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CLINICAL STUDY

Changes of portal flow in heart failure patients with liver congestion

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Abstract: *Aim:* The goal of the study was to describe the changes of the portal vein (PV) flow in patients with an exacerbation of advanced chronic congestion heart failure (CHF) in relation to central hemodynamics and biochemical indicators of liver lesion.
Patients and methods: 90 pts (76 males) aged 49.2±11.2 years admitted for an acute exacerbation of chronic heart failure based on severe left ventricular systolic dysfunction (LVEF 20±4.3 %) were evaluated. The PV flow was sampled from the main portal vein using the intercostal approach. Systolic and diastolic flow velocities were measured and the the pulsatility index (PI, max – min/max PV flow velocity) was calculated.
Results: The median of PI in all patients was 0.82 (0–2.0). PI ≥0.5 was found in 77 (86 %) of patients. There was a significant linear correlation of PI and right atrium pressure (RAP), pulmonary vascular resistance (PVR) and mean pulmonary artery pressure (mPAP) ($p < 0.01$, $r = 0.68$, 0.51 and 0.49 resp). Out of 75 patients with RAP ≥8 mmHg, 67 (89 %) had the pulsatility index ≥0.5. The mean RAP was 7.2±3.1 mmHg in patients with continuous flow, 14.9±5.9 mmHg in the group with pulsatile flow pattern, and 20.1±6.3 and 21.1±6.5 mmHg in intermittent and alternating flow, respectively ($p < 0.01$).
Conclusion: The flow pulsatility increases with increasing right ventricular filling pressure so that an analysis of the PV flow can detect the elevation of right atrial pressure and allow a quantitative estimation of RAP. The finding of flat portal vein flow wave patterns in HF patients with signs of congestion draws the attention to concurrent primary liver disease. This information could be important in the risk stratification as well as in the therapeutic decision *(Tab. 1, Fig. 6, Ref. 19)*. Full Text in free PDF *www.bmj.sk.*
Key words: heart failure, liver congestion, portal vein flow.

Heart failure (HF) is a complex syndrome with multiple organ manifestations. Extracardial organ damage (kidney, liver, lung, and skeletal muscle) present typically in the advanced stages of chronic heart failure and have nonspecific morphological as well as functional manifestations. Liver disorders in chronic heart failure result from either congestion and/or hypo perfusion. Regional or systemic neurohormonal activation may also play a role in liver dysfunction in chronic or acute heart failure.

Liver damage in heart failure is manifested by hepatomegaly and subicterus, especially in cases where right-heart failure is present. In patients with acute heart failure and a low cardiac index, in whom the predominant mechanism of liver damage is hypoperfusion, liver transaminases rise significantly as a manifestation of ischemic hepatitis. Clinical manifestations of hepatic lesions in heart failure are very unspecific, and often are a differential diagnostic puzzle. Increased serum levels of liver aminotransferases and total bilirubin in patients with chronic heart failure (1) or pulmonary arterial hypertension (2) indicate a worse prognosis. Several observations also showed that patients with elevated serum bilirubin have a higher mortality after the heart transplantation (3) or after circulatory support systems implantation (4). There are also some reports demonstrating the unique changes of portal vein flow in heart failure with right ventricular dysfunction (5, 6).

The portal vein (PV) is interposed between the capillary network of splanchnic circulation and hepatic sinusoids. The PV is easily accessible for ultrasound examination and its flow can be quantitatively analyzed using the Doppler imaging (7). Liver congestion causes structural changes permitting the transmission of flow waveforms during right ventricular filling and ventricular contraction to the portal vein. Hepatomegaly and hepatojugular reflux are classic signs of systemic congestion and a lot of effort was recently put forth regarding the assessment and grading of congestion (8). A simple measurement of portal flow could be a good tool for detection and quantification of systemic congestion.

The goal of this study was to describe the changes of the PV flow in patients with an acute exacerbation of heart failure (HF) in relation to central hemodynamics and biochemical indicators of liver lesion.

Patients and methods

We examined 90 patients with the acute exacerbations of HF, who were admitted for evaluation as heart transplant candidates.

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Tab. 1. Characteristics of patients.

Total number of patients (n)	90
Men (n)	76
Age (years)	49.2 (±11.2)
Etiology of HF (CAD/DMP) (N)	39/51
NYHA (II/III/IV) (n)	10/48/32
BP S/D (mmHg)	105.6/71.2 (± 8.1/4.0)
LVEF (%)	20 (±4.3)
CI (L/min/m^2)	2.0 (±0.3)
TR III/IV (n)	30

n = number, HF = heart failure, BP = blood pressure, S = systole, D = diastole, CAD = coronary artery disease, DMP = dilated cardiomyopathy, LVEF = left ventricular ejection fraction, CI = cardiac index, TR = tricuspid regurgitation

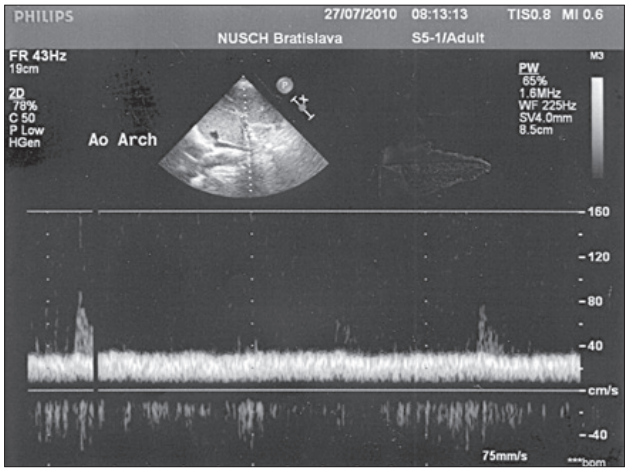

Fig. 1. Continuous flow through the portal vein (PV). The background shows weak signal peaks from the hepatic artery (AH).

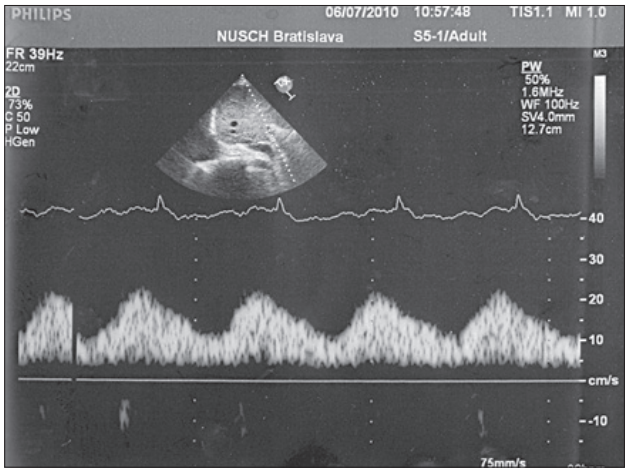

Fig. 2. Pulsatile flow. In diastole, the flow velocity is significantly higher than in systole.

The basic characteristics of the patients are presented in Table 1. None of the patients had a history of chronic liver or biliary disease, alcoholism or other serious illnesses. All patients received diuretics, 95 % received ACE-inhibitors, 74 % received beta-

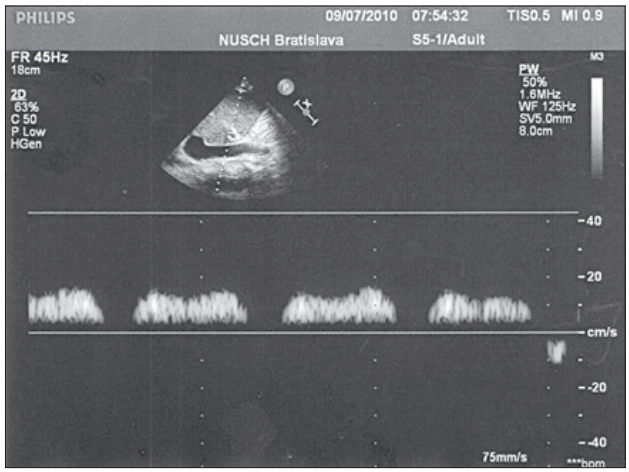

Fig. 3. Intermittent flow. Short hepatopetal flow in diastole. In systole, the flow signal is missing.

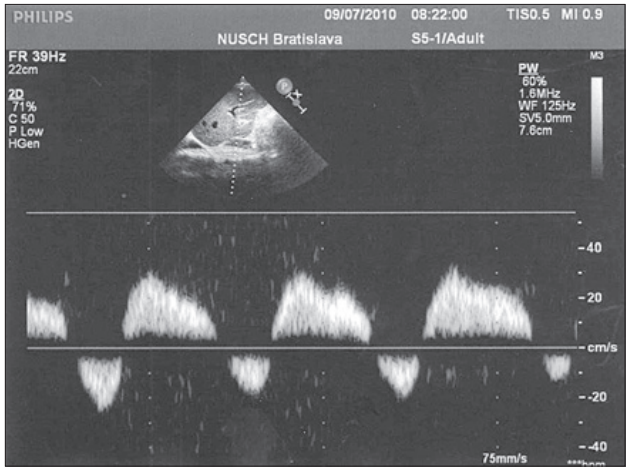

Fig. 4. Example of alternating flow – reverse (hepatofugal) flow in ventricular systole.

blockers, 68 % received digoxin and 76 % received spironolactone.

The Doppler examination of the PV flow was performed in all patients via the intercostal approach in a supine position after at least 8 – 12 of fasting utilizing a Philips IE 33 with a 2.5 MHz probe. The PV was sampled over its main ramification. In patients, where this was not possible, sample volumes were taken from the main right branch of the PV. Using the intercostal approach, the insonation angle was sharp enough to allow for no applying the angle correction. Low filter for noise was used.

Sample volumes were adjusted individually to cover the maximum amount of flow. Doppler traces were recorded during short interruption of breathing in a slight inspirium. We calculated the pulsatility index (PI) as the ratio of the difference of maximal and minimal velocity to maximal flow velocity (Vmax – Vmin / Vmax).

Based on PI, the flow was categorized to the one of four groups. If the PI was less than 0.5 the PV flow was classified as

continuous or sub continuous (Group 1). We considered the flow as pulsatile when the PI was 0.5 – 0.99 (Group 2). If the flow over the cardiac cycle decreased to zero, we took it as intermittent, PI = 1 (Group 3). In cases when flow reversed in systole (PI > 1) it was considered as alternating (Group 4) (Figs 1 – 4).

Central hemodynamics were evaluated using the Swan–Ganz thermodilution catheters inserted through the right internal jugular vein. We measured pressures in the right atrium (RAP), the right ventricle (RVP), the pulmonary artery (PAP) and the wedge (PCWP). We also evaluated the cardiac output (CO) and calculated the pulmonary vascular resistance (PVR) and the cardiac index (CI). Right heart catheterization was performed within 24 hours of echocardiography and ultrasound examinations.

All patients had routine echocardiographic examinations as well as biochemical liver function tests (LFT) consisting of total bilirubin (TB), alkaline phosphatase (ALP), aspartate aminotransferase (AST).

For statistical analysis, the methods of descriptive statistics, linear correlation and regression analysis, and the unpaired Student t-test were used.

Results

The median PI in the whole group was 0.83 (0 – 2.0). The pulsatile flow of any extent (PI ≥0.5) was found in 77 (86 %) patients. Continuous or sub continuous flow in the PV (PI < 0.5) was found in 13 patients. The pulsatile flow (PI 0.5 – 0.99) was detected in 35, intermittent (PI = 1) in 25 of them. Seventeen patients had alternating flow (PI > 1) in PV.

There were significant linear relationships between the PI and RAP (r = 0.68), PI and PVR (r = 0.53) and PI and MPAP (r = 0.51), PI and PCWP (r = 0.49; all p < 0.01). Out of 75 patients with RAP ≥8 mmHg, 67 (89 %) had the pulsatility index ≥0.5. The mean RAP was 7.2 ± 3.1 mmHg in patients with continuous flow, 14.9 ± 5.9 mmHg in the group with the pulsatile flow pattern, 20.1 ± 6.3 and 21.1 ± 6.5 mmHg in the intermittent and alternating flow, respectively (Fig. 5).

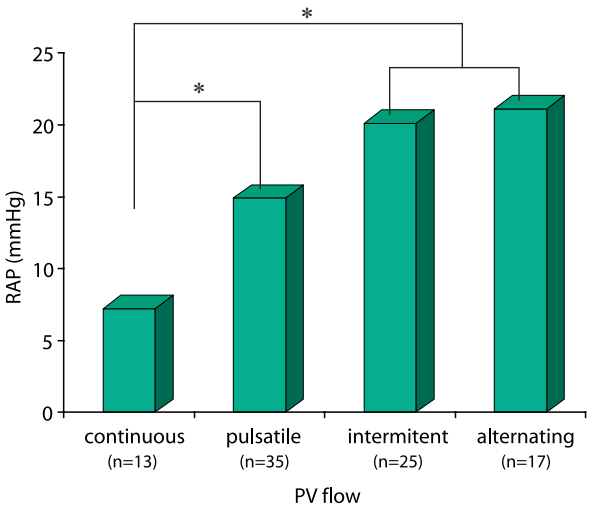

Fig. 5. The mean values of RAP in different groups of patients according to the flow character in the portal vein (PV). * = p < 0.01

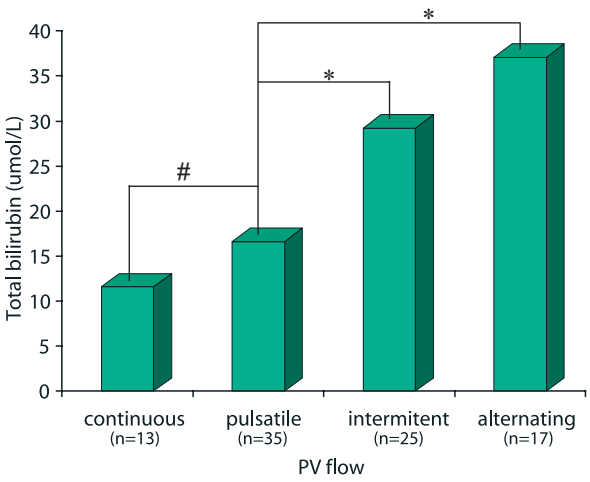

Fig. 6. Mean values of total bilirubin in different groups of patients according to the flow character in the portal out (PV). * = p < 0.01, # = p < 0.05.

Patients with a severe tricuspid regurgitation (TR) (III / IV) (n = 30) had a significantly higher PI than patients with milder TR (I / II), 1.26 ± 0.51 vs 0.68 ± 0.46, p < 0.01). Of the 30 patients with severe TR alternating flow (IP > 1), the PV was found in 15 (50 %) of them. The flow classified as continuous/subcontinuous was found in 3 patients only.

The average value of TB in the whole group was 23.2 ± 6.4 μmol/L, AST 0.52 ±0.17 and 0.65 ALP ±0.23 μkat / L. Serum values of TB in patients with continuous/sub continuous flow in PV were significantly lower than in the remaining patients (11.6 ± 4.7 vs. 28.6 ± 10.4 μmol / l, p < 0.01). There was a significant difference in the concentration of serum TB among the groups of patients with pulsatile, alternating and intermittent flow in the PV (16.6 ± 8.2 vs 29.2 ± 8.3 vs 37.1 ± 13.7, p < 0.01) (Fig. 6). There were no significant differences in serum levels of AST and ALP in relation to flow in the PV.

Discussion

HF leads to morphological and functional changes of the liver. These are a result of the complex disorders of liver perfusion. Liver congestion caused by the right ventricular dysfunction and/or tricuspid regurgitation is a predominant mechanism. In the right ventricular failure, RAP increases. Measurements of the vena cava diameter and its changes during respiration and /or hepatic veins flow is a common part of the echocardiographic evaluation of tricuspid regurgitation, right ventricular function and for the non-invasive estimation of RAP (9, 10). The interpretation of spectral analysis of the hepatic vein flow may be difficult due to the complex nature of traces and significant changes caused by respiration. Problems in the correct assessment may also occur in tachycardia. An inappropriate echocardiographic estimation of RAP is the main cause of dissonance be-

tween echocardiographic and direct measurement of systolic pulmonary arterial pressure.

A high right ventricular filling pressures lead to liver congestion and cause secondary changes in portal vein flow. This means that an increased right ventricular filling pressure in heart failure leads to changes in flow velocities, modifications in the diameter of the inferior vena cava, and hepatic veins which are transmitted through the liver sinusoids to the portal vein. The latter changes are not widely recognized. Under normal circumstances, the portal vein flow is continuous or more often sub continuous, with small fluctuations in velocity and PI < 0.5 (11). The pulsatile flow could sometimes be detected in young, healthy, lean individuals, where pulsatility is explained by the transfer from the inferior vena cava lying very close to the PV (12).

In our study, we followed the relation of PI to the parameters of central hemodynamics in patients with an acute worsening of HF. We found a statistically significant linear correlation between PI and RAP (r = 0.68), and 89 % of patients with elevated RAP had a PI > 0.5. In patients with the pulsatile flow, the median RAP was 14.9 mmHg and in the intermittent or alternating flow 20.1. and 21.1 mmHg, respectively. There are other authors who achieved similar results, with even closer linear dependence (13) and showed that 90 % of patients with the pulsatile flow had an increased pressure in the right atrium (> 8 mmHg). This observation is consistent with the findings of Hu et al (14), who found the pulsatile or alternating flow in the PV in all patients with HF and the RAP = 10 mmHg. It is possible that our observations were partly affected by the fact that right heart catheterization and echocardiography was not performed at the same time but up to 24 hours later. It is reasonable to propose a closer correlation between RAP and pulsatility in the PV under the condition of simultaneous measurements.

In 15 (50 %) of patients with severe TR, we observed a reverse portal vein flow during ventricular systole. Lopefrido et al (15) detected an alternating flow in the PV in 32 % of patients with severe TR. In four patients, who had severe TR and continuous flow was found through the PV, liver biopsies were done. In all four cases advanced fibrotic changes were found. None of our patient had a history of primary liver disease. So the alternating flow in the portal vein could be a specific sign of severe tricuspid regurgitation. Evaluation of the reversibility of these changes has not been the aim of the study. According to our experience, however, after an effective treatment of an episode of acute heart failure, an attenuation of congestion leads to diminishing or disappearing of the PV flow pulsatility.

The flow through the PV also changes in different primary liver diseases. The portal vein waveform is flat (continuous) or only slightly pulsatile in liver cirrhosis or fatty infiltration. There was a negative inverse correlation between the grade of fatty infiltration as well as severity of liver disease and the portal vein PI (16, 17). This means that in pure cardiac liver disease the PV flow becomes pulsatile and conversely in primary liver disease (cirrhosis, steatosis, hepatitis) it is flat. This differentiation could be very useful in the diagnosis of primary liver disease in HF patients. Primary liver disease is not frequent in HF patients (up to 2 %) but its presence is one of the most powerful predictors of mortality (18, 19).

Biochemical response of congestive hepatic injury in chronic heart failure is usually not striking. Sharp increase, particularly in aminotransferases may occur in prolonged or abrupt hypotension and shock-like states, as the result of hepatic ischemia (19). In cases of HF decompensation with systemic congestion, an increase in concentrations of total and particularly conjugated bilirubin is regularly encountered (2, 19). Recently it was also revealed that elevated total bilirubin was one of the strongest independent predictors of a poor prognosis in HF patients (1). In our investigation, we found slight increases in the values of serum TB associated with the PV pulsatility with the highest values in the group of patients with the alternating flow. The values of AST and ALT were normal or only slightly increased and not related to the character of the flow through the PV.

The flow through the PV in patients with heart failure is rarely investigated despite the fact that measurement is fast and easy. Experienced clinicians can reach a good quality of PV trace in almost all of patients via intercostal access. The analysis of Doppler traces from PV in patients with HF can give an answer to at least two clinically relevant questions. Flow pulsatility increases with increasing right ventricular filling pressure so the analysis of PV flow can detect elevations in the right atrial pressure and allow quantitative estimation of RAP. The findings of flat portal vein flow wave pattern in HF patients with signs of congestion draw attention to the concurrent primary liver disease. This information could be important in the risk stratification as well as in the therapeutic decision.

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