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Effects of Length of Bed Rest during Hospitalization on Skeletal Muscle in Patients with Conservatively Treated Acute Aortic Dissection

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Abstract

Background: Little evidence exists on the effects of exercise guidance in patients with acute aortic dissection after a period of complete bed rest. Few studies have examined changes in skeletal muscle during such periods in patients with cardiovascular disease. This retrospective study sought to investigate changes in skeletal muscle in the standard rehabilitation period in patients with aortic dissection and to discuss an optimal rehabilitation approach to promote safe early return to the community.

Methods: Subjects were 54 patients with conservatively treated acute aortic dissection in whom serial computed tomography (CT) was performed for assessment of complications and follow-up observation of the aortic dissection. Using CT images, cross-sectional areas of the erector spinae muscle at the 7th cervical (A) and 3rd lumber vertebrae (B), the rectus abdominis muscle at the umbilical level (C), and the psoas major muscle at the 5th lumbar vertebra (D), were compared at different time points.

Results: All patients were hypertensive, with the proportion of untreated patients being higher than that of treated patients. Cross-sectional areas of (A) and (B) significantly decreased approximately one week after admission compared with those at admission (p=0.0001). Cross-sectional area of (D) significantly decreased approximately one month after admission (near discharge) (p=0.0002). The decrease in the cross-sectional area of these muscles persisted up to two months after admission (p=0.0002). There were no changes over time with (C).

Conclusion: Muscle weakness not only leads to reduced activities of daily living but also adverse events such as a fall. Development of a rehabilitation program involving resistance training is needed to promote early return to the community, although control of blood pressure is a prerequisite.

Keywords: Cardiac rehabilitation; Acute aortic dissection; Skeletal muscle; Bed rest; Cardiovascular disease; Conservative treatment

Introduction

Some cardiovascular diseases may become serious suddenly and unexpectedly. Patients with such diseases are often forced to restrict the amount of physical activity to a level totally different from their lifestyle before the onset of disease. Acute aortic dissection is one such disorder and patients are confined to complete bed rest in the acute stage. There is subsequently a gradual reduction in the degree of immobilization along with improvement of the disease. Bed rest level is determined by the patient's condition including changes in blood pressure and symptoms, the number of days after onset, and imaging findings of the lesion [1]; however, insufficient consideration is given to the loss of muscle strength and physical ability during the bed rest period. In clinical practice, we often encounter patients who have anxiety about returning to activities of daily living (ADL) because their physical performance has not fully recovered at the time of discharge. This anxiety may be due in part to the nature of the disease, in which sudden restriction in physical activity level is imposed, making the patients bewildered or stressed. However, there is also a possibility that healthcare professionals do not provide sufficient guidance on return to the community, due to the lack of exercise guidelines during bed rest based on the patient's physical performance.

Muscle strength in humans decreases with age and long-term physical inactivity [2,3]. A previous study reported that even a relatively short period of bed rest of approximately 20 days caused a decrease in muscle strength in the lower extremities [4]. While there are numerous studies measuring the cross-sectional area of skeletal muscle using computed tomography (CT) for evaluation of myopathy or sarcopenia [5,6], few studies have examined changes in skeletal muscle during bed rest in patients hospitalized with cardiovascular diseases.

In our hospital, we provide rehabilitation services for patients with conservatively treated acute aortic dissection, in which the bed rest level is determined according to the guidelines of the Japanese

Circulation Society (JCS 2011). The standard course is as previously described [1]: the patient is confined to bed (light activity may be allowed) until Day 6; the patient starts stepping exercises at bedside on Day 7; the patient is not allowed to walk for approximately 10 days after admission in order to avoid exacerbation of disease. Subsequently, walking distance is gradually increased and the patient is discharged approximately 3-4 weeks after admission if there are no problems. During hospitalization, the patient's muscle condition may change. We consider that it is important to understand the changes in muscle condition of patients in order to assist their early return to the community and prevent adverse events such as a fall. The objectives of this study were to investigate changes in the cross-sectional area of skeletal muscle over time during hospitalization using CT images recorded for follow-up of acute aortic dissection and discuss an optimal rehabilitation approach for such patients.

Methods

Study design

Patient selection (Figure 1): This is a retrospective study. Subjects were selected from 101 patients with acute DeBakey type III aortic dissection who were emergently transferred to the coronary care unit (CCU) of Hyogo College of Medicine Hospital and admitted for medical treatment between April 2007 and March 2016. Excluded were 21 patients who were unable to complete the standard rehabilitation program according to the JCS 2011 guidelines due to exacerbation of symptoms, 7 patients who had not been able to walk without assistance before admission due to cerebrovascular diseases or orthopedic disorders, 8 patients from whom CT images for comparison were not available due to the patient's conditions (such as kyphotic spine), and 11 patients who were unable to be followed up with a CT scan on an outpatient basis. A retrospective analysis was performed in the remaining 54 patients (38 males, 16 females, mean age of 67 ± 13 years).

This study was conducted after approval by the ethics committee of Hyogo College of Medicine (approval number 2110).

Study procedure

Patient characteristics (Table 1): Subjects were examined for history of smoking and obesity, presence of complications including hypertension, diabetes mellitus, and dyslipidemia and their treatment conditions, and presence of arterial diseases (ischemic heart disease, peripheral arterial disease) by reviewing their medical records on admission.

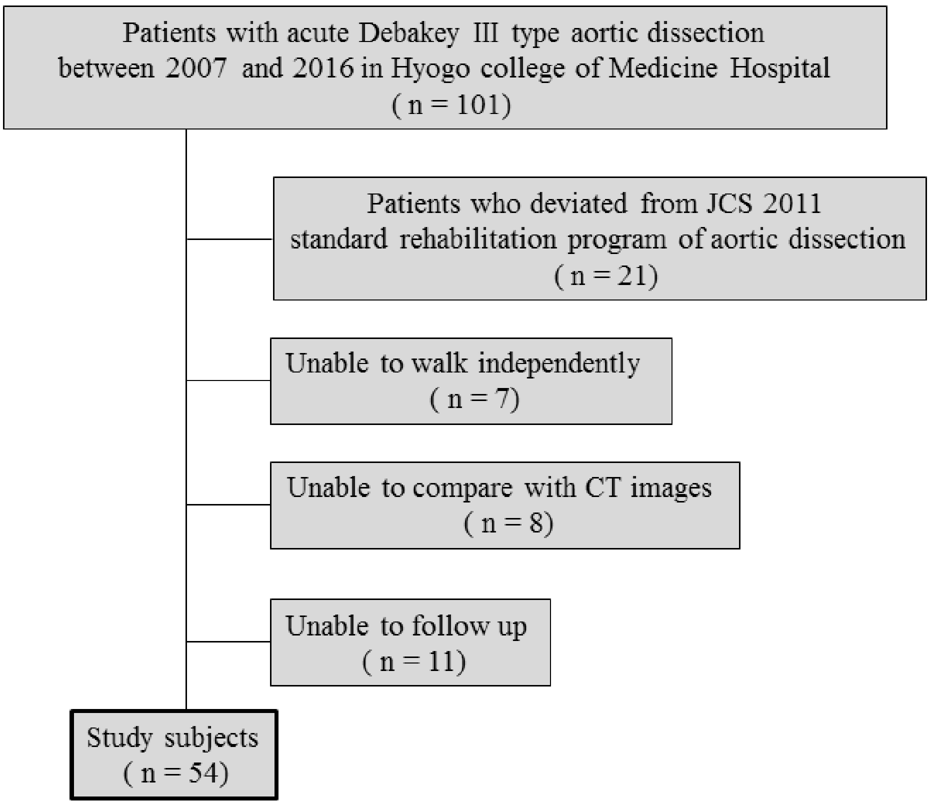

Figure 1: Disposition of patients (The figure shows the selection of patients).

n (%male)	54 (70.3%)	
Age (years, mean±SD)	67 ± 13	
Current Smoker (n. %)	28 (51.9%)	
Obesity (n. %)	10 (18.5%)	
Complications (n. %)	**treated**	**untreated**
Hypertension	16 (29.6%)	38 (70.4%)
Lipid Disorder	12 (22.2%)	10 (18.5%)
Diabetes Mellitus	10 (18.5%)	8 (14.8%)
	with	**without**
Ischemic Heart Disease	5 (9.0%)	39 (91.0%)
Peripheral Arterial Disease	2 (3.7%)	52 (96.3%)

Table 1: Characteristics of patients at hospitalization.

Evaluation of muscle by Computed Tomography (CT) images (Figure 2): CT images obtained for follow up of aortic dissection were used in the present study. CT was performed five times for each patient: on admission (control), at approximately one week (Day 6–8: 1W), approximately two weeks (Day 13-16: 2W), approximately one month (Day 24–29: 1M), and approximately two months (Day 55-60: 2M) after admission.

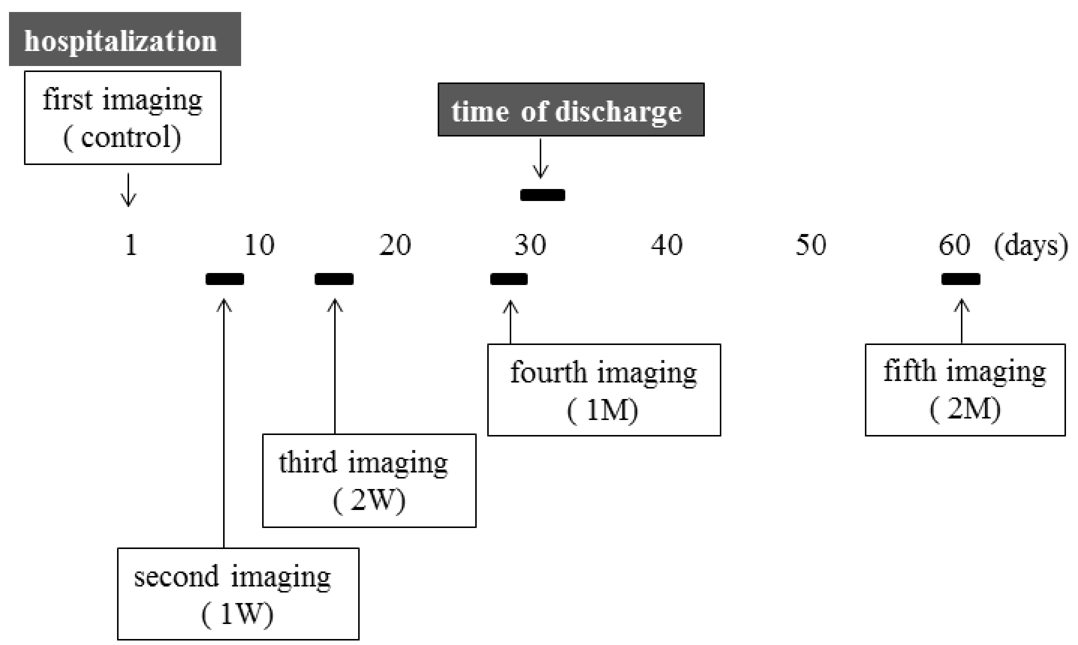

Figure 2: Timing of Computed Tomography imaging (The clinical course of patients and the timing of CT scans are indicated).

CT was performed using a SOMATOM Sensation Cardiac CT scanner (SIEMENS Munich, Germany) with a tube voltage of 120Kv and tube current of 160 mAs. Slice width was 8 mm. After plain CT scanning, a contrast agent (Iopamiron injection 300 syringe, 100 mL; Bayer, Osaka, Japan) was injected at a speed of 1.5 mL/sec, and repeat CT was performed 70 seconds after the injection of contrast agent. Plain CT images were used in the present analysis.

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Measurement of muscle cross-sectional area (Figure 3A-D): Among the skeletal muscles identified in plain CT images, four anatomically comparable regions were chosen: the erector spinae muscle at the 7th cervical vertebra (C7 ESM), the erector spinae muscle at the 3rd lumbar vertebra (L3 ESM), the rectus abdominis muscle at the umbilical level (RAM), and the psoas major muscle at the 5th vertebra (L5 PMM). Cross-sectional areas (CSA) of the skeletal muscles were measured by CT, and the changes in areas over time were analyzed. The analysis was performed on the same reduced scale using area-measuring software (Adobe Acrobat 9 Standard, Tokyo, Japan).

The CSAs of four muscles on admission were used as controls, and rates of change of CSAs over time were analyzed. CSA values were calculated as the means of right and left CSAs of each muscle.

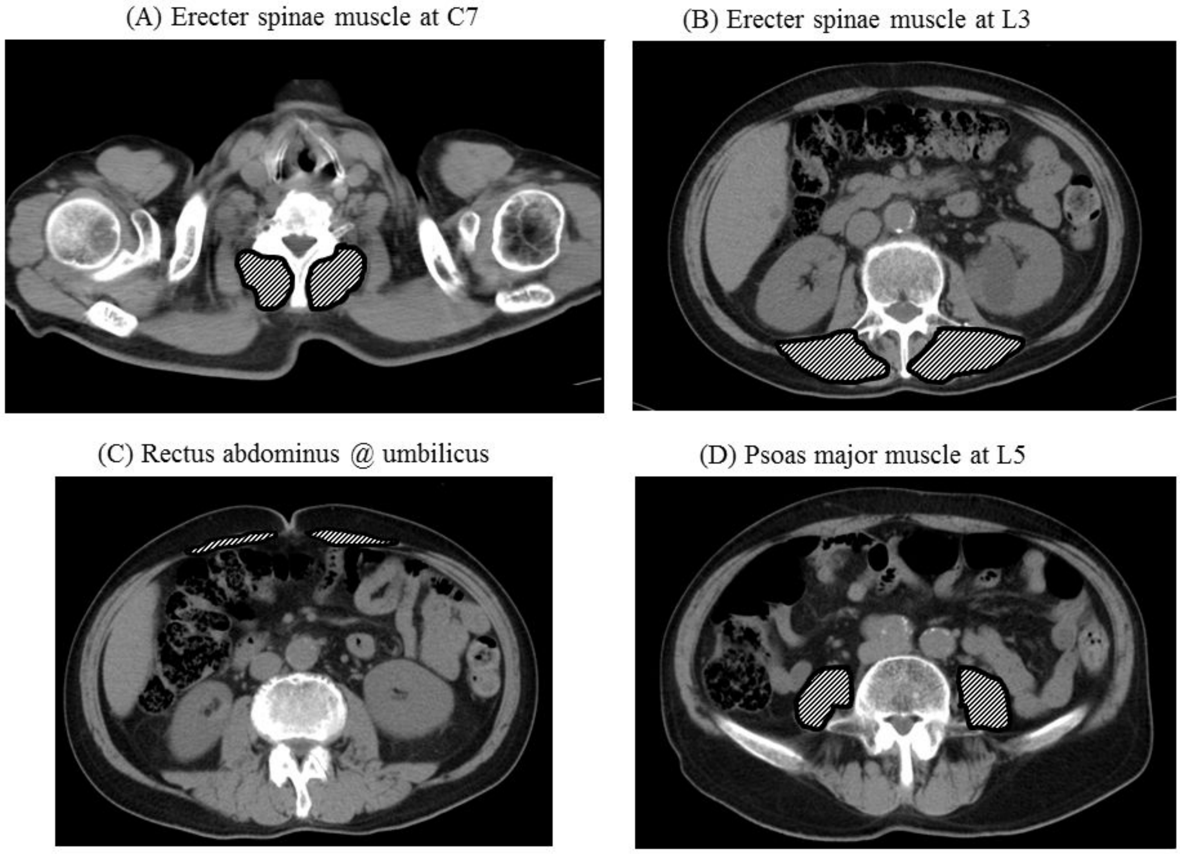

Figure 3: Examples of measurements made in each muscle type. Cross-sectional areas of skeletal muscle samples are shown: (A) the erector spinae muscle at the 7th cervical vertebra; (B) the erector spinae muscle at the 3th lumbar vertebra; (C) the rectus abdominis in the umbilical level; (D) the psoas major muscle at the 5th lumbar vertebra. The shaded areas are measured as cross sectional areas of muscle types.

Statistical Analysis

Age was expressed as mean values ± SD. Intergroup comparisons were performed using Mann-Whitney's U test. Statistical significance was set at $p<0.001$. All statistical analyses were performed using SPSS statistical package ver 20.0 (SPSS, Inc. Chicago, IL, USA).

Results

Patient characteristics (Table 1)

Of the patients in the present study, 70.3% were male. Approximately half of patients (51.9%) were smokers and 18.5% of patients had obesity. All were hypertensive and 29.6% of these were receiving treatment, i.e. the proportion of untreated patients was much greater than that of treated patients. The proportion of patients with ischemic heart disease or peripheral arterial disease was markedly lower than of those without these arterial diseases (with ischemic heart disease, peripheral arterial disease *vs.* without ischemic heart disease, peripheral arterial disease ; 9.0%, 3.7% *vs.* 91.0%, 96.3%).

Changes in muscle cross-sectional area (CSA)

CT scan at admission (control), 1W, 2W, and 1M was performed during hospitalization and that at 2M was performed in an outpatient setting (Figure 2).

	control	1W(mean ± SD)	p-value	2W (mean ± SD)	p-value

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erecter spine muscle at C7	1	0.9470 ± 0.0289	0.0001	0.8913 ± 0.0242	0.0003
erecter spine muscle at L3	1	0.9452 ± 0.0290	0.0001	0.9031 ± 0.0184	0.0001
rectus abdominus at umblicus	1	1.0023 ± 0.0116	1	1.0004 ± 0.0200	0.2568
psoas major muscle at L5	1	1.0018 ± 0.0076	0.4497	0.9938 ± 0.0161	0.0233
	control	1M(mean ± SD)	p-value	2M(mean ± SD)	p-value
erecter spine muscle at C7	1	0.8815 ± 0.0335	0.0003	0.9486 ± 0.0318	0.0001
erecter spine muscle at L3	1	0.9295 ± 0.0244	0.0002	0.9560 ± 0.0207	0.0002
rectus abdominus at umblicus	1	1.0028 ± 0.0129	0.4497	1.0017 ±0.0101	1
psoas major muscle at L5	1	0.9379 ± 0.0247	0.0002	0.9423 ± 0.0141	0.0002

C7, 7th cervical vertebra; L3, 3th lumbar vertebra; L5, 5th lumbar vertebra; control, first imaging at hospitalization 1W, approximately one week after admission; 2W, approximately two weeks after admission; 1M, approximately one month after admission; 2M, approximately two months after admission.

Table 2: Comparisons of changes in cross-sectional area versus control.

CSA of the erector spinae muscle (ESM) at C7 and L3 levels significantly decreased one week after admission (control *vs.* EMS C7, p=0.0001; control *vs.* EMS L3, p=0.0001) and a significant reduction was also observed at 1M (control *vs.* EMS at C7, p=0.0003; control *vs.* EMS at L3, p=0.0002) and 2M (control *vs.* EMS at C7, p=0.0001; control *vs.* EMS at L3, p=0.0002). Even at 2M (after discharge) CSA values were significantly lower than controls, indicating a lack of recovery to pre-admission levels. The CSA of the psoas major muscle (PMM) at L5 level did not show significant change at 1W and 2W compared with control (1W, 2W; p=0.4497, p=0.0233), but significantly decreased at 1M (near discharge), and was significantly lower than control even at 2M again indicating a lack of recovery to pre-admission levels (1W, 2W; p=0.0002, p=0.0002). The CSA of RAM at umbilical level showed no significant changes over time compared with control (Table 2).

Discussion

This study analyzed changes in the cross-sectional area of skeletal muscle over time during hospitalization, using CT images in patients with acute DeBakey type III aortic dissection who underwent standard rehabilitation according to the JCS 2011 guidelines.

All patients were hypertensive, among whom the proportion of patients with untreated hypertension was significantly higher than that of treated patients. Fewer patients had diabetes, dyslipidemia or other arterial diseases. Regarding changes in the cross-sectional area of skeletal muscle measured by CT images, the RAM involved in flexion and rotation of the body [4] did not show changes over time, whereas the ESM at C7 and L3 levels and the PMM at L5 level showed significant decrease in cross-sectional area up to two months after onset, suggesting that the cross-sectional area had not recovered to the level before admission even in the outpatient follow-up period.

A close association between hypertension and development of aortic dissection has been reported [7]. In the present study, hypertension was present in all patients, while diabetes mellitus and dyslipidemia were present in a small number of patients. Arteriosclerosis is also a potential cause of aortic dissection [1]. However, histopathological studies have reported that arteriosclerosis of the vessel wall in patients with aortic dissection was mild or moderate [7], and their histological vessel image was different from that in patients with peripheral artery disease who had severe arteriosclerosis requiring systemic management [8]. In our study, only a small proportion of patients had ischemic heart disease or peripheral artery disease, suggesting a possibility that not only arteriosclerosis, but also other factors were involved in the development of aortic dissection.

A previous study reported that muscle strength was mostly determined by muscle mass, and strongly correlated with cross-sectional area values of skeletal muscle calculated from imaging studies [9]. The present study examined changes in cross-sectional area of skeletal muscle using CT images. Cross-sectional area of the ESM in the cervical and lumbar regions decreased approximately one week after admission. The cross-sectional area of the PMM started to decrease later than that of the ESM. The latter has an important role in maintaining body posture and controlling body balance during exercise [10]. The PMM, as well as the femoral muscle, is important in walking [11]. Given that the reactivity of skeletal muscle differs depending on muscle fiber composition [12] and the degree of deterioration from prolonged bed rest differs among muscle types [4], the difference in the starting time of changes in the cross sectional area in the present study was probably due to differences in muscle composition. When applying the results to the standard course program according to the JCS 2011 guidelines [1], we assumed that the reduction of cross-sectional area of the ESM both in the cervical and lumbar regions may start around the time when the patient is allowed to walk, and that of the PMM may start around the time of discharge. In addition, the cross-sectional area of both ESM and PMM did not recover to the point before admission until approximately one month after discharge, suggesting a possibility that patients had problems in their ADL. The reduction in thickness of lumbar and spinal muscle leads to decreased walking speed [13], and dysfunction of the PMM can be a cause of falls [11]. It is also reported that muscle strength of individuals in their 70s and 80s decreases by 20-40% compared to that of younger individuals, and 30% of those in their 60s may suffer from sarcopenia [14]. The peak age of onset for aortic dissection is the 70s for both males and females [1], and mean age of the patients in the present study was 67 years. It would therefore be expected that a majority of patients with aortic dissection would have decreased muscle strength at the time of onset. If a patient receiving rehabilitation has a decreased cross-sectional area of the skeletal muscle involved in maintaining posture and walking when allowed to walk longer distances, he or she may have reduced ADL and there may be a risk of adverse events from the perspective of medical safety.

Regarding the effects of rehabilitation for aortic dissection, intervention in the acute phase is reportedly effective in reducing respiratory complications, suggesting the efficacy of early rehabilitation [15-17]. However, patients with aortic dissection need complete bed rest for at least 48 h after onset because there is an increased risk of aortic rupture [1], and there is little evidence of the influences of physical activity and exercise after the period of complete bed rest. It has previously been reported that patients tended to be short of exercise and depressed after aortic dissection, and there was a possibility that forced bed rest without an underlying rationale might have caused patients to become anxious [18]. In our clinical practice, we encountered patients with conservatively treated aortic dissection who became aware of reduced physical strength as the degree of bed rest became less strict, and became depressive due to anxiety about economic issues or return to work [19]. Patients with aortic dissection require bed rest, but a severe restriction of physical activity may decrease the patient's physical function and quality of life [20]. Muscle fiber type changes in response to an exercise environment [21], and a study has reported that resistance exercise three times a week counteracted the atrophy of lumbar muscle even in patients on bed rest [22]. Therefore, a careful observation of symptoms and a rehabilitation program involving resistance exercise with awareness of the potential reduction in muscle strength due to bed rest is needed to support early return to the community, although control of blood pressure is a prerequisite.

Conclusion

Cardiac rehabilitation is expected to reduce the tension due to sympathetic nerve system activation and is reported to increase exercise tolerance by increasing skeletal muscle blood flow [23]. Cardiac rehabilitation intervention for patients with aortic dissection is likely to be beneficial in not only improving muscle strength, but also stabilizing blood pressure. In addition, the safety of relatively high-intensity resistance training in patients with cardiac disease has been confirmed [24]. Therefore, to regain muscle strength lost during hospitalization and improve security and ADL, comprehensive cardiac rehabilitation intervention focusing on maintenance of muscle strength through inpatient and outpatient settings is needed, while paying particular attention to the primary disease.

Study Limitation

This study was limited by the small sample size at a single institution; therefore, further analysis would be needed to investigate complications in patients with aortic dissection. Analysis of the cross-sectional area using the imaging study was performed on the same reduced scale; therefore, it was not a real life comparison of the cross sectional area of the skeletal muscle.

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Conflict of Interest

The authors have no conflict of interest.

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