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NOTE

Treatment of hydrocephalus with high-pressure valve ventriculoperitoneal shunt in a dog

Jong Min Kim[1)], Jinuk Park[1)], Ji-hye Kim[1)], Tae Sung Han[1)], Dongwoo Chang[2)], Ki-Jeong Na[3)], Seok Hwa Choi[1)] and Gonhyung Kim[1,*)]

[1)]Laboratory of Veterinary Surgery, Veterinary Medical Center, College of Veterinary Medicine, Chungbuk National University, Cheongju, 361–763, Korea

[2)]Laboratory of Veterinary Radiology, Veterinary Medical Center, College of Veterinary Medicine, Chungbuk National University, Cheongju, 361–763, Korea

[3)]Laboratory of Veterinary Clinical Pathology, Veterinary Medical Center, College of Veterinary Medicine, Chungbuk National University, Cheongju, 361–763, Korea

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Abstract

A 5-month-old male Maltese with right-sided circling, deafness, and blindness was presented. A diagnosis of communicating hydrocephalus was made. A ventriculoperitoneal shunt was implanted and the cerebrospinal fluid was drained by using an adjustable valve type (Medtronic Strata®). The valve was set at 2.5 (135–155 mmH_2O). This was done to prevent the possibility of an overdrainage-induced collapse of the brain parenchyma, which can occur rarely when canine hydrocephalus is treated by using a low-pressure valve. Computed tomography performed 6 weeks and 1 year after surgery revealed the ventricles had decreased in size. Thus, a high-pressure valve used during the treatment of hydrocephalus was able to maintain normal intracranial pressure.

Key words; Dog, High-pressure valve, Hydrocephalus

Hydrocephalus is a disease that induces enlargement of cerebral ventricular system because of increasing CSF volume[14)]. Massive CSF induces secondary compression or atrophy of nerve tissue[2)]. Medical treatment (steroid, mannitol, carbonic anhydrase inhibitors) for hydrocephalus relieves symptoms by decreasing CSF production[13)]. Surgical treatment for hydrocephalus is the placement of a ventriculoperitoneal (VP) shunt that allows the excess cerebrospinal fluid (CSF) to drain into the peritoneal cavity[13)]. Low-, medium-, or high-pressure valves can be used for VP shunts[1)]. Several reports have described the treatment of hydrocephalus in veterinary medicine by VP shunt placement[5,7–9,16,17)]. Low-pressure valves are the most compatible to canine normal ventricular pressure[7)]. However, in human medicine recently, it was shown that an adjustable valve used at a high-pressure setting can prevent the

*Corresponding author: Gonhyung Kim, Laboratory of Veterinary Surgery, Veterinary Medical Center, College of Veterinary Medicine, Chungbuk National University, Cheongju, 361–763, Korea
Phone: +82-43-261-3171. Fax: +82-43-261-3224. E-mail: ghkim@cbu.ac.kr

overdrainage-induced collapse of brain parenchyma[11]. In the case described in the present paper, an adjustable valve set at high pressure successfully prevented overdrainage and the collapse of brain parenchyma in a dog treated for hydrocephalus with a VP shunt.

A 5-month-old male Maltese was presented with a dull mental status, right hemiparesis, and right-sided circling for at least one month before hospitalization and sudden deafness and blindness for one week. The papillary light reflex was normal. An ultrasonographic examination performed through the atlanto-occipital space revealed enlargement of the fourth ventricle (Fig. 1). Computed tomography (CT) indicated that the lateral, third ventricle, mesencephalic aqueduct, fourth ventricle were enlarged (Fig. 2). The ventricle to brain ratio (VB ratio) at the tympanic bulla level in axial image was calculated from these measured areas by image analyzer (ImageJ v. 1.43u, NIH, USA) and expressed as a percentage[2]. Preoperative VB ratio was 79% (Fig. 2). Diagnosis was communicating hydrocephalus. Medical treatments to decrease the CSF volume were initiated. Initially, a single dose of mannitol 1 g/kg, IV, methylprednisolone sodium succinate 30 mg/kg IV was provided. Prednisolone 0.5 mg/kg per oral was given twice daily. The dose was gradually reduced in weekly intervals to 0.1 mg/kg every other day. Subsequently, furosemide 2 mg/kg IV QID and cefazolin 20 mg/kg IV TID were given. After 2 weeks of this medical treatment, the symptoms of circling and hemiparesis had decreased slightly. When the dog was 7 months old, the owner consented to VP shunt placement. Preoperative magnetic resonance imaging (MRI) revealed enlargement of the lateral, third ventricle, mesencephalic aqueduct, fourth ventricle, the quadrigerminal cistern, and the intracranial arachnoid space (Fig. 3).

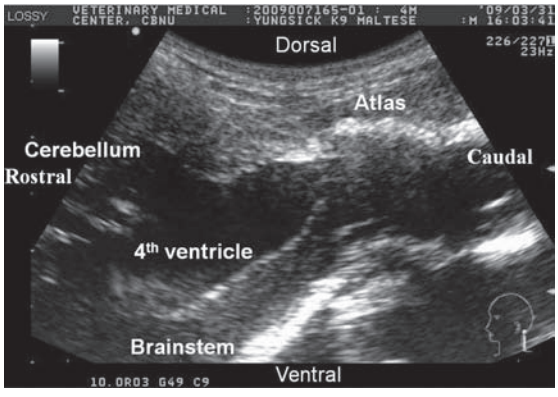

Fig. 1. An ultrasonographic examination performed through the atlanto-occipital space revealed enlargement of the fourth ventricle.

Intracranial pressure (ICP) was normal range and CSF analyses didn't reveal any significant finding from ventricular catheter during surgery. A VP shunt with an adjustable

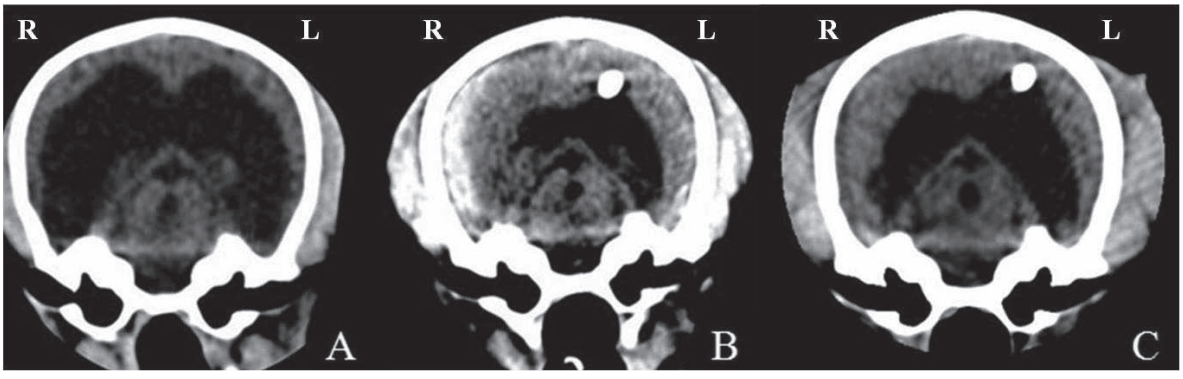

Fig. 2. A: A preoperative CT examination revealed enlargement of the lateral ventricle. The ventricle to brain (VB) ratio was 79% at the tympanic bulla level in axial image. B: CT performed 6 weeks after surgery indicated that the lateral ventricle had decreased in size (VB ratio; 25%). C: At 1 year after the surgery, the lateral ventricle was larger than the size of that in B. The VB ratio was 52%. The white spot is a ventricular catheter.

valve type (Medtronic Strata®, Medtronic, USA) was applied. To prevent slit ventricular syndrome, the open valve pressure was set at a performance level of 2.5 (135–155 mmH_2O). The normal CSF pressure of dogs is 8–12 mmHg[1]. ICPs were measured once weekly for four weeks after the surgery, once six weeks after surgery, once six months after surgery and once a year after the surgery. The ICP was measured in the reservoir of the VP shunt, with the thoracic inlet serving as the reference point. The ICPs were 4–10 mmHg (Fig. 4). When both jugular veins were compressed for 10–20 seconds to confirm the patency of the catheter, the ICP was elevated to above 20 mmHg. This phenomenon is similar to the increase of ICP by about 4–5 mmHg that is seen when both jugular veins of horses are occluded for 15–30 seconds[3]. Thus, a normal ICP can be maintained when the valve is set at high pressure after VP shunt placement.

By 6 weeks and 1 year after the operation, the right-sided circling had disappeared and the right hemiparesis had improved to mild paresis of the right hind limb. CT showed that the ventricles had decreased in size before surgery. The VB ratio at 6 weeks after the surgery was 25% and that at 1 year after the surgery was 52% (Fig. 2). However, the visual deficit and the deafness did not improve until 1 year after surgery.

The clinical signs of hydrocephalus are ataxia, delay in learned behaviour (house training), dullness, circling, periodic aggression, and seizure[18]. Visual deficits can occur due to damage to the optic radiation and occipital cortex[2,4,14]. Since neuronal loss and cortical laminar destruction are not reversible, it is essential to treat hydrocephalus aggressively[1]. Vestibular dysfunction can also occur if the fourth ventricle is enlarged[2]. The choice of treatment is generally determined by physical status, age of the animal and cause of the hydrocephalus[2]. Medical treatment of hydrocephalus is aimed at reducing CSF production and at decreasing ICP[7]. Oral prednisolone or/and acetazolamide administration may be successful[2]. A VP shunt should be considered if the ventricle to brain ratio exceeds 60%[2], if the patient deteriorates during medical therapy, if there is no improvement during medical therapy for two weeks[1,2], or if the tumor causing the obstructive hydrocephalus is not resectable[2].

Hydrocephalus is categorized as obstructive or communicating[13]. Obstructive hydrocephalus occurs when the flow of the CSF in the ventricular system is blocked. The obstruction occurs in anatomically narrow areas in the CSF flow, namely between the lateral and third ventricles (i.e., the intraventricular foramen), or

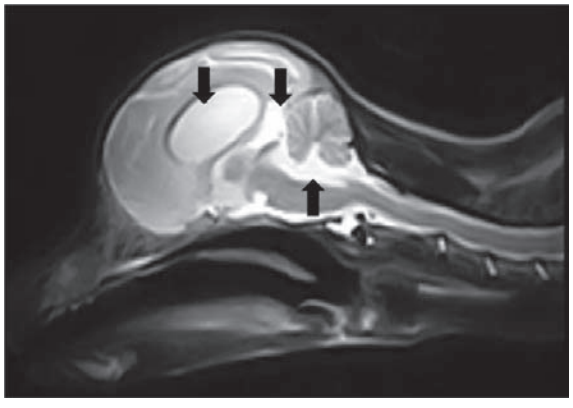

Fig. 3. A preoperative MRI revealed enlargement of the lateral ventricle (leftmost arrow), the fourth ventricle (rightmost arrow), and the quadrigerminal cistern (arrow in the middle).

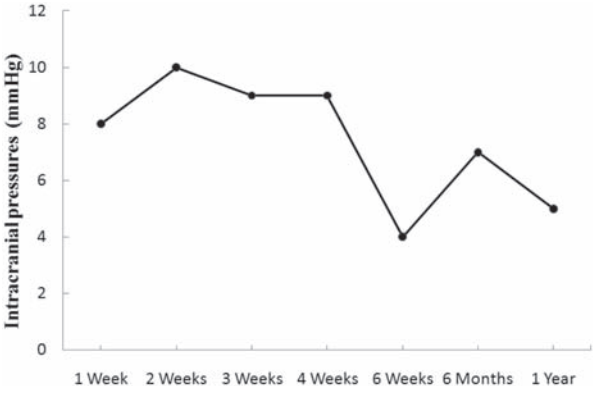

Fig. 4. Intracranial pressures (ICPs) were measured for 1 year postoperatively. The range of ICPs was normal of 4–10 mmHg.

between the third and fourth ventricles (i.e., the mesencephalic aqueduct). For example, a parainfluenza virus infection can induce the destruction of ependymal cells in the ventricular system, which leads to the occlusion of the mesencephalic aqueduct[18]. In communicating hydrocephalus, the CSF flow is not obstructed; rather, the whole ventricular system becomes enlarged[13]. This diffuse dilation occurs when the absorption of the CSF from the subarachnoid space to the venous drainage system is disturbed[13]. For example, canine distemper virus can induce communicating hydrocephalus because it causes meningitis, which can decrease the absorption of the CSF[14]. In our case, MRI revealed that the lateral, third ventricle, mesencephalic aqueduct, fourth ventricle, the quadrigerminal cistern, and the intracranial arachnoid space were dilated. Thus, a diagnosis of communicating hydrocephalus was made.

Ultrasonography performed through the atlanto-occipital space revealed the fourth ventricle was enlarged. CT indicated that the lateral, third, and fourth ventricles were enlarged. However, MRI revealed that the lateral, third, and fourth ventricles, the quadrigerminal cistern, and the intracranial arachnoid space were enlarged. Therefore, MRI may be a much more effective diagnostic method than ultrasound or CT for the diagnosis of hydrocephalus[2,4].

The complications of VP shunts in dogs are excessive trauma to the cerebral parenchyma, migration of the shunt, infection, and shunt blockage. The incidence of one or more of these complications is about 20%[2]. In humans, the complications of shunt therapy are infection, shunt obstruction and overdrainage. These complications appear on average 6.5 years after the operation and the incidence rate is 10–12%[15]. Overdrainage induces subdural hematoma, craniosynostosis, slit ventricle syndrome, and low intracranial pressure syndrome in humans[15]. In addition, in human infants, low-pressure valves are used to prevent permanent ventriculomegaly while the suture is open, but as the child grow up, the valve has to be replaced with a high-pressure valve to prevent overdrainage and intracranial hypotension[15]. However, the risk of overdrainage and slit ventricle syndrome with low-pressure valve is theoretical, and there is no report of clinically problematic such complication in dogs. One of the two dogs treated by low-pressure valve VP shunt developed apparent slit ventricle only detected by MRI, but there was no clinical signs associated to it and actual incidence of this complication is unknown[9]. In our case, CT performed 1 year after the operation revealed the complication of overdrainage had been successfully avoided. Use of high-pressure valve still resulted in normalization of the ICP. Those results support the effectiveness of high-pressure valve system in canine hydrocephalus, and would facilitate the clinical evaluation of its supposed advantages (lower risk of overdrainage).

Valves can be divided into set-pressure valve types and adjustable valve types[11]. The two types do not differ in the incidence of distal obstruction, infection, valve obstruction, and shunt disconnection. However, compared to set-pressure valves, adjustable valves decrease the risk of proximal shunt obstruction and shunt revision. Proximal shunt obstruction is the occlusion of the ventricular catheter hole due to the overdrainage-induced collapse of brain mass[15]. Adjustable valves are thus suitable for patients who have experienced proximal shunt failure[11]. It is important to select the most appropriate shunt system for treating communicating hydrocephalus in humans because an inappropriate system can induce the stricture or obstruction of the sylvian aqueduct, which is the human equivalent of the mesencephalic aqueduct in the dog[6]. Adjustable valves have a number of advantages over set-pressure valves. First, the proper CSF drainage pressure for individual patients with hydrocephalus is not obvious at the time the

shunt is placed and it changes after VP shunt placement[10]. Second, when low-pressure valves of the set-pressure valve type are used in infants, they have to be replaced with high-pressure valves to prevent overdrainage as the patient grows up to prevent intracranial hypotension[15]. Such revision is not needed when an adjustable valve is used. Third, adjustable valves provide control over the ICP, thus preventing overdrainage and underdrainage[11]. For this reason, an adjustable valve was used in the case described here to drain the CSF after VP shunt placement. This is a report of a dog with hydrocephalus treated with a pressure-adjustable shunt system. To the authors knowledge is no report using an adjustable system for a dog with hydrocephalus.

In summary, a high-pressure valve can be considered to be a suitable treatment option for canine hydrocephalus.

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