Interdisciplinary Neurosurgery: Advanced Techniques and Case Management 10 (2017) 114–118

Contents lists available at ScienceDirect

Interdisciplinary Neurosurgery: Advanced Techniques and Case Management

journal homepage: www.inat-journal.com

Technical Notes & Surgical Techniques

Training model for cerebral aneurysm clipping

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ARTICLE INFO

Article history:
Received 11 April 2017
Revised 18 July 2017
Accepted 30 July 2017
Available online xxxx

Keywords:
Cerebral aneurysm
Training model
Polyvinyl alcohol

ABSTRACT

Clipping of cerebral aneurysms is still an important skill in neurosurgery. We have made a training model for the clipping of cerebral aneurysms. The concepts for the model were 1: training model for beginners, 2: three dimensional manipulation using an operating microscope, 3: the aneurysm model is to be perfused by simulated blood causing premature rupture. The correct relationship between each tissue, and softness of the brain and vessels were characteristics of the model. The skull, brain, arteries, and veins were made using a 3D printer with data from DICOM. The brain and vessels were made from polyvinyl alcohol (PVA). One training course was held and this model was useful for training of cerebral aneurysm surgery for young neurosurgeons.

1. Purpose

Clipping of cerebral aneurysms is still an important skill in neurosurgery. As endovascular treatment for cerebral aneurysms is increasing, neurosurgical residents have less experience performing surgery. Training for clipping has become difficult. One solution for clipping training is simulation surgery. In other fields, 3D printer models have been produced, for example, for the ear [1], orbit [2], heart [3–7] and abdomen [8,9]. Also in neurosurgical field, there were several models to simulation surgery [10–15]. Here, we have made a training model for the clipping of cerebral aneurysms. The concepts for the model were as follows: 1: training model for clipping of cerebral aneurysms for beginners as senior residents of neurosurgery, 2: three dimensional manipulation using an operating microscope for skin incision, craniotomy, dissection of Sylvian fissure, aneurysm dissection, and simulation of clipping, 3: the aneurysm model is to be perfused by simulated blood causing premature rupture which may develop from rough manipulation. To carry out these concepts, we made model skull, model brain, and model aneurysm by polyvinyl alcohol (PVA) using 3D printer, and these parts were assembled with the separating brain surface by model arachnoid membrane and pia mater. We examined the usefulness of this model through a training course.

2. Methods

The cerebral artery bifurcation aneurysm model was made using PVA (Fig. 1). The aneurysm and parent artery were made hollow, and simulated blood (red-colored water) was perfused. The scalp, temporal muscle, skull, dura matter, arachnoid membrane, brain, Sylvian vein, and parent artery were also constructed. A cast of the skull, brain, arteries, and veins was made using a 3D printer from data of digital imaging and communications (DICOM) in patients used standard triangulated language (STL) conversion. Using the cast of the skull, brain, arteries, and veins, a mold of each part was made using a specific process by Wetlab Corporation. Finally, the brain and vessels were made from PVA using each mold. The skull was made from two kinds of specific Wetlab bone material. Dura matter was made from cloth, and arachnoid and pia mater were made from thin paper. After making each part, the model was assembled. The middle cerebral artery bifurcation aneurysm was installed in the model brain in the Sylvian fissure (Fig. 2). The Sylvian fissure was closed with artificial arachnoid membrane (Fig. 3). The model brain was set in the model skull covered by model skin.

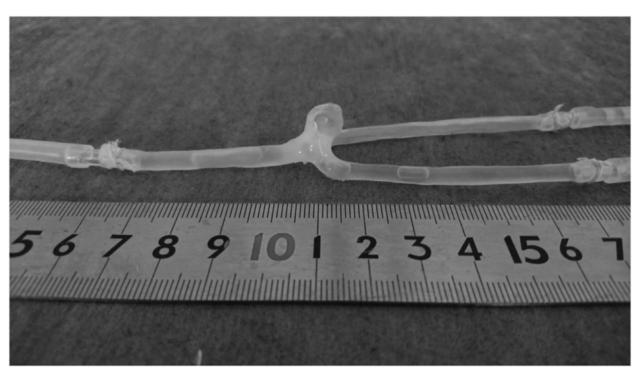

Fig. 1. A model bifurcation aneurysm was made from polyvinyl alcohol.

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http://dx.doi.org/10.1016/j.inat.2017.07.018

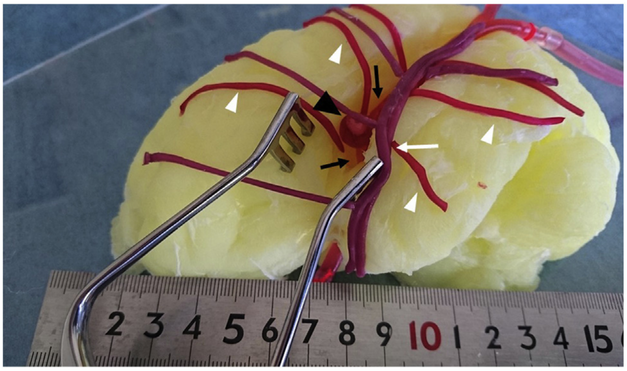

Fig. 2. Model left middle bifurcation aneurysm was installed in the Sylvian fissure. Black arrowhead shows the model aneurysm. Black arrows show the model middle cerebral artery. White arrowheads show the cortical arteries. White arrow shows the Sylvian vein.

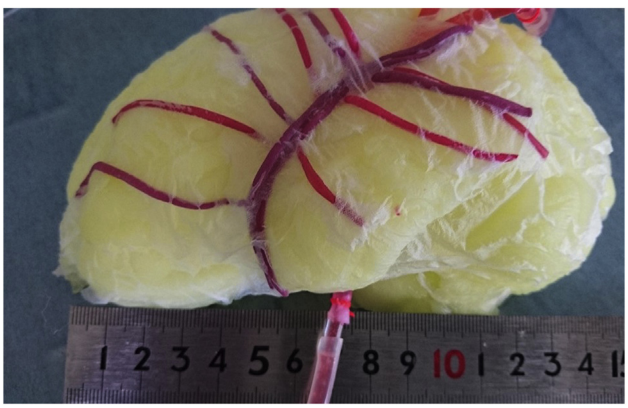

Fig. 3. The Sylvian fissure was closed with model arachnoid membrane. The model middle cerebral artery bifurcation aneurysm was installed in the Sylvian fissure as in typical clinical patients.

The location and shape was confirmed using angiography (Fig. 4-A, B) by perfused angiographic contrast medium (Iopamidole 300).

The model was fixed to a surgical fixture and skin incision was planned. The simulated blood was perfused with approximately

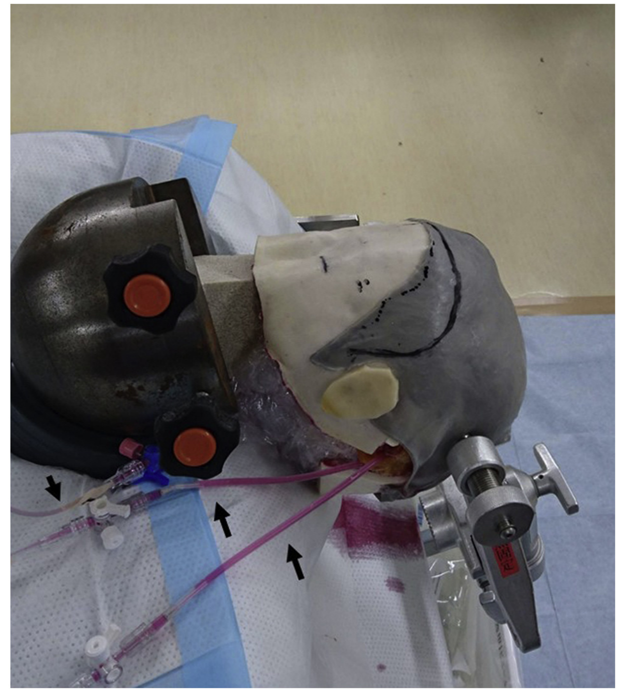

Fig. 5. Positioning and plan for skin incision. The vessels were perfused with simulated blood (arrows).

200 cm of H_2O by gravity (Fig. 5). The model skin was incised, model temporal muscle was turned over, and craniotomy was performed (Fig. 6). Model dura was opened in a u-shaped fashion and the model arachnoid was incised along the model Sylvian vein (Fig. 7) (modelVTR.mpg). The frontal lobe was retracted with a spatula (Fig. 8). The Sylvian fissure was opened using a spatula, and the model M2 superior and inferior trunk were dissected (Fig. 9). The aneurysm was then dissected carefully. M1 and the superior and inferior trunks of M2 were also dissected (Fig. 10). The aneurysm was clipped carefully using two clips (Fig. 11). Patency of the arteries was confirmed.

Nineteen middle cerebral artery bifurcation aneurysm models were made. Two instructors were trained before the training course. A training course was held for eight residents (Fig. 12). Impressions of the course were heard from the trainees.

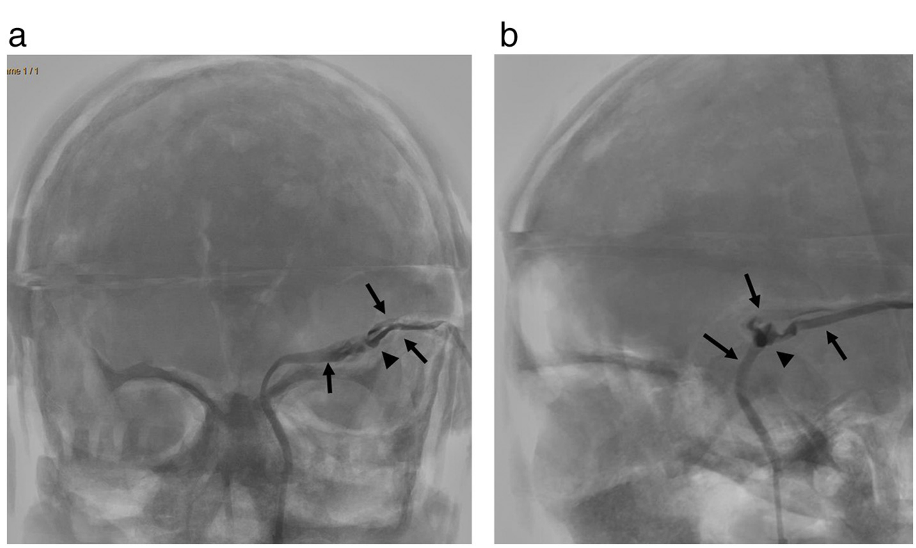

Fig. 4. Angiography of a model aneurysm, A: A-P view, B: lateral view, Arrowhead shows the location of the aneurysm. Arrows show the middle cerebral artery.