Internal Thoracic Artery Graft (ITAG): Patency and Functional Status at Rest and During Dobutamine-Stress Echocardiography

José Sebastião de Abreu, Tereza Cristina Pinheiro Diógenes, André Luís de Castro Abreu, José Erirtônio Façanha Barreto, José Maria Bonfim de Morais, Marília Esther Benevides de Abreu, Jorge Henrique Azevedo Pinto, José Nogueira Paes Júnior
Hospital Prontocárdio de Fortaleza, Fortaleza, CE - Brazil

Summary

Background: **The patent internal thoracic artery graft (ITAG) usually has a diastolic fraction (DF) > 50% of the flow. The functional assessment can be evaluated by the coronary reserve index (CRI).**

Objective: **The objective was to evaluate the patency and functional status of the ITAG through echocardiography and Doppler.**

Methods: **Data from sixty-six patients who underwent dobutamine-stress echocardiography (DSE) were prospectively collected and analyzed. Group I (GI) had 49 ITAG without stenosis, Group II (GII), 10 ITAG with significant stenosis (> 50% and <100%) and Group III (GIII) had 7 ITAG with total occlusion. Diameters and Doppler spectrums from the ITAG at rest and during DSE were evaluated.**

Results: **Considering patency a DF >50%, it was observed in 49 ITAG (GI= 40, GII= 8 and GIII= 1) at rest and in 61 ITAG (GI=49, GII=10 and GIII=2) during DSE. The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy were respectively, 81%, 86%, 98%, 35% and 82%, and 100%, at rest and 71%, 97%, 100% and 97% in the DSE. The ITAG with DF >50% at rest were patent and the ones with DF<50% in the DSE presented total occlusion. Considering a CRI≥1.8 for a good functional status, it was observed in 42 ITAG (39 from GI, 2 from GII and 1 from GIII), determining sensitivity=79%, specificity=85.7%, PPV=94%, NPV=59% and accuracy= 80.9%. The CRI in GI was higher (p= 0.02) than in GII or GIII.**

Conclusion: **In our study, the non-invasive assessment of the ITAG was effective to verify the patency and the functional status. (Arq Bras Cardiol 2008;90(1):36-43)**

Key words: **Internal thoracic artery; echocardiography; dobutamine.**

Introduction

The internal thoracic artery (ITA) has been called a "living graft", due to its adaptive capacity after being grafted onto the coronary bed and its effectiveness as long-term ITA graft (ITAG) has been verified[1-5].

Due to the fact that its peculiar *in situ* anatomy can allow a non-invasive assessment, without the need for any contrast agent, the duplex scan was first used by Takagi and cols[6] in the study of the ITA at supraclavicular level, which allowed the estimate of the patency of the ITAG through the percentage of the diastolic component of the flow (diastolic fraction), but did not provide a satisfactory result regarding the functional status[6-8]. This has been demonstrated non-invasively through the coronary reserve index (CRI), which can be obtained under different forms of stress such as the use of certain drugs (dipiridamol, adenosine, dobutamine, papaverine), a pacemaker or during exercise[4,8-11].

The dobutamine action regarding the increase of oxygen consumption by the myocardium, the modification of the coronary flow and the use of digitalized images favored the dissemination of the dobutamine-stress echocardiography (DSE) as an accurate and safe method to assess coronary artery disease[12-19] and, due to these dobutamine actions and the possibility of non-invasive assessment of the ITAG, the patency of the latter was verified at supraclavicular level, concomitantly to the DSE[20]. The non-grafted ITA flow is predominantly systolic, whereas that of the ITAG, being a hybrid system, usually has diastolic predominance, reflecting the myocardial contractility and the perfusion of the coronary bed in a patent ITAG. This flow pattern can, however, be modified in case of significant stenosis of the ITAG and/or subjacent coronary bed, or even by the involvement of the myocardium related to the graft[21-25].

Considering that the ITAG is a frequently used graft in myocardial revascularization and that it has an easy, non-invasive visualization, the aim of the present study was to verify, at supraclavicular level, the ITAG patency and functional status, at rest and during DSE, through echocardiography and Doppler.

Methods

Three study groups were defined and the data from patients with ITAG who were submitted to DSE at our Echocardiography

Mailing address: José Sebastião de Abreu •
Rua Dr. João de Deus, 158/37 - 60040-350 - Fortaleza, CE - Brazil
E-mail: jsabreu@cardiol.br
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Service, located in a Cardiology Emergency Center, were prospectively collected. The DSE and hemodynamic studies were carried out following the assistance physicians' criteria. Considering as reference pattern the results of the coronary angiography in the assessment of the ITAG and the subjacent coronary beds, the patients were divided in group I (GI), with 49 individuals without stenosis of the vascular lumen, group II (GII) with 49 patients presenting stenosis (≥50% and <100%) and group III (GIII) with 7 patients presenting 100% of vascular occlusion.

Data collection was started in May 1996 and ended in October 2004. For the groups with significant stenosis of the ITAG-native coronary conduit (GII and GIII), only patients whose coronary angiographies with ITAG assessment had been carried out a maximum of 120 days after the DSE should be included. Group I had no limitation regarding the period between the DSE and the subsequent coronary angiography, as the absence of stenosis was the feature that characterized this group. Apogee CX 200 and Vingmed System Five equipment were used and the results were recorded in video-tape.

Dobutamine was administered at doses of 10, 20, 30 and 40μg/ kg^{-1}/min^{-1}, at 3-minute intervals, with the aim of attaining at least 85% of the maximum heart rate (HR) (220 minus age in years) and/or determining contractile abnormality compatible with myocardial ischemia. Atropine could be started at the third or fourth stage, according to our protocol[16]. All DSE were performed by two echocardiographists (simultaneously) and the interpretation (by consensus) was carried out immediately after the end of the test.

As described by Takagi and cols[6], for the visualization of the ITAG, the patient was kept in the dorsal decubitus position with the cervical region partially extended and slightly rotated to the opposite side of the ITAG under assessment. Using high-frequency (5 to 8 MHz) transducers, and a depth range of 3-4 cm, we recorded, at supraclavicular level, the ITAG emerging from the subclavian artery; by adjusting with small angulations or rotations of the transducer, the ITAG was visualized in its longest possible extension and thus the vessel diameter was measured. Afterward, the volume sample of the pulsatile Doppler (with the smallest possible angle) was positioned and the best spectral curve was selected, followed by the analysis of its systolic and diastolic components. The ITAG diameter, systolic peak velocity (SPV), diastolic peak velocity (DPV), mean systolic velocity (MSV), mean diastolic velocity (MDV), time of systolic (TS) and diastolic (TD) flow duration, systolic velocity time integral (SVTI) and diastolic velocity time integral (DVTI), diastolic fraction (DVTI/DVTI + SVTI), heart rate (HR), total cardiac output [π . (diameter/2)^2 . (DVTI + SVTI). HR] and CRI (DPV during DSE/DPV at rest) were measured at rest. Subsequently, the patient was placed in left lateral decubitus position and, with lower-frequency transducers (1.7 to 4 MHz), the DSE was started. At the peak of the DSE and after the images had been captured, the patient was immediately placed in dorsal decubitus for new measurements of all the ITAG parameters.

Statistical analysis - The data were collected according to the repeated measurement model (rest/dobutamine) for Groups I, II and III. The adjusted model was the factorial type.

The analysis of the normal distribution was carried out through the Shapiro-Wilks test and the equality of variance among the groups, through Levine's test. Ln transformation was performed when necessary. The comparison among the group at rest with the one under dobutamine stress was performed through the minimal square test and the analysis of variance (ANOVA) was used for the interaction among the groups.

Results

The study population (table 1) consisted of sixty-three patients, of which 37 (56%) were males with a mean age of 62 ± 9 years (43 to 81 yrs) and the patients had undergone revascularization within a mean period of 920 days (7 to 3,711 days) before the DSE. The maximum period between the DSE and the coronary angiography for the groups with stenosis (GII

Table 1 - **Risk factors and anti-angina medication use**

	Patients	Percentage
Study population	66	100%
Age (yrs)	62±9 (43 to 81)	
Male sex	37	56%
Systemic arterial hypertension	43	65%
Hypercholesterolemia (total cholesterol >200mg/dl)	30	45%
Diabetes mellitus	19	29%
Family history of coronary disease	18	27%
Previous myocardial infarction	10	15%
Smoking	10	15%
Medication use		
Betablocker	13	20%
Nitrate	25	38%
Calcium channel antagonist	26	39%

and GIII) was 83 days and for the group without stenosis (G I), the maximum period was 721 days after the DSE.

Assessment at rest (Table 2)

For the 49 ITAGs without stenosis (GI), the mean±standard deviation (SD), minimum and maximum values were, for the diameter (0.25±0.04;0.19 and 0.33cm), SPV (33±13;14 and 68cm/s), DPV (20.6±8;0.00 and 0.37cm/s), ST (0.26±0.4;0.20 and 0.34 sec), DT (0.51±0.15;0.00 and 0.93seg), DVTI (7.34±3.2;0.00 and 14.7cm), SVTI (5.35±2.2;1.8 and 9.9cm), DF (57% ±12%;0% and 70%), HR (73±12;50 and 93bpm) and total output (TO) (0.05±0.03;0.008 and 0.119 l/min). We observed that the diastolic components presented a minimum value close to zero, a fact that was determined by the GI patient that presented systolic flow, only. In this case, there was an evident flow competition between the ITAG and the anterior descending artery (ADA) and the ITAG diameter was 0.19 cm. Although grafted onto fully pervious coronary beds, DF<50% occurred in 9 ITAGs (18% of GI). The DT/ST ratio was approximately 2:1.

Among the 10 ITAGs from GII, the percentage of stenosis was 50% (4 cases), 60% (1 case), 70% (2 cases), 80% (1 case) and 90% (2 cases). The mean±SD, minimum and maximum values were, for the diameter (0.22±0.04;0.15 and 0.30cm), SPV (32±15;12 and 55 cm/sec), DPV (17.5±10;0.00 and 37cm/sec), ST (0.27±0.05;0.20 and 0.40 sec), DT (0.43±0.17;0.00 and 0.70 sec), DVTI (5.79±3.5;0.00 and 11.2 cm), SVTI (5±1.8;2.5 and 8cm), DF (50% ±18%;0% and 60%), HR (72±15;49 and 94 bpm) and TO (0.03±0.02; 0.006 and 0.070 l/min).

GII also presented minimum values of the diastolic components of the flow equal to zero, which was due to a thin ITAG (diameter 0.18 cm and ostial stenosis of 50%). Another thin ITAG (diameter = 0.15 cm) persisted with diastolic flow at rest. The DT/ST ratio was 1.6. Two ITAGs (20% of GII) presented DF<50%.

Among the 7 patients with total occlusion of the ITAGs (GIII), the mean±SD, minimum and maximum values were, for the diameter (0.19±0.04;0.12 and 0.24cm), SPV (27.6±7;17 and 38cm/sec), DPV (7.7 ±6.8;0.00 and 18cm/sec), ST (0.28±0.03;0.00 and 30 sec), DT (0.33±0.24; 0.00 and 0.50 sec), DVTI (2.44 ±2.3;0.00 and 6.6cm), SVTI (4.88±1.36; 3.8 and 7.8cm), DF (28% ±0.23;0% and 60%), HR (64±30;70 and 97 bpm) and TO (0.01±0.01;0.002 and 0.017 l/min). Despite the total occlusion of the ITAG-native coronary conduit, only 2 patients presented absence of the diastolic component of the flow; DF<50% was observed in 6 patients (86% of GIII). In the only case with DF≥50%, the total occlusion occurred after the anastomosis and there was retrograde flow to small diagonal arteries. Four patients presented ITAG with a diameter < 0.2 cm. The DT/ST ratio was only 1.2.

Assessment during DSE (Table 2)

The mean±SD, minimum and maximum values measured for GI were, for the diameter (0.26±0.04;0.20 and 0.35cm), SPV (35±19;0.00 and 114cm/s), DPV (42±15;15 and 81 cm/s), ST (0.12±0.06;0.00 and 0.24 sec), DT (0.28±0.04;0.21 and 0.45 sec), DVTI (8.31±3.1;2.5 and 16.24cm), SVTI (2.86±1.97;0.00 and 10.8), DF (74% ±14%;51% and 100%), HR (138±17;90 and 167 bpm), TO (0.09 ±0.05;0.022 and 0.217 l/min) and CRI (2.12±0.66;0.84 and 4.83). During

Table 2 - **Measurements (mean ± standard deviation) carried out in the internal thoracic artery graft (ITAG)**

Parameters	At Rest			Dobutamine		
	GI	GII	GIII	GI	GII	GIII
DIAM (cm)	0.25±0.04	0.22±0.04	0.19±0.04	0.26±0.04	0.23±0.04	0.19±0.04
SPV (cm/s)	33.29±13.05	31.90±14.95	27.57±7.00	35.12±19.43	33.60±11.95	33.43±6.37
DPV (cm/s)	20.61±8.00	17.50±10.19	7.71±6.85	41.96±15.14	27.70±12.49	12.71±11.37
STI (sec)	0.26±0.04	0.27±0.05	0.28±0.03	0.12±0.06	0.15±0.05	0.20±0.03
DTI (sec)	0.51±0.15	0.43±0.17	0.33±0.24	0.28±0.04	0.26±0.05	0.18±0.13
MSV (cm/s)	19.57±6.29	18.70±6.93	17.57±4.96	20.96±11.39	20.00±6.32	19.14±5.70
MDV (cm/s)	14.29±5.73	12.20±7.64	5.86±5.15	29.59±11.08	20.20±9.22	9.43±8.18
SVTI (cm)	5.35±2.17	5.02±1.83	4.88±1.36	2.86±1.97	3.05±1.45	3.71±1.24
DVTI (cm)	7.34±3.23	5.79±3.49	2.44±2.30	8.31±3.14	5.08±2.41	2.47±2.41
DF (%)	0.57±0.12	0.50±0.18	0.28±0.23	0.74±0.14	0.62±0.11	0.33±0.27
HF (bpm)	72.57±12.25	71.70±15.54	64.43±30.03	137.67±16.88	137.40±18.50	129.29±12.11
CRI	-	-	-	2.12±0.66	1.55±0.48	1.40±0.86
TO (l/min)	0.05±0.03	0.03±0.02	0.01±0.01	0.09±0.05	0.05±0.03	0.03±0.02

Group I (GI) – ITAG without stenosis; GII - ITAG with stenosis (≥50% and < 100%); GIII - ITAG with total occlusion; DIAM – Diameter; SPV – Systolic peak velocity; DPV – Diastolic peak velocity; STI – Systolic time intervals; DTI – Diastolic time intervals; MSV – Mean systolic velocity; MDV – Mean diastolic velocity; SVTI – Systolic velocity-time integral; DVTI – Diastolic velocity-time integral; DF – Diastolic Fraction (diastolic flow component);CRI – coronary reserve index; FC – Heart frequency; TO – Total output by ITAG.

the DSE, no diastolic component was equal to zero, no ITAG diameter was < 0.2 cm and all DF were > 50%. The DT/ST ratio of 2.3 showed a slight increase when compared to the at-rest assessment.

Considering the CRI as an adequate parameter of functional graft evaluation, we observed that, in 39 ITAGs (80% of GI) CRI was ≥ 1.8. It is noteworthy the fact that the systolic components were equal to zero in five patients.

In the ITAGs without total occlusion (GII), the mean±SD, minimum and maximum values were, for the diameter (0.23±0.04;0.15 and 0.31cm), SPV (33.6±12;12 and 47cm/s), DPV (27.7±12;10 and 46cm/sec), ST (0.15±0.05;0.07 and 0.22 sec), DT (0.26±0.05;0.18 and 0.34 sec), DVTI (5.08±2.41; 1.62 and 10.2cm), SVTI (3.05±1.45;1.3 and 5.7cm), DF (62% ±11%;50% e 81%), HR (137±18; 105 e 172bpm), TO (0,05±0,03;0,007 e 0,089 l/min) and CRI (1.55±0.48;0.83 and 2.5). No diastolic or systolic component of the flow was equal to zero, no DF was < 50% and 2 patients persisted with diameters < 0.2 cm. As in the GI, there was a decrease in flow duration; however, the DT/ST ratio of 1.73 was slightly lower. The assessment of the graft functional status showed a CRI ≥1.8 in only 2 patients (20% of GII), who presented 50% of stenosis of the ITAG-native coronary conduit.

In GIII, the mean±SD, minimum and maximum values were, for the diameter (0.19±0.04;0.13 and 0.24cm), SPV (33±6; 23 and 44cm/sec), DPV (12.7±11;0.00 and 31cm/sec), ST (0.20±0.03;0.14 and 0.21 sec), DT (0.18±0.13;0.00 and 0.31 sec), DVTI (2.47±2.41;0.00 and 6.16 cm), SVTI (3.71±1.24;2.42 and 6.09 cm), DF (33% ±27%;0% and 66%), HR (129±12;111 and 145 bpm), TO (0.03±0.02; 0.004 and 0.052 l/min) and CRI (1.4±0.86;0.00 and 2.33). Two patients persisted with diastolic components equal to zero and 4 persisted with a diameter < 0.2 cm; the decrease in the duration of the systolic and diastolic flows was notable, as well as the DT/ST ratio, with a value of 0.9.

Five cases (72% the GIII) presented DF<50% and one of the cases that presented DF>50% also showed many collaterals for the ADA. Six cases (86%) presented a CRI<1.8 and in that case with CRI >1.8, DF was only 35%.

Comparison of parameters among the groups at rest, during DSE and at the variation from rest to stress (Figure 1) - The diameter at rest and during DSE was larger when comparing GI with GII (p=0.01) and GI with GIII (p<0.0001). At the variation from rest to stress, the increase was significant (p=0.006) for GI and GII. The SPV in the three groups was not statistically different (p=NS) at rest, during DSE or at the variation from rest to stress. The DPV at rest was higher for GI (p=0.0003) and for GII (p<0.019), when compared to GIII; however, there was no difference (P=NS) between GI and GII. We also observed that, during the stress, DPV was higher for GI (p<0.0001) and for GII (p=0.039) in comparison to GIII; however, at the stress phase, it was possible to differentiate Groups I and II, as the DVP was higher (p=0.006) in GI when compared to GII.

Not only at rest, but also at stress, DVTI was higher for GI when compared to the other groups (GI *vs*. GII; p=0.014), (GI vs. GIII; p<0.0001), and for GII when compared with GIII (GII vs. GIII; p=0.03); the variations from rest to stress were small and non-significant (p=NS) for the three groups. The SVTI of the three groups were not different (p=NS) when compared during the at rest phase and the at the stress phase. However, when we observed the variation from rest to stress, the decrease in SVTI was significant (p<0.0001) for the three groups. During rest, DF was higher when GI was compared to GIII, with p< 0.0001, and GII *vs*. GIII with p=0.003. The variation from rest to stress was significant for GI (p<0.0001) and GII (p=0.014). At the stress phase, the DF remained higher for GI (p<0.0001) and for GII (p=0.0003), when compared to GIII, but it was also possible to observe a difference (p=0.02) when comparing GI to GII (which was not observed at rest), demonstrating the same significant variations observed when analyzing DVP. HR was not different (p=NS) when compared at rest or during DSE; however, it increased significantly in the three groups (p<0.0001) at the variation from rest to stress. The CRI was higher for GI (p=0.02), when compared to GII as well as GIII, with no statistical difference (p=NS) between GII and GIII.

The output through the ITAG at rest was significantly different (p=0.0005) only when GI was compared to GIII; during stress, the output was higher for GI when compared to the other groups (GI *vs*. GII; p=0.007 and GI *vs*. GIII; p=0.004). Only GI showed a significant increase in output (p<0.0001) from rest to stress variation.

DF in the assessment of ITAG perviousness - Considering that at least 50% of the ITAG flow has to be diastolic for establishing the patency of the vessel, we observed that 49 patients, at rest (40 from GI, 8 from GII and 1 from GIII) presented a DF≥50%, which determined the sensitivity, specificity, positive predictive value, negative predictive value and accuracy of 81%, 86%, 98%, 35% and 82%, respectively. During stress, 61 patients (49 from GI, 10 from GII and 2 from GIII) presented DF≥50%, which determined the sensitivity, specificity, positive predictive value, negative predictive value and accuracy of 100%, 71%, 97%, 100% and 97%, respectively.

The CRI in the assessment of the ITAG functional status (Figure 2) - The ROC curve was performed and a cutoff of 1.8 was determined to distinguish ITAGs without stenosis and with good functional status. Thus, for a CRI≥1.8, we observed that 42 patients (39 from GI, 2 from GII and 1 from GIII) had CRI≥1.8 and 24 patients (10 from GI, 8 from GII and 6 from GIII) presented CRI<1.8. Sensitivity, specificity, positive predictive value, negative predictive value and accuracy were 79%, 85.7%, 94%, 59% and 80.9%, respectively.

Discussion

The ITA (Figure 3), which showed a predominance of systolic flow (Figure 4), becomes a hybrid system upon being grafted onto the coronary bed and usually starts to present a predominance of diastolic component (Figure 5). Therefore, the DF in the ITAG is expected to be ≥50, whereas in the non-grafted ITA, the DF is expected to be always <50%. Due to the amputation of the ITA branches and the "diastolization" of the grafted vessel flow, the ITAG starts to present a SPV approximately 40% lower than the contralateral non-grafted ITA, which can facilitate

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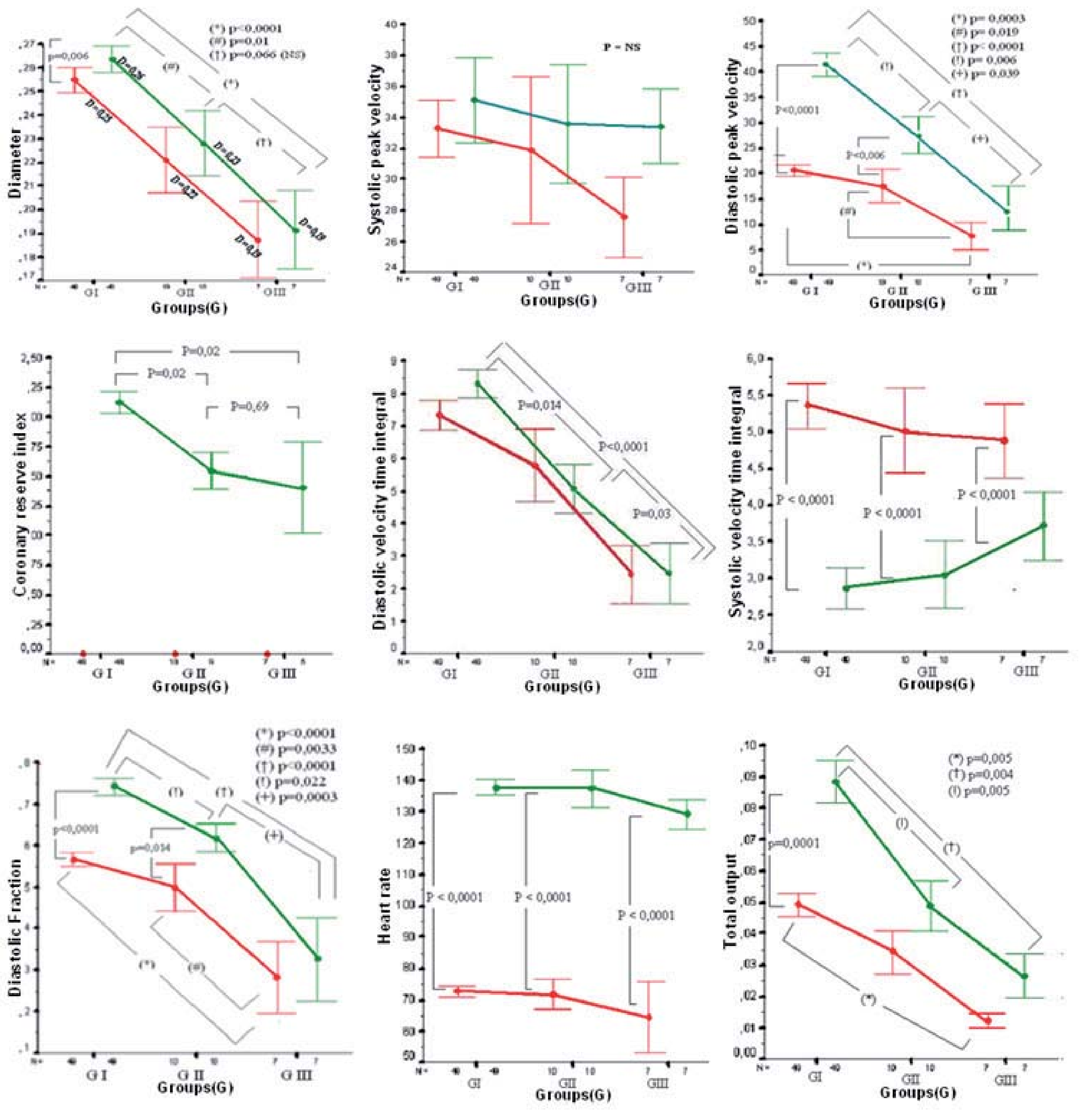


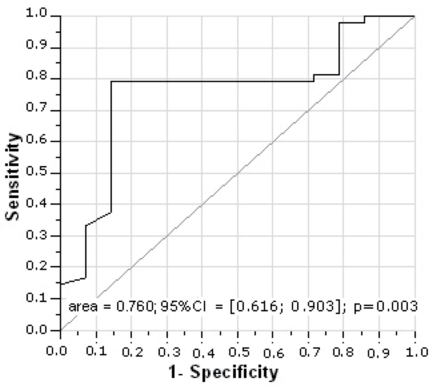
Group I (GI) – ITAG without stenosis; GII - ITAG with significant stenosis (≥50% and <100%); GIII - ITAG with total occlusion.

Fig. 1 - Comparison of the parameters of the internal thoracic artery graft (ITAG) at rest (in red), during dobutamine-stress (in green) and during rest to stress variation.

its immediate recognition, even if the examiner does not know which ITA has been grafted[22-24]. As the myocardial contractility results in the inhibition of the systolic component, this effect tends to be more evident during the DSE[21] and, in fact, as observed in some patients, the high inotropic activity of the dobutamine has gone as far as determining the absence of systolic flow, demonstrating fully patent grafts with diastolic flow only and excellent functional status (Figure 6).

During diastole, the intramyocardial resistance decreases and the stenotic resistance, if present, becomes the main determinant of coronary flow[26,27]; in systole, the resistance is determined mainly by the myocardial contraction[21]. Hence, as previously reported, we emphasize the diastolic component to verify the ITAG patency and functional status. The flow competition between the graft and the native coronary, questioned by some authors[28,29] and defended by others[30-35], can even determine the "physiological atrophy" of the ITAG[31-35], characterized by a graft diameter < 1 mm (called cord sign), when a fine contrast can be perceived in the graft, but not in the receiving coronary.

Such competition occurred in 6% of the cases as reported



CRI ≥ 1.8 to verify absence of stenosis

Sensitivity (S)	CI for (S) with 95% of confidence		Specificity (Sp)	CI for (Sp) with 95% of confidence	
	LI	LS		LI	LS
79.17%	67.48%	90.60%	85.71%	67.48%	100.00%

Positive Predictive Value	Negative Predictive Value	Accuracy
94.04%	59.11%	80.9%

Cutoff value = 1.8 (p = 0.003) to distinguish ITAG with and without stenosis.

Fig. 2 - Cutoff value = 1.8 (p = 0.003) to distinguish ITAG with and without stenosis.

by Seki et al[34]; however, an indisputable observation of flow competition was made by Kitamura et al[31], when they totally occluded the ADA with a balloon catheter and demonstrated that the non-functioning ITAGs started to present normal flow, as they had been latent. One case from GI did not present the diastolic component of the flow at rest; however, its occurrence was well demonstrated during the DSE, determining a DF of 52%. Hence, the absence of diastolic flow at rest is not a synonym of compromised functional status and/or patency, but can also mean latency due to flow competition, although it is an unusual condition.

The diameter < 0.2 cm at rest was observed in 8 cases, with 2 (4%) from GI, 2 (20%) from GII and 4 (57%) from GIII; during the DSE, there were alterations only in GI and these 2 ITAGs persisted with a diameter of 0.2 cm. Therefore, diameters < 0.2 cm (mainly during DSE) can be an indication of compromised graft patency or functional status.

It was observed that during rest, the diastolic component of flow measured by DPV or DF allowed the significant distinction of GI and GII in relation to GIII, but no difference was observed (p=NS) when the ITAGs of GI was compared to those in GII. It is thus demonstrated the importance of the assessment during the DSE, considering that, in addition to the significant difference of GI and GII in relation to GIII, it was also possible to significantly distinguish GI from GII, which was rather relevant for the verification of the ITAG patency and functional status.

When the DF is verified, one must remember that it suffers the influence of myocardium contractility, the status of muscle subjacent to the graft, the ITAG diameter and the flow competition. Despite all these factors, the FD≥50% at rest has shown to be safe when inferring the ITAG patency, due to its excellent accuracy, which was also verified by Nasu et al[30]. When the DF is analyzed during the DSE, its exceptional importance was to demonstrate that all ITAGs that persisted with DF<50% presented total occlusion.

As patency alone is not enough to assess the graft, we sought to verify the functional status of these ITAGs and good accuracy was obtained when the CRI≥1.8. Several factors can influence the importance of the CRI, specifically when it is obtained at pre-stenotic level. It is worth mentioning, however, that among the ten cases from GI with CRI<1.8, 8 already presented DPV at rest above the mean and, considering that the CRI is the division of the obtained DPV obtained at the DSE by the one obtained at rest, we speculate the relevance of this fact to justify these lower CRI values. The only case from GIII with CRI>1.8 had already called our attention due to the low DVP at rest and DSE and mainly for presenting a DF of only 35% at the DSE.

Revascularized patients with ITAG are often referred to the Service in order to undergo an echocardiogram (at rest or under stress), which allows the follow-up to be carried out by the database, as well as checking the results of a hemodynamic study. As the coronary angiography was a decision taken solely by the assistance physician, the patients were included in the present study according to the aforementioned methodology and our access to the performed coronary angiography.

As our patients often presented lesions in more than one coronary, the comparison between flow abnormality of the ITAG and of the segmental contraction was not performed; however, in the study by Takeuchi M et al[36], dobutamine and microbubble contrast were used for the direct evaluation of the non-revascularized ADA and an equivalence between CRI≤ 2 and the contractile abnormality was observed.

In the present study, the only patient from GIII in whom the contractile abnormality was not observed during stress, presented low-velocity diastolic flow and, mainly, a DF=25%, which, during stress, is compatible with a severely compromised flow.

Study limitations – We know that the blood velocity is only proportional to the volumetric blood flow when the sectional area of the vessel is kept constant[37]. However, as in the cited literature, we used the same diameter for the systole and the diastole. We did not perform angle correction and it is possible that the velocities at Doppler might have been underestimated, with direct influence on the output calculation by the ITAG. As the main parameters of the study (DF and CRI) are divisions that suffer the same influences, such underestimation loses its relevance. Another limitation was the difficulty to state whether disorders in other arterial territories were compromising the CRI of the coronary bed subjacent to the ITAG.

In the present study, in which the ITAG was assessed in a region of easy and fast recording, concomitantly with a widely applied test such as the DSE, it was important to distinguish

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Figure 3

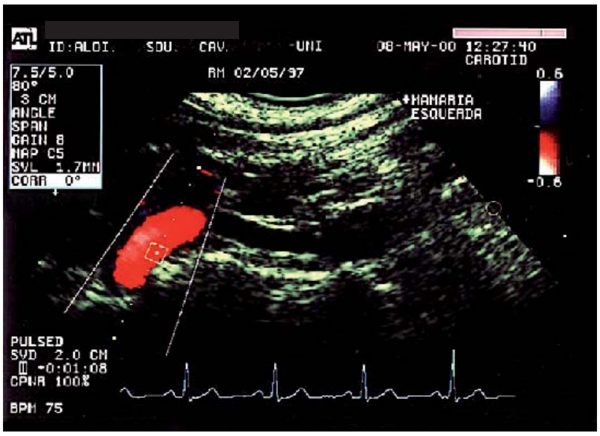


Figure 4

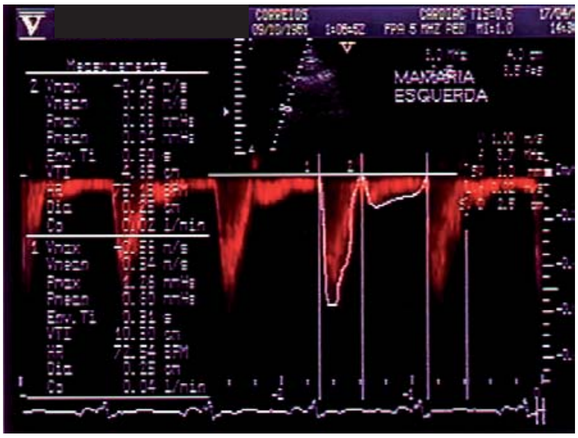


Figure 5

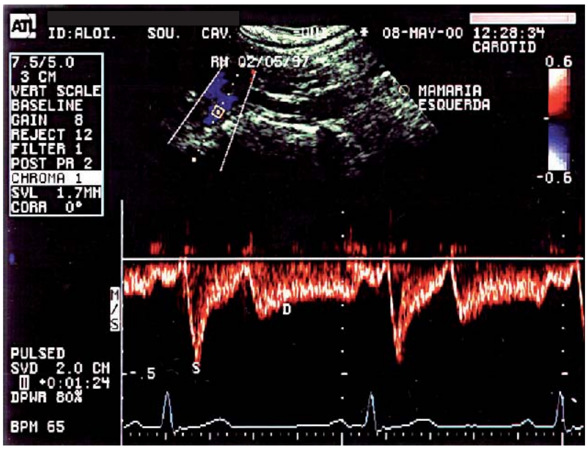
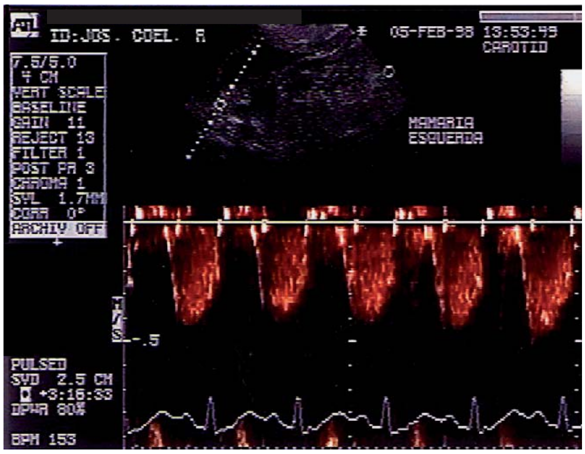


Figure 6



Non-grafted ITA and ITAG (Internal Thoracic Artery Graft)

Fig. 3 - ***ITA emerging from the subclavian;*** *Fig 4 -* ***Non-grafted ITA;*** *Fig 5 -* ***ITAG in patent rest and with predominance of diastolic flow.*** *Fig 6 -* ***ITAG in patent stress and diastolic flow only.***

the ITAGs without lesion and ITAGs with relevant stenosis (GII) from those with total occlusion; however, we consider especially important to have been able to distinguish ITAGs without lesions from those with relevant stenosis. Therefore, we conclude, in the present study, that the echocardiography and the Doppler allow an adequate assessment of the ITAG at supraclavicular level. A DF ≥50% at rest is an excellent way to demonstrate that the ITAG is pervious and a DF<50% during DSE is excellent for the identification of total occlusion. A CRI ≥1.8 showed good accuracy in assessing the functional status and detection of ITAGs without lesions.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Study Association

This study is not associated with any graduation program.

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