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ORIGINAL ARTICLE

Impact of preoperative regular physical activity on postoperative course after open abdominal aortic aneurysm surgery

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Abstract Early ambulation after open abdominal aortic aneurysm (AAA) surgery is assumed to play a key role in preventing postoperative complications and reducing hospital length of stay. However, the factors predicting early ambulation after open AAA surgery have not yet been sufficiently investigated. Here, we investigated which preoperative and intraoperative variables are associated with start time for ambulation in patients after open AAA surgery. A total of 67 consecutive patients undergoing open AAA surgery were included in the study [male, 62 (92 %); mean age, 68 years (range, 47–82 years), mean AAA diameter, 53 mm (range, 28–80 mm)]. Preoperative physical activity was examined by means of 6-min walk distance (6MWD) and a medical interview. Patients were divided into two groups, according to when independence in walking was attained: early group <3 days ($n = 36$) and late group ≥3 days ($n = 31$), and the pre-, intra-, and postoperative recovery data were compared. There were no significant differences in patient baseline characteristics or intraoperative data between the two groups. The number of patients engaging in preoperative regular physical activity and 6MWD were significantly greater ($p = 0.042$ and $p = 0.034$, respectively) in the early group than in the late group. In addition, time to hospital discharge was significantly shorter in the early group than in the late group ($p = 0.031$). Binary logistic regression analysis showed that preoperative regular physical activity was the only independent factor for identifying patients in the early group (odds ratio 2.769, 95 % confidence interval 1.024–7.487, $p = 0.045$). These results suggest that engaging in regular physical activity is an effective predictor of early ambulation after open AAA surgery.

Keywords Abdominal aortic aneurysm · Open surgery · Early ambulation · Physical activity

Introduction

The most commonly used strategies for the treatment of abdominal aortic aneurysm (AAA) are open surgery, endovascular aortic repair (EVAR), and laparoscopic aortic surgery (LAS) [1]. Open surgery, EVAR, and LAS are considered complementary but non-concurrent techniques [1]. Open surgery is considered suitable for patients presenting with an anatomy requiring complex repairs or for patients who have a very high surgical risk [1]. Postoperatively, open surgery requires greater operative stress, longer bed rest and hospitalization than EVAR [2–5] or LAS [6, 7]. Therefore, in open surgery, attainment of early ambulation may play a key role in preventing postoperative complications and reducing hospital length of stay [8–10]. Many studies have examined time to ambulation after gastroenterological, cardiac, and orthopedic surgery [11–14]; however,

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few studies have examined the association between early ambulation and time to discharge after open AAA surgery [9, 15]. Furthermore, for the selection of the most appropriate postoperative treatment approach, it is important for medical staff to be able to assess ambulation ability and surgical risk preoperatively. It has been reported that preoperative physical activity level is predictive of postoperative outcome after a number of orthopedic [13, 14] and abdominothoracic [16] surgical procedures, however, factors predicting ambulation after open AAA surgery have not yet been sufficiently investigated. We therefore investigated which pre- and intra-operative variables are associated with time to ambulation in patients undergoing open AAA surgery.

Methods

Study population and outcome measures

A total of 67 consecutive patients undergoing successful open AAA surgery from August 2012 to March 2014 at Nagoya University Hospital were included in the study. Patients undergoing thoracoabdominal or emergency aneurysm repairs were excluded. Medical assessments were conducted for all patients, and demographic characteristics, AAA size, preoperative physical activity level, intraoperative data such as blood loss and the use of suprarenal aortic cross-clamping, and the postoperative time to ambulation during hospitalization were recorded. Acute renal dysfunction was defined according to the RIFLE criteria [17] with the modifications detailed in a previous report concerning open AAA surgery [18]; data regarding the presence of renal failure, 200 % increase in creatinine or cystatin C, oliguria <0.5 ml/kg/h for 24 h, or anuria were extracted from the patients' medical records. All patients were provided similar operation and postoperative rehabilitation. This study was approved by the ethics committee of Nagoya University Hospital, Japan (No. 250).

Preoperative physical activity

Preoperative physical activity level was examined by means of the 6-min walk distance (6MWD) and a medical interview. The 6MWD was performed by following a standardized procedure [19]. Briefly, patients were instructed to walk the length of a predetermined course at their own pace while attempting to cover as much ground as possible in 6 min. Standardized encouragement was given each minute during the test. At the end of the 6 min, patients were instructed to stop walking and the distance covered was measured to the nearest meter.

All patients were also interviewed on admission about their pre-diagnosis level of physical activity. There are many definitions of regular physical activity [20]; however, in a national survey published by the Japan Health and Welfare Statistics Association, regular physical activity was defined as more than 30 min of exercise on two separate days of the week, kept up for more than 1 year [21]. This criterion was used in the present study.

Classification of patients

The number of days postoperatively to attaining independence in maintaining a sitting position, maintaining a standing position, walking, resuming eating, and hospital discharge were extracted from the patients' medical records. All resumption of activity was performed under supervision of medical staff. All patients were administered epidural anesthesia for 48–96 h postoperatively, non-steroidal anti-inflammatory drugs, or oral acetaminophen as required.

Patients were into two groups, using the median time to independence in walking as a threshold. The early group included patients who attained independence in walking before postoperative day 3, even if the distance was limited (e.g., 50 m), and the late group included patients who attained independence in walking on or after postoperative day 3. The independence in walking was judged from supervised walking with physical therapist. All patients eventually attained independence in walking. Postoperative diets were restarted, even in the absence of bowel movement, if flatus could be confirmed and there was no clear abdominal distension or pain. Criteria for hospital discharge were that the patient was afebrile with normal vital signs, was able to eat, and was ambulatory.

Statistical analysis

Pre-, intra-, and post-operative recovery data were compared between the two groups. The Chi-squared and Mann–Whitney U tests were used for the statistical analyses. Stepwise binary logistic regression was used to investigate the effect of the pre- and intraoperative variables showing $p < 0.25$ in the intergroup comparison analysis using grouping based on time to attaining independence in walking, and odds ratios were calculated for each variable. The data were analyzed with SPSS software (version 20.0 for Microsoft Windows, SPSS Inc, Chicago, IL, USA). $p < 0.05$ was considered statistically significant.

Results

Patient baseline characteristics and preoperative physical activity level are shown in Table 1. Preoperatively, there

Table 1 Patient baseline characteristics and preoperative physical activity

	Early group ($n = 36$)	Late group ($n = 31$)	p value
Age (years)	68.7 ± 6.1	69.0 ± 7.6	0.777
Male/female (*n*)	35/1	27/4	0.116
Height (cm)	164.5 ± 6.9	160.2 ± 30.8	0.320
BMI (kg/m^2)	22.9 ± 4.4	22.7 ± 4.2	0.980
Smoking history (*n*)	25 (69 %)	24 (82 %)	0.463
Hypertension (*n*)	27 (75 %)	27 (87 %)	0.212
Diabetes mellitus (*n*)	5 (13 %)	5 (16 %)	0.798
Dyslipidemia (*n*)	23 (74 %)	17 (54 %)	0.451
COPD (*n*)	2 (5 %)	4 (12 %)	0.294
Coronary artery disease (*n*)	10 (27 %)	14 (45 %)	0.139
Chronic kidney disease (*n*)	7 (19 %)	4 (12 %)	0.471
Cerebrovascular disease (*n*)	5 (13 %)	7 (22 %)	0.355
Sleeping disorder (*n*)	6 (16 %)	3 (9 %)	0.403
Taking an anti-anxiety drug (*n*)	4 (11 %)	5 (16 %)	0.548
Engaging in regular physical activity (*n*)	24 (66 %)	13 (41 %)	0.042*
6MWD (*m*)	447.6 ± 82.3	409.8 ± 119.5	0.034*

Data of sex, hypertension, diabetes mellitus, dyslipidemia, sleeping disorder, COPD, coronary artery disease, chronic kidney disease, cerebrovascular disease, smoking history, and engaging in regular physical activity are number and (%) of patients replied subjective "yes". These data were analyzed χ^2 test. And data of age, height, BMI, and 6MWD are mean ± standard deviation of the mean (SD). These data were analyzed Mann–Whitney *U* test

BMI body mass index, *COPD* chronic obstructive pulmonary disease, *6MWD* 6-min walking distance

* Different between early group and late group

were no significant differences in patient baseline characteristics, such as age and height between the two groups. However, the number of patients engaging in regular physical activity in the early group was significantly greater than that in the late group ($p = 0.042$). In addition, preoperative 6MWD was significantly longer in the early group than that in the late group ($p = 0.034$).

Intraoperative variables and postoperative course are shown in Table 2. There were no significant differences in the intraoperative variables between the two groups. No patients suffered obvious ileus symptoms. Time to attaining independence in sitting, standing, and walking were significantly shorter in the early group compared with in the late group ($p = 0.017$, $p < 0.001$, and $p < 0.001$, respectively). Time to hospital discharge was significantly shorter in the early group compared with in the late group ($p = 0.031$).

The results of the binary logistic regression analysis are shown in Table 3. Five preoperative and intraoperative variables showing $p < 0.25$ in the intergroup comparison analysis (i.e., sex, hypertension, coronary artery disease, engaging in regular physical activity, and 6MWD) were entered into the binary logistic regression models for early ambulation (within 3 days), and odds ratios were calculated. Engaging in regular physical activity was the only variable significantly associated with attaining early ambulation (odds ratio 2.769, 95 % CI 1.024–7.487, $p = 0.045$).

Discussion

The results of the present study suggest that preoperative regular physical activity is associated with early ambulation after open AAA surgery and provides a good marker of early postoperative course.

In the preoperative period, it is important for medical staff to be able to assess reserve physical capacity in abdominal surgery patients [22, 23]; however, there is currently no simple screening tool available. There are several reports showing that preoperative physical activity is related to postoperative course after several types of abdominal surgery [24, 25]. For example, in elective colon resection surgery, preoperative 6MWD is correlated with postoperative 6MWD at 3 and 6 weeks [24], and in total hip arthroplasty, muscle strength, and the Timed Up and Go (TUG) test score are useful predictive indicators of postoperative ambulation ability [13]. In addition, poor preoperative physical status, including poor TUG test score, functional reach, and handgrip strength, are associated with prolonged recovery of activities of daily living at 3 months after major abdominal surgery in the elderly [25]. To our knowledge, the present study is the first to show that regular physical activity predicts early ambulation after open AAA surgery.

Table 2 Intraoperative variables and postoperative recovery

	Early group ($n = 36$)	Late group ($n = 31$)	p value
Intraoperative data			
Aneurysm diameter (mm)	53.6 ± 10.9	53.3 ± 8.2	0.854
Operative time (min)	243.0 ± 47.4	247.6 ± 52.0	0.955
Blood loss (ml)	1637.2 ± 1516.2	1957.5 ± 1683.9	0.428
Suprarenal aortic cross-clamping (*n*)	7 (19 %)	7 (22 %)	0.753
Acute renal dysfunction (*n*)	1 (2 %)	4 (12 %)	0.116
Postoperative data			
Max CRP (mg/dl)	19.3 ± 5.3	18.7 ± 5.7	0.458
Max WBC (mg/dl)	10.1 ± 2.3	10.2 ± 3.9	0.930
Time to independence in sitting (days)	1.1 ± 0.4	1.5 ± 0.6	0.017*
Time to independence in standing (days)	1.4 ± 0.5	2.0 ± 0.6	<0.001*
Time to independence in walking (days)	1.8 ± 0.3	3.7 ± 0.9	<0.001*
Time to resuming preoperative diet (days)	2.1 ± 0.6	2.2 ± 0.4	0.162
Time to hospital discharge (days)	9.8 ± 2.1	11.2 ± 2.8	0.031*

Data of surrenal aortic cross-clamping, and acute renal dysfunction are number and (%) of patients replied subjective "yes". These data were analyzed χ^2 test. And data of aneurysm diameter, operative time, blood loss, max CRP, max WBC, time to independence in sitting, standing, resuming preoperative diet, and hospital discharge are mean ± standard deviation of the mean (SD). These data were analyzed Mann–Whitney *U* test

CRP C-reactive protein, *WBC* white blood cell count

* Different between early group and late group

Table 3 Binary logistic regression analysis for early ambulation (within 3 days)

	Odds ratio	95 % CI		p value
		Lower limit	Upper limit	
Engaging in regular physical activity	2.769	1.024	7.487	0.045*

Five preoperative and intraoperative variables with $p < 0.25$ (i.e., sex, hypertension, coronary artery disease, engaging in regular physical activity, and 6-min walking distance) were entered into the binary logistic regression models. Engaging in regular physical activity was the only statistically significant variable

The 6MWD test is a simple, safe, and inexpensive alternative to aerobic exercise testing [26]. It reflects the capacity to undertake day-to-day activities, and has been used extensively [27]. In the present study, preoperative 6MWD and engaging in regular physical activity were significantly greater in patients attaining early independence in walking. In addition, the 6MWD was significantly weak correlated with postoperative day of independent walk ($r = –0.265$, $p = 0.030$, data not shown). Engaging in regular physical activity is only significantly associated with attaining early ambulation by multivariate analysis, suggesting that it could improve not only survival time but also postoperative course regardless of age or background. However, these observations should be interpreted with caution because the 6MWD is influenced by age and height [27], and engaging in preoperative regular physical activity was treated as binary data, whereas the 6MWD as continuous variables.

The mean value of 6MWD (average of all subjects; 430 m) in the present study was lower than in an age-matched sample of the Japanese general population (561–625 m; data provided by the Ministry of Education, Culture, Sports, Science and Technology, Japan) [28]. One reason for this might be that patients undergoing AAA surgery are educated to refrain from strenuous exercise until after the operation, and therefore the patients in the present study avoided exercise during the preoperative period. In contrast, the proportion of patients engaging in regular physical activity (average of all subjects; 55.2 %) made a little difference in an age-matched sample of the Japanese general population (43.2–49.2 %; data obtained from the National Livelihood Survey) [21]. The 6MWD under medical supervision is safe and feasible in preoperative cardiovascular patients [16], however, the preoperative patients have a fear of exercise. The 6MWD was needed to be performed by providing sufficient explanation in preoperative cardiovascular patients.

Early ambulation is useful for preventing postoperative complications, generating patient motivation, and reducing overall healthcare costs [8–11]. Therefore, in addition to patient characteristics, preoperative physical activity should also be assessed during the preoperative medical examination. In the present study, patients who started walking on

or after postoperative day 3 followed an overall delayed postoperative course, as shown in Table 2. Furthermore, time to discharge was significantly shorter in patients attaining early independence in walking. A previous study showed that the sooner independence in ambulation is reached, the sooner patients are discharged, and the lower are the overall hospital-related costs [9]. Therefore, our findings on the prediction of postoperative ambulation will help medical staff assess time to recovery and help patients understand their own postoperative course.

The success of the postoperative course relies on a cooperative effort between the medical staff and the patient [8]. Patients are anxious about their postoperative course and feel uneasy when discharged from hospital soon after surgery [29]. In addition, techniques for postoperative rehabilitation in patients undergoing open AAA surgery are not yet sufficiently developed [17], despite the substantial functional impairment associated with AAA [30, 31]. This suggests that predicting postoperative ambulation is important not only for assessing the impact of surgery but also for reassuring patients regarding their postoperative progress. To achieve early recovery and discharge, further investigations of the effects of postoperative care after open AAA surgery are needed. Moreover, assessment during the preoperative medical interview of whether the patient is engaging in regular physical activity will provide the medical staff with information that can help in discharge planning by indicating the need for acute postoperative rehabilitation or the provision of healthcare services.

The present study was limited by its retrospective nature, and because we included only a small number of patients from a single medical center, our observations must be interpreted with caution. A larger study to further investigate the relationship between preoperative regular physical activity and postoperative time to ambulation is required.

Conclusions

Preoperative regular physical activity is associated with early ambulation after open AAA surgery, leading to early discharge. Our findings contribute to providing a marker of the postoperative course in patients after open AAA surgery.

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Conflict of interest Both Takahisa Kondo and Akihiro Hirashiki belong to a department that receives endowments from Actelion Pharmaceuticals Japan Ltd.

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