Patient-reported outcomes after cardiac surgery

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DOI:
10.33612/diss.131754816

Publication date:
2020

Chapter

7

THE INFLUENCE OF CORONARY BYPASS ON COGNITIVE FUNCTION AND QUALITY OF LIFE

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Submitted

ABSTRACT

Objectives: This study aimed to explore the influence of coronary artery bypass grafting on both postoperative cognitive dysfunction and quality of life and the association between both patient-related outcomes.

Methods: In a prospective, observational cohort study, patients with elective, isolated coronary artery bypass grafting were included. Cognitive function was assessed using the Cogstate computerised cognitive test battery preoperatively, 3 days and 6 months after surgery. Quality of life was measured preoperatively and at 6 months using the RAND-36 questionnaire divided in a physical and mental component score. Regression analysis, with adjustment for confounders, was used to evaluate the association between postoperative cognitive dysfunction and quality of life.

Results: A total of 142 patients were included in the study. Evidence of persistent cognitive dysfunction was observed in 33% of patients after six months. At six months the physical component score was improved in 59% and decreased in 21% of patients, and the mental component score increased in 49% and decreased in 29%. Postoperative cognitive changes were not associated with quality of life scores.

Conclusions: Postoperative cognitive dysfunction and decreased quality of life are common six months after surgery, although cognitive function and quality of life were found to have improved in many patients at six months follow-up. Impaired cognitive function is not associated with impaired quality of life at six months.

INTRODUCTION

During the past few decades improvements in operative techniques and perioperative care have led to a steady decline in mortality after cardiac surgery. Although survival rates have improved, elderly patients are at increased risk of postoperative complications such as neurological and pulmonary problems (1,2). Neurological complications after cardiac surgery have been classified by The American College of Cardiology and the American Heart Association into two categories (3). Type-I deficits result from well-defined local or regional insults resulting in transient ischaemic attack, stroke, coma and fatal brain injury. Type-II deficits result from more diffuse and poorly understood insults, and include delirium and postoperative cognitive dysfunction (POCD). Delirium is an acute and short-lasting disorder of fluctuating changes in attention, mental status and level of consciousness, which is clearly defined in the Diagnostic and Statistical Manual for Mental Disorders-V (4). In contrast, the definition and operationalization of POCD is less clear, it is mostly described as a deficit of concentration, attention, memory and motor speed that lasts for several weeks or months (3). Recently, an expert working group produced a set of recommendations for diagnosis and nomenclature for post-operative neurocognitive disorders to align the terminology used with that of the DSM-V (5). They have recommended that the term POCD be used for mild or major neurocognitive disorders found to be present between 1 and 12 months after a surgical operation. Studies of patients who have undergone coronary artery bypass grafting (CABG) describe an incidence of POCD of 30-60% depending on the timing, type and interpretation of cognitive tests used, and the patient-population involved (6,7). Despite this high incidence, and the fact that in vulnerable elderly patients even a small decline may have important consequences such as loss of independence (8,9), data on the impact of POCD on quality of life (QoL) are scarce. The primary aim of this study was to explore the influence of CABG on cognitive function and QoL, and to investigate the association between POCD and QoL in adult patients after CABG. Our secondary aim was to explore identifiable risk factors for POCD.

METHODS

We conducted a prospective single-center observational cohort study. The study protocol is registered at ClinicalTrials.gov (NCT03774342). The study was waived by the institutional review board (reference number 2018/226) and conducted in agreement with the principles of the Helsinki declaration. The study results are reported according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines (10) (Supplementary Material Section S1 checklist).

Eligibility criteria

We included adult patients admitted for elective on-pump CABG in the University Medical Center Groningen, the Netherlands. Exclusion criteria were previous cardiac surgery and combined (i.e. valve) surgery due to the increased risk of complications, pre-existing neurological deficits (i.e. dementia, stroke, epilepsy) and psychiatric illness limiting reliability of screening tests. If patients were likely to experience difficulty completing cognitive testing due to impaired eyesight or hearing, or problems understanding the Dutch language, they were also excluded from the study.

Procedures

On the day of admission, usually the day before surgery, patients were identified and contacted for informed consent by the attending doctor or nurse practitioner. After informed consent patients were included and baseline preoperative measurements were obtained. Postoperative assessment of cognitive function was performed in the hospital three days after surgery (short-term) and at the patients' homes six months after surgery (long-term).

Demographic and medical characteristics

Baseline demographic data were retrieved from the electronic patient medical records and included age, sex, body mass index, education level, log EuroSCORE I and the presence of comorbidity such as diabetes (11), pulmonary disease (12), arterial vascular disease (12), renal disease (13) and impaired ventricular function (14). Definitions of comorbidities are included in the Supplementary Material Section S2. The log EuroSCORE I is a widely used risk stratification system for adult cardiac surgery patients from which an individual patient mortality risk can be calculated (15). Perioperative data included duration of surgery, time on cardiopulmonary bypass (CPB) both in minutes and the number of (arterial) grafts.

Outcome measures

Cognitive function was assessed using the Cogstate brief computerised cognitive test battery (Cogstate Ltd, Melbourne, Vic., Australia). The test battery we used consisted of 4 tasks: the detection task (DET), the identification task (IDN), the one card learning task (OCL) and the one back task (ONB), assessing psychomotor speed, selective attention, visual learning and working memory, respectively (16). The Cogstate tests have been used in several other studies indicating a good sensitivity for detecting subtle changes in cognitive performance and strong test-retest reliability (16,17). On the day before surgery, the battery of tests were performed twice. The first was to minimise practice effects and the second was used as baseline test. Before starting, each task was introduced by the researcher using standardized written instruction. Each set of 4 tests required approximately 20 minutes to complete. All cognitive function scores were standardised according to normative data from age-matched controls, provided by the software vendor (18). A standardized score higher than 100 indicated a better than average score compared with the age-matched population (19). To perform a within-subject analysis a standardized reliable change Z-score for each postoperative cognitive test was calculated, based on the difference between the postoperative and baseline score, and normalized using test-retest variability data provided by the software vendor (20). The standardized change Z-scores of all four individual tasks were summed to generate a composite Z-score (7). POCD was operationally defined as a Z-score <-2 in two or more individual tasks or a composite Z-score of <-2 (20). The threshold of <-2 was chosen to provide consistency with the suggestion of the expert working party of defining POCD as equivalent to major neurocognitive disorder if the decline in test scores is >2 standard deviations (5).

QoL was measured using the RAND-36 version-2 questionnaire. The questionnaire is a widely used and validated instrument containing eight health domains: physical functioning, social functioning, role limitations due to physical health problems, role limitations due to emotional problems, mental health, vitality, pain, and general health perception (21). Each dimension is scored on a scale between 0 and 100, where a higher score is equivalent to better health. Two summarized scores were calculated: a physical component score (PCS) and a mental component score (MCS). We considered a minimal clinically important difference (MCID) to be five points, and calculated the change in QoL for each patient. QoL was judged as being improved (>5 points), worse (<5 points), or unchanged (≤5 points decrease or increase in score) (22).
Secondary outcomes were postoperative complications including delirium (23), atrial fibrillation (24), myocardial infarction (25), surgical re-exploration (11), deep sternal wound infection (26), and renal failure (12) within 30 days after surgery and stroke within 72 hours after surgery (27). Definitions of complications are included in the Supplementary Material Section S2. Additional outcomes were duration of stay at the Intensive Care Unit and discharge destination.

Analyses
The sample size calculation was based on the hypothetical association between POCD and QoL. POCD was assumed to be the independent variable and QoL as the dependent variable. A previous study on patients with POCD after CABG reported an SD of 8.5 (19) and a study on QoL after cardiac events reported an SD of 11 (28). A sample size of 123 patients was required for a two-tailed test at a minimal detectable difference of 0.33, an α of 0.05 and power of 80% to detect an association between POCD and QoL. To account for missing data, we included 142 patients.

Characteristics of patients are presented as numbers (with percentages) for dichotomous variables and as means (with standard deviations) or medians (with interquartile ranges) for continuous variables depending on distribution. Differences between baseline and six months follow-up of cognitive function and QoL were tested using paired t-tests. Differences between the patients with and without POCD were tested using the chi-square or Fisher's exact test. Linear regression analysis was used to evaluate the impact of POCD on the difference in QoL (dependent variable) and possible risk factors for POCD based on literature, as well as age and baseline PCS/MCS, were included in the multivariable model. All analyses were tested 2-sided and variables with P-values of <0.05 were considered statistically significant. All data were analysed using SPSS version 25.0 (IBM Corp. Released 2015. IBM SPSS Statistics for Windows, Version 25.0, Armonk NY).

RESULTS

A total of 142 patients undergoing elective CABG were enrolled (CONSORT chart in Figure 1). Table 1 presents all baseline, operative and postoperative characteristics. Based on the standardized composite Z-score at baseline, two patients already had mild cognitive impairment preoperatively. Short term postoperative cognitive tests were performed after a median of three days [range 3-7] after surgery. Three patients refused further participation and 5 patients were unable to complete the early postoperative test due to pain or dizziness during testing (3 patients), a prolonged stay in the ICU (1 patient) and transfer to another hospital on day 3 (1 patient). Among the remaining 134 patients, 80 patients (60%) fulfilled the criteria for early cognitive dysfunction based on delayed neurocognitive recovery in the terminology suggested by Evered (5). Two patients died during follow-up, one patient moved abroad, and 5 patients refused further participation. Long-term cognitive tests were performed in 131 patients after a median of 192 days [range 177–219] after surgery. Forty-three patients (33%) had persistent cognitive dysfunction at long-term follow-up, whereas 29 patients (22%) showed improved cognitive function with a >2 increase in their composite cognitive function scores. Mean cognitive test scores are presented in Table 2.

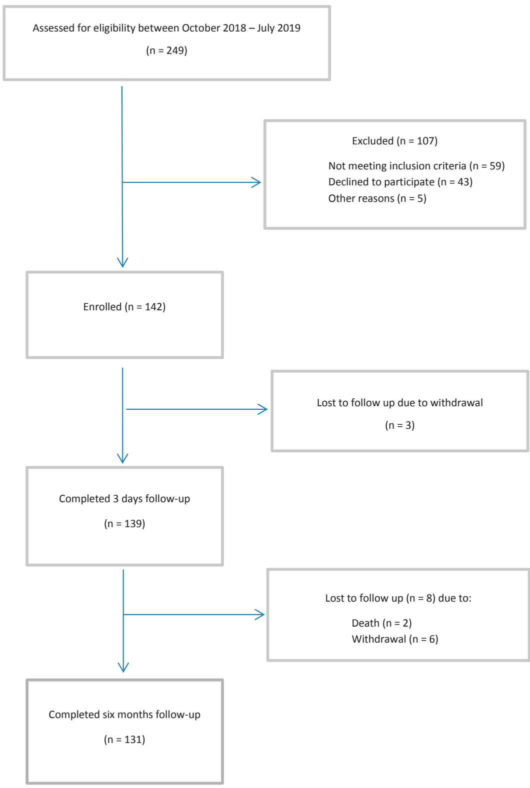

Figure 1. CONSORT study flowchart

Table 1. Baseline, operative and postoperative characteristics of patients with CABG

	n = 142
Baseline characteristics	
Sex (female)	18 (13)
Age (years),mean (SD)	64.3 (9.4)
BMI (kg/m^2)	
< 25	34 (24)
25-30	71 (50)
> 30	37 (26)
Log EuroSCORE I	
< 10%	133 (94)
10-20%	9 (6.3)
> 20%	0 (0.0)
Diabetes mellitus	31 (22)
Pulmonary disease	15 (11)
Arterial vascular disease	7 (4.9)
Renal disease	14 (9.9)
LVEF	
> 50%	96 (68)
30-50%	45 (32)
< 30%	1 (0.7)
Education level[1]	
Low	40 (28)
Moderate	55 (39)
High	46 (33)
Operative characteristics	
Number of grafts	
One graft	1 (0.7)
Two grafts	139 (98)
Three grafts	2 (1.4)
Number of arterial grafts	
Use of 1 arterial graft	100 (70)
Use of 2 or more arterial grafts	39 (27)
No arterial grafts	3 (2.1)
Surgical time[2] , mean (SD)	254 (41)
CPB-time[2],median (IQR)	64 (48–78)
Postoperative characteristics	
Delirium	7 (4.9)
Atrial fibrillation	14 (9.9)
Myocardial infarction	2 (1.4)
Surgical re-exploration	3 (2.1)
Deep sternal wound infection	3 (2.1)
Stroke	0 (0.0)
Renal failure	0 (0.0)
ICU stay[3],median (IQR)	21 (18-25)
Discharge destination	
Home	99 (71)
Other hospital	21 (15)
Rehabilitation centre	18 (13)
Nursing home	1 (0.7)

Values are presented as n (%) unless otherwise indicated. [1]Education level for one patient unknown. [2] surgical time and CPB-time in minutes. [3]ICU-stay in hours. BMI:body mass index; CPB:cardiopulmonary bypass; ICU:intensive care unit; IQR:interquartile range; LVEF:left ventricular ejection fraction.

Table 2. Standardised cognitive test-scores of patients before and after CABG

Test	Preoperative (n = 142)	3 days[1] (n = 134)	6 months (n = 131)	P value[2]
DET; speed	101.8 ± 6.2	98.1 ± 8.4	100.5 ± 8.3	0.07
IDN; speed	100.6 ± 4.8	98.2 ± 6.3	100.8 ± 5.5	0.26
OCL; accuracy	103.6 ± 8.7	100 ± 9.0	104.5 ± 9.4	0.58
ONB; speed	98.3 ± 5.6	95.6 ± 6.2	97.5 ± 5.8	0.08

[1]Five patients did not complete the test. [2] paired T-test only from patients with complete dataset; P-value based on preoperative and 6 months scores. DET:detection task; IDN:identification task, OCL:one card learning task; ONB:one back task. All numbers are presented as mean with standard deviation.

Quality of life

Mean MCS, PCS and subscale scores are presented in table 3. At six months follow-up, PCS was increased (>5 points) in 59% of the patients and decreased (>5 points) in 21%. MCS was increased in 49% of the patients and decreased in 29%.

Association between postoperative cognitive dysfunction and quality of life

Table 4 shows the results of the linear regression analysis. Associations between POCD and difference in QoL six months after surgery were non-significant (PCS P=0.66 and MCS P=0.91; respectively). In the multivariable analysis baseline PCS and education level were statistically significantly correlated with difference in PCS at six months follow-up. Baseline MCS was associated with the difference in MCS six months after CABG.

Table 3. Quality of life of patients before and after CABG –subscale scores

Scores	Preoperative (n = 140)	6 months (n = 131)	P value
Physical component score	63.4 ±19.9	73.0 ±17.4	<0.001
General health	64.0 ±17.4	65.7 ±17.3	0.24
Physical functioning	64.9 ±27.1	79.4 ±20.2	<0.001
Role physical	57.4 ±30.2	64.3 ±29.0	0.009
Bodily pain	70.5 ±25.1	83.1 ±20.5	<0.001
Mental component score	70.6 ±20.4	74.6 ±18.7	0.018
Mental health	74.7 ±19.2	78.3 ±18.1	0.012
Vitality	61.6 ±23.9	63.6 ±19.9	0.29
Social functioning	74.3 ±26.7	81.6 ±21.2	0.001
Role emotional	74.6 ±25.7	75.5 ±26.9	0.68

All numbers are presented as mean with standard deviation.
For a few patients not all scores on all subscales are known.

Table 4. Univariable - and multivariable linear regression model of the effect of pre- and postoperative factors on the difference in quality of life 6 months after coronary artery bypass grafting

Univariable analysis				**Multivariable analysis**		
Physical component score				Physical component score		(R^2 = 0.42)
	Beta	95% CI	P value	Beta	95% CI	P value
6 months POCD Z-score	0.20	-0.68 to 1.07	0.66	0.18	-0.53 to 0.88	0.62
Age	-0.35	-0.71 to 0.02	0.06	-0.23	-0.52 to 0.07	0.13
Baseline PCS	-0.59	-0.73 to -0.45	<0.001	-0.59	-0.73 to -0.45	<0.001
Baseline cognitive functioning	7.83	-19.8 to 35.1	0.57	6.99	-15.3 to 29.3	0.54
Education level	4.50	0.17 to 8.84	0.04	5.00	1.52 to 8.48	0.05
Delirium	3.72	-12.3 to 19.8	0.65	-4.06	-17.5 to 9.45	0.55
Mental component score				Mental component score		(R^2 = 0.28)
	Beta	95% CI	P value	Beta	95% CI	P value
6 months POCD Z-score	0.03	-0.71 to 0.76	0.94	-0.18	-0.85 to 0.50	0.61
Age	-0.10	-0.41 to 0.21	0.52	0.06	-0.23 to 0.34	0.69
Baseline MCS	-0.41	-0.53 to -0.29	<0.001	-0.43	-0.56 to -0.30	<0.001
Baseline cognitive functioning	-0.99	-32.1 to 14.1	0.44	-1.99	-23.4 to 19.4	0.86
Education level	0.16	-3.52 to 3.84	0.93	0.60	-2.69 to 3.89	0.72
Delirium	3.78	-9.78 to 17.3	0.58	-5.00	-18.0 to 7.97	0.45

Patients with and without POCD at six months follow-up

Of 80 patients with POCD at short-term follow-up, 37 (46%) had recovery of their POCD, and 43 (54%) were classified as having POCD at long-term follow-up. Baseline characteristics, operative characteristics and postoperative complications of patients with and without POCD at six months after surgery, are presented in Table 5. Age (P = 0.040), education level (P = 0.046) and postoperative delirium (P = 0.015) were different between the groups, all other variables were not. Differences in PCS and MCS between the groups were not significantly different (Figure 2).

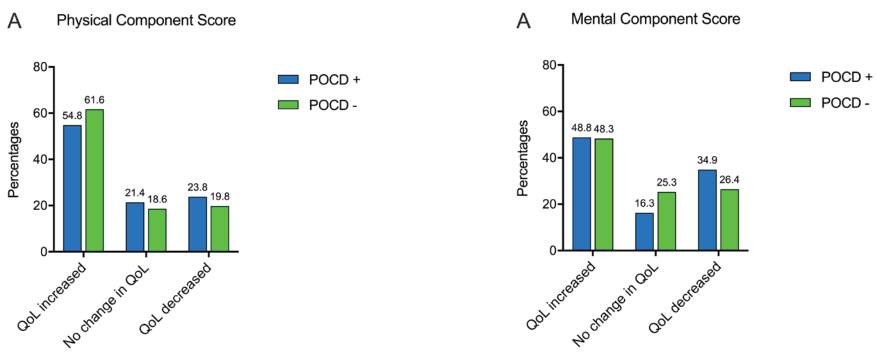

Figure 2. Difference in QoL of CABG-patients with and without POCD: physical and mental component score.

Table 5. Characteristics of patients with or without POCD six months after CABG

	No POCD (n = 88)	POCD (n = 43)	P value
Baseline characteristics			
Sex (female)	10 (11)	5 (12)	>0.99
Age (years),mean(SD)	63 (9.2)	67 (9.0)	0.040
BMI (kg/m^2)			0.29
< 25	18 (20)	13 (30)	
25-30	49 (56)	18 (42)	
> 30	21 (24)	12 (28)	
Log EuroSCORE I			0.72
< 10%	83 (94)	40 (93)	
10-20%	5 (6.0)	3 (7.0)	
Diabetes mellitus	20 (2.3)	9 (20.9)	0.79
Pulmonary disease	7 (8.0)	7 (16.3)	0.23
Arterial vascular disease	4 (4.5)	3 (7.0)	0.68
Renal disease	8 (9.1)	5 (11.6)	0.76
LVEF			0.54
> 50%	58 (66)	33 (36)	
30-50%	29 (33)	10 (23)	
< 30%	1 (1.1)	0 (0.0)	
Education level			0.046
Low	27 (31)	9 (21)	
Moderate	39 (44)	14 (33)	
High	22 (25)	20 (46)	
Baseline PCS, mean (SD)	65 (20)	63 (19)	0.46
Baseline MCS, mean (SD)	71 (20)	73 (21)	0.51
Cognitive test results, mean (SD)			
DET	101 (6.7)	103 (5.3)	0.24
IDN	100 (4.9)	101 (4.9)	0.69
OCL	104 (8.7)	104 (8.4)	0.71
ONB	98 (5.6)	98 (6.1)	0.49
Operative characteristics			
Surgical time[1],mean (SD)	257 (46)	249 (33)	0.24
CPB-time[1],median (IQR)	69 (26)	64 (26)	0.23
Postop. characteristics			
Delirium	1 (1.1)	5 (12)	0.015
Atrial fibrillation	9 (10)	5 (12)	>0.99
Myocardial infarction	1 (1.1)	0 (0.0)	>0.99
Surgical re-exploration	2 (2.3)	0 (0.0)	>0.99
Deep sternal wound infection	2 (2.3)	0 (0.0)	>0.99
ICU stay[2],median (IQR)	21 (18-25)	21 (17-23)	0.247
Discharge destination			0.99
Home	63 (72)	31 (72)	
Other hospital	12 (14)	6 (14)	
Rehabilitation center	12 (14)	6 (14)	
Nursing home	0 (0.0)	0 (0.0)	

Values are presented as n (%) unless otherwise indicated. [1] surgical time and CPB-time in minutes. [2] ICU-stay in hours. BMI:body mass index; CPB:cardiopulmonary bypass; DET:detection task; ICU:intensive care unit; IDN:identification task; IQR:interquartile range; LVEF: left ventricular ejection fraction; OCL:one card learning task; ONB:one back task.

DISCUSSION

In this prospective study we observed that many patients showed a postoperative improvement in cognitive function, and in the physical and mental component of QoL. Persistent POCD was however present in 33% of patients, and there was either no change or a decline in QoL in approximately half of all patients. Contrary to expectations, no association between POCD and difference in QoL six months after coronary bypass was found. A possible explanation for not finding an association could be that people with impaired cognitive function can still experience a high QoL or that patients adjust their intended level of QoL (glad to be alive), so that the difference between the new and the intended level is normalized after surgery.

Many studies have been performed on POCD after CABG, mostly addressing the incidence and etiology of POCD (6,19,29). Conflicting results often appear in studies on POCD, which can be explained by the fact that there are no universally accepted definition and operationalization, statistical methods or gold standards for measuring POCD (6,9). As in other POCD studies, we used the reliable change index that relates the change scores to the normal test-retest variation in an age-matched control group (7,19,20,29). Other commonly used statistical methods are an absolute decline (usually >1 SD calculated from baseline scores) or a percentage change from baseline (usually a decline >20%) however, these methods do not relate to data from age-matched controls and therefore do not account for normal variability among a population (30). Efforts should be made to establish a well-defined definition and a standard to measure POCD as the incidence of POCD appears high and its impact on patients' lives remain unclear. The Cogstate batterytest may be suitable as standard instrument, because data are comparable to data from age-matched controls, and several studies indicate this instrument to be sensitive and reliable (16–18).

The high numbers of patients not improving after CABG in our study, indicate that CABG may have a high impact on patient's QoL as suggested by other studies (31,32). The incidence of POCD at long-term in our study is also rather high, which is in line with other studies (6,7). It will be interesting to monitor improvements in QoL in future studies, as well as POCD at longer follow-up (>1 year). This is relevant because Kok et al. have reported that POCD three months after CABG is an important risk factor for POCD at 15 months after surgery (19) suggesting that the found incidences of POCD at six months in our study, may not further improve over time. Other explanations for the long-term decline in QoL and the high incidence of long-term POCD could be side-effects of surgery (i.e. new comorbidities or reduced independence) or other confounding factors unrelated to the intervention. Perhaps future studies should also assess functional status and work resumption alongside QoL, to learn more about the real impact of subtle changes in cognitive functioning on patients' daily lives.

Although not the primary outcome of our study, we found several significant differences between the groups with and without POCD at long-term. Age, education level and postoperative delirium differed significantly between both groups and have all previously been identified as risk factors for POCD after CABG in other studies (6,19). Risk factors for a decreased QoL after CABG identified in this study, are high baseline PCS and MCS, suggesting that patients with a good QoL before surgery are more likely to experience a decreased QoL after surgery also confirmed by other studies (32,33). Information on risk factors for POCD and a decreased QoL after CABG, can be useful to identify patients at risk during the process of shared decision making between patients and their healthcare professionals.

Our study has some important limitations. First, our patient selection might differ from other hospitals which may limit generalizability although we included only elective patients in our study population and mortality risk was low with a mean EuroSCORE of 3.8 (SD ±3). Second, it is likely that the early postoperative cognitive tests performed at three days after surgery, were influenced by factors like sleep disturbance and opioids. We specifically chose day three for assessment of short-term POCD due to logistic reasons: many of our patients are transferred back to other hospitals four days after surgery. Third, this is an observational study without a control group: further studies are needed to evaluate specifically the effect of alternative interventions (i.e. CABG vs. percutaneous coronary intervention) on POCD and QoL, as patients are not only subjected to surgery.

The outcomes of our study show high incidences of persistent POCD and a decreased QoL six months after CABG which may not recover in time and may negatively influence patients' daily lives. QoL and POCD are important for patients, relatives and thus for doctors taking decisions to operate or not. Studies addressing these topics can provide valuable information regarding shared decision making.

Acknowledgements
The authors wish to thank all participating patients and all involved students and research nurses. We specially thank Karin Havinga who ensured data processing and management.

Supplementary Material
Only supplement S2 is printed here due to space limitations.

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Supplementary Material S2. Definitions of comorbidities & complications

COMORBIDITIES
Diabetes: oral therapy or insulin dependent diabetes (11).
Pulmonary disease: prolonged use of steroids or other lung medication (12).
Arterial vascular disease: peripheral or abdominal vascular pathology or operation due to arterial vascular disease (12).
Renal disease: a reduced renal function prior to surgery with an estimated Glomerular Filtration rate (eGFR) <60 ml/min/1.73 m^2 (13).
Impaired ventricular function: left ventricular ejection fraction good >50%, moderate 30-50% or poor <30% (14).

POSTOPERATIVE COMPLICATIONS
Delirium during hospital admittance defined as:
1. A DOS score ≥ 3 at hospital ward and/or
2. A positive CAM-ICU score at the ICU and/or
3. Diagnosis confirmed by a psychiatrist or geriatrist according to the DSM-IV criteria (23).

Atrial fibrillation defined as new onset atrial fibrillation or atrial flutter requiring medical treatment or cardioversion within 30 days after surgery (24).

Myocardial infarction (MI) in the postoperative period. Myocardial infarction associated with CABG (within 48 hours after CABG) is arbitrarily defined by elevation of cardiac biomarker values >10 x 99th percentile upper reference limit (URL) in patients with normal baseline cardiac troponin values. In addition, either (i) new pathological Q waves or new LBBB, or (ii) angiographic documented new graft or new native coronary artery occlusion, or (iii) imaging evidence of new loss of viable myocardium or new regional wall motion abnormality (25). After 48 hours, the standard definition of myocardial infarction is appropriate. The following criteria meets the diagnosis for MI: detection of a rise and/or fall of cardiac biomarker values, preferably cardiac troponin, with at least one value above the 99th percentile URL and in addition, either (i) symptoms of ischaemia, or (ii) new or presumed new significant ST-segment–T wave (ST–T) changes or new left bundle branch block (LBBB), or (iii) development of pathological Q waves in the ECG, or (iiii) imaging evidence of new loss of viable myocardium or new regional wall motion abnormality or identification of an intracoronary thrombus by angiography or autopsy (25).

Surgical re-exploration within 30 days after surgery: thoracotomy due to bleeding, cardiac tamponade or graft failure (11).

Deep wound infection within 30 days after surgery: when deeper tissues are affected (muscle, sternum and mediastinum) and one or more of the following three criteria are met:

1. surgical drainage or refixation
2. an organism is isolated from culture of mediastina tissue or fluid
3. antibiotic treatment because of a sternal wound (26).

Stroke: an acute neurological event within 72 hours after surgery with focal signs and symptoms and without evidence supporting any alternative explanation. Diagnoses of stroke requires confirmation by a neurologist (27).

Renal failure within 30 days after surgery when one or more of the following criteria are met:
1. renal replacement therapy (dialysis or CVVH) which was not present preoperatively
2. highest postoperative creatinine level > 177 µmol/L and a doubling of the preoperative value (the preoperative creatinine value is the value on which the EuroSCORE is calculated) (12).