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Hemifasial Spazm Tedavisinde Uygulanan Endoskopik Mikrovasküler Dekompresyon Cerrahisi Eğitimi için Kadavra Koyun Başi Modellerinin Kullanilmasi

Training for Endoscopic Microvascular Decompression Surgery Using Cadaveric Sheep Head Models for Hemifacial Spasm Treatment

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ÖZET

AMAÇ: Hemifasiyal Spazm (HS) yaşam kalitesini etkileyen bir durumdur. Yüzün tek taraflı istemsiz, tonik veya klonik kasılmaları olarak tanımlanır. Mikrovasküler dekompresyon (MVD) yedinci sinir üzerine vasküler bası var ise birinci seçenek tedavisidir. Son zamanlarda endoskop kullanılarak yapılmaya başlanmıştır. Çalışmamızdaki amaç full endoskopik MVD cerrahisi için gerekli becerilerin gelişimi için kadavra koyun başı modeli geliştirilmesidir.

GEREÇ VE YÖNTEM: Çalışmada kullanılan materyal, yerel bir kasaptan temin edilen 5 adet taze koyun başıdır. Cerrahi adımlar, koyun kafalarının posterioru cerraha bakacak şekilde konumlandırılması, oksipital kondilin 1 cm üzerinden kraniyektomi yapılması, dura materin açılması, serebellar dokunun tanımlanması ve mediale çekilmesi, endoskop kullanılarak sisternlerin ve ardından kraniyal sinirlerin tanımlanması ve mikrovasküler dekompresyonun simüle edilmesinden oluşmaktadır.

BULGULAR: Koyun kafataslarıyla full endoskopik MVD cerrahisi simüle edilmiştir.

SONUÇ: Endoskopik MVD cerrahisine aşina olmaya olanak sağlaması açısından kadavra koyun başı modellerinin kullanılması endoskopik cerrahi pratiği ve egitimi için faydalı olabilir.

Anahtar Kelimeler: Koyun kafatası, cerrahi eğitim, endoskopi, mikrovasüler dekompresyon

ABSTRACT

AIM: Hemifacial Spasm (HFS) is a condition that significantly impacts quality of life. It is characterized by involuntary, tonic or clonic contractions on one side of the face. Microvascular decompression (MVD) is the primary treatment option when vascular compression on the seventh cranial nerve is present. Recently, endoscopic techniques have been introduced for this procedure. The aim of our study is to develop a sheep head cadaver model to facilitate the acquisition of necessary skills for fully endoscopic MVD surgery.

MATERIAL AND METHOD: The material used in the study was 5 fresh sheep heads, obtained from a local butcher. The surgical steps consist of positioning the sheep's heads with its posterior facing the surgeon, performing a craniectomy 1 cm above the occipital condyle, opening the dura mater, identifying the cerebellar tissue and retracting it medially, identifying the cisterns and then the cranial nerves using an endoscope, and simulating microvascular decompression.

RESULTS: Fully endoscopic MVD surgery was successfully simulated using the sheep skulls.

CONCLUSION: The use of sheep head cadaver models may be beneficial for endoscopic surgical training and practice, as they provide a practical means for familiarization with endoscopic MVD techniques.

Keywords: Sheep skull, surgical training, endoscopy, microvascular decompression

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INTRODUCTION

Hemifacial Spasm (HFS) has a prevalence of approximately 7 to 15 cases per 100,000 people. It affects women twice as often as men, with diagnosis typically occurring in the 5th and 6th decades of life (1). The condition initially presents as involuntary, tonic, or clonic contractions of the facial muscles on one side (2,3). Although HFS is predominantly unilateral, rare cases of bilateral symptoms have been reported. Studies have shown that patients with HFS often experience increased levels of anxiety, depression, and functional impairment, underscoring its significant impact on quality of life (4). HFS can be classified into three types: typical, idiopathic, and secondary. Typical HFS is usually caused by benign vascular compression of the facial nerve near its root exit zone in the brainstem (5). This condition may occasionally be associated with increased intracranial pressure, posterior fossa flattening, and arachnoid adhesions (6). In typical HFS, the orbicularis oculi muscle is usually the first to be affected, followed by the involvement of other muscles such as the orbicularis oris, buccinators, and platysma (7). Idiopathic HFS presents with similar symptoms, but its exact cause remains unknown. Secondary HFS is less common and is associated with underlying conditions such as tumors or multiple sclerosis (5). Microvascular decompression (MVD) was first performed by Gardner in 1959 for trigeminal neuralgia and later in 1962 for HFS (Gardner WJ2). The symptomatic improvement observed with this procedure is attributed to the alleviation of ephaptic neural transmission. Various surgical techniques have been employed, but microscopic retrosigmoid craniotomy remains the most common approach (8). In the last decade, endoscopy has been introduced to improve visualization of neurovascular structures, particularly for viewing areas behind the nerve (9). However, advancements in neuroendoscopic technology have opened the door to fully endoscopic treatments for brain surgeons. Literature reviews indicate that endoscopic surgery yields better outcomes and fewer complications compared to microsurgery. Although MVD performed with microsurgery is relatively straightforward and has a shorter learning curve, neuroendoscopic MVD is more surgically complex and requires a longer learning curve (10).

Laboratory training models play a crucial role in enhancing surgical skills and ensuring patient safety by minimizing risks (11). Among these models, sheep have been widely utilized for various surgical training procedures, including anterior clinoidectomy, endoscopic cordotomy, retrosigmoid approach extensions, and posterior fossa approaches in microneurosurgery (12-15). The sheep model is particularly valuable in neuroscience due to the anatomical similarities between the sheep and human brain. Several studies have also proposed in vitro sheep models for training neurosurgical residents (16). Recognizing the importance of refining surgical techniques while reducing the reliance on live animals, this paper proposes a practical neurosurgical training model using a nonliving sheep head. Our objective is to emphasize the anatomical features of the sheep posterior fossa and evaluate the benefits and limitations of this model for endoscopic microvascular decompression (MVD) surgical training.

MATERIAL AND METHOD

Ethical approval for the study was obtained from the Local Committee for Animal Cadaver Study (approval number 798, dated 01/11/2024). The material used in the study was 5 fresh sheep heads, obtained from a local butcher at a relatively low cost (US$ 4.00/each), with the scalp removed.

Surgical Steps

The surgical steps consist of positioning the sheep's heads with its posterior facing the surgeon, performing a craniectomy 1 cm above the occipital condyle, opening the dura mater, identifying the cerebellar tissue and retracting it medially, identifying the cisterns and then the cranial nerves using an endoscope, and simulating microvascular decompression.

RESULTS

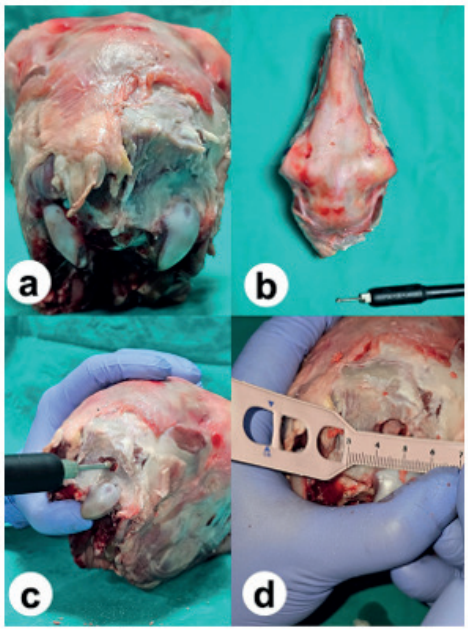

Figure 1:

a) Positioning of the sheep skull,

b) Preparation of extension-equipped hand drill,

c) Creating the burr hole,

d) Measuring the burr hole width.

The sheep's skull were positioned with the posterior side facing the surgeon (Figure 1a,b). A burr hole was created 1 cm above the right occipital condyle using an extended hand drill (Figure 1c). The bone edges were widened sufficiently to allow the endoscope to enter (Figure 1d). The dura mater was reflected toward the sinus

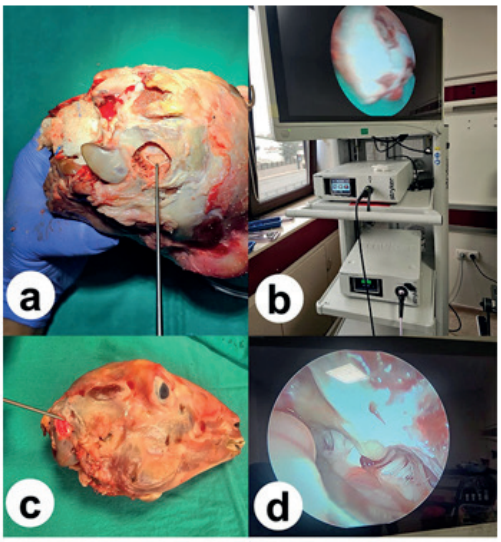

Figure 2:

a) Opening the dura mater and folding it over the sinus,

b) Stryker endoscopic system,

c) Preparing and placing the endoscope into the burr hole,

d) Opening the cerebellomedullary cistern using the endoscope

While the assistant held the endoscope, the surgeon performed microsurgical operations using both hands, with the procedure displayed on a Stryker HD screen (Figure 2b-c). In the first step,

the endoscope was advanced from the lateral cerebello-medullary lobe to access the lateral cerebello-medullary cistern and cerebello-pontine region (Figure 2d). The second step involved using tools such as bipolar forceps, an arachnoid knife, micro scissors, and an aspirator under endoscopic guidance for arachnoid dissection. During this step, the lower cranial nerves (IX, X, XI, XII) and adjacent vascular structures were identified

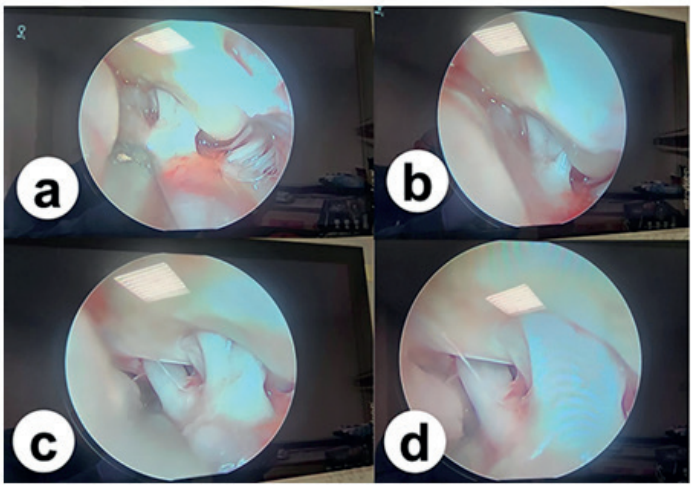

Figure 3:

a) Exposure of cranial nerves IX, X, XI using the endoscope,

b) Exposure of cranial nerves VII and VIII,

c) Exposure of cranial nerve V,

d) Advancing dissection towards the anterior pons.

In the third step, the right cerebellopontine angle and cranial nerves V, VII, and VIII were identified. Arachnoid dissection was performed around the brainstem, and cranial nerves and vessels were identified (Figure 3d). In the final step, the facial nerve's exit zone from the brainstem was visualized through the endoscope, and microvascular decompression of the nerve was simulated using a small piece of plastic cover

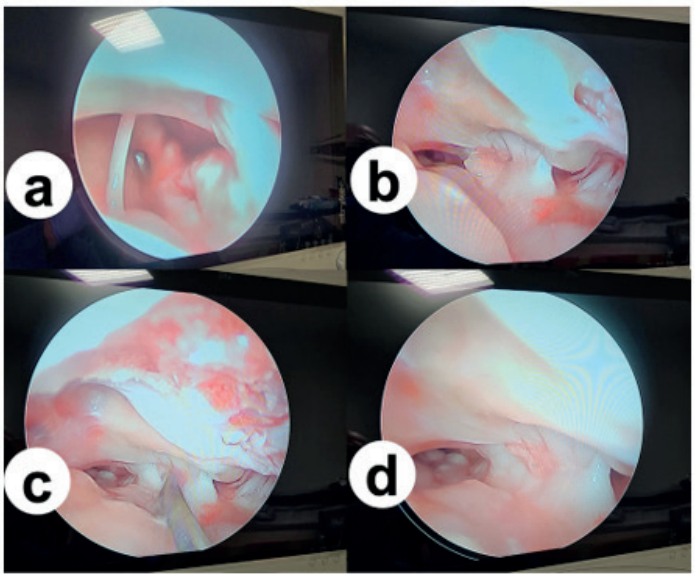

Figure 4:

a) Exposure of cranial nerve IV with endoscope,

b) Placement of fabric paddy superior to VII-VIII complex,

c) Manipulation of fabric paddy,

d) Final position of paddy placed lateral to cranial nerve VII.

DISCUSSION

Neurosurgery demands a high level of surgical skill, which can only be acquired through continuous practice and ongoing training to understand the anatomical basis of surgical approaches. Surgical residents often need years to fully master the necessary surgical skills, and laboratory training models play a critical role in this vital development before applying their skills in clinical settings (17). While human cadaver heads are often inaccessible due to ethical concerns, animal models offer advantages such as cost-effectiveness and repeatability. Regular hands-on training significantly enhances operating room performance. Over the past decade, medical education has increasingly incorporated virtual reality for surgical practice. However, biological materials remain invaluable for hands-on training due to their similarity to human tissue. Ruminant and porcine models have been effective in simulating high-precision neurosurgical procedures. A comparative study by Sidhu et al. demonstrated that training on biological tissues is more effective than synthetic models in developing fine motor skills (18). Some studies have identified gaps in surgical skills training. For instance, Boszczyk et al. highlighted confidence issues among European neurosurgical trainees in managing spinal trauma and various surgical approaches. They noted that residents need frequent practice of basic techniques to train their striatum and cerebellar functions (19).

Live animals offer distinct advantages over inanimate models, but cadaver models are also valuable for neurosurgery trainees to understand anatomical structures (17). Familiarity with the anatomical features of sheep, cattle, or pig brains and spines helps residents improve their understanding of human anatomy. Handling various components with micro-instruments assists in developing manual dexterity for managing delicate neural structures (16). Surgical interventions on live animals require ethical approvals, compliance with veterinary standards, and adherence to local laws and animal research codes. Meeting these standards can be challenging. When seeking permission, the justification for animal use must be clear, and alternative methods (such as cadavers or simulation workshops) should be considered if live animals are not available. Participants in live animal surgery require appropriate postgraduate training (Laboratory Animal Certificate), and veterinary supervision is essential to monitor anesthesia and minimize animal suffering. Cultural restrictions, such as bans on cattle and pig models in India and the Middle East, necessitate alternative animal options (11). Cadaver brains lack bleeding indicators, making educational procedures on cadavers more comfortable due to the absence of hemostasis needs. If specimens are obtained from veterinary-supervised units, the risk of sheep and cattle contracting slow viruses that could cause central nervous encephalopathy is minimized (15).

Training in neurosurgery has also been reported using nonliving animal models. Hicdonmez et al. described a laboratory training model utilizing fresh cadaveric cow craniums to simulate standard microneurosurgical steps, such as the interhemispheric-transcallosal approach to the lateral ventricle.20 The same authors also created a training model using cadaveric sheep craniums to mimic the steps of posterior fossa surgery in humans (15). Both methods were found to be effective in helping neurosurgery residents refine their skills and gain a deeper understanding of brain surgery. In our study, similar procedures were successfully carried out using a sheep brain model.

MVD is considered the primary treatment option for HFS (21). Research shows that MVD can be highly effective in managing HFS, with success rates reaching 95.37% and recurrence rates remaining below 2.4% (22). The fully endoscopic MVD approach has shown promising results in treating HFS, as demonstrated by Feng et al (23). They reported a success rate of 91.1% in 39 cases, while Zhu et al. documented a success rate of 88.9% in 54 cases (24). Zheng X, in a study involving 16 patients, reported a 100% surgical success rate, although the limited sample size necessitates further research to validate these findings (10).

The most common complications of MVD for HFS are facial nerve paralysis and hearing loss, followed by intracranial infection and wound-related issues (10). Peng and colleagues demonstrated that fully endoscopic MVD surgery reduces recurrence and complications, suggesting that endoscopic surgery should become more widely adopted (25). The authors attributed this reduction to the enhanced field of view provided by neuroendoscopy, which allows for clearer visualization of the compression area, enabling more accurate resolution of the compression. Postoperatively, warm saline

can be injected under neuroendoscopic guidance to simulate normal brain pulsations and verify the effectiveness of vascular retraction, while also simulating cerebrospinal fluid circulation around the brainstem, thereby reducing complications and recurrence (26). Neuroendoscopy minimizes damage to blood vessels, nerves, and brain tissue by facilitating close examination along the lateral cerebellar space without the need for bone removal or excessive brain tissue tension, further reducing postoperative complications and recurrence.

In this study, we have described the endoscopic MVD surgical technique using a sheep head model for the first time in the literature. Although previous studies have explored the posterior fossa surgical anatomical region using sheep heads, none have utilized the techniques we have described. Our study found that the color and texture of sheep brain tissue are remarkably similar to human brain tissue. Additionally, sheep heads are more cost-effective than human cadaver heads and are suitable for neurosurgical training. This study also confirmed that the brain tissue, cranial nerves, and arteries in sheep are not significantly different from those in humans.

CONCLUSION

Although endoscopic MVD surgery simulation on sheep heads cannot replicate bleeding, it can positively contribute to anatomical orientation and the use of endoscopes in this region. With its tissue and anatomical structure closely resembling that of a human head, the sheep head model shows significant promise as a training tool for neurosurgical procedures.

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