# Laboratory Studies of Bovine Progressive Degenerative Myeloencephalopathy in Brown Swiss Cattle

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## Introduction

Bovine progressive degenerative myeloencephalopathy (BPDME) or "weaver", a disease of purebred Brown Swiss cattle, is characterized by progressive hind limb ataxia and weekness leading to permanent recumbency.[16] Reported here are laboratory findings in nine affected and six control cattle.

## Materials and Methods

*Cattle*

The 15 cattle were described previously.[16]

*Hematology*

Whole blood was collected in 5 ml vacutainer tubes containing EDTA and submitted to the KSU Veterinary Medical Clinical Pathology Laboratory (VCPL) for complete blood counts (CBC).

*Serum Chemistries*

Serum was collected and submitted to the VCPL for routine serum chemistries: sodium, potassium, chloride, carbon dioxide, glucose, urea nitrogen, creatinine, total protein, albumin, globulin, A/G ration, calcium, and phosphorus.

*Serum Enzymology*

Serum was submitted to the VCPL for the following quantitative serum enzyme determinations: creatine kinase (CK), lactate dehydrogenase (LDH), sorbitol dehydrogenase (SDH), and alkaline phosphatase (AP).

*Urinalysis*

Urine was collected at necropsy by cystocentesis and submitted to the VCPL for routine urinalysis.

*Cerebrospinal fluid*

Cerebrospinal fluid was collected from the cisterna magna prior to euthanasia via a 3½ inch, 18 gauge spinal needle with a stylet and submitted to the VCPL for cytology, CK assay, and routine analysis including glucose, protein, Pandy test, and specific gravity.

*Toxicology*

Whole blood was collected in 5ml vacutainer tubes containing EDTA and submitted to the KSU Veterinary Medical Comparative Toxicology Laboratory. Cholinesterase and pseudocholinesterase assays were performed on whole blood and plasma, respectively. Fresh liver samples were collected at necropsy and submitted to this laboratory for selenium and copper assays.

*Virology*

Fresh, chilled spleen and mesenteric lymph node were collected at necropsy from test cattle under 9 months of age and submitted to the KSU Veterinary Diagnostic Virology Laboratory for isolation of bovine virus diarrhea (BVD) and bluetongue viruses.

*Serology*

Serum samples from test cattle 9 months of age or older were submitted to the KSU Veterinary Diagnostic Laboratory for serum neutralization testing for BVD virus and agar gel immuno-diffusion testing for bluetongue virus.

Serum samples collected prior to euthanasia were frozen and shipped to the Animal Health Diagnostic Laboratory (Nutrition section) at Lansing, Michigan for quantitative vitamine E serum analysis.

*Statistics*

The numerical data generated in these clinical and laboratory studies were organized into table form and submitted for statistical evaluation. Values for each parameter were averaged to produce mean values for both control and affected groups, collectively. Student's t-test was used to evaluate the respective means of parameter values for control and affected groups. The computed T-statistics and the corresponding p-values were used to make inferences concerning differences in the mean parameter values between control and affected groups.

## Results

*Hematology*

No significant shifts from normal values were recorded in red blood cell (RBC) and white blood cell (WBC) parameters of affected or control cattle.

*Serum Chemistries*

Serum chemistry values were within normal limits for both the affected and control groups. Significant differences or deviation trends were not observed between affected and control animal groups.

*Serum Enzymology*

Serum enzyme levels mean values, standard deviations, and probability values of the serum enzyme parameters tested in affected and control cattle are listed in Table 1.

Numerical mean values for CK for both affected and control groups were considerably elevated above normal mean reference values listed [11] whereas test values for all but two (one control and one affected) cattle were within the normal range. However, no significant differences were detected in the mean values between control and affected groups at the .05 level of significance.

Mean values for SDH for both affected and control cattle were mildly elevated above normal mean reference values[11] whereas test values for all but two (one control and one affected) cattle fell within the normal range. However, no significant differences were detected in the mean values between control and affected groups at the .05 level.

Significant differences were not detected between the LDH levels computed for affected and control cattle at the .05 level. The mean LDH values for both groups were evevated above reported mean values.[11] LDH test results for all cattle were also well above the normal range.

The mean level of AP computed for BPDME affected cattle was significantly higher than the mean AP level computed for control cattle at the 0.5 level. However, mean values for both test groups were well below the mean normal value listed for this parameter.[11] In addition, all individual test results for AP from both affected and control cattle fell within the normal ranges listed, and AP values for all but three affected cattle fell within the normal range. Values for the three affected cattle that deviated were above normal range.

*Toxicology*

Results, mean parameters, and statistical evaluation of RBC and plasma cholinesterase levels are summarized in Table 2. Significant differences were not detected (P > .05) between mean blood and plasma cholinesterase levels for control and affected groups. Moderate depression of parameters below the clinical sign threshold (normal and diagnostic values) was observed in individual cattle from both test groups in isolated cases.

Liver copper and selenium levels in affected cattle did not differ significantly (P > .05) from those detected in controls. Test results and statistical evaluation of parameters are summarized in Table 3. There was a wide range of values, some well below the normal range reported in both control and affected cattle.[17]

*Virology*

Serum neutralization (SN) titers and results of virus insolation studies are summarized in Table 4. Significant

TABLE 1 Serum enzyme levels and statistics in all test cattle (all values are expressed in international units per liter IU/L).

| Animal #, status [1] and statistics | CK [2] | SDH [3] | LDH [4] | Alk Phos [5] |
|---|---|---|---|---|
| A-1 | 210 | 11.8 | 1314 | 65 |
| A-2 | 217 | 10.6 | 963 | 132 |
| A-3 | 256 | 9.8 | 959 | 105 |
| A-4 | 119 | 10.4 | 928 | 153 |
| A-5 | 149 | 17.3 | 1138 | 119 |
| A-6 | 430 | 13.8 | 1429 | 249 |
| A-7 | 204 | 19.7 | 1023 | 171 |
| A-8 | 328 | 11.2 | 956 | 307 |
| A-9 | 231 | 12.3 | 1101 | 271 |
| C-1 | 306 | 7.2 | 1205 | 60 |
| C-2 | 198 | 14.4 | 1399 | 152 |
| C-3 | 99 | 8.5 | 1049 | 52 |
| C-4 | 408 | 13.2 | 1133 | 52 |
| C-5 | 318 | 20.0 | 1115 | 92 |
| C-6 | 176 | 8.8 | 966 | 99 |
| Mean | | | | |
| A | 238 | 12.9 | 1090 | 175 |
| C | 251 | 12.0 | 1145 | 85 |
| S D | | | | |
| A | 93.41 | 3.39 | 176.60 | 82.61 |
| C | 112.87 | 4.83 | 148.60 | 38.21 |
| Range | | | | |
| A | 119-430 | 9.8-19.7 | 928-1429 | 65-307 |
| C | 99-408 | 7.2-20.0 | 966-1399 | 52-152 |
| p-value | 0.8170 | 0.6528 | 0.5458 | 0.0279 |

1. Status: C = control; A = affected
2. creatine kinase
3. lactate dehydrogenase
4. sorbital dehydrogenase
5. alkaline phosphatase

Normal Ranges (KSU Clinical Pathology Laboratory):

| | |
|---|---|
| CK | 90-350 IU/L |
| SDH | 8-18 IU/L |
| LDH | 0-200 IU/L |
| Alk Phos | 0-200 IU/L |

TABLE 2 Plasma and red blood cell (RBC) cholinesterase levels and statistics (expressed as percent of normal).

| Animal #, status and statistics | Plasma | RBC |
|---|---|---|
| A-1 | 92 | 30 |
| A-2 | 80 | 36 |
| A-3 | 52 | 92 |
| A-4 | 75 | 40 |
| A-5 | 98 | 54 |
| A-6 | 69 | 40 |
| A-7 | 75 | 34 |
| A-8 | 80 | 43 |
| A-9 | 92 | 42 |
| C-1 | 63 | 48 |
| C-2 | 79 | 34 |
| C-3 | 63 | 30 |
| C-4 | 52 | 61 |
| C-5 | 97 | 36 |
| C-6 | 69 | 42 |
| Mean | | |
| A | 79 | 46 |
| C | 70 | 42 |
| S D | | |
| A | 13.79 | 18.63 |
| C | 15.67 | 11.32 |
| Range | | |
| A | 52-98 | 30-92 |
| C | 52-97 | 30-61 |
| p-value | 0.2773 | 0.6611 |

1. Status: C = Control; A = Affected

Quantization and Critical Values (Dr. F. W. Oehme, Comparative Toxocology Laboratory, KSU, Personal communication, 1990):

RBC: 100% = 58.5 micromoles substrate hydrolyzed per millimeter per minute. Clinical signs expected at less than 40% of normal.

Plasma: 100% = 98.0 nanomoles substrate hydrolyzed per milliter per minute. Clinical signs expected at less than 20-30% of normal.

SN titers (greater than 1:32) for BVD virus were detected in four control cattle. Affected cattle that were not tested by virus isolation all had BVD SN titers less than 1:2.

Virus isolation studies on spleen and mesenteric lymph nodes from four affected cattle were negative. Virus isolation on spleen and mesenteric lymph node from one control yielded Orbi-virus identified as a strain of epizootic hemorrhage disease virus. Final characterization and serotyping of this virus was done by Dr. Richard Oberst, Recombinant DNA Laboratory, Dept. of Pathology, KSU, and Dr. Bennie Osburn, Dept. of Pathology, College of Veterinary Medicine, University of California, Davis, CA.

*Serology*

Results of agar gel immuno-diffusion testing for bluetongue virus in test cattle are summarized in Table 4. Positive results were detected in one control and two affected cattle.

The results of serum vitamin E assays and statistical evaluation are summarized in Table 5. Serum vitamin E levels in control cattle were not significantly different from those detected in affected cattle. In general, all values recorded for both groups were within or above the normal range (normal ranges provided by the Animal Health Diagnostic Laboratory, Lansing, Michigan) expected for that corresponding age-group of cattle.

TABLE 3 Liver selenium and liver copper levels and statistics in affected and control cattle (in parts per million, ppm).

| Animal #, status[1] and statistics | Liver Selenium | liver Copper |
|---|---|---|
| A-1 | 0.16 | 21.6 |
| A-2 | 0.13 | 37.0 |
| A-3 | 0.18 | 60.0 |
| A-4 | 0.25 | 14.8 |
| A-5 | 0.19 | 44.7 |
| A-6 | 0.45 | 59.0 |
| A-7 | 0.27 | 25.5 |
| A-8 | 0.25 | 50.6 |
| A-9 | 0.79 | 35.0 |
| C-1 | 0.27 | 5.8 |
| C-2 | 0.14 | 2.0 |
| C-3 | 0.27 | 54.8 |
| C-4 | 0.44 | 42.9 |
| C-5 | 0.21 | 39.6 |
| C-6 | 0.27 | 18.2 |
| Mean | | |
| A | 0.30 | 38.7 |
| C | 0.27 | 27.2 |
| S D | | |
| A | 0.21 | 16.9 |
| C | 0.10 | 21.6 |
| Range | | |
| A | 0.13-0.79 | 14.8-60.0 |
| C | 0.14-0.44 | 2.0-54.8 |
| p-value | | |

1) A = Affected
C = Control

Ranges in liver selenium levels (Puls, 1988):

| | |
|---|---|
| Deficient | 0.02-0.17 |
| Marginal | 0.12-0.25 |
| Adequate | 0.25-0.50 |
| High | 0.75-1.25 |
| Toxic-chronic | 1.25-7.00 |
| Toxic-acute | 7.00-47.00 |

Range in liver copper levels (Puls, 1988):

| | |
|---|---|
| Deficient | 0.5-10.0 |
| Marginal | 5.0-25.0 |
| Adequate | 25.0-100.0 |
| High | 200.0-550.0 |
| Toxic | 250.0-800.0 |

*Cerebrospinal Fluid*

Results of cerebrospinal fluid analysis and statistical evaluation are summarized in Table 6. Individual test values for CSF CK and protein in control and affected cattle were elevated above normal.[11] However, significant differences between mean numerical CSF parameters (CK, glucose, and protein) for control and affected cattle were not detected ($P > .05$).

TABLE 4 Results of serological and virolgical testing for bovine virus diarrhea virus (BVD) and bluetongue virus (BT) and virus isolation (VI).

| Animal #,[1] and status | BVD | BT | VI |
|---|---|---|---|
| A-1 | <1:2 | + | NR[2] |
| A-2 | NR | - | - |
| A-3 | 1:2 | - | NR |
| A-4 | NR | NR | - |
| A-5 | NR | NR | - |
| A-6 | NR | NR | - |
| A-7 | <1:2 | - | NR |
| A-8 | <1:2 | + | NR |
| A-9 | <1:2 | 0 | NR |
| C-1 | >1:256 | + | NR |
| C-2 | NR | NR | EHD[3] |
| C-3 | 1:64 | - | NR |
| C-4 | 1:8 | - | NR |
| C-5 | 1:256 | NR | NR |
| C-6 | >1:256 | - | NR |

[1]A = Affected; C = Control
[2]NR = Not recorded
[3]EHD = Epizootic hemorrhagic disease virus

TABLE 5 Serum vitamin E levels and statistics in all test cattle (all values are recorded in micrograms per milliliter ug/ml).

| Animal # and status[1] | Age in months | Vitamin E levels | Normal range |
|---|---|---|---|
| A-1 | 18 | 3.74 | 1.25-2.25 |
| A-2 | 8 | 1.60 | 0.50-1.50 |
| A-3 | 18 | 5.25 | 1.25-2.25 |
| A-4 | 10 | 4.23 | 0.50-1.50 |
| A-5 | 6 | 5.13 | 0.50-1.50 |
| A-6 | 8 | 2.13 | 0.50-1.50 |
| A-7 | 10 | 4.36 | 0.50-1.50 |
| A-8 | 21 | 3.56 | 1.25-2.25 |
| A-9 | 13 | 4.65 | 1.25-2.25 |
| C-1 | 42 | 2.79 | 2.00-4.00 |
| C-2 | 9 | 7.71 | 0.50-1.50 |
| C-3 | 60 | 7.37 | 2.00-4.00 |
| C-4 | 72 | 5.93 | 2.00-4.00 |
| C-5 | 24 | 6.84 | 2.00-4.00 |
| C-6 | 12 | 3.14 | 1.25-2.25 |
| Mean | | | |
| A | - | 3.85 | |
| C | - | 5.63 | |
| S D | | | |
| A | - | 1.26 | |
| C | - | 2.15 | |
| Range | | | |
| A | - | 1.60-5.25 | |
| C | - | 2.79-7.71 | |
| p-value | | 0.0603 | |

[1]A = Affected
C = Control

*Urinalysis*

Urinalysis results for all cattle tested in both groups were within normal limits. Differences or trends between the two groups were not observed.

## Discussion

Routine blood counts and serum chemistries were performed primarily as an aid in evaluating the general health of affected and control cattle as well as screening for infectious disease in test cattle. Normal hematological and routine serum chemistry parameters for affected cattle in this study are in agreement with previous studies.[1,7,22-24] Normal findings implied that cattle affected with BPDME are otherwise in good health.

TABLE 6 Cerebrospinal fluid analysis and statistics in all test cattle.

| Animal #, status and statistics | CPK (IU/L) | Protein (mg%) | Glucose (mg%) | Pandy |
|---|---|---|---|---|
| A-1 | 9 | 127 | 56 | 2+ |
| A-2 | 3 | 40 | 65 | trace |
| A-3 | 9 | 15 | 45 | neg |
| A-4 | NR** | NR | NR | NR |
| A-5 | 2 | 0 | 45 | trace |
| A-6 | 9 | 36 | 66 | 1+ |
| A-7 | 3 | 113 | 75 | NR |
| A-8 | 6 | 57 | 46 | trace |
| A-9 | 2 | 36 | 59 | 1+ |
| C-1 | 10 | 19 | 43 | neg |
| C-2 | 6 | 32 | 72 | trace |
| C-3 | NR | NR | NR | NR |
| C-4 | 8 | 104 | 68 | 3+ |
| C-5 | 5 | 52 | 73 | neg |
| C-6 | 0 | 49 | 46 | 1+ |
| Mean | | | | |
| A | 15.00 | 53 | 57 | |
| C | 6.00 | 51 | 60 | |
| S D | | | | |
| A | 29.89 | 44.87 | 11.23 | |
| C | 3.77 | 32.40 | 14.65 | |
| Range | | | | |
| A | 2-89 | 0-127 | 45-75 | |
| C | 0-10 | 19-104 | 43-73 | |
| p-value | 0.3994 | 0.9397 | 0.6571 | |

Normal Ranges (KSU Clinical Pathology Laboratory):

| | |
|---|---|
| CPK | 0.8 IU/L |
| Protein | 12-40mg% |
| Glucose | 40-80mg% |
| Pandy test | 0-trace |

Creatine kinase isoenzymes are the most organ-specific serum enzymes used in clinical testing.[13] They catalyze reversible phosphorylation of creatine by ATP to form creatine phosphate, the major storage form of high-energy phosphate required by muscle tissue.[13] In veterinary medicine, separation of the four CK isoenzymes (CK-BB, CK-MB, CK-MM, and CK-Mt) has not proven to be of any greater diagnostic significance than total serum CK activity.[13] Creatine kinases have their highest specific activity in skeletal muscle.[3,13]

Lactate dehydrogenase (LDH) catalyzes the reversible oxidation reaction of pyruvate to L(+)-lactate utilizing the cofactor NAD.[13] Various combinations of the molecule subunits result in formation of five isoenzymes. Skeletal muscle contains isoenzyme $LDH_5$, whereas cardiac muscle contains isoenzyme $LDH_1$. The other isoenzymes are hybrids found in various amounts in many different organs.[3,13] Its presence in significant amounts in multiple body tissues renders LDH nonspecific for organ function testing.[3,13]

Sorbitol dehydrogenase (SDH) catalyzes reversible oxidation of D-sorbitol to D-fructose using the cofactor

NAD.[13] It is liver-specific in mammalian species, and hepatic injury is apparently the only mechanism of elevated SDH activity.[13]

Akaline phosphatases comprise a group of isoforms of nonspecific enzymes hydrolyzing many types of phosphate esters and are located within most cells.[13] Assay for these compounds is not organ-specific but can be diagnostically significant in hepatic and bone diseases in the canine and feline species.[13]

Mean values for CK, LDH, and SDH in BPDME-affected cattle did not differ significantly from mean values of these enzyme in control cattle. This implies that the signs observed in affected cattle did not contribute to significant alteration in these serum enzymes. Statistical comparison revealed mean AP values to be sigificantly higher for the affected cattle than the control group. Mean values from both control and affected groups for CK, SDH, and AP were found to be well within the normal ranges. Although elevated above reported normal ranges, the mean LDH levels for both control and affected cattle were within the normal range.[11] The significant statistical difference detected between control and affected cattle for AP is not considered meaningful because the mean levels were well within normal ranges. It was concluded that alterations in serum CK, LDH, SDH, and AP were not specific for BPDME.

A similar study[23] reported elevations in serum CK, LDH, and SDH levels and decreased AP levels in affected cattle based on comparison of test parameters to normal mean values and ranges. A comparison of the present and a previous study shows that values are relatively similar.[23] Differences between parameter values and interpretation in the two studies could be contributed to variation in severity of clinical signs of affected cattle in the two studies or differences between the normal parameters and the methods utilized in interpretation of the data. When mean results from affected cattle in this study are compared to the normal mean values reported by Kaneko,[11] then interpretation of these results would be similar to those reported previously.[23] It is important to keep in mind that normal values for serum enzymes vary from one laboratory to the next. In addition, the mean age of affected cattle in this study was 12.4 months compared to a mean of 22.4 months in the previous study.[23] Because weaver syndrome is reported to be progressive, it would follow that the older cattle used in the previous study would show more severe clinical signs as a group than younger group utilized in this study. Stuart and Leipold reported good correlation between the severity of clinical signs in affected cattle and the magnitude of CK and LDH values.[23] It would follow that, though considered nonspecific for the syndrome, elevations in serum CK and LDH could be detected in severely affected cattle late in the clinical syndrome of BPDME in direct correlation with muscle damage sustained from the associated ataxia and recumbency.

These subtleties illustrated the difficulties encountered in comparing clinical pathology results between studies and between laboratories. In this present study, statistical comparison between mean parameters for control and affected cattle was the most equitable method of evaluation. Mean normal parameters from the laboratory performing the assays or from other published sources of normal values[11] were utilized only as guidelines and as comparative references.

Cholinesterase and pseudocholinesterase levels were assayed to determine if acute toxic exposure or prolonged low level exposure to cholinesterase-inhibiting compounds, such as organophosphates or organocarbamates, had occurred[2]. Collective mean values of both test groups for true cholinesterase (RBC) and pseudocholinesterase (plasma) were elevated above levels interpreted to be associated with clinical signs of cholinesterase inhibition in cattle. Individual true cholinesterase (RBC) levels were mildly depressed below the clinical threshold in a limited number of control and affected cattle. The levels were not associated with clinical signs of acute organophosphate toxicity, and the depression was not consistent nor of a sufficient magnitude to suggest a trend or account for the clinical signs exhibited by BPDME-affected cattle. It was concluded that anticholinesterase toxicity was not involved in the pathogenesis of BPDME.

Selenium concentrations in the liver were measured as an indicator of the body selenium status in test cattle. Selenium is distributed throughout the body, with the highest concentrations found in the kidney and liver, but skeletal muscle contains approximately 50% of the body pool of selenium.[12] The major recognized function of selenium is as a component of glutathione peroxidase (GPx) that catalyzes reduction of hydrogen and organic peroxides ROOH) to their respective alcohols and water.[12] Nutritional muscular dystrophy is a selenium-responsive disorder of striated muscle affecting young cattle, sheep, cattle, pigs, horses, and poultry.[12] The myopathy reflects excessive peroxidation of lipids, particularly mitochondrial lipids, resulting in degeneration, necrosis, and ensuing fibrosis of myofibers of skeletal muscle and heart.[12] Muscles of locomotion (epaxial and appendicular muscles) are usually more severely affected in mammalian species, with resulting gait abnormalities.[10,12] The mean selenium levels for both the affected and control cattle were within the reported range.[17] No significant differences were found between control and affected normal cattle in liver selenium concentrations. Based on these findings, it would follow that selenium deficiency or toxicity is not involved in the pathogenesis of BPDME.

Liver copper levels were assayed to survey the body copper balance. The highest concentrations of copper are found usually in liver, brain, heart, and hair, with liver and brain containing about one-third of the total body copper stores.[12] Skeletal muscle, though relatively low in copper,

also contains approximately one-third of the total body copper stores because of its large mass.[12] Ruminants are unique in that they have a very high storage capacity for copper in their livers, often exceeding two-thirds of their total body pool.[12] The mechanism for this liver storage capacity is thought to be a higher retention of absorbed copper rather than a difference in dietary intake of copper or its absorption.[12] Copper is associated with several oxygenases including cytochrome c oxidase, a terminal component of the electron transport chain.[12] The two major copper-containing enzymes of the body are copper-zinc superoxide dismutase, which catalyzes dismutation of superoxide anion to hydrogen peroxide and ceruloplasmin (ferroxidase I), a copper transport protein with weak oxidizing properties that may be required for incorporating iron from the liver into transferrin for its transport to extrahepatic tissue and hemoglobin synthesis.[12] A wide variety of disorders have been linked to deficiency or excess of copper within body tissues. Neurologic disease occurring secondary to copper deficiency is particularly important in sheep. "Swayback" (congenital) and "enzootic ataxia" (delayed onset) are two syndromes in sheep manifested by copper deficiency.[25]

The mechanisms involved in the pathogenesis of these two conditions have been debated but not definitely determined. The commonly accepted theory of pathogenesis is that a deficiency of copper and cytochrome oxidase, for which it is a cofactor, results in deficient kinetics of respiratory enzymes, leading to inadequate production of phospholipid and other myelin lipids.[25] Both hypomyelinogenesis and myelin degeneration are thought to occur. The congenital form is characterized by spinal demyelination and by regressive neuronal changes in the spinal cord and brain stem.[25] The delayed onset syndrome starts at several weeks of age and is progressive.[25] Various degrees of ataxia and muscle weakness are observed in both syndromes.

Mean liver copper values for both test groups were in the normal range.[17] This suggests that copper imbalance or deficiency is not involved in the pathogenesis of BPDME.

Several test cattle had significant serum neutralization titers to BVD virus and positive bluetongue titers. Virus isolation studies in cattle under 9 months were negative, except for isolation of epizootic hemorrhagic disease virus of deer in one control. Clincial signs or effects of this virus were not detected. Significant evidence for the participation of viral agents in the pathogenesis of weaver syndrome was not detected.

Vitamin E (alpha-tocopherol) levels in serum were assayed to survey body stores of this vitamin in all test cattle. Vitamin E serves in mammalian biological systems primarily as an antioxidant and as a scavenger of free radicals, particularly unsaturated fatty acids occurring in phospholipids of cell membranes.[15] Its presence is vital for the protection of cell membranes in all tissues. A wide variety of vitamin E-responsive conditions have been reported in various body tissues.[15] Vitamin E-responsive syndromes with some similarity to weaver syndrome include nutritional myopathy and equine degenerative myeloencephalopathy (EDM). EDM is characterized by symmetric ataxia and paresis, with laryngeal adductor, cervicofacial, local cervical, and cutaneous trunci hyporeflexia.[14] Serum vitamin E levels are deficient in affected horses, and a possible familial predisposition has been hypothesized.[14] Vitamin E levels for all test cattle were adequate or elevated above the normal range. Significant differences were not detected. This suggests that imbalance of vitamin E is not involved in the pathogenesis of BPDME.

Routine cerbrospinal fluid (CSF) analysis plus CSF cytology and CSF creatine kinase (CK) assays were performed as part of the examination of the nervous system of test cattle. Of particular interest was the determination of CSF-CK, which has received considerable attention and study as a possible indicator of neurologic disease in both humans and cattle.[5,6,8,9,18,19,26,27] Plasma CK is usually excluded from the brain by the "blood-brain barrier," so that levels of CK activity in CSF are normally considered specific for the central nervous system.[18] Elevated levels of CSF-CK have been reported in a wide variety of CNS disorders, including tumors of brain and spinal cord, degenerative CNS diseases such as encephalomalacia, inflammatory CNS diseases such as feline infectious peritonitis and canine distemper, herniated intervertebral discs, and seizure disorders.[4,8,9,18,19,20,21,26,27] The mean CSF-CK levels for affected cattle were mildly elevated over normal values but significant differences were not detected. Results of the CSF-CK assays were considered inconclusive because they did not correlate well with severity of the CNS signs in affected cattle and the majority of the affected cattle tested had CSF-CK values within the normal range. Significant differences were not detected between other CSF mean parameters (protein and glucose). Significant evidence of inflammation within the CNS of either affected or control cattle was not suggested by cytological evaluation and other CSF findings.

## Summary

Laboratory evaluation of cattle affected with bovine progressive degenerative myeloencephalopathy (BPDME) revealed normal CBC's, routine serum chemistries, and normal urinalysis results. Statistically significant differences were not detected between control and affected cattle for CK; SDH; LDH; blood cholinesterase; plasma cholinesterase; liver selenium; liver copper; serum vitamin E; and CSF parameters of CK; protein; and glucose. Cytological examinations of CSF from affected cattle were within normal limits and did not suggest degenerative or inflammatory conditions. BPDME is currently classified as a spinocerebellar degenerative disease with familial pre-

dispostion. It is concluded from this study that the parameters tested are not involved in the pathogenesis of BPDME.


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