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ORIGINAL ARTICLE

Analysis of the perioperative change in cognitive function of patients with risk factors for cognitive impairment in cardiovascular surgery

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Abstract

Objective The purpose of the present study is to assess the perioperative changes in the cognitive function of patients after cardiovascular surgery (CVS) and to find out risk factors for early postoperative cognitive decline.

Materials and methods From December 2013 to March 2017, 291 patients underwent elective or urgent CVS with cardiopulmonary bypass in our institution. One hundred and fifteen patients, who agreed to an evaluation of their cognitive function, were included in this study. The cognitive function was evaluated by the HDS-R and MMSE at three time points: before surgery, in the early postoperative period and at discharge. The patients' characteristics, perioperative data, HDS-R and MMSE scores were obtained by reviewing their medical records retrospectively.

Results The patients were stratified into three age groups. In all of the age groups, the early postoperative cognitive functional scores were severely decreased in comparison to the preoperative values. However, by the time of discharge, the function had improved to the same level as before surgery in each of the groups. In addition, the similar tendency was observed in patients with preoperative cognitive dysfunction. Moreover, multiple regression analysis demonstrated that preoperative cognitive function and age were significant risk factors for early cognitive impairment.

Conclusion Although preoperative cognitive decline and patients' age were the risk factors for early postoperative cognitive impairment after CVS, a significant recovery can be expected even in elderly patients or patients with low preoperative cognitive function by the time of discharge.

Keywords Cognitive function · Postoperative cognitive impairment · Cardiovascular surgery · Rehabilitation

Introduction

Cardiovascular operations are known to be associated with perioperative cognitive decline and dementia [1–8], which might severely impair the patients' recovery and quality of life (QOL) after cardiovascular surgery (CVS). In association with the aging of the population, a relatively large number of elderly patients have multiple comorbidities. Such patients tend to be easily affected by perioperative cognitive impairment. The cognitive function at discharge has been reported to be a significant predictor of long-term cognitive dysfunction [1]. However, the importance of perioperative cognitive decline might be underestimated, mainly because the decline appears to be subclinical in most of patients. Moreover, although there are some reports on the relationship between cognitive dysfunction and mortality after cardiovascular surgery [1, 2], the mechanisms are not clearly understood, which makes the issue difficult to manage.

In our opinion, patients' age could be a definitive risk factor for the impaired perioperative cognitive function and recovery. The purpose of this study is to investigate the perioperative changes in the cognitive function of patients with risk factors for early postoperative cognitive decline after CVS and to detect risk factors for the early postoperative cognitive impairment.

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Materials and methods

In our institution, 291 patients underwent elective or urgent cardiovascular surgery with cardiopulmonary bypass (CPB) from December 2013 to March 2017. One hundred and fifteen patients, who agreed to undergo a cognitive evaluation, were included in the present study. Patients who had a past history of symptomatic cerebrovascular disease or who were not suitable for cognitive evaluation due to preoperative circulatory instability, loss of consciousness for stroke or under sedation were excluded from our study. Cases of early surgical mortality were excluded as well. All of the patients started rehabilitation before their operation based on the rehabilitation protocol of our hospital. These patients were stratified into three groups based on their age, ≦64 years, 65–74 years and ≧75 years old. The cognitive function of the patients was evaluated individually by experienced occupational therapists using the Revised Hasegawa's Dementia Scale (HDS-R) and the Mini Mental State Examination (MMSE) at the following three time points: before surgery (the day before operation), the early postoperative period, and at discharge (the day before discharge). The early postoperative evaluation was performed on the day that the patient resumed rehabilitation after surgery (1.36 ± 0.65 postoperative days on average). Scores less than 20 on the HDS-R are an indicator of cognitive impairment, which is almost equivalent to a scores of 23 on the MMSE [9, 10]. The patients' characteristics, perioperative data, HDS-R and MMSE scores were obtained by reviewing their medical records retrospectively. Student's *t* test, an analysis of variance and a multiple regression analysis were used for the analysis of the results. All of the statistical analyses were performed using the SPSS software program.

Results

The patients' characteristics, including age, sex, past medical history of hypertension (HT) and diabetes mellitus (DM), proportion of patients with preoperative impaired cognitive function, type of operation, duration of operation, anesthesia, cardiopulmonary bypass (CPB), lowest body temperature and mean arterial pressure during operation, period from operation to resumption of rehabilitation and hospital stay, are summarized in Table 1. Significant differences were observed in the gender ratios of the groups. No significant difference was observed in the ratio of HT, DM, the type of operation or the period from the operation to the resumption of rehabilitation in any of the groups. The hospital stay in the oldest age group was significantly longer in comparison to

Table 1 Patient background

	≦64 y.o. (31 cases)	65–74 y.o. (32 cases)	≧75 y.o. (52 cases)	*P* value
Age	54.5 ± 8.8	68.8 ± 2.9	80.3 ± 3.6	< 0.01*
Male	25 (80.6%)	22 (68.8%)	26 (50%)	0.014*
Female	6 (19.4%)	10 (31.2%)	26 (50%)	
HT	19 (61.3%)	28 (87.5%)	42 (80.8%)	0.17
DM	4 (12.9%)	5 (15.6%)	9 (17.3%)	0.91
Preoperative cognitive impairment				
HDS-R < 20	0 (0%)	0 (0%)	9 (17.3%)	< 0.01*
MMSE < 23	0 (0%)	0 (0%)	11 (21.2%)	< 0.01*
Operation				
Coronary surgery	15 (48.4%)	18 (56.3%)	29 (55.8%)	0.74
Valve surgery	10 (32.3%)	9 (28.1%)	15 (28.8%)	
Aorta surgery	5 (16.1%)	3 (9.4%)	8 (15.4%)	
Others	1 (3.2%)	2 (6.3%)	0 (0%)	
Operation time (min)	240 ± 99	239 ± 68.8	229 ± 71.9	0.80
Anesthesia time (min)	326 ± 109	308 ± 76.6	297 ± 82.4	0.40
CPB time (min)	119 ± 65	114 ± 39	116 ± 31.6	0.93
Ltemp during operation	32.8 ± 3.9	34.0 ± 2.4	32.5 ± 3.8	0.10
LMAP during operation	51.2 ± 6.6	49.9 ± 6.4	49.6 ± 5.5	0.53
Post-Op. start of rehabilitation (days)	1.3 ± 0.6	1.3 ± 0.8	1.8 ± 2.3	0.37
Hospital stay (days)	10.9 ± 3.8	10.4 ± 2.8	15.2 ± 7.6	< 0.01*

HT hypertension, *DM* diabetes mellitus, *Ltemp* lowest temperature during operation, *LMAP* lowest mean arterial pressure during operation

the other age groups. There were no significant differences in the duration of operation, anesthesia and CPB, the lowest body temperature, mean arterial pressure during surgery among the groups.

The neurocognitive tests scores are presented in Figs. 1 and 2. In terms of the cognitive outcomes, the HDS-R and MMSE scores in the early postoperative period, were dramatically decreased in comparison to the preoperative values in all age categories. However, by the time of discharge these scores had recovered to the preoperative level in all groups.

Preoperative cognitive impairment was observed in 9 patients for HDS-R and 11 patients for MMSE, who were both included in the oldest age group. Additional analysis was performed for patients with the low preoperative cognitive function, which indicated the statistically significant drop and recovery that was similar to the whole cohort (Fig. 3).

The result of multiple regression analysis for HDS-R (Table 2) revealed that preoperative HDS-R score was the significant risk factor for early postoperative HDS-R drop. In addition, regarding MMSE (Table 3), preoperative MMSE score and age were risk factors for early postoperative MMSE deterioration.

Discussion

Although neurocognitive decline has been well recognized as a complication after cardiovascular surgery (CVS), the importance of a postoperative cognitive decline tends to be overlooked because it appears to be transient, subtle and subclinical in most patients [1]. However, cognitive decline can complicate the early postoperative recovery and there is a significant correlation between the cognitive function and QOL after CVS [1, 2], which might imply the clinical importance of an early recovery from postoperative cognitive impairment.

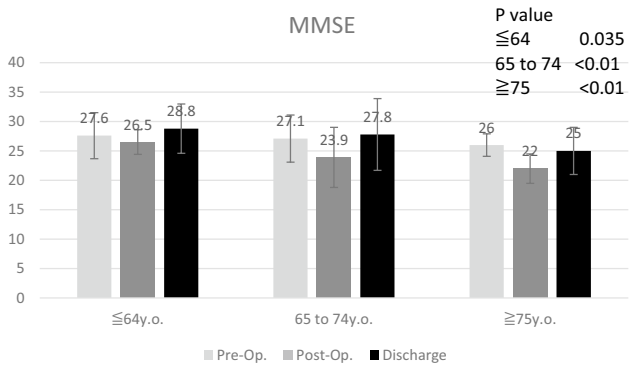

Fig. 2 Perioperative changes of MMSE score

There is a significant difference in the reported incidence of postoperative cognitive impairment after CVS, which ranges widely from 3 to 50% [1, 3, 4]. This difference might be due to methodological issues and difficulties in evaluating the cognitive function because a multitude of neuro-psychologic measures and definitions of cognitive decline are used throughout the world [1–3]. The timing of the evaluation of the cognitive function is another issue because these scores tend to be time-dependent. The early postoperative period might be plausible time for investigating the effects of surgery on the cognitive function. Another report stated that the cognitive function at discharge appears to be substantially important because it can be a significant predictor of the long-term cognitive function [1]. Thus, we adopted the day before discharge as one of the time points for the evaluation of the cognitive function in the present study.

Several reports have discussed the risk factors for cognitive dysfunction after CVS [3–7, 11], these have included age [5], preoperative cognitive impairment [11], a low mean intra-operative arterial pressure [7], the use of CPB [4, 6], the type of anesthesia, the degree of surgical trauma, systemic atheromatous disease [4], and mental stress due to hospitalization [6] as risk factors for

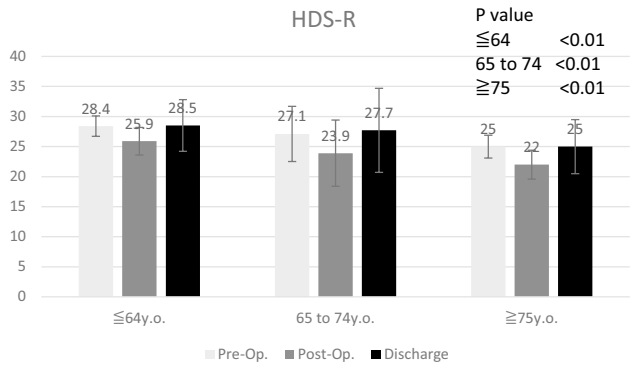

Fig. 1 Perioperative changes of HDS-R score

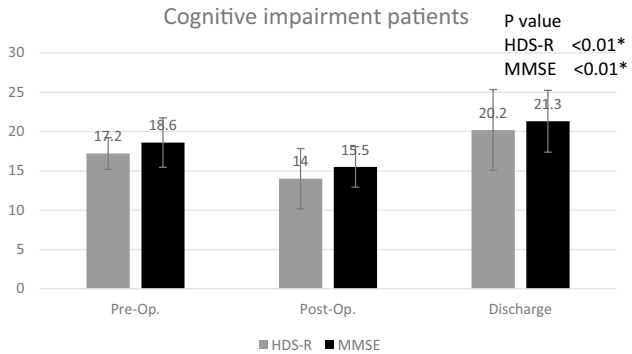

Fig. 3 Perioperative score changes in cognitive impaired patients

Table 2 Multiple regression analysis for early postoperative HDS-R drop (preoperative HDS-R – early postoperative HDS-R)

Variables	Regression coefficient estimates	Lower 95% CI	Upper 95% CI	*P* value
Age	0.00253	−0.0983	0.103	0.960
Male	−1.607	−3.922	0.707	0.171
HT	0.0387	−2.680	2.757	0.978
DM	−0.214	−2.921	2.493	0.876
Preoperative HDS-R	−0.178	−0.380	0.239	0.0329*
Operation time	−0.00158	−0.0311	0.0343	0.924
Anesthesia time	0.0124	−0.0214	0.0461	0.469
CPB time	−0.0123	−0.0570	0.0325	0.588
Ltemp	0.113	−0.282	0.509	0.570
LMAP	−0.0431	−0.227	0.141	0.643

HT hypertension, *DM* diabetes mellitus, *Ltemp* lowest temperature during operation, *LMAP* lowest mean arterial pressure during operation

Table 3 Multiple regression analysis for early postoperative MMSE drop (preoperative MMSE – early postoperative MMSE)

Variables	Regression coefficient estimates	Lower 95% CI	Upper 95% CI	*P* value
Age	0.106	0.0223	0.196	0.0137*
Male	−1.049	−3.154	1.056	0.325
HT	−0.402	−2.882	2.078	0.748
DM	−0.379	−2.848	2.090	0.761
Preoperative MMSE	−0.251	−0.496	−0.00637	0.0444*
Operation time	−0.00385	−0.0335	0.0259	0.798
Anesthesia time	0.0193	−0.0115	0.0500	0.217
CPB time	−0.0157	−0.0566	0.0252	0.447
Ltemp	0.0251	−0.0335	0.386	0.891
LMAP	−0.0926	−0.258	0.0725	0.268

HT hypertension, *DM* diabetes mellitus, *Ltemp* lowest temperature during operation, *LMAP* lowest mean arterial pressure during operation

cognitive decline after CVS, which could mean that postoperative cognitive decline is a multifactorial issue. Some reports have pointed out that adverse inflammation and neuroendocrine responses to surgery might be a cause of cognitive dysfunction [6]. Others have reported that small brain infarction derived from brain micro-emboli or hypoperfusion can cause a postoperative cognitive decline [6, 8]. However, it is true that the mechanisms underlying the postoperative cognitive decline remain unclear, which might make the prevention of a postoperative cognitive decline after CVS almost impossible.

In our study, preoperative cognitive function and patients' age were the statistically significant risk factors for early postoperative cognitive impairment after CVS. Furthermore, it has been reported that elderly patients tend to be vulnerable to cognitive decline, which might lead to severe impairment of postoperative QOL or even mortality [5]. Therefore, the cohort was stratified into three age groups to confirm the differences in the perioperative changes of the cognitive function after CVS between generations, which had been rarely reported.

In this research, the cognitive decline occurred in the early postoperative period in all age groups. However, the impairment recovered to approximately the same level as before the operation by the day before discharge. Furthermore, an equal recovery was observed in each of the age categories. A previous study reported that a cognitive decline was evident in as many as three-quarters of CVS patients at the time of hospital discharge and in a third of patients after 6 months [1]. The results of our research were superior in terms of the cognitive functional recovery; however, the reasons for these differences are currently unclear. It is hypothesized that the early initiation of the intensive rehabilitation might help to accomplish a prompt recovery of cognitive function after CVS. In our institution, plenty of staff have been occupied in the perioperative rehabilitation around CVS. As a result, it has been possible for a CVS patient to receive the rehabilitation at least 2 h per day (2.48 ± 0.27 h on average) as long as

the hemodynamic status allows, which might bring about the immediate recovery of the cognitive function in the all age categories. In addition, the fact that even the preoperative cognitive impairment group showed the same postoperative recovery as the whole cohort in cognitive function after CVS could be encouraging for all staff engaging in the perioperative management around CVS.

The present study was associated with some limitations. First, it was a short-term study and the study period ended on the day before discharge. Second, it was difficult to establish a control group (non-rehabilitation group) because of ethical issues. Finally, it might be difficult to exclude the effects of practice on the patients' neurocognitive evaluation test scores.

Conclusion

Though preoperative cognitive dysfunction and patients' age were significant risk factors for early postoperative impairment after CVS, a significant recovery in the cognitive function can be expected even in elderly patients or patients with low preoperative cognitive function by the time of discharge.

Compliance with ethical standards

Conflict of interest The authors have declared that no conflict of interest exists.

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