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Case study

Electrophysiological influence of temporal occlusion of the parent artery during aneurysm surgery

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ABSTRACT

Intraoperative monitoring of the motor evoked potential (MEP) during cerebral aneurysm surgery has been widely used to confirm surgical safety. In this study, we retrospectively analyzed the influence of the MEP amplitude resulting from temporal occlusion of the parent artery, and appropriate judgement in the surgery was discussed. Ten patients underwent temporal occlusion of the parent artery during aneurysm surgery, and five of these patients showed a decrease in the MEP amplitude following temporal arterial occlusion. Clinical factors in patients with and without MEP decrease were compared. The time gap between the surgical procedure and the MEP change and recovery was then investigated. A decrease in the MEP amplitude caused by temporal occlusion had a significantly higher occurrence compared with permanent clip failure. The time from the release procedure to MEP amplitude recovery was relatively longer than the time from the occlusion procedure to the decrease in MEP amplitude. The time from release procedure to MEP amplitude recovery showed a weak correlation with the parent artery occlusion time. There is a time gap between releasing the temporal arterial occlusion and MEP recovery that is similar to temporal parent arterial occlusion and the MEP decrease. The cause of MEP amplitude should be judged carefully, and influence of parent artery temporal occlusion should be taken into consideration during aneurysm clipping.

1. Introduction

Intraoperative monitoring of motor evoked potential (MEP) during cerebral aneurysm surgery has been established, and it is widely used to improve surgical safety [1–4]. A decrease in MEP amplitude reflects the cerebral ischemia of descending motor pathways, and neurosurgeons should try to minimize prolonged temporary occlusion or perforator occlusion that contributes to ischemic complications. When the MEP amplitude had recovered from the temporal decrease, postoperative motor impairment was not recognized or was minimal [5–7]. Conversely, the possibility of postoperative motor impairment should almost never occur in patients where the MEP amplitude was not decreased during the surgery [1,3–6,8,9]. Warning criteria for the MEP amplitude reduction include >50% D-wave reduction, which is a major criterion for stopping resection in brain tumor surgery [1,3,5,6,8–10]. However, there is no definitive recommendation for aneurysm surgery because there are limited situations in which the surgical procedure can be performed. Moreover, false-negative errors with regard to postoperative motor impairment has been reported in several studies that examined MEP monitoring, and thus, interpretation of monitoring and its judgement is required [6].

Anatomically, MEP has been used to detect patency of the internal carotid artery (ICA) [11], anterior choroidal artery (AChoA) [3,11–14], lateral lenticulostriate artery (LSA) [1,14], and middle cerebral artery (MCA) [1,15–18]. Therefore, a decrease in MEP amplitude might occur because of a temporal occlusion of the parent artery. However, there has been little discussion about the decrease and recovery of MEP amplitude resulting from temporal occlusion of the parent artery during aneurysm surgery. In this study, we retrospectively analyzed the change in MEP amplitude resulting from temporal occlusion of the parent artery, and interpretation and judgement in the surgery were discussed.

2. Patients and methods

2.1. Patients

Between January 2012 and June 2016, 60 consecutive patients with cerebral aneurysm were surgically treated at our hospital. Of these, 33 aneurysms that were located in the anterior

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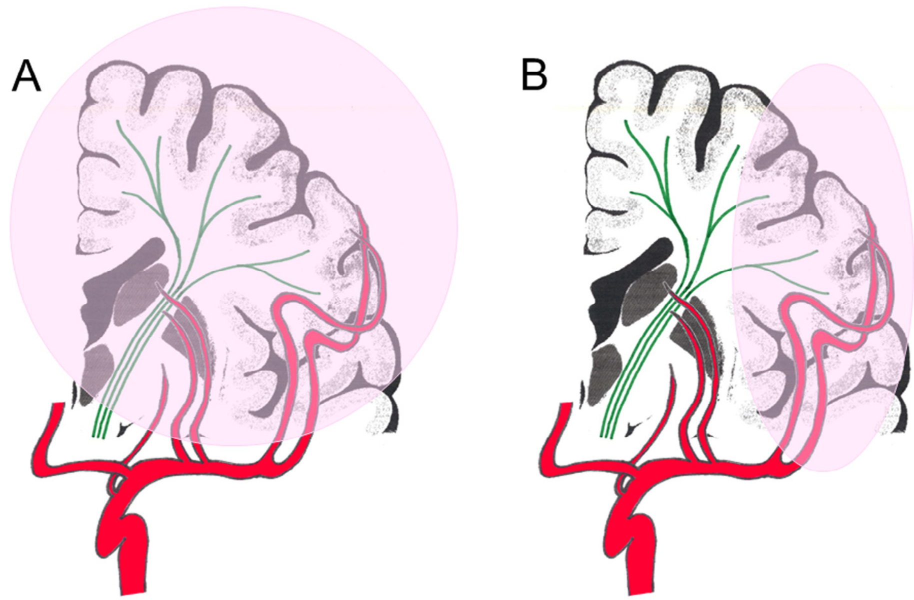

Fig. 1. Schematic drawing of the relationship between the cause of the ischemic area and the responsible artery in terms of decreasing the MEP amplitude. (A) ICA aneurysms are associated with a risk of ICA, AChoA, and lateral lenticulostriate artery ischemia. (B) The MCA aneurysm has a risk of ischemia in MCA territory that is distal to M2. The green line indicates the corticospinal tract.

circulation were assessed using corticospinal MEP monitoring with direct cortical stimulation, and these patients were included in this study. Thirty-one aneurysms were treated using neck clipping and two aneurysms were treated using trapping and revascularization. Of these, temporal occlusion of the parent artery was performed in 10 patients. Five of these patients showed a decrease in the MEP amplitude because of temporal occlusion of the parent artery. Four patients had no change in MEP even though temporal occlusion of the parent artery was performed. One patient showed a decrease in the MEP amplitude because of a permanent clip failure. This MEP decrease was improved by replacing the clip, and this patient was excluded from the analysis. We examined the clinical characteristics of these nine patients (sex, age, aneurysm size, aneurysm location, occlusion time, presence of subarachnoid hemorrhage, setting of extracranial–intracranial (EC-IC) bypass and modified Rankin Scale (mRS)) with and without a MEP decrease resulting from the temporal occlusion of the parent artery, and these were compared between the two groups, as described below. The duration of the parent artery temporal occlusion was compared with the time between the surgical procedure and the MEP change.

The aneurysm location was classified into two groups based on the area of hypoperfusion caused by the parent arterial occlusion procedure: the ICA aneurysm group, and the MCA aneurysm group. ICA aneurysms have a risk of ICA, AChoA, and lateral lenticulostriate artery ischemia (Fig. 1A). The MCA aneurysm has a risk of ischemia in MCA territory that distal to M2 (Fig. 1B).

2.2. Intraoperative MEP monitoring

Our methods of intraoperative electrical stimulation have been previously described in detail [19]. The bilateral abductor pollicis brevis, biceps, brachialis, deltoid, gastrocnemius, quadriceps femoris, and tibialis anterior muscles were selected for electromyographic recording using neurological monitoring (MEE-1232; Nihon Koden, Tokyo, Japan). General anesthesia was induced and maintained using intravenous propofol infusion during the craniotomy. Muscle relaxants were administered only for intubation procedures and not during surgery. A peripheral nerve stimulator was used to confirm train-of-four muscle contractions. After dural incision, a 4×5 electrode grid (Unique Medical, Tokyo, Japan) was placed into the subdural space of the precentral and postcentral gyri using a navigation system (Fig. 2).

To identify the central sulcus, the biggest N20-P20 phase reversal of somatosensory-evoked potentials was recorded. To monitor the motor function of the corticospinal tracts electrophysiologically, the precentral gyrus was stimulated directly to identify a positive control MEP, and to determine the intensity that would be subsequently used to stimulate the subcortical fibers. The intensity for direct cortical stimulation was increased by 1-mA increments, from 5 mA to a maximum of 15 mA. Although after-discharges were not observed in these patients, if they were induced, the test was repeated with the same current level or with a current level 1 mA lower. During the subsequent surgical procedure, the MEP was monitored every 1 min. If the MEP amplitude decreased to less than 50% of the control level, it was defined as "MEP decrease". If the MEP amplitude recovered to 50% of the control level, it was defined as "MEP recovery".

2.3. Statistical analysis

Data are presented as the mean ± standard deviation. Differences among groups were assessed using the Mann-Whitney *U* test and Fisher's exact probability test. Spearman's correlation coefficient was used to compare differences between the occlusion time and the time from occlusion procedure to the MEP decrease or the time from clip release to MEP recovery. Differences were deemed statistically significant at $p < 0.05$. SPSS software (IBM SPSS Statistics version 22, Chicago, IL, USA) was used to perform the analysis.

3. Results

A decrease in MEP resulting from the temporal occlusion of the parent artery was found in seven surgical procedures in five patients, and these were called the "MEP decreased group". Overall, 55.6% of all the patients who underwent temporal occlusion of the parent artery showed a decrease in MEP. A MEP decrease resulting from temporal parent arterial occlusion was significantly higher than a MEP decrease resulting from a permanent clip failure