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Noninvasive Femoral Arterial Pulse Correlates to RNV Determined Parameters of Systolic Cardiac Function

G. Cieslinski, G. Hör

A newly designed non-invasive Doppler analysis of femoral arterial pulses was compared to cardiac ^{99m}Tc radionuclide ventriculographies (RNV) in 22 consecutive patients (mean age: 51.6 y; 17 male).

15 patients had proven or suspected coronary artery disease, 4 had orthotopic cardiac transplantation and 3 were under antimalignant chemotherapy. The patients underwent simultaneous RNV and 4 MHz femoral arterial Doppler in a stress protocol.

Postexertional Doppler values (peak velocity, mean velocity, diastolic velocity and acceleration) showed significant correlations to RNV parameters of systolic cardiac function at rest and post exercise. The best correlation was seen between cardiac output and mean velocity or peak velocity of femoral arterial pulses ($R = 0.822$, $p < 0.001$ and $R = 0.732$, $p < 0.001$ respectively).

This non-invasive Doppler test should be considered as a valuable supplement to routine exercise protocol to analyse systolic left ventricular function. *J Clin Basic Cardiol 2000; 3: 59–60.*

Key words: exercise cardiac output, Doppler, femoral artery, pulse, non-invasive, RNV

Determination of exercise cardiac output can be of great value for diagnostic procedures including prognostic implications [1, 2]. Many of the methods used to determine cardiac output are expensive and are too sensitive to the technique of the investigator [3]. The aim of this study is to assess the reliability and reproducibility of non-invasive Doppler-analysis of femoral arterial pulses for determination of cardiac output with respect to a gold standard, namely radionuclide ventriculography (RNV).

Methods

The study is based on consecutive analyses of 22 patients (17 male, mean age 51.6 ± 14.2 years). 10 patients had proven, 5 suspected coronary artery disease (with impaired LV function, data not shown), 4 had orthotopic cardiac transplantation in the past and 3 were under antimalignant chemotherapy. The patients were referred by the clinician. In every case, the RNV study was indicated.

The study complies with the declaration of Helsinki and local ethics committee approval was given. Patients unable to tolerate the non symptom-limited exercise protocol, or with known peripheral arterial vascular disease were not included. After giving informed consent, simultaneous non-invasive studies were performed as follows.

Each ECG-monitored exercise test was performed as a supine bicycle test lasting for five minutes. Baseline studies included ^{99m}Tc-RNV study (equilibrium technique) and two channel recording of femoral arterial pulses with a 4 MHz probe of a Kranzbühler Doppler device, type 762 (Kranzbühler, Solingen, Germany). RNV studies were done in the manner of the 'Frankfurt modification' [4, 5]. A more complete description of the method is available elsewhere [6].

Statistical analysis was performed by applying the two-tailed R. A. Fisher's test or the Student's t-test. Statistical significance was assumed when $p < 0.05$.

Results

Mean exercise capacity was 63.7 (± 27.5) W in a range from 25 to 125 W. Cardiac output (CO) at rest determined by the radionuclide correlated significantly ($p < 0.01$) with post-exertional Vmax ($R = 0.608$), Vm ($R = 0.634$), dV/dt ($R = 0.550$) and Vdia ($R = 0.533$, $p < 0.05$) as is shown in Table 1 and Figure 1. A similar correlation was found for stroke volume (SV) and Doppler findings. Peak filling rate (PFR) and

Table 1. Comparison of both postexertional radionuclide ventriculography and femoral arterial Doppler: Correlation coefficients. There is a significant correlation to parameters of systolic cardiac function.

RNV-stress	Vmax-stress [cm/s]	Vm-stress [cm/s]	Vdia-stress [cm/s]	dV/dt-stress [cm/s²]
EF [%]	0.472*	0.609**	0.511*	0.424*
PER [1/s]	0.551**	0.723***	0.621**	0.514*
EDV [ml]	0.083	–0.168	–0.219	0.059
PFR [1/s]	0.602**	0.744***	0.700**	0.564**
CO [l/min]	0.731***	0.821***	0.673**	0.602**
SV [ml]	0.598**	0.579**	0.401	0.510*

Vmax: peak velocity; Vm: mean Velocity; Vdia: diastolic velocity; dV/dt: acceleration; EF: ejection fraction; PER: peak ejection rate; EDV: end diastolic volume; PFR: peak filling rate; CO: cardiac output; SV: stroke volume
$n = 22$; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

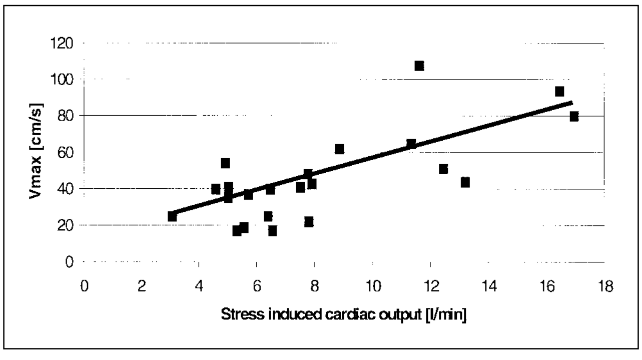

Figure 1. Individual data plots for the comparison between RNV cardiac output to Doppler derived femoral arterial blood velocity; $n = 22$, $R = 0.731$, $p < 0.001$

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ejection fraction (EF) showed a weak correlation, while peak ejection rate (PER) showed a marginal correlation with non-invasive femoral arterial Doppler. As expected, end diastolic volume (EDV) at rest was not correlated with femoral arterial pulse (R = –0.190 to R = 0.182).

Almost every postexercise non-invasive Doppler-parameter was closely correlated with RNV values of systolic cardiac function (see Table 1). The best correlation was seen between cardiac output and the Doppler measured mean or peak velocity (R = 0.821, $p < 0.001$ or R = 0.731, $p < 0.001$) as is illustrated in Table 1 and Figure 1. Vdia was best correlated to PFR (R = 0.673, $p < 0.01$); dV/dt to CO (R = 0.601, $p < 0.01$) and PFR (R = 0.564, $p < 0.01$). And again, end diastolic left ventricular volume did not correlate to the non-invasive Doppler findings (R = –0.219 to R = 0.083, p = n.s.).

Discussion

Exercise femoral arterial pulse correlates well to ^{99m}Tc-RNV findings of left ventricular systolic function. A subtraction from postexercise of baseline values (Δ-parameters) led to significant results identifying patients with coronary multivessel disease in formerly published data analysing ascending aortic velocity [7]. This arithmetical procedure is not necessary for femoral arterial pulse, since the absolute postexercise values correlated better with systolic ventricular function than Δ-values (data not shown). Immediate postexercise examination as we did is often used to avoid exertional artifacts even in a sophisticated stress-echo protocol [8]. So most established stress protocols can accommodate this additional Doppler test.

One can argue that cardiac output (CO = SV × heart rate) and stroke volume (SV = EF × EDV) were parameters derived from RNV data. Therefore, it is possible that errors would accumulate. However, cardiac output reflects the influence of heart rate in patients with impaired left ventricular function which is mainly responsible for its increase due to the Frank-Starling mechanism. Heart rate "independent" radionuclide findings such as ejection fraction, peak ejection rate or peak filling rate do still correlate to postexertional Doppler results in a significant matter.

There were baseline ejection fractions ranging from 12–77 % and stress ejection fractions ranging from 11–74 %. Compared to normal values, only 5 of 22 postexertional ejection fractions could be regarded as inconspicuous [4]. This is mainly a result of patient selection. All of them were regarded to have a cardiac disease which led clinicians to refer them to a RNV study. Six patients had pathological low peak filling rates at rest. A similar result was seen analysing peak ejection rate, 3 out of 22 patients were undernormal. This might be a limitation of this study, further investigations on larger populations could assure more statistical power. A further possible disadvantage of femoral arterial pulse analysis may be seen in the unknown arterial diameter. This might be one cause for less significant correlations with baseline RNV studies. Another explanation can be seen in the fact that many patients with impaired left ventricular function were analysed in whom diverging results may occur. Comparing two different established methods of analysing cardiac output, one wonders about sometimes unsatisfying results. In a former published series of our own comparing oxymetric calculated cardiac output versus thermodilution-measured values there was a correlation of only R = 0.44 [9] due to diverging results especially in patients with reduced cardiac output. Similar to this, 7 patients of these Doppler series had a reduced ejection fraction of below 50 %. However an ejection fraction dependent correlation to Doppler results was not seen (data not shown).

The impaired systolic function at exercise is a marker of ischaemic or non-ischaemic cardiac disease and has important prognostic implications. Before and after percutaneous transluminal coronary angioplasty RNV was applied to analyse the success of revascularisation [10]. Also non-invasive Doppler analysis separates in a statistically highly significant manner patients with incomplete revascularisation from patients with completely revascularisation after PTCA [7]. In this setting, complete revascularised patients could be seen as controls in order to estimate physiologic pulse response on exercise. Peak velocity and mean velocity showed an increase of more than 50 %, dV/dt of more than 33 % compared to the individual baseline. There was a sensitivity of 86.6 % and a specificity of 90.9 % to differentiate both patient groups using Doppler estimated postexertional cardiac output.

This easily applicable noninvasive Doppler test of systolic cardiac function can be considered as a simple supplement to routine exercise protocol.

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