degeneration to loss of Purkinje cells. In the Purkinje cell layer where neurons were lost, there were empty baskets. Degenerate Purkinje cells were accompanied by axonal torpedoes in the granular layer. The empty baskets indicate Purkinje cell loss normally developed, while axonal torpedoes are a nonspecific sign of Purkinje cell degeneration and not a consequence of developmental failure. Thus, Purkinje cell degeneration in the present cases may have occurred after they attained normal development and reached the proper location.

In the present cases, there was a relationship between degree of Purkinje cell degeneration and severity of granular cell diminution. This suggests that granular cell alteration was secondary to Purkinje cell degeneration.

Granular cells are formed from the external germinal layer later in gestation than Purkinje cells, and their formation is not complete until the postnatal period. Investigation of cerebellar mutant mice suggested that there was an interaction between Purkinje cells and the external granular layer, i.e., the number of granular cells formed was appropriate to the number of Purkinje cells nearby. In the present dogs, development of granular cells might have been disturbed by degeneration or loss of Purkinje cells. Thus, the hypoplastic process might have contributed to development of the present granular cell lesions.

Early regressive changes found in the cerebellar nucleus neurons are regarded as transsynaptic degeneration after the Purkinje cell damage. Involvement of the cerebellar nuclei has been described in Airedale dogs.

The pathological features of the present cases were degeneration or loss of normally developed Purkinje cells and ensuing granular cell lesion. Thus, cerebellar cortical degeneration seems appropriate descriptive terminology for the present beagles.

Acknowledgements
The authors thank Mr. S. Fukagawa, Mr. T. Maeda, and Ms. S. Monta for technical assistance.

Cerebral Infarction with Associated Venous Thrombosis in a Dog

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Occlusive cerebrovascular diseases with infarction are rare in domestic animals when compared to their frequency in humans. Previously reported canine cases involved the cerebral arterial system and resulted from bacteria-associated thrombosis and embolism, marrow emboli after trauma and/or fractures of bones, microfilarial emboli, neoplastic emboli, and rarely, atherosclerosis. The present case is of spontaneous cerebral venous thrombosis in a dog with clinical signs and histologic lesions compatible with hemorrhagic infarction.

A 10-year-old mixed breed obese female crossbred dog with a history of peracute onset of seizures had left-sided hemiparesis and compulsive walking with circling to the right. There was no direct or consensual pupillary light reflex in the left eye. Reflexes of the right eye were slow, but vision appeared to be normal. The dog resisted having its head turned to the left. No head tilt was observed. There was no evidence of head trauma. Hematologic findings were consistent with a stress leukogram. Blood urea nitrogen, glucose, alkaline phosphatase, alanine aminotransferase, and am-
monia levels were normal. The albumin level was slightly decreased. During the first 24 hours of hospitalization, two grand mal seizures occurred. The dog was euthanized.

At necropsy, no gross visceral lesions other than obesity were seen. There was no evidence of head trauma. The uncut surface of the brain was normal; however, upon formalin fixation and serial sectioning, the right telencephalon, primarily the head of the caudate nucleus, and rostral diencephalon, were hemorrhagic and edematous (Fig. 1). The cranial and caudal extent of the lesion was the subcortical white matter of the prorean and caudal suprasylvian gyri, respectively. The dorsal limit was the optic radiation, and the ventral limit was the hypothalamus.

Histologically, the right caudate nucleus was the most severely affected area. Edema, hemorrhage, and displacement of the interventricular septum was seen. The right optic radiation was severely edematous, and associated oligodendrocyte nuclei were pyknotic. Similar, but less severe lesions were found in other regions of the right brain (Fig. 2). In addition, there was some edema of the neuropil and perivascular hemorrhage in the left hypothalamus. Neurons in all affected areas exhibited varying degrees of central chromatolysis or shrinkage of their somas. Ischemic neurons were seen in the most severe areas of hemorrhage and edema. Astrocytes contained swollen or pyknotic nuclei and were surrounded by vacuoles. There was no demyelination.

Most medium to small diameter blood vessels within the affected neuropil were characterized by fibrinoid necrosis, edema, and diapedesis of erythrocytes. Many endothelial cells were swollen or necrotic. Small blood vessels and capillaries contained fresh fibrin thrombi. Perivascular accumulations of a few neutrophils and occasionally macrophages were seen at the margin of the hemorrhagic lesion. Mild accumulations of neutrophils were also seen throughout the neuropil of the right caudate nucleus. The adjacent portion of the right lateral and third ventricles contained fibrinohemorrhagic exudate.

The right basal vein contained an occluding thrombus extending from the rostral perforating substance to the dorsolateral branch of the basal vein. Rostrally, the thrombus had undergone organization and endothelial-associated recanalization (Fig. 3). The left basal vein contained a fresh multilaminated occluding thrombus at the level of the hypothalamus. Special stains failed to reveal bacteria or fungi in any of the thrombi. There were no thrombi in the right or left rostral, middle, or caudal cerebral arteries or their respective branches. Lesions were not seen in visceral organs.

Obstruction of single cerebrospinal veins is usually of no great pathologic significance, since these veins lack valves and also have rich anastomotic interconnections. These two factors allow almost instantaneous shunting of blood to collateral veins when spontaneous or experimental occlusion of cerebrospinal veins or sinuses occurs. However, clinical signs and lesions occasionally have been produced by experimental occlusion of the cerebral venous system. The production and severity of clinical signs and lesions in cerebrovascular occlusive disease (venous or arterial) depend on the degree of collateral flow with nonoccluded vessels, the region of the brain supplied, the diameter of the vessel occluded, proportion of the lumen occluded, the rate of thrombus development, the type of vessel involved, the blood pressure, and the oxygen and nutrient requirements of the nervous tissue involved.

In domestic animals, both thrombophlebitis and noninflammatory thrombosis have occurred within the cerebral venous system. The former is commonly associated with retrograde spread of extra or intracranial meningeal infections. In rhesus monkeys, cerebral venous thrombosis was associated with ulcerative colitis. Noninflammatory thromboses have been reported in cranial dural sinuses following prolonged brain swelling such as occurs in cattle with polioencephalomalacia or in other animal species secondary to head injuries. In the present case, the cerebral venous thrombosis was noninflammatory and apparently idiopathic, although investigation for coagulation disorders was not done.

In the present case, hemorrhagic infarction in the right deep cerebral nuclei and subcortical white matter of the temporal region was similar to lesions found in humans with venous thrombosis of the great cerebral vein and its tributaries. In humans, two of these tributaries, the right and left basal veins, specifically drain the temporal lobes, the upper part of the brain stem, the subthalamus, the hypothalamus, the preoptic area, and the medial portion of the globus pallidus. Although the brain field served by the basal veins in the dog has not been defined, the similarity in anatomic position of the vein and the area infarction in the present case of right basal vein thrombosis suggest that areas drained by the canine and human basal veins are similar. However, infarction of the major portion of the right basal nucleus and affected portions of the diencephalon cannot be accounted for by the right basal vein thrombosis. Such areas are drained by the internal cerebral veins and their tributaries. In the present case, no thrombi were seen in these veins, but fibrin thrombi and fibrinoid necrosis were found in the capillaries and small blood vessels of all affected areas. It is not known whether these fibrin thrombi and the fibrinoid

Fig. 1. Hemorrhage and edema in right basal nucleus, subcortical white matter of right cerebral hemisphere. Bar = 1 cm.
Fig. 2. Distribution of hemorrhage, necrosis, and edema in the dog with deep cerebrovenous thrombosis. Areas affected in right brain include: basal nuclei, rostral commissure, internal and external capsules, claustrum, external medullary lamina of the thalamus, reticular nucleus of the thalamus, optic radiation, hypothalamus, subthalamus, ventricular aspect of the corpus callosum and subcortical white matter of the prorean, caudal suprasylvian, rostral and caudal sylvian, and caudal ectosylvian gyri. Left hypothalamus also affected.

Necrosis caused the infarction or resulted from infarction of these regions.

Significant differences exist between human and canine cerebral venous anatomy. The basal veins in the human drain into the great cerebral vein, but in the dog, the basal veins drain primarily into the paired dorsal petrosal sinuses via the dorsolateral branch of each basal vein. Minor drainage of the basal veins also occurs to the great cerebral vein via a dorsomedial branch of each basal vein. Since blockage of human basal veins is associated with thrombosis of the
Fig. 3. Fibrin thrombus with organization in right basal vein. HE. Bar = 250 μm.

The fresh fibrin thrombus in the midportion of the left basal vein was considered to be responsible for the lesion in the left hypothalamus. The thrombus within the right basal vein was histologically a subacute lesion undergoing fibrous organization, whereas clinical signs, neuropil lesions, and thrombi in the small blood vessels and capillaries were compatible with a more acute process. Such multi-aged thrombi also have been reported in cases of human and nonhuman primates with deep cerebral vein thrombosis. The large venous thrombus in the right basal vein in the present case may have aggravated the hypoxic injury elicited by the acute thrombosis of small blood vessels and contributed to clinical signs and lesions.

**References**


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