Hydrocephalus is a condition characterized by the accumulation of CSF within the ventricular system of the brain. A positive correlation between hydrocephalus and short stature or slow growth velocity has been reported for humans. Therefore, it is possible that calves with hydrocephalus may have a short stature or reduced growth, which could result in economic loss. Although the criteria for a diagnosis of hydrocephalus in humans and some breeds of dogs have been reported, similar studies have not been performed in cattle. Diagnostic imaging modalities that have been used for the evaluation of cattle with diseases of the brain include CT and magnetic resonance imaging. Advantages of CT include rapid acquisition of high-quality images and relatively widespread availability. In addition, despite size constraints that limit the applications of CT in cattle, CT of the head is feasible in all patients.

Computed tomographic evaluation of cerebral ventricular size in clinically normal calves

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Objective—To evaluate lateral ventricular size in clinically normal calves by use of computed tomography and to examine the relationships between ventricular height (Vh), ventricular area (VA), and ventricular volume (VV).

Animals—14 Holstein calves.

Procedures—14 calves underwent computed tomography of the head with transverse images acquired from the rostral aspect of the frontal lobe continuing caudally to the level of the foramen magnum. Hemispheric height, Vh, VA, and hemispheric area were measured on images obtained at the level of the interventricular foramen. Ventricular volume was calculated by multiplying the sum of VAs measured on each transverse image by the total slice thickness. The left Vh-to-right Vh ratio was calculated to determine the degree of ventricular asymmetry, which was categorized as normal (ie, symmetric) to minimally asymmetric, mildly asymmetric, or severely asymmetric.

Results—Mean ± SD values for Vh and the Vh-to-hemispheric height ratio were 4.96 ± 1.56 mm and 7.47%, respectively. The mean VA was 114.29 ± 47.68 mm², and the mean VV was 2,443.50 ± 1,351.50 mm³. Normal to minimally asymmetric ventricles were identified in 13 calves, and mildly asymmetric ventricles were identified in 1 calf. Significant correlations were found between Vh and VA and between Vh and VV.

Conclusions and Clinical Relevance—These results establish reference values for ventricular size in clinically normal calves and suggest that Vh measurement may be a simple and useful technique for examining size of the cerebral ventricles in calves. (Am J Vet Res 2010;71:135–137)
Materials and Methods

Animals—Fourteen Holstein calves, 8 females and 6 males, 10 to 90 days of age (mean, 29 days of age) were included in the study. Mean body weight was 41 kg (range, 30 to 70 kg). Prior to enrollment, calves were considered healthy and free from evidence of neurologic disease on the basis of results of complete physical and neurologic examinations by 2 experienced veterinarians (KJL and MK). This study was approved by the Animal Use and Care Administrative Advisory Committee of Obihiro University of Agriculture and Veterinary Medicine. All calves had a complete physical examination and hematologic and serum biochemical testing 24 hours before general anesthesia. Prior to CT imaging, each calf was anesthetized by administration of pentobarbital sodium via indwelling jugular venous catheter; an initial 7 mg/kg bolus injection was administered, and a total dose of 14 mg/kg was given. When an appropriate level of anesthesia was reached, calves were positioned on the CT table in ventral recumbency. Heart rate was continually monitored by ECG, respiratory rate was visually monitored, and palpebral reflex was also periodically checked. On completion of the procedure, calves were allowed to recover from anesthesia and then returned to their usual environment on the university farm.

Experimental protocol—Computed tomography of all calves was performed with a helical multidetector-row CT scanner. Contiguous 3-mm-wide images of the skull were obtained beginning immediately rostral to the frontal lobe and continuing caudally to the level of the foramen magnum. Transverse images were obtained vertically to the level of the hard palate.

Data analysis—Computed tomography data were reconstructed by use of a commercial image-processing workstation. Hemispheric height, Vh, and HA were measured on transverse images at the level of the interventricular foramen (window width, 80 HU; window level, 50 HU) on the brain window. Ventricle height was the maximum length of the lateral ventricles parallel to Hh (Figure 1). Ventricle area and HA were determined at the level of the interventricular foramen and remaining levels of the brain that were imaged, with a freehand image tracing software tool. Ratios of Vh:Hh and VA:HA were calculated and expressed as percentages. Ventricle volume was calculated by multiplication of the total VA measured on each transverse image by the total slice thickness of all slices that included portions of the lateral ventricles. On the basis of the rVh value, the degree of asymmetry was categorized as normal (ie, symmetric) to minimally asymmetric (rVh < 1.5), mildly asymmetric (rVh, 1.5 to 1.9), or severely asymmetric (rVh ≥ 2).

Statistical analysis—A paired t test was used to compare left Vh and right Vh. Pearson correlations were used to examine the relationships between Vh and VA, Vh and VV, VA and VV, Vh and body weight, and Vh and age. Linear regression analysis was used to determine...
whether Vh was related to VV or to VA. All analyses were performed with a commercially available software program. A value of $P < 0.05$ was considered significant.

**Results**

The CT images did not reveal any abnormalities in the brain parenchyma of any of the calves. There was no significant difference between the mean values for left Vh and the mean values for right Vh measured at the level of the interventricular foramen. Mean ± SD values for Vh, VA, and VV were $4.96 ± 1.56$ mm, $114.29 ± 47.68$ mm$^2$, and $2.443.50 ± 1.351.50$ mm$^3$, respectively. The upper limits of the 95% confidence interval of the mean predicted values for the Vh, VA, and VV values were 5.56 mm, 141.82 mm$^2$, and 3,223.83 mm$^3$, respectively. Mean values for Vh:Vh and VA:HA ratios were 7.47% and 2.52%, respectively. The upper limits of the 95% confidence interval of the mean predicted values for the Vh:Hh and VA:HA ratios were 8.53% and 3.11%, respectively.

Thirteen calves had normal to minimally asymmetric ventricles (Figure 2), and 1 calf had mildly asymmetric ventricles. There were significant correlations between the Vh and VA values and the Vh and VV values (Figure 3). There was no significant relationship between Vh and body weight or between Vh and age.

**Discussion**

In the present study, mean values for Vh, Vh:Hh ratio, and VV in clinically normal calves were determined by use of CT. Measurement of Vh and the Vh:Hh ratio provide a simple method for evaluating the size of the lateral ventricles. Mean Vh in Holstein calves in the present study was approximately 5.0 mm, which was similar to values reported for some breeds of dogs.$^{5}$ However, most of the calves in the present study had normal or minimally asymmetric lateral ventricles, whereas the dogs in prior reports$^{5,6}$ had mildly asymmetric or severely asymmetric lateral ventricles. In previous reports, ventricular size has been evaluated by measurement of several variables, including Vh,$^{6,10,11}$ ventricular width,$^{11}$ and area$^7$ and volume of the lateral ventricles.$^{5,7}$ Measurement of volume of the lateral ventricles has been reported as an accurate method for evaluation of ventricular size$^5$, however, this technique is more complicated than measurement of ventricular size by other methods. Therefore, in the present study, we evaluated the relationship between Vh and VA values and Vh and VV values. A significant relationship was identified between Vh and VV. Results of the present study suggest that measurement of Vh may be used for assessment of lateral ventricular size.

A limitation of the present study was that a comparison between different breeds was not performed. In addition, adult cattle were not evaluated. Results of a previous study$^6$ indicate that brain volume and VV appear to change substantially with increasing age in dogs, and VV varies significantly in young dogs. Although in the present study no significant relationship was found between age and Vh or between body weight and Vh, this may be because calves of varying ages were included. Future studies of brain morphometrics in cattle should include evaluation of the relationship between age and ventricular size and shape.

**References**