Institutional report - Coronary

A policy to reduce stroke in patients with extensive atherosclerosis of the ascending aorta undergoing coronary surgery

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Abstract

Since 1995 we have routinely used epiaortic scanning in cardiac surgery and since 1998 we have employed off-pump surgery for coronary revascularization. In patients with extensive atherosclerosis in the ascending aorta we tried to assess whether or not conversion from a planned on-pump to off-pump coronary surgery affects the incidence of postoperative stroke. We studied 28 consecutive patients with extensive atherosclerosis in the ascending aorta undergoing coronary surgery. Extensive atherosclerosis, detected by epiaortic ultrasound, was defined as involvement of 6 or more out of 12 segments. Since 1998 we have converted 15 patients with extensive atherosclerosis in the ascending aorta from on-pump to off-pump. Thirteen patients with similar disease who underwent on-pump before the introduction of off-pump were used as controls. The incidence of stroke in the off-pump group was 0\% as compared with 31\% in the coronary artery bypass grafting group (\(P = 0.03\)). Y-grafts were used more often in the off-pump (47\%) than in the on-pump group (0\%, \(P < 0.01\)). The non-touch technique of the ascending aorta was also more frequently used in the off-pump group (73 versus 0\%, \(P < 0.001\)). Off-pump reduces the incidence of stroke in patients with aortic atherosclerosis when the disease occupies 50\% or more of the ascending aorta.

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1. Introduction

It has recently been suggested that coronary artery bypass grafting without cardiopulmonary bypass (off-pump coronary artery bypass, OPCAB) is associated with a lower incidence of postoperative stroke, especially in the elderly [1,2]. We have previously demonstrated that the presence of atherosclerosis in the ascending aorta, detected by intraoperative epiaortic scanning, is a better predictor for postoperative stroke than advanced age [3]. It was, therefore, reasonable to surmise that OPCAB may reduce the incidence of stroke particularly in patients with extensive atherosclerosis in the ascending aorta.

The aim of this study was to evaluate if in patients with extensive atherosclerosis in the ascending aorta, detected by epiaortic scanning, conversion from a planned on-pump coronary artery bypass grafting (CABG) to OPCAB reduces the incidence of postoperative stroke.

2. Patients and methods

The Hospital Ethical Committee approved the study, and informed consent was obtained from all patients. Between 1995 and 2001 28 patients with extensive atherosclerosis in the ascending aorta received either conventional CABG or OPCAB (Fig. 1). Since 1995 we have routinely used epiaortic scanning in order to identify atherosclerosis in the ascending aorta of patients undergoing cardiac surgery. From early on we realized that extensive disease in the ascending aorta, detected by intraoperative epiaortic scanning, is a better predictor for postoperative stroke than advanced age [3]. It was, therefore, reasonable to surmise that OPCAB may reduce the incidence of stroke particularly in patients with extensive atherosclerosis in the ascending aorta.

The aim of this study was to evaluate if in patients with extensive atherosclerosis in the ascending aorta, detected by epiaortic scanning, conversion from a planned on-pump coronary artery bypass grafting (CABG) to OPCAB reduces the incidence of postoperative stroke.

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Sclerosis in 50% or more of the ascending aorta. Atherosclerosis was defined as the number of segments involved. Extensive atherosclerotic disease in the ascending aorta was performed as follows: the ascending aorta was divided into three equal transverse (proximal, middle and distal third) and four equal longitudinal segments (anterior, posterior, lateral and medial) [3]. The presence of ascending aortic atheroma (intimal thickening >0.5 mm) and calcification were recorded for every segment. Extent of disease was defined as the number of segments involved. Extensive atherosclerosis in the ascending aorta was defined as ≥6 segments out of totally 12 segments with epiaortic signs of atherosclerosis. Clinical demographics were prospectively recorded. Carotid artery disease was defined as either asymptomatic carotid stenosis or carotid bruit or carotid stenosis associated with a transient ischemic attack and/or a history of stroke. Arterial serum levels of Troponin-T were taken in the morning of the first postoperative day.

Since 1998 we have employed OPCAB for coronary revascularization especially in patients with extensive atherosclerosis in the ascending aorta.

After induction of anesthesia an experienced anesthetist evaluated all patients with transesophageal echo using a multiplane probe (Hewlett Packard Sono 1500, Andover, Massachusetts or System V, Vingmed-GE, Horten, Norway) according to a standard protocol. Apart from studying the heart, special attention was paid to the ascending aorta, aortic arch and descending aorta with regard to atherosclerotic changes. After a median sternotomy, the surgeon carefully examined the ascending aorta by digital palpation and by epiaortic ultrasound. The surgeon used his index finger to gently palpate the entire wall of the ascending aorta. Epiaortic ultrasound was performed with an ultrasound scanner (Site-Rite II, 9.0 MHz, Dymax Corporation, Pittsburgh, Pennsylvania). Two assessors, the surgeon and the anesthetist, interpreted the epiaortic ultrasound. In case of disagreement a third assessor was asked for his opinion, while unaware of the other two’s views. The mapping of the atherosclerotic disease in the ascending aorta was performed as follows: the ascending aorta was divided into three equal transverse (proximal, middle and distal third) and four equal longitudinal segments (anterior, posterior, lateral and medial) [3]. The presence of ascending aortic atheroma (intimal thickening >0.5 mm) and calcification were recorded for every segment. Extent of disease was defined as the number of segments involved. Extensive atherosclerosis in the ascending aorta was defined as ≥6 segments out of totally 12 segments with epiaortic signs of atherosclerosis. Clinical demographics were prospectively recorded. Carotid artery disease was defined as either symptomatic carotid stenosis or carotid bruit or carotid stenosis associated with a transient ischemic attack and/or a history of stroke. Arterial serum levels of Troponin-T were taken in the morning of the first postoperative day.

2.1. Coronary artery bypass grafting (CABG)

Conventional CABG included cardiopulmonary bypass at 34 °C between a double stage venous cannula in the right atrium and arterial return to the distal ascending aorta. Myocardial protection was achieved with antegrade and retrograde cold blood cardioplegia (St Thomas 1:4). Distal anastomoses were performed with a cross-clamp across the ascending aorta and proximal anastomoses with a side-bitting clamp after removing the cross-clamp.

All patients in the study received 400 units/kg of heparin sulfate i.v. after harvesting of the internal thoracic artery and the activated clotting time was kept above 400 s. Aspirin was given postoperatively to all patients in the study. The sites of cannulation and clamping were adjusted according to the findings of the epiaortic scanning in order to avoid direct manipulation of diseased segments. The internal thoracic artery, left and/or right, was harvested under direct vision. If the radial artery was used as a graft the patient received intravenous nitrate infusion for the first 24 postoperative h. Distal anastomoses were constructed with a continuous running 7-0 or 8-0 monofilament suture (Prolene). Proximal anastomoses were performed to the aorta with a side-bitting clamp using 5-0 or 6-0 Prolene suture.

2.2. Off-pump coronary artery bypass (OPCAB)

OPCAB surgery was performed via a midline sternotomy. Mechanical stability of the coronary arteriotomy area was achieved with suction stabilizers (Octopus I and II, Medtronic Inc., Minneapolis, MN). In order to visualize the arteriotomy area a CO2-water spray was used (Clearview blower/mister kit; Medtronic, Inc. Minneapolis, MN). To maintain hemostasis a soft plastic flow-shunt was passed into the coronary arteriotomy or a small arterial clamp or tourniquet was placed on the coronary artery. Exposure of the circumflex branches and right coronary artery branches was accomplished by elevation of the heart with deep pericardial sutures placed above the entry of the left lower pulmonary vein, deep to the apex of the heart and laterally to the entry of the inferior vena cava.

If epiaortic scanning revealed atherosclerosis in the ascending aorta this prompted construction of proximal anastomoses on an in situ internal thoracic artery pedicle and if possible avoidance of aortic clamping. However, sometimes the surgeon chose to use partial clamping of a non-diseased segment of the ascending aorta in order to avoid undergrafting. The surgeon also used sequential grafting as a mean to reduce the number of proximal anastomoses.

2.3. Neurological evaluation

A surgical consultant performed the preoperative and daily postoperative neurological examinations in the ward.
The first postoperative neurological examination was performed in the intensive care unit on the morning after the operation by a senior surgeon in cooperation with a senior anesthetist-intensivist. At the neurological examination the following functions were checked and compared with the preoperative status: patients’ pupillary size and function, speech, orientation to time and place, memory function and power and symmetry of movements of feet, legs, hands, arms and facial muscles. The major outcome variable was postoperative stroke, defined as a clinically evident temporary or permanent new neurological focal deficit during the same hospitalization. The neurological deficit was confirmed by a computed tomography scan of the brain and clinically by a senior neurologist unaware of the study status.

2.4. Statistical analysis

Student’s t-test was used to compare continuous variables between groups and Chi-square or Fisher’s Exact Test for categorical variables. Results were expressed as mean ± standard deviation. Differences were considered significant at a probability level of \( P < 0.05 \). Data were analyzed with SPSS version 11.0 statistical program (SPSS Inc., Chicago, IL) and with Confidence Interval Analysis (Newcombe), Version 2.0.0 by Trevor Bryant, University of Southampton, UK.

3. Results

In 1998 the OPCAB technique was adopted by our department. Based on the aforementioned data we gradually changed our policy, so that patients with \( \geq 50\% \) atherosclerosis in the ascending aorta preferably underwent OPCAB. This transition took place gradually, as shown in Fig. 1. In 29\% (8/28) of cases atherosclerosis in the ascending aorta was not identified by palpation only. From a total of 28 patients with extensive (\( \geq 50\% \)) atherosclerosis in the ascending aorta 13 underwent conventional CABG and 15 OPCAB. The incidence of stroke in the conventional group was 31\% (4/13) and in the OPCAB group 0\% (0/15, \( P = 0.03, 95\% \) confidence interval for the difference 3.5–57.6\%, Fig. 2).

Patients’ demographics and clinical characteristics are presented in Table 1. It is worthy of note that there were no statistically significant differences between the groups as to the possible risk factors for stroke including extent of atherosclerosis of the ascending aorta. However, the number of proximal anastomoses was statistically lower in the OPCAB group (\( P < 0.01 \)), whereas the number of distal anastomoses did not differ between the groups. Y-grafts were used more often in the OPCAB group (7/15) in comparison with the CABG group (0/13, \( P < 0.01 \)) and the non-touch technique of the ascending aorta was also more frequently used in the OPCAB group (73\%, 11/15 versus 0\%, 0/13, \( P < 0.001 \)). The OPCAB patients had significantly lower levels of Troponin-T than the CABG group. Postoperatively, two patients, both belonging to the CABG group, developed new Q-waves on their electrocardiogram. One of the 28 patients died during the hospital stay. This patient never regained consciousness after a massive stroke following on-pump CABG.

4. Comment

Although OPCAB has been met with a certain degree of enthusiasm relatively few cardiac surgeons have so far changed practice. This is not surprising since conventional CABG has long been established as the generally accepted standard, and in combination with improvements in myocardial protection and postoperative care it has led to a dramatic reduction in morbidity and mortality. As indicated by data available to date, OPCAB does not necessarily further improve survival [4–8]. Reduction in morbidity, in terms of atrial fibrillation, infections and blood transfusion, has not been conspicuous enough to stimulate abandonment of a successful technique. Here we advocate an alternative approach to OPCAB versus CABG controversy by attempting to establish specific indications for OPCAB.

The present study has shown that OPCAB may significantly reduce the incidence of postoperative stroke in patients with at least 50\% of the ascending aorta affected by atherosclerotic disease. The successful outcome was based on the combination of epiaortic scanning and OPCAB. It is worthy of note that in 29\% of cases the operating surgeon failed to diagnose the disease when he relied on palpation only. Previous publications have provided conflicting results on the effect of OPCAB on perioperative stroke. In a large non-randomized study Stamou et al. [9] using propensity scores found a lower incidence of stroke with OPCAB along with seven others independent predictors. However, a number of other studies
failed to show a similar benefit [10–13]. More recently, OPCAB’s benefit in terms of fewer strokes was found in two retrospective studies of octogenarians [1,2]. It is likely that this advantage of OPCAB in octogenarians could be explained by their tendency to suffer from atherosclerosis in the ascending aorta. It should be observed that the mean age of the 28 patients in the present study was 71 years, ranging from 52 to 83 years. Thus, the use of epiaortic scanning targeted patients who benefited from OPCAB in terms of neurological complications.

Completeness of revascularization remains a limiting factor in OPCAB. Apart from the internal thoracic arteries, saphenous veins and radial arteries, which are the most commonly used grafts, necessitate a proximal anastomosis unless Y-grafts are used. The preferred area to place these anastomoses is the ascending aorta. In our study OPCAB patients received about the same number of distal anastomoses as patients undergoing conventional CABG, but with fewer proximal anastomoses. This was due to the use of sequential grafting and Y-grafts. The preferred area to place these anastomoses is the ascending aorta. In fact, in our study the ascending aorta was not touched in 11 of the 15 patients (73%) that were converted to OPCAB, and almost half of the patients received Y-grafts.

There are several limitations in the present study. Firstly, it was not a controlled randomized trial. Secondly, data regarding OPCAB efficacy in patients with <50% atherosclerosis in the ascending aorta were obscure. Thirdly, we realized the high stroke rate of patients with severely diseased ascending aorta at about the same time as OPCAB was being introduced. Under these circumstances we considered it unethical not to try to use the non-touch technique as well as jump and Y-graft provided that the patient was not undergrafted. These limitations are inherent in clinical reality, as OPCAB surgery is slowly establishing itself and clinicians try to improve its technical aspects and define accurate indications for its use. It is worthy of note that only the use of routine intraoperative epiaortic scanning will identify the consecutive patients with severe atherosclerosis in the ascending aorta that may be converted to OPCAB.

To sum up, OPCAB, preferably without touching the aorta, reduces the incidence of stroke in patients with aortic atherosclerosis when the disease occupies 50% or more of the ascending aorta. Whether OPCAB is indicated in patients with less extensive atherosclerosis remains to be elucidated.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Patients characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Conventional CABG</td>
</tr>
<tr>
<td></td>
<td>n = 13</td>
</tr>
<tr>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Age (years)</td>
<td>72.5 6.0</td>
</tr>
<tr>
<td>Gender (male)</td>
<td>69% 53%</td>
</tr>
<tr>
<td>NYHA</td>
<td>3.08 0.76</td>
</tr>
<tr>
<td>Unstable angina</td>
<td>38% 40%</td>
</tr>
<tr>
<td>Left main stem disease</td>
<td>46% 80%</td>
</tr>
<tr>
<td>Hypertension</td>
<td>46% 80%</td>
</tr>
<tr>
<td>Non-insulin dependent diabetes mellitus</td>
<td>23% 13%</td>
</tr>
<tr>
<td>Insulin dependent diabetes mellitus</td>
<td>8% 13%</td>
</tr>
<tr>
<td>Hypercholesteremia</td>
<td>70% 87%</td>
</tr>
<tr>
<td>Intermittent claudication</td>
<td>31% 27%</td>
</tr>
<tr>
<td>History of cerebral embolism</td>
<td>15% 20%</td>
</tr>
<tr>
<td>Redo operation</td>
<td>0% 6%</td>
</tr>
<tr>
<td>Atherosclerosis of the arch</td>
<td>85% 73%</td>
</tr>
<tr>
<td>Carotid disease</td>
<td>14% 25%</td>
</tr>
<tr>
<td>Calcification in ascending aorta</td>
<td>62% 67%</td>
</tr>
<tr>
<td>Extent of atherosclerotic disease of the ascending aorta (12 possible segments)</td>
<td>8.5 2.4</td>
</tr>
<tr>
<td>Cross-clamp time (min)</td>
<td>37.8 21.3</td>
</tr>
<tr>
<td>Cardiopulmonary bypass time (min)</td>
<td>37.8 21.3</td>
</tr>
<tr>
<td>Number of proximal anastomoses</td>
<td>1.3 0.8</td>
</tr>
<tr>
<td>Number of distal anastomoses</td>
<td>3.2 0.8</td>
</tr>
<tr>
<td>Non-touch technique of the ascending aorta</td>
<td>0% 79%</td>
</tr>
<tr>
<td>Y-grafts</td>
<td>0% 47%</td>
</tr>
<tr>
<td>Troponin-T (µg/l) Day 1</td>
<td>2.9 3.7</td>
</tr>
</tbody>
</table>
Acknowledgements

Karolinska Institute Stockholm, Sweden, supported the study.

References


Appendix A. ICVTS on-line discussion

Authors: Dr. Ulrich Von Oppell, Consultant Cardiothoracic Surgeon, University Hospital of Wales, Cardiothoracic Surgery, Heath Park, Cardiff CF14 4X, UK

Date: 09-Oct-2003

Message: Could the authors expand on their method of grading ascending aortic atherosclerosis, as they make no comment as to the depth or Grade of atherosclerosis in terms of protuberances into the lumen. What constituted ‘atherosclerosis’ in a segment? In addition, the authors mention that this study was reviewed by their ethics committee but do not mention whether this was a prospective randomised study or merely a retrospective review of patients treated by one or the other method?

Response

Author: Dr. Jan van der Linden. Karolinska Institute, Department of Cardiothoracic Surgery & Anesthesiology, Huddinge University Hospital, Stockholm, Sweden

Date: 30-Oct-2003

Message: In response to your first question: In Methods we wrote: The mapping of the atherosclerotic disease in the ascending aorta was performed as follows: the ascending aorta was divided into three equal transverse (proximal, middle and distal third) and four equal longitudinal segments (anterior, posterior, lateral and medial) [van der Linden J, Hadjinikolaou L, Bergman P, Lindblom D. Postoperative stroke in cardiac surgery is related to the location and extent of atherosclerotic disease in the ascending aorta. J Am Coll Cardiol 2001;38:131-5.]. The presence of ascending aortic atheroma (intimal thickening ≥ 0.5 mm) and calcification were recorded for every segment. Extent of disease was defined as the number of segments involved. Extensive atherosclerosis in the ascending aorta was defined as ≥ 6 segments out of a total of 12 segments with epicardiac signs of atherosclerosis.

In an earlier study [Bergman P, Hadjinikolaou L, van der Linden J. Aortic atheroma is related to number of particulates captured by intra-aortic filtration in CABG. Eur J Cardiothorac Surg. 2002 Oct;22(4):539-44.] we related to number of particulates captured by intra-aortic filtration in CABG with the presence and number of ascending aortic atheroma (intimal thickening ≥ 0.5 mm) as well as the maximal thickness. The grading of atheromatous disease in the ascending aorta was defined as follows: Class 0: normal aorta, Class 1: atheroma < 1 mm, Class 2: 1 < 2 mm, Class 3: 2 < 3 mm; Class 4: 3 < 4 mm, Class 5: > 4 mm or mobile atheroma. A logistic regression model could explain 46% (χ2 = 0.46, p < 0.001) of the number of particulates harvested in the filters (Table III). The most important independent risk factors for particulates were number of plaques in the ascending aorta (p < 0.01), hypertension (p < 0.02), obesity (p < 0.02), and number of proximal anastomoses (p < 0.02). When the number of plaques was exchanged with atheromatous grade the statistical outcome remained the same.

In response to your second question, this was a prospective non-randomized study.