Ventrolateral temporal lobectomy in normal dogs as a counterpart to human anterior temporal lobectomy: a preliminary study on the surgical procedure and complications

Summary of Doctoral Thesis

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INTRODUCTION

Epilepsy is a common neurological disorder in human and veterinary medicine, and antiseizure drug (ASD) therapy is the primary approach for human and animal patients with epilepsy. Despite adequate ASD treatment, proper seizure control is not achieved in approximately 30% of human and canine patients.

In humans, epilepsy surgery is a generally accepted treatment option for patients with drug-resistant epilepsy. The surgical techniques are selected for each patient depending on the situation. However, there are very few reports about epilepsy surgery in the veterinary literature, which describe corpus callosotomy (disconnection surgery), vagus nerve stimulation or deep brain stimulation (neuromodulation), and resection of the lesion in structural epilepsy, and partial cortico-hippocampectomy (feline cadaveric study; resection surgery).

Anterior temporal lobectomy (ATL) is a type of resection surgery that is characterized by the removal of unilateral mesial temporal lobe structures that cause epileptic seizures as the epileptogenic zone. It is commonly accepted that ATL is a recommended treatment option for achieving seizure control in eligible patients with drug-resistant temporal lobe epilepsy. This surgical procedure is performed with a temporal craniotomy to expose the sylvian fissure and remove temporal structures, i.e., the anterolateral neocortex, part of the fusiform gyrus, amygdala, uncus, hippocampus, and parahippocampal gyrus. Most of the human medical centers performing ATL report low operative morbidity and mortality, and freedom from or reduction of seizures is achieved in 60–80% of patients with temporal lobe epilepsy after ATL. In veterinary medicine, there is only one case report in which a hemangioma in the mesial temporal lobe was removed from a dog using a surgical technique similar to ATL.

The aims of the present study were 1) to establish an ATL-like procedure for dogs, 2) to identify its surgical complications, and 3) discuss its feasibility. In order to achieve these aims, we performed ATL-like surgery on normal dogs and evaluated the success rate and postoperative complications by follow-up observations using magnetic resonance imaging (MRI) and histopathology.

MATERIALS AND METHODS

This study was approved by the Animal Care and Use Committee of Nippon Veterinary and Life Science University and performed according to the guidelines of the committee.

Eight healthy laboratory beagles (5 males and 3 females) were used in this study. All dogs had normal physical, neurological, and blood findings. The median age of the dogs was 120 months (range: 101–140 months) and the median body weight was 9.3 kg (range: 8.4–12.4 kg).

Under the general anesthesia, all dogs underwent MRI and computed tomography (CT) of the head before surgery. MRI was obtained with a 3.0-Tesla unit. The obtained sequences included transverse plane T2-weighted imaging (T2WI), fluid-attenuated inversion recovery (FLAIR), T1-weighted imaging (T1WI), contrast-enhanced (CE) T1WI, 3D T2WI, 3D T1WI, and CE-3D T1WI.

We defined the procedural goal as the removal of the gray and white matter of part of the left ventrolateral temporal lobe, amygdala within the piriform lobe, and ventral part of the hippocampus (hippocampal head).

The dog was positioned in a sternal recumbent position with the head held slightly higher than the trunk. The head was shaved from the level of the superior orbital margin to the occipital bone area and sterilized as usual. A horseshoe-shaped (inverse U) incision was made on the left scalp rostral from the temporal fossa to the caudal end of the zygomatic arch. Following the scalp incision, the left temporal muscle was cut along the external sagittal crest and detached from the parietal bone to the level of the zygomatic arch.

A rectangular craniectomy was performed on the left pterion area. At first, four burr holes were made and connected in the parieto-temporal region, and the bone within the area was removed using a high-speed drill. Following fenestration, the ventral edge of the surgical window was extended cranioventrally with a rongeur to expose the anteroventral part of the temporal lobe. Bleeding from the diploic layer was controlled using bone wax.

Intracranial surgery was performed under a surgical microscope. A U-shaped durotomy was performed and the ventrolateral aspect of the lateral temporal lobe was exposed. The resection area in the lateral temporal cortex was composed of the ventral part of the caudal sylvian gyrus, which was caudal to the pseudosylvian fissure, and the ventral part of the caudal ectosylvian gyrus and caudal composite gyrus, which were rostral to the caudal suprasylvian sulcus, under the main course of the middle cerebral artery (MCA). During cortical resection, the MCA was preserved using neurosurgical sheets. The temporal cortex, including the gray and white matter within the abovementioned area, was removed with bipolar cautery and suction until the ventral horn of the lateral ventricle was reached. This cortical resection allowed visualization of the mesial temporal structures, i.e., the tip of the ventral part of the hippocampus interiorly and the amygdala rostrally, via the lumen of the lateral ventricle. Removal of the amygdala and piriform lobe was also performed with bipolar cautery and suction. Partial removal of the ventral part of the hippocampus was performed. The removed part of the hippocampus was stored in 10% formalin for pathology. Bleeding from the brain parenchyma or surrounding tissues was controlled with bipolar cautery, fibrin tissue adhesive, microfibrillar collagen hemostat, and oxidized regenerated cellulose. Only a 3D-T2WI sequence was used intraoperatively to determine whether the procedural goal had been achieved. If not, additional resection was performed until the remaining target was removed.

To close the surgical site, the area of craniectomy was covered with artificial dura mater and sealed with fibrin tissue adhesive. The temporal muscle, subcutaneous tissues, and scalp were closed as usual. After finishing all surgical procedures, postoperative CT and MRI were performed.

Follow-up observations included visual assessments of mental and neurological signs such as abnormal behavior and seizure activity for 3 months with direct observations, daily general physical examinations, weekly neurological examinations, and monthly follow-up MRI scans.

After the 3-month observation period, the dogs were euthanized, the surgical site was observed macroscopically and the brain was removed from the skull and immersed in 10% formalin for pathological evaluation. After fixation, the partially resected ventral hippocampus and postmortem brain tissues were embedded in paraffin, and 4-μm- thick sections were made in the transverse plane. These sections were stained with hematoxylin-eosin and evaluated by two neuropathologists.

RESULTS

Postoperative MRI revealed that the procedural goal, i.e., resection of part of the lateral temporal cortex, amygdala, and hippocampal head, was achieved in six (75%) dogs. In these cases, intraoperative views and anatomical structures were confirmed during the stable surgical phase. Intraoperative MRI was performed at least once in those dogs, and was required twice in two dogs and three times in two dogs until surgery was completed. However, one of the six dogs had a sudden cardiac arrest during skin suturing and resuscitation was attempted, but the dog did not recover and was euthanized. After euthanasia, postmortem MRI and autopsy were performed, but no surgical-related intracranial lesion such as hemorrhage or infarction was identified, and no link between surgery and cardiac arrest was revealed. The remaining five dogs recovered completely from surgery, but two had a convulsive seizure during the recovery phase (mentioned below). The median total anesthesia time and operation time (from incision to closure) were 640 min (range: 603–1,147) and 500 min (range: 400–745), respectively.

The other two dogs developed a massive arterial hemorrhage from the origin of the MCA, where it branches from the arterial circle, during the basal approach procedure for hippocampal resection. The surgeon tried to stop the bleeding by various approaches, but it could not be controlled. As a result, the operation was discontinued and both dogs were euthanized.

Finally, the overall survival rate and mortality of ATL-like surgery in this study were 62.5% (5/8 dogs) and 37.5% (3/8 dogs), respectively.

During the observation period, none of the surviving dogs exhibited any negative mental signs or recurrent seizures. On neurological examination, three dogs had a loss or reduction of the menace response in the right eye, which lasted for 1 month in one dog, but it was sustained to the end of the observation period in two dogs. Two dogs had a reduction of postural reactions in the right limbs for 1 week and 1 month, respectively. Other abnormalities noted included mydriasis of the left eye with loss of pupillary light reflexes in one dog and left circling in another dog throughout the observation period. Conversely, other two dogs, which were operated on in the latter part of the study, had no clinical signs and no abnormal findings on neurological examination.

Follow-up MRIs of all surviving dogs showed no evidence of bleeding, hematoma, or cerebrospinal fluid leak. Two dogs had focal lesions with hyperintensity on T2WI/FLAIR and iso- to hypointense lesions on T1WI without contrast enhancement, which were considered to represent ischemic changes, in the ventral margin of the internal capsule including the optic tract and endopeduncular nucleus and in the external medullary lamina including the reticular nucleus, respectively. These lesions persisted during the 3-month observation period. In addition, persistent temporal muscle atrophy of the operated side compared with the contralateral side was observed in three dogs.

On microscopic examination, the surgically resected tissue samples revealed hippocampal structures such as Ammon's horn, demonstrating that partial hippocampectomy was definitely performed. On macroscopic observation at necropsy, severe adhesions were noted at the surgical site of the left temporal area. On histopathological examination of the surgical site, ischemic changes and extensive gliosis were observed in the temporal lobe cortex adjacent to the resected area in all dogs. In the specimens of two dogs with parenchymal damage on follow-up MRI, tissue defects were observed in the corresponding area to the MRI lesions, which were surrounded by ischemic changes with gliosis.

Taking all of the results of this study into consideration, because the surgically removed area of the temporal lobe for resecting mesial temporal structures was different from ATL in humans due to the anatomical differences between humans and dogs, we named this ATL-like surgery in dogs "ventrolateral temporal lobectomy" (VTL).

DISCUSSION

This is the first report describing the procedure, availability, and complications of ATL-like surgery, i.e., VTL, in dogs. The results of this study provide fundamental information for veterinarians to perform temporal lobe surgery. Although the procedural goal was achieved in 6 dogs (75%), the final survival rate and mortality of VTL in this study were 62.5% and 37.5%, respectively. In contrast, the operative mortality rate of ATL for humans is less than 1%. This major disparity in surgical outcome may be associated with surgical proficiency and the visibility of the surgical field.

The most common complications in this study were loss of the menace response and atrophy of the temporal muscles. Visual abnormalities and temporal muscle damage are also common adverse effects in humans. The loss or reduction of postural reactions occurred in two dogs after surgery. This complication may have been caused by damage to the internal structures (thalamus and internal capsule) in the surgical target area. One dog showed surgery-related damage to the internal capsule, and the reduction of postural reactions persisted throughout the observation period. In another one, there was no damage other than to the resection site on MRI, and the reduction of postural reactions was transient, suggesting that the symptoms were caused by transient pressure or ischemia due to surgical manipulation.

The main limitation of this study is that we operated on a small number of normal beagle dogs. As the same breed of dog was used, the difficulty and success rate of VTL in other breeds may differ from those of the present study. However, the purpose of this study was to evaluate the availability and complications of the ATL-like technique in dogs. Finally, to determine the appropriate extent of resection and efficacy of VTL in dog patients with drug-resistant epilepsy, a clinical study based on adequate presurgical evaluations and sufficient informed consent is needed.