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Surgical angioplasty of the left main coronary artery and/or proximal segment of the right coronary artery by pulmonary autograft patch

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Abstract

Objectives: There are controversial opinions about the expediency of performance of the surgical angioplasty of the left main coronary artery (LMCA) and/or proximal segment of the right coronary artery (RCA) in rare cases of isolated lesion or with limited involving of distal coronary branches. One of the many fears restraining a wider performance of this operation is the uncertainty in longevity of patch material. It is supposed that the autovein has tendency to proliferating degeneration similar to that in case of coronary artery bypass grafting (CABG), while the autopericardium may be subjected to calcification. Autoarterial patches have a limited width. To withdraw these real or hypothetical negative properties of patch materials we offer to harvest the pulmonary autograft patch (PAP) for coronary angioplasty.

Methods: Our experience with PAP-angioplasty of LMCA and/or proximal segment of RCA includes four cases. Simultaneous angioplasty of LMCA and proximal segment of RCA was performed in one patient; angioplasty of LMCA – in two patients; angioplasty of RCA – in one patient. In two cases the stenosis of LMCA was accompanied by stenotic lesion of left anterior descending coronary artery (LAD). The surgical approach to LMCA was performed by complete crossing of pulmonary artery (PA). There was no necessity to use any plastic material for restoring of PA integrity in all cases.

Results: All patients survived after the operation. The postoperative course was uncomplicated except one case of LMCA/LAD lesion. There was a temporary low cardiac output syndrome and ventricular arrhythmia resulting in additional CABG as “back-up” procedure. This complication was not a consequence of impassability of LMCA because its good patency was established at control coronary angiograms. The postoperative coronary angiograms were performed in all cases. They showed a satisfactory width of the main coronary vessels. The maximal follow-up period is 30 months.

Conclusion: We suppose that the use of viable pulmonary autograft patch for surgical angioplasty of LMCA and proximal segment of RCA removes one of a lot of fears, which restrain the wider use of this alternative to CABG operation.

Keywords: Coronary artery surgery; Left main coronary artery; Surgical angioplasty; Right coronary trunk; Patch angioplasty

1. Introduction

After some period of oblivion surgical patch angioplasty of the left main coronary artery (LMCA) was revived by Hitchcock et al. [1]. Soon this operation was revived for correction of the stenosis of the proximal segment of the right coronary artery (RCA) [2]. There are still controversial opinions about the expediency of the performance of this procedure in rare cases of isolated lesion of LMCA/RCA or with limited involving distal coronary branches [3,4]. One of the fears giving doubt in the possibility of a reliable performance of the surgical angioplasty is the uncertainty in longevity of patch materials [5]. It is supposed that the autovein has tendency to proliferative degeneration similar to that in case of coronary artery bypass grafting (CABG) [6] or to dilating because of its natural elasticity [7]. At the same time the autopericardium may be subjected to calcification (Appendix A to ref. [8]) and does not have fibrinolitic properties [9]. Autoarterial patches have a limited width. To withdraw these real or hypothetical negative properties of patch materials we offer to harvest the pulmonary autograft patch (PAP) for coronary angioplasty.
This report contains our experience in PAP angioplasty of LMCA and/or proximal segment of RCA.

2. Material and methods

The excellent results reported by Dion et al. [2,8], Jegaden et al. [7] and others encouraged us to perform surgical angioplasty of right and left coronary trunks, or both, since 1998. We have experience in 11 cases of patch angioplasty of main coronary vessels with maximal follow-up period 57 months. Since December, 2000 we have applied a harvest of angioplastic patch from the pulmonary artery. At present time our limited experience with PAP-angioplasty of LMCA and/or proximal segment RCA includes four cases. Patients’ perioperative characteristics and coronary risk factors are listed in Table 1.

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age (years)</th>
<th>Sex</th>
<th>Risk factors</th>
<th>LV function</th>
<th>Symptoms</th>
<th>Date of operation</th>
<th>Coronary lesion</th>
<th>Surgical procedure</th>
<th>The time of postoperative CAG (months)</th>
<th>Follow-up (months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>44</td>
<td>M</td>
<td>Hyperlipidemia heavy smoker</td>
<td>Preserved</td>
<td>Class III angina</td>
<td>12/2000</td>
<td>LMCA (middle third) LAD</td>
<td>Surgical angioplasty of LMCA by PAP, LIMA-LAD shunt</td>
<td>5</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>43</td>
<td>M</td>
<td>Hyperlipidemia hypertension heavy smoker</td>
<td>Preserved</td>
<td>Class IY angina</td>
<td>03/2001</td>
<td>LMCA (ostium) RCA (ostium)</td>
<td>Surgical angioplasty of LMCA and RCA by PAP</td>
<td>2</td>
<td>27</td>
</tr>
<tr>
<td>3</td>
<td>45</td>
<td>M</td>
<td>Hyperlipidemia hypertension heavy smoker</td>
<td>Preserved</td>
<td>Class IY angina</td>
<td>01/2002</td>
<td>LMCA (middle third) LAD</td>
<td>Surgical angioplasty of LMCA by PAP</td>
<td>1</td>
<td>17</td>
</tr>
<tr>
<td>4</td>
<td>53</td>
<td>M</td>
<td>Hypertension AMI in history heavy smoker</td>
<td>Preserved</td>
<td>Class IY angina</td>
<td>09/2002</td>
<td>RCA (ostium)</td>
<td>Surgical angioplasty of RCA by PAP</td>
<td>1</td>
<td>9</td>
</tr>
</tbody>
</table>

AMI, acute myocardial infarction; LAD, left anterior descending coronary artery; LIMA, left internal mammary artery; LMCA, left main coronary artery; RCA, right coronary artery; PAP, pulmonary autograft patch; CAG, coronary angiography; DB, diagonal coronary branch; and OM, obtuse marginal coronary branch.

This report contains our experience in PAP angioplasty of LMCA and/or proximal segment of RCA.

Fig. 1. The angioplasty of LMCA by the pulmonary autograft patch (the patient N3 – the view from the patient’s head). Blue arrow – the creation of the ‘funnel’-shaped entrance into LMCA; and red arrow – the proximal part of the completely crossed pulmonary trunk.
Surgery was performed using a standard balanced fentanyl anesthesia. Myocardial preservation includes moderate hypothermic (30°C) cardiopulmonary bypass, aortic cross-clamping and cardiac arrest by cold blood antegrade intermittent cardioplegia in combination with topical cooling with ice cold saline. The left ventricle was vented through the right superior pulmonary vein. The time of aortic cross-clamping was 38, 101, 80, 42 min; the CPB time was 79, 138, 129, 74 min correspondingly.

In all cases of PAP-angioplasty of LMCA we used the anterior approach with complete crossing of the main pulmonary artery. The tailoring of a pulmonary autograft patch was performed predominatingly from the anterior pulmonary artery wall or by wider (up to circular) cutting in case of biostial lesion. In cases of LMCA PAP-angioplasty we followed the methodology of Dion et al. [8], consisting of creation of a ‘funnel’ shape of the entrance into LMCA with a wide angioplastic patch (Fig. 1).

In cases of RCA PAP-angioplasty, before the CPB the proximal segment of RCA was dissected through the fat of the epicardium from its aortic origin. The procedure was performed by direct longitudinal opening of the RCA lumen with cutting enough far along aortic wall. The length of the opening of RCA and the adjoining aortic wall sometimes achieved more than 3 cm. Although the creation of a wide ‘funnel’ shape entrance has less importance in case of angioplasty of RCA in comparison with LMCA, we try to do this independently on the right or left angioplasty performance. The endarterectomy was avoided in all cases.

The restoration of the pulmonary artery integrity was carried out in all cases by a simple double continuous prolene suture without any graft materials.

3. Results

All patients survived after the operation. The postoperative course was uncomplicated in all cases except one with stenosis of LMCA and left anterior descending coronary artery (LAD) (N3). There were problems with his weaning from cardiopulmonary bypass. This patient demonstrated low cardiac output and ventricular arrhythmia. We were sure that the patient’s condition was not consequence of poor patency of the proximal part of LMCA because it was determined by transesophageal echocardiography. But we did not exclude the possibility of a poor patency of distal parts of the left stem, that is why we performed the back-up CABG to obtuse marginal and large diagonal coronary branches. There was a good patency of LMCA and all ‘back-up’ shunts at the control postoperative coronary angiograms.

The control coronary angiography was carried out in all cases. It showed a sufficient width of angioplasty subjected vessels (Fig. 2).

The maximal follow-up period is 30 months.

Fig. 2. Coronary angiograms of RCA before (A) and after (B) PAP-angioplasty (the patient N4). (C) Aortic angiogram showing the ‘funnel’ shape of the entrance into the RCA.
4. Discussion

The surgical patch angioplasty has a lot of more superior properties in comparison with conventional CABG in the surgical management of stenosis of LMCA and/or proximal segment of RCA [10–13]. At the same time, still there are controversial opinions in published articles about the expediency of the performance of this procedure due to the possibility of development of restenosis in this area with dangerous consequences (discussion in ref. [1], [3,4,14,15]). Despite encouraging follow-up results with venous and pericardial patch in Dion’s series [8], some authors fear the development of restenosis after patch angioplasty because of negative properties of different patch materials (discussion in ref. [16]). It is supposed that autovein has tendency to specific proliferative degeneration as it is in case of CABG (6, discussion in ref. [15]) and has a property to dilate because of its natural elasticity [7]. A fresh autopericardium does not have fibrinolytic properties [9] but has a possibility of later shrinkage with an unpredictable behavior of the coronary entrance [17]. To avoid this negative property of a fresh autopericardium, some surgeons treat it with 0.6% solution of glutaraldehyde for 5–30 min [17–20], but this treatment gives a new condition of tissue – to be subjected to calcification (discussion in ref. [15]).

We have reviewed the published data about the performance of patch angioplasty of main coronary vessels since the time of reviving of this procedure in 1983 [1] with accentuation of the kind of patch material used and the rate of restenotic failure (Table 2). There are definite limitations for the recognition of these data as a statistical parameter because the authors of these articles did not always have special purposes to determine the rate of restenotic failure and to assess the follow-up results. However it may be recognized as a certain marker for an approximate assessment of different patch materials. As one can see from Table 2, the rate of restenotic failure in the autovein patch group is about 3.4% (five cases of restenosis to 147 operations). While in the group including all kinds of autopericardium patch this marker is about 4.9% (five cases of restenosis to 102 operations). This difference is not great, which results in the difficulty to choose the best kind of patch material. It determines that the same author often uses both kinds of popular patch materials without any preferences [8,15,21].

The encouraging results have been achieved with the use of autoarterial patches harvested from the distal segment of the left internal mammary artery [22] or proximal segment of the right internal mammary artery [5,23] but the number of these cases is small and the follow-up results are not yet assessed. At the same time, the width of the internal mammary artery patch may be insufficient to perform a safe extensive patch angioplasty of LMCA. If to accept the pattern of LMCA angioplasty, proposed by the most experienced in this field Dion et al. [8], the sufficient width of patch plays an important role in creation of funnel-shaped LMCA ostium [24]. There is an acute angle formed by the junction between the axis of LMCA and the aortic wall at the anterior approach, giving the best visualization of all LMCA parts. It is demanded to create angioplasty with an extensive patch to avoid the patch kinking and the restenosis at this point. Besides that, the expending of the internal mammary artery for patch angioplasty excepts its use for CABG in case of a new distal coronary stenosis in the future.

We offer the alternative material for angioplastic patch – the wall of autopulmonary artery. In comparison with autovein and autopericardium, the theoretical advantage of an autopulmonary wall is the uniform embryologic origin with the wall of the aorta. The embryologic formation of aorta and of the main pulmonary artery occurs by partitioning of the aortic embryologic sac into aortic and pulmonary pathways [25]. The uniform embryologic origin means the similar properties of the endothelium of the vessel walls, especially concerning the abilities to produce fibrinolytic effect and for translumenal nutrition of the endothelial cells. The longevity of pulmonary autograft in Ross procedure proves the possibility of translumenal nutrition of the autograft tissues.

One more advantage of pulmonary autograft is that tailoring of an angioplastic patch does not have size limitations and is able to give any patch shapes. At the same time, the elastic properties of the pulmonary artery allow to restore its integrity without using any plastic material.

At last, if the anterior approach is used with complete dividing of PA the harvesting of the patch performs in

<table>
<thead>
<tr>
<th>The kinds of patch material</th>
<th>Glutaraldehyde treated autopericardium</th>
<th>Autopericardium without specification</th>
<th>Bovine pericardium</th>
<th>Autovein</th>
<th>Synthetic material (PTFE, Dacron)</th>
<th>Internal mammary artery</th>
<th>Radial artery</th>
<th>Unspecified patch material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh autopericardium</td>
<td>52 (1)**</td>
<td>22 (2)</td>
<td>1</td>
<td>147 (5)</td>
<td>22 (0)</td>
<td>1</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Autovein</td>
<td>102 (5)**</td>
<td>28 (2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* – the digits without brackets – total number of cases; and ** – the digits in brackets – the restenotic failure cases.
passing without the appearance of an additional stage in the procedure.

Thus, it may be assumed that the pulmonary autograft patch is an alive tissue with a simultaneously excellent elastic property and the ability to counteract the high pressure without the development of dilatation, calcification and degradation in the course of time. We suppose that the use of pulmonary autograft patch for surgical angioplasty of LMCA and proximal segment of RCA promotes the increase of reliability of this procedure and removes one of a lot of fears restraining a wider use of this alternative to the conventional CABG operation.

References

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