

Duplex-Doppler ultrasound evaluation of intrapancreatic blood flow in patients with insulin-dependent diabetes mellitus

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Background. The purpose of the study was to assess the value of pulse-wave and color-Doppler ultrasound (CDUS) in estimation of the pancreatic blood flow, and to test the hypothesis that accelerated atherosclerosis in insulin-dependent diabetes mellitus (IDDM) causes an increased vascular resistance.

Patients and methods. Gastroduodenal arteries in 40 patients with IDDM and 30 healthy volunteers were insonated, and resistance index (RI) and pulsatility index (PI) were assessed. The statistical significance of the difference between Doppler indices among examined groups, as well as the correlation with the age, sex and duration of the disease were tested.

Results. In the control group, median RI was 0.71 and median PI was 1.46. In IDDM patients group median RI was 0.74 and median PI was 1.54. The differences between these Doppler indices were not significant, with a $p=0.82$ for RI, and $p=0.74$ for PI. Also, no significant correlation was observed between RI and PI and the duration of the disease.

Conclusions. CDUS is simple noninvasive imaging modality for the estimation of blood flow in the gastroduodenal artery, which, in our work, did not prove to be of particular value in the assessment of pancreatic flow in IDDM patients.

Key words: diabetes mellitus, insulin-dependent; pancreas-blood supply- ultrasonography; Doppler, duplex

Introduction

Pulse-wave color-Doppler flow imaging enables examination of blood flow in almost all vessels, with the superb ability to position sample volume in as small vessel as is gastroduodenal artery. The flow spectrum of the superior mesenteric artery (SMA) before a meal is typical for high-resistant bed, with short protodiastolic reverse flow and small diastolic run-off. After a meal, the spectra in SMA and in celiac axis are similar, triphasic,

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without diastolic reverse flow.¹⁻³ The persistence of flow in diastole is the consequence of low distal vascular impedance of the receiving hepatic circulation. As the blood reaches the more distal branches of smaller size, the "systolic window" is being filled. The spectrum of the gastroduodenal artery reflects its slow flow with parabolic velocity profile.² In such a small vessel, vascular resistance is critical for the whole intraluminal range of velocities; hence, small changes in vascular resistance sensitively influence Doppler indexes. The atherosclerotic process, that is by its nature vessel-obstructing, is undoubtedly accelerated in the patients with insulin-dependent diabetes mellitus (IDDM) in comparison to non-diabetic patients. We wished to examine its consequences in the pancreas expecting an increased vascular resistance.

The purposes of our work were: (a) to evaluate usefulness of pulse-wave and color-Doppler in the assessment of flow in the gastroduodenal artery and its branches; (b) to determine RI and PI values in the group of IDDM patients and in control group of healthy volunteers; (c) to compare Doppler indices between these groups and (d) to determine the correlation between the duration of IDDM and age with Doppler indices.

Patients and methods

In the period from January 1996 to June 1997, 70 persons, 40 patients with IDDM and 30 healthy controls, were examined. The age ranged from 18 to 44 years (mean 30.3 ± 7.2), and male/female ratio was 32/38.

Forty patients (17 males/23 females), aged from 18 to 44 years (mean 31.1 ± 7.6), had IDDM of mean duration of 10.6 ± 8.4 years. All patients were hospitalized because of the necessity for the regulation of glycaemia and were under medical control for at least seven days. Inclusion criteria were: the absence of endogenous insulin secretion on the basis of

insulin and C-peptide level follow-up, the absence of other diseases of pancreas, the absence of heart diseases, and the blood pressure before the examination below 140/90 mm Hg.

In the control group, 30 healthy volunteers, predominantly medical staff, with an equal number of males and females, were observed. The inclusion criteria were absence of the diabetes mellitus and glycaemia below 6.7 mmol/L (capillary blood), the absence of any other pancreatic disease as well as of heart diseases in medical history, and the blood pressure values below 140/90 mm Hg before the examination.

The aims of the study and the nature of the method applied were explained to the patients and they agreed to be examined.

All examinations were performed with Acuson 128 XP/4 ultrasonic unit, equipped with curved array 3.5 MHz probe (assigned by manufacturer as C3) for general purposes, with footprint size of 66 mm. The frequency of color Doppler velocity mode was 3.5 MHz, and color Doppler energy mode (power-Doppler) 2.5 MHz.

The examination began with B-mode morphological analysis. The identification of pancreatic contours and measurement of the head, body and tail were performed for orientation of pancreatic status. In a fifth of patients, difficulties occurred with insonation of pancreatic head, although we had instructed the examinees to adhere to recommended preparative diet. Color-Doppler or power-Doppler was used to identify the gastroduodenal artery in the head of pancreas, or cephalad to it. The sample-volume was then positioned in the site of the strongest color signal while the patient was holding his breathe back. Spectral analysis was performed. The color signal was sometimes so weak and inconstant that it could hardly be traced, especially with restless patients unable to hold their breath; those spectra were received blindly from the estimated

area. The sample volume was set at the length of 2 mm. Semiquantitative spectral analysis was performed. RI and PI were determined as a mean value of three measurements. Each examination took about 30 minutes.

"Goodness-of-fit test" (Kolmogorov-Smirnov) was used to evaluate whether the distribution of variables was normal. Mann-Whitney U-test was used to assess the significance of difference of observed variables, and correlation was assessed with Spearman's method.

Results

In the group of IDDM patients with the mean duration of disease of 10.6 ± 8.4 years, the distribution of Doppler indices were as follows: median for RI was 0.74 with quartiles (25th percentiles) at 0.64 and 0.78; median for PI was 1.54 with quartiles at 1.26 and 1.88.

In the group of healthy controls, median for RI was 0.71 with quartiles at 0.64 and 0.77; median for PI was 1.46 with quartiles at 1.40 and 1.80.

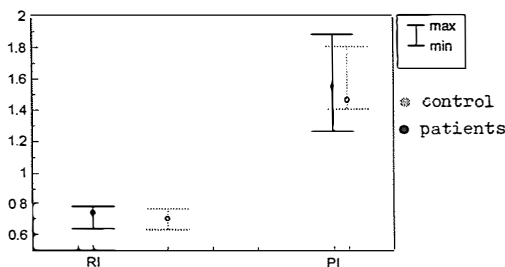


Figure 1. Doppler indexes RI and PI in IDDM patients and healthy controls.

n.s.= statistically nonsignificant difference

Figure 1 shows distribution of Doppler indices in the patients and control group.

Mann-Whitney U-test was used to compare RI and PI values in IDDM patient group and controls. There was no significant difference between these Doppler indices, with

$p=0.82$ for RI, and $p=0.74$ for PI. Median for RI was slightly lower in the control group than in the patients group, and the quartiles were almost identical. Median for PI values in IDDM group was higher than in the controls, with a slightly larger interquartile range as well, but the difference did not reach the statistical significance.

There was no significant difference of RI and PI values between males and females when examined as a common group (patients + controls). For RI was $p=0.21$ and for PI was $p=0.44$.

No significant sexual difference of Doppler indices was observed in control group either for RI ($p=0.40$) or for PI ($p=0.74$). Similarly, RI and PI values did not differ significantly between males and females in IDDM patients ($p=0.41$ and 0.15 , respectively).

Spearman's rang-correlation method disclosed the absence of significant correlation between Doppler indices and the age in the patients and controls observed as a unique group as well as in the IDDM patients, but the correlation was significant for RI in healthy controls ($r=0.37$, $p=0.04$) (Table 1).

Table 1. Correlation between age and Doppler indices

	Patients + Controls	Patients	Controls
RI	$r=0.13$ $p=0.27$	$r=0.06$ $p=0.72$	$r=0.37$ $p=0.04$
PI	$r=0.14$ $p=0.25$	$r=0.12$ $p=0.48$	$r=0.17$ $p=0.36$

Non-significant correlation was observed between Doppler indices and the duration of the disease in the IDDM patients group (Table 2).

Table 2. Correlation between duration of IDDM and Doppler indices in patients

RI	$r = -0.08$	$p = 0.63$
PI	$r = -0.05$	$p = 0.76$

Discussion

Pulse-wave and color-Doppler is a useful method in noninvasive assessment of blood flow. It adds a new dimension to "classic" gray-scale ultrasound enabling, in addition to morphological estimation, also functional one.¹ The flow spectrum of celiac axis is similar to that of the superior mesenteric artery after a meal, both having a significant diastolic flow as a result of low resistance. The spectral waveforms of the gastroduodenal artery reflect higher resistance, while amplitudes are lower and spectral "window" absent because of small diameter and tortuosity of the vessel.²⁻⁴

Nghiem *et al.* used pulse-wave and color-Doppler in the assessment of blood flow in the transplanted pancreas in 7 patients. Their RI values ranged from 0.7 to 0.9, and PI from 1.1 to 1.4.⁵ Our values of Doppler indices do not differ significantly either from those by Nghiem *et al.*, or those of observed groups, *i.e.* of diabetic patients (RI=0.74, PI=1.54) and control group (RI=0.71, PI=1.46).

Lang *et al.* refer to their preliminary experiences with color Doppler ultrasound after combined kidney/pancreas transplantation. In normal pancreatic grafts, median RI was 0.61 (range 0.55-0.70). When rejection process occurred, RI exceeded 0.80. Other cases of pancreatic dysfunction were not associated with the change of RI.⁶

Our results did not support our preliminary hypothesis that the diabetics will have increased vascular resistance in pancreas because of accelerated process of atherosclerosis that is inherent to the disease itself.

No significant differences in Doppler indexes' values were observed between males and females (we proved significant difference of size of the pancreas between males and females within the same population).

Significant correlation of Doppler indices and age was observed only for RI in the group of healthy examinees. The influence of age,

hypertension and morphologic changes of small arteries related to diabetes on vascular resistance is not easy to explain fundamentally, and this is surely a serious limitation to the clinical value of Doppler methods in diabetic patients.

Measurements of RI and PI reflect the intrapancreatic blood flow only approximately, estimating vascular resistance as a decisive factor of circulation in the gland. As these indices are not exact predictors, a precise estimation of volume flow rate would give more valuable results. It is, however, questionable whether the differences of volume flow would be significant, the more so the measurement of flow is linked to difficulties of precise measurement of vessel diameter and velocity simultaneously, and at the same point of the vessel. Small errors of measured variables will result in a significant inaccuracy of blood flow rates.⁷

Finally, we can conclude that duplex-Doppler flow imaging does depict blood flow in the gastroduodenal artery, and may noninvasively contribute to the estimation of pancreatic circulation. However, in our work, the differences between normal subjects and IDDM patients, as well as the correlations between the indices and age, sex and duration of the disease, have not reached a statistical significance, although resistance in diabetics proved to be slightly higher than in controls.

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