

Superior mesenteric artery blood flow in celiac disease "Estimation with Doppler ultrasound"

* Wissam A. Al-Attar FICMS ** Saad Eldin Majeed CABM
*** Amira H. Shubbar . MRCP FRCP Edin

Abstract

Background:

Knowledge of the splanchnic hemodynamics in celiac disease is scarce and incomplete.

Objective:

To evaluate splanchnic arterial blood flow in celiac disease.

Methods:

This is a prospective case-control study that enrolled 15 patients with untreated celiac disease and 5 healthy subjects who had attended Al-Yarmouk Teaching Hospital-Baghdad, during the period 1st of January to the 30 of June, 1997. Peak systolic velocity, end diastolic velocity, mean flow velocity and pulsatility index had been assessed by Doppler echocardiographic examination of the superior mesenteric artery. Five patients from the untreated group were re-evaluated after 4 months of gluten free diet.

Results:

Significant difference in hemodynamic variables of the superior mesenteric artery were shown

between the three groups (untreated patients with celiac disease, treated patients with celiac disease and healthy controls). An increase in both mean flow velocity and end diastolic velocity and a reduction in pulsatility index occurred in untreated celiac patients compared with treated patients ($P < 0.0002$; $P < 0.0005$, $P < 0.001$) and with healthy controls ($P < 0.0001$, $P < 0.0005$, $P < 0.001$). Significant statistical results were obtained for the 5 patients evaluated statistically as a paired sample before and after treatment, in whom the mean flow velocity and end diastolic velocity were decreased and pulsatility index increased after 4 months of gluten free diet ($P < 0.001$, $P < 0.02$, $P < 0.01$). No significant statistical differences were noticed between celiac patients and healthy controls.

Conclusions:

The pathophysiological events in small bowel mucosa during the active phase of celiac disease induce a hyperdynamic mesenteric circulation that decrease after treatment.

Keyword:

Mesenteric, blood, flow, celiac, Doppler.

*Dr. Wissam A. Al-Attar , Department of Medicine, College of Medicine, Al-Mustansiriya University.

**Dr. Saad Eldin Majeed ,Assistant professor, Department of Medicine, College of Medicine, Al-Mustansiriya University.

***Dr. Amira H. Shubbar ,Professor, Department of Medicine, College of Medicine, Al-Mustansiriya University.

Introduction:

Changes in the mucosal vascularity in celiac disease can give rise to modifications in the blood flow in the small intestine^(1,2). The splanchnic circulation is doubly complex system as it serves a variety of organs with different functions and its structural arrangement is intricate. The intraluminal intestinal vasculature consists of a number of parallel-coupled vascular sections supplying the different wall layers. The pre-capillary resistance section and the pre-capillary sphincters are the main determinants of the intestinal blood flow and are the site of autoregulation of blood flow in the small intestine⁽³⁾.

Villous atrophy in celiac disease determines not only a great reduction in the intestinal absorption surface, but also destroying the underlying microcirculation which depends on the small artery of the villus and the rich network of capillaries. This may result in a significant shortening in the mesenteric bed with consequent alteration of the blood flow in the small intestine⁽⁴⁾. To date few studies and little information are available on splanchnic hemodynamic changes during celiac disease⁽⁴⁻⁷⁾.

Doppler ultrasound flowmetry has in the recent years been validated and received increasing interest as a non invasive and accurate method in the investigation of arterial⁽⁸⁻¹¹⁾ and venous⁽¹²⁻¹³⁾ splanchnic hemodynamics. Its ability to reliably measure changes in blood flow to a particular organ or region of the body has been a long-sought-after goal in medicine.

The aim of this study was to investigate Doppler hemodynamic parameters of the superior mesenteric artery in Iraqi patients with celiac disease before and after treatment and comparing them with those of healthy subjects to identify possible differences between groups.

Patients and methods:

Fifteen patients with celiac disease (11 females, 4 males, mean age 24.6 ± 4.5 years) and five healthy subjects enrolled in this retrospective and prospective case-control study, during the period between January-June, 1997.

In all of the 15 consecutive patients with untreated celiac disease, biopsies of the mucosa of the small intestine showed a flat mucosa. In the 5 patients of this group reexamined after 4 months of gluten free diet, treatment induced a clinical and histological improvement. Serological studies for celiac disease were not carried out as they were not available in the hospital during the study period.

The control group comprised 5 healthy subjects (3 females, 2 males, mean age 26.4 ± 3.6 years) matched by sex and age. Neither the healthy subjects nor the patients were taking any drugs known to cause vasoactive phenomena.

The nature of the study was fully explained to each patient and informed consent was obtained from each, table-1.

In all patients and controls duplex Doppler measurements of the blood flow were done in the superior mesenteric artery. Blood flow velocities were measured by a duplex scanner, comprising a real time, 2 dimensional, ultrasonic scanner and an associated 2.8MHz pulsed Doppler flow meter. The following Doppler variables were evaluated, the mean velocity (MV), the peak systolic velocity (PSV), the end diastolic velocity (EDV) and the pulsatility index (PI) which had been measured according to the formula $(PI=PSV-EDV/MV)$.

The results were reported as mean \pm SD and the statistical analysis included use of Fisher's exact test for qualitative variables (sex) and student's *t* test for comparison between different study groups. P value <0.05 was considered significant⁽¹⁴⁾.

Results:

The analysis of Doppler variables in the three groups (untreated patients with celiac disease, treated patients with celiac disease and healthy controls) showed statistical differences in the superior mesenteric artery blood flow velocities.

The comparison of Doppler hemodynamic parameters between the three groups showed that the absolute values of both mean flow velocity (MV) and end diastolic velocity (EDV) were greater in untreated patients (60.6 ± 6.7 cm/s, 26.6 ± 6.5 cm/s) than in treated patients with celiac disease (39.8 ± 3.5 cm/s, 15 ± 2.5 cm/s), ($P < 0.0002$, $P < 0.001$), or healthy controls (35 ± 2.7 cm/s, 13.2 ± 2.6 cm/s), ($P < 0.0001$, $P < 0.0005$). Moreover, in the superior mesenteric artery

pulsatility index (PI) was significantly lower in untreated patients with celiac disease (1.55 ± 0.3) than in treated patients with celiac disease (2.29 ± 0.1), ($P < 0.001$) or healthy subjects (2.64 ± 0.3), ($P < 0.001$). No significant statistical differences were noted between treated celiac patients and healthy controls, table-2.

Significant statistical differences in hemodynamic variables of the superior mesenteric artery were shown for the 5 patients of the untreated group evaluated statistically after treatment as a paired sample. In this group of patients, both MV and EDV decreased and PI increased after 4 months of gluten free diet ($P < 0.001$, $P < 0.02$, $P < 0.01$), table-3, figure-1. The systolic component of arterial blood flow did not change significantly between the three groups.

Table-1: Cases and controls characteristics

	UTCD	HC
Sex	11 females, 4 males	3 females, 2 males
Age	24.6 ± 4.5	26.4 ± 3.6
UTCD=Untreated celiac disease		
HC=Healthy Control		

Table-2: Mean blood flow velocity of the superior mesenteric artery in cases and controls.

Doppler variables cm/s	Blood flow velocities (mean \pm SD)			P-value		
	UTCD	TCD	HC	UTCD v TCD	UTCD v HC	TCD v HC
PSV	114 \pm 14	107 \pm 7.5	105 \pm 6.7	NS	NS	NS
EDV	26.6 \pm 6.5	15 \pm 2.5	13.2 \pm 2.6	<0.001	<0.0005	NS
MV	60.5 \pm 6.7	39.8 \pm 3.5	35 \pm 2.7	<0.0002	<0.0001	NS
PI	1.55 \pm 0.3	2.29 \pm 0.1	2.64 \pm 0.3	<0.001	<0.001	NS

Student's t test $p < 0.05$ = significant.

UTCD=untreated celiac disease, TCD= treated celiac disease, HC=healthy controls, PSV=peak systolic velocity, EDV=end diastolic velocity, MV=mean velocity, PI=pulsatility index, SD=standard deviation, NS=non-significant.

Table-3: Values of statistical analysis of paired sample (five patients) before and after treatment.

Doppler variables cm/s	Blood flow velocities Mean \pm SD		P-value
	UTCD	TCD	UTCD & TCD
PSV	123 \pm 10.5	107 \pm 7.5	NS
EDV	28.6 \pm 8.6	15 \pm 2.5	<0.02
MV	62.6 \pm 6.9	39.8 \pm 3.5	<0.001
PI	1.53 \pm 0.2	2.29 \pm 0.1	<0.01

Discussion:

The duplex derived velocity waveform measurements obtained from the superior mesenteric artery in celiac patients during this study showed a statistically significant increase in both mean flow velocity and end diastolic velocity and a reduction in pulsatility index occurred in untreated patients compared with treated patients ($P<0.0002$, $P<0.001$, $P<0.001$) and with healthy controls ($P<0.0001$, $P<0.0005$, $P<0.001$).

The present investigation supports the results of a previous Doppler ultrasonographic study of 18 celiac patients reported by Alvarez et al, who found an increase (50%) in the mean basal blood flow of the superior mesenteric artery and an increased and delayed post-prandial blood flow ($P<0.002$, $P<0.005$) in celiac patients as compared to controls ⁽⁷⁾. The results of this study agree well with those of Arienti et al, who studied the Doppler hemodynamic parameters of the superior mesenteric artery in 22 patients, in whom the mean velocity and end diastolic velocity were higher and pulsatility index was lower in untreated patients compared with treated patients ($P<0.002$, $P<0.04$, $P<0.035$) and with controls ($P<0.001$, $P<0.025$, $P<0.0003$)⁽⁶⁾.

The comparison of ultrasonographic measurements of the celiac patients evaluated before and after treatment during the present study revealed that the mean flow velocity, the diastolic component of the Doppler waveform, and pulsatility index were changed significantly, whereas the systolic component of the Doppler waveform didn't change significantly between the three groups.

All these data show that intestinal hyperemia and hyperdynamic mesenteric circulation occur in celiac disease due to the reduction in the vascular resistance. The cause of the drop in resistance is not yet well established, but an important role can be attributed to the structural rearrangement of the intestinal mucosa during celiac disease ⁽⁶⁾.

Since the mucosa of the small intestine is damaged in patients with celiac disease, the underlying microcirculation and the myogenic control system, localized at the arterioles and precapillary sphincter level, are consequently greatly altered. The changes of the mucosal vasculature, i.e. the superficial network of vessels and the increase in the arteriovenous shunts, causes a loss in the precapillary muscle tone. This determines a drop in intestinal resistance and consequently an increase in mesenteric blood flow velocity in the vascular bed. This may represent the pathophysiological mechanism that explains the results of this study ⁽⁶⁾.

Another mechanism that has been suggested is the inflammation of the intestinal wall. In celiac disease, the surface epithelium is infiltrated with intra-epithelial lymphocytes and the lamina propria is infiltrated with increased numbers of plasma cells, lymphocytes, eosinophils and mast cells ^(1, 15). In these circumstances mast cells can only be activated and driven by T-lymphocytes-derived factors. Furthermore, the full expression of the relation between these cells and the pathogenesis of mesenteric hyperemia may be dependant on the release of vasoactive agents from the mast cells granules ⁽¹⁵⁾. Alternatively, antigliadin antibodies may form immune complexes with gliadin components, releasing mediators such as histamin from mucosal inflammatory cells ⁽¹⁾. This relevant inflammatory component can contribute to the pathogenesis of hyperdynamic circulation in celiac disease ⁽¹⁶⁾.

In conclusion, the data obtained in our study showed that in untreated celiac disease: (a) a hyperdynamic mesenteric circulation is present, (b) the increase of mesenteric blood velocity is due to increase in the diastolic component in the arterial bed, (c) these hemodynamic changes are easily assessed by Doppler ultrasound, (d) they are due to drop in vascular resistance, and (e) they are linked to the active clinical phase of the disease and improve after successful treatment with gluten free diet.

Overall, the results of this study emphasize the need to include a much larger group of patients and controls to confirm and validate the proposition that Doppler ultrasound flowmetry as being safe and non-invasive technique may be applied in the future for follow up and reassessment of splanchnic hemodynamic parameters in patients with celiac disease to determine the influence of treatment.

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