Ischemic Event and Risk Factors of Embolic Stroke in Atherosclerotic Cerebral Aneurysm Patients Treated with a New Clipping Technique

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Background: We would like to know the exact rate of ischemic event and the risk factors associated with embolic stroke by treatment of atherosclerotic cerebral aneurysm with a new technique. *Methods:* This is a retrospective cohort study in patients diagnosed as unruptured atherosclerotic cerebral aneurysm who underwent microsurgical clipping between January 2012 and August 2014. All intraoperative video recordings were reviewed and chosen in patients who were identified as atherosclerotic lesion on the dome, neck, or parent artery of the aneurysm. The demographic, radiographic, operative, and postoperative data were collected. The primary end point was the incidence of cerebral infarction and the neurologic outcomes using the discharge modified Rankin Scale (mRS) score at postoperation time. A statistical analysis of the factors associated with embolic stroke was done by Fisher exact and Wilcoxon rank-sum tests. The individual surgical technique was demonstrated as an illustration for use as a guide. *Results:* Among 103 atherosclerotic cerebral aneurysms, only 3 patients (2.9%) were associated with postoperative cerebral infarction and 1 of them had permanent neurologic deficit. A good mRS score (0-2) was found in 99% of patients and only 1% had a fair mRS score (3-4). A factor associated with ischemic outcome was duration of operation ($P = .046$). The differences in the atherosclerotic location showed no statistical significance. *Conclusions:* We found a very low incidence of embolic infarction after clipping of an atherosclerotic cerebral aneurysm with our new technique. Only duration of the operation time was a dependent risk factor for embolic infarction. **Key Words:** Atherosclerotic cerebral aneurysm—ischemic event—thromboembolism—hemodynamics wall shear stress.

Unruptured cerebral aneurysms (UCAs) are commonly found in the general population (.4%-6%). The number of incidental findings of UCAs has increased because of the advantages of noninvasive imaging technology. The surgery and endovascular techniques for the treatment in this type of aneurysm are still debated.[1]

The higher the prevalence of chronic diseases (ie, chronic hypertension, diabetes mellitus, hypercholesterolemia, advanced age, and smoking), the higher the prevalence of atherosclerotic or calcified aneurysms.[2] No previous studies focused on the incidence or the exact data of atherosclerotic aneurysms. They reported only the atherosclerotic type of aneurysm which was related with a poor outcome after surgery, which was more than 7.8 times higher when compared with patients who had nonatherosclerotic aneurysms.[3] The role of

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surgery in atherosclerotic aneurysm should be concerned with the aneurysmal sac that can shower emboli during manipulation or placing the clip because it can break the unstable local plaque resulting in distal arterial occlusion that leads to brain infarction. On the other hand, the outcome for this type of aneurysm treatment is not satisfied by the endovascular surgery option. Furthermore, one study showed that thromboembolic complications reached 30% of associated endovascular coiling,[4] which is more common than in the clipping technique.[5] However, surgical clipping has some limitations because of the difficulty in placement of the clip to the neck or dome of the aneurysm near calcification or an atherosclerotic plaque area. It is impossible to completely achieve adequate obliteration and avoid clip slippage. The ideal technique to solve this problem is to trap the parent artery with revascularization or make a thrombectomy of an aneurysmal thrombus with clip reconstruction. Unfortunately, these techniques usually have unfavorable outcomes.[6,7]

There are only a few studies on the incidence of ischemia and factors associated with thromboembolic events after treatment with surgical clipping, and none of the studies refer to the technique of surgery. The aim of this study is to review the ischemic events of atherosclerotic aneurysm clipping and the associated factors for embolic stroke after clipping an aneurysm. Furthermore, with the techniques proposed in this study, an aneurysm can change from an unclippable to a clippable aneurysm.

Methods

A retrospective cohort study was performed at a university hospital. The study was approved by the ethics committee of Fujita Health University, and each patient signed an informed consent before receiving the treatment. All patients who were admitted between January 2012 and August 2014 were operated on by a senior neurosurgeon (Y.K.) in the Neurosurgical Department. The operative video records of each patient were reviewed. The baseline characteristics of the patients (ie, demographic, radiographic, intraoperative, and postoperative data) were noted. The eligibility criteria were a diagnosis of unruptured atherosclerotic cerebral aneurysm, aged older than 18 years, cooperative, postoperative duration in the hospital for at least 7 days, and a computed tomography (CT) scan of the brain performed postoperatively within 24 hours. Magnetic resonance imaging (MRI) scan of the brain was performed to confirm infarction in the symptomatic patient. The ineligibility criteria were ruptured cerebral aneurysm, not cooperative for evaluation, optional procedure such as endovascular treatment or revascularization of the aneurysm, or clinical condition of cerebral infarction because of prior surgery.

All patients were operated on under standard techniques. After they were diagnosed as UCA from 3-dimension (3D) CT angiography (CTA), an informed consent was obtained from them and their relatives before surgery was scheduled. The patients were admitted at least 1 day before the operation and had a preoperative evaluation. Intraoperative physiologic monitoring such as motor evoke potential (MEP) or somatosensory evoke potential was applied in selected cases who had a risk of injury to small perforator arteries during surgery that could lead to a neurologic deficit. A neuroprotective anesthetic technique was chosen and the standard frontotemporal transsylvian approach was used for internal carotid artery, posterior communicating artery, anterior choroidal artery, anterior communicating artery (ACoA), and middle cerebral artery aneurysms. The other approach was the frontal interhemispheric approach for distal anterior cerebral artery or high position ACoA aneurysms. The tractionless technique was applied for exposure of brain parenchyma. Indocyanine green videoangiography (ICG-VA) with FLOW-800 software generated with infrared (ZEISS, OPMI Pentero, Germany) was used in all patients before and after clipping to check the anatomical architecture of the aneurysm and associated arteries such as the parent and perforating arteries. The patency of these arteries and the completeness of exclusion of the aneurysmal neck after clipping the aneurysm can be checked with this device. Additional software of this device, color map, and flow intensity were analyzed for blood flow dynamics which included the sequence of blood flow after aneurysm clipping in cases of suspected incomplete exclusion. Endoscope-assist microsurgery was used for anatomical safety to check before and after aneurysm clipping in case the neck or small perforator arteries could not be seen. Doppler ultrasonography was used to determine the characteristics of the blood flow after clipping of the aneurysmal sac and identify unintentional injury to small perforator or parent arteries. Postoperative CT scan of the brain was routinely performed within 24 hours to check for complications. A physical and neurologic examination was performed hourly by the attending neurosurgeon during the first day after the operation. The Glasgow coma scale score was routinely recorded on a daily basis, and the outcome evaluation was estimated by the modified Rankin scale (mRS) score on the day before discharge. For the patients who developed complications, the correctable causes were treated by medication or operation.

Ischemia or embolic stroke was defined as symptomatic or asymptomatic. Symptomatic ischemia referred to a deteriorated neurologic condition after the operation in one or more of the following conditions: hemiparesis or hemiplegia, cranial nerve palsy, decreased sensation, memory or conscious change, or all of these proved by CT and diffusion-weighted imaging form of MRI scan of the brain that showed evidence of hypodensity or