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VOLUME OF THE SYNOVIA IN CERTAIN JOINT CAVITIES IN THE HORSE

By

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EKMAN, L., G. NILSSON, L. PERSSON and J. H. LUMSDEN: *Volume of the synovia in certain joint cavities in the horse.* Acta vet. scand. 1981, *22*, 23—31. — A method of determining the volumes of synovia in certain articular cavities in the horse is described. The method is based on the degree of dilution of human serum albumin labelled with ^{125}I that is injected into the joint. It is shown that uniform distribution of the injected substance is attained within 20 min post injection. The elimination of the labelled substance was found to follow the pattern of a single exponential function. The following volumes of synovia were determined (mean ± s): hock, 39.8 ± 2.1 ml; radio-carpal, 12.6 ± 1.5 ml; intercarpal, 14.9 ± 0.6 ml; foreleg fetlock joint, 12.5 ± 1.0 ml.

synovia volume; horses.

The over-all amounts of synovial fluid in various joints in the horse have been determined by *Van Pelt* (1962), who used the quantity of synovia that could be aspirated by a syringe, following arthrocentesis, as a measure of the total amount of synovia present in the joint cavity. Owing to the considerable difficulties associated with complete drainage of a joint cavity, however, this technique seems to be of doubtful value.

The method of *Van Pelt* has been adopted by *Amrousi et al.* (1966) for determining the overall amount of synovia in hocks of cattle in slaughterhouses.

The present article describes a method of determining the total amount of synovia in various joint cavities in vivo by applying an uncomplicated isotope dilution technique.

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MATERIAL AND METHODS

The horses used throughout this investigation ranged from 5—10 years of age. Eight of them were halfbreds and 2 thoroughbreds. The average weights of the halfbreds and thoroughbreds were 485 and 445 kg, respectively. All joints used for measuring the volume of synovia appeared to be clinically sound, i.e., none of the horses had displayed any sign of lameness affecting the leg concerned, palpations of the joints had been negative, and no significant galls had been found.

Human serum albumin labelled with ^{125}I in a concentration of approximately 100 μCi/ml and with a specific activity of 10 μCi/mg was used*. This stock solution was diluted with isotonic saline, yielding a solution with a concentration of about 10 μCi/ml. Of the solution, 0.5 ml, corresponding to 5 μCi of ^{125}I-labelled serum albumin (0.5 mg albumin), was aspirated into a syringe, which was then weighed together with the cannula to be used for the injection into the joint. The syringe and cannula were weighed again, enabling an accurate determination of the amount of isotope that had been injected.

Technique of injection and sampling

The arthrocenteses were effected using routine aseptic technique. For injecting the ^{125}I-labelled serum-albumin solution 0.80 mm cannulae were used; for the sampling, 1.25 mm cannulae.

The tests were carried out either on standing horses, following premedication with acepromazin,** a tranquillizer, or on lying, anaesthetized horses. In the tests on standing horses the animals were given 5 min exercise at a walking pace after the injection. In the tests on lying horses the joint concerned was subjected to 5 min of passive flexions in order to increase the rate of mixing the injected substance with the synovial fluid.

Hock joint. Injections of the labelled albumin solution were given, while legs were bearing weight, from the lateral aspect of the hock where the talocrural joint capsule projects upward between the distal end of the tibia and calcaneus. Arthrocenteses for sampling the synovia were effected from the medial aspect of the hock, mediad of the saphenous vein and about 2 cm distad of the medial malleolus of the tibia.

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Radio-carpal and intercarpal joint sections. Injections of the labelled solution were made into the flexed extremity, the sites of injection being, for both carpal joint sections, on the dorsal aspect of the carpus and 2—3 cm mediad of the long extensor tendon. Arthrocenteses for sampling the carpal synovia were also carried out with extremities flexed, on the dorsal aspect of the carpus, 2—3 cm lateral to the long extensor.

Fetlock joint. All arthrocenteses were made on the dorsal surface of the joint, to avoid the pronounced risk of hemorrhage usually associated with puncture of the fetlock joint, through the protuberance of the articular bursa on the volar side. The cannula entered the joint on a level with the proximal insertions of the collateral ligaments, about 1 cm mediad or lateral of the long extensor tendon. It was directed obliquely downward-inward, enabling puncture of the part of the joint capsule that extends upward behind the tendon, the injections of the labelled albumin solution being made on the medial, and the samplings of synovia on the laterial, side of the tendon. This part of the investigation involved foreleg fetlock joints only.

From all joints submitted to our experiments, samples of synovia were withdrawn at regular intervals throughout a period of 2—3 h. The exact times of sampling will be seen from RESULTS. To avoid synovial trauma with ensuing hemorrhage, which might follow from repeated punctures, only one puncture of each joint was made for the purpose of sampling, the cannula being inserted then fixed in position by strips of adhesive plaster, and sealed by a plastic stopper. Prior to collection of each synovial fluid sample, 3—4 drops within the cannula were withdrawn and discarded. None of the test horses showed any reaction that could be associated with the procedure.

RESULTS

The concentration of the ^{125}I-labelled serum albumin in the hock joint of the first horse in the test series was checked on 9 occasions following the injection, the first time after 10 min and the last time after 5 h (Fig. 1). The concentration curve from 10 min after the injection follows the pattern of a single exponential function, which implies that at least from this stage

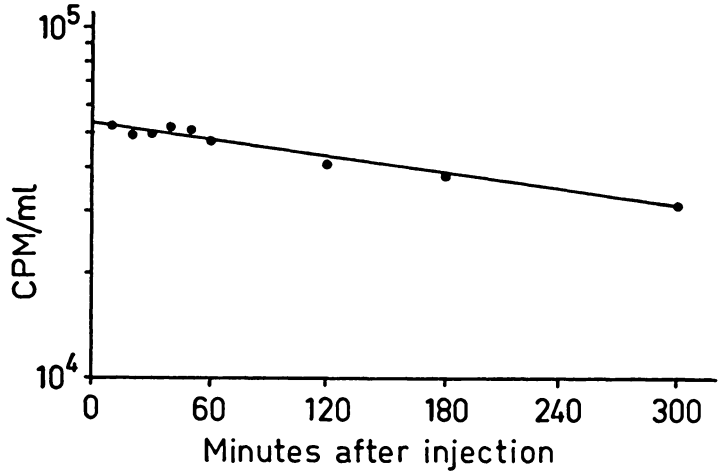

Figure 1. Concentration of ^{125}I-labelled human serum albumin in the synovia of the hock joint of a horse at certain times after the injection.

onward the labelled albumin was distributed uniformly in the fluid of the joint. In the remaining horses the concentration of ^{125}I-labelled albumin in the injected hock was checked on 5 or more occasions from 10 min until 2 h after the injection. In each case the synovia and the injected albumin had mixed completely by 20 min after the injection. In these cases as well, the concentration curve for the labelled albumin in each of the examined hocks followed the pattern of a single exponential function from 20 min after the injection or even earlier. This means that from this point onward the concentration curve can be expressed by the equation:

$$A_t = A_o \cdot e^{-kt}$$

where A represents the concentration of ^{125}I-labelled albumin at times t and o (= moment of injection), respectively, and k is the "disappearance rate constant". Table 1 shows these constants for the 8 hocks examined in 8 horses. Fig. 2 is a graphical representation of the concentration curves for the various hocks.

In calculating the volumes of the synovia present in each hock the values pertaining to the moment of injection have been extrapolated. The quantities of synovia found have been compiled in Table 1, the average quantity in the hock being 39.8 ml (range 29.2—47.8 ml). Table 1 also shows the volume that would have been estimated, had the calculations been based on the con-

Table 1. Volume of synovial fluid in hock joints of 8 horses. Values based on concentration of ^{125}I-labelled human serum albumin at time of injection (t = 0; values extrapolated) and 20 min after injection (t = 20). Differences between these volume values given as percentages of volumes at t= 0. Disappearance rate constant (k) for the elimination of the labelled albumin in each case is given.

Volume ml at t = 0	Volume ml at t = 20	Difference %	Disappearance rate const. k (min^{-1})
45.7	50.3	10.1	0.0048
33.9	34.6	2.1	0.0011
35.1	35.5	1.1	0.0005
38.1	39.1	2.6	0.0012
45.0	45.5	1.1	0.0005
43.8	46.0	5.0	0.0025
29.2	31.5	7.9	0.0038
47.8	50.2	5.0	0.0025
Mean 39.8	41.5	4.4	0.0021

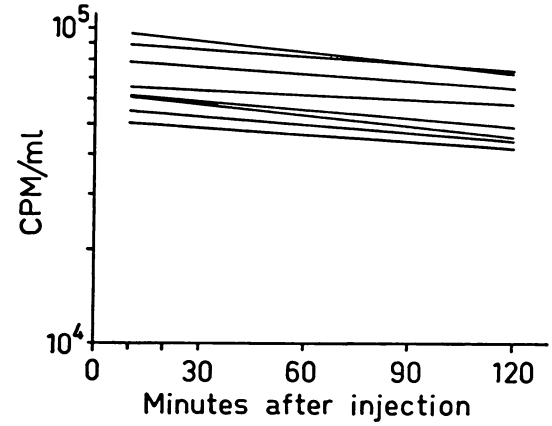

Figure 2. Disappearance curves of ^{125}I-labelled human serum albumin in hock joints of 8 horses.

centrations of the labelled albumin present 20 min after the injections. As can be seen there would have been a 4.4 per cent overestimate of the volumes on an average (range 1.1—10.1 per cent).

The middle carpal joint of one leg was investigated in each of 7 horses, the concentrations of the ^{125}I-labelled albumin being checked from 10 min to 100 min efter the injection by at least 5 samplings in each case. Similar investigations were carried out

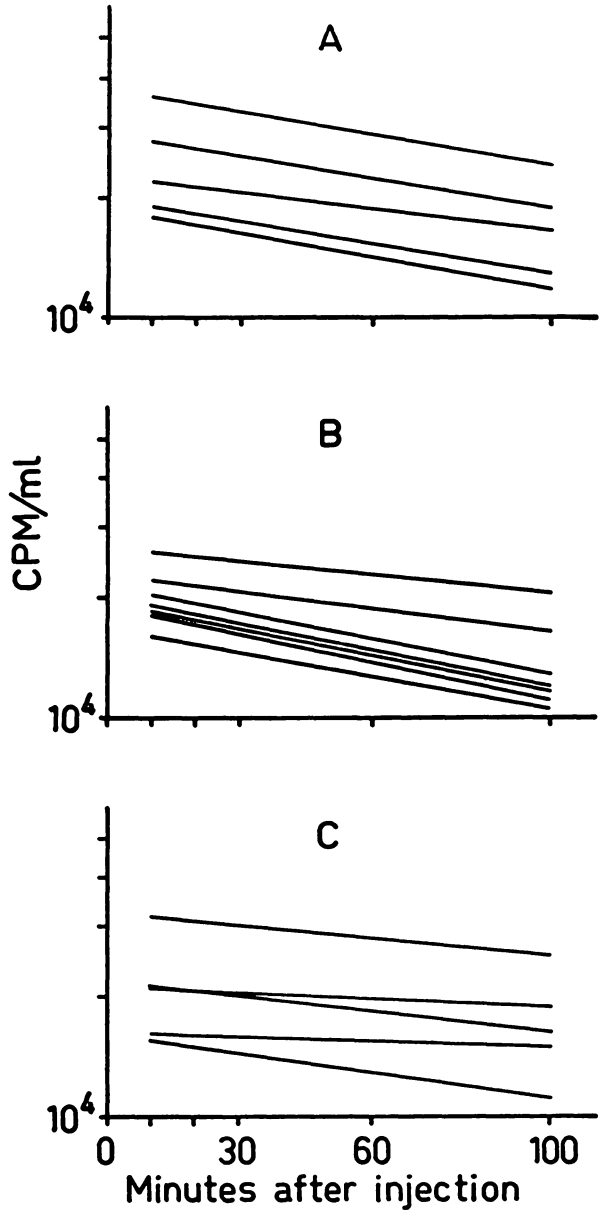

Figure 3. Disappearance curves of ^{125}I-labelled human serum albumin injected into radio-carpal (A), intercarpal (B) and foreleg fetlock (C) joints of different horses.

on upper carpal and foreleg fetlock joints in 5 horses. Complete mixing of the albumin solution and the synovia in each case was established within 20 min of the injection. The concentration curves for all these joints follow a single exponential pattern (Fig. 3, Table 2).

Table 2. Volume of synovia in middle carpal (n = 7), upper carpal (n = 5) and foreleg fetlock (n = 5) joints. Cf. also caption of Table 1.

Joint	Volume ml at t = 0	Volume ml at t = 20	Difference %	Disappearance rate constant, k (min^{-1})
Radio-	8.8	9.5	6.7	0.0038
carpal	10.0	11.9	19.0	0.0087
	16.8	19.5	16.1	0.0075
	12.7	13.0	2.4	0.0012
	14.9	15.9	6.7	0.0033
Mean	12.6	13.9	10.2	0.0049
Inter-	16.0	17.5	6.1	0.0045
carpal	14.9	15.1	1.3	0.0007
	17.2	18.5	7.6	0.0036
	13.6	13.7	0.7	0.0004
	16.1	17.5	8.7	0.0042
	13.1	14.5	10.7	0.0051
	13.0	14.3	10.0	0.0048
Mean	14.8	15.8	6.4	0.0033
Foreleg	13.0	15.2	16.9	0.0078
fetlock	9.8	11.0	12.2	0.0053
	12.2	12.3	0.8	0.0002
	15.7	17.2	9.6	0.0045
	11.8	12.2	2.5	0.0004
Mean	12.5	13.5	10.3	0.0040

In the same manner as in the hock investigations, comparisons have been made between the volumes arrived at when using as a basis of calculation (i) the extrapolated concentrations at the time of injection and (ii) the actual concentrations 20 min after the injection (Table 2). The greatest differences between the volumes calculated according to (i) and (ii) are those relative to the fetlock joints, which is attributable to the faster elimination of the labelled albumin from these joints. The mean difference for the fetlock joints amounted to 10.3 per cent (range 0.8—16.9 per cent).

DISCUSSION

As can be seen from Figs. 2 and 3 and from the values of the disappearance rate constant (Tables 1 and 2) the elimination of the ^{125}I-labelled human serum albumin has occurred at different rates in the various joints. The lowest elimination rate was found in the hock, which is the most voluminous joint, whereas the fastest elimination was observed in the fetlock joint, which is the smallest joint category examined in this investigation. It would thus seem as if the elimination rate would be inversely related to the size of the joint. The occurrence of numerous synovial folds and villi increases the relative resorptive surface of a fetlock joint as compared to that of a hock, which may imply a higher resorption rate of a fetlock joint than of a hock (*Nilsson & Olsson* 1973, *Johansson & Rejnö* 1976). The "exclusion phenomenon" described by *Laurent & Ogston* (1963) may provide another explanation. Thus, at a high concentration and degree of polymerization of hyaluronic acid a substance of comparatively large molecular size will be separated faster than at a lower concentration and degree of polymerization of the hyaluronic acid. The anatomical and physiological differences are quite marked between the fetlock and the hock joint, the radio-carpal and intercarpal joints being intermediate (*Persson* 1971). These theories, individually or together, may offer the explanation why the elimination rate of ^{125}I-labelled albumin varies in different joint categories. From Tables 1 and 2 it can be seen that the volumes of synovia in the present material were as follows: hock joints, 39.8 ± 2.1 ml (i.e., mean $\pm$ s); radio-carpal, 12.6 ± 1.5 ml; intercarpal, 14.9 ± 0.6 ml, and foreleg fetlock joints, 12.5 ± 1.0 ml. According to *Van Pelt* (1962), the volumes of synovia amount to: hock, 10.3 ± 1.4 ml; radio-carpal, 4.2 ± 0.6 ml; intercarpal, 6.2 ± 0.5 ml; and foreleg joints, 3.3 ± 0.6 ml. The discrepancy between the figures achieved in the two investigations is probably attributable to the marked difficulty associated with complete drainage of the synovial fluid in a joint by arthrocentesis.

By determining the concentration of a synovial component and the total volume of the synovia in the joint concerned, applying the technique described in the present paper, it is now possible to calculate the over-all amount of the synovial component in question. This should be of advantage especially when intra-articular substitution therapy is being contemplated. In a

more general sense determinations of changes in articular volume should be of considerable interest in connection with studies of physiological variations relative to changing external conditions. In most cases it should be sufficient to withdraw a single sample of the synovial fluid 20 min following injection of the labelled substance. At that time, the mixing of the synovial fluid and the injected albumin is known to be completed. The rate of disappearance of the injected labelled albumin may differ in joints with pathological changes. Investigations to elucidate this problem are in progress.

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SAMMANFATTNING

Synoviavolymen i vissa ledkaviteter hos häst.

En metod för att bestämma synoviavolymen i vissa ledkaviteter hos häst beskrives. Metoden baseras på utspädningen av humant serumalbumin märkt med ^{125}I som injiceras i leden. Det visas att den märkta substansen är jämnt fördelad i leden 20 min efter injektionen. Eliminationen av det märkta albuminet kan beskrivas matematiskt som en enkel exponentiell funktion. Följande synoviavolymer uppmättes: has, 39,8 ± 2,1 ml (Medeltal ± s); radio-carpal, 12,6 ± 1,5 ml; intercarpal, 14,9 ± 0,6 ml, kotled, framben, 12,5 ± 1,0 ml.

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