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Case Report

A case of acute aortic dissection with successful return to normal daily life following severe acute respiratory distress syndrome through continuous rehabilitation from the acute stage to the convalescent stage

Naonori Tashiro, RPT, PhD,[1,2] Tokutada Sato, MD, PhD,[3] Hiroshi Suzuki, MD, PhD,[3] Fumihito Kasai, MD, PhD[4]

[1]Department of Physical Therapy, School of Nursing and Rehabilitation Sciences, Showa University, Yokohama, Kanagawa, Japan
[2]Rehabilitation Center, Showa University Fujigaoka Rehabilitation Hospital, Yokohama, Kanagawa, Japan
[3]Department of Internal Medicine, Showa University Fujigaoka Hospital, Yokohama, Kanagawa, Japan
[4]Department of Rehabilitation Medicine, Showa University, Shinagawa-ku, Tokyo, Japan

ABSTRACT
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A 70-year-old male with back pain presented to the hospital for Stanford type B acute aortic dissection. Treatment was initiated using rest and a combination of antihypertensive drugs and analgesics. On day 2 of hospital stay, he developed hypoxemia and was diagnosed with acute respiratory distress syndrome (ARDS). On day 4 of hospital stay, PaO_2/FiO_2 (P/F ratio) of 124.7 indicated persistence of hypoxemia and physical therapy was initiated. Prone positioning therapy for 11–16 hours per day was performed continuously for four days. On day 7, his P/F ratio was maintained at ≥300. Image findings also indicated improvement. On day 10, he was weaned off the ventilator and began meals and ambulation. On day 12, his grip strength (right/left) was 26.8/25.5 kg, quadriceps muscle strength (right/left) was 0.22/0.19 kgf/kg, Medical Research Council (MRC) score was 56, and Functional Status Score for the Intensive Care Unit (FSS-ICU) was 28. He was therefore discharged from the ICU. His exercise load was gradually increased in stages while maintaining his systolic blood pressure at ≤140 mmHg. On day 37, he was able to walk with a cane and ascend/descend stairs. Therefore, he was transferred to the rehabilitation hospital. On day 65 of hospital stay, he was able to walk and stand without mechanical assistance. His grip strength was 34.0/33.0 kg, quadriceps muscle strength was 0.48/0.49 kgf/kg, MRC score was 60, FSS-ICU score was 35, and six-minute walking distance was 342 m, indicating satisfactory recovery of functions, and therefore he was discharged home.
Key words: acute respiratory distress syndrome, acute aortic dissection, rehabilitation, return to normal daily life

Introduction

The mortality rate of acute respiratory distress syndrome (ARDS) has gradually been on the decline because of advances in medical technology [1]; however, the rate of successful return to normal daily life among survivors is low and their quality of life (QOL) is also low. Long-term ventilator management of severe respiratory failure causes respiratory dysfunction and disorders of motor, cognitive and mental functions. Such problems persist even after discharge from the ICU. This so-called Post-Intensive Care Syndrome (PICS) has an effect on QOL. Recently, therapeutic outcomes for ARDS have shown that, in addition to the short-term survival rate, a shift towards effectiveness in long-term vital prognosis and functional recovery has also occurred.

In the present case, the patient suffered severe ARDS comorbidity with Stanford type B acute aortic dissection, and therefore required long-term ventilator management. Owing to the continuous rehabilitation performed in the ICU from the acute stage to the convalescent stage, the patient showed satisfactory

Correspondence: Naonori Tashiro, RPT, PhD
Rehabilitation Center, Showa University Fujigaoka Rehabilitation Hospital, 2–1–1 Fujigaoka, Aoba-ku, Yokohama, Kanagawa 227–8518, Japan.
E-mail: tashiro@cmed.showa-u.ac.jp
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functional improvement, which eventually allowed his return to normal daily living.

Consent to publish this data was obtained from the patient after providing a detailed description of this report.

Case

Case: A 70-year-old male, height 177 cm, weight 68.7 kg.

Medical history: At age 37, he underwent pharmacotherapy for acute pancreatitis; at 40, he underwent surgery for rupture of an Achilles tendon; at 47, he underwent surgery and pharmacotherapy for chronic recurrent otitis media. Since age 69, he has been undergoing outpatient treatment at a local hospital for hypertension.

History of current illness: After retirement he lived independently. While playing mahjong near his residence, he experienced sudden back pain and was transported to an acute-care hospital on an emergency basis.

Findings upon arrival at the hospital: He was conscious and alert upon arrival. Blood pressure (BP) was 170/86 mmHg, heart rate was 70 bpm, respiratory rate was 20 breaths/min, and arterial blood gas analysis while wearing an oxygen mask (10 L/min) showed pH 7.415, $PaCO_2$ 38.8 mmHg, PaO_2 166.8 mmHg, and HCO_3^- 24.3 mEq/L. CT findings indicated an invasive shadow in the left lung field and early-stage thrombosed-type aortic dissection from the origin of the left subclavian artery to superior to the renal artery branch.

Post-admission course: Based on the test findings, the patient was diagnosed with Stanford type B acute aortic dissection. A treatment course was initiated, which comprised rest, antihypertensive drugs, and analgesics. On day 2 of hospital stay PaO_2/FiO_2 (P/F ratio) was 108, indicating rapid onset hypoxemia. Non-invasive positive-pressure ventilation therapy was performed, but on day 3, his P/F ratio was 75.1, which indicated no improvement. In addition to elevated inflammatory response as indicated by CRP of 23 mg/dL, a chest radiograph showed diffuse invasive shadows mainly in the bilateral hilar regions Therefore, he was diagnosed with ARDS and placed on ventilation management. On day 4, the P/F ratio was 124.7, indicating little improvement in the hypoxemia. Consequently, range of motion (ROM) training and airway clearance therapy were initiated, which comprised prone positioning therapy and manual respiratory assistance procedures. His first prone positioning therapy session lasted three hours. He placed his face, anterior chest, pelvis, and knees on a memory foam urethane mat. He underwent depressurization each hour, and he changed his position every two hours. During this period, he was examined for skin problems such as pressure ulcers. His P/F ratio changed from 124.7 to 344.3, indicating immediate improvement in oxygenation. His systolic BP decreased from 105 to 103 mmHg, mean pulmonary arterial pressure decreased from 30 to 25 mmHg, and cardiac output increased from 4.6 to 5.6 L/min (Table 1). For the next four days, he underwent at least 11 hours per day of prone positioning therapy, which improved his P/F ratio to at least 300 and his image findings. Therefore, prone positioning therapy was discontinued on day 7 of hospital stay (Figure 1). During prone positioning therapy, no adverse events, such as progression of the aortic dissection, skin trouble, or tube trouble, were observed. On day 10, he was weaned off the ventilator, and began meals and ambulation. His subsequent course is shown in Table 2. On day 12 of hospital stay, his grip strength (right/left) was 26.8/25.5 kg, quadriceps muscle strength (r/l) measured using a handheld dynamometer was 0.22/0.19 kgf/kg, Medical Research Council (MRC) score was 56, Functional Status Score for the Intensive Care Unit (FSS-ICU) was 28, indicating recovery of motor functions, and Barthel Index score was 45. Therefore, he was discharged from the ICU. Subsequently, his exercise load was gradually increased in stages to maintain his systolic BP at ≤140 mmHg to expand his activities of daily living (ADL). On day 37, he was able to walk with a cane and ascend/descend stairs, grip strength (r/l) was 32.0/30.4 kg, quadriceps muscle strength (r/l) was 0.39/0.38 kgf/kg, MRC score was 60, FSS-ICU score was 33, and Barthel Index score was 100, all showing improvement. The patient expressed a desire to further improve his physical functions; therefore, on day 37, he was transferred to a rehabilitation hospital where he underwent the following physical therapy continuously at two sets/day: muscle strengthening, balance training, walking training, and ADL training. A cardiopulmonary exercise test performed on day 46 showed that his peak VO_2 was 16.6 mL/min/kg and exercise tolerance predicted value decreased to 72%. Thus, he began aerobic exercise with the target set at an anaerobic threshold of heart rate at 71 bpm. On day 65 he was able to stand without mechanical assistance and walk; his grip strength (r/l) was 34.0/33.0 kg, quadriceps muscle strength (r/l) was 0.48/0.49 kgf/kg, MRC score was 60, FSS-ICU score was 35, and six-minute walking distance was 342 m, all of which showed improvement. His ADL was rated at a Barthel Index score of 100, and therefore he was discharged home. After discharge, he was able to use public transport when making outpatient visits to this hospital.

Discussion

Acute aortic dissection is reportedly associated with sudden worsening oxygenation two or three days after onset, regardless of whether respiratory status was preserved immediately after onset [2]. Possible explanations for this include inflammatory response

Table 1. Cardiopulmonary parameters at pre and post prone position (on day 4).

	Pre prone position	Post prone position
TV (mL)	650	750
RR (bpm)	12	12
pH	7.415	7.423
$PaCO_2$ (mmHg)	43	42.5
PaO_2 (mmHg)	74.8	206.6
HCO_3^- (mEq/L)	27	27.1
P/F ratio	124.7	344.3
Lac (mmol/L)	1.11	1.15
SvO_2 (%)	76	79
HR (bpm)	115	110
BP (s/d/m) (mmHg)	105/68/80	103/65/78
PCWP (mmHg)	16	16
mPAP (mmHg)	30	25
RAP (mmHg)	25	10
CO (L/min)	4.6	5.6
CI ($L/min/m^2$)	2.4	2.6
SVR ($dyn \cdot sec/cm^5$)	1,515	1,425
SVRI ($dyn \cdot sec \cdot m^2/cm^5$)	2,757	2,622
Noradrenaline (μg/kg/min)	0.1	0.1
DOB (μg/kg/min)	3	3
Dexmedetomidine (μg/kg/h)	0.1	0.2
Fentanyl (μg/kg/h)	0.5	1.4

TV, tidal volume; RR, respiratory rate; SvO_2, venous oxygen saturation; PCWP, pulmonary artery wedge pressure; mPAP, mean pulmonary artery pressure; RAP, right atrial pressure; CO, cardiac output; CI, cardiac index; SVR, systemic vascular resistance; SVRI, systemic vascular resistance index; Lac, lactate; DOB, dobutamine.

caused by damage to the vascular endothelium and the smooth muscle, the appearance of pleural effusion, and atelectasis due to bed rest; however, the exact mechanism remains unknown. In the present case, on day 2 of hospital stay the patient was found to have been suffering from sudden hypoxemia due to ARDS; therefore, we considered prone positioning therapy. Although this was a case of early-stage thrombosed-type aortic dissection, rest and antihypertensive treatment led to hemodynamic stabilization. Since the subjects in the PROSEVA study [3] conducted by Guérin et al. had the same respiratory status as the present case, we decided to perform prone positioning therapy. As a result, we achieved marked improvement in oxygenation, and the patient was able to maintain normal hemodynamic status while pulmonary arterial pressure decreased and cardiac output increased. Regarding the improvement in oxygenation, as previously reported [4, 5], the prone position reopens the dorsal alveoli, decreases intra-alveolar water content in the dorsal lungs and reduces interstitial edema, which we believe led to the improvement in the ventilation/perfusion ratio as a result of the effects of body position drainage and other factors. Furthermore, Jozwiak et al. reported that changes in hemodynamics achieved as a result of prone positioning therapy were not significant changes in heart rate and BP, but rather increases in cardiac output in cases of decreased pulmonary vascular resistance [6]. In the present case, we observed decreased

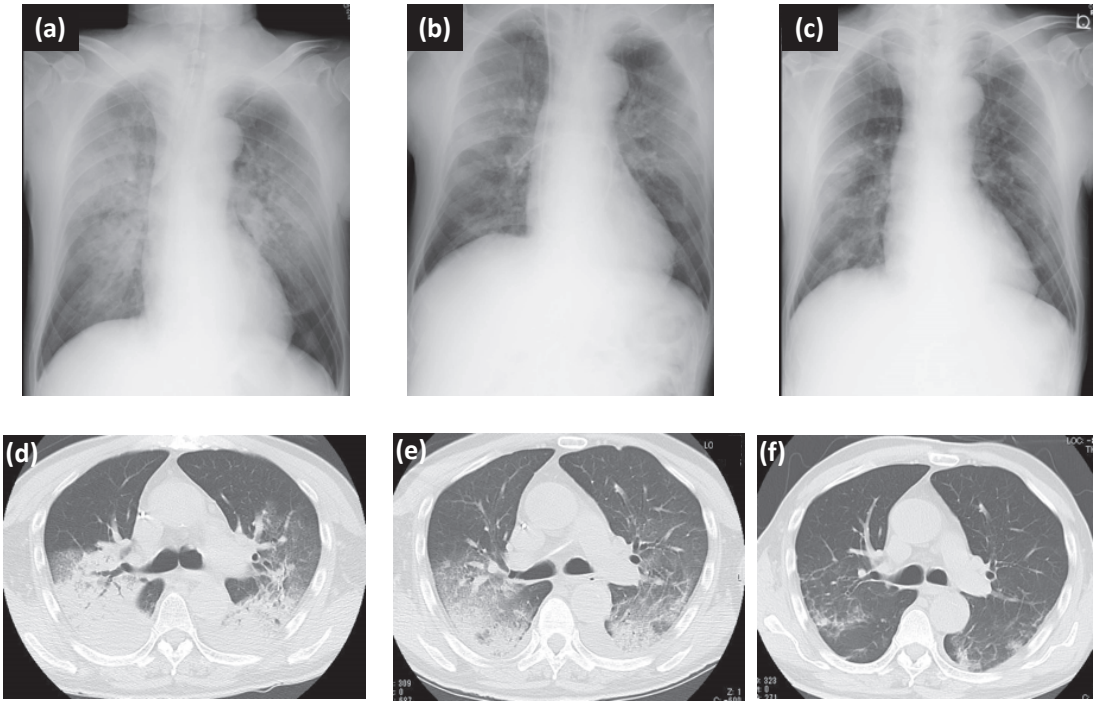
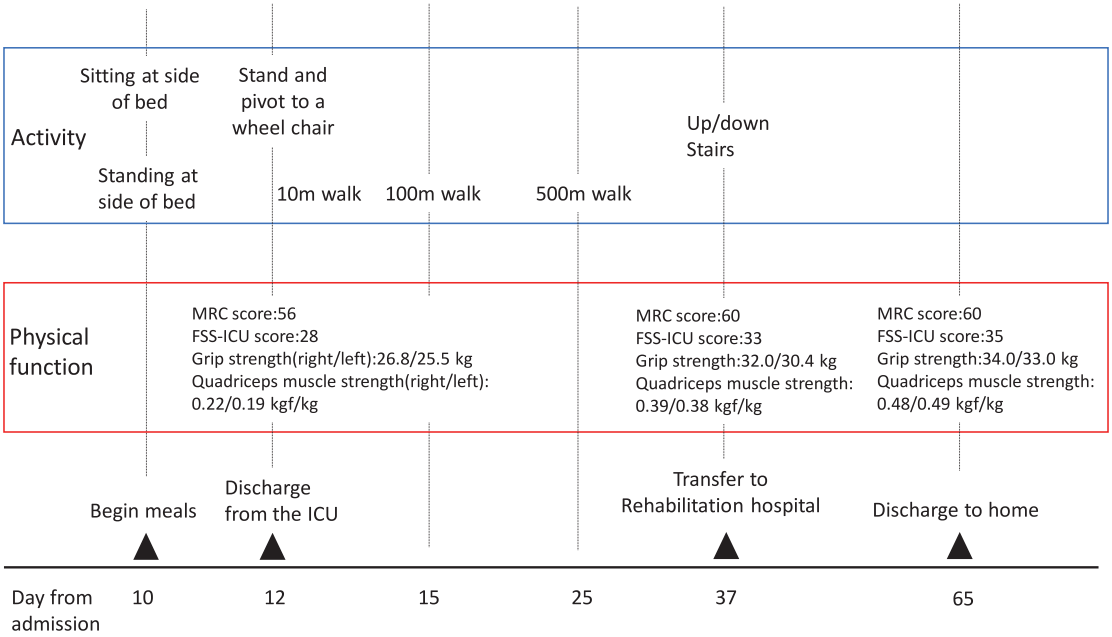


Figure 1. Chest radiography and CT findings.
(a) and (d) On day 3 after admission (pre prone position), (b) and (e) On day 6 after admission (prone position phase), (c) and (f) On day 13 after admission (post prone position).

Table 2. Summary of the clinical course.



MRC; Medical Research Council, FSS-ICU; Functional Status Score for the Intensive Care Unit.

pulmonary arterial pressure, and the dilated pulmonary arteries and resulting decrease in pulmonary vascular resistance associated with improved oxygenation and the increase in the pulmonary vascular bed resulting from the improvement in the ventilation/perfusion ratio alleviated the afterload on the right ventricle, which we believe led to the increased cardiac output.

The present case had severe ARDS that required long-term artificial ventilator management over eight days, but intervention in the form of rehabilitation led to an MRC score of 56 and an FSS-ICU score of 28 at the time of discharge from the ICU and an MRC score of 60 and FSS-ICU score of 33 at hospital discharge, indicating recovery of satisfactory motor functions.

The MRC score is an index of muscle strength in three muscle groups in each of the four extremities. The maximum total score for all four extremities is 60, and a score of <48, which indicates diffuse muscle weakness, is used as screening for ICU-acquired weakness (ICU-AW). The FSS-ICU is an evaluative index of movement capacity and is comprised of five basic movements: rolling over in bed, sitting up in bed, maintaining a seated position at the edge of the bed, standing up, and walking. Cases that are able to progress from an acute-care hospital to discharge to home are reported to have an FSS-ICU score of 19 within four days of hospital admission and a score of 28 at discharge [7]. The present case was able to avoid ICU-AW and at discharge from the ICU his FSS-ICU score was higher than 28, which is used as a rule-of-thumb for determining fitness for discharge to home [7]. However, on his detailed muscle strength evaluation using instrumentation, he did not achieve the minimum of 0.43 kgf/kg in quadriceps muscle strength that is required for independent walking in the hospital [8]. Thus, points were deducted from his walking score on the FSS-ICU at discharge, and he required continuous physical therapy at a rehabilitation hospital. On day 65 after disease onset, his scores for muscle strength, basic movement capacity, and exercise tolerance had improved markedly, enabling him to return to normal daily life. A study on the motor functions of ARDS patients [9] reported that the six-minute walking distance score after three months was a median of 281 m, which was a recovery of 49% of the predicted value. In the present case, 65 days after disease onset, the score improved to 342 m, indicating he had made remarkably good progress. Aggressive and comprehensive rehabilitation intervention after a patient moves out of the acute stage can be expected to result in improvement in the functional prognosis of severe ARDS patients. Even in cases of severe ARDS that require acute-stage treatment, continuous treatment planning designed to support patient improvement from the acute stage to return to normal daily life is required.

Conclusion

We experienced a case in which continuous rehabilitation from the acute stage to the convalescent stage was provided. The patient was suffering from Stanford type B acute aortic dissection with ARDS comorbidity that required artificial ventilation. Management led to improvement in functional prognosis and allowed the patient to return to normal daily life. In cases of severe ARDS, aggressive and continuous rehabilitation from the acute stage to the convalescent stage is required.

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