Journal of Neurological Sciences [Turkish] **32:(1)**# 43; 023-029, 2015
http://www.jns.dergisi.org/text.php3?id=845
Research Article

Laboratory Training in Bifrontal and Frontolateral Approaches Using Cadaveric Silicone-Injected Cow Craniums

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Summary

Background: A microneurosurgical laboratory training model was designed for trainees in neurosurgery to help them to learn how to handle surgical microscopes and microneurosurgical instruments. A silicone-injected fresh cadaveric cow cranium is a suitable alternative to using a cadaveric human brain for gaining familiarity with the frontal cranial nerves and vascular structures for bifrontal and frontolateral approaches.
Methods: A silicone-injected cadaveric cow cranium was prepared by irrigating the major vessels, followed by the injection of silicone colored either red or blue.
Results: A three-step approach was designed to simulate microneurosurgical dissection along the frontal lobe and for the dissection of cranial nerves and vascular structures. This laboratory training model is useful for trainees to gain experience in the use of an operating microscope and become more familiar with the anterior neural and vascular structures in bifrontal and frontolateral approaches.
Conclusion: The aim of this study was to develop an innovative model to create a life-like microneurosurgical training system. This model simulates bifrontal and frontolateral approaches performed on the human brain.

Key words: Cadaver, anterior vascular structures, silicone injection, cow cranium, microneurosurgical training, resident training

Silikon İnjekte Edilmiş İnek Kranium Kadavrası Kullanarak Bifrontal ve Frontolateral Yaklaşımlar İçin Laboratuar Eğitimi

Özet

Arka plan: Nöroşirürji asistanlarının cerrahi mikroskop ve mikronöroşirürji cerrahi el aletlerini nasıl kullanacaklarını öğrenmelerine yardım etmek için bir mikronöroşirürji laboratuar eğitim modeli tasarlanmıştır. Bifrontal ve frontolateral yaklaşımlarda frontal kranial sinirler ve vasküler yapılara aşinalık kazanmak için silikon injekte edilmiş taze inek kranium kadavrası kullanmak, insan beyin kadavrası kullanmaya uygun bir alternatiftir.
Yöntem: Silikon injekte edilmiş inek kranium kadavrası, ana damarların suyla temizlenmesi ve sonrasında mavi ve kırmızı silikon ile damarların doldurulması ile hazırlandı.
Bulgular: Kranial sinir ve vasküler yapıların diseksiyonunu ve frontal lob boyunca mikronöroşirürjikal diseksiyonunu simüle etmek için, üç aşamalı bir yaklaşım tasarlanmıştır. Bu laboratuar eğitim modeli, bifrontal ve frontolateral yaklaşımlarda anterior nöral ve

vasküler yapıları daha aşina hale getirmede ve cerrahi mikroskop kullanmada asistanlara deneyim kazandırmada faydalıdır.
Sonuç: Bu çalışmanın amacı; yaşam boyu sürecek mikronöroşirürji eğitim sistemi sağlamak için yenilikçi bir model oluşturmaktır. Bu model, insan beyni üzerinde yapılan bifrontal ve frontolateral yaklaşımları simüle etmektedir.

Anahtar Kelimeler: Kadavra, anterior vasküler yapılar, silikon injeksiyonu, inek kraniumu, mikronöroşirürji eğitimi, asistan eğitimi

INTRODUCTION

Cranial models have previously been described for use in cranial anatomy training and experimentation[1,2,3,4,5,6,7,9]. These models are purely supplementary and cannot not replace real-surgery microneurosurgical experience, which alone brings about the transformation from novice to expert. Sufficient practice and experience are necessary, however, if good neurosurgical skills are to be developed, while regular practice is required to improve or maintain surgical skills.

Based upon a previously reported model utilizing fresh cadaveric cow and sheep craniums, we describe an advanced technique where colored silicone is injected into the cranium of a fresh cadaveric cow to be utilized for training purposes. The aim of this novel model is to provide experience in the use of microneurosurgical techniques, including an operative microscope, by creating a life-like microneurosurgical training system for bifrontal and frontolateral approaches. The model uses a fresh cadaveric cow cranium injected with silicone and achieves the aim of familiarizing trainees in neurosurgery with surgical techniques used in cranial approaches in the early years of their residency program.

MATERIAL AND METHODS

The laboratory model was designed at the Dr. Lütfi Kırdar Kartal Education and Research Hospital, Istanbul, Turkey and was developed in the Prof. Albert Rhoton Neuroanatomy Laboratory, Institute of Neurological Sciences, Marmara University, Istanbul, Turkey as an innovative application of a previously designed model utilizing a fresh cadaveric cow cranium.

The material for the model was a fresh one-year-old cow cranium, which was obtained from a butcher and was fixed in formaldehyde. The cranium was separated at the neck to isolate the blood vessels for cannulation. The following major blood vessels were dissected and isolated for infusion: jugular veins, carotid arteries, and vertebral arteries.

A silicone mixture was prepared by mixing 3110 RTV silicone rubber with thinner (polydimethylsiloxane) at a ratio (thinner:silicone volume) of 2:1 for arteries and 1:1 for veins. Pigment of the desired color was then added (either red or blue). A higher concentration of the pigment provided the vasculature with a more vivid color.

The colored silicone was injected manually according to the following guidelines: for arteries, internal carotid, 50ml each x 2 = 100 ml; and for veins, internal jugular 75 ml each x 2 =150 ml. The ICAs were injected first with 50 cc of the red silicone; as soon as the flow could be seen coming out of the contralateral ICA, this vessel was clamped and steady pressure was applied through the ipsilateral ICA to promote the flow into the posterior communicating arteries (PComAs), toward the vertebrobasilar system. The venous system was then injected with the blue silicone solution. A larger volume of silicone is needed for this injection, because of the larger volume of the venous system; therefore, 75 cc of blue silicone was attached to the catheter of the IJV, and the venous system was filled until the flow out of the contralateral IJV was seen. Both

Foley catheters were then clamped, and the procedure was repeated with the contralateral IJV. After the injection of both IJVs, the catheters were closed and the balloons in each catheter were inflated to encourage the further flow of silicone into the venous system.

RESULTS

Before beginning the microsurgical procedure, the cow cranium, the scalp, and the anterior part of the head, including the nasal and buccal structures, were removed. In addition, the large frontal sinus overlying the cranium was removed. The cranium was positioned and stabilized with a self-retaining retractor (Figure 1A, B). Firstly, a moderate-sized right frontolateral craniectomy was performed (Figure 1C). The dura overlying the sylvian area and the frontal lobe was opened in a semicircular fashion, simulating the standard frontolateral approach in the human brain (Figure 1D). Secondly, a bilateral frontoparietal craniectomy was performed. The dura bilaterally overlying the frontoparietal lobe was opened in a semicircular fashion, simulating the bifrontal approach used on the human brain (Figure 1E).

For the microneurosurgical procedures, an operating microscope (OpMi 99, Zeiss Inc, Oberkocken, Germany) with a magnification of ×6 to ×10 was used. The first step involved dissecting the right internal carotid artery as it pierces the dura to enter the intracranial cavity in the right frontolateral approach. Dissection exposed the two main branches of the brain: the caudal communicating artery, which corresponds to the human posterior communicating artery, and the posterior segment of the rostral cerebral artery. A self-retaining retractor was used to allow easy visualization of the right middle cerebral artery, the right optic nerve, and the right oculomotor nerve (Figure 2).

The second step consisted of gently retracting the bilateral frontal lobe posteriorly with a self-retaining retractor to allow easy access to the carotid and chiasmatic cisterns and to visualize the bilateral optic nerve, the chiasma, the anterior cerebral artery and the contiguous segment of the rostral cerebral artery (A1 segment of the human brain) (Figure 3). Microneurosurgical instruments (a bipolar tip, an arachnoid knife, microscissors, and the tip of a suction tube) were used for arachnoid dissection.

The third step involved simulating aneurysm clipping of a major artery. In surgery, whether or not this step is used very often depends on the vascular characteristics of the specimen. In our model, we applied the aneurysm clip to the exit of the caudal communicating artery from the internal carotid artery (Figure 4A, B).

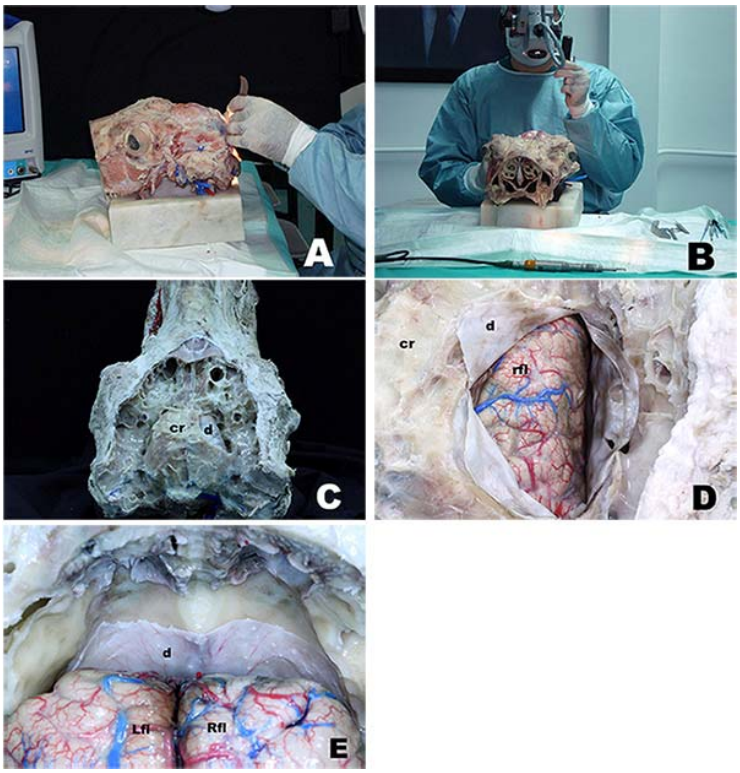

Figure 1: (A) *Preparation and stabilization of the cow cranium training model with the anterior nasal and buccal area removed. A self-retaining retractor system is stabilizing the specimen. (B) Training session photographs from the operating microscope. (C) Performing a moderate-sized, right frontolateral craniectomy. (D) Opening the dura, which is overlying the right frontal lobe in a semicircular fashion, simulating the frontolateral approach in the human brain. (E) Performing a bilateral frontoparietal craniectomy. Opening the dura bilaterally, which is overlying the frontoparietal lobe, simulating the bifrontal approach in the human brain. (cr: cranium, d: dura, Lfl: left frontal lobe, and Rfl: right frontal lobe)*

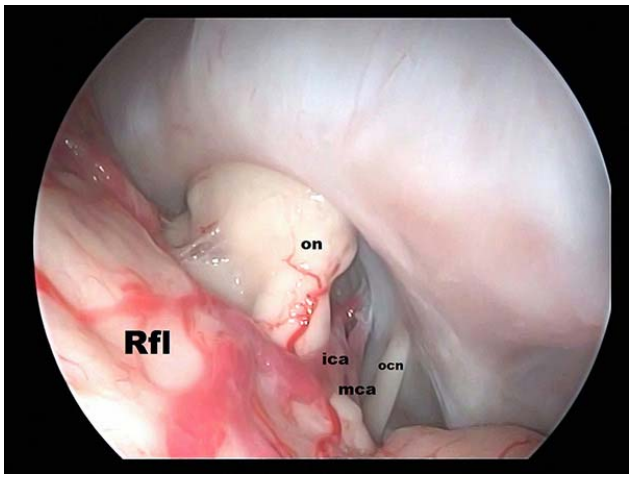

Figure 2: *The brain surface as it appears upon beginning microsurgery of the dura, which is reflected laterally at the right frontal lobe. Medial retraction of the right frontal lobe and visualization of the right internal carotid artery, the right middle cerebral artery, the right optic nerve and the right oculomotor nerve (ica: internal carotid artery, mca: middle cerebral artery, and ocn: oculomotor nerve, on: optic nerve, and Rfl: right frontal lobe).*

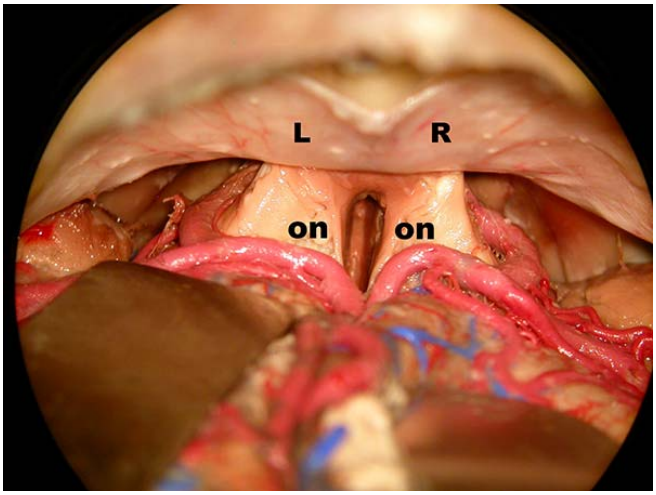

Figure 3: *The bifrontal approach allows easy access and entrance into the carotid and chiasmatic cisterns and to visualize the bilateral optic nerve, the chiasma, the anterior cerebral artery, and the contiguous segment of the rostral cerebral artery (L: left, on: optic nerve, and R: right).*

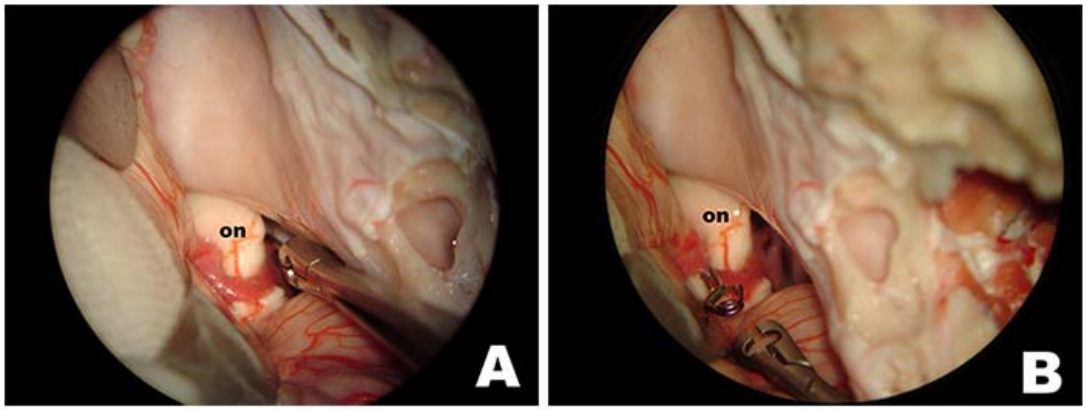

Figure 4 A,B: *Simulating aneurysm clipping to a major artery. Whether or not this step is used very often depends on the vascular characteristics of the specimen. We applied the aneurysm clip to the exit of the caudal communicating artery from the internal carotid artery (on: optic nerve).*

DISCUSSION

Training models play an increasingly important role in the development of neurosurgical trainees. Several models have been developed to give residents experience with neurosurgical and microsurgical procedures. The majority use cadaveric tissue, animal tissue, or synthetic materials[1,2,3,8]. Cadaver studies are superior to those using synthetic materials because the anatomical structure of the cadaver is the exact structure that will be encountered during live surgery. However, the absence of hemodynamic features in the cadaver, which are present during live surgery, is a disadvantage in both the human and animal cadaver models. This may partly be overcome by circulating colored fluids in the cerebrovascular structures. In our model, red fluid was circulated through the arteries and blue fluid was circulated through the veins, which made the observation of vascular structures possible, and the distinction of arterial and venous structures was easier.

A cow brain is different from a human brain in several important aspects. The volume of a cow brain is slightly less than half of the volume of a human brain, and the topographic anatomy of the lateral and inferior surfaces and the Circle of Willis of a cow brain are slightly different to those of a human brain. Furthermore, although a sylvian fissure exists in a cow brain, it does not contain the middle cerebral artery as in the human brain. However, our training model is not an anatomical study of the cow cranium as it would be in the context of veterinary medicine and, except for its neurosurgical similarities to the corresponding structures in the human brain, the cow brain's anatomy is not the subject of the training model. The cow cranium with silicone model was proven to be ideal for training residents for performing neurosurgical techniques. The ready availability of cow craniums and the low cost of the model, combined with its ease of preparation and reproducibility, make the training process efficient and highly effective[2,3,4,5,9].

CONCLUSION

This dissection process familiarizes trainees with microneurosurgical techniques for bifrontal and frontolateral approaches. The fresh cadaveric cow cranium model, besides being inexpensive, is a useful laboratory training method to accustom trainees to dissecting cranial nerves and vascular structures around the frontal lobe. In our model, the vascular and neural structures can easily be observed and their locations examined for future surgical interventions. We believe that this study model will contribute to the teaching of neuroanatomical structures and will provide a secure and ethical experience for those involved in intracranial surgery. We propose that our fresh cadaveric cow cranium model is used to train surgeons who have mastered the basic techniques of microneurosurgical practice.

Conflict of interest

There is no conflict of interest.

Acknowledgements

We have no financial relationship to the study, we have not received any other form of financial support and we have not received any government or company grants or research support. We are not employees of a company, consultants for a company, stockholders of a company or members of a speakers' bureau.

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Received by: 25 August 2014
Accepted: 18 December 2014

The Online Journal of Neurological Sciences (Turkish) 1984-2015
This e-journal is run by Ege University Faculty of Medicine,
Dept. of Neurological Surgery, Bornova, Izmir-35100TR
as part of the Ege Neurological Surgery World Wide Web service.
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E-mail: editor@jns.dergisi.org
URL: http://www.jns.dergisi.org
Journal of Neurological Sciences (Turkish)
Abbr: J. Neurol. Sci.[Turk]
ISSNe 1302-1664

REFERENCES

1. *Galeano M, Zarabini AG. The usefulness of a fresh chicken leg as an experimental model during the intermediate stages of microsurgical training. Ann Plast Surg. 2001; 47(1): 96–7*
2. *Hamamcioglu MK, Hicdonmez T, Tiryaki M, Cobanoglu S. A laboratory training model in fresh cadaveric sheep brain for microneurosurgical dissection of cranial nerves in posterior fossa. Br J Neurosurg. 2008; 22(6): 769–71*

3. *Hicdonmez T, Hamamcioglu MK, Parsak T, Cukur Z, Cobanoglu S. A laboratory training model for interhemispheric-transcallosal approach to the lateral ventricle. Neurosurg Rev. 2006; 29(2): 159–62*
4. *Hicdonmez T, Hamamcioglu MK, Tiryaki M, Cukur Z, Cobanoglu S. Microneurosurgical training model in fresh cadaveric cow brain: a laboratory study simulating the approach to the circle of Willis. Surg Neurol. 2006; 66(1): 100–4*
5. *Hicdonmez T, Parsak T, Cobanoglu S. Simulation of surgery for craniosynostosis: a training model in a fresh cadaveric sheep cranium. Technical note. J Neurosurg. (2 Suppl) 2006; 105: 150-2*
6. *Hino A. Training in microvascular surgery using a chicken wing artery. Neurosurgery 2003; 52(6): 1495-7*
7. *Menovsky T. A human skull cast model for training of intracranial microneurosurgical skills. Microsurgery 2000; 20(7): 311–3*
8. *Popesko P. Atlas der topographischen anatomie der haustiere. Band I: Kopf und hals. Stuttgart, Ferdinand Enke Verlag, 1989, pp. 44-5*
9. *Turan Suslu H, Ceylan D, Tatarlı N, Hıcdonmez T, Seker A, Bahrı Y, Kılıc T. Laboratory training in the retrosigmoid approach using cadaveric silicone injected cow brain. Br J Neurosurg. 2013; 27(6): 812-4*