Noninvasive femoral arterial pulse correlates to RNV determined parameters of systolic cardiac function

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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.

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<tbody>
<tr>
<td>EF [%]</td>
<td>0.472*</td>
<td>0.551**</td>
<td>0.083</td>
<td>0.602**</td>
<td>0.598**</td>
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<tr>
<td>PER [1/s]</td>
<td>0.609**</td>
<td>0.723***</td>
<td>-0.166</td>
<td>0.744***</td>
<td>0.731***</td>
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<tr>
<td>EDV [ml]</td>
<td>0.511*</td>
<td>0.621**</td>
<td>-0.219</td>
<td>0.700**</td>
<td>0.821***</td>
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<tr>
<td>PFR [1/s]</td>
<td>0.424*</td>
<td>0.514*</td>
<td>0.059</td>
<td>0.564**</td>
<td>0.673**</td>
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<tr>
<td>CO [l/min]</td>
<td>0.059</td>
<td>0.059</td>
<td>0.401</td>
<td>0.602**</td>
<td>0.501*</td>
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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, $p < 0.001$
Exercise femoral arterial pulse correlates well to $^{99m}$Tc-RNV findings of left ventricular systolic function. A subtraction from postexercise of baseline values ($\Delta$-parameters) led to significant results identifying patients with coronary multi-vessel 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 $\Delta$-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 findings ($R = -0.219$ to $R = 0.083$, $p = n.s.$).

**Discussion**

Femoral arterial pulse correlates well to $^{99m}$Tc-RNV findings 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 $R = 0.083$, $p = n.s.$).

**References**