Work in progress report – Coronary

Morphological and histopathological comparison of left and right internal thoracic artery with implications on their use for coronary surgery

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Abstract

Goal of this study was the morphological comparison of the left (LITA) and right internal thoracic artery (RITA). Both ITAs were taken out in 20 autopsy cases. Sections over the entire length of vessel were cut and histomorphological examination was performed. There were no significant differences between the LITA and RITA concerning length, diameter, wall thickness and structure. The occurrence rates of atherosclerosis were equal. Four vessels showed luminal narrowing of more than 50%. There was a good correlation between the length of the sternum and the ITA. According to our findings the morphology of LITA and RITA is similar.

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1. Introduction

The disappointing long-term results of saphenous vein grafts in coronary artery bypass grafting have increased cardiologists’ interest in the use of multiple arterial grafts [1].

The supply of the left anterior descending coronary artery (LAD) with a graft of the left internal thoracic artery (LITA) in situ remains the standard procedure. Other arterial grafts used for myocardial revascularisation are right internal thoracic artery (RITA), radial artery, gastroepiploic artery and epigastric artery.

Many studies deal with the morphology of these conduits and their suitability as coronary artery bypass grafts. The morphology of the LITA is well known. It is characterised as an elastic type with a gradual decrease of elastic fibres along its course [2]. However, no study has confirmed the similarity of the LITA with RITA, although bilateral internal thoracic artery (ITA) grafting has already been introduced to clinical routine and shows good results [3–5].

The aim of the present study is the morphometric and histologic comparison of the LITA with the RITA because anatomic and pathologic characteristics may influence the surgical technique and patient outcome.

2. Materials and methods

The subclavian artery segments with their skeletonised ITA branches of both sides were harvested from 20 autopsy cases without any selection. The mean patient age was 71.2 ± 11.4 years and the male to female ratio was 8:12.

After preparation and fixation in buffered 10% formalin solution in a flaccid state [6], one lengthwise and nine transverse sections in equal distances of each vessel were cut and embedded in paraffin wax. Sections of 5 μm thickness were stained with hematoxylin-eosin and elastica-van-Giesson. Because of inconsistent results in autopsies due to autolysis, we did not perform immunohistochemistry investigations. The histologic slides were digitalised using a spot digital video camera (Visitron systems, Puchheim, Germany) on a Leica DMR light microscope (Leica, Bensheim, Germany) and morphometric measurements were performed after calibration of the system using Sigma Scan 3.0 software (SPSS Science, Chicago, IL, USA). The intimal (at the internal elastic lamina) and the medial (at the border between media and adventitia) circumferences were measured. Based on these values the intimal, medial diameter and the wall thickness were calculated (Fig. 1). The number of
elastic fibres in the media without the lamina elastica interna of each layer was counted. The occurrence and grade of atherosclerosis in the ITA was evaluated during histopathologic screening of the slides and classified according to the grade of stenosis. Atherosclerosis was defined as low grade (grade 1) when the resulting stenosis was less than 50% of the lumen area. Stenosis between 50 and 70% was graded as moderate (grade 2) and lumen reduction higher than 70% was defined as severe (grade 3). The occurrence of atherosclerosis in any other arteries was summarised as general atherosclerosis and also classified depending on the highest degree of stenosis in one or more arteries (no evident atherosclerosis = grade 0, low grade in cases of atherosclerosis without stenosis = grade 1, moderate = grade 2 when the resulting stenosis is not hemodynamically relevant and severe = grade 3 in relevant stenosis or occlusion).

Statistics. For calculating the strength of association between several variables Pearson Product Moment Correlation for numeric values and Spearman Rank Order Correlation for data measured by ranks were used. The values of right and left vessels were compared by paired t-test or Wilcoxon Signed Rank Test depending on the distribution type. A probability value of less than 0.05 was considered significant. Statistical analyses were performed using Sigma Stat 2.0 software (SPSS Science, Chicago, IL, USA). Data are presented as mean ± standard deviation where appropriate.

3. Results

The mean length values of the LITA and the RITA were equal (19.9 ± 2.3 versus 19.9 ± 2 cm, P = 1). The mean sternal bone length was 20.0 ± 2.0 cm. We were able to demonstrate a good correlation between the length of the sternal bone and the internal thoracic arteries (r = 0.54; P = 0.02).

No statistical difference was found between LITA and RITA concerning mean intimal diameter (1.52 ± 0.24 versus 1.58 ± 0.28 mm, P = 0.06) medial diameter (2.21 ± 0.27 versus 2.52 ± 0.28 mm, P = 0.15) and wall thickness (0.39 ± 0.12 versus 0.41 ± 0.16 mm, P = 0.47). The intimal diameters diminish significantly from the origins (1.69 ± 0.34 and 1.86 ± 0.41 mm, respectively) to the terminations (1.25 ± 0.26 and 1.14 ± 0.25 mm, respectively) of both vessels (Fig. 1).

There was also no significant difference regarding to the distribution and the number of elastic fibres in the media of LITA and RITA (Fig. 2).

Along the ITA there were two peaks in the number of elastic lamellae. The first was localised directly at the origin from the subclavian artery and the second was found in the middle part. Therefore, the typical ITA changes its type four times starting with an elastic type. The proximal segment about one to two centimetres from the origin and the distal part of the artery show a muscular or elastomuscular structure. This typical sinusoid distribution curve with different altitudes was seen nearly in all vessels. Only in one LITA and one RITA a continuous decrease of elastic lamellae beginning from the origin was found. Interestingly the contralateral vessel of each showed a typical distribution.

The occurrence and grade of atherosclerosis was similar in the ITA of both sides. Twelve LITAs and 13 RITA showed atherosclerotic lesions. Low grade stenosis was found in ten and 11 arteries, respectively. In four and five, respectively of these vessels less than half of the screened layers were affected. Like in all other cases the origin from the subclavian artery was a preferred spot. A moderate stenosis with more than 50% narrowing was seen in two...
LITAs and two RITAs (10%) (Fig. 3). In all cases only the fibrotic type of atherosclerosis was found without any calcification or lipid cores.

In five individuals general atherosclerosis was to classify as low grade. The arteries of another five individuals showed moderate lesions and in six cases severe alterations were found. There was a good correlation between the degree of general atherosclerosis and atherosclerosis of the ITA ($r = 0.56$, $P = 0.016$) and all three cases of moderate stenosis in the ITA were found in the group of individuals with severe general atherosclerosis (Fig. 4).

4. Discussion

The results of surgical myocardial revascularisation depend mainly on the patency of the conduit material used. In many studies the revascularisation of LAD with the LITA in situ has shown favourable results. In comparison the use of saphenous vein grafts as conduits to the LAD is correlated with a lower survival rate and an earlier and more frequent recurrence of angina, myocardial infarction and necessity of reoperation [1]. Saphenous vein grafts to the circumflex coronary artery and the right coronary artery showed no better results [7]. As a consequence of these experiences, the LITA grafting became the gold standard for revascularisation of the LAD. In the face of that, the question arises whether revascularisation of the other coronary arteries would also be improved by use of other arterial grafts instead of venous bypass grafts. In this context several authors proved the superiority of the RITA over vein conduits [8]. Several different strategies for the bilateral use of ITA have been established. The so-called T-graft is a very promising technique, were the LITA as a in situ graft is connected to the LAD and the RITA as a free graft is attached end-to-side to the LITA [3,4]. Remarkably, the patency rate of the free RITA is lower than the rate of the LITA in situ [5,9]. We performed this study in order to find a possible conduit inherent reason for that behaviour. The macroscopic and the histologic comparison of LITA and RITA showed no statistically significant differences. Therefore, the question is whether a better implantation technique could improve the results of bilateral ITA grafting.

We found a good correlation between length of sternal bone and both ITAs. Under this condition a preoperative estimation of length of the available conduits is possible. In our view, the necessity of several coronary anastomoses in a patient with a short sternum is a contraindication for the use of RITA for T-graft due to a reduced length of the conduit. In such patients, we would use the left radial artery instead of the RITA for the T-graft. In our study both ITAs had similar diameters, decreasing from proximal to distal. Under these conditions we recommend attaching the RITA as proximal as possible to the LITA for the T-graft in order to avoid a mis-match.

Often no attention is paid to the problem of moderate LITA stenosis which can also lead to an inadequate revascularisation. In autopsies the rate of LITA stenosis ranges from 0 [10] to 5% [11]. Sasajima found intimal hyperplasia without lumen narrowing in 94% of the screened vessels [10]. Interestingly the intimal hyperplasia without calcification or lipid cores is the only type of atherosclerosis that is seen in ITA [2].

Alterations of the distal part seem to be less common. Nataf found such alterations in this area and recommended therefore not to use this segment [12]. Angiographic investigations in patients with coronary artery disease showed stenosis of the ITA in 0.66 [13] to 6.6% [14]. In our study we found moderate stenosis of the ITA even in 10% of the screened vessels. In accordance to the literature we only found the fibrotic type of atherosclerosis.

We could demonstrate a good correlation between atherosclerotic lesions in the ITA and atherosclerosis in other

Fig. 3. Lengthwise section from the origin of a left mammary artery showing a moderate stenosis caused by intimal hyperplasia. Stain: hematoxylin-eosin SA = subclavian artery, LITA = left internal thoracic artery.

Fig. 4. Mean grade of atherosclerosis in the ITA depending on the degree of general atherosclerosis (GA). No atherosclerosis $=$ 0, low grade $=$ 1, moderate $=$ 2, severe $=$ 3. Error bar = one standard deviation.
arteries defined as general atherosclerosis. Since hemodynamically relevant ITA stenosis can not be accepted in general, the question arises whether preoperative angiography of the ITA should be performed routinely. In fact, this is discussed controversially and most groups disagree [15]. In our opinion preoperative angiography should be restricted to patients were T-grafting, consisting of both ITAs, is planned and clinical signs of general atherosclerosis are evident.

As mentioned previously, the patency rate of free RITA grafting is lower than the rate of LITA in situ. For the T-graft the distal end of the RITA is attached to the coronary artery of the posterior wall. The proximal end of the RITA is anastomosed end-to-side with the middle part of the LITA. Our investigations show that predominantly, the proximal and distal segments of ITA show a muscular structure (Fig. 2) and therefore are prone to spasm and development of intimal hyperplasia with the consequence of graft stenosis and finally occlusion. This hypothesis can be supported by several other studies, dealing with results after revascularisation with T-grafts. Angiography in 41 patients after T-graft implantation with visualisation of a total of 108 anastomoses revealed five occlusions [9]. Two of these were located at the proximal implantation area of the RITA. Tector reported six occlusions of anastomoses after implantation with T-grafts. Angiography in 41 patients after T-graft implantaion revealed five occlusions [9]. Two of these were found in the area of the distal RITA anastomosis [5]. As a consequence we do not favour the use of the very proximal or distal ends of the RITA as a free graft and the very distal end of the LITA.

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References


Appendix A. ICVTS on-line discussion

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Date: 20-Dec-2002 08:27

Message: The left internal thoracic artery (LITA) has better long term results than the right internal thoracic artery (RITA). The interest of this study resides in the demonstration that there were no histological differences between LITA and RITA, which could explain this observation. It was probably obvious but it remained to be clearly determined. However, this difference of long term patency between these two arteries may also be explained by differences in the functional properties of the ITAs, such as the endothelium-derived nitric oxide release (endothelial function) or the parietal compliance. Indeed, favourable mechanical properties of the ITA’s wall could be involved since the compliance mismatch between the graft and the coronary artery at the anastomotic site influences the long term patency results of bypasses.

Measurement of the parietal compliance of the ITAs is certainly of interest to understand how it affects the long term patency, and a comparison between parietal compliance of the LITA and the RITA may be of interest. These measurements require a high frequency ultrasound microprobe (20 MHz). The better understanding of the endothelial function and of the biomechanical properties of the ITAs and a comparative functional study between the LITA and the RITA, may be of interest to explain a long term difference of patency. However, the geometry of the LITA anastomosed on the LAD is probably better than with the RITA, and this also could easily explain a long-term patency difference.