Modified Three-Dimensional Brain Model for Study of the Trans-sylvian Approach

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Abstract

The trans-sylvian approach is one of the most frequently employed neurosurgical procedures, but it is difficult for medical students to understand the approach stereoscopically. A three-dimensional model equipped with an arachnoid membrane and sylvian vein was developed which can be repeatedly used to simulate surgery for the education of medical students and residents in the trans-sylvian approach. The model was prepared using existing models of the skull bone, brain, and cerebral artery. Polyvinylidene chloride film, commonly used as plastic wrap for food, was adopted for the arachnoid membrane, and wetted water-insoluble tissue paper for the arachnoid trabeculae. The sylvian vein was prepared by ligating woolen yarn with cotton lace thread at several sites. Students and residents performed the trans-sylvian approach under a microscope, and answered a questionnaire survey. Using this model, simulation of division of the arachnoid membrane and arachnoid trabeculae, and dissection of the sylvian vein was possible. In the questionnaire, the subjects answered 8 questions concerning understanding of the stereoscopic anatomy of the sylvian fissure, usefulness of the simulation, and interest in neurosurgical operation using the following ratings: yes, very much; yes; somewhat; not very much; or not at all. All items rated as ‘yes, very much’ and ‘yes’ accounted for more than 70% of answers. This model was useful for medical students to learn the trans-sylvian approach. In addition, repeated practice is possible using cheap materials, which is advantageous for an educational model.

Key words: trans-sylvian approach, arachnoid membrane, arachnoid trabeculae, sylvian vein, three-dimensional model

Introduction

The trans-sylvian approach through frontotemporal craniotomy is the most common operative procedure performed by neurosurgeons, and is frequently used for the treatment of arterial aneurysms located in the circle of Willis and lesions in the suprasellar region.2,13) This procedure is also applied for the orbitozygomatic approach and skull base surgery.4,8,12) Therefore, the trans-sylvian approach is important to master during the initial training of neurosurgeons. Neurosurgeons acquire surgical techniques using surgical texts and watching procedures performed by skilled physicians. However, medical students and residents may find stereoscopic understanding of the approach difficult to achieve only by referring to texts and videos.

Therefore, we have developed a three-dimensional (3D) model equipped with an arachnoid membrane and sylvian vein which can be repeatedly used to simulate surgery of the trans-sylvian approach in the education of medical students and residents. We also performed a questionnaire survey involving medical students and residents who used this model to evaluate its usefulness for education.

Materials and Methods

Commercial skull bone, brain, and cerebral artery models were used (OMeR model; ONO & Co., Ltd., Tokyo). The skull bone model is made from polyamide nylon and glass beads. The convex region in the skull bone model was opened, and a right frontotemporal craniotomy was performed before simulation (Fig. 1A). The brain model is made from soft elastomer. Only the right cerebral hemisphere was

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used, and the small blood vessels were painted on the cerebral surface (Fig. 1B). The cerebral artery model is made from urethane resin. The right internal carotid artery over the right anterior and right middle cerebral arteries was modeled (Fig. 1C).

The arachnoid membrane was made from 0.011-mm thick polyvinylidene chloride (PVDC) film normally used for food wrapping (Saran Wrap™; Asahi Kasei Corporation, Tokyo). The sylvian vein and its branches was modeled with 3-mm thick woolen yarn ligated with cotton lace thread at several sites. The sylvian vein model was applied to the PVDC film with glue (Cemedine Super-X®; CEMEDINE Co., Ltd., Tokyo) (Fig. 1D). The arachnoid trabeculae were made with water-insoluble tissue paper.

A skull model retention table (ONO & Co., Ltd.) was used to rotate and fix the head, as performed in surgery. The skull bone model was set on a plate, so the head could be rotated at various angles centered at 30° by adjusting the lengths of 4 columns (Fig. 1E). Sites for setting spatula retainers were also prepared. The total cost for the models of the skull bone, brain, and cerebral artery, and the skull model retention table was about 600,000 yen.

The cerebral artery model was placed in an anatomically correct position relative to the sylvian fissure in the brain model. The cerebral surface of the brain model was then covered with wetted water-insoluble tissue paper (Fig. 2A). The brain model was wrapped with PVDC film to position the sylvian vein model on the sylvian fissure in the brain model (Fig. 2B). This brain model was placed in the skull bone model, and the frontal and temporal lobes, and sylvian fissure were exposed through a frontotemporal craniotomy window (Fig. 2C). To immobilize the brain model in the skull bone model, the space in the model was filled with packing materials used for shipping.

Simulation of trans-sylvian approach used an operating microscope, microscissors, microforceps, spatula, and microsuction tube connected to a portable sputum aspirator for actual aspiration. Use of these surgical instruments was explained to the

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Fig. 1 Parts of the model. A: Skull bone model. B: Brain model. C: Cerebral artery model. D: Sylvian vein and arachnoid membrane models prepared with polyvinylidene chloride film, woolen yarn, and cotton lace thread. E: Skull bone model retention table.

Fig. 2 Assembly of parts. A: Brain model with the cerebral artery placed in the sylvian fissure and covered with wetted water-insoluble tissue paper. B: Brain model covered with the sylvian vein-applied arachnoid membrane. C: Brain model placed in the skull bone model and retained on the retention table.

Fig. 3 Microscopic simulation. A: Division of the arachnoid membrane. B: Division of the arachnoid trabeculae. C: Exposure of the right middle cerebral artery. D: Exposure of the right internal cerebral artery.
medical students and residents. The trans-sylvian approach was described beforehand using anatomy and surgery texts, and videos of the surgery. The medical students and residents performed the trans-sylvian approach using the model on the table. Under a microscope, the frontal and temporal lobes were retracted using a spatula, and the arachnoid membrane proximal to the sylvian vein was divided (Fig. 3A), followed by dissection and division of the arachnoid trabeculae (Fig. 3B). These procedures were repeated to expose the middle cerebral artery (Fig. 3C), and the internal carotid artery was finally reached (Fig. 3D).

A questionnaire comprised of 8 questions was completed by the medical students and residents after surgical simulation using the model. The model was evaluated by rating 8 items as: yes, very much; yes; somewhat; not very much; or not at all. Free comments were also invited. The questionnaire content was not included in the clinical practice evaluation of the students. To avoid identifying individual students, only the sex and school year were filled in, without the name and date of the simulation. The questionnaires were collected in each group and submitted on the final day of clinical training. This study was approved by the Ethics Committee of Toho University School of Medicine (approval number 22037).

**Results**

Twenty-one medical students (13 males and 8 females) and 2 residents (2 males), 23 trainees in total, used this model to simulate the trans-sylvian approach in microsurgery, and replies to the questionnaire were collected from all of them. All items were rated as ‘yes, very much’ by more than 40% of the trainees, and ‘yes, very much’ and ‘yes’ accounted for more than 70% of answers (Fig. 4). No item was rated ‘not at all.’

Summarizing the free comments, 17 subjects stated ‘interest in surgery was increased by performing the actual procedure,’ and 10 subjects stated ‘I could acquire a stereoscopic image of the brain anatomy’ (including multiple answers). On the other hand, 2 subjects commented ‘it was difficult to assess how much this surgery stresses the brain,’ and 1 subject stated that ‘the difference in the difficulty level between the actual brain and brain model was unclear.’ The durability of this model showed no major problem. The skull and skull retention table can be used semipermanently, and the brain model was judged to be usable for several years. The cerebrovascular model was the least durable, lasting for about one year when used several times weekly.

**Discussion**

Accurate skull bone models for the simulation and practice of skull base surgery, vascular models resembling blood vessels in the body for the practice of anastomosis, a desk-type microscope for practice, and a skull bone model for deep vascular anastomosis have been developed. These models are useful to improve the surgical techniques of neurosurgeons, but simulation using them is difficult and inappropriate for the general education of medical students and residents because they have no experience of surgery and insufficient knowledge of neurosurgery. The trans-sylvian approach is the most common microsurgical procedure in neurosurgery and mainly employs basic techniques of microsurgery, such as division and dissection of the arachnoid membrane and retraction of the brain. Therefore, this may be the first operative approach that should be taught to medical students.

Our 3D model was developed to help medical students to readily understand the trans-sylvian approach.
The important first step to learn the trans-sylvian approach is to understand the surgical position of the rotated head, so a table to rotate and retain the skull bone model at an appropriate angle is necessary. The retention table developed in this study allows change of the rotation angle of the head by adjusting 4 columns of the table, facilitating learning of the surgical posture. The second step is to learn the range of craniotomy. Frontotemporal craniotomy was applied to the model beforehand, so the trainees learned its range. This also demonstrated how the frontal and temporal lobes and sylvian fissure of the brain model appear through the craniotomy window. Simulating a craniotomy window covered with a bone flap may facilitate more efficient learning. The 3rd step is to experience microsurgical manipulation, and learn the angle and depth of the sylvian fissure in the microsurgical view. For this simulation, models of the arachnoid membrane, arachnoid trabeculae, and sylvian vein are necessary, in addition to the brain model.

Preparation of an accurate model closely resembling the arachnoid membrane, arachnoid trabeculae, and sylvian vein employing engineering technology is ideal, but costly. In contrast, preparation of a model using cheap materials which can be repeatedly employed at any time is advantageous for the education of many students. We selected materials for the models, focusing on acquiring the appropriate senses of surgical procedures in the surgical simulation. The basic surgical procedure for the arachnoid membrane in the trans-sylvian approach is division using microscissors during tension loading with spatulas. Readily purchasable PVDC film is thin and transparent, and visually similar to the arachnoid membrane. This film also has physical properties similar to those of the arachnoid membrane: the film does not become vulnerable when wet, microscissors are necessary to cut the film, and the film can be torn by pulling both ends with microforceps after cutting. For the arachnoid trabeculae, water-insoluble tissue paper was adopted. The arachnoid trabeculae are also mainly divided using microscissors during tension loading. Wetted tissue paper becomes thin on mild retraction, resembling the arachnoid trabeculae. The microsurgical manipulation could be appropriately simulated because of this similarity. For the model of the sylvian vein and its branches, woolen yarn and cotton lace thread were used. These materials become soft when wet and are similar to the vein both visually and physically. By applying them to the PVDC film with glue, the presence of the sylvian vein right below the arachnoid membrane and their close contact were reproduced.

The questionnaire completed by the students and residents demonstrated that this model was useful for the anatomical understanding of the arachnoid membrane, arachnoid trabeculae, and sylvian vein, and stereoscopic understanding of the sylvian fissure. In addition, both the surgical procedures, and use of surgical instruments to perform microsurgery are important to master. Simulation using this model may be useful for education in how to use an operating microscope, microscissors, microforceps, spatula, and microsuction tube. Furthermore, as shown in the results for the 8th question in the questionnaire, this model promoted interest in surgery in medical students and residents, which may also be useful for education in neurosurgery.

This model was useful for medical students and residents to understand and learn the trans-sylvian approach. Repeated practice using cheap materials is advantageous for an educational model.

References

10) Mori K, Yamamoto T, Oyama K, Nakao Y: Modification of three-dimensional prototype temporal bone...
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