PREOPERATIVE AND INTRAOPERATIVE ASSESSMENT OF VOLUMETRIC BLOOD FLOW VELOCITY THROUGH THE INTERNAL THORACIC ARTERY IN PATIENTS WITH CAD

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The left internal thoracic artery (ITA) is currently an artery of choice for revascularization of coronary arteries. Ultrasonographic duplex scanning (USDS) and ultrasound Doppler flowmetry (UDF) are sequential techniques to control patency of the ITA at stages of rendering care for patients on restoring coronary blood flow. We compared two methods of measuring the volumetric blood flow velocity: by means of USDS and UDF. The obtained results were statistically processed. It was determined that transthoracic USDS and intraoperative UDF in the assessment of the volumetric blood velocity through the ITA in patients with coronary artery disease are comparable methods, provided the patients have similar parameters of central haemodynamics.

Key words: *internal thoracic artery, duplex scanning, ultrasound Doppler flowmetry, volumetric blood flow velocity.*

INTRODUCTION

The left internal thoracic artery (ITA) is currently an artery of choice for revascularization of coronary arteries. This is conditioned by the anatomical and functional peculiarities of the artery, as well as by the fact that this artery is predominantly used for shunting the anterior interventricular branch of the left coronary artery which itself to a considerable degree determines the prognosis, which was confirmed by a series of randomized studies conducted as long ago as in the 1980s [1, 2], as well as by contemporary studies [3, 4].

A repeat intervention on coronary arteries is usually associated with an increased risk as compared with the primary procedure of revascularization. Therefore, the problem concerning an optimal choice of transplants still remains of current importance [5, 6]. Ultrasonographic duplex scanning (USDS) and ultrasound Doppler flowmetry (UDF) are sequential techniques of controlling patency of the ITA at stages of rendering care for patients on restoration of coronary blood flow.

There exist numerous data characterising the blood flow through the ITA transthoracally [7–9] and intraoperatively [10], but we came across comparing the preoperative and intraoperative findings in the same patients in only one work [11].

Objective. The study was aimed at comparing two ultrasound techniques – USDS and UDF – in assessing volumetric blood flow velocity through the ITA in patients with coronary artery disease.

PATIENTS AND METHODS

The study included a total of 106 patients subjected to 129 isolated procedures of mammary-coronary artery bypass grafting (MCABG) over the period from March 2015 to May 2015 at the Federal Centre for Cardiovascular Surgery (Penza, Russia). The patients were divided into two groups. Group One comprised 74 patients and Group Two consisted of 32 patients. There were no clinicodemographic differences between the groups (Table 1). MCABG was performed using both the left and right ITA. The patients were assigned to the groups statistically, i.e., based on the data of the linear regression analysis.

Statistics. The database was compiled as electronic tables using the Microsoft Office Excel 2007 software. At the first stage of processing the obtained findings we used linear regression. The dependent variable was the Q_{mean} obtained intraoperatively, with the independent variable being the Q_{mean} obtained transthoracally. The equation of regression was regarded as statistically significant at the level of the F-criterion $\leqslant 0.05$. We also estimated the coefficient of determination of the model (R^2), showing the percentage of variability in the independent variable, that is explained by the obtained model. We separately determined the most influential cases by means of the standardized DfBeta

Table

Clinical and demographic characteristics of patients

	Group I (n=74)	95% CI	Group II (n=32)	95% CI	p
Age (years)	59.6±9.8	57.3–61.9	58,5±8,1	55.6–61.4	0.6
Men (n)	36		20		0.3
EuroScore (%)	4.1±1.8	3.7–4.5	3.9–1.5	3.3–4.4	0.7
EF (%)	52.4±8.7	50.4–54.9	55.2±6.9	52.7–57.7	0.08

Note: EF – left ventricular ejection fraction, CI – confidence interval.

(DfBetaS) reflecting the difference between the regression coefficients when all cases are included into the model and when a particular case is removed therefrom. I.e., if exclusion of the case leads to a significant "leap" in assessing particular parameters of the model it means that this case is influential. It is generally accepted that most significant are cases wherein the values of DfBetaS ⩾2 [12, 13].

The patients were then divided into groups based on the values of DfBetaS. If the value of DfBetaS ⩾2, the patients were assigned to the second group, with other patients included into group one. A repeat linear regression equation was set up for each of the two groups thus formed.

To compare the two methods of measuring volumetric blood flow velocities, inside the group, we used the Bland-Altman technique of assessing agreement between measurements [14, 15]. For each pair of measurements we calculated the difference, the mean value of the difference (M_{diff}) with the indication of the 95% confidence interval (95% CI), followed by testing the hypothesis of difference of M_{diff} from 0.

The significance of changes and inter-group differences was determined using the t-test. Differences were regarded as statistically significant if $p \leqslant 0.05$. The results are expressed as M±SD with the indication of the 95% CI, wherein M stands for the mean value and SD stands for the standard deviation. Calculations were performed using the software Statgraphics Plus 3 (1997) and SPSS (Statistical Package for the Social Sciences).

During the preoperative period, USDS of the ITA was performed on the unit "SONOLINE" G60 S (manufactured by the SIEMENS Corporation) with the use of a 5–8 MHz microconvex transducer. The ITA was visualised from the supraclavicular approach in the 2–3 intercostal space along the parasternal line with the patient in the supine position. In the mode of colour Doppler mapping (CDM) using pulsed Doppler and with the correction of the Doppler angle (less than 60 degrees) we measured the volumetric blood flow velocity with regard to the arterial diameter. Then, the same patients were subjected to intraoperative examination of the ITA with the help of UDF. Blood flow was measured with the help of the VeriQ MediStim® flowmeter (Oslo, Norway) at a portion of the skeletonised ITA measuring 2–2.5 cm in length. We assessed the value of the average volumetric velocity of blood flow (Q_{mean}). Probes measuring 1.5 and 2 mm in diameter were used most often in this study.

RESULTS

Group One patients demonstrated no dependence between the Q_{mean} obtained intraoperatively and transthoracally (R^2=0.04) [see Fig. 1].

The two method of measuring volumetric blood flow velocities were compared using the Bland-Altman technique of agreement of measurements with graphical visualization of the data. Figure 2 shows the correlations of the difference between the measurements of volumetric blood flow velocity and the mean arithmetical value of these measurements. In Group One patients, the mean difference between the measurements equalled -11.95 ml (95% CI: -15.7; -7.0). When comparing the sample mean to the hypothetic generalized mean, the difference was statistically significant (p=0.001), thus suggesting systematic divergence.

Group Two patients showed interrelationship between the Q_{mean} values obtained intraoperatively and transthoracally (R^2=0.97; p=0.0001). The approximation equation: Q_{mean} intraoperatively=0.98×Q_{mean} (transthoracally)+0.57 (see Fig. 3). Comparing the two methods of measuring the volumetric blood flow velocities by the Bland–Altman method of agreement (see Fig. 4) showed that Group Two patients had the mean difference between the measurements equalling -0.28 ml/min (95% DI: -1.4–0.8). Comparing the sample mean to the hypothetical generalized mean yielded p=0.47, thus suggesting absence of systematic divergence.

Comparing the Q_{mean} transthoracally in Group One patients this index amounted to 57.2 ± 7.8 ml/min (95% CI: 54.8–57.9) and in Group Two patients to 50.5±3.2 ml/min (95% CI: 49.0–51.9), p=0.002. Analysing the intraoperative Q_{mean} yielded the following results: the value of volumetric blood flow velocity in Group One patients amounted to 42.4±9.0 ml/min (95% CI: 40.5–42.4) and in Group Two patients to 44.3±11.2 ml/min (95% CI: 40.1–47.8), p=0.2.

The level of systolic arterial pressure in Group One patients prior to surgery amounted to 148.0±15.9 mm Hg (95% CI: 144.7–151.3) and intraoperatively to 92.1±9.3 mm Hg (95% CI: 90.19–94.0), p=0.001, while in Group Two patients equalling 105.8±17.8 mm Hg (95% CI; 99.1±111.3) and 101.5±14.2 mmHg (95% CI: 96.6–106.6), respectively (p=0.09). The level

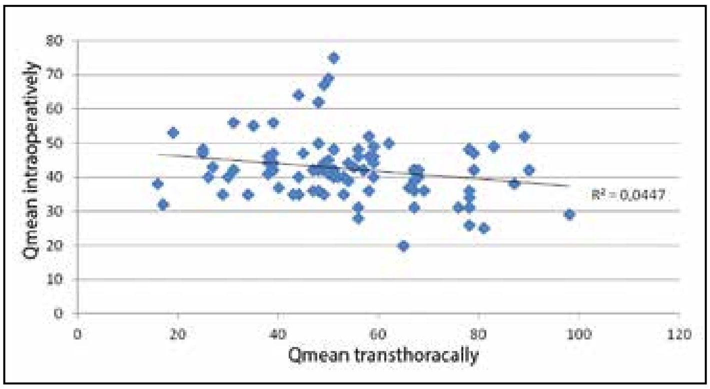

Fig. 1. Plot of dependence of volumetric blood flow velocities obtained by different methods in Group One patients

of diastolic arterial pressure in Group One patients before the operation was 82.6±9.4 mm Hg (95% CI: 80.6±84.5) and intraoperatively – 62.3±6.7 mm Hg (95% CI: 60.9–63.6), p=0001 while in Group Two patients – 69.1±8.3 mm Hg (95% CI: 66.8–71.4) and 65.7±10.1 mm Hg (95% CI: 62.2–69.2), respectively (p=0.07).

The value of the stroke index (SI) in Group One patients before surgery was 32.8 ± 4.9 ml/m² (95% CI: 31.8–34.1) and intraoperatively – 28.5±5.0 ml/m² (95% CI: 27.3–29.6), p=0.001, while in Group Two patients 20.7±7.5 ml/m² (95% CI: 27.8–31.1) and 29.3±5.2 ml/m² (95% CI: 27.5±31.8), respectively (p=0.8).

The heart rate in Group One patients prior to surgery amounted to 70.5±7.7 bpm (95% CI: 68.6–72.3) and intraoperatively to 76.5±8.3 bpm (95% CI: 74.7–79.0), respectively (p=0,001), while in Group Two patients to 77.4±8.8 bpm (95% CI: 66.3±77.6) and 80.4±7.2 bpm (95% CI: 69.9–79.8), respectively (p=0.3).

DISCUSSION

Currently, there exist various methods of assessing the condition of vessels that may be used as shunts of coronary arteries. Transthoracic USDS and intraoperative UDF make it possible to assess suitability of the ITA as a shunt. Assessing the ITA by means of USDS and suitability of its use for shunting commenced in the early 1990s [16, 17]. The method of UDF makes it possible to provide quantitative characteristics of blood flow in the conduit and to determine the shunt's function [18–20].

The physiological norm of the ITA Q_{mean} obtained with the help of USDS varies widely ranging from 17.2 to 104.4 ml/min. [21, 22].

The volumetric velocity of blood flow through the ITA, according to N. Ohtani was 54.6±29.0 ml/min in men and 56.8±38.2 ml/min in women [23], which is comparable with the findings obtained in our study. Thus, USDS of the ITA showed that in Group One patients the value of the Q_{mean} was 57.2±7.8 ml/min (95% CI: 54.8–57.9) and slightly lower in Group Two patients, equalling 50.5±3.2 ml/min (95% CI: 49.0–51.9), p=0.002. The differences in the values of the Q_{mean} obtained in our study in patients of different groups are explained by various haemodynamic parameters. It is generally known that volumetric velocity of blood flow in a vessel depends upon a series of factors, including the value of peripheral resistance [24, 25]. It was confirmed intraoperatively while studying the effect of spasmolytics on carrying capacity of skeletonized shunts. It was noted that administration of papaverin was followed by a dramatic increase in the volumetric blood flow (197±66.2 ml versus 147.1±70.5 ml) [26, 27].

In our series we revealed that patients found to have difference in the values of arterial presume, SI and heart rate prior to and during the operation demonstrated no relationship between the values of the Q_{mean} obtained by different methods and they significantly differed from each other; if the haemodynamic parameters did not

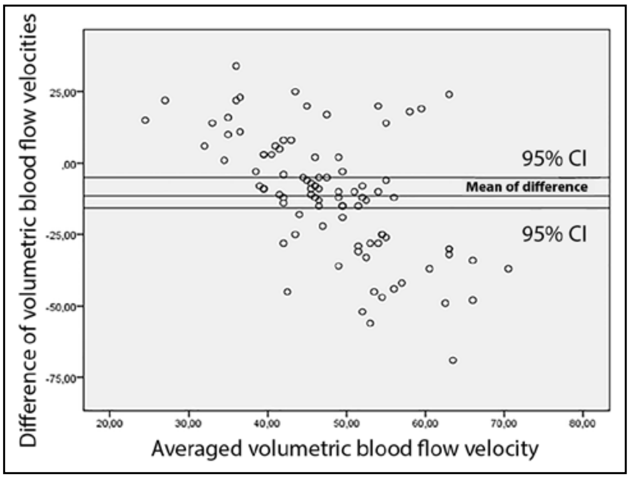

Fig. 2. Difference of volumetric blood flow velocities for each averaged value in Group One patients

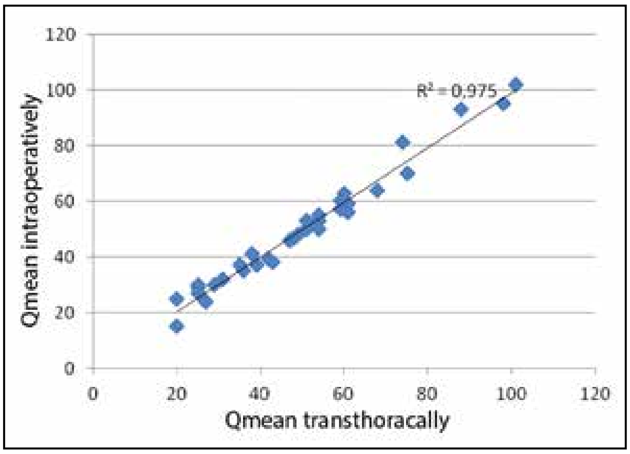

Fig. 3. Plot of dependence of volumetric blood flow velocities obtained by different methods in Group Two patients

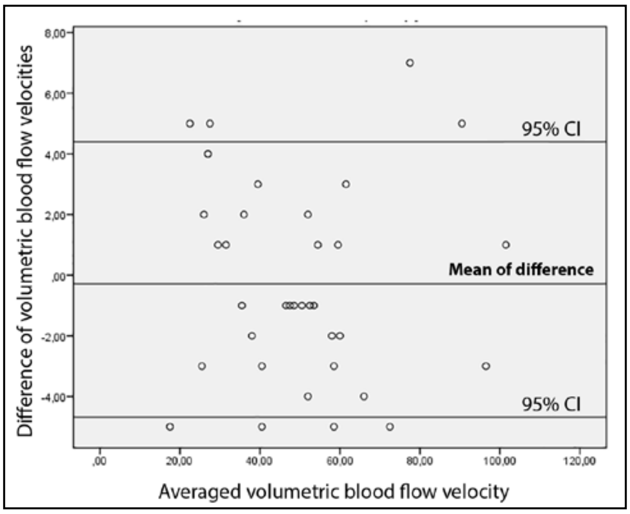

Fig. 4. Difference of volumetric blood flow velocities for each averaged value in Group Two

differ before and during the operation, neither did differ the volumetric blood flow. A similar dependence was obtained by Cagli K. in his study. Thus, the intraoperative Q_{mean} obtained by the free bleeding technique amounted to 32.42±12.33 ml/min, which was considerably less than the pre- and postoperative ultrasonographic findings (42.22±10.77 ml/min and 45.36±19.52 ml/min, respectively). He explained this the influence of anaesthesia on cardiac haemodynamics and vascular tonicity [11].

CONCLUSIONS

Hence, USDS and intraoperative UDF in the assessment of the volumetric blood flow velocity through the ITA in patients with coronary artery disease are comparable techniques, provided the patients have similar parameters of central haemodynamics.

The authors declare no conflict of interest.

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