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**A CONTRIBUTION TO THE QUESTION OF THE
DANGER OF INFECTION WITH TUBERCULOSIS
THROUGH ORDINARY MILK.¹**

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AS is well known, it was some years ago established that tubercle bacilli can pass into the milk. Therewith the scientific proof of the possibility of infection through the use of milk was at the same time furnished. Numerous inoculation and feeding experiments, in combination with clinical observations regarding spontaneous infection of human beings through milk, have been made with the object of solving the question under what circumstances such an infection can take place. On the ground of these experiments it has actually been regarded as firmly established that the milk of cows affected with udder tuberculosis must in all cases be considered infectious, since it always contains tubercle bacilli (Bollinger, Bang, Hirschberger, etc.).

It has further been found that not only is the milk infectious in the tuberculous quarter of an udder, but also that the milk from the apparently healthy quarters of a cow affected with mammary tuberculosis may contain tubercle bacilli (Bang, May).

Lastly, it has been certainly proved by a number of cases that the milk of cows suffering from a more or less advanced tuberculosis, but without any clinically recognisable udder tuberculosis, may be infectious, although to a much smaller degree. Thus Ernst inoculated with milk from cows without any udder tuberculosis, and had positive

¹ The above article, which is based on the results of several investigations carried out by the author for the Copenhagen Health Commission, is translated from the *Deutsche Zeitschrift für Thiermedizin*, March 1893.

results in 37·5 per cent. in the case of guinea-pigs and in 15·15 per cent. in the case of rabbits. Bang found the milk infectious in 9 out of 63 cows without udder tuberculosis.¹

The experiments above-cited and many others made with the same object are nearly all intra-peritoneal inoculation experiments, which certainly have over feeding experiments the great advantage of much more surely and quickly producing infection, and thus of furnishing evidence regarding the percentage of cases in which the milk of tuberculous animals proves infectious. Whereas formerly feeding experiments were mostly used, on these grounds intra-peritoneal inoculations have in recent times been much more frequently employed, since the latter are much more prompt and certain in furnishing results. Thus Schmidt Mülheim² says that the inoculated experimental animals may be killed as early as the 3rd or 4th week after inoculation, since if tubercle bacilli are present in the inoculated milk the tuberculous process within that time will have developed sufficiently to be certainly recognised as such. But opposed to these obvious advantages, it must always be asserted that inoculation experiments, especially those recently made almost exclusively by the intra-peritoneal method, are very far removed from the natural way of infection, and that in a practical connection feeding experiments are vastly more important, because they alone show us how great is the actual danger of infection from the ingestion of milk carrying the virus of tuberculosis.

With regard to the latter, the experiments carried out in recent years prove that the certainty with which the infection is set up through the use of milk depends essentially upon the richness of the milk in tubercle bacilli. Koch had already called attention to that, and Baumgarten and Fischer have proved these facts experimentally. Both observers made experiments with milk which they had artificially infected with tubercle bacilli from pure cultures, and they found that the tuberculous processes were wide-spread and severe in proportion to the number of tubercle bacilli that had been added to the milk. Whereas formerly when one wished to continually take uncooked milk a particular cow was selected and its milk exclusively used, the above experiments appear to show the danger of such a procedure, and prove that the danger of infection from mixed milk is very decidedly lessened through the circumstance that the infectious product of one or several tuberculous animals is annulled through the added milk of a larger number of sound cows. This view appears also to be proved through the experiments which Gebhardt carried out under Bollinger's³ guidance in the year 1889. These experiments were instigated by the frequency with which tuberculosis occurred among the cows in the Munich dairies, and they were designed to show whether the ordinary milk sold for consumption was virulent even when it had been mixed with the milk from a single tuberculous cow. In order to discover whether the ordinary milk, as bought from the various milk-shops in Munich, was infectious, ten different samples of milk were procured from as many different shops. These were injected in doses of 2 ccm. into the abdominal cavity of a corresponding number of guinea-pigs. The animals were killed 5 or 6 weeks after inoculation, and it was found that they were all healthy. Sub-

¹ *Tidskrift f. Veterinärer*, 1891, 5 Heft.

² *Archiv. f. Animal. Nahrungsmittelk.*, iv. Bd.

³ Reference in *Archiv. f. Animal. Nahrungsmittelk.*, v. Bd., and vi. 2.

sequently samples of milk were taken from tuberculous animals with apparently sound udders. These were mixed with water in various proportions—1:40, 1:50, and 1:100—and inoculated in the same way. All experiments thus prove that virulent milk from tuberculous cows loses its infective properties when it is to a certain extent diluted with the milk of healthy cows, and also that the mixed ordinary retail milk will constitute a vastly less danger of infection, and indeed that through the dilution with large quantities of wholesome milk any infectious milk present may often be certainly rendered harmless. Milk from large dairies is therefore greatly to be preferred to the milk from establishments where only a few cows are kept, or indeed to the milk from a single cow (Bollinger).

These few experiments are the only ones which, so far as I am aware, have been undertaken in order to show to what extent the ordinary retail milk constitutes, according to the degree of its dilution, a greater or less danger of infection with regard to tuberculosis. They form a guiding basis for the following investigations, which I have carried out in order to solve the same question.

In Copenhagen there is no hygienic control of the dairies that furnish milk for the population. Such a control has been introduced, as far and as well as it is practically possible to carry it out, in only one private company—the Copenhagen Milk-supply Association—and also in a way deserving of recognition by a few other milk dealers. By far the greater part of the retail milk is sold without the slightest assurance that the cows furnishing it are sound. Moreover, in the Copenhagen laws regarding public health there is nothing under which such a control could be demanded; only a single paragraph ordains that “the Health Commission can temporarily forbid the introduction of milk from places in which dangerous infectious diseases have broken out among men or animals.”

Should such a control be induced, it can only be done by an indirect or round-about way, viz., by first discovering tubercle bacilli in the milk of a certain lot of cows, and on the ground of this discovery detecting tuberculosis in the herd in question, by which means it becomes possible to bring the latter under the action of the paragraph quoted above.

Proceeding from these considerations, I have since the beginning of May of this year, according to an agreement with the medical officer for Copenhagen, carried out a series of inoculations with ordinary retail milk, which at the instance of the police had been taken at various shops in Copenhagen, the object being to obtain results that would afford an answer to the following questions:

1. Is the ordinary retail milk infected with tubercle bacilli, and to what extent?
2. Is it possible, in a way that can be practically carried out, to discover tuberculosis in herds by inoculating the milk (retail milk) to animals?

The experiments were carried out in the following way. Milk is ordinarily purchased several times weekly by the Public Health officials, kept in the Laboratory of the Health Commission under observance of the most extreme care and cleanliness, and chemically examined. From this milk there was filled at my request, as soon as

possible after purchase, a sample of about 60 grms. into a sterilised flask. In doing this strict care was taken to note the name of the milk-seller, as the possessor of the cows from which the milk came, so that in case of positive inoculation results one could take occasion to examine the herd.

Whereas other experimenters have advised the use of guinea-pigs for such inoculations, it was evident to me, as, for example, to Schmidt-Mülheim also, that only rabbits can be used for these investigations. Thus the guinea-pigs that I inoculated all died in the course of 12 hours. The cause of that lay in the fact that the milk used as inoculating material, which after being milked in the ordinary more or less uncleanly way, had passed through not altogether clean vessels, and then had been transported for a long time in the warm summer time, contained a notable quantity of bacteria, and these set up a rapidly fatal septicæmia, before the tuberculous processes had time to develop.

Guinea-pigs thus prove absolutely unusable, while rabbits, on the contrary, on inoculation resisted the acute septic action of the milk in pretty considerable numbers. Besides, rabbits, in the country here, are to be had much more easily and cheaper than guinea-pigs. Whether spontaneous tuberculosis is less common among guinea-pigs than among rabbits I do not know, nor have I found any mention of the fact in literature. However, I believe I am justified in asserting that spontaneous tuberculosis very seldom occurs among rabbits kept under normal conditions; here in Denmark, at least, I have never heard or read of such a thing. Cornet mentions that out of 1000 bought guinea-pigs only 3 were tuberculous. Besides, these occasional cases, even if they do occur now and again, play absolutely no rôle in the present experiments, since, through the lungs and bronchial glands being alone or notably affected, they are distinguished from a peritoneal tuberculosis induced by intra-peritoneal inoculation; the latter spreads to the thoracic organs very late, and in the first weeks after inoculation generally only the abdominal organs form the seat of the tuberculous processes.¹

As a rule I inoculated, as a control of spontaneous tuberculosis, 2 animals with each sample of milk. Only in one case was the inoculation subcutaneous; in all others it was made into the abdominal cavity by the aid of a pointed glass pipette of 5-10 ccm. capacity, which quantity of milk was always used. Such glass pipettes are convenient to handle, and above all things easily cleaned and sterilised. In this respect they, in my opinion, are preferable to the more or less complicated syringes and other injection apparatuses, of which several varieties have been constructed and recommended.

In all 46 samples of milk were inoculated, and these came from 44 different herds, each comprising 10-80 cows. The inoculations were practised in all on 84 rabbits and 4 guinea-pigs. But, as already mentioned, an important number of rabbits, 37 in all, died, as did also the whole four guinea-pigs, and indeed very quickly after inoculation, mostly in the course of 12 hours, seldomer in 2-4 days, from a septic peritonitis. The autopsy gave about the same result in all these animals, viz., as a rule no special reaction at the seat of inoculation, the peritoneal cavity tensely filled with a turbid, yellowish, sero-

¹ Schmidt-Mülheim, *Archiv f. animalische Nahrungsmittelkunde*, Bd. v. S. 4.

fibrinous fluid, and all the abdominal organs more or less adherent by means of a fibrinous exudate. Microscopic examination of the latter in most cases showed a mixture of cocci and streptococci, sometimes mixed with short rods, and in some cases a perfectly pure culture of cocci.

Through these fatalities 18 samples of milk from as many herds were excluded from the investigation, so that only 28 samples remained over. The experiments made with these, in order to afford a rapid survey, are represented in tabular form, and afterwards described in detail.

<i>Number.</i>	<i>Experimental Animal.</i>	<i>Quantity of Milk injected in ccm.</i>	<i>Duration of Experiment in Days.</i>	<i>Result of Post-mortem Examination.</i>
1	¹ R a	10	54	Extensive caseous, at some places croupous, inflammation of the various abdominal organs, which processes, macroscopically regarded, were at some places very similar to those of tuberculosis. A very careful microscopic examination showed no tubercle bacilli.
	R b	10	54	Healthy.
2	R a	10	54	Icterus as a result of a large tumour of the liver. Otherwise healthy.
	R b	10	54	Abscess at the seat of inoculation. No tubercle bacilli.
3	R a	10	54	A large abscess filled with thin pus in the liver. No tubercle bacilli.
	R b	10	54	Healthy.
4	R a	10	48	Healthy.
	R b	10	48	Healthy with the exception of some unimportant white nodules in the gastric omentum. No tubercle bacilli.
5	R a	10	48	Healthy.
	R b	10	48	Healthy.
6	R a	10	48	In the mesentery of the stomach and small intestine very numerous, up to lentil size, yellowish-white nodules, which contained thick pus. Microscopic examination showed a few tubercle bacilli.
	R b	10	48	An almond-sized abscess at the seat of inoculation. Inguinal glands at the same time suppurating. Otherwise healthy. Numerous tubercle bacilli on microscopic examination.

¹ R = Rabbit.

<i>Number.</i>	<i>Experimental Animal.</i>	<i>Quantity of Milk injected in ccm.</i>	<i>Duration of Experiment in Days.</i>	<i>Result of Post-mortem Examination.</i>
7	R a	10	45	Abscess at the seat of inoculation. An exudative inflammation with single abscess at the stomach. Abscess in the liver. No tubercle bacilli.
	R b	10	45	Abscess at the seat of inoculation. Serous peritonitis. No tubercle bacilli.
8	R a	10	45	Healthy.
	R b	10	45	A large tumour containing pus on the peritoneal side of the seat of inoculation. No tubercle bacilli.
9	R a	10	Died the 2nd day after inoculation	Peritonitis.
	R b	10	45	A large tumour containing pus on the peritoneal side of the seat of inoculation. No tubercle bacilli.
10	R a	10	Died 5 days after inoculation	Peritonitis.
	R b	10	45	Healthy.
11	R a	10	Died 2 days after inoculation	Peritonitis.
	R b	10	44	Abscess at the seat of inoculation, both between the skin and muscles, and also intra-peritoneal. Smaller abscesses in the mesentery. No tubercle bacilli.
12	R a	10	44	Healthy.
	R b	10	44	Healthy.
13	R a	10	44	Small abscess in the mesentery of the large bowel. No tubercle bacilli.
	R b	10	44	The mesentery of the stomach and small intestine inflamed and beset with scattered small white nodules containing pus. No tubercle bacilli.
14	R	5	Died from asphyxia 7 days after inoculation	Slight serous peritonitis. The gastric omentum much inflamed, dull, traversed by tensely filled vessels and beset with scattered small purulent nodules. A microscopic examination revealed very numerous tubercle bacilli.

<i>Number.</i>	<i>Experimental Animal.</i>	<i>Quantity of Milk injected in ccn.</i>	<i>Duration of Experiment in Days.</i>	<i>Result of Post-mortem Examination.</i>
15	R	5	52	Two large abscesses firmly adherent to the small intestine. No tubercle bacilli.
16	R a	5 subcutaneously	52	Healthy.
	R b	5 intra-peritoneally	52	Healthy.
17	R a	5	46	Healthy.
	R b	5	46	A number of white nodules in the mesentery of the stomach and bowel. In the splenic omentum and the uterine ligaments two nut-sized abscesses. No tubercle bacilli.
18	R	5	46	A string as thick as a lead pencil running from the point of inoculation towards the inguinal glands. The lymphatic glands suppurating, very much enlarged, and containing thin tough pus. Widespread miliary tuberculosis in all the organs, as well as in the entire peritoneum. Tuberculous processes on the diaphragm. In the lungs miliary up to pea-sized recent nodules containing sparingly a thin pus. Microscopic examination revealed <i>numerous tubercle bacilli in all the tuberculous lesions examined.</i>
19	R a	5	Died 2 days after inoculation	Peritonitis.
	R b	5	42	Healthy.
20	R a	5	42	Healthy.
	R b	5	42	Healthy.
21	R a	5	Died 4 days after inoculation	Peritonitis.
	R b	5	53	Healthy.
22	R a	5	53	Healthy.
	R b	5	53	Healthy.
23	R a	5	Died 33 days after inoculation	Five large abscesses in the liver and at the seat of inoculation. No tubercle bacilli but cocci and streptococci in the pus.

<i>Number.</i>	<i>Experimental Animal.</i>	<i>Quantity of Milk injected in ccm.</i>	<i>Duration of Experiment in Days.</i>	<i>Result of Post-mortem Examination.</i>
24	R b	5	53	Healthy.
	R a	5	Died 9 days after inoculation	Peritonitis.
25	R b	5	53	Healthy.
	R a	5	Died 3 days after inoculation	Peritonitis.
26	R b	5	44	Healthy.
	R a	5	44	Healthy.
	R b	5	44	Healthy.
27	R a	5	44	Healthy.
	R b	5	44	Healthy.
28	R a	5	44	The seat of inoculation much infiltrated with a number of lentil- to pea-sized greyish-white firm nodules; very wide-spread miliary tuberculosis of the entire abdominal organs as well as the peritoneum; fewer distributed on both surfaces of the diaphragm and in the lungs. Microscopic examination revealed everywhere <i>very numerous tubercle bacilli</i> .
	R b	5	44	At the seat of inoculation several lentil- to pea-sized purulent nodules. Very wide-spread miliary tuberculosis of the entire abdominal organs and the peritoneum. Fewer distributed in the lungs and in the serous covering on both sides of the diaphragm. Microscopic examination showed everywhere <i>numerous tubercle bacilli</i> .

In addition to these experiments I fed 2 rabbits for about four months with milk from a lot of 50 cows. These rabbits were found to be healthy when killed, but they are not reckoned in the above series of experiments.

About a third of the inoculated samples of milk were at the same time submitted to a microscopic examination for tubercle bacilli, as a rule very carefully made. In the case of some samples this was done according to the plan recommended by Johne, viz., by first diluting the milk with water and then precipitating the casein by the addition of acetic acid, so as to more readily detect the tubercle bacilli; in no case, however, were tubercle bacilli found.

As regards the different samples of milk the following remarks have to be made.

As will be seen from the preceding tables, four samples of milk, viz., Nos. 6, 14, 18, and 28, produced tuberculosis on inoculation. The autopsy of the rabbits in question showed that the tuberculous processes were very slight in Nos. 6 and 14, although the pathological changes were quite characteristic, and the diagnosis was made perfectly certain by recognising tubercle bacilli microscopically. Cases Nos. 18 and 28, on the contrary, showed advanced and widespread, miliary tuberculosis. On the ground of the results of these inoculations and *post-mortem* examinations it was now possible for me with the assistance of the Public Health authorities to examine those herds of cows from which the tuberculous infective milk had been obtained. The result of this examination was briefly as follows:—

Sample No. 6 came from a herd of 30 especially well kept large fat cows. With the exception of a cow suffering from another disease—ordinary inflammation of the udder and articular rheumatism—there was in the lot only one old cow with a cough, and on auscultation of the left side of the abdominal cavity slight friction sounds could be recognised, which, taken in connection with the general appearance of the cow, was suspicious of tuberculosis.

Sample No. 14 came from a herd of 20 cows in good condition. One cow showed on examination of the chest occasional respiratory abnormalities, and also a tumour as large as a goose egg in the region of the throat, and these justified a suspicion of tuberculosis, although I could not diagnose the disease with certainty. Otherwise the animal showed nothing abnormal. After the lapse of a month the cow was again examined, but on this occasion also my suspicion could not be positively confirmed.

Sample No. 18 came from a herd of 20 cows in bad condition and badly kept. Two of them were suffering from mammary tuberculosis with apparently unaltered milk. In one lean cow with a cough pulmonary tuberculosis could be definitely made out. In addition there were in the herd various other cows which had to be regarded as suspicious of tuberculosis, on account of tumours about the throat and in the region of the flanks, and occasional respiratory abnormalities.

Sample No. 28 was furnished by a herd of 30 fairly well kept cows. Among them there was one animal affected with far advanced udder tuberculosis involving all four quarters. The milk of this cow was converted into a thin yellow secretion intermixed with white coagula, and microscopic examination showed numerous tubercle bacilli in it. It was only within the preceding 14 days that the milk had become so altered; previous to that the udder had certainly been somewhat swollen, but the milk apparently good, and therefore mixed with the other milk of the herd. That had also been the case at the time when the sample used for inoculation had been taken from the mixed milk. In addition, this cow was the subject of pulmonary tuberculosis, and was altogether in such a miserable condition that it could scarcely rise. It was only during the preceding 3 days that the cow had been under veterinary treatment.

In addition to this cow several others had to be regarded as highly suspicious on account of swollen lymphatic glands in the region of the

throat and changes in the lungs ; besides, I was informed that about half the herd were continually in œstrum (nymphomania).

It will thus be seen that the foregoing results of my experiments for the most part were in complete agreement with those furnished by the subsequent clinical examination. Samples 6 and 14 came from herds of respectively 30 and 20 cows each, among which one cow suspicious of tuberculosis was found. These could have added to the total yield of milk only a very small number of tubercle bacilli, and hence the relatively slight tuberculous changes in the experimental animals. While one would now have been fully justified from a theoretical and practical stand-point in absolutely forbidding the sale of such milk, since it contained tubercle bacilli capable of development, one could not adopt such a course so long as the method of investigation described was still in its early stage, and so long as tuberculous cows could not with certainty be found in the herds in question. Should such a control of market milk be permanently set up, it would obviously be enjoined to submit such herds to veterinary control, and by means of repeated intra-peritoneal inoculation of rabbits with milk to find out which cows were adding the tubercle bacilli to the mixed milk. • These control inoculations would be greatly simplified by inoculating the mixed milk from any three cows to one experimental animal, by which means it would finally be possible to discover the tuberculous animal.

The conditions are naturally different in the case of those samples of milk through whose inoculation (as in samples 18 and 28) the experimental animals become diseased in a higher degree, and where the clinical examination of the corresponding herds yields positive grounds for the diagnosis, or allows the tuberculous cows to be discovered with certainty. Such herds would naturally be sharply proceeded against, and all the regulations applied to prevent the introduction of their milk into Copenhagen.

In such cases above all the owner in question would in the first place be required to remove the tuberculous animals, not merely out of the byre but out of the premises. To this absolutely no exception ought to be made, as there are many owners who will not understand the danger to which they expose their fellow creatures by selling such milk as an article of human diet. But furthermore, it would still be necessary to cleanse the affected byres thoroughly, to disinfect them with 5 per cent. watery solution of carbolic acid, and after that to whitewash them afresh. Lastly, for such herds a continuous and careful inspection must be introduced, which at least for the first month ought to be carried out every 14 days and always supported by new inoculations. These, on the ground above described, ought to be carried out by subdividing the herd into several smaller divisions.

In my opinion the following conclusions are plainly warranted from what precedes :—

1. A rather important proportion of the samples of milk retained in Copenhagen have been proved on examination to carry with them a danger of infection.
2. The degree of dilution (especially when one regards the two last cases), in the case of inoculation experiments made with market milk, has had no noteworthy influence on the development of the tuberculous processes, since these within the short space of

44 to 46 days had attained quite as strong a development as one observes after inoculation with the undiluted milk of a cow suffering from mammary tuberculosis.

I am further of the opinion that in these and similar methods of investigation Health Authorities possess a certain means of discovering such herds as furnish dangerous milk, and at the same time, in an indirect way, of compelling the cow-owners to submit their herds to veterinary inspection. A further use of this control would be that by its means the veterinary surgeon would have his attention called to the presence of tuberculosis in the herds treated by him.

And I ought not to omit to point out the importance which the method of examination by inoculating rabbits with milk must have for the owner. The latter would in this way in doubtful cases ascertain whether his herd or single individuals of it were healthy or not.

Finally I beg that these reports may be regarded merely as provisional, for I hope through continued examinations to still further investigate the questions herewith connected, and all the more because Dr. Tryde, the city officer of health, takes a very kindly interest in this matter.

DIFFERENT METHODS OF ADMINISTERING PRUSSIC ACID TO CAUSE DEATH.

By F. HOBDAV, M.R.C.V.S., Redhill, Surrey.

HAVING read of, and also observed, the rapidly fatal action of Scheele's hydrocyanic acid, I felt a desire to test the effect of administering it in different ways, so as to learn the method of introducing it into the body which would cause death in the shortest time, and with as little apparent pain as possible. With that object in view the acid was given in various ways as a poison to animals condemned to death, the modes of administration employed being: hypodermic, intra-venous, intra-tracheal, and intra-thoracic injection; by introducing it into the mouth, the eyes, the ears, and the rectum; and by inhalation.

I. HYPODERMIC INJECTION.

CASE I.—Cat, about 8 lbs. ; aged.

<i>Hour.</i>	<i>Remarks.</i>
5.49 p.m.	Injected m. x. of hydrocyanic acid (Scheele's) subcutaneously at the root of the tail. In 3 minutes the respiration became very much accelerated, and the animal mewed several times; pupil of eye dilated, limbs rigid, head drawn back.
5.55 p.m.	A few spasmodic gasps.
5.57 p.m.	Dead.