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Rehabilitation Perspectives in Spinal Cord Ischemia After Major Vascular Surgery: A Case Series

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Abstract

Objectives: This observational study aims to summarize the disability profile, rehabilitation strategies, and six-month outcomes in patients with Spinal Cord Ischemia (SC-ischemia) following Major Vascular Surgeries (MVS) at our institution. **Methods:** Retrospective data were collected from seven patients who underwent MVS between April 2016 and March 2020. **Results**: All patients were male, with a mean age of 68.7 years. SC-ischemia affected predominantly Th10 (six patients) and Th12 (one patient), resulting in severe motor paralysis in six patients and moderate paralysis in one. The average intensive care unit stay was 19.6 days, with delayed mobility observed (9.6 days to sit upright, 14.9 days to sit in a wheelchair). Patients had a prolonged hospital stay (average 70.6 days) and showed minimal improvement in activities of daily living (median Barthel Index of 10). At six months, two patients regained walking ability, while five showed little improvement. **Conclusion**: Recovery post-MVS-associated SC-ischemia is inconsistent and often limited. Future research should focus on optimizing rehabilitation strategies for these patients suffering from this catastrophic complication.

Keywords: Acute Care, Major Vascular Surgeries, Neurorehabilitation, Spinal cord ischemia, Surgical Complications

Introduction

More than 200 million people are affected by peripheral arterial disease worldwide, with 10-20% of them requiring surgery[1]. In Japan, about 4% of people over 65 years old have abdominal aortic aneurysms (AAAs), and the prevalence increases to 9.2% in males and 5.7% in females aged 80 years or older[2]. Major vascular surgeries (MVS), including aortic aneurysm repair, carotid endarterectomy, and lower limb revascularization, are increasingly common in modern medicine and carry a high risk of complications associated with the procedure itself and the presence of multiple comorbidities, such as diabetes, hypertension, a history of smoking, and cardiac disease among patients undergoing MVS[1]. One of the most devastating complications of MVS is the occurrence of spinal cord injury associated with the reduction or interruption of the blood flow to a region of the spinal cord[3]. Since, in the vast majority of cases, the damage to the spinal cord following MVS involves an ischemic event, in this manuscript, this condition will be referred to hereafter as spinal cord ischemia (SC-ischemia). The overall prevalence of SC-ischemia is very low, representing just 0.3 to 1% of all strokes and about 7% of all acute myelopathies. Consequently, due to its rarity, SC-ischemia can be an overlooked cause of disability. In addition, little is known regarding the clinical outcomes, prognostic factors, disability profile, and rehabilitation outcomes in patients with SC-ischemia following MVS.

Data from patients who have suffered traumatic spinal cord injury (SCI), such as those caused by traffic accidents, falls, and violence, indicate that the most important factor that determines prognosis is whether the injury is clinically complete or incomplete, where up to 75% of patients with

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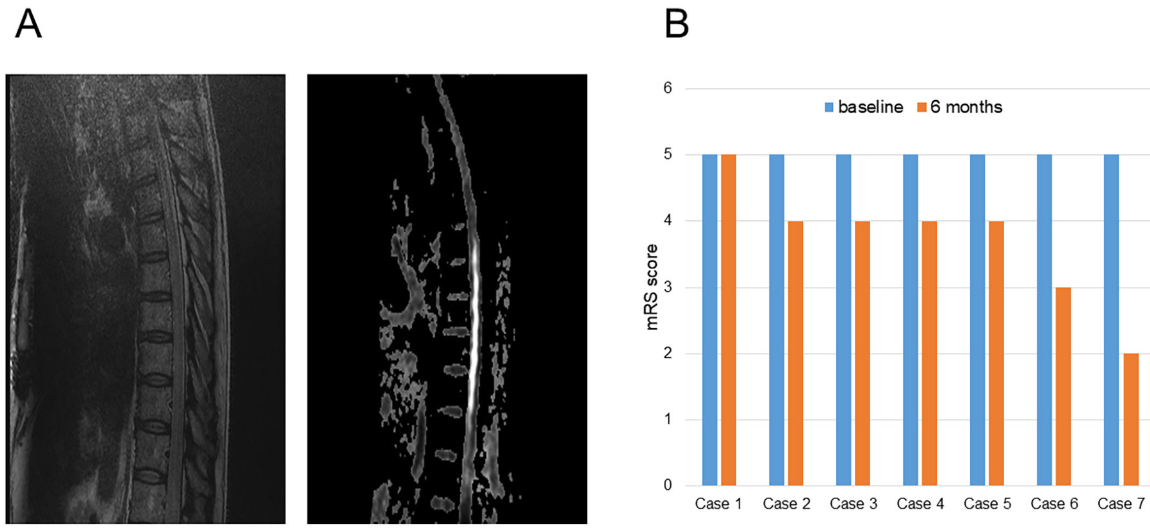

Figure 1. A) Representative MRI images of a patient (Case 3) showing spinal cord ischemia. B) The degree of disability or dependence in the daily activities of patients as measured by the Modified Ranking Scale (mRS) at baseline and six months after the SCI event.

incomplete spinal cord injury recover some degree of walking ability by one year after the event, whereas a robust motor recovery, namely weight-bearing and ambulation following complete spinal cord injury after a traumatic event is limited or absent or extremely rare. However, around 20% of complete injuries convert to incomplete during the first year after injury[4,5]. Overall, most complete and incomplete injuries recover during the first 9-12 months after injury, followed by a relative plateau reached by 12-18 months post-injury[6]. Furthermore, rehabilitation interventions have been shown to contribute to maximizing functional status among patients suffering a traumatic spinal cord injury, and it is started as soon as the patient is clinically stable after injury. This can vary from a few days to many weeks and is oriented to enable the person to return to a productive and satisfying life[5]. Unfortunately, as pointed out above, the literature regarding the disability profile and rehabilitation outcomes in patients with SC-ischemia is scarce, which may be due to the low frequency of this condition. Here, we summarized the disability profile, rehabilitation strategies, and outcomes six months after follow-up in patients who presented with SC-ischemia after MVS.

Materials and Methods

This case series included seven patients who underwent MVS between April 2016 and March 2020 at Kanazawa University Hospital and developed postoperative SC-ischemia (Figure 1A). They received physical rehabilitation and occupational therapy at our hospital. The data was retrospectively retrieved from their medical records. The initial disability status was determined according to the Asia Impairment Scale (AIS) and the classification of the International Medical Society of Paraplegia (IMSOP). It was accordingly classified into anterior spinal artery syndrome (ASAS), posterior spinal artery syndrome (PSAS), Blansekar syndrome (BSS), and complete spinal cord transection (CSCT). The survey items were patient characteristics such as age, gender, preoperative risk factors, surgical technique, and infarction level. In addition, as a secondary endpoint, clinical findings such as postoperative complications, presence of delirium, length of intensive care unit (ICU) stay, time to initiation of end positioning, time to initiation of wheelchair seating, length of hospital stay, and Barthel Index before transfer preoperative risk factors were taken from JAPAN SCORE PART D. The functional disability at 6 months postoperatively was evaluated using the modified Ranking Scale. This study conforms to all CARE guidelines and reports the required information accordingly.

Results

All patients in this study were male; the mean age was 68.7 years. The ischemic damage to the spinal cord was documented by imaging studies in all patients (Figure 1A), with the infarction level at T10 in six patients and at T12 in one patient. Preoperative risk factors were smoking history in seven patients and hypertension in seven patients. Comorbidities recorded included diabetes in three patients, renal dysfunction in two patients, previous neuropsychiatric

Table 1. Demographic and clinical characteristics.

Variable	Case 1 to Case 7 (C1~C7)	C1	C2	C3	C4	C5	C6	C7
Gender: Male (m)/ Female (f)		m	m	m	m	m	m	m
Age (years)		66	76	70	78	68	72	51
Surgical technique (○/×)	Arch replacement: 1 case	×	×	×	○	×	×	×
	Arch replacement + TEVAR: 1 case	×	○	×	×	×	×	×
	Abdominal prosthetic vascular replacement + TEVAR: 1 case	×	×	×	×	×	×	○
	Thoracoabdominal prosthetic vessel replacement: 4 cases	○	×	○	×	○	○	×
Infarction level (○/×)	Thoracic (Th10): 6 cases	○	○	×	○	○	○	○
	Thoracic (Th12): 1 case	×	×	○	×	×	×	×
Pre-operative risk factors								
Smoking (○/×)	7 cases	○	○	○	○	○	○	○
Hypertension (○/×)	7 cases	○	○	○	○	○	○	○
Diabetes Mellitus (○/×)	3 cases	○	×	○	×	×	×	○
Renal dysfunction (○/×)	2 cases	○	×	○	×	×	×	×
Neuropsychiatric disorder (○/×)	1 case	○	×	×	×	×	×	×
Postsurgical events								
Developed delirium (○/×)	3 cases	○	×	×	○	○	×	×
Time to start the training of sitting on the edge of the bed	9.6 (±4.3)	14	5	7	15	11	11	4
Time to start wheelchair seating (days)	14.9 (±7.7)	23	5	10	27	11	13	15
Days in ICU (days)	19.6(±16.9)	53	6	10	24	14	20	10
Hospitalization (days)	70.6 (±30.7)	126	45	63	40	50	58	112
Barthel index before transfer to another Facility	10 (5-30)	5	30	10	5	10	15	10
ASIA impairment scale								
ASAS (B) (○/×)	3 cases	○	×	×	×	×	○	○
ASAS (C) (○/×)	1 case	×	○	×	×	×	×	×
CSCT (A) (○/×)	3 cases	×	×	○	○	○	×	×

Abbreviations: TEVAR: Thoracic endovascular aortic repair; ASIA: American Spinal Injury Association; ASAS: anterior spinal artery syndrome; CSCT: complete spinal cord transection; ○: positive; ×: negative; ICU: intensive care unit.

Table 2. Other postoperative complications.

Postoperative complications	
Case 1	Sepsis, acute kidney failure
Case 2	Sepsis, urinary tract infection
Case 3	Sepsis, coagulopathy, brain infection
Case 4	
Case 5	Atelectasis, severe anemia, femoral artery aneurysm
Case 6	Intraoperative left injury, hypotension, postoperative pyothorax
Case 7	

disorder in one patient, and previous brain injury in one patient (Table 1). Regarding the initial disability profile, six patients had severe motor paralysis, and one patient had moderate motor paralysis. Also, three patients had ASIA impairment scale A and complete spinal cord amputation; three patients had ASIA impairment scale B and anterior spinal artery syndrome; and one patient had ASIA impairment scale C and anterior spinal artery syndrome (Table 1). The postoperative complications observed included sepsis, wound infection, cerebrovascular disease, and respiratory complications (Table 2).

The initial clinical presentation included delirium in three patients. The average length of stay in the ICU was 19.6 days. Delayed regain of mobility was also observed, with an average of 9.6 and 14.9 days for the start of sitting upright and wheelchair sitting, respectively. The average hospital stay was 70.6 days, and the median Barthel Index before being transferred to another hospital was 10 points, indicating that the patients had difficulty improving their activities of daily living (ADL) (Table 1). All seven patients in this study were transferred to the hospital, and occupational therapy was started after discharge from the ICU.

Rehabilitation therapy was started on day three after admission to the ICU. It consisted of training to strengthen residual muscle strength and respiratory support muscles to improve respiratory function and sitting and standing training with full assistance to increase circulating blood. After discharge from the ICU, active muscle strengthening training, wheelchair self-propulsion training, and orthostatic training were performed. In addition, patients with delirium were given work activities to reduce their mental stress. Once the patient could sit in a wheelchair, the approach to changing clothes and toileting was performed.

According to the Modified Ranking Scale (mRS), a commonly used scale for measuring the degree of disability or dependence in the daily activities of patients who have suffered a stroke or other causes of neurological disability, performed six months after suffering the SC-ischemia, two patients (cases 6 and 7) improved their motor function, becoming able to walk. Still, five patients did not show significant functional improvement even after transfer to a wheelchair, especially in the early stage of ASIA (Figure 1B).

Discussion

Traumatic and nontraumatic SCI constitutes a devastating neurological condition with numerous physical, social, psychological, and economic consequences for the injured patient. Physical rehabilitation and occupational therapies are essential components of patient management in clinical practice. Despite the beneficial contribution of individual rehabilitation, the lack of standardization in terms of the type of interventions, therapeutic doses, endpoint outcome, and studied populations, as well as difficulties finding appropriate control groups, represent formidable challenges associated with rehabilitation research, making it difficult to identify and quantify the level of contribution of single rehabilitation interventions after SCI. A systematic review of 19 studies of adult patients with acute and subacute complete or incomplete traumatic SCI found limited evidence regarding the timing of rehabilitation, specific interventions, therapeutic dose (intensity, frequency, duration), role and impact of patient and injury characteristics, cost-effectiveness, and efficiency of alternative interventions for acute and subacute traumatic SCI[13]. Due to the low frequency of SC-ischemia after MVS, studies regarding the clinical outcomes of this condition are limited, with most of them being heterogeneous in design and including a very small number of subjects[10-12,14]. Also, little is known about the optimal rehabilitation strategies for this condition[4]. In this study, we report the clinical outcomes from the rehabilitation perspective of seven patients who presented with SC-ischemia following MVS. All subjects in this study were men, which is consistent with what is observed in traumatic SCI and also in SC-ischemia after MVS, where the male gender has been reported to be a risk factor[10-12,14]. However, the apparent gender bias in the present study may be due to the small number of cases included here.

Spinal cord stimulation, which involves the application of mild electrical current to the spinal cord and has been largely used as an alternative approach for managing chronic pain, induced beneficial functional effects in 74% of patients with critical limb ischemia[15]. Similarly, in patients with traumatic SCI, spinal stimulation via epidural spinal stimulation and transcutaneous stimulation has been shown to improve lower and upper-extremity motor control, along with improvements in bladder function and blood pressure control after SCI, and alleviate the severe pain associated with this condition[16,17]. The utility of this approach in SC-ischemia is currently unknown. Novel approaches, including epidural electrical stimulation, exoskeleton rehabilitation robot, motor imagination, and rehabilitation training, with variable effects on the activation and reorganization of the cerebral cortex, have been tested in preclinical models, and some have been introduced in clinical practice in patients with SCI with variable but promising results[18-20]. Due to their apparent beneficial effects in modulating neurological structure and function[21], the combination of these technologies will contribute to developing personalized rehabilitation strategies for patients with spinal cord damage, including those suffering from SC-ischemia.

Ethics approval

This study was conducted according to the statements of the Declaration of Helsinki and was approved by the Ethical Committee of Kanazawa University Hospital (Approval number: 2021-309).

Authors' Contributions

YN: Conceptualization, investigation, original draft preparation, and patient management; PTI: Conceptualization, investigation, and original draft preparation; ET, SH, NM, TY: investigation and patient management; JLE: Conceptualization, writing—review, and editing. All authors have read and agreed to the published version of the manuscript.

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