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Combination of Myogenic and Neurogenic Motor Evoked Potential Monitoring During Thoracoabdominal Aortic Surgery

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ABSTRACT

A 64-year-old woman was evaluated for thoracoabdominal aortic aneurysms (TAAAs). Preoperative computed tomography showed a TAAA extending from the level of the diaphragm to the renal arteries. The Adamkiewicz artery (AKA) arose at the Th10 level, close to the aneurysm, and an abdominal aortic prosthesis and left iliac artery aneurysm were detected. Myogenic and neurogenic motor evoked potentials (MEPs) were monitored during the surgical repair of the TAAA, and there were differences between the two types of MEPs during surgery. Both MEPs fell below 50% of their baseline levels during surgery, which suggested critical ischemia, but the decrease in the myogenic MEP occurred at a different time from the decrease in the neurogenic MEP. A time-course analysis suggested that AKA reimplantation was unnecessary and all intercostal arteries were ligated. Both MEPs recovered completely by the end of surgery and there were no postoperative neurologic deficits. Our findings suggest that the combination of myogenic and neurogenic MEP monitoring is helpful in evaluating spinal cord injury during the surgical repair of TAAAs.

Key words: *motor evoked potential*, *thoracoabdominal aortic aneurysm*, *Adamkiewicz artery*

INTRODUCTION

Spinal cord ischemia is a serious complication of thoracoabdominal aortic aneurysm (TAAA) repair. The use of endovascular aortic repair techniques have decreased the incidence of postoperative complications, but the risk of ischemia remains[10]. Several strategies have been used for protecting against spinal cord injury, including distal perfusion via atrial-femoral bypass, cerebrospinal fluid drainage, mild systemic hypothermia[7], reattachment of the intercostal artery[3], regional hypothermia with epidural cooling[1], hypothermic cardiopulmonary bypass with circulatory arrest[6] and detection of spinal cord ischemia by assessing several types of evoked spinal cord potentials[3,5], including myogenic motor evoked potentials (MEPs) and neurogenic MEPs. This is typically done by passing transcranial stimuli through the spinal cord and recording myogenic and neurogenic MEPs using limb electrodes placed in the peripheral muscles and lumbar intrathecal electrodes, respectively. Recently, the use of myogenic MEPs and somatosensory evoked potentials have been reported with useful, but arguable, results[2,5]. The case presented here demonstrates that myogenic and neurogenic MEPs have unique characteristics and monitoring them simultaneously has the potential for increased precision in detecting spinal cord ischemia.

CASE REPORT

A 64-year-old woman was evaluated for TAAAs (Crawford type III). She had a history of two aortic operations, including total arch replacement using a frozen elephant trunk for an aortic arch aneurysm after an acute aortic dissection (DeBakey type IIIb) seven years prior and infrarenal abdominal aortic replacement for a ruptured abdominal aortic aneurysm one year prior. Computed tomography (CT) showed a TAAA, caused by chronic aortic dissection that measured 55 mm of maximal aortic diameter and had an ulcer-like projection extending from the Th10 to L2 level (Figure 1 (A),(C)). Imaging also showed branching celiac and superior mesenteric arteries, the occlusion of the right renal artery and a 30-mm left common iliac artery aneurysm (Figure 1(C)). Furthermore, the communication between the Adamkiewicz artery (AKA) and the left intercostal artery at the Th10 was near the proximal edge of the TAAA (Figure 1 (A)(B)). The angulation of the proximal neck of the aneurysm was 90 degrees. The following procedures were considered: 1) endovascular thoracoabdominal

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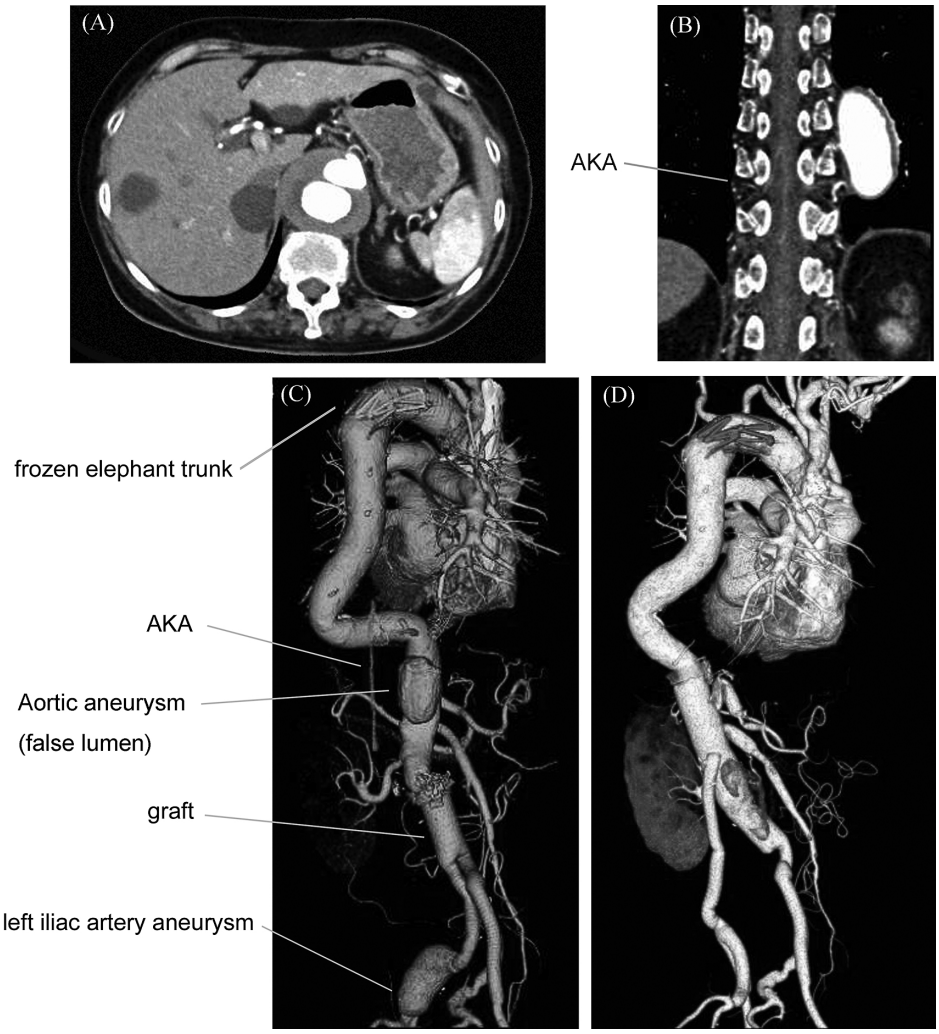

Figure 1 This preoperative computed tomography (CT) scan shows chronic aortic dissection. The diameter of the aorta is 55 mm including an ulcer-like projection (A). This preoperative CT scan shows the Adamkiewicz artery communicating with the left intercostal artery of Th10 (B). This preoperative 3-dimensional CT scan shows the aortic arch, which was previously repaired with a frozen elephant trunk; the abdominal aorta, which was previously repaired with a graft; the left iliac artery aneurysm, the thoracoabdominal aortic aneurysm, and the Adamkiewicz artery (C). This postoperative 3-dimensional CT scan shows successful aortic reconstruction (D).

repair with debranching visceral arteries and iliac artery stent grafting, and 2) open thoracoabdominal aortic repair. Owing to the patient's complex history and anatomy, a decision was made to proceed with open surgery rather than endovascular repair.

MEP monitoring

On the day before surgery, one pair of bipolar recording electrodes (UKG-100-5PM, Unique Medical, Tokyo, Japan) was placed in the dorsal epidural space at L2 for neurogenic MEP monitoring. A cerebrospinal fluid (CSF) drainage catheter was inserted at L4. The electrodes and catheter did not interfere with each other.

General anaesthesia was induced with fentanyl (4 μg/kg) and pancuronium (0.08 mg/kg) and maintained with fentanyl (2 μg/kg/h) and propofol (2 mg/kg/h). Muscle relaxants were not used during the operation. One pair of bipolar screw-type platinum electrodes was placed bilaterally on the anterior parietal cranial regions for the transcranial electrical stimulation of the cerebral motor cortices. Two pairs of bipolar needle electrodes were inserted bilaterally into the palmar and plantar muscles for the evaluation of myogenic MEPs. Neurogenic and myogenic MEPs were recorded (Figure 2). Nerve stimulation and nerve and muscle recordings were performed using the EpochXp system (Nihon Koden, Tokyo). Nerve stimuli (intensity, 100 mA; duration, 0.2 ms) were delivered at a rate of 3.3–7.3 Hz. Neurogenic MEPs were elicited by a single stimulus and amplified by averaging 20–50 responses. Myogenic MEPs were elicited by a single response of three to five train stimuli. All data were analysed immediately during the operation and stored in the EpochXp system.

Surgical procedure

A left thoracoabdominal retroperitoneal approach was chosen. A spiral incision allowed the exposure of the descending aorta, abdominal aortic graft, celiac artery, superior mesenteric artery, left renal artery and left iliac artery aneurysm. After the left iliac artery aneurysm was repaired with a bifurcated graft, which was anastomosed with the left internal and external iliac arteries, a partial

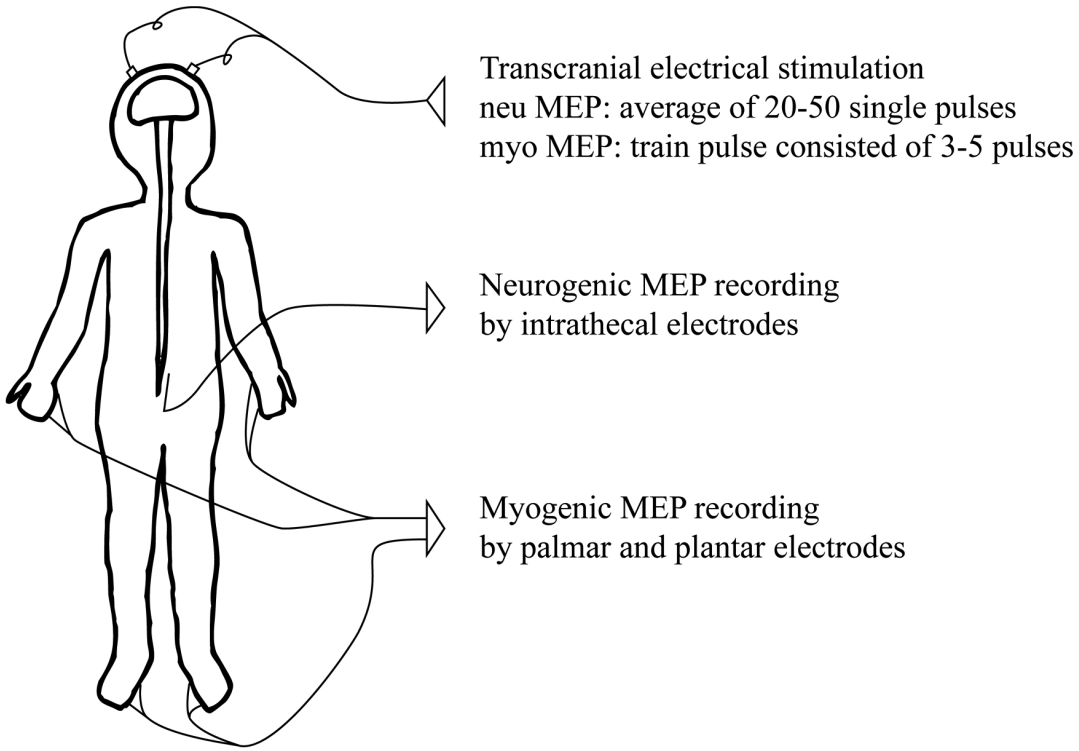

Figure 2 Schema of neurogenic and myogenic motor evoked potential monitoring. The electrical stimulation first activates the motor cortex, and then travels along the spinal cord before reaching the upper and lower limb muscles. Neurogenic MEPs were recorded with an intrathecal electrode and myogenic MEPs were recorded with electrodes inserted into the palmar and plantar muscles. Neu MEP, neurogenic MEP; Myo MEP, myogenic MEP

cardiopulmonary bypass was established through the left leg of the abdominal aortic graft and left femoral vein. Intraspinal pressure was kept below 10 cm H_2O by constant CSF drainage. Prior to open the aorta, selective perfusion for left renal artery was established. The aorta was clamped above the TAAA at Th9 and infrarenally. Then, the clamped aortic segment was opened. At this point, the neurogenic MEP immediately disappeared and the myogenic MEP amplitude fell to 40% of the baseline. The Th10 intercostal artery communicating with the AKA was rapidly exposed and clamped. The proximal and distal mean arterial pressures were increased to 100 mmHg and 60 mmHg by infusing catecholamine, respectively. At this point, the neurogenic MEP amplitude recovered to 80% of the baseline. Selective perfusion of the celiac artery and superior mesenteric artery was then established. The aorta was reconstructed with a branched graft (Coselli thoracoabdominal graft, Vascutek Ltd, Scotland, UK), thereby re-establishing systemic arterial circulation. Thirty minutes after the aorta was opened, the myogenic and neurogenic MEP amplitudes stabilized at 40% and 90% of their baseline levels, respectively, and all intercostal arteries that arose from the TAAA were ligated. The superior mesenteric artery, celiac artery, and left renal artery were anastomosed with grafts. The bifurcated graft of the left iliac artery was anastomosed with a branch from the thoracoabdominal aortic graft. By the completion of the operation, the myogenic and neurogenic MEP amplitudes recovered to 100% and 90% of their baseline levels, respectively (Figure 3). The patient had no postoperation neurologic deficits, and a CT scan showed successful aortic reconstruction (Figure 1 (D)).

DISCUSSION

TAAA operations pose a risk for ischemic spinal cord injury. Therefore, MEPs are widely used for spinal cord monitoring during TAAA surgery. Among the multiple types of MEPs, myogenic MEPs are most commonly used during thoracic and TAAA surgery because it has been shown to reliably reflect spinal cord ischemia occurence[3]. Jacobs et al. reported that critical spinal cord ischemia can be detected within two minutes after cross-clamping by observing a decrease in myogenic MEP amplitudes from the baseline. They also reported that 6 of 70 patients had low myogenic MEP amplitudes at the end of the operation, despite the reattachment of intercostal arteries, and this resulted in no neurologic deficits. Moreover, hypotension was shown to decrease myogenic MEP amplitudes, and the mean distal arterial pressure was maintained at > 60 mmHg to record accurate MEP amplitudes. Several reports have suggested that myogenic MEP monitoring correlated with neurologic outcomes when severe spinal cord ischemia was indicated by irreversible MEP changes, but the sensitivity and positive predictive values of this correlation are low[5]. Therefore, a decrease in myogenic MEP amplitudes requires the critical evaluation of the waveform.

We have previously reported on the efficacy of neurogenic MEP monitoring during thoracic and thoracoabdominal surgeries[8,9]. Neurogenic MEPs are affected by the

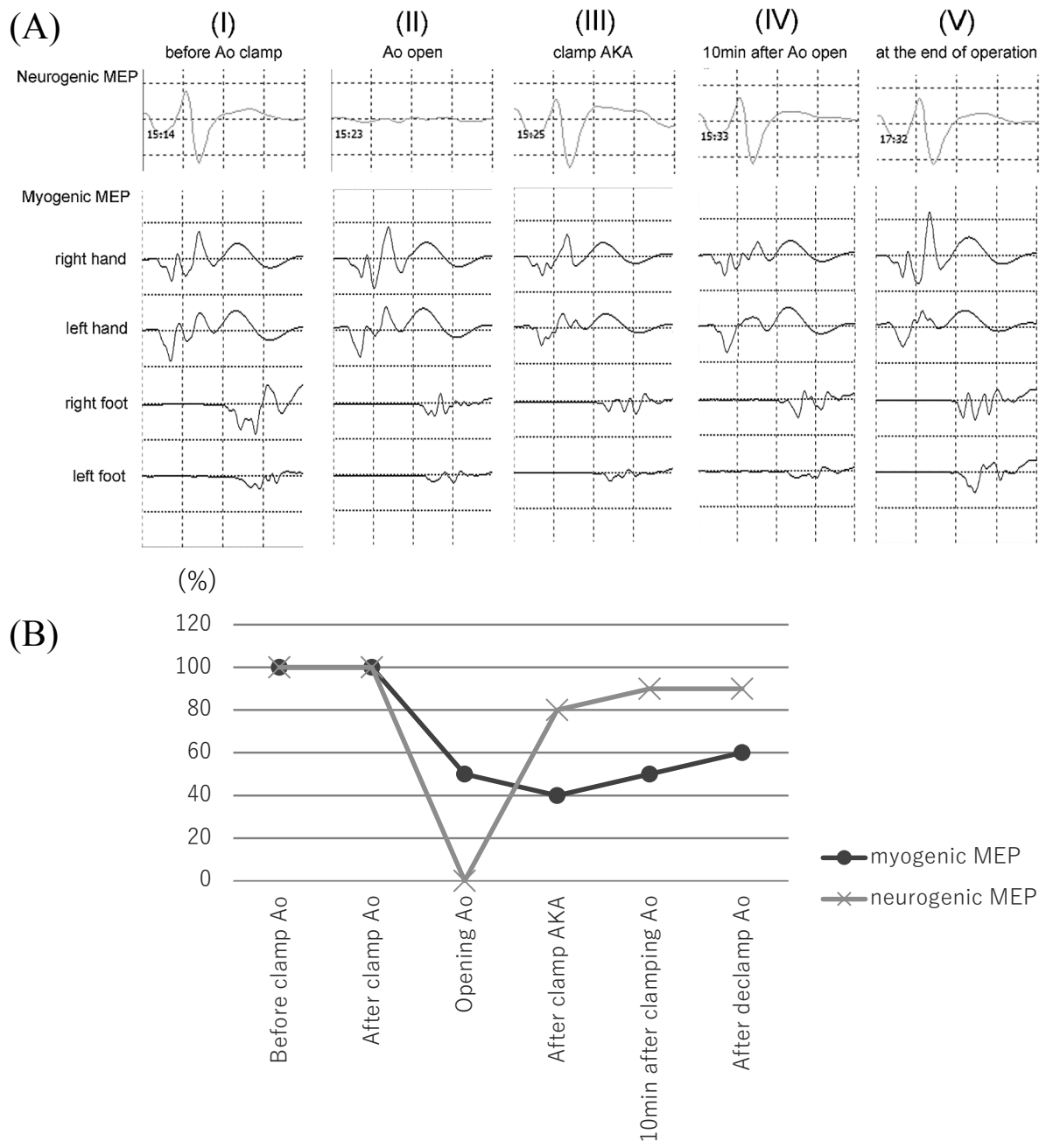

Figure 3 Time course of neurogenic and myogenic motor evoked potentials (MEPs). (I) Baseline (recorded before the aorta was clamped). (II) After opening the aorta. (III) After clamping the intercostal artery that communicated with the Adamkiewicz artery. (IV) Thirty minutes after opening the aorta. (V) At completion of surgery (A). Time course of neurogenic and myogenic MEP amplitudes (B).

brain-to-spinal cord conduction pathway and may detect ischemia in a narrower area than myogenic MEPs. The amplitude of neurogenic MEPs can take more than 10 minutes to deteriorate, and this method requires more time to evaluate spinal cord ischemia than that involving the use of myogenic MEPs. There are only a few published studies on neurogenic MEPs, so the meaning of neurogenic MEPs must be carefully evaluated.

Considering the different characteristics of neurogenic and myogenic MEPs, we monitored both to improve the diagnosis of spinal cord ischemia. We believe that there were two important points in time to evaluate spinal cord ischemia during our case study. The first was when the aorta was opened and the intercostal artery communicating with the AKA was clamped. At this point, both the myogenic and neurogenic MEPs immediately decreased to < 50% of their baseline levels, which suggested the presence of spinal cord ischemia[4]. However, the neurogenic MEP immediately recovered to 80% of its baseline level. Therefore, we proceeded with the reconstruction of the aorta because the spinal cord was thought to not be ischemic. Moreover, this difference between the myogenic and neurogenic MEPs also suggested a conduction disturbance below the L3 level that may have been caused by a low distal perfusion pressure or hypothermia of the lower limbs. This indicated that reimplantation of the AKA was not necessary. The second important time point was when systemic aortic flow

was restarted and 30 minutes had passed after opening the aorta. At this time, both MEPs were unchanged, and this suggested that spinal cord conduction was preserved without the AKA, due to the collateral circulation[2].

Conclusion

Combined monitoring of myogenic and neurogenic MEPs may improve the detection of spinal cord ischemia. Our case describes the usefulness of monitoring both the myogenic and neurogenic MEPs. There are few reports about combined monitoring of myogenic and neurogenic MEP and further investigation on this topic is needed.

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