EXPERIMENTAL STUDIES ON OSTEOMALACIA IN THE HORSE. THIRD REPORT.

EFFECT OF THE TREATMENT BY MEANS OF COMPENSATION OF CALCIUM CARBONATE.

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INTRODUCTION.

It is of great interest to study the treatment of osteomalacia by applying calcium, phosphoric acid, vitamin and ultraviolet rays. Marek and his students emphasized that, if either calcium or phosphoric acid which is deficient in fodder is compensated and its alkalinity of the alkaline earth salts is suitably regulated, the disease may be cured and the metabolism of the inorganic salt is renewed and the calcification of bone is improved. But it is said by the other investigators that vitamin D also may bring the same effect by a process such as it regulates the balance of calcium and phosphoric acid in the organism and elevates a utilization of the same substances taken up from the diet. McCollum, Simmonds, Nina, Shipley and Park in rat, Mellanby and Killick in children, in rabbit or in dog and Tsukamoto in rabbit proved respectively that the animals can be prevented from the onset of osteomalacia or rickets and their growth is accelerated if cod liver oil which contains vitamin D is added to their diet. Ultraviolet rays may be illuminated upon animal's body or diet for the same object as that of adding vitamin D. This fact was proved by the experiments which were carried out by Mellanby, Killick, Hess, Steenbock, Rosenheim, Goldblat, Daniels, Tsukamoto and

others. So it tends to appear that the vitamin D and the ultraviolet rays are able to stimulate a deposition of inorganic salts where these are lacking.

It was already proved by our works that osteomalacia could be experimentally produced in horses, if the feeding is limited to barley only which is remarkably deficient of calcium salt and its alkalinity of the alkaline earth salts is very low, but when calcium salt is added to the same diet and its alkalinity of the alkaline earth salts is elevated to +25mg, then the animals are completely prevented from the disease. We continued the experiment in order to cure the disease by adding calcium carbonate to the ordinary diet and by elevating its alkalinity of the alkaline earth salts to about +35mg, as Marek directed, and at the same time, tested the efficiency of vitamin D added to the diet, and of ultraviolet rays applicated on it.

I. EXPERIMENTAL.

1. *Experimental animals.*

The artificial osteomalacia has been produced in two horses by feeding them on barley only as carried out in our second work; we tried to make use of these animals with other two horses already affected spontaneously with the disease for this experiment. The animals are shown as follows:

Case	Color	Age (years)	Sex	Constitution	Body height	Nutrition	Body weight	Condition
No. 8	black	7	male (castrated)	good	1.51 ^{m.}	good	395 ^{kg.}	sound
No. 9	red	12	male (castrated)	good	1.52	good	414	sound
No.10	dark red	10	male (castrated)	good	1.55	not good	453	osteomalacia
No.11	red	6	male (castrated)	a little good	1.56	a little good	428	osteomalacia

The horses No. 8 and No. 9 were treated after the onset of osteomalacia, while in No. 10 and No. 11 the treatment was made in that condition. As preparatory work, their general conditions were inspected for 14–21 days under the ordinary feeding and management.

2. *Experimental diets.*

(1) Osteomalacia-producing diet.

As an osteomalacia-producing diet, crashed barley, daily quantity of which was 6kg, was given to each of horses 4 times a day in equal quantity as in the second experimental work.

(2) Osteomalacia-curing diet.

(a) Basal diet.

Basal diet for the treatment consisted of oats, hay and rice-straw adding some table salt to them, but the hay was increased twice as much as the ordinary and calcium carbonate was especially added to the diet in order to elevate its alkalinity of the alkaline earth salts to +35mg. Thus it is shown as follows:

Kind	Oats	Hay	Rice-straw		Table salt	CaCO ₃
			cut	litter		
daily quantity (kg.)	2.250	7.500	0.375	3.375	0.037	0.052

The horses No. 8 and No. 9 have been fed on this basal diet only after the onset of the disease.

(b) Illuminating the basal diet by the rays produced by the mercury vapor lamp.

Oats, hay and cut straw in the basal diet were daily illuminated by the rays produced by the mercury vapor lamp in place of ultraviolet rays for fifteen minutes at thirty centimetres distance.

(c) Adding of cod liver oil to the basal diet.

We gave to the horse No. 11 20c.c. cod liver oil (21.44g, about 0.2 percent of the total amount of the diet) mixing with the basal diet twice a day.

All the experimental animals were managed in the ways and means such as in the second experimental work.

3. *Special examination.*

Besides making observation of the clinical signs, examinations of the urine and blood serum, and the post-mortem examination, we have done the following in this experiment.

(1) Measurement of volumes of bones.

We measured volumes of the lacrymal and the maxillary

bones with a machine which was especially designed to measure them directly at the surfaces of bones by means of sticking soft tissues, that is, skin, subcutaneous tissues and muscles. This examination was carried out every ten days in each of the horses.

(2) Test of hardness of bones.

The hardness of lacrymal, maxillary and rib bones were now and then tested with the two kinds of larger and smaller needles of injectors, the points of which were damped not too sharp.

(3) Histological examination of rib bone during life.

We carried out the operation on No. 8 for the object of proving the elapse of the disease by the histological examination of rib bones during life. A piece of every bone (length 1.5 cm., breadth that of the rib, thickness one-half that of the rib) from the seventeenth to the thirteenth rib bone on the left side during the period of the onset of the disease and then from the thirteenth to the fifteenth rib bone on the right side for the period of the treatment was cut off with trepan and chisel at the horizontal line passed through the point at thirteen centimetres upward from the extremitas sternalis of the seventeenth rib bone. And then every piece was histologically studied.

4. *Duration of the experiment.*

Duration of the experiment is shown as follows :

Period	Case	Beginning	Termination	Duration	Effect
Producing	No. 8	June 6, 1927	October 6, 1927	122	osteomalacia produced
	No. 9	June 6, 1927	October 6, 1927	122	osteomalacia produced
Curing	No. 8	October 7, 1927	January 10, 1928	95	bled to death after recovery
	No. 9	October 7, 1927	January 10, 1928	95	bled to death after recovery
	No. 10	June 6, 1927	September 10, 1927	96	left the hospital after recovery
	No. 11	November 4, 1927	January 30, 1928	91	bled to death after recovery

II RESULT OF THE EXPERIMENT.

The result of the producing experiment on osteomalacia in the

horses was similar to our previous works and the results of the treatment of the disease are summarized as follows :

(1) All the phenomena of the artificial and spontaneous osteomalacia disappeared within 100 days by the above mentioned treatment.

(2) The swelling of bones (lacrymal, maxillary and rib) remarkably diminished in general, but only a part of them which had been very large in the beginning of treatment remained.

(3) Hardness of bones gradually increased during the treatment. The bones of No. 8 and No. 9 became harder than those of the normal, and also in No. 10 and No. 11 they reached generally to a normal degree except the central part of the upper jaw bone which is a little soft as yet. Now we may arrange the cases in the order of No. 8, No. 9, No. 10 and No. 11 according to the hardness of the bones.

(4) The quantity of urine was measured 4.76–9.56 litres a day. It has been made to decrease in general except No. 10, in which case it increased on the contrary, the more the amount of urine before the beginning of our treatment, the more the decrease of it during the period of the treatment.

(5) The quantity of phosphoric acid in the urine of every case has shown remarkable decrease. It was measured 0.58–1.19g. a day and 0.008–0.020g in 100c.c. of urine, decreasing 0.47–3.31g. in the former, and 0.026–0.047g. in the latter respectively.

(6) The quantity of inorganic phosphorus in the blood serum was measured 2.64–4.05 mg./dl., showing the increase of 0.16–0.97 mg./dl. in general except No. 9, in which case on the contrary it has decreased 0.16 mg./dl. on an average. .

(7) The quantity of calcium in the blood serum was measured 12.62–13.57 mg./dl., showing the increase of 0.13–0.80 mg./dl. in general except No. 8, in which case on the contrary it has decreased 0.61 mg./dl. on an average.

(8) The histological change of the rib bones gradually disappeared during the treatment in opposition to the onset of the disease. Now we may arrange the cases in the following order according to the degree of recovery of the disease: No. 8, No. 9 and No. 11, but no histological examination has been

carried out in No. 10, which left our hospital after recovery.

III. CONCLUSION.

1. Osteomalacia in the horse can be cured within 100 days when it is fed on ordinary diet, to which is added a suitable amount of calcium carbonate to elevate its alkalinity of the alkaline earth salts to + 35mg., and there is shown on difference between the effects of the experimental and the spontaneous diseases, but the slighter the symptoms and the younger the animal, the quicker the recovery of the disease.

2. It seems to be uneffectual that the adding of vitamin D or the application of ultraviolet rays is taken to the diet for the treatment of the disease if its contents of calcium and phosphoric acid and its alkalinity of the alkaline earth salts are suitable.

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EXPLANATION OF THE PLATES.

PLATE IV

Change of the volumes of bones in the duration of onset and cure of the disease in No. 8.

PLATE V

No. 9. ditto.

PLATE VI

Change of the volumes of bones in the duration of cure of the disease in No. 10.

PLATE VII.

No. 11, ditto.

PLATE VIII

Progression of softening of the spongoid trabeculae of the rib of No. 8.

- Fig. 1 The seventeenth rib on the left side (beginning).
 2 The sixteenth rib on the left side (elapsed 32 days).
 3 The fifteenth rib on the left side (elapsed 63 days).
 4 The fourteenth rib on the left side (elapsed 92 days).
 5 The thirteenth rib on the left side (elapsed 119 days).

PLATE IX

Progression of curing in the spongoid trabeculae of the rib of No. 8.

- Fig. 1 The thirteenth rib on the right side (elapsed 32 days).
 2 The fourteenth rib on the right side (elapsed 60 days).
 3 The fifteenth rib on the right side (elapsed 96 days).

PLATE X

Progression of curing in the operated fields in the rib of No. 8.

- Fig. 1 The seventeenth rib on the left side (elapsed 222 days).
 2 The sixteenth rib on the left side (elapsed 187 days).
 3 The fifteenth rib on the left side (elapsed 156 days).
 4 The fourteenth rib on the left side (elapsed 128 days).
 5 The thirteenth rib on the left side (elapsed 100 days).
 6 The thirteenth rib on the right side (elapsed 65 days).
 7 The fourteenth rib on the right side (elapsed 37 days).

馬ノ骨軟症ノ實驗的研究 第3回報告

かるちうむノ補給ニ依ル治療成績

新 美 信 太 加 藤 精

(陸 軍 獸 醫 學 校)

(昭和3年7月25日受附)

かるちうむ鹽類ノ含量ニ乏シク且土類あるかり度ノ著シク低キ
 飼料(大麥)ヲ以テ馬ヲ飼養スレバ骨軟症ヲ發生スルモ飼料ニかる
 ちうむ鹽類ヲ補償シテ土類あるかり度ヲ +25 mg. ニ高ムレバ本
 症ノ發生ヲ豫防シ得ルハ本研究ノ第1回及第2回報告ノ如シ茲ニ

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於テ余等ハ更ニ一步ヲ進メテ Marek ノ提唱ニ從ヒ飼料ノ土類あるかり度ヲ +35mg. ニ高ムルコトニ依リ馬ノ骨軟症ヲ治癒セシムベキ想定ヲ解決シ一方ニ於テハ斯ノ如クかるちうむ及磷酸ノ含量適當ナル飼料ニヴイタミン(肝油)ヲ添加シ又ハ紫外光線(水銀石英燈)ヲ照射シタルモノノ效果ヲ檢セムガ爲本實驗ヲ續行シ次ノ成績ヲ得タリ

1. 馬ノ骨軟症ハ沈降炭酸かるちうむヲ添加シ土類あるかり度ヲ +35mg. ニ規正シタル普通飼料ヲ以テ飼養スレバ100日以内ニ概ネ恢復ス此成績ハ實驗的骨軟症ト自然的骨軟症トノ間ニ差異アルヲ見ズ唯症狀ノ程度及年齡ニ依リ恢復ニ遲速ノ差アルノミ

2. 飼料ノ土類あるかり度(かるちうむ及磷酸ノ含量)適當ナル場合ニ在テハヴイタミン又ハ紫外光線ヲ應用スルモ其效果顯著ナラズ

(自抄)