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Hemiparesis following carotid endarterectomy

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Introduction

Many monitors have been designed for use during carotid endarterectomy (CEA) surgery to detect cerebral ischemia during carotid artery clamping [1]. Electroencephalography (EEG) is one of the monitors often used during CEA surgery. EEG is a useful system for the detection of cerebral ischemia, but it does not detect all cases of cerebral ischemia.

We report a case of hemiparesis following CEA surgery where the EEG indicated an improvement in the pattern of ischemic irregularities after surgery compared with the preoperative EEG pattern. In this case, we could not detect cerebral ischemia during CEA surgery.

Case report

A 67-year-old man, who had had a thoractomy 25 years previously due to tuberculosis, experienced transient ischemic attacks consisting primarily of weakness in the right arm and leg. The patient's body weight was 67kg and his height was 170cm. His Arterial blood pressure was 125/57mmHg, and his heart rate was 65 beats·min^{-1}. Brain computed tomography (CT) indicated no irregularities, but angiography indicated approximately 99% stenosis at the bifurcation of the left carotid artery. The left middle cerebral artery (MCA) was shown slightly by angiography. The results of neurological examination were normal. He underwent an emergency operation.

No premedication was performed. Prior to anesthetic induction in the operating room, the patient's arterial blood pressure was 120/63mmHg and his heart rate was 64 beats·min^{-1}. Anesthesia was induced with an intravenous administration of 0.2mg fentanyl, 200mg thiopental, and 8mg vecuronium, and the trachea was intubated. Anesthesia was maintained with nitrous oxide–oxygen–isoflurane (0.8–1.0MAC). The concentrations of expired isoflurane and end-tidal CO_2 tension ($ETCO_2$) were monitored using a Capnomac Ultima (Datex, Helsinki, Finland) and $ETCO_2$ was maintained within 40–45mmHg. During the CEA operation, the arterial systolic blood pressure was maintained between 120 and 150mmHg.

After the induction of anesthesia, EEG was monitored using a Lifescan (Neurometrics™, San Diego, CA) monitor [2]. The five Lifescan electrodes were placed bilaterally with one over the frontal and mastoid areas and a reference electrode attached to the middle of the frontal region.

Figure 1 shows the recording produced by the Lifescan monitor during CEA surgery. Figure 1(a) shows the recording obtained after the induction of anesthesia. The left-hand EEG panel indicates the presence of ischemic irregularities compared with the right-hand EEG panel, and the activity edge shows asymmetry. Figure 1(b) shows the recording obtained during carotid artery occlusion. The arrow indicates the time when the carotid artery was clamped. The carotid artery was clamped at 7cm proximal from MCA bifurcation. The endarterectomy was 5cm in length in the left carotid artery. Figure 1(c) shows the recording obtained after the carotid artery was declamped. Figure 1(b) and (c) also show ischemic irregularities and the activity edge shows asymmetry. Figure 1(d) shows the recording obtained at the end of surgery during anes-

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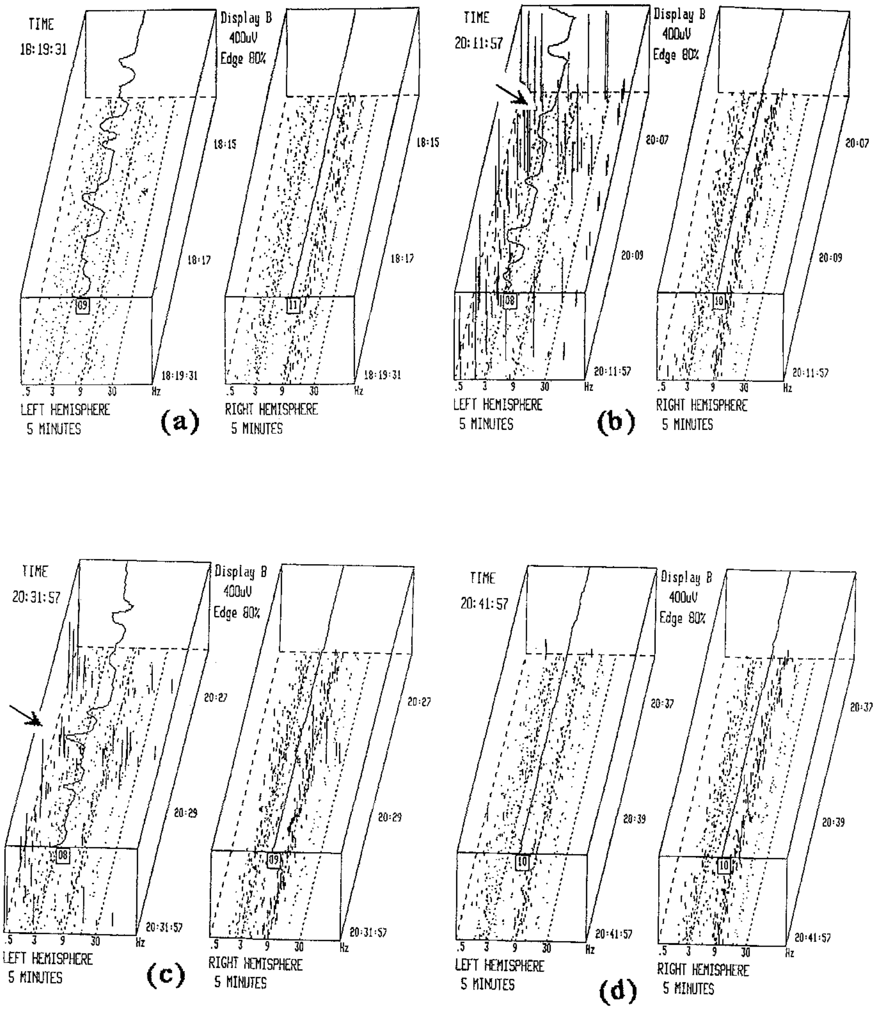

Fig. 1. Recordings produced by the Lifescan monitor during carotid endarterectomy (CEA) surgery. **a** Recording obtained after the induction of anesthesia. The *left-hand* EEG panel shows ischemic irregularities compared with the *right-hand* EEG panel, and the activity edge shows asymmetry. **b** Recording obtained during carotid artery occlusion. The *arrow* indicates the time when the carotid artery was clamped. **c** Recording obtained after the carotid artery was declamped. The *arrow* indicates the time when the carotid artery was declamped. **b** and **c** also show ischemic irregularities and the activity edge shows asymmetry. **c** shows that a few minutes after the carotid artery was declamped the activity edge had almost recovered. **d** Recording obtained at the end of surgery during anesthesia. There are no irregularities in the ischemic condition and the activity edge shows symmetry

thesia. This figure shows that there are no ischemic irregularities and the activity edge shows symmetry. The carotid artery occlusion time was 27 min. Thirty minutes after all anesthetic agents were stopped, the patient had a weak reaction to command and pain responses, and his consciousness level was drowsy. Therefore, brain CT was performed immediately, and this suggested that a new, low-density area had formed in the middle cerebral artery. Several hours after the operation, 16-lead EEG was performed, and this showed no remarkable change except for the global low voltage amplitudes (Fig. 2). One day after surgery, the patient developed right hemiparesis.

Discussion

During CEA surgery, the carotid artery was temporarily occluded, so that the brain was in an ischemic condition during carotid artery occlusion. During that period, the brain blood flow was dependent upon the opposite internal carotid and vertebral arteries. The new neurological complications which occur in 1%–2% of cases after a CEA operation are caused by the decrease in brain blood flow during carotid artery occlusion [1]. To prevent the occurrence of new neurological complications, certain strategies are used: (1) reduction of the carotid artery occlusion time; (2) avoidance of the

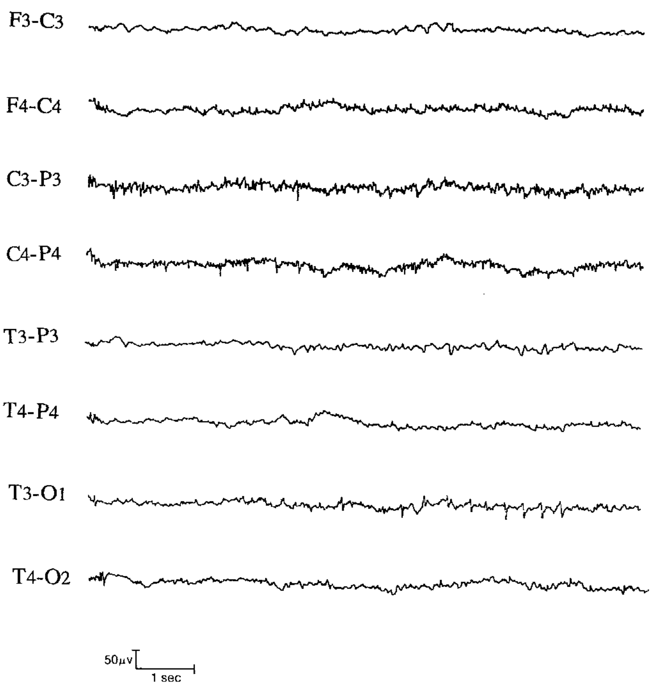

Fig. 2. Recordings produced by the 16-lead EEG several hours after the operation. This indicates that global now voltage was shown, but asymmetry of right and left hemispheres was not shown

reduction of brain blood flow by making an intracarotid bypass shunt; (3) drug therapies such as barbiturates; (4) the use of monitors for indicating brain ischemia [1,3,4].

Many monitors are used today to detect brain ischemia; examples include stump pressure, EEG, hemoglobin oxygen saturation of the internal jugular vein, and somatosensory evoked potential (SEP) [1,3,4]. The Lifescan uses aperiodic analysis, which maps each waveform in relation to its frequency, amplitude, and time of occurrence rather than averaging a large number of waveforms over a given period. The frequency is displayed on the X-axis, the amplitude of each mapped EEG wave is a vertical "pole," and time is displayed on the diagonal axis. The activity edge is also displayed by the line on the box in order to determine the electrical activity of EEG more easily. The activity edge is indicated as the 80% point of sum of all amplitudes from the slow wave side. The refore 80% of all amplitudes are under the activity edge, and this represents the global activity of the whole brain. For example, the event of brain ischemia or brain hypothermia induces the activity edge line to shift to the left, and a sudden decrease in the activity edge indicates that the EEG monitor has detected ischemic irregularities [2,5,6].

In this case, ischemic irregularities occurred before and during carotid artery occlusion according to the activity edge, which showed an asymmetric pattern. However, these ischemic irregularities were improved after the declamping of the carotid artery.

Stump pressure was always maintained at more than 50 mmHg during the CEA operation. The stump pressure is one criterion for determining the necessity of an intracarotid bypass shunt during carotid artery occlusion. It is advisable to make an intracarotid bypass shunt when the stump pressure is less than 50 mmHg in order to maintain brain blood flow [1,3,4]. In this patient, stump pressure was maintained above 50 mmHg during carotid artery occlusion. As making an intracarotid bypass shunt may induce thrombosis, we did not carry out that procedure. However, some reports have suggested that there is no relation between the brain blood flow and stump pressure [7]. Furthermore, an appropriate brain blood flow is not always maintained with a stump pressure of greater than 50 mmHg.

During the CEA operation, $ETCO_2$ was kept within 40–45 mmHg and the systolic blood pressure was maintained at 120–150 mmHg. Nevertheless, the patient suffered cerebral infarction in the region of the middle cerebral artery. It may be that air or thrombus entered the carotid artery when it was declamped. This phenomenon was not detected using the Lifescan monitor. It has been reported that hemiparesis occurred after a CEA operation, but that the EEG, consciousness, and motor disturbance did not indicate any irregularities during the operation, which was with local anesthesia [8]. Therefore, the EEG monitor may not be capable of detecting all types of ischemic irregularities.

In conclusion, a case of hemiparesis occurred following a CEA operation where the post-CEA EEG indicated improvement in the pattern of ischemic irregularities compared with the preoperative EEG. We were unable to detect the occurrence of cerebral ischemia during CEA surgery using a Lifescan EEG monitor.

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