Hyperplasia of the thyroid gland and concurrent musculoskeletal deformities in western Canadian foals: Reexamination of a previously described syndrome

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Abstract

A syndrome of neonatal foals characterized by hyperplasia of the thyroid gland and concurrent musculoskeletal deformities (TH-MSD) has been described in western Canada and may be increasing in incidence. In an attempt to improve recognition and understanding of this syndrome, 2946 records of equine abortuses, stillborns, and dead neonatal foals were examined to determine the laboratory involved, the year and month of submission, the breed and sex of the fetus or foal, the type of perinatal loss, the length of gestation, and whether or not the submission had evidence of a lesion of the thyroid gland, the musculoskeletal system, or other abnormal clinical or postmortem findings.

One hundred and fifty-four (5.2%) records indicated the presence of an abnormal thyroid gland. Of these, 79 (2.7%) had additional lesions consistent with the TH-MSD syndrome described in the 1980s, while 75 (2.5%) were without these additional lesions.

Comparisons among these two groups and a third group of fetuses and foals without lesions of the thyroid glands are described. The results confirm that the TH-MSD syndrome is a specific and unique disease with no breed or sex predilection. It is argued that there may be an "exposure-related" cause, and based on a review of similar disease syndromes of the horse, it is suggested that an examination of the feed is indicated in outbreaks of the TH-MSD syndrome.

Résumé

Hyperplasie de la glande thyroïde et difformités musculo-squelettiques chez les poulains dans l'Ouest canadien : Revue d'un syndrome déjà décrit

Cette étude porte sur un syndrome néonatal caractérisé par une hyperplasie de la glande thyroïde et des difformités musculo-squelettiques (TH-DMS) lequel a été décrit chez les poulains de l'Ouest canadien. L'incidence de cette pathologie est peut-être en croissance. Les dossiers de 2946 animaux comprenant des avortons, des sujets mort-nés et des poulains néonatals morts ont été examinés afin de mieux reconnaître et comprendre ce syndrome. Les éléments retenus ont été le laboratoire consulté, l'année et le mois de la présentation des échantillons, la race et le sexe du fœtus ou du poulain, le type de perte périnatale, la durée de la gestation et s'il y avait ou non évidence de lésions à la glande thyroïde, au système musculo-squelettique ou présence d'autres anomalies cliniques ou post-mortem.

Cent cinquante-quatre (5,2 %) dossiers ont démontré la présence d'anomalies de la glande thyroïde. De ce nombre, 79 (2,7 %) avaient des lésions additionnelles compatibles avec le syndrome (TH-DMS) décrit dans les années '80 alors que 75 (2,5 %) ne présentaient pas ces lésions additionnelles.

Les auteurs décrivent et comparent ces deux groupes à un troisième comprenant des poulains et des fœtus ne présentant pas de lésions à la glande thyroïde. Les résultats confirment que le syndrome TH-DMS est une pathologie unique et spécifique sans prédilection de race ou de sexe. Il est mentionné qu'il pourrait y avoir un facteur d'"exposition" et il est suggéré que l'alimentation devrait être considérée lors d'apparition de cas cliniques du syndrome TH-DMS.

(Traduit par Dr Thérèse Lanthier)

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Introduction

Congenital lesions of the thyroid gland appear to be infrequent in domestic animals (1–3). In foals, congenital enlargement of the thyroid gland (goiter) has been reported in association with diets fed to pregnant mares that were suspected to be deficient in iodine (4–7) or to have excessive iodine (8–11). Lesions of the thyroid gland have also been reported in newborn foals in which the underlying cause was not determined (12,13).

A syndrome of neonatal foals characterized by hyperplasia of the thyroid gland, flexural deformities of the forelimbs, ruptured tendons of the common digital extensor muscles, mandibular prognathia, and immature carpal and tarsal bones has been described in western Canada (14,15) and may be increasing in incidence (16). This syndrome, referred to here as thyroid hyperplasia and musculoskeletal deformity (TH-MSD), is believed to be unlike any other reported in perinatal horses. The cause of TH-MSD remains unknown,

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Table 1. Summary of the 143 lesions of the thyroid gland of equine fetuses and foals diagnosed at pathology laboratories in western Canada between 1980–1989, inclusive

Thyroid lesion		Syndrome cases[a]	Thyroid cases	Total[a]
Hyperplastic:	normal size	43	55	98
	mildly enlarged	19	13	32
	small	6	2	8
	goitrous[b]	0	1	1
Colloid goiter		0	3	3
Unilateral aplasia		0	1	1
Totals		68	75	143

[a]Reports from 11 syndrome cases lacked comments about the thyroid glands
[b]Thyroid glands described as being at least twice normal size

although the syndrome has been recognized for many years.

The objectives of the studies reported herein were: first, to estimate the prevalence of lesions of the thyroid gland in equine fetuses and foals submitted to diagnostic veterinary laboratories in western Canada; second, to estimate the prevalence of foals with additional lesions consistent with the TH-MSD syndrome described in the 1980s, as well as those without the additional lesions submitted to the same laboratories; and third, to compare these two groups to each other and to fetuses and foals without lesions of the thyroid gland, with respect to signalment, history, clinical findings, and postmortem abnormalities.

Materials and methods

Records of the eight veterinary diagnostic laboratories located in western Canada (Abbotsford, British Columbia; Fairview, Edmonton, Airdrie, and Lethbridge, Alberta; the Western College of Veterinary Medicine (WCVM) and Regina, Saskatchewan; and Winnipeg, Manitoba) were surveyed for the 10-year period, 1980-1989, inclusive. Any report involving the submission of a whole carcass or tissues of an equine fetus or foal with a known age of 30 days or less was examined. Variables that were recorded included the laboratory involved, year and month of submission, breed and sex of the fetus or foal, type of perinatal loss, length of gestation, and whether or not the submission had evidence of a lesion of the thyroid gland. Multiple animals submitted or reported together were considered separately. Twins, submitted separately or together, were considered as one report. The completeness of pathological reports was highly variable and not all information of interest was available for every submission.

Length of gestation and age of neonatal foals were recorded in days. For this purpose, one year equalled 365 days, and one month equalled 30 days. Where the length of gestation was indicated relative to the expected date of foaling, the expected or due date was assumed to be 340 days gestation (17,18).

For this study, mutually exclusive categories of perinatal loss, i.e., abortion, stillbirth, or death of a neonatal foal, were required. A report was considered to involve an abortion if the submission was a fetus expelled dead or surviving less than 24 hours, prior to 300 days gestation (17,19,20), or if the submission was classified as an abortion without an indication of gestational age. A report was considered to involve a stillbirth if the submission was a fetus expelled dead or surviving less than 24 hours after 300 days gestation (19), or if the submission was classified as a stillbirth without an indication of gestational age. A report was considered to involve a neonatal death if the submission was any foal with a known age between one and 30 days, regardless of the length of gestation.

Reports of all submissions were examined and placed into one of three categories: syndrome cases, thyroid cases, or noncases, based on the presence of a thyroid gland lesion and other concurrent anomalies. A submission was considered to involve a syndrome case if it had a lesion of the thyroid gland of any kind and at least one of the musculoskeletal lesions consistent with the TH-MSD syndrome described previously (14,15), or if it had two of the musculoskeletal lesions consistent with the TH-MSD syndrome and the thyroid gland was not examined. Thyroid cases included submissions that had a lesion of the thyroid gland of any kind, but none of the musculoskeletal lesions characteristic of the TH-MSD syndrome. Noncases included all animals not classified as syndrome or thyroid cases. Cases refer to the sum of syndrome and thyroid cases.

A thyroid gland described as being at least twice normal size was considered goitrous (3,21). A diagnosis of thyroid gland hyperplasia was based on histological changes present throughout the thyroid gland. Typically, thyroid follicles were irregular in size and shape, with some follicles appearing collapsed or small and containing little or no colloid. The epithelium tended to be columnar; sometimes, it was multilayered; and, occasionally, it formed papillary projections into the lumen of follicles (1,5). Thyroid glands could be hyperplastic with or without being increased in size.

Data were sorted and statistically analyzed using the Statistical Analysis System (SAS) (Version 6.06.01. Copyright 1989: SAS Institute Inc., Cary, North Carolina, USA) on the mainframe computer at the University of Saskatchewan, and Epistat (Copyright 1984: Dr. Tracy L. Gustafson, 1705 Gattis School Road, Round Rock, Texas, USA) on a personal computer.

Results

There were 2946 submissions. Of these, 79 (2.7%) were syndrome cases and 75 (2.5%) were thyroid cases.

Table 2. Number of syndrome cases, thyroid cases, and noncases diagnosed at different laboratories between 1980 and 1989, inclusive[a]

Laboratory	Syndrome cases	Thyroid cases	Noncases	Totals
Abbotsford	4 (5.1)	2 (2.7)	450 (16.1)	456 (15.5)
Fairview	2 (2.5)	21 (28.0)	115 (4.1)	138 (4.7)
Edmonton	10 (12.7)	7 (9.3)	715 (25.6)	732 (24.8)
Airdrie	11 (13.9)	16 (21.3)	485 (17.3)	512 (17.4)
Lethbridge	7 (8.9)	10 (13.3)	165 (5.9)	182 (6.2)
WCVM[b]	40 (50.6)	13 (17.3)	327 (11.7)	380 (12.9)
Regina	0 (0)	0 (0)	270 (9.7)	270 (9.2)
Winnipeg	5 (6.3)	6 (8.0)	265 (9.5)	276 (9.4)
Totals	79 (100.0)	75 (100.0)	2792 (100.0)	2946 (100.0)

[a]Column % in parentheses
[b]Western College of Veterinary Medicine

Table 3. Number of syndrome cases, thyroid cases, and noncases reported in each year of the study[a]

Year	Syndrome cases	Thyroid cases	Noncases	Totals
1980	16 (20.2)	8 (10.7)	274 (9.8)	298 (10.1)
1981	17 (21.5)	8 (10.7)	339 (12.1)	364 (12.4)
1982	10 (12.7)	8 (10.7)	352 (12.6)	370 (12.6)
1983	5 (6.3)	10 (13.3)	366 (13.1)	381 (12.9)
1984	4 (5.1)	13 (17.3)	352 (12.6)	369 (12.5)
1985	4 (5.1)	5 (6.7)	267 (9.6)	276 (9.4)
1986	4 (5.1)	6 (8.0)	252 (9.0)	262 (8.9)
1987	6 (7.6)	11 (14.7)	225 (8.1)	242 (8.2)
1988	7 (8.9)	4 (5.3)	173 (6.2)	184 (6.2)
1989	6 (7.6)	2 (2.7)	192 (6.9)	200 (6.8)
Totals	79 (100.0)	75 (100.0)	2792 (100.0)	2946 (100.0)

[a]Column % in parentheses

The remaining 2792 submissions were noncases.

Lesions of the thyroid glands present in western Canadian fetuses and foals

The majority of the lesions diagnosed involved hyperplastic change (97.2%; 139/143). Anomalous thyroid glands were considered to be normal in size or only mildly enlarged in 90.9% (130/143) of cases, small in 5.6% (8/143) of cases, and goitrous in 2.8% (4/143) of cases. There was one instance of unilateral aplasia of the thyroid glands in an aborted Percheron fetus; the cause of the abortion was not determined and the remaining thyroid lobe appeared histologically normal (Table 1).

All submissions classified as syndrome cases that had the thyroid gland examined microscopically had a thyroid gland with hyperplastic change, and the majority of these glands (91.2%; 62/68) were described as being normal in size or only mildly enlarged. Seven of the 62 were also characterized as being firm. The remainder of the syndrome cases (8.8%; 6/68) had thyroid glands that were reported as being small; four of these six were described as firm. There were no reports of syndrome cases with thyroid glands described as goitrous. Other anomalies of the thyroid glands that were reported, such as colloid goiter and one case of unilateral aplasia, were not associated with musculoskeletal lesions consistent with the TH-MSD syndrome.

Comparisons between syndrome and thyroid cases

Fetuses and foals with lesions of the thyroid glands were reported at seven of the eight diagnostic laboratories in western Canada. The majority of syndrome cases (50.6%; 40/79) were diagnosed at the WCVM, where only 12.9% (380/2946) of all submissions were examined. The laboratory at Fairview examined only 4.7% (138/2946) of all submissions, but diagnosed the most thyroid cases (28.0%; 21/75) (Table 2).

Both syndrome and thyroid cases were diagnosed in each year of the study, and the frequencies appeared to vary independently from each other. In 1980–1983, syndrome cases were reported almost twice as often as thyroid cases (42 versus 24). Between 1984 and 1987, this trend was reversed, and syndrome cases totalled about one-half the number of thyroid cases (23 versus 45). However, in 1988 and 1989, the situation was reversed again with syndrome cases outnumbering thyroid cases 13 to 6 (Table 3).

There was a trend present within each type of perinatal loss where the peak number of submissions occurred later in the year for cases relative to noncases. Further, the peak number of syndrome-case stillbirths occurred in May, while the peak submission rate for thyroid-case stillbirths occurred in April. Submissions of syndrome-case dead neonatal foals were highest in June compared to submissions of thyroid-case dead neonatal foals, which were highest in May.

Table 4. Number of syndrome cases, thyroid cases, and noncases classified by type of perinatal loss[a]

Type of perinatal loss	Syndrome cases	Thyroid cases	Noncases	Totals
Abortion	0 (0.0)	17 (22.7)	1189 (42.6)	1206 (40.9)
Stillbirth	15 (19.0)	25 (33.3)	632 (22.6)	672 (22.8)
Neonatal foal	64 (81.0)	33 (44.0)	971 (34.8)	1068 (36.3)
Totals	79 (100.0)	75 (100.0)	2792 (100.0)	2946 (100.0)

[a]Column % in parentheses

Table 5. Clinical anomalies reported in equine fetuses and foals diagnosed with a lesion of the thyroid gland[a]

	Number of submissions reporting anomaly[b]		
Clinical anomaly	Syndrome cases	Thyroid cases	Significance[c]
Premature lactation (mare)	4 (79)	4 (75)	0.611
Dystocia	8 (79)	8 (75)	0.560
Weakness/inability to stand at birth[d]	38 (64)	10 (33)	0.006
Unusual foal size[e]: total	13 (79)	3 (58)	0.036
unusually large	8 (13)	3 (3)	0.295
unusually small	5 (13)	0 (3)	0.295
Signs of immaturity[e]:			
total[f]	20 (79)	4 (58)	0.004
lax joints	3 (19)	2 (4)	0.193
lax hind leg flexor tendons	3 (19)	2 (4)	0.193
pulmonary hyaline membranes	3 (19)	0 (4)	0.547
pliable ears	0 (19)	3 (4)	0.002
"silky" coat	2 (19)	0 (4)	0.676
Excessive umbilical hemorrhage[d]	5 (64)	1 (33)	0.330

[a]Reported in two or more submissions
[b]Appropriate denominator in parentheses
[c]p-value associated with Fisher's exact test of significance
[d]Includes dead neonatal foals only
[e]Includes stillborns and dead neonatal foals only
[f]Includes poorly ossified carpal and/or tarsal bones

There was no apparent difference in the breed distribution of syndrome cases and thyroid cases. More than 75% of both syndrome cases and thyroid cases involved Thoroughbred, standardbred, Arabian, and quarter horses.

Pregnant mares of any breed kept for the extraction of estrogens from their urine were considered separately because of their unique and consistent management throughout western Canada (7,22). Pregnant mare urine (PMU) farms received subsidized diagnostic pathology services and, as a result, submissions were relatively high (197 abortuses, 11 stillborns, 10 dead neonatal foals, and 8 submissions in which the type of perinatal loss was not indicated); however, no syndrome or thyroid cases were diagnosed in this group. This absence of lesions was significantly different from the rate of lesions of the thyroid gland diagnosed in mixed breed fetuses and foals that were selected as a reference group.

Syndrome cases and thyroid cases had about equal numbers of males and females (36 males / 26 females and 30 males / 25 females, respectively) ($p = 0.844$). There were no twins affected with the TH-MSD syndrome compared with five twin foals that were thyroid cases.

The type of perinatal loss associated with syndrome cases involved predominantly dead neonatal foals (81.0%; 64/79), a few stillbirths, and no abortions. This distribution is different from that associated with thyroid cases, which were more equally distributed over the three types of perinatal loss ($p < 0.001$) (Table 4). There were no concurrent lesions or recognizable causes for abortion in 70.6% (12/17) of the abortuses with a thyroid gland lesion. This percentage was similar ($p = 0.956$) to the 67.0% (797/1189) of noncase abortuses in which no recognizable cause for the abortion was identified.

The length of gestation for thyroid case abortuses at the time of their expulsion was not significantly greater than that for noncase abortuses ($p = 0.191$). The mean length of gestation for all syndrome-case and thyroid-case stillborns and dead neonatal foals was significantly longer, 359.6 d ($p < 0.001$) and 341.0 d ($p < 0.001$), respectively, than that for full-term noncases (326.3 d). Further, the mean gestational period for syndrome-case stillborns and dead neonates was significantly longer ($p < 0.001$) than that for thyroid case stillborns and dead neonates. Among the syndrome cases, one was stillborn at 300 d gestation, five foals were delivered at

Table 6. Musculoskeletal anomalies reported in equine fetuses and foals diagnosed with a lesion of the thyroid gland[a]

Musculoskeletal anomaly	Number of submissions reporting anomaly[b] Syndrome cases	Thyroid cases	Significance[c]
Head and neck			
Mandibular prognathia	60 (79)	0 (75)	NA
Hydrocephalus or other craniofacial deformities	7 (79)	4 (75)	0.297
Kyphosis/torticollis/scoliosis	3 (79)	2 (75)	0.525
Front legs			
Flexural deformity	54 (79)	0 (75)	NA
Rupture of a CDET[d]	34 (79)	0 (75)	NA
ALD[e] (carpi and/or fetlocks)	6 (79)	0 (75)	0.017
"Crooked" front legs	4 (79)	0 (75)	0.067
Hind legs			
Flexural deformity	9 (79)	0 (75)	0.002
ALD[e] (tarsi and/or fetlocks)	5 (79)	1 (75)	0.117
Bilateral luxating patellas[f]	1 (64)	1 (33)	0.567
Other			
Poorly ossified carpal or tarsal bones[g]: total	12 (79)	0 (58)	NA
carpal	7 (12)	—	
both	3 (12)	—	
tarsal	2 (12)	—	
Osteopetrosis	3 (79)	2 (75)	0.525
Poor muscle development	4 (79)	0 (75)	0.067
Other ruptured tendons of the legs	2 (79)	0 (75)	0.262

[a]Reported in two or more submissions
[b]Appropriate denominator in parentheses
[c]p-value associated with Fisher's exact test of significance
[d]Common digital extensor tendon
[e]Angular limb deformity
[f]Includes dead neonatal foals only
[g]Includes stillbirths and dead neonatal foals only

term, which was assumed to be 340 d gestation, and 25 foals for which precise breeding dates were recorded had gestational periods lasting from 348 d to 390 d.

The 154 different case submissions originated from 132 different farms. Twenty-four of these farms reported multiple foals with similar clinical histories, many of which were not submitted for postmortem examination. Eleven of these farms described multiple cases during one foaling season, another eight farms experienced single cases over multiple years, and five farms reported multiple cases each year over several years. Further, 26 of 79 syndrome cases came from farms where other syndrome cases were present in the same foaling season, other foaling seasons, or both.

Clinical and postmortem lesions associated with syndrome and thyroid cases

Reports of weakness and/or inability of foals to stand at birth, unusually large or unusually small foals, and signs of immaturity were reported significantly more often among syndrome cases than thyroid cases (Table 5). Musculoskeletal anomalies that were significantly more common among syndrome cases than thyroid cases, other than those that define the TH-MSD syndrome, included angular limb deformities and flexural deformities of the hind legs. There was also a trend for poor muscle development to be more frequently associated with syndrome cases (Table 6). Abdominal hernia was the only soft tissue anomaly, other than those included as a sign of immaturity, that was significantly more common among syndrome cases than thyroid cases (Table 7). However, there was a suggestion that a small thymus may also be more common in syndrome cases than in thyroid cases. In contrast to these findings, other types of developmental or congenital anomalies were reported in only 4.3% (120/2792) of noncases.

Discussion

The finding that more than 90% of thyroid glands with lesions were of normal size or only mildly enlarged emphasizes the previous recommendation (5) that the thyroid glands of perinatal horses submitted for necropsy should be routinely examined histologically. It suggests that lesions of the thyroid glands may be more common than the records used in this investigation have indicated, although the incidence of lesions of the thyroid glands in this study is higher (5.2%; 154/2946) than that reported by Conway and Cosgrove (11), who found only one anomalous thyroid gland among 95 foals examined at postmortem. While the authors did not indicate that histological examinations of the thyroid glands were routinely performed, it was required to make the diagnosis in the one case described.

While the reason for thyroid cases being most commonly diagnosed at the Fairview laboratory is unknown, it is reasonable to speculate either that pathologists

Table 7. Soft tissue anomalies reported in equine fetuses and foals diagnosed with a lesion of the thyroid gland[a]

Soft tissue anomaly	Number of submissions reporting anomaly[b] Syndrome cases	Thyroid cases	Significance[c]
Enlarged pituitary gland	7 (79)	3 (75)	0.186
Abdominal hernias: total	7 (79)	0 (75)	0.008
umbilical	5 (7)	—	
inguinal	1 (7)	—	
not specified	1 (7)	—	
Small thymus	6 (79)	1 (75)	0.067
Polycystic/dysplastic kidneys	4 (79)	3 (75)	0.529
Patent urachus[d]	4 (63)	0 (33)	0.179
Anasarca	1 (79)	1 (75)	0.738
Benign congenital neoplasms	1 (79)	1 (75)	0.738

[a]Reported in two or more submissions
[b]Appropriate denominator in parentheses
[c]p-value associated with Fisher's exact test of significance
[d]Includes dead neonatal foals only

there examine thyroid glands more commonly than do pathologists at other laboratories, or that there are one or more factors present in the environment of horses submitted there that result in these lesions.

The importance of abnormal appearing thyroid glands relative to the cause of perinatal foal loss is not clear. For example, 17 aborted fetuses were diagnosed as having a lesion of the thyroid gland, and in 12 of these there were no concurrent lesions or other apparent causes for the abortion. This finding is similar to the percentage of noncase abortuses for which no etiological diagnosis was made, and may suggest that the hyperplastic thyroid glands observed in thyroid-case abortuses were not related to the cause of the abortion, and that the hyperplastic appearance may be typical of fetal horses, per se. Comparatively, it is known that, in fetal humans (23) and sheep (24), thyroid weight and thyroid hormone levels remain low until midgestation and then increase progressively. In our survey, two of the 17 aborted thyroid-case fetuses were less than 160 d gestation, six others were less than 215 d gestation, and two were of unknown gestational age. Therefore, 10 of 17, or close to 60% of all abortuses with hyperplastic appearing thyroid glands were, or could have been, less than two-thirds of full gestation. A study of equine fetal thyroid gland development is required to document its normal morphology during gestation and thus avoid, what may be, an incorrect diagnosis of hyperplasia in aborted fetuses.

Conversely, the findings of this study agree with those of previous reports (14–16) with regard to the characterization of the TH-MSD syndrome. All TH-MSD syndrome foals that had their thyroid glands histologically examined had hyperplastic thyroid glands. While it is true that the presence of abnormal appearing thyroid glands does not necessarily indicate the type, or even the existence, of abnormal thyroid function (25), it is believed that foals with the TH-MSD syndrome are hypothyroid. McLaughlin and Doige (26) used surgically thyroidectomized foals to demonstrate that normal thyroid function was required for normal ossification, particularly of the carpal and tarsal bones. These findings were supported by reports of foals with naturally occurring hypothyroidism and/or abnormal thyroid gland morphology with concurrent retarded skeletal ossification (15,27–29).

The TH-MSD syndrome was found to be associated with prolonged gestation; however, these foals also have various signs of immaturity. Foals born after 320 d gestation and exhibiting symptoms of immaturity are referred to as dysmature (30). The cause of dysmaturity in foals is not often determined, but the most frequently recognized cause is placentitis or other forms of placental insufficiency. Placentas from TH-MSD syndrome foals have not been examined in the past.

About one-half of the 79 foals diagnosed with the TH-MSD syndrome were reported at the WCVM. There are several reasons why this might have occurred. The WCVM serves as a referral center for all of western Canada, and since all animals dying or euthanized while at the WCVM receive a postmortem examination, syndrome cases may have been submitted more commonly. Also, clinicians and pathologists at the WCVM, where the syndrome was first reported, may be more likely to recognize foals with the condition. It is also possible that the Saskatoon area has a higher occurrence of the TH-MSD syndrome in its equine population.

The TH-MSD syndrome was diagnosed in eight different "breeds" including light breed (quarter horse, standardbred, Thoroughbred, Appaloosa, Arabian), heavy breed (Percheron) and mixed breed horses, as well as in a group of donkeys. It affects males and females equally, and for these reasons, a genetic predisposition for the TH-MSD syndrome is considered unlikely. The group with an apparent low risk for the TH-MSD syndrome was the PMU horses. However, we discount the importance of this finding as PMU horses are not a true genetic breed, but rather a grouping of horses that are kept for a unique and specific purpose and share an

unusual management style.

The TH-MSD syndrome was originally described in foals a few days to a few weeks of age (14,15); recently, it has been recognized in stillborn foals (16), and stillborn foals with the TH-MSD syndrome were also found in this study. The syndrome has not been recognized in aborted fetuses expelled prior to 300 d of gestation; however, our current case definition may exclude the diagnosis of the TH-MSD syndrome in fetuses, as it requires the presence of lesions that only become apparent in the late stages of development.

The cause of the TH-MSD syndrome is unknown. For reasons outlined above, we do not suspect a heritable condition. However, since almost one-third of all syndrome cases came from farms where the syndrome was present in other foals during the same foaling season, other foaling seasons, or both, it seems reasonable to suspect an exposure-related cause, that is, dietary deficiency, toxic substance, or infectious agent.

Many of the lesions associated with the TH-MSD syndrome are similar to those reported in the foals born in the late 1920s to mares fed a diet suspected to be deficient in iodine (4). These foals were described as being full term, but weak and often unable to stand at birth. They also had flexural deformities of the forelimbs and, overall, foal mortality was high. However, these foals also had palpably enlarged thyroid glands, a finding that is not a feature of the TH-MSD syndrome. They also appear to have lacked the other lesions characteristic of the TH-MSD syndrome. Another report of a suspected iodine deficiency described premature delivery of weak fetuses and foals with flaccid bodies and goiter (7).

Pregnant mares fed a diet believed to contain excessive levels of iodine also produced goitrous newborn foals that were found to be otherwise normal (9), were delivered early, and had limb weakness (10) or were weak with flexural limb deformities (8). There appears to be great variation and sometimes contradiction in the reported signs of suspected hypothyroidism in foals and there is no set of signs that is considered diagnostic for the condition (31). The fact that the 1935 observational findings of Rodenwold and Simms (4) remains the basis of the National Research Council recommendations for the feeding of iodine to pregnant mares (32) emphasizes the need for more work in this area. Controlled experimental studies of the effects of a dietary deficiency of iodine on the pregnant mare and the foal she produces appears to be long overdue and would contribute greatly to the investigation of TH-MSD foals in western Canada.

Feeds contaminated with fungi have been known to produce disease syndromes of foals similar to that of TH-MSD. Prolonged gestations, dystocias, thickened placentas, agalactia, and high perinatal mortality have been associated with pregnant mares ingesting fescue grass contaminated with the fungal endophyte *Acremonium coenophialum* (33,34). The lesions present in the foals from these mares, including an increased thyroid gland follicle size (35), are somewhat different from the TH-MSD syndrome foals seen in western Canada. A similar syndrome has been reported in pregnant mares receiving feed contaminated by ergot (*Claviceps purpurea*) (36). The ingestion of locoweed (*Astragalus mollisimus*) by pregnant mares has resulted in a high incidence of abortion and limb deformities (angular limb deformity, forelimb flexural deformities, ruptured tendons of the common digital extensor muscles, hind limb flexor laxity) in the foals (37). Based on these reports, an examination of the feed is indicated in outbreaks of the TH-MSD syndrome.

While this study has provided a descriptive epidemiological, clinical and postmortem characterization of the TH-MSD syndrome, additional epidemiological studies and specific testing of potential etiologies are required to identify the cause of the TH-MSD syndrome in western Canadian foals. CVJ

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Answers to Quiz Corner/Les réponses du Test Éclair

1. d — These nerves provide the primary source of sensory innervation to the horn in goats.
   d — Ces nerfs fournissent l'innervation sensorielle principale aux cornes des chèvres.

2. a — The signs described are most consistent with foal-heat diarrhea. Treatment and laboratory assessment are not necessary; however, the foal should be monitored because early rotaviral infection or salmonellosis cannot be ruled out.
   a — Les signes décrits sont surtout observés lors de la diarrhée qui accompagne les premières chaleurs de la jument après le poulinage. Aucun traitement ou analyse de laboratoire n'est nécessaire; cependant, une surveillance de la pouliche est nécessaire car la possibilité d'un début d'infection au rotavirus ou une salmonellose ne peut être écartée.

3. a

4. d — Hypertrophic osteodystrophy is characterized by hot, swollen metaphyses, multiple-limb lameness, and a "double physeal line" on radiographs.
   d — L'ostéodystrophie hypertrophiante est caractérisée par des métaphyses tuméfiées et chaudes, de la boiterie à plusieurs membres, et une "double ligne épiphysaire" sur les radiographies.

5. b — Baking soda (sodium bicarbonate) can cause sodium loading.
   b — Le bicarbonate de soude peut causer une surchage de sodium.

6. b — Thymoma is the most likely diagnosis, as it is observed in older cats. Lymphoma should be a secondary consideration; however, cranial mediastinal lymphoma is typically seen in cats that average three years old and are FeLV positive.
   b — Le thymome est le diagnostic le plus probable puisqu'il est observé chez les chats plus âgés. Le lymphome devrait être considéré en deuxième lieu; cependant, les lymphomes médiastinaux crâniens sont rencontrés typiquement chez des chats qui ont environ trois ans et qui sont positifs pour le virus de la leucémie féline.

7. e — Coccidiosis and respiratory disease are the leading infectious causes of feeder lamb morbidity.
   e — La coccidiose et les maladies respiratoires sont les principales causes infectieuses de morbidité chez les agneaux à l'engraissement.

8. b — Nephrogenic strains of the virus may be involved.
   b — Des souches néphrogènes du virus peuvent être responsables de cette condition.

9. d

10. c — Pulmonary abscesses are common in the aftermath of shipping fever bronchopneumonia. The walled-off nature and poor blood flow to the center of the abscesses makes them resistant to antimicrobial therapy.
    c — Des abcès pulmonaires sont souvent rencontrés comme séquelles aux bronchopneumonies accompagnant le complexe respiratoire des jeunes bovins. La présence de la capsule et la circulation sanguine déficiente dans le centre des abcès causent une résistance aux thérapies antimicrobiennes.