THE INCIDENCE OF HUMAN TRICHINOSIS IN THE
VANCOUVER AREA AS DETERMINED BY THE EXAMINATION
OF FOUR HUNDRED DIAPHRAGMS

by

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ABSTRACT

Four hundred diaphragms from Vancouver hospitals were examined for Trichinae by direct compression and by digestion technique. Sixteen, or four percent were found to contain trichina cysts. By applying the formula $M \pm 3\alpha$, where $M$ is the mean, and $\alpha$ is the standard deviation, theoretical range of the incidence of trichinosis in the entire population was determined to be between 1.02% and 6.98%. Limitation of the amount of tissue examined, viz. one gram by compression and ten grams by digestion, and limitations imposed by the fact that only diaphragm muscle was examined, allowed an opportunity for certain light infections to pass unnoticed. It is therefore concluded that the incidence of human trichinosis in the Vancouver area is probably somewhat above four percent. While no recent infections were discovered, this incidence, which is over double that found in Eastern Canada, and in some cases the intensity of infection, the highest being seventy cysts per gram of muscle, conclusively show that trichinosis constitutes a serious public health problem in the Vancouver area.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acknowledgements</td>
<td>1</td>
</tr>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Historical Review</td>
<td>3</td>
</tr>
<tr>
<td>Natural History</td>
<td>7</td>
</tr>
<tr>
<td>Methods</td>
<td>9</td>
</tr>
<tr>
<td>Basic Techniques</td>
<td>9</td>
</tr>
<tr>
<td>Compression Method</td>
<td>11</td>
</tr>
<tr>
<td>Digestion Method</td>
<td>12</td>
</tr>
<tr>
<td>Experiment designed to discover more satisfactory digestion technique</td>
<td>13</td>
</tr>
<tr>
<td>Results</td>
<td>15</td>
</tr>
<tr>
<td>Results of the present survey</td>
<td>15</td>
</tr>
<tr>
<td>Results of an attempt to infect Goldfish with <em>Trichinella spiralis</em></td>
<td>16</td>
</tr>
<tr>
<td>Discussion</td>
<td>17</td>
</tr>
<tr>
<td>Possible sources of error in results</td>
<td>17</td>
</tr>
<tr>
<td>Analysis of data and case histories</td>
<td>20</td>
</tr>
<tr>
<td>Comparison of local findings with those obtained elsewhere</td>
<td>23</td>
</tr>
<tr>
<td>Possible explanations for local incidence</td>
<td>26</td>
</tr>
<tr>
<td>References</td>
<td></td>
</tr>
<tr>
<td>Plates</td>
<td></td>
</tr>
</tbody>
</table>
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The Incidence of Human Trichinosis in the Vancouver Area as Determined by the Examination of Four Hundred Diaphragms

Introduction

Trichinosis, a disease affecting man and other animals, is caused by the parasitic nematode *Trichinella spiralis*, which invades the skeletal muscle fibres of its host. While the vast majority of human infections remain subclinical and are not recognized, the numerous epidemics and fatal cases on record clearly indicate that the very existence of trichinosis in a community constitutes a serious medical problem.

Human infection is generally attributed to eating raw or improperly cooked pork. Similarly, hogs are known to become trichinosed by eating garbage containing infected pork scraps. Control is directed first of all toward prevention of hog infection, and secondly to treatment of pork destined for raw consumption. Since heat is known to kill trichina larvae, (Wright and Bozicévich 1943), the former type of control is exercised in Canada by a Federal law which decrees that all garbage used as hog swill must
be cooked. It is noteworthy that no such law exists in the U. S. A. The second type of control, viz. treatment of pork to be used in products normally eaten uncooked, is governed by law in both Canada and the U. S. A. (Cameron 1937). In each case law decrees that pork destined for raw consumption must be treated by heat, cold, or salt, in such a way as to kill any larvae present.

Final control rests with the cook. For only pork which has been cooked until no natural pink colour remains can be regarded as absolutely safe. Unfortunately, the average Canadian or American feels well protected by Government meat inspection. What he does not realize is that in neither country is there any inspection made for the only disease he can commonly contract from pork, trichinosis.

Up to the time of the present survey, nothing has been known of the incidence of human trichinosis in Western Canada. Theoretically we are adequately protected in our own country. However we have had no proof that our control measures have been conscientiously practised. Furthermore, the city of Vancouver is located a bare thirty miles from the United States border. On the basis of some twelve thousand necropsy examinations, it has been estimated that one American in every six, or a total of twenty-one million Americans harbour Trichinae within their bodies. Stoll (1947) estimates that there is three
times as much trichinosis in the U. S. A. as there is in all the rest of the world put together. Stoll also states that four and one half per cent of the positive cases found, showed counts of fifty or more larvae per gram of muscle, infection of an order "capable of causing pronounced clinical symptoms." He further estimates that such individuals, if adults, would be carrying loads in excess of one million larvae.

Besides describing a serious medical problem in the United States, the foregoing figures represent a tremendous number of meals of pork containing infective trichinae. It seems only reasonable then, to assume that a great number of infectious meals await the Canadian visitor.

The present survey has been carried out to determine the adequacy of our controls, and whether or not trichinosis constitutes a medical problem in the Vancouver area.

**Historical**

The history of our knowledge of trichinosis follows a pattern which is common in biological progress. It began with uncritical awareness, was catapulted into scientific focus at a single stroke, was developed along descriptive lines, and at present is being further developed physiologically. The fact that trichinosis is still very much in scientific focus is born out by the
fact that at least nine surveys have been made at various points in the last three years, and that at least one major work has been published on the subject in that time. The major work referred to is a very complete book, "Trichinosis," by S. E. Gould, from which the following historical summary has been compiled.

The earliest existence of *Trichinella spiralis* is obscure. Many writers however, feel that its adaptability to a wide range of host species points to a long evolutionary history. Indeed it has been suggested that the ancient Mosaic law which forbids the eating of swine flesh was instigated following a number of trichinosis epidemics.

Probably the first recorded observation of Trichina cysts is that made by Tiedman in 1821, in which he described seeing "Small oval shaped whitish stony concretions" in the muscles of a cadaver which he was studying. Credit for first observing the nematode in its cyst is given to Sir James Paget, who in 1834 observed "little specks in the muscles" of a cadaver, and who was curious enough to examine them microscopically. Sir Richard Owen, who was familiar with Paget's work, read a paper before the Zoological Society of London in 1835 in which he named the worm *Trichina spiralis*.

The next important advance was made by Joseph Leidy in 1846, who discovered Trichinae in the muscles of a hog. This was followed by the works of Herbst (1851),
Virchow (1859) and Leuckart (1860) in which the anatomy of the worm was more completely described, and the fact was established that an animal eating trichinous meat may develop trichinosis.

In 1860 Zenker discovered a heavy infection of live Trichinae in the muscles of the body of a Dresden servant girl. Subsequently he found adult Trichinae in the intestine, and infection in the ham and sausage at the house where the girl had worked. Thus he postulated, trichinosis can be fatal to human beings, the complete life history of the worm takes place in one host, and human infection can result from eating infected pork. Furthermore he correctly surmised that the larvae were disseminated by way of the chyle ducts and the blood stream.

Examination of pork for Trichinae was begun in Germany as early as 1863, and largely at the insistence of Virchow was made compulsory by Prussian law in 1879. At the same time pressure was exerted toward the banning of importation of American pork products. By 1881 most of the Central and Western European countries had such bans in effect. In order to regain these markets, the U. S. A. adopted a pork examination scheme in 1898. This was continued until 1906 when it was abandoned.

Since the name Trichina was already applied to a genus of Diptera, Railliet, in 1896, changed the name proposed by Owen, viz. Trichina spiralis to Trichinella
spiralis. Around the same time considerable work was being done on the life history and diagnosis of the parasite. In 1897 Brown noticed a high eosinophilia associated with the disease, and suggested its diagnostic value. Many workers, notably Fielder (1864), Cerfontaine (1895) and Askowazy (1895) made life history studies and conclusively showed that the larvae were disseminated through the lymphatics and blood stream to the muscles.

The first Trichina antigen was prepared by Ströbel in 1911. This has been improved upon by Bachman (1928), Augustin and Theiler (1932), McCoy, Miller and Friedlander (1933) and finally by Bozicivich (1939). In each case the antigen has consisted of an extraction of dried larvae, the constant improvement being directed to specificity of the antigen.

As was previously stated, the common source of human infection is trichinosed pork. The only other possible source is the meat of an edible game animal. Such a possibility has been mentioned by Steffanson (1948) who reported that Trichinae are prevalent in polar bears in Frans Josef Land, where they are used as a food source.

Surveys of animal populations have shown that most carnivorous and omnivorous animals may become infected by Trichinae. Gould states that the following animals have been found naturally infected: mouse, rabbit, beaver,
domestic cat, polecat, palm civet, dog, wolf, coyote, fox, marten, ferret, European and American badger, raccoon, polar bear, common bear, and mongoose, while the following have been experimentally infected: Guinea pig, monkey, sheep, cattle, horse, young chickens, pigeon, magpie, rook, hamster, gopher, ape, crow, jackdaw and hawk.

Gould expresses skepticism about the published claims of certain writers concerning the finding of naturally infected frog, eel, sparrow and pike. The possibility of cold-blooded vertebrates acting as hosts to *Trichinella spiralis* particularly intrigues the author. In this connection an experiment was performed in which an attempt was made to infect goldfish. The details of this experiment appear in a later section.

**Natural History**

The life cycle of *Trichinella spiralis* takes place within the body of a single host, and is the same regardless of the host species. Infection takes place when meat containing live larvae is eaten. Excystment of the larvae occurs in the stomach within a few hours, after which they migrate to the small intestine where sexual maturation takes place. This process is completed in forty-eight hours, and the females, which are more numerous than the males, have been fertilized at the end of that time. The
males, having completed their function, pass out with the faeces, while the females burrow into the intestinal mucosa, where they begin to give birth to living young on the sixth day. It has been estimated that a female Trichina produces some fifteen thousand larvae. The vast majority of these are born prior to the twentieth day. A diminishing number, however, continue to be produced until the death of the parent somewhere between the seventh and twelfth week. The newborn larvae penetrate the intestinal lymphatic vessels from which they pass to the thoracic duct, the right side of the heart, and finally are distributed to the skeletal muscles by the peripheral circulation. The invading larvae are apparently guided by a histotropism for although some apparently penetrate "foreign" visceral and nervous tissues, the vast preponderance enter the endomysia of skeletal muscle fibres. In this site the larvae develop in size, apparently feeding on necrotic muscle cells, until the third week after invasion when they assume their characteristic spiral form, and a closed capsule begins to develop around each. This capsule becomes progressively thicker, and is two walled. In all probability its outer wall is derived from host tissues and the inner one from the nematode products. As early as the sixth month a calcification process may begin. This usually starts at the poles of the capsule, and
spreads from there to the lateral capsule walls and to the worm itself. During the processes of encapsulation and calcification the worm undergoes no further development.

The period of life has been found to vary considerably since some die prior to calcification, while Langerhans (in Gould) in 1892 recorded live larvae being present in calcified cysts 31 years after infection. A second host may be infected by eating such meat as described above at any time during the life of the larvae after they become infectious, which condition is reached at the time encapsulation begins.

It is interesting to note that the invading larvae demonstrate a preference for active muscles with a good blood supply, and that development cannot take place in any other site than skeletal musculature. The crura and costal regions of the diaphragm are favorite sites, while intercostal, laryngeal, tongue, and eye muscles are also heavily infected.

**Methods**

**Basic Techniques**

A knowledge of the life history of *Trichinella spiralis* leads to the realization that cases of trichinosis may be most successfully discovered by an examination of diaphragm tissue. Accordingly, for the purpose of this
Survey, diaphragms were collected twice weekly from the Vancouver General Hospital, St. Paul's Hospital, and Shaughnessy Hospital, in Vancouver. The sampling was unbiased as far as the author was concerned, inasmuch as it represented a consecutive series of autopsies, broken only by forgetfulness on the part of the morgue attendants. Hospitals were asked to save as much of the diaphragm as possible.

Each sample was examined as soon as possible by two methods. First of all a one gram portion was squeezed between glass plates and examined directly under the microscope x45. Secondly a ten gram sample was removed, ground up, and digested in an artificial gastric juice for thirty-six to forty-eight hours, after which it was put into a modified Baermann apparatus. This was allowed to stand for two hours to allow any larvae to concentrate in the stem of the funnel. Subsequently 30 c.c. were drawn off and inspected microscopically.

The modifications of these basic techniques used in the early part of the survey were those employed by T. W. M. Cameron (1938) Montreal. These were adopted in an effort to maintain uniformity in Canadian surveys. Unfortunately certain aspects of the original technique proved unsatisfactory. To remedy this situation tests and experiments were performed and more suitable methods
adopted. The details of these procedures are discussed below.

Compression Method

During the early part of the survey, examination was carried out in the type of compressor shown in Fig. I. This consisted of two plates of quarter inch glass, two inches by eight inches, clamped together by one-quarter inch bolts running through counter-sunk holes three-quarters of an inch from the ends of the plates. Breakages soon proved this device to be unsuitable. An attempt at strengthening was made by using a one-half inch plate on the bottom, but the top plate still broke, and the cost and time lost demanded a more practical arrangement. To meet this end the author and his father fashioned the compressor pictured in Fig. II. These plates were of one-quarter inch plate glass four inches by five and a half inches. The frame was made of one-sixteenth inch brass and leaves a window two and a half inches by four inches. This latter compressor proved to be entirely satisfactory.

When the all glass compressor was used, a one gram sample of tissue was weighed out and examined. However after the brass-framed device had been in operation for a short time the weighing procedure was eliminated. It was discovered that the window held approximately one and a quarter grams of tissue, and subsequently a spacial
criterion was used.

Beginning with the two hundred and fiftieth sample Cameron's iodine stain technique was adopted. This procedure involved staining the muscle in a 0.5% solution of iodine for ten minutes, and then destaining in 2% photographic hypo until the iodine colour was removed from muscle tissue. This method was tested on experimentally infected rat tissue and was found to stain live larvae a deep reddish brown.

**Digestion Method**

The digestion technique used in the early examinations was similar to that used by Cameron and consisted of digesting ten grams of chopped muscle in a gastric juice composed of 0.01 grams of Papain in 30 c.c. of normal (8%) saline for thirty-six hours at 37°C. After this time the residue was allowed to stand for two hours in a Baermann apparatus. This apparatus consisted of an eight inch 60° funnel stopped at the bottom, with a kitchen seive lying in the funnel, and three layers of cheesecloth lining the seive. Unfortunately no heat controlled room was available, so the procedure used was as follows. The funnel was warmed up and filled with warm (37°C) water until the level was just above the inside of the seive. Then the digest residue was poured into the seive and the whole was allowed to stand for two hours to allow any live larvae to wriggle through the filtering apparatus and down into
the stem of the funnel. At the end of that time the lower 30 c.c. were drawn off and examined x45 under the microscope.

Firstly papain proved to be conducive to putrefaction and the resultant odour was most offensive to say the least. A surface film of chloroform or toluol diminished this effect slightly, but neither was completely successful, and the use of either increased the cost of materials. Secondly, the digestions did not run to satisfactory completion. Probably any live larvae would have been freed, but a residual mucus-like slime resulted in every case which increased the time required for cleaning up the Baermann apparatus.

In order to discover a satisfactory digestive juice an experiment was set up wherein various concentrations of pepsin and papain were used to digest ground lean beef. The conditions and results of this experiment are found in Table I.

**Experiment designed to discover more satisfactory Digestion Technique**

In all cases the sample was five grams in weight, and of uniformly lean ground beef. The gastric juices were 50 c.c. in volume, the pepsin being dissolved in 0.01 M HCl and the papain in 0.8% NaCl. The solutions were uncorrected for pH and were not stirred, but were left to incubate in the 37° oven. After twelve, sixteen, twenty,
twenty-four, and thirty-six hours of incubation, the solutions were examined for condition, and an estimate was made as to whether or not digestion had proceeded to a degree sufficient to free any larvae that might be present.

The results of these tests showed pepsin to be far superior to papain. As opposed to the slimy vile-smelling papain residue, pepsin was found to be practically odourless and to leave a clear amber solution with a fine precipitate. A solution of 0.2% pepsin was found to digest the beef to completion in sixteen hours, and was chosen to be used throughout the remainder of the survey, beginning at the one hundred fifteenth diaphragm sample.

The only other departure from the original technique was the elimination of the use of a meat grinder. The author found that he could save considerable time by cutting the tissue into fine pieces with scissors in preference to using a meat grinder which required cleaning and boiling. The efficiency of the digestion was not impaired by the modification.

In the cases where Trichinae were found to be present, the intensity of infection was determined on the basis of a compression examination of five grams of tissue. The intensity was expressed in terms of the number of larvae per gram of diaphragm.
Table I

The Efficiency of Various Concentrations of Pepsin and Papain in Digested Ground Beef

<table>
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<th>% Pepsin</th>
<th>12 hrs.</th>
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<th>20 hrs.</th>
<th>24 hrs.</th>
<th>36 hrs.</th>
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<td>N</td>
<td>N</td>
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<table>
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<th>% Papain</th>
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<th>24 hrs.</th>
<th>36 hrs.</th>
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<td>I</td>
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</table>

Index to Symbols used in Table I

I - Incomplete       N - Nearly Complete       C - Complete
Results

Results of the Present Survey

A total of four hundred diaphragm samples were examined, and of these sixteen, or four per cent were found to contain Trichina cysts. This figure remained consistent throughout the survey inasmuch as the successive groups of one hundred contained four, three, four, and five positive tissues respectively.

Theoretical range of the incidence was calculated using the method suggested by Simpson and Roe, who state that such a range will be represented by $M \pm 3\alpha$, where $M$ is the mean and $\alpha$ is the standard deviation. The latter figure is arrived at by using the formula $\alpha = \sqrt{npq}$ (Ricker 1937) where $n$ is the total number of cases examined, $p$ is the percentage of positive cases, and $q$ is the percentage of negative cases. The value of $\alpha$ is found to be 0.99. When this figure is applied to the first formula it is seen that the theoretical range of incidence is from 1.02% to 6.98%. This means that there is a 95% probability that the incidence of trichinosis in the whole population sampled lies within this range.

Table II shows the distribution of positive cases with respect to the hospitals from which they came. Ten positive tissues came from the Vancouver General Hospital, two from St. Paul's Hospital, and four from Shaughnessy Hospital.
Table II

The Distribution of Positive Tissues with Respect to Source

<table>
<thead>
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<th>Source</th>
<th>Number Examined</th>
<th>Number Positive</th>
<th>% Positive</th>
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<tr>
<td>Vancouver General</td>
<td>213</td>
<td>10</td>
<td>4.7</td>
</tr>
<tr>
<td>St. Paul's</td>
<td>87</td>
<td>2</td>
<td>2.3</td>
</tr>
<tr>
<td>Shaughnessy</td>
<td>100</td>
<td>4</td>
<td>4.0</td>
</tr>
<tr>
<td>TOTAL</td>
<td>400</td>
<td>16</td>
<td>4.0</td>
</tr>
</tbody>
</table>

In nine of the positive cases, the cysts were discovered by compression method only, while the remaining seven were detected by both compression and digestive techniques. In only three instances were live larvae found. The remaining thirteen positive tissues contained cysts in which the worms were dead or absent, and the worms, cysts, or both were calcified (Figures 5 - 13).

Results of an Attempt to Infect Goldfish with *Trichinella spiralis*

The fact that Trichinae tolerate a wide range of host species tempted the author to consider the possibility of infecting a cold-blooded vertebrate. In an attempt to test this possibility two experiments were set up using Goldfish *Carassius auratus* L. as subjects.

In the first experiment, approximately two thousand Trichina larvae were forced by means of an eyedropper down
the throat of each of four fish. After four days the fish were killed, the intestine removed, slit open, and scraped, and the scrapings examined for adult Trichinae. No worms were found in any of the four fish.

Subsequently approximately three thousand larvae were forced down the throat of each of six fish. To further expose them to infection, they were fed for four successive days on ground rat meat which was heavily trichinised. The fish were kept in an aquarium for nine weeks after which they were killed, skinned, decapitated, and eviscerated. One gram of muscle was examined by direct compression, and the remainder of the carcass was chopped up and examined by the routine digestion method.

Not a single larva was discovered by these examinations.

Failure to infect Carassius auratus with Trichinella spiralis is probably attributable to the low body temperature of the fish. The relatively short intestine of Goldfish may also play a role however, and the author feels that similar experiments performed on fish with a more complex digestive tract might show positive results.

Discussion

Possible Sources of Error in Results

On considering his methods the writer is forced to conclude that a certain number of positive tissues have been missed, and that the incidence of trichinosis in this
area is actually higher than the four percent indicated. Four possible sources of error exist which might have allowed such tissues to escape unnoticed.

The first such possibility concerns the fact that the present survey was confined to an examination of the diaphragm tissues. Evans 1938 (in Kerr et al) found an incidence of 36% in one hundred consecutive autopsies at Cleveland, Ohio, but would have reported a 25% incidence had he confined his examinations to the diaphragms. The remaining 10% were found in the sternomastoid and intercostal muscles. Similarly Walker and Breckenridge 1938 (in Kerr et al) reported an incidence of 33% in one hundred autopsies in Alabama, nine of which were discovered in intercostal, rectus abdominis, and pectoral muscles and not in the diaphragm. Thus the writer concludes that while the diaphragm is the most likely seat of a trichina infection, any survey which bases its results on diaphragm examination alone is likely to miss up to 10% of the positive cases.

Secondly this survey has been carried out utilizing only one gram of tissue for compression examination and ten grams for the digestion. It seems very possible that one or more very light infections may have escaped notice. This contention is born out by the work of Jacobs 1938 (in Kerr et al) who, using direct compression only, examined ten gram samples of one hundred tissues recorded as negative
by routine one gram sample methods. In this one hundred supposedly negative tissues Jacobs found six to be positive.

The third possible means by which certain positive tissues may not have been recognized as such, involves the length of time the digestive mixture was allowed to incubate. Gursch (1948) has shown that the viability of Trichinella larvae is definitely reduced by peptic digestion of longer than twelve hours duration. Thus it seems not unreasonable to suppose that live larvae may have existed in some of the tissues and may not have survived the thirty-six to forty-eight hours digestion used in the present survey.

Finally the author acknowledges the fact that his Baermann apparatus was not ideal. No incubation room was at his disposal, so, as mentioned previously, compensation was attempted by warming the apparatus and filling the funnels with warm (37°) water. This quickly cooled down to room temperature (≈20°) however, and would have decreased the activity of any larvae present to a very great degree. Thus the author regards his apparatus as having been actually a simple sedimentation system rather than a true Baermann apparatus. (The efficiency of the latter being due to the activity of larvae being concentrated.)

A further observation was made while larvae from experimentally infected animals were being concentrated. The author noted that the angle of the funnels was great
enough (60°) to allow many larvae to settle on the funnel wall. This situation probably would not have been so pronounced had the larvae been kept active in a 37° constant temperature room. Nevertheless, light infections might have been missed on this account, and certainly a more acute angled funnel would have been desirable.

Taking into consideration all the aforementioned channels by which some positive cases may have escaped notice, the author feels justified in presuming the incidence of human trichinosis to be somewhat above four percent.

**Analysis of data and case histories**

An attempt to correlate the incidence of trichinosis with such factors as racial origin, military service, residence, and economic status, had originally been planned to be included in this study. However the size of the sample examined and the incompleteness of many of the hospital records proved this aim to be infeasible. Further modification was required by the fact that on six separate occasions, two diaphragms arrived from the Vancouver General Hospital bearing the same autopsy number. These were designated in the laboratory as tissue A and tissue B. Examination revealed that in four of these pairs, both diaphragms were negative, but in the case of autopsy number 842, A was negative and B was positive, while in autopsy number 848, A was positive and B was negative. This means that there is only a fifty percent chance that the hospital
records of the numbers 842 and 848 actually refer to the positive tissues.

The limited data available, as seen in Table III suggests a possible correlation between the incidence of trichinosis and certain national food customs, such as the eating of raw sausage. It is noted that four of the positive cases in which the nationality is known are from Central or Western European countries. Hall (1938) noted a higher incidence in Americans of European origin than in those of English, Scottish, or Irish origin.

The writer, in his study of case histories, has attempted to pick out from the recorded symptoms any conditions suggestive of the actual infection. Here again, however, he found that for the most part his efforts were frustrated by a lack of history in the hospital records.

In the documents of the seventy-four year old Italian male the following statement occurs "Brain weighs 1380 grams and on sectioning presents in the left internal capsule rather scattered areas of softening and one or two small cystic spaces suggestive of old infarction." An attempt was made to locate the mentioned slide, but it was found that only lung and kidney slides of this case had been saved. It is unlikely that the cystic spaces mentioned had any connection with the trichinosis condition. However larvae have been known to penetrate "foreign" tissues, and the spaces may just possibly have been lesions left by such
<table>
<thead>
<tr>
<th>Hospital</th>
<th>Age</th>
<th>Sex</th>
<th>Racial Origin</th>
<th>Residence in Vancouver</th>
<th>Military Service</th>
<th>Condition of Larvae</th>
<th>Number per Gram</th>
</tr>
</thead>
<tbody>
<tr>
<td>V.G.H.</td>
<td>74</td>
<td>M</td>
<td>Italian</td>
<td>20 Yr.</td>
<td>No</td>
<td>Dead. Cysts Calcified</td>
<td>4</td>
</tr>
<tr>
<td>V.G.H.</td>
<td>71</td>
<td>M</td>
<td>Hungarian</td>
<td>6 Yr.</td>
<td>No</td>
<td>Dead and fragmented Cysts &amp; worms calcified</td>
<td>70</td>
</tr>
<tr>
<td>V.G.H.</td>
<td>50</td>
<td>F</td>
<td>English</td>
<td>?</td>
<td>No</td>
<td>Mixed dead and alive not calcified</td>
<td>1</td>
</tr>
<tr>
<td>V.G.H.</td>
<td>67</td>
<td>M</td>
<td>German</td>
<td>?</td>
<td>No</td>
<td>Dead. Worms calcified cysts not.</td>
<td>1</td>
</tr>
<tr>
<td>V.G.H.</td>
<td>6 weeks</td>
<td>M</td>
<td>?</td>
<td>6 weeks</td>
<td>N/A</td>
<td>Dead or absent. Cysts calcified or not.</td>
<td>22</td>
</tr>
<tr>
<td>V.G.H. *?</td>
<td>69</td>
<td>M</td>
<td>Spanish</td>
<td>Pt. Alberni</td>
<td>?</td>
<td>Mixed dead and alive worms &amp; cysts calcified or not.</td>
<td>9</td>
</tr>
<tr>
<td>V.G.H. *?</td>
<td>61</td>
<td>F</td>
<td>English</td>
<td>24 Yr.</td>
<td>No</td>
<td>Dead or absent worms &amp; cysts calcified or not.</td>
<td>0.2</td>
</tr>
<tr>
<td>V.G.H.</td>
<td>35</td>
<td>F</td>
<td>?</td>
<td>21 Yr.</td>
<td>?</td>
<td>Dead. Worms &amp; cysts calcified or not.</td>
<td>52.8</td>
</tr>
<tr>
<td>V.G.H.</td>
<td>83</td>
<td>M</td>
<td>Irish</td>
<td>?</td>
<td>?</td>
<td>Dead &amp; fragmented worms &amp; cysts calcified or not.</td>
<td>4.2</td>
</tr>
<tr>
<td>Shaughnessy</td>
<td>88</td>
<td>M</td>
<td>?</td>
<td>11 Yr.</td>
<td>Yes</td>
<td>Dead or absent Larvae calc. cysts not.</td>
<td>0.8</td>
</tr>
<tr>
<td>Shaughnessy</td>
<td>67</td>
<td>M</td>
<td>?</td>
<td>?</td>
<td>Yes</td>
<td>Dead. Cysts cal. larvae not.</td>
<td>0.8</td>
</tr>
<tr>
<td>Shaughnessy</td>
<td>77'</td>
<td>M</td>
<td>?</td>
<td>?</td>
<td>Yes</td>
<td>Dead. Cysts heavily cal.</td>
<td>6</td>
</tr>
<tr>
<td>Shaughnessy</td>
<td>79</td>
<td>M</td>
<td>?</td>
<td>?</td>
<td>Yes</td>
<td>Alive. Cyst cal.</td>
<td>2</td>
</tr>
<tr>
<td>St. Pauls</td>
<td>72</td>
<td>M</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>Dead. Cysts &amp; larvae cal or not</td>
<td>8</td>
</tr>
<tr>
<td>St. Pauls</td>
<td>67</td>
<td>F</td>
<td>?</td>
<td>10 Yr.</td>
<td>?</td>
<td>Dead. Larvae cal., cysts not.</td>
<td>0.2</td>
</tr>
</tbody>
</table>

* Question marks in column L indicate tissues which may have wrong number. Question marks in other columns indicate information unavailable in Hospital records.
invading larvae. Brain lesions caused by Trichinae are discussed by Gould.

Particular note was taken of the number of positive cases having histories of rheumatic conditions. In this regard it was found that only two of the sixteen had recorded histories of arthritic conditions and that one of these was found at autopsy to be an osteoarthritis of the spine. The other, the sixty-seven year old German male had a seven year old history of arthritis in the pectoral-scapular region with pronounced atrophy of the muscles. While the latter case might possibly have some significance, these results certainly do not offer any evidence toward incriminating trichinosis as a factor in rheumatic conditions.

The appearance of Trichinae in the diaphragm of a six weeks old baby presented a noteworthy case. Early writers believed that intrauterine infection did not take place. However Roth 1935, 1936, (In Gould) demonstrated muscle trichinae in the foetuses of guinea pigs infected during pregnancy, and Kuitunen Ekbaum (1941) reported finding four live larvae in 6.5 grams of diaphragm tissue from a seven months old foetus. Dr. L. Ranta (Personal communication) described the finding of a heavy infection of trichinae in a foetus at autopsy in Toronto.

In the present case, the baby was born five weeks prematurely in a frail condition. He fed poorly and
coughed a lot, and X-ray showed increasing opacity in the right lung. Six weeks after birth the baby died, and an autopsy was performed. The report showed bronchitis, partial obstruction of the right side of the bronchial tree, and insipient croup. The writer contacted the physicians who had attended the confinement and the child's illness, and was informed that the mother, a seventeen year old Canadian woman, had suffered no illness during pregnancy. The condition of the cysts is worthy of note inasmuch as the larvae were dead or absent, and many of the cyst walls showed calcification. Ehrhardt quoted by Gould, observed in 1896, death of muscle larvae as early as the third week, and larval calcification between the forty-second and sixtieth days. Similarly Leukart (In Gould) demonstrated calcification as early as the eightieth day. Nonetheless, the process of calcification does not usually commence until after the sixth month of infection, and the writer feels that this case may indicate a difference in the rate of calcification in foetus over that in the adult.

Comparison of local findings with those obtained elsewhere

The incidence of human trichinosis is governed by two main factors; viz. care exercised in raising hogs and preparing pork products, and food and cooking habits.

Table IV presents a picture of the incidence in humans in various areas. Unfortunately no mathematical correlations can be drawn because in certain areas i.e. Germany, no recent surveys have been made, and the figures represent
only approximate values. Furthermore the situation is com-
plicated by the fact that hog surveys which are so inti-
mately tied up with human surveys, are in places lacking, 
and in other places not representative of the pork which 
appears on the public market. The latter case exists 
locally. The author's information on this subject comes 
from personal communications with Dr. I. W. Moynihan who 
has a trichinosis survey of rats and hogs in the Vancouver 
area in progress. The figures to be used represent only 
approximate values, since the mentioned surveys are not com-
plete, and furthermore do not represent a cross section of 
British Columbia's market pork, inasmuch as they refer 
largely to British Columbia raised hogs, whereas a great 
portion of the pork consumed in British Columbia is raised 
in the prairie Provinces.

Table IV

Comparison of Local Findings with those Obtained Elsewhere

<table>
<thead>
<tr>
<th></th>
<th>Size of Sample</th>
<th>% Positive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>?</td>
<td>1.5%</td>
</tr>
<tr>
<td>U. S. A.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>California</td>
<td>5213</td>
<td>16.1%</td>
</tr>
<tr>
<td>Oregon</td>
<td>129</td>
<td>17.8%</td>
</tr>
<tr>
<td>Washington</td>
<td>33</td>
<td>12.1%</td>
</tr>
<tr>
<td></td>
<td>200</td>
<td>20.0%</td>
</tr>
<tr>
<td>Canada</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Montreal</td>
<td>1359</td>
<td>2.2%</td>
</tr>
<tr>
<td>Toronto</td>
<td>539</td>
<td>1.5%</td>
</tr>
<tr>
<td>Vancouver</td>
<td>410</td>
<td>1.75%</td>
</tr>
<tr>
<td></td>
<td>400</td>
<td>4.0%</td>
</tr>
</tbody>
</table>
On analyzing Table IV we see that the United States of America has the highest incidence of any country, having 16.1% (Wright et al). As opposed to this Gould states that the hog incidence in the U. S. A. is between one and two percent, giving a ratio of about one trichinosed hog to ten trichinosed humans. Germany, on the other hand, has a human incidence of roughly 1.5% (Gould) and a hog incidence of 0.00044% (Todd 1948) or a ratio of one hog to three thousand persons infected. From these figures we conclude that careful hog control as practiced in Germany, sponsors a much lower human incidence than does a system of poor hog control as practiced in the U. S. A. The above figures also demonstrate that food habits conducive to Trichina infection can so enlarge the ratio of hog infection to human infection as to still leave a noteworthy human incidence.

The Canadian picture, as based on examination of two thousand, nine hundred ninety-five hogs and one thousand, five hundred fifty-nine humans, shows a 0.57% hog infection opposed to a 2.2% human infection, or a ratio of one trichinosed hog to 3.8 infected humans. This low ratio would indicate that human trichinosis in Canada is largely a result of poor hog control, and not of cooking habits. From Table IV it is seen that while the 4% human incidence in Vancouver is considerably below that of the United States, it is well above that found in Eastern Canada. The present
survey is not strictly comparable to that made by Cameron in Montreal, since children under the age of one year were excluded from the latter. However even if compensation is made for this discrepancy, the local incidence remains over double that found in Montreal.

Possible explanation of local incidence

The fact that human incidence in the Vancouver area is over twice that found in Eastern Canada is explained on two major bases.

First of all, present data indicates that the incidence in hogs in this area is considerably higher than that present in Eastern hogs. Cameron (1940) has shown an incidence of 0.57\% in two thousand, nine hundred ninety-five hogs (mixed grain and garbage feeders) of which nine hundred ninety-five known garbage feeders showed an incidence of 0.2\%. Moynihan, on the other hand, demonstrated that 2.2\% of six hundred ninety-one mixed British Columbia hogs were infected, while 4.0\% of the three hundred seventy-four garbage feeders included in the above six hundred ninety-one, were positive. The trichinosed hogs found by Moynihan were all raised at piggeries managed by Orientals on Lulu Island, near Vancouver. The reader is asked to bear in mind the fact that Moynihan's results do not represent an incidence in hogs marketed in British Columbia, but only those raised and marketed here. The author has been unable to obtain a statement of the ratio of Prairie raised hogs
to British Columbia raised hogs which are marketed in British Columbia. However Moynihan's survey does lend itself to the supposition that the incidence in total marketed pork in British Columbia is somewhat higher than that in Eastern Canada.

The relatively high incidence in locally raised hogs is likely due to careless feeding by the farmers, but may also be attributable to hog infection from rats. Thus far Moynihan has examined the entire diaphragms of five hundred ninety rats by compression only. Of this number ninety-five or 16.1% were trichinosed, 87.3% of the positives being rats from around piggeries, and the remaining 12.7% from around garbage dumps. This incidence in rats is not unusual and it is doubtful if such a condition is responsible for the high incidence in hogs, although some hogs probably do become infected by eating these rats.

The second basis of explanation for the high human incidence in this area is found in considering the high traffic to the United States. People in Eastern Canadian cities are likely to make their week-end excursions in an Eastern-Western plane, confining themselves to other Canadian cities. Locally however, Vancouver is the sole large Canadian city on the mainland, and week-end travel by motor car is largely directed South across the International border. The 20% human incidence in the State of Washington (Ref. Table IV) would indicate a fairly high hog incidence. Then considering that it takes only one meal of trichinous
pork to cause infection, it seems very likely that con-
siderable of the local incidence may be attributed to in-
fection contracted across the border.

At the time when this survey was being organized, the
author noted that nearly every medical man contacted ex-
pressed the opinion that no trichinosis problem existed in
the Vancouver area. This survey however shows not only
that local human beings are trichinosed, but also that the
incidence and in some cases the intensity is sufficiently
high to be considered a serious medical problem. It must
be born in mind that the mere presence of Trichinosis
represents potential epidemics and possible fatal infections.

The author believes that if hog infections, which are
apparently quite localized, were adequately controlled, and
if the public was informed of the trichinosis situation in
the United States and discouraged from eating pork in that
country, that human trichinosis could be virtually wiped
out in this area.
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Studies on Trichinosis. XV. Summary of the Findings of Trichinella spiralis in a Random Sampling and Other Samplings of the Population of the United States. 
Fig. 1 Compressor used during the early part of the survey with broken top plate.

Fig. 2 Compressor used during the latter part of the survey disassembled.
Fig. 3  Brass framed compressor partially assembled.

Fig. 4  Brass framed compressor assembled.
Fig. 5  Trichina larvae in rat muscle prior to encapsulation X80

Fig. 6  Trichina cyst in human muscle showing polar fat bodies X80
Fig. 7  Calcified cyst in human muscle cracked by compression X80

Fig. 8  Human muscle containing spindle shaped cyst. Both larva and cyst calcified X80
Fig. 9  Heavily calcified larva in uncalcified cyst. Note double wall of the cyst X80

Fig. 10  Human muscle containing heavily calcified cyst with larva fragmented and calcified X80
Fig. 11  Uncalcified cyst containing broken and calcified larva X80

Fig. 12  Dead and calcified larva with cyst wall practically absent, in human muscle X80
Fig. 13  Calcified cyst with larva absent X80