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Short communications

The incidence and severity of cognitive decline after major noncardiac surgery: a comparison with that after cardiac surgery with cardiopulmonary bypass

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Cognitive dysfunction after cardiac surgery is a well-recognized complication and a significant cause of morbidity [1–4]. However, the incidence and severity of cognitive dysfunction after noncardiac surgery have been less well studied compared with that after cardiac surgery [5]. This study was therefore conducted to compare the incidence and severity of short-term cognitive decline in patients having undergone noncardiac surgery with those having undergone cardiac surgery.

After obtaining institutional approval and informed consent, 126 patients who underwent elective cardiac or noncardiac surgery under general anesthesia were studied. Patients with a history of neurological or psychiatric disorder were excluded from the study. Patients were divided into three groups: the noncardiac group (n = 24) underwent noncardiac vascular surgery without cardiopulmonary bypass (CPB), the CABG group (n = 65) underwent coronary artery bypass grafting (CABG) with CPB, and the V group (n = 37) underwent valvular surgery with CPB. Anesthesia was induced with fentanyl, midazolam or propofol, and vecuronium. After the trachea was intubated, the lungs were mechanically ventilated. Anesthesia was maintained with fentanyl and propofol or midazolam with or without nitrous oxide. The target rectal temperature during CPB was 28°C in the CABG and V groups.

Cognitive function was assessed 1–3 days before the operation and 10–14 days after the operation by a single investigator (NS). For the assessment of cognitive function, a revised version of Hasegawa's dementia scale (HDS-R), Benton's revised visual retention test, and the digit symbol test were used. The HDS-R is a simple and reliable method which consists of nine questions to test orientation, immediate and delayed memory recall, word-list generation, and calculation. The scores range from 0 to 30 points. The Benton revised visual retention test measures short-term visual memory, and visuomotor and visuoconstructional skills, and requires subjects to draw a series of geometric shapes from memory after a 10-s exposure. This test has a standard criterion for scoring, and the possible score is 0–1.0. The digit symbol test is a subtest of the Wechsler adult intelligence scale, revised (WAIS-R), which measures psychomotor performance and speed. The scores range from 0 to 93 points.

Cognitive decline (incidence) was defined as a decline of at lease 20% from baseline in any test. The average percentage decline from baseline over all tests (severity) was scored for each individual as described previously [5]. In this calculation, any improvement was counted as zero decline. For example, a patient whose scores decreased by 10% on one test, dropped by 26% on another, and improved by 10% on a third would show an average percentage decline over three tests of $(10 + 26 + 0)/3 = 12\%$. The score in each test was also converted to a z-score by using the mean and standard deviation of the baseline scores of patients [6]. For example, for the group mean baseline score for the Benton revised visual test, the mean was 5.0 with a standard deviation of 1.8. For a patient with a score of 3.2 on this test, this would correspond to a z-score of $(3.2 - 5.0)/1.8 = -1.0$. Then, the z-scores from three tests were averaged as a single z-score. Z-scores after the operation were calculated in the same way by using the mean and standard deviation of the baseline scores. To compare the physiological variables and cognitive parameters among the groups, analysis of variance (ANOVA) with the Bonferroni post hoc test was used. To compare the categorical variables among the groups,

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Table 1. Demographic details of subjects

	Control (n = 24)	CABG (n = 65)	V (n = 37)	
Age (years)	67 ± 8	63 ± 9	63 ± 9	$P = 0.1332$
Weight (kg)	61 ± 9[a]	62 ± 9	53 ± 10[c]	$P < 0.0001$
Height (cm)	164 ± 7[a]	161 ± 7	157 ± 8[c]	$P = 0.0028$
Sex (F/M)	1/23[a]	11/54	11/26	$P = 0.0381$
Education (years)	10 ± 2	11 ± 3	10 ± 3	$P = 0.3107$
Hypertension	15 (63%)[b]	21 (32%)	4 (11%)[c]	$P < 0.0001$
Diabetes mellitus	15 (63%)[b]	23 (35%)	7 (19%)	$P = 0.0024$
Hyperlipidemia	10 (42%)	23 (35%)	6 (16%)	$P = 0.0594$
Operation time (min)	307 ± 127[b]	495 ± 107	402 ± 98[c]	$P < 0.0001$
Anesthesia time (min)	416 ± 140[b]	619 ± 114	522 ± 107[c]	$P < 0.0001$
Fentanyl (mg)	0.5 ± 0.2[b]	2.7 ± 1.1	2.0 ± 0.9[c]	$P < 0.0001$
Blood loss (l)	1.1 ± 1.1	1.6 ± 1.0	1.3 ± 1.0	$P = 0.0893$
Transfusion	5 (21%)	18 (28%)	16 (43%)	$P = 0.1295$
Lowest temperature (°C)	35.3 ± 0.6[b]	28.2 ± 1.3	28.1 ± 1.3	$P < 0.0001$
CPB time (min)		176 ± 48	194 ± 72	
Arrest time (min)		126 ± 34	143 ± 43	

Data are expressed as mean ± SD

[a] $P < 0.05$ *vs* V; [b] $P < 0.05$ *vs* CABG, V; [c] $P < 0.05$ *vs* CABG

Control, noncardiac vascular surgery; CABG, coronary artery bypass grafting; V, valvular surgery; CPB, cardiopulmonary bypass

the χ^2 test or Fisher's exact test were used. Data were expressed as mean ± SD. A value of $P < 0.05$ was considered to be statistically significant.

The demographic variables in the three groups are shown in Table 1. Age and years of education were similar among the three groups. Weight and height in the noncardiac group were significantly higher than those in the V group ($P < 0.05$). The incidence of hypertension and diabetes mellitus was significantly higher in the noncardiac group than in the CABG and V groups ($P < 0.05$). Operating time, anesthesia time, and total dose of fentanyl were significantly lower in the noncardiac group than in the CABG and V groups ($P < 0.05$). Intraoperative blood loss and transfusion rate were similar among the three groups. Intraoperative lowest temperature was significantly higher in the noncardiac group than in the CABG and V groups ($P < 0.05$).

The results of the neuropsychological tests are shown in Table 2. There were no significant differences in preoperative scores in any test among the three groups. The incidence of a 10% and 20% reduction from the baseline score in each test was also similar among the groups. The average percentage decline (% decrease), the preoperative and postoperative z-scores, and the incidence of a 10% and 20% reduction from the baseline in any test were similar among the three groups.

The results in this study showed that the incidence of cognitive decline, defined as a 20% reduction of preoperative value in any test, was 38%, 46%, and 46% in the noncardiac, CABG, and V groups, respectively. The average percentage decrease in test scores (severity) was also similar among the three groups. These results indicate that the incidence and severity of short-term postoperative cognitive decline after major noncardiac vascular surgery were similar to those after cardiac surgery with CPB. This suggests that short-term cognitive decline after surgery may in part be related to nonspecific factors of surgery and anesthesia.

Several authors have investigated the influence of noncardiac surgery on postoperative neuropsychological function [4,5,7,8]. Treasure et al. [7] reported that short-term neuropsychological changes, which had not improved after 8 weeks, were observed in 50% of patients who underwent major noncardiac surgery. Shaw et al. [4] investigated neuropsychological function in 312 cardiac surgical patients and 50 patients who underwent peripheral vascular surgery, and reported that the incidence of neuropsychological dysfunction at discharge was 38% and 31% after cardiac and noncardiac surgery, respectively. Vingerhoets et al. [8] compared the neuropsychological consequences of cardiac surgery with CPB with those of major noncardiac surgery, and found that the incidence of short-term cognitive decline was similar between the cardiac and noncardiac patients (45% *vs* 40%, respectively). These findings are compatible with the results in this study.

A number of investigators have attempted to identify preoperative or intraoperative predictors of cognitive decline after cardiac surgery [1,9,10]. Short-term studies have identified several predictors which are different from those found in long-term studies [6,11]. In short-term assessments (1 week to 1 month), increasing age, little education, and a large number of emboli were

Table 2. Results of neuropsychological tests before and after the operations

	Control	CABG	V	
Hasegawa dementia rating scale	$n = 24$	$n = 65$	$n = 37$	
Preoperation	25 ± 3	26 ± 4	25 ± 4	$P = 0.5439$
Postoperation	25 ± 3	26 ± 4	24 ± 4	$P = 0.1011$
10% reduction	7 (29%)	10 (15%)	12 (32%)	$P = 0.1054$
20% reduction	2 (8%)	2 (3%)	5 (14%)	$P = 0.1398$
Benton revised visual retention	$n = 21$	$n = 57$	$n = 33$	
Preoperation	4.4 ± 1.9	5.4 ± 1.8	5.0 ± 1.7	$P = 0.1127$
Postoperation	4.3 ± 2.0	4.6 ± 2.0	4.6 ± 2.0	$P = 0.8258$
10% reduction	11 (52%)	34 (60%)	17 (52%)	$P = 0.7091$
20% reduction	8 (38%)	28 (49%)	11 (33%)	$P = 0.3126$
Digit symbol	$n = 21$	$n = 56$	$n = 33$	
Preoperation	37 ± 14	39 ± 11	36 ± 14	$P = 0.5916$
Postoperation	37 ± 13	39 ± 13	36 ± 16	$P = 0.6776$
10% reduction	3 (14%)	12 (21%)	6 (18%)	$P = 0.7673$
20% reduction	1 (5%)	6 (11%)	4 (12%)	$P = 0.6421$
Total	$n = 24$	$n = 65$	$n = 37$	
% decrease	9 ± 10	10 ± 10	9 ± 8	$P = 0.7738$
z score before	−0.1 ± 0.7	0.1 ± 0.7	−0.1 ± 0.8	$P = 0.3264$
z score after	−0.1 ± 0.7	0.1 ± 0.8	−0.1 ± 0.9	$P = 0.4787$
10% reduction in any test	15 (63%)	40 (62%)	28 (76%)	$P = 0.3253$
20% reduction in any test	9 (38%)	30 (46%)	17 (46%)	$P = 0.7485$

Data are expressed as mean ± SD
There were no significant differences among the coronary artery bypass grafting (CABG), vulvular surgery (V), and control groups
% decrease reflects an overall decline with improvement set to 0
The z score in each test was calculated using mean and SD as described previously, and then the z score from each test was averaged as a single z score

associated with a higher incidence of cognitive changes. In contrast, age and education were not associated with worse outcomes in the longer-term assessment. Instead, diabetes and severity of arteriosclerotic disease of the aorta were associated with postoperative cognitive decline. Selnes et al. [11] therefore suggested that immediate postoperative changes might result from nonspecific effects of surgery or anesthesia, whereas the persistent or late cognitive changes may be directly attributable to the cardiac operation. There have been only a few reports about the predictors of cognitive decline after noncardiac surgery. Grichnik et al. [5] demonstrated that age predicted the incidence and severity of cognitive dysfunction after major noncardiac surgery, and suggested that aging might lead to a reduced tolerance for the stress of anesthesia, the operation, and postoperative events. In the present study, the incidence and severity of cognitive declines were similar among the three groups, suggesting that nonspecific factors might be involved to some extent in short-term cognitive declines.

The reported differences in the incidence of neuropsychological dysfunction after CABG and after valvular surgery have been controversial. Several authors have demonstrated that patients undergoing valvular surgery are more vulnerable to postoperative neurobehavioral disorders compared with patients undergoing CABG [12,13]. Slogoff et al. [12] reported that the incidence of postoperative cerebral dysfunction was more than twice as high in patients undergoing intracardiac operations than in patients having extracardiac (CABG) operations. Hermann et al. [14] compared the incidence of postoperative neuropsychological dysfunction in patients undergoing valve replacement with CABG, and indicated that the incidence of neuropsychological dysfunction was statistically higher in patients with valve replacement 1 week after the operation, but not 6 months after the operation. Kuroda et al. [15] reported that patients undergoing CABG were at great risk of neurological damage compared with those undergoing valve surgery, although greater age, hypertension, diabetes mellitus, and cerebrovascular disease were more common in patients undergoing CABG. In this study, we did not observe any differences in the incidence and severity of short-term postoperative cognitive dysfunction between the patients undergoing CABG and those undergoing valve surgery. The reasons for the discrepancy in these results are not known. Further study with more patients is required.

In summary, short-term cognitive changes after major noncardiac surgery were compared with those after cardiac surgery with CPB. The incidence and severity of cognitive decline were similar between the cardiac and noncardiac surgery. Since this is a preliminary study of only a small number of patients without long-term cognitive assessments, there may be considerable limitations to our findings. Further study with more patients is definitely required. However, the results obtained in this study suggest that short-term cognitive function after surgery may be affected by nonspecific influences of anesthesia, the operation, and hospitalization.

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