Anatomical studies concerning technical feasibility of minimally invasive axillocoronary bypass grafting

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Abstract

Objective: Minimally invasive multiple vessel revascularization has been accomplished using all arterial graft concepts and aortocoronary vein grafts. The aim of the present study was to determine the technical feasibility of minimally invasive axillary artery to coronary artery vein grafting in the human cadaver.

Methods: In seven human cadavers the axillary artery was approached bilaterally via a small incision above the anterior axillary fold. The left anterior descending coronary artery system and the right coronary artery system were exposed via a left anterior minithoracotomy and a subxiphoid incision respectively. Saphenous vein grafts were anastomosed end to side to the axillary artery and brought to the target vessels following a transpleural route. The vein grafts were then sutured to the left anterior descending artery and to the posterior descending artery through the mini-incisions.

Results: Axillocoronary bypass grafting to the left anterior descending artery was performed successfully in seven cases, axillocoronary bypass grafting to the posterior descending artery was accomplished in six cases. The mean length of the mini-incisions was as follows: left axillary artery exposure 5.1 ± 1.5 cm, right axillary artery exposure 5.5 ± 2.0 cm, left anterior minithoracotomy 10.8 ± 1.9 cm, subxiphoid incision 9.4 ± 1.9 cm. The mean length of saphenous vein required for the left axillary artery to left anterior descending artery bypass was 18.9 ± 2.8 cm, the mean length of vein required for the right axillary artery to posterior descending artery bypass was 26.0 ± 2.6 cm. This was significantly longer than the aortocoronary route (ascending aorta to left anterior descending artery 12.5 ± 2.2 cm, ascending aorta to posterior descending artery 18.3 ± 2.9 cm P < 0.0001).

Conclusion: From this study we conclude that minimally invasive axillocoronary venous bypass grafting to the left anterior descending artery system and to the distal right coronary artery system is technically feasible in the human cadaver.

Keywords: Coronary artery bypass; Minimally invasive; Axillary artery; Saphenous vein graft

1. Introduction

The first successful clinical applications in 1994 [2] and further development of the technique [5,13] have lead to a huge increase in the use of minimally invasive direct coronary artery bypass grafting (MIDCAB) for the treatment of coronary artery disease. Single revascularization of the left anterior descending artery (LAD) using an in situ left internal mammary artery graft via a minithoracotomy seems to be a clinically useful procedure. Concerning multivessel revascularization minimally invasive approaches to the right coronary artery (RCA) system in addition to left internal mammary artery (LIMA) to LAD have been conducted via a right anterior minithoracotomy or a subxiphoid incision [8,13]. The RCA has been grafted either with the right internal mammary artery (RIMA) or with arterial and arteriovenous composite grafts [13]. Also the right gastroepiploic artery (RGEA) has been used clinically to reach the posterior descending artery (PDA) [8,13]. Recently aortocoronary venous bypass grafts have been performed via minithoracotomy [9]. As proof of better long-term results of multiple arterial revascularization versus a combination of LIMA to LAD and saphenous vein grafts (SVG) to other coronary arteries is still lacking, further research concerning minimally invasive vein grafting techniques is needed. The axillary artery represents a useful arterial inflow source in peripheral vascular surgery and has recently been chosen as the proximal anastomotic site for coronary bypass grafts [4,11]. The aim of our present study was to assess the fea-
sibility of minimally invasive saphenous vein grafting from the axillary artery to the right coronary artery system and LAD system in the human cadaver

2. Methods

The human cadaver studies were undertaken in cooperation with the Institute of Forensic Medicine at the Innsbruck University on cadavers undergoing autopsy according to section 37 of the Tyrolean law for Public Hospitals. The procedures were carried out on seven cadavers with demographic characteristics as depicted in Table 1.

2.0.1. Access to the axillary artery

With the body in supine position the skin was incised bilaterally between the pectoralis major muscle and the deltoid muscle cranially to the anterior axillary fold. After retraction of these muscles the axillary artery was exposed and encircled. The medial cord of the brachial plexus was gently pulled aside. The axillary artery was incised and a piece of saphenous vein, which was harvested from the leg, was anastomosed to the artery using a 6/0 Prolene running suture.

2.0.2. Access to the left anterior coronary artery system

The skin was incised above the fourth intercostal space and the pectoralis major muscle was divided. After division of the intercostal muscles and the pleura, a standard rib spreader was inserted. The pericardial fat pad was mobilized and the pericardium opened to inspect the LAD system. The pericardium was fixed to the skin in the lateral part of the minithoracotomy using 0/0 silk stay sutures.

2.0.3. Access to the right coronary artery system

A skin incision was made from the lower end of the sternum along the xiphoid process extending into the upper epigastrium. The linea alba was divided and the xiphoid process was resected. After insertion of a rib spreader the pericardium was approached and incised. The pericardium was pulled caudal by an assistant and the distal RCA as well as the posterior descending artery were exposed. To facilitate this 3/0 Prolene stay sutures were placed into the myocardium beside the target vessel.

2.0.4. Placement of axillocoronary bypass grafts

The intercostal space adjacent to the axillary artery anastomotic site was incised and generously dilated. A long endoscopic grasping forceps was inserted through this opening and brought to the subxiphoid and fourth interspace mini-incision, respectively. A 0/0 silk thread was brought transpleurally to the axillary region. The axillocoronary vein graft was then tied to this thread and pulled through the pleura and pericardium to reach the coronary anastomotic site. After trimming the vein to adequate length, an end to side anastomosis to the target vessel was performed using a 6/0 Prolene suture. The anatomical route of axillocoronary venous bypass grafts to the LAD and PDA is shown in Fig. 1.

2.0.5. Comparison with standard CABG via sternotomy

The subxiphoid incision was extended to a standard sternotomy which was measured in length. After opening of the pericardium, the previously completed axillocoronary bypass grafts were transected at the axillary artery anastomotic site, measured and brought to the ascending aorta using the conventional transpericardial route. After trimming, they were sutured to the ascending aorta using 6/0 Prolene and again measured in length.

2.1. Statistical analysis

Comparison between mini-incision length and sternotomy as well as comparison of saphenous vein graft length required to perform the axillocoronary or aortocoronary bypasses was done using the non-parametric Wilcoxon test for related samples on SPSS for Windows. A P-value < 0.05 was regarded as significant.
LAD, left anterior descending artery; PDA, posterior descending artery.

Incision mean length

<table>
<thead>
<tr>
<th>Graft</th>
<th>Left anterior descending artery</th>
<th>PDA, posterior descending artery</th>
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</thead>
<tbody>
<tr>
<td>Length standard sternotomy</td>
<td>23.8 ± 3.7 (21–30) cm</td>
<td>18.3 ± 2.9 (13.5–21) cm</td>
</tr>
<tr>
<td>Sum incisions left unilateral procedure</td>
<td>15.9 ± 1.2 (15–18) cm</td>
<td>13.0 ± 1.4 (11–16) cm</td>
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<tr>
<td>Sum incisions right unilateral procedure</td>
<td>14.9 ± 3.6 (10–20) cm</td>
<td>12.5 ± 2.2 (10–16) cm</td>
</tr>
<tr>
<td>Sum all thoracic incisions</td>
<td>30.8 ± 4.8 (25–38) cm</td>
<td>22.8 ± 3.1 (19–26) cm</td>
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</table>

4. Discussion

Minimally invasive single coronary artery bypass grafting of the left anterior descending artery via a left anterior minithoracotomy using an in situ internal mammary artery graft seems to become a standard procedure in cardiac surgery. Multiple coronary artery bypass grafting by limited access has also been carried out mainly with arterial grafts [13]. Although in general multiple arterial concepts show excellent results, a definitive proof of their superiority over combinations of a LIMA to LAD and SVG to other coronary arteries is not available at present. In a recent paper by Carrel, multivariate analysis did not demonstrate any benefit from bilateral arterial grafting over unilateral IMA bypass combined with saphenous vein grafting in terms of overall survival as well as event free and intervention free survival [6].

A search for ways to establish minimally invasive vein grafting seems to be one of the next steps in the development of this new field in coronary surgery. Minimally invasive vein grafting has been carried out in cases of non-usable left internal mammary artery during classical MIDCAB. Coulson and Bakshay, when faced with the fact that the left internal mammary artery was caught by a sternal wire during a previous sternotomy, performed a saphenous vein graft from the left subclavian artery to the LAD. They approached the subclavian artery through a window in the left second rib [7]. Knight et al. recently advocated an axillary-to-coronary bypass for cases of unsuitable IMA during MIDCAB. Subramanian has described MIDCAB with vein grafts connected to the internal mammary artery [13]. Guillemos has demonstrated the clinical feasibility of limited access aortocoronary bypass grafting [9].

One of the backgrounds of our anatomical study was the fact that the axillary artery can be easily reached without opening bony structures of the thorax as well as the fact that its suitability as an arterial inflow vessel is well proven. Axillofemoral bypasses show satisfactory patency rates and problems with tension of grafts arising from the axillary artery seem to be very rare events. The subclavian artery has been successfully used as an inflow site for coronary bypass grafts in cases of untouchable aorta or during redo proce-
dures [3,14]. Proximal parts of the subclavian artery however require resection of bony or cartilaginous parts of the thorax if exposed by limited access [7]. More distal parts of the vessel can be easily exposed by full anterolateral thoracotomy, but are difficult to reach if an anterior minithoracotomy is applied [13]. Therefore the exposure chosen in our study seems to us the appropriate for a limited access concept. The same access has been used by our group for axillocoronary bypass grafts in cases of severely atherosclerotic aorta during conventional coronary artery bypass grafting [4].

The vicinity of the axillary artery to the brachial plexus might represent a certain danger of plexus lesions if the suggested procedure is applied clinically. These lesions however are seldom encountered when the axillary artery is used as an inflow site for axillofemoral bypasses or as a cannulation site for cardiopulmonary bypass [12].

One point of criticism might be the fact that the length of vein graft required for minimally invasive axillocoronary bypass grafting is significantly longer than for the conventional aorto coronary route and that the graft crosses several anatomical structures such as the intercostal space, the pleural cavity and the pericardium. All these structures might theoretically lead to a mechanical trauma and development of neointimal hyperplasia. Provided a smooth run without tension or kinking is achieved we are convinced that this risk is quite low. Axillofemoral or even axillopopliteal bypasses [10] by comparison do also pass a much longer distance to the target vessel and still do show acceptable long-term patency.

In our study a left anterior minithoracotomy and a subxiphoid incision were chosen to approach the target vessels as described in the literature [5,8,13]. The total incision length was significantly longer than a standard sternotomy if a bilateral axillocoronary bypass was placed. Alternatively a ministernotomy [1] could have been applied giving the advantage of access to both the left anterior descending and the right coronary artery system. Also, instead of exposing both axillary arteries one single axillary artery might be sufficient as an inflow vessel for the axillocoronary bypass and additional vein grafts could be anastomosed to this bypass. This also could reduce total incision length. It has to be stressed however that preservation of sternal stability, avoidance of sternal reentry in redo cases as well as avoidance of aortic manipulation rather than better cosmetic results would be the advantages of our suggested procedure.

The PDA and the LAD were chosen as example target vessels for the left anterior descending and right coronary artery system. It can be anticipated that the length of vein required to reach the RCA or Diagonal branches would not be significantly different from the length of vein measured when sutured to the LAD and PDA. For potential clinical application we think that axillocoronary vein grafts would most likely be suitable to graft diagonal branches of the LAD and RCA branches in addition to a left internal mammary artery graft to the left anterior descending artery. As mentioned above it also might be necessary to use an axillocoronary vein graft to the LAD in cases of a non-usable left internal mammary artery during the classical MIDCAB procedure. Placement of an additional vein graft to the LAD represents a theoretical solution if the internal thoracic artery shows doubtful flow.

The present study in human cadavers demonstrated that minimally invasive axillocoronary bypass grafting is technically feasible. Axillocoronary vein grafts which shortly after conduct of this study have been applied clinically could be useful for minimally invasive multiple bypass grafting, for reoperations, for cases of known untouchable aorta and for MIDCAB emergencies such as an unusable left internal thoracic artery or an anastomotic problem. Regardless of future procedures which deserve the term ‘minimally invasive’ we think that the axillocoronary bypass could serve as a suitable adjunct in this new field in cardiac surgery.

References


