



HOKKAIDO UNIVERSITY

Title	Treatment of hydrocephalus with high-pressure valve ventriculoperitoneal shunt in a dog
Author(s)	Kim, Jong Min; Park, Jinuk; Kim, Ji-hye et al.
Citation	Japanese Journal of Veterinary Research, 58(2), 137-142
Issue Date	2010-08
DOI	https://doi.org/10.14943/jjvr.58.2.137
Doc URL	https://hdl.handle.net/2115/43315
Type	departmental bulletin paper
File Information	JJVR58-2_p137-142.pdf



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

Jong Min Kim¹⁾, Jinuk Park¹⁾, Ji-hye Kim¹⁾, Tae Sung Han¹⁾,
Dongwoo Chang²⁾, Ki-Jeong Na³⁾, Seok Hwa Choi¹⁾ 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

Received for publication, March 25, 2010; accepted, June 16, 2010

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 mmH₂O). 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 volume¹⁴⁾. Massive CSF induces secondary compression or atrophy of nerve tissue²⁾. Medical treatment (steroid, mannitol, carbonic anhydrase inhibitors) for hydrocephalus relieves symptoms by decreasing CSF production¹³⁾. Surgical treatment for hydrocephalus is the placement of a ventriculoperitoneal (VP) shunt that allows the

excess cerebrospinal fluid (CSF) to drain into the peritoneal cavity¹³⁾. Low-, medium-, or high-pressure valves can be used for VP shunts¹⁾. 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 pressure⁷⁾. 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 parenchyma¹¹⁾. 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

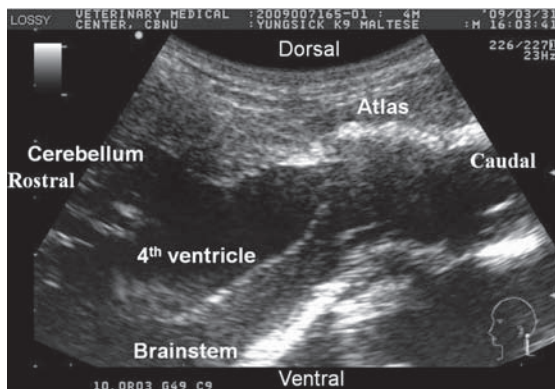


Fig. 1. An ultrasonographic examination performed through the atlanto-occipital space revealed enlargement of the fourth ventricle.

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 percentage²⁾. 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 quadrigeminal cistern, and the intracranial arachnoid space (Fig. 3).

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

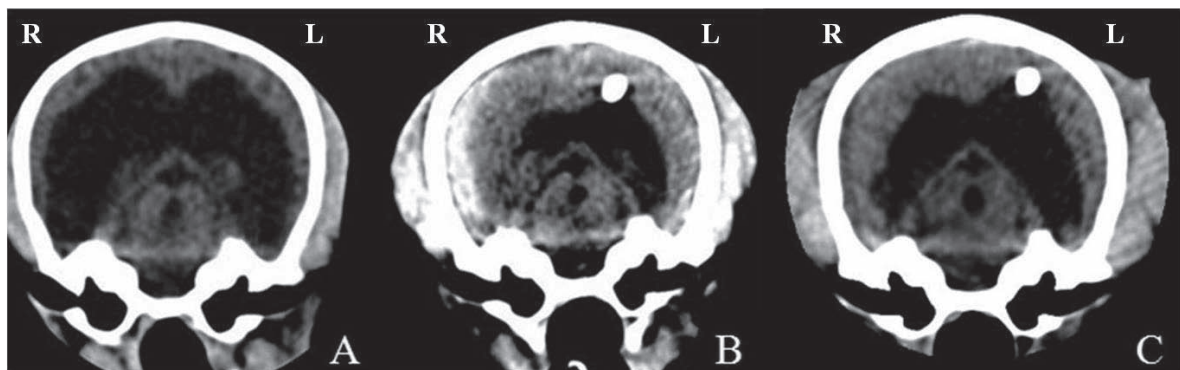


Fig. 2. A: A preoperative CT examination revealed enlargement of the lateral ventricle. The ventricle to brain (VB) ratio was 79% at the tympanic bulla level in axial image. B: CT performed 6 weeks after surgery indicated that the lateral ventricle had decreased in size (VB ratio; 25%). C: At 1 year 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 mmH₂O). The normal CSF pressure of dogs is 8–12 mmHg¹⁾. 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 seconds³⁾. 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

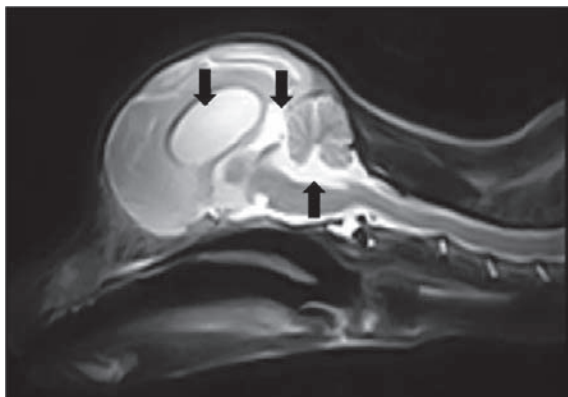


Fig. 3. A preoperative MRI revealed enlargement of the lateral ventricle (leftmost arrow), the fourth ventricle (rightmost arrow), and the quadrigerminal cistern (arrow in the middle).

surgery.

The clinical signs of hydrocephalus are ataxia, delay in learned behaviour (house training), dullness, circling, periodic aggression, and seizure¹⁸⁾. 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 aggressively¹⁾. Vestibular dysfunction can also occur if the fourth ventricle is enlarged²⁾. The choice of treatment is generally determined by physical status, age of the animal and cause of the hydrocephalus²⁾. Medical treatment of hydrocephalus is aimed at reducing CSF production and at decreasing ICP⁷⁾. Oral prednisolone or/and acetazolamide administration may be successful²⁾. 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 resectable²⁾.

Hydrocephalus is categorized as obstructive or communicating¹³⁾. 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

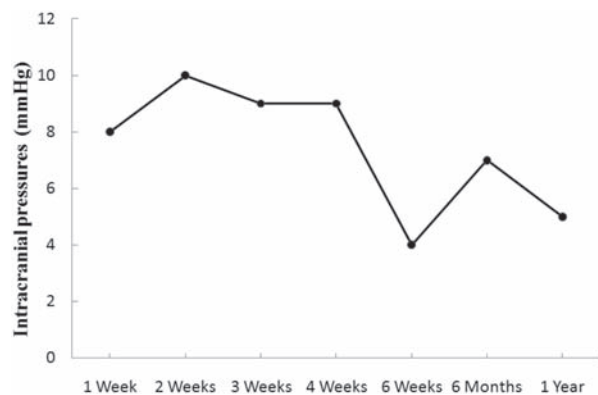


Fig. 4. Intracranial pressures (ICPs) were measured for 1 year postoperatively. The range of ICPs was normal of 4–10 mmHg.

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 aqueduct¹⁸. In communicating hydrocephalus, the CSF flow is not obstructed; rather, the whole ventricular system becomes enlarged¹³. This diffuse dilation occurs when the absorption of the CSF from the subarachnoid space to the venous drainage system is disturbed¹³. For example, canine distemper virus can induce communicating hydrocephalus because it causes meningitis, which can decrease the absorption of the CSF¹⁴. In our case, MRI revealed that the lateral, third ventricle, mesencephalic aqueduct, fourth ventricle, the quadrigeminal 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 quadrigeminal 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 humans¹⁵. In addition, in human infants, low-pressure valves are used to prevent permanent

ventriculomegaly while the suture is open, but as the child grows up, the valve has to be replaced with a high-pressure valve to prevent overdrainage and intracranial hypotension¹⁵. 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 unknown⁹. 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 types¹¹. 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 mass¹⁵. Adjustable valves are thus suitable for patients who have experienced proximal shunt failure¹¹. 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 dog⁶. 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 placement¹⁰⁾. 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 hypotension¹⁵⁾. Such revision is not needed when an adjustable valve is used. Third, adjustable valves provide control over the ICP, thus preventing overdrainage and underdrainage¹¹⁾. 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.

References

- 1) Bagley, R. S. 1993. Intracranial Surgery. In: *Textbook of Small Animal Surgery*, 3rd ed., pp. 1271-1272, Slatter, D. ed., Saunders, Philadelphia.
- 2) Bagley, R. S. 2004. Coma, stupor and behavioural change. In: *Bsava Manual of Canine and Feline Neurology*, 3rd ed., pp. 120-122, Platt, S. R. and Olby, N. J. eds., British Small Animal Veterinary Association, Quedgey.
- 3) Brosnan, R. J., LeCouteur, R. A., Steffey, E. P., Imai, A. and Kortz, G. D. 2002. Direct measurement of intracranial pressure in adult horses. *Am. J. Vet. Res.*, **63**: 1252-1256.
- 4) de Lahunta, A. and Glass, E. 2009. *Veterinary Neuroanatomy and Clinical Neurology*, 3rd ed., pp. 67-76, Saunders Elsevier, St. Louis.
- 5) Dewey, C. W. 2002. External hydrocephalus in a dog with suspected bacterial meningoencephalitis. *J. Am. Anim. Hosp. Assoc.*, **38**: 563-567.
- 6) Foltz, E. L. and Shurtleff, D. B. 1966. Conversion of communicating hydrocephalus to stenosis or occlusion of the aqueduct during ventricular shunt. *J. Neurosurg.*, **24**: 520-529.
- 7) Harrington, M. L., Bagley, R. S. and Moore, M. P. 1996. Hydrocephalus. *Vet. Clin. North. Am. Small. Anim. Pract.*, **26**: 843-856.
- 8) Kim, H., Itamoto, K., Watanabe, M., Nakaichi, M. and Taura, Y. 2006. Application of ventriculoperitoneal shunt as a treatment for hydrocephalus in a dog with syringomyelia and Chiari I malformation. *J. Vet. Sci.*, **7**: 203-206.
- 9) Kitagawa, M., Ueno, H., Watanabe, S., Igarashi, O., Uzuka, Y., Kanayama, K. and Sakai, T. 2008. Clinical improvement in two dogs with hydrocephalus and syringohydromyelia after ventriculoperitoneal shunting. *Aust. Vet. J.*, **86**: 36-42.
- 10) Maixner, W. J., Morgan, M. K., Besser, M. and Johnston, I. H. 1990. Ventricular volume in infantile hydrocephalus and its relationship to intracranial pressure and cerebrospinal fluid clearance before and after treatment. A preliminary study. *Pediatr. Neurosurg.*, **16**: 191-196.
- 11) McGirt, M. J., Buck, D. W., Sciubba, D., Woodworth, G. F., Carson, B., Weingart, J. and Jallo, G. 2007. Adjustable vs set-pressure valves decrease the risk of proximal shunt obstruction in the treatment of pediatric hydrocephalus. *Childs. Nerv. Syst.*, **23**: 289-295.
- 12) O'Brien, D. F., Javadpour, M., Collins, D. R., Spennato, P. and Mallucci, C. L. 2005. Endoscopic third ventriculostomy: an outcome analysis of primary cases and procedures performed after ventriculoperitoneal shunt malfunction. *J. Neurosurg.*, **103**: 393-400.
- 13) O'Brien, D. P. and Axlund, T. W. 2005. Brain Disease. In: *Textbook of Veterinary Internal Medicine*, 6th ed., pp. 822-823, Ettinger, S. J. and Feldman, E. C. eds., Elsevier Saunders, St. Louis.
- 14) Oliver, J. E., Lorenz, M. D. and Kornegay, J. N. 1997. *Handbook of Veterinary Neurology*, 3rd ed., pp. 303-309, W.B. Saunders Company, Philadelphia.
- 15) Pudenz, R. H. and Foltz, E. L. 1991. Hydrocephalus: overdrainage by ventricular shunts. A review and recommendations. *Surg. Neurol.*, **35**: 200-212.
- 16) Tani, K., Taga, A., Itamoto, K., Iwanaga, T., Une, S., Nakaichi, M. and Taura, Y. 2001. Hydrocephalus and syringomyelia in a cat. *J. Vet. Med. Sci.*, **63**: 1331-1334.
- 17) Woo, J. N., Lee, H. B., Kim, M. S., Lee, K. C. and Kim, N. S. 2009. Application

- of ventriculoperitoneal shunt placement through fontanelle in a hydrocephalus dog: a case report. *Vet. Med.*, **54**: 498-500.
- 18) Zachary, J. F. 2007. Nervous system. In: *Pathologic Basis of Veterinary Disease*, 4th ed., pp. 873-875, McGavin, M. D. and Zachary, J. F. eds., Mosby Elsevier, St. Louis.