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OFF PUMP CORONARY ARTERY BYPASS GRAFTING – MIDTERM RESULTS

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Abstract
Objective: Off pump coronary artery bypass (OPCAB) grafting is still discussed controversially in the cardiac surgical community. Early perioperative results are encouraging. Only few reports have focused on midterm recurrence of angina and freedoms from death or re-intervention.
Methods: 107 OPCAB patients (mean age 63 ± 1 years, 77 male, log EuroScore 5.6 ± 0.7, number of distal anastomoses 2.0 ± 0.1), operated on between January 1999 and December 2003, were systematically followed up comparing pre- and post-op NYHA- and CCS-classifications and assessing freedom from death and re-intervention. 52 of 107 patients underwent postoperative angiography or multi-slice computed tomography (MSCT); 6 of the latter 52 patients were symptomatic, 3 with unstable angina, the others underwent follow-up studies having given their informed consent.
Results: The 30 day mortality was 2%. Freedom from death or re-intervention at 5.5 years was 91% and 80%, respectively. Only three patients required re-intervention in an OPCAB-related vessel. CCS classification was 2.8 ± 0.1 before surgery and 1.8 ± 0.2 ($p<0.01$) at follow-up (3.3 ± 0.3 years). NYHA classification was 2.7 ± 0.1 and 2.2 ± 0.1 ($p<0.01$), respectively. Out of 107 patients, 52 underwent coronary angiography or MSCT (6 for cardiac symptoms) at a mean follow-up of 2.2 ± 0.3 years. Left internal thoracic artery was patent in 91%, venous graft patency rate was 83%.
Conclusions: In this small but consecutive OPCAB population with a considerable perioperative risk according to the EuroScore, freedom from death and re-intervention at 5.5 years is acceptable and graft patency rate at 2.2 ± 0.3 years is in the expected range. Significant reduction in both CCS and NYHA classification indicate sustained clinical improvement at midterm.

Key words: Off pump coronary artery bypass grafting, midterm results, patency rate

INTRODUCTION

The amount of data published on off-pump coronary artery bypass (OPCAB) grafting is vast, comprising a large number of observational studies and some randomised studies, the latter recently pooled in a meta-analysis [1]. Regarding a one year time interval, there was no difference in graft patency rate in patients operated with or without cardiopulmonary bypass (CPB) [2]. Pooled data of randomised studies revealed no significant difference concerning a combined endpoint of mortality, stroke and myocardial infarction after 1 year between 801 OPCAB and 783 ONCAB (on-pump coronary artery bypass grafting) patients [1]. In a randomised study, 54 OPCAB and 50 ONCAB (on-pump coronary artery bypass) patients underwent reangiography at 3 months after surgery. A significant difference in graft patency rate, in favour of the ONCAB technique, was established concerning all three large vessel territories [3]. In an observational study, OPCAB patients were followed up at 1 year after surgery by performing coronary angiography to assess graft patency [4]. Follow up was complete in 74% of patients, patency rate of arterial grafts was 97.8%, patency rate of venous grafts was 67.9%. In a large observational study with 3333 consecutive OPCAB patients, 3-month survival was reported to be 96.7% [5].

In a retrospective analysis, cardiac event free survival in OPCAB patients at 3 years was 69% when revascularisation was incomplete [6]. In a propensity matched study, survival 4 years after surgery was 87.5% in OPCAB patients and 91.2% in ONCAB patients [7]. In an observational cohort study, event-free survival following OPCAB surgery was reported to be 74% after 50 ± 23 months, following an initial zero hospital mortality [8]. Randomised studies investigating midterm- or longterm data concerning the OPCAB technique do not exist.

The aim of the present study was to perform a midterm follow up after OPCAB surgery, incorporating late mortality, the need for repeated coronary intervention and clinical symptoms.

METHODS

PATIENTS

Coronary artery bypass grafting without cardiopulmonary bypass was performed on 107 consecutive patients between March 1999 and January 2004. Table 1 shows the demographic data of these patients.

Table 1. Demographic data of 107 OPCAB patients. Values are mean ±SEM or absolute numbers with percentage in parentheses. CAD: Coronary artery disease. CCS: Canadian Cardiovascular Society.

Women [n]	30
Age [years]	63.2 ± 1.0
Body mass index	27.0 ± 0.5
Family history of CAD [n]	28 (26)
Hypertension [n]	80 (74)
Hyperlipidemia [n]	82 (76)
Chronic obstructive lung disease [n]	26 (24)
Diabetes [n]	28 (26)
Renal disease [n]	12 (13)
History of stroke [n]	3 (3)
Left ventricular ejection fraction [%]	56 ± 1
1 vessel disease [n]	34 (31)
2 vessel disease [2]	32 (30)
3 vessel disease [3]	41 (38)
CCS III-IV [n]	57 (53)

Anesthesia and Surgery

The anesthesia technique has been described previously [9]. In brief, anesthesia was induced with intravenous sufentanil (1 μg/kg), etomidate (50 μg/kg), and pancuronium (100 μg/kg). Anesthesia was maintained with isoflurane (0.6%-1.0%), discontinuously given sufentanil (0.3-0.5 μg/kg), and pancuronium (30 μg/kg). Aprotinin (Trasylol® Bayer, Leverkusen, Germany) was given according to the Hammersmith protocol (total dose 6 million KIU). After systemic heparinisation the target ACT was 400 sec.

Patients were operated on by two surgeons. Distal anastomoses were performed using standard purchasable stabilisers (Octopus®, Starfish®, Medtronic, Inc., USA). In all patients, proximal anastomoses were performed using tangential clamping. Postoperative treatment in the intensive care unit was standardized for all patients. Intravenous heparin was given 2 hours after arrival on the intensive care unit and, if there was no bleeding tendency, 500 mg of intravenous acetylsalicylic acid were applied 4 hours after arrival on the ICU.

Coronary Re-angiography and Multislice Computed Tomography Coronary Angiography

52 patients were either controlled using postoperative coronary re-angiography (n = 36) or MSCT (n = 16). Cardiac catheterization or MSCT were performed at a mean follow-up of 825 ± 96 days (2.3 years) after surgery. All patients gave informed consent to re-angiography and study of their coronary conduits. The study was approved by the institutional ethics Committee.

Coronary angiography was performed in a biplane or monoplane catheterization laboratory (Hicor, Siemens Medical Systems). Vascular access was obtained using the femoral approach, and 6F sheaths and catheters were used [10]. Coronary angiography was done with a minimum of 3 views of the left native coronary system and 2 views of the right coronary artery and bypass grafts. Only Fitzgibbon grafts A&B were considered patent [11]. Narrowing ≥ 50% of the lumen diameter of native vessels or bypass grafts was defined as obstructive stenosis and documented for each of the major coronary arteries. Catheter intervention was carried out when considered to be necessary.

The MSCT exams were performed using a recently developed, commercially available 16-row detector CT scanner (Somatom Sensation 16, Siemens, Forchheim, Germany) with a gantry rotation time of 420 ms (collimation: 0.75 mm, table feed: 1.5 mm/ rotation, reconstruction increment: 0.5 mm). For cardiac protocols, only the 12 inner detector rings are applied. Image acquisition was performed during an inspiratory breath-hold. To familiarize the patient with the protocol, the exam, including breath-holding, was practiced in advance. Beta-blockers (esmolol) were injected intravenously for heart rates (HRs) exceeding 70 beats/min.

A total of 120 ml of the iodinated contrast agent Xenetix 300 (300 mg iodine/ml, Guerbert GmbH, Sulzbach, Germany) was continuously injected into an antecubital vein via an 18-gauge catheter with an infusion rate of 3.5 ml/s. To find the suitable point of time for the beginning of the scan, a region of interest was placed into the ascending aorta. As soon as the signal intensity in the region of interest reached a threshold of 120 Hounsfield U, the patient was instructed to maintain an inspiratory breath-hold, and data acquisition was commenced.

Three separate data sets were reconstructed during different time instants of the cardiac cycle (-30%, -40%, -50% of the R to R interval). After reconstruction, CT raw data were transferred to a PC-based workstation Wizard, Siemens Medical Solutions, Erlangen, Germany). Image interpretation was based on source as well as thin maximum intensity projection images. Furthermore, the three-dimensional data sets were viewed with volume rendering techniques.

Patient Interrogation

After a mean follow-up of 1175 ± 102 days (3.2 years) after surgery, a questionnaire was sent to all surviving patients. All patients were asked to report their current complaints according to the New York Heart Association (NYHA) and the Canadian Cardiovascular Society (CCS) classifications. These reports were compared with the respective preoperative status. All patients were asked to indicate whether any postoperative interventions like balloon angioplasty, stent implantation or operative re-coronary artery bypass grafting had been performed in the meantime.

Data Presentation

Data are reported as mean ± SE. Kaplan-Meier graphs were performed using SPSS 10.0 (SPSS, Chicago, IL, USA).

RESULTS

Intraoperative patient data are shown in Table 2.

Table 2. Intra- and perioperative data of 107 OPCAB patients. Values are mean ± SEM.

Operating time [minutes]	158 ± 5
Distal anastomoses [n]	2.0 ± 0.1
Proximal anastomoses [n]	0.7 ± 0.1
Number of grafts [n]	1.7 ± 0.1
Blood loss over tube drainage [ml]	769 ± 66
Packed red blood cells [n]	1.0 ± 0.1
Postoperative ventilation time [h]	9.2 ± 0.9

During the first 30 days two of the 107 patients died (2%). One patient had emergency surgery for a femoral artery embolus one day after the OPCAB procedure and died in therapy refractory cardiac failure on the same day. One patient, who was intraoperatively converted from OPCAB to ONCAB after a iatrogenically destroyed LITA to LAD anastomosis died 10 days after surgery in multiorgan failure. Overall conversion rate was 6 out of 107 patients.

At a mean follow-up of 1175 ± 102 days (3.2 years), all patients who had survived surgery, received a follow-up questionnaire. Out of 107 patients, 91% were still alive, the follow-up of these patients was 100% complete. Data concerning preoperative and postoperative NYHA (New York Heart Association) and CCS (Canadian Cardiovascular Society) classification are shown in Figure 1. There was a significant postoperative improvement of both, NYHA and CCS class.

At a mean follow-up of 825 ± 96 days (2.3 years), 52 patients, of whom 6 were symptomatic (3 with unstable angina), underwent coronary re-angiography or multi-slice computed tomography. Patency of 56 internal mammary artery anastomoses and 42 venous anastomoses was investigated in 52 patients using either coronary angiography or computed multi-slice tomography. Out of 56 ITA anastomoses, 91% were patent. Patency rate of the 42 venous anastomoses was 83%.

1 out of 2 early deaths and 2 out of 8 late deaths were in patients who were intraoperatively converted

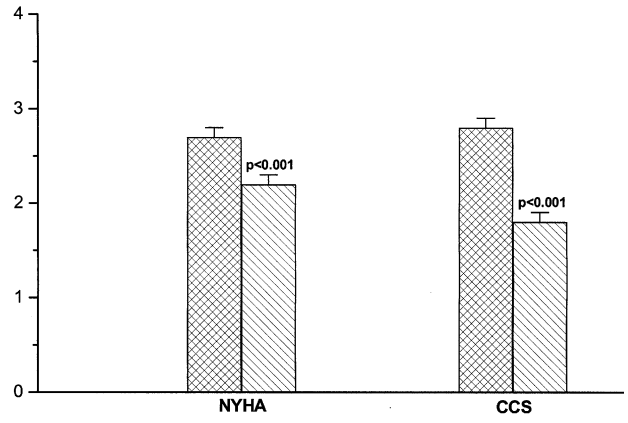

Fig. 1. Preoperative (cross-hatches bars) and postoperative (hatched bars) NYHA (New York Heart Association) and CCS (Canadian Cardiovascular Society) classification. Data are mean ± SEM. Statistic comparison with Student's t-test for unpaired samples.

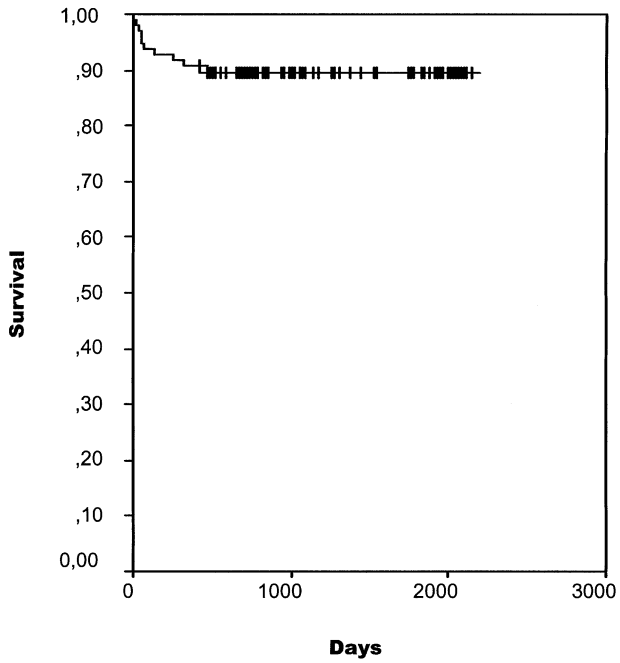

Fig. 2. Freedom from death at over 5.5 years of follow-up. Kaplan-Meier graph using SPSS 10.0.

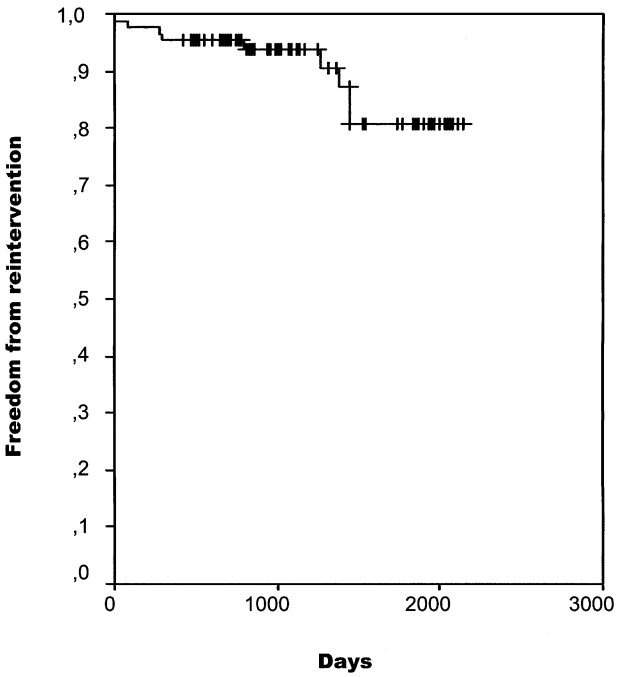

Fig. 3. Freedom from re-intervention at over 5.5 years of follow-up. Kaplan-Meier graph using SPSS 10.0.

from OPCAB to ONCAB. With a total of 6 conversions, 50% of this population had died 3.2 years after surgery.

Figure 2 shows freedom from death as a Kaplan-Meier graph. After a follow-up of 5.5 years, freedom from death was 91%. Figure 3 shows freedom from coronary re-intervention. After a mean follow-up of 5.5 years, freedom from re-intervention was 80%. 10 patients required interventions. Only three patients required re-intervention in an OPCAB related vessel.

Discussion

The mean percentage of OPCAB surgery in cardiac surgical centers in Germany was 6.1% in the year 2001, 5.3% in the year 2002 and 4.9% in the year 2003 [12, 13, 14]. In the present study 107 patients underwent an OPCAB procedure between March 1999 and September 2003, averaging 24 OPCAB cases per year. In the same time interval the unit performed 2642 isolated CABG procedures with or without cardiopulmonary bypass. Thus, over a time interval of 4 years, 4.1% of the isolated CABG procedures were performed off-pump, which resembles the low case load average for the whole of Germany.

Centers with a high case load report promising results after the OPCAB procedure. Three-months survival was published to be 96.7% in 1740 OPCAB patients, compared with a three month survival of 95.9% in 1593 propensity matched patients operated with CPB [5]. In another propensity matched study comparing 406 OPCAB with 406 ONCAB patients, 4 year survival was 87.5% in the OPCAB group and 91.2% in the ONCAB group [7]. Both studies did not find significant differences between the OPCAB and the ONCAB groups. A randomised study comparing 3 month graft patency in 54 off-pump and 50 on-pump patients found that patency was significantly higher in all graft territories in the on-pump group compared to the off-pump group. It became obvious, however, that with a total of 98 OPCAB procedures so far, the experience of the two surgeons who were operating the OPCAB cases was not very large [3].

Apparently, many surgeons do not understand the OPCAB procedure as a replacement therapy for on-pump CABG, but reserve it for specific indications, such as severe peripheral artery disease, severe chronic obstructive lung disease, severely compromised left ventricular function, young patient age, etc. Favourable results have been demonstrated concerning the occurrence of intraoperative cerebral emboli and subsequent postoperative neurocognitive dysfunction [15], the incidence of perioperative stroke in the subgroup of patients with significant carotid disease and the need for postoperative renal replacement therapy in patients with compromised renal function [5, 16]. Following this strategy, as demonstrated in the present study, even centers without large experience in OPCAB surgery and with a low case load, can obtain respectable short- and midterm results. Significant mortality was only observed in the group of patients that were converted from OPCAB to ONCAB and this corresponds to earlier reports in the literature [17]. In this respective large study reporting 1644 patients, 61 were converted from OPCAB to ONCAB. Operative mortality was 18% in converted patients vs. 2.7% in non-converted patients. In our patient population, both NYHA class and CCS class were still significantly improved compared to the preoperative state at a mean follow up of 3.2 years.

The time interval of 2.3 years between surgery and re-angiography is longer than most intervals described in the literature for re-angiography after OPCAB surgery. Recent studies reported re-angiography intervals of no longer than 12 months [2, 3, 4]. Yet, the patency rate, as obtained in the present study, is comparable with the results recently published for OPCAB surgery so far [2, 3, 14], confirming the assumption that the quality of the OPCAB anastomosis does not suffer from the fact that the heart is beating. In a large recent study, following up on 1254 patients who had previously undergone CABG using CPB, 33% of the surviving patients underwent re-angiography at 3 years after surgery and more than 50% of the surviving patients underwent re-angiography at 10 years after surgery. At 10 years, 369 of 731 surviving patients were catheterised. Overall vein graft patency rate 10 years after CABG was 61%, overall IMA patency was 85% [18]. Otherwise, long term results after CABG, concerning the patency rate of individual anastomoses, are sparse. Therefore, the present study considerably contributes to our understanding of the long term quality of OPCAB surgery.

Limitations

The study is a non randomised observational cohort study, reporting single center midterm results after OPCAB surgery. Combined angiographic and multislice computed follow up was complete in only 54% of surviving patients, however, freedom from death and freedom from reintervention were both described for a period of 5.5 after surgery, which, in comparison with most earlier studies, represents a reasonably long follow-up.

In conclusion, we have shown, that even in a center with a low case load, OPCAB surgery can be performed with a low operative risk and with midterm results concerning survival, clinical symptoms and patency rate which can well withstand respective results of on-pump coronary artery bypass grafting.

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