.06	0.80 (0.05)	0.1
Site of lesion							
Ileum	36	1523 (338)		853 (274)		0.81 (0.04)	
Colon	13	1394 (366)		888 (580)		0.85 (0.03)	
Ileum and colon	27	1368 (372)	0.2	884 (384)	0.9	0.81 (0.06)	0.08
Stenosis							
No	35	1400 (383)		874 (374)		0.84 (0.04)	
Yes	41	1494 (331)	0.3	867 (352)	0.9	0.81 (0.06)	0.04
Smokers							
No	23	1469 (469)		908 (390)		0.82 (0.04)	
Current	42	1436 (266)		870 (354)		0.81 (0.06)	
Ex-smoker	10	1526 (354)	0.9	831 (334)	0.9	0.83 (0.02)	0.8
Length of lesion (min, max, mean)	*						
1 tertile (4.0, 18.0, 11.5)	21	1439 (425)		828 (428)		0.84 (0.03)	
2 tertile (20.0, 30.0, 25.5)	23	1451 (349)		977 (366)		0.81 (0.04)	
3 tertile (35.0, 75.0, 44.8)	21	1490 (309)	0.9	816 (244)	0.5	0.81 (0.07)	0.1
Thickness							
(min, max, mean)	*						
1 tertile (3.5, 6.5, 5.1)	22	1229 (365)		698 (424)		0.84 (0.03)	
2 tertile (7.0, 7.5, 7.1)	21	1483 (317)		840 (196)		0.82 (0.04)	
3 tertile (8.0, 13.0, 9.2)	30	1613 (312)	0.004	1034 (372)	0.03	0.80 (0.06)	0.1
Number of recurrences (min, max, mean)							
1 tertile (none)	24	1427 (424)		900 (366)		0.84 (0.03)	
2 tertile (1, 3, 1.9)	26	1529 (347)		1041 (418)		0.83 (0.05)	
3 tertile (4, 15, 6.3)	26	1407 (287)	0.5	747 (271)	0.1	0.80 (0.06)	0.02
CRP							
(min, max, mean)	*						
1 tertile (0.0, 0.4, 0.17)	21	1361 (409)		774 (254)		0.83 (0.03)	
2 tertile (0.5, 2.8, 1.44)	25	1467 (245)		885 (424)		0.82 (0.05)	
3 tertile (2.9, 15.5, 7.40)	24	1492 (392)	0.4	978 (378)	0.5	0.80 (0.06)	0.6
CDAI							
(min, max, mean)	*						
1 tertile (23, 138, 85.5)	23	1369 (399)		812 (350)		0.84 (0.03)	
2 tertile (140, 215, 182.4)	23	1475 (310)		965 (348)		0.82 (0.04)	
3 tertile (221, 456, 288.2)	23	1483 (338)	0.4	839 (378)	0.4	0.80 (0.07)	0.3
Duration of disease (months)							
(min, max, mean)							
1 tertile (1, 10, 4.1)	26	1503 (359)		937 (318)		0.84 (0.03)	
2 tertile (14, 72, 43.2)	26	1357 (343)		939 (439)		0.82 (0.04)	
3 tertile (76, 218, 119.5)	24	1477 (363)	0.3	733 (272)	0.2	0.79 (0.06)	0.02

Results are expressed as mean (SD).

*Available data.

Discussion

An increase in splanchnic blood flow in both arterial and venous beds has been shown in Crohn's disease by means of invasive and/or complex methods, such as microangiography, vascular casts, mesenteric angiography, radioisotopic techniques, and recently also by Doppler US.^{2 3 5 7 18} Among these techniques, Doppler US can be considered an ideal method, as

it is safe, non-invasive, accurate, quantitative, and reproducible; moreover, it respects physiological conditions and it does not alter blood flow. For these reasons, Doppler US has, in recent years, brought about increasing interest in the investigation of splanchnic haemodynamics in several hepatic and gastrointestinal diseases. Despite the fact that vascular factors are involved in the pathogenesis of Crohn's disease,⁴ to date very little information exists on intestinal blood flow in patients with Crohn's disease. The few available articles on this topic report on limited numbers of patients and yield conflicting results, particularly when patients with active versus quiescent disease were compared.⁵⁻¹⁰ In fact, while a hyperdynamic splanchnic circulation is a common finding in active Crohn's disease, the data concerning quiescent Crohn's disease are conflicting and do not show clear differences from active Crohn's disease. Two main reasons may account for such a discrepancy: differences in the degree of activity between active and quiescent Crohn's disease cases in the various published series; or a major role of factors other

Table 4 Variables selected from stepwise procedure

	Cumulative R ²	p Value *
Portal flow		
Thickness	0.25	0.002
Ileocolic lesion	0.36	0.01
Mesenteric flow		
Colonic lesion	0.39	0.03
Thickness	0.49	0.04
Resistance index		
Colonic lesion	0.22	0.05
Number of recurrences	0.27	0.10

Multiple regression model including age, sex, and body mass index as fixed variables and current treatment, site of lesion, presence of stenosis, length of lesion in cm, thickness in cm, number of recurrences, disease duration in months, CDAI, and CRP as independent variables.

*Wald test of regression estimate.

than disease activity in influencing splanchnic haemodynamics. In this regard, it must be emphasised that no study has evaluated the relation between splanchnic blood flow and other clinical and pathological variables of the disease.

For this reason, in a large number of consecutive patients with active and quiescent Crohn's disease, we have prospectively studied the relation between the PV and the SMA, the main and more frequently investigated indexes of splanchnic venous outflow and arterial inflow, and a series of anatomical, clinical and biochemical variables such as duration of disease, previous surgical resections, number of recurrences, smoking habit, activity index (CDAI), CRP, current medical treatment, presence of stenosis, intestinal location, and length of affected intestinal tract. In addition, we also considered and correlated with the aforesaid splanchnic blood flow parameters the maximum bowel wall thickness of affected bowel segments (measured by US) as a surrogate index of transmural inflammation in the involved tracts,^{13,15} as the pathological examination of resected specimens was available only in a few complicated cases of Crohn's disease.

Our results show that splanchnic blood flow is mainly affected by the anatomical location of Crohn's disease and by bowel wall thickness, whereas no relation with clinical and biochemical activity of Crohn's disease emerged both at univariate analysis and stepwise regression analysis. As far as the latter aspect is concerned, previous studies provided conflicting results. First Bolondi *et al*, evaluating the relation between V_{mean} of the PV, the RI of the SMA, and disease activity, found that the V_{mean} of the PV was significantly higher in patients with active Crohn's disease than inactive disease; however in this study no significant difference was noted between active and inactive Crohn's disease with regard to the RI of the SMA.⁵ van Oostaynen *et al* studied the SMA only and found a significant difference between active and quiescent Crohn's disease both for flow volume and for RI.^{6,9} In contrast, in a previous study of ours⁷ we did not find differences between active and inactive Crohn's disease both for PV flow and V_{mean} for mesenteric vein flow and V_{mean} , and for the RI of the SMA (flow volume of SMA was not evaluated). Furthermore, preliminary reports investigated SMA volume flow in patients with Crohn's disease and found that it was not sufficiently discriminatory for diagnostic purposes or for defining disease activity.^{8,10} However, the number of patients with Crohn's disease evaluated in these studies was low (22 in Bolondi *et al*'s study, 20 in the van Oostaynen *et al* studies, and 31 in our previous series) and a clear correlation between clinical and biochemical disease activity parameters and splanchnic blood flow was not evaluated. The above uncertainties strongly suggest that factors other than disease activity may contribute to increased splanchnic blood flow.

In the present series, among the clinical variables considered, we showed by univariate analysis that previous surgical resection and

current treatment with steroids affected SMA blood flow. The reduced SMA flow in patients who had undergone surgical resection in the past is probably attributable to the reduced size of the vascular bed. There is no clear explanation for the potential effect of systemic steroids on blood flow (also evident on PV flow). As this effect was previously reported in another small series of patients with Crohn's disease,⁵ it deserves to be evaluated in further large longitudinal series in order to establish whether this measurement can be useful in the clinical and therapeutic follow up of patients with Crohn's disease.

With respect to the finding of a decreased RI of the SMA in patients with ileal or ileocolonic Crohn's disease versus those with colonic disease only, this concurs well with what one could theoretically expect considering the anatomical location of the inflamed bowel segments; indeed, in patients with Crohn's disease with ileal or ileocolonic involvement the intestinal inflammation should result in a decrease in vascular resistance of the SMA, which normally provides blood supply to the ileum and the right colon. In contrast, in patients with colonic disease only, one could expect changes, if any, in the blood flow of the inferior mesenteric artery; this however, was not evaluated in the present study.

Much more difficult to explain is the relation found between splanchnic blood flow and the maximum bowel wall thickness of affected intestinal segments. This is mainly attributable to the fact that bowel wall thickness, as detected by US, depends on various factors, some of which are related to the activity of Crohn's disease (submucosal oedema and cellular infiltration), but others (such as fibrosis) are independent of disease activity. This is the reason why bowel wall thickness by itself is only a weak marker of Crohn's disease activity, as was documented in a previous study.¹⁵ As it has been widely shown that several vascular and microvascular changes, such as vasculitis, neo-vascularisation, and dilatation of feeding arteries and draining veins characterise the affected bowel segments of patients with Crohn's disease,^{1-4,19} it is possible that the relation we found between maximum bowel wall thickness and splanchnic blood flow mainly reflects the degree of these vascular changes within the affected bowel tracts. In particular, shunting of blood across a potentially ischaemic mucosa, inflammatory infiltration into the vessel walls, and thrombosis of small arteries have been shown in patients with Crohn's disease and may be considered to be possible mechanisms involved in increased PV flow.^{1-4,20} Furthermore, it is possible that within the bowel wall, feeding or starved flow rates may be responsible for the abnormal splanchnic haemodynamics observed by means of Doppler US. However, further studies using different techniques (magnetic resonance imaging, scintigraphy) and longitudinal studies, based on repeated Doppler US measurements of splanchnic blood flow in the same individuals in different phases of their disease, should be carried out to test this hypothesis.

In conclusion, our findings show that a hyperdynamic splanchnic circulation exists in patients with Crohn's disease which, however, does not reflect either the clinical or the biochemical activity of the disease; it seems to be mainly related to some anatomical/pathological features of Crohn's disease, such as the disease location within the bowel and the maximum bowel wall thickness of the affected segments. Therefore, splanchnic blood flow determination seems to be of little value in the diagnostic work up of patients with Crohn's disease, as it does not provide any helpful information from the clinical or therapeutic point of view. Future prospective studies should assess in the same patients the behaviour of splanchnic blood flow over the course of Crohn's disease, to establish whether it may eventually identify peculiar pathogenic subsets or specific forms of Crohn's disease.

- 1 Brahme F, Lindstrom C. A comparative radiographic and pathological study of intestinal vasoarchitecture in Crohn's disease and ulcerative colitis. *Gut* 1970;11:928-40.
- 2 Eriksson U, Fagerberg S, Krauss U, et al. Angiographic studies in Crohn's disease and in ulcerative colitis. *AJR Am J Roentgenol* 1970;110:385-92.
- 3 Boijesen E, Reuter SR. Mesenteric angiography in the evaluation of inflammatory and neoplastic disease of intestine. *Radiology* 1966;87:1028-36.
- 4 Wakefield AJ, Sawyerr AM, Dhillon AP, et al. Pathogenesis of Crohn's disease: multifocal gastrointestinal infarction. *Lancet* 1989;ii:1057-62.
- 5 Bolondi L, Gaiani S, Brignola C, et al. Changes in splanchnic haemodynamics in inflammatory bowel disease. Non invasive assessment by Doppler ultrasound flowmetry. *Scand J Gastroenterol* 1992;27:501-7.
- 6 van Oostaynen JA, Wesser MNJ, van Hogeand RA, et al. Activity of Crohn's disease assessed by measurement of superior mesenteric artery flow with Doppler US. *Radiology* 1994;193:551-4.
- 7 Maconi G, Imbesi V, Bianchi Porro G. Doppler ultrasound measurement of intestinal blood flow in inflammatory bowel disease. *Scand J Gastroenterol* 1996;31:950-3.
- 8 Hare C, Hassan MT, Bartram CI, et al. Superior mesenteric artery Doppler flow: a valuable indicator of disease activity in Crohn's disease [abstract]. *Gut* 1996;38:A639.
- 9 van Oostaynen JA, Wesser MNJ, van Hogeand RA, et al. Doppler sonography evaluation of superior mesenteric artery flow to assess Crohn's disease activity: Correlation with clinical evaluation Crohn's disease activity index, and α 1-antitrypsin clearance in feces. *AJR Am J Roentgenol* 1997;168:429-33.
- 10 Adams C, Britton I, Maguire C, et al. Assessment of Crohn's disease activity by duplex/colour Doppler sonography [abstract]. *Gut* 1996;39(suppl 1):A36.
- 11 Bernades P, Hecksweiler P, Benozio M, et al. Proposition d'un systeme de criteres pour le diagnostic des enterocolites inflammatoires (maladie de Crohn et rectocolite hemorragique). Un etude cooperative du GREC. *Gastroenterol Clin Biol* 1978;2:1047-54.
- 12 Best WR, Becktel JM, Singleton JW, et al. Development of a Crohn's disease activity index. *Gastroenterology* 1976;79:439-44.
- 13 Brignola C, Belloli C, Iannone P, et al. Comparison of scintigraphy with indium-111 leukocyte scan and ultrasonography in assessment of X-ray-demonstrated lesions of Crohn's disease. *Dig Dis Sci* 1993;38:433-7.
- 14 Hata J, Haruma K, Suenaga K, et al. Ultrasonographic assessment of inflammatory bowel disease. *Am J Gastroenterol* 1992;87:443-7.
- 15 Maconi G, Parente F, Bollani S, et al. Abdominal ultrasound in the assessment of extent and activity of Crohn's disease: clinical significance and implication of bowel wall thickening. *Am J Gastroenterol* 1996;91:1604-9.
- 16 Norris CS, Pfeiffer JS, Rittgers SE, et al. Non invasive evaluation of renal artery stenosis and renovascular resistance: experimental and clinical studies. *J Vasc Surg* 1984;1:192-201.
- 17 Barbara L. The value of Doppler US in the study of hepatic haemodynamics. Consensus conference. Bologna, Italy, 12 September 1989. *J Hepatol* 1990;10:353-5.
- 18 Hulten L, Lindhagen J, Lundgren O, et al. Regional intestinal blood flow in ulcerative colitis and Crohn's disease. *Gastroenterology* 1977;72:388-96.
- 19 Wakefield AJ, Sankey EA, Dhillon AP, et al. Granulomatous vasculitis in Crohn's disease. *Gastroenterology* 1991;100:1279-87.
- 20 Bacaner MB. Quantitative measurement of regional colon blood flow in the normal and pathological human bowel. *Gastroenterology* 1966;51:764-77.