OBSERVATIONS ON THE

SIGNS AND SYMPTOMS

OF

ASCARIASIS

as seen in Tropical Practice.

by

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1919
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Literature.
INTRODUCTION

The purport of the following thesis is to recount the experiences of an investigator into the effects produced on the human body by the Ascaris Lumbricoides, or Common Round Worm.

While at Paddington Green Children's Hospital, London, as house-physician, the Author was impressed by the number of children presenting symptoms associated with an Ascaris infection, and later, while at Singapore, he was able to carry out investigations which shew that Ascaris Lumbricoides produce serious pathological states in at least one per cent of all those infected.

The importance of this discovery is manifest. It is the common belief of practitioners in England (a belief shared by the authors of medical text-books) that round worms do little harm to the host who harbours them, that they are no doubt very unpleasant, but that certainly they do not produce his death. Such a belief is entirely erroneous; each round worm is a danger to its unfortunate host. True, the chances are ninety-nine to one against their doing any damage to him, yet in the hundredth case the damage may be fatal.

Chinamen, Malays, Tamils and British have come under his observation both during their life and in death; several hundred post-mortem examinations have been con-
ducted, and many other investigations have been carried out in order to obtain original observations on this much belittled intestinal parasite.

Before this thesis was written up, the needs of the Army demanded the presence of the author in a theatre of war; the thesis was laid aside until the advent of better days and it was not possible to complete it until this year. Original photographs have faded with the lapse of time. The dates referred to are not now so recent as the presenter would have wished. It is a record, however, of original observation, and is thought to retain its value.
General Appearances and Characteristics.

It need scarcely be said that individual round worms from the intestine vary considerably in size, from the small two-inch fledgling to the fully-grown worm seven or eight inches long. The Author measured a large number of round worms from different cadavera, and found that the average length was about five inches, and the breadth four mm. The longest worm measured was ten and a half inches in repose; the smallest an inch or under. Breadth of course varies with the length, but five mm. may be regarded as average to a worm of six inches long. Like the ordinary earth worm the Ascaris can elongate itself, thereby increasing its length and proportionately reducing its breadth; it can also reduce its length by contraction at the expense of an increase in breadth.

The colour of the Ascaris Lumbricoides is a creamy white, with a pinkish tinge throughout. The shape is tapering at each end, and the outer surface is transversely striated. Each worm has a mouth at one extremity, surrounded by three tubercles or lips provided with fine teeth, and the mouth communicates with an intestine running the whole length of the animal.

The male is smaller than the female and not so common. Its posterior extremity is bent hook-like; the female's is straight. The former has a testicular tube about the middle of its body; the latter has ovaries which commence about the junction of the anterior and (middle
middle third of the body.

Each mature female worm lays a very large number of eggs. These ova are passed in the faeces of the host literally by the thousand, and one observer records that each mature female worm is capable of forming five million eggs annually. The Author has never failed to find in the faeces of a known infected person ova from the Ascarides in his intestine. These eggs can be easily seen under the microscope; they are oval in shape and vary very little in size, which is from fifty to seventy micrones in length and forty to fifty micrones in breadth. Each ovum has a rough, knobbed, mammilated or tuberculated outer albuminous covering, which stains a yellowish brown with the bile of the faeces. The inner layer of the shell is transparent, colourless, and rather thick, with a multiple outline. The centre of the ovum is granular or homogeneous.

While the geographical distribution of Ascaris Lumbricoides is practically universal, the Author has observed that British patients seldom harbour more than a few round worms—the native of a tropical country harbours a great many more. In the former instance he has never seen an English subject infested with more than a dozen; in the latter instance he has counted as many as seventy-two in a Chinese corpse, and other writers have counted many more than this.

It is said that the warmth of a tropical climate favours the growth of intestinal parasites and accounts (for
for this difference, but British children in Singapore were not found to harbour any larger number of worms than did the children of Paddington, London. The habits of the native races present a more likely explanation of this variance; the British victim endeavours to get rid of his troublesome guest just as soon as he is aware of its presence; the uneducated native does not—and the worms multiply.

Infection is thought to be to the direct ingestion of the ovum—no intermediate host being necessary. The albuminous shell is dissolved in the stomach, the contained embryo is set free, and in a month the animal is mature. Investigators have infected themselves by swallowing the ova. Eppstein, experimenting on three children, shewed that direct infection with embryo containing eggs is beyond doubt.

Ova survive dessication or cold for a long time, and it can readily be seen how easy is the spread of infection. A British mother brought her child to see the Author on one occasion because she had vomited a worm; a microscopic examination of the stools of the remainder of her family shewed negative results, but within a month three children out of four were passing ova in their stools, and the conclusion that infection was introduced into the household by one member and passed on to the others seems justifiable. In a tropical island like Singapore infected vegetables must be a frequent source of infection; the Chinaman—one of the best vegetable gardeners in the
world—manures his garden with human faeces, and the ova of Ascarides is thus quickly disseminated on the leaves of his produce.

Again, the Chinese pigsty, which is so often an integral part of the Chinese dwelling-house, may spread the infection by polluting the domestic water supply, for pigs are infested with this worm. The writer visited a pigsty owned by a Chinaman in which, for over a century, the family had lived in the right half of the building, the pigs in the left, and the household well was within a few feet of the house, and almost flush with the surface of the ground; the water of the well was grossly polluted, and the only member of the family tested was carrying four different varieties of intestinal parasite, one of which was the Ascaris Lumbricoides.

Another suspected source of infection is the hard sandy floorings of many of the native houses; the children play about on the floor and swallow much sand and grit; the ova of Ascaris will live for long periods in warm, dry sand.

Lastly, the ova may be blown about as dust from fields manured with infected faeces (human or animal) and contaminate foodstuffs.

Ascarides are most commonly found in the small intestine of the human being—usually the Jejunum. On opening the Jejunum they may be seen lying about quite unattached to the intestinal wall. The Author noted that they seldom shewed signs of life until touched or moved. (Usually
Usually they lie singly, but occasionally they may be seen to have intertwined with each other to form a solid mass; but the writer considers this mass formation rare because, out of many hundred infected cadavers, he only observed it on two occasions.

Round worms presumably find in the Jejunum conditions highly conducive to their personal well-being and the propagation of their species, but occasionally they wander away from there in ones and twos to quite remote parts of the body.

Like their near neighbours the common Earthworm, they dearly love to put their heads through small openings and wriggle their bodies through. The following little experiment is illustrative; the writer placed six round worms from a dead body into a box divided into two compartments by a perforated shutter, and two out of the six had passed through the small perforations within twelve hours of being placed in the box. This characteristic has been exploited by physicians who forced their infected patients to swallow a perforated button in the hope that the button would emerge with a round worm sticking out of each hole. The duodenal orifice of the bile duct, the pyloric opening of the stomach, and the orifice of the appendix present similar narrow openings, and in order to account for the migration of the worm through these channels the Author submits this explanation as the most likely one.
Frequency of Infection.

During a period of one year as house-physician in the Edinburgh Royal Infirmary, the Author had charge of two adult wards and frequent out-patient experience, but he cannot recollect seeing there a single instance of Ascariasis. Paddington Green Children's Hospital, London, presented a different picture during his six months' residence there, and never lacked examples of Ascariasis amongst its young inmates.

It was not until the Author was stationed at Singapore that he was able to obtain some idea of the frequency of infection. His observations were carried out among the British as well as the native population, and may be summarised as follows:—British adults seldom if ever harbour round worms (like R.I.E.); British children are very frequently infected (like P.G.C.H., London); natives of all classes, both adults and children, are freely infested.

The British patients observed were drawn from the soldier garrison and their families on the islands of Blakan Mati and Pulo Brani. These islands are about three miles distant from the large island of Singapore. With the exception of native servants, the population of Blakan Mati was entirely British, about 500 adults and twenty-six children.

During the writer's two years' residence on these islands, not a single case occurred among the adults. In
order to make more certain that none harboured parasites unawares, microscopic examinations of the stools of forty soldiers, (patients in the little hospital on Blakan Mati), were carried out and did not reveal a single ovoid of Ascaris or of any other type of intestinal parasite.

In his first month in Blakan Mati three children were brought for examination and found by him to be suffering from Ascarasis. This led the Author to examine the faeces of all the children on Blakan Mati, irrespective of complaint, and it was found that out of twenty-six children between the ages of two and fourteen years thirteen had ova of Ascaris in their stools. Of these thirteen six had never complained of discomfort, and their parents were quite unaware of the existence of anything unusual. Four had been treated for worms at dates varying from one to three years before, and had been pronounced cured, but now all were infected. These figures give a proportion of 50%. All the children had lived in foreign parts the greater period of their lives (in Tientsin, Hong Kong and lastly Singapore) so that they had been infected in the East.

Goodhart and Still, in their book on children's diseases, consider from evidence obtained at Great Ormond Street Children's Hospital that the commonest type of intestinal parasite found in children in England is the Oxyuris Vermicularis; this was not the writer's experience in Singapore, and in the examinations recounted above the

(Ascaris
Ascaris Lumbricoides was the only intestinal parasite present.

Before leaving the subject of the Blakan Mati experiences it is worth mentioning the mode of infection of these children; the drinking water of the island was collected in large catchment area and distributed direct to the houses by pipes—it was tested monthly and was beyond suspicion of contamination; there were no fields in the island from which ova could be blown on to uncooked foods; dogs and chickens were the only animals allowed in barracks, and no pigsty existed on the island. The Chinese servants seemed a likely cause of transmission of the disease, and the Chinese cooks of seven different households were tested—two were found to be positive.

The native population of Singapore is cosmopolitan. The Chinaman lives in very poor surroundings and is treated at the Government Hospital when he is ill (if he does not prefer to seek a native doctor's advice). Many Chinese coolies came under the Author's professional care, but he was rarely (if ever) consulted by one of them for intestinal parasites. The Author carried out a large number of post-mortem examinations at the mortuary of the Government Hospital on the bodies of patients who died from a large variety of diseases. In four years 6748 post-mortems were conducted at the mortuary, and the Ascaris was noted as present in the cadavers of 706, a percentage of about 10.
This percentage is a low one as compared with the figures produced by other investigators; the Franco-Liberia Boundary Commission (1914-16) found a percentage of 37; Marshall Ledger, in Cayenne, a percentage of 38; Bowman and Saylor’s results amongst Northern Chinese labourers was 88%. This difference is probably due to local conditions—Comme, for instance, found that the natives of Upper Senegal were very commonly infected with intestinal helminthes, and obtained from the waters of the Nile—which was their drinking supply—the eggs of tricocephalus, Ascaris, and ankylostomes, and he further noted that Ascaris eggs occurred in the waters in greatest abundance during the winter months.

Singapore has no seasonal variation, and its water supply is pure and above suspicion, so therefore its lower incidence may thus be accounted for; it has, however, a bad disposal system, for the faeces of the inhabitants are carried away in carts and buckets to the surrounding country.

It will be seen from the foregoing record how common in the tropics is the infection by Ascaris Lumbricoides; commoner, the writer feels certain, than that existing in the British Isles; but although the frequency of infection is perhaps greater in the Far East than at home, the effects produced by Round Worms on their hosts are as serious in Great Britain as in any part of Asia.
Signs and Symptoms.

It is an inexplicable fact that Round Worms may be harboured by some people without causing any ill effects, whereas in others they produce an extraordinary assortment of signs and symptoms.

The Writer proposes to describe cases as presented to him, without attempting to describe all the diseases which have been attributed to Ascariasis.

It is convenient to discuss the signs and symptoms associated with round worm infection under the following sub-headings, but it must be remembered that two, three or all of the sub-heads may be presented in one patient.

a) Those referable to a Toxin.
b) Those produced reflexly.
c) Those caused by the migration of the worm.
d) Those produced mechanically.

Signs and Symptoms referable to a Toxin.

There has been considerable controversy over the question of the toxicity of this parasite.

The worm cannot be an entirely passive resident in the intestine, as it is able to produce an alteration in the blood constituents, viz. eosinophilia. It must act in some way on the bone marrow of its host to provoke the eosinophilia. The toxic theorists declare that the eosinophile cells
are thrown into the blood stream to antagonise the toxin, much as polymorphonuclears antagonise bacilli.

M. Weinberg and M. Julien have carried out researches on the Ascarides of the horse. By a special technique they recovered "the peri-enteric liquid of Ascaris Megalocephala in a state of purity and sterility, and they found that the instillation of some drops of this liquid into the eye of the horse produced often at the end of a few minutes an intense congestion of the eye and considerable tumefaction of the eyelids. Sometimes reaction was more general and the horse suffered from dysphoea, profuse sweat, and even sometimes the symptoms of severe diarrhoea". But the Ascaris Megalocephala is not the Ascaris Lumbricoides.

Shima Mura and Fujii sought to isolate the toxin from the Ascaris Lumbricoides, and produced a substance which they called "Askaron", a mixture of albumoses and peptones, but it is very doubtful if it is really the specific toxin.

The clinical aspect of certain cases of Ascariasis (quite apart from those attempts to isolate a toxin) leaves no doubt in the Author's mind that sometimes these worms are associated in the human subject with an intoxication process.

**Blood Changes.**

Perhaps the earliest and the most constant sign of the absorption of the toxin from the bowel is the eosin-
philia in the blood. It is present in cases which do not shew any other toxic manifestation—where immunity is well nigh perfect—and it is also present when immunity fails and the patient is suffering from fever and the other signs of acute Ascariasis. Whether an artificial eosinophilia has ever been produced by the injection of Weinberg's peri-enteric liquid or Shima Mura's Askaron, the Author is unable to trace.

Normally about one to three per cent of the total number of leucocytes, the eosinophiles are increased to six, eight, or ten per cent in this form of parasitic infection. The following blood count was taken by the writer from a boy aged two years, known to be suffering from a pure infection of Round Worms, and is regarded as an average case:

<table>
<thead>
<tr>
<th>Total number of Leucocytes 12,000 per cm.</th>
<th>Polymorphs</th>
<th>Lymphocytes</th>
<th>Eosinophilia</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Small</td>
<td>Large</td>
<td></td>
</tr>
<tr>
<td></td>
<td>42%</td>
<td>35%</td>
<td>17%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>6%</td>
</tr>
</tbody>
</table>

**NOTE.**—The blood examination was made about an hour after a meal, and the age of the patient accounts for the post digestive leucocytosis being lymphatic.

Eosinophilia may be used as a means of diagnosis, as it is such a constant feature. The Author found, however, that in young children under six years of age the eosinophilia was smaller than in children of ten years and upwards. In the former case four per cent was the usual
The number of worms borne by the patient does not seem to exert any influence on the eosinophile changes in the blood. Two cases examined by the Author may be cited as examples:— (i) Molly Rollinson, aged 10, passed (after Santonin treatment) ten worms, and her excreta was full of ova, yet the differential count shewed only six per cent of eosinophiles. (ii) William Cleaves, aged 10½ yrs, passed a few ova and but one worm in his faeces, and possessed an eosinophilia of 7%.

The maximum eosinophilia count obtained by the Author was 8.2%, but Sinton and Baily record cases of 20% and over. It may be mentioned that other varieties of intestinal parasite, notably the ankylostoma duodenale and the trichuris trichura, also produce an eosinophilia in their host. It is essential, in making the eosinophile count, to make certain that the Ascaris is the sole infecting agent. The writer was perhaps fortunate in his survey of the soldiers' children on Blakan Mati (mentioned on page 8) in that the Ascaris was the only intestinal parasite harboured.

The blood changes recorded above are present in almost every infected case, but the febrile state now to be described is not.

FEVER

Many tropical physicians of experience are well aware of a mild feverish condition which is often found
amongst children of the native races, associated with lumbricoid worms; but very little about it is really known. Col. Hehir wrote to the Indian Medical Gazette in 1910 drawing attention to its occurrence, and asking for the opinions of others, and several observers wrote confirmatory letters.

The following case, the first of its kind seen by the Author, is a good example, and he has seen several since:--

"Jack Adams, aet 4 yrs., had a mild attack of abdominal pain, vomiting and diarrhoea. The pain was diffusely spread over the abdomen, and colicky in nature. Temp. 101°F., Pulse 84 per min., Respirations 22 per min. The abdomen was generally tender, but all the organs were of normal size and healthy. The stools contained mucous but no blood, three or four motions being passed in the day. A portion of stool was plated out on McConkey's plates and tested by the sugars for any of the bacilli of Dysentery with negative results. On examining microscopically for the Amoeba of Dysentery none were found, but large numbers of ova of Ascaris were apparent. The boy was placed on anthelmintic treatment, and his condition completely cleared up after passing half a dozen Round Worms. Malaria was most unlikely, and his blood was negative; he harboured no other type of intestinal parasite."
If the fever is not attributable in cases such as this to the Round Worm, it is difficult to see what else could be the cause. Malaria and Enteric conditions are carefully excluded; anthelmintic treatment is adopted, the worms expelled and the fever ceases.

Another type of case which may be seen has no fever, a profound nervous prostration being the outstanding feature. The child may lie for hours apathetic, with a tender humid abdomen which she will not allow anyone to touch. Round Worms are suspected, anthelmintics administered, the worms expelled and immediate recovery ensues.

If the worm secretes a toxin, then one must consider that the human host can immunise itself against its effects; otherwise why do so few subjects suffer from these intoxication symptoms. Immunity to parasitic disease, however, is surely unknown.

The Ascaris is provided with fine teeth with which it may possibly erode the intestinal mucous membrane, and permit of the absorption of toxins from the bowel; perhaps this is the true explanation of these feverish states.

Be the method of production what it may, the Author is convinced that the Ascaris is responsible for both the pyrexial condition and the general intoxication.

It must be mentioned that these two types may be combined in the same case and a very perplexing clinical picture presented. It is so like Typhoid Fever that Chauvard, Marie and Tauchon name this aspect of Ascariasis "Typho-

(lumbricosis)
"Typho-lumbricosis." Barsi called it "Febris typhoides helminthiatica." It is a very rare condition, but extremely difficult to diagnose. The writer saw such a case in Greece, in which a woman presented typical signs of enteric, but unexpectedly, after a good deal of abdominal pain, passed a dozen of living Round Worms. She then felt better. A hurried examination of her faeces proved her to be still carrying Ascarides, and for this she was promptly treated, with the result that her temperature fell at once a couple of degrees, and gradually fell to normal by the end of the week. She had quite recovered her spirits and her health two days after the last worms had been expelled. A Widal reaction test was carried out, however, as her temperature was falling, and found to be positive, so her case had to be regarded as a combination of the toxic signs of Ascariasis and true typhoid. Unfortunately a blood culture was not made, but the change in her condition after the worms had been removed was very marked, and the typhoid, considering she had not had prophylactic inoculation ran an extraordinarily mild course.

Col. Hehir, I.M.S., believes that the fever of Ascariasis, if untreated, runs a course similar to what used to be called "simple continued fever" and returns at irregular intervals of five to six weeks, each bout lasting five or six days. The Author cannot, however, from experience, criticise this statement.
A great many clinical phenomena have been credited to the toxic characters of Ascaris Lumbricoides, but these the Author has not seen and is not prepared to accept or refute. To shew the diversity of these a few may be mentioned:--"Pain in one or both knee joints combined with swelling;"--"Meningism;"--"Toxic amaurosis;"--"Hemiplegic states;"--etc.

Reflex phenomena dependent on Ascarides.

There are certain signs produced by other forms of intestinal irritation which may be seen in Round Worm infections. A condition of the tongue is typical, and when seen is almost diagnostic. Various nervous manifestations, some small in significance, others great, are present in many of the cases in children, and sometimes in adults. They also cease when the worms are expelled from the intestine, and in order to account for them it is said that they are reflex in origin.

Anorexia and thirst are said to be common. It was not frequently complained of in the cases which came under the Author's observation. The children affected on the island of Blakan Mati (described on page 8), although especially interrogated on the subject, replied in the negative. Two native children once complained of it, but the Writer considers that these two subjective phenomena are not nearly so common as is sometimes stated.

There is a condition of the tongue which frequently accompanies conditions of gastro-intestinal irritation
in the tropics. It is very similar to the strawberry tongue of scarlet fever. "The dorsum is moderately coated and pale, while large bright pink papillae stand out in sharp contrast; the tip is red and moist." This condition of the tongue is widespread in India during the summer months when diarrhoea and other gastro-intestinal disorders are prevalent. Doctor Ethel Landon lays great stress on this tongue condition, which she says is her index as to the necessity for anthelmintic treatment. The Author has observed the condition in many of the native children, but seldom if ever in the British.

Headaches are frequent among those who suffer from Ascariasis. The last two cases seen among soldiers complained of severe frontal headache.

Convulsions in younger children are sometimes associated with a worm infection. Gastro-intestinal irritation is a common cause of convulsions in the tropics, but it was seldom that the Author found in these cases the Ascaris as the sole cause. Popular belief attributes to worms almost every case of convulsions, but while this may be true in a few cases, there are usually the signs of rickets or other digestive disorders to account for them.

Picking of the nose, grinding of the teeth, restlessness and irritability are irritative phenomena frequently observed in children. Adults seldom show them
except an irritability of temper which may or may not be laid at the Round Worm's door.

There are many cases on record of extraordinary nervous developments coinciding with the presence of Round Worms in the intestine. Sigaud recorded the case of a child aet. 6 yrs who, "whilst eating his supper suddenly became unconscious; the right arm and leg were paralysed, and when consciousness returned and the administration of Santonin had resulted in the passage of twenty Round Worms, the paralysis and the impairment of speech that accompanied it passed off in a few days." Magi records the case of a little girl in whom sharp clonic contractions of the right facial muscles, right arm and forearm occurred. These are but samples from the literature on the subject to shew the extraordinary variety of symptoms which may be produced. Death from fright has actually occurred as a result of a worm appearing in a patient's mouth.

(c) Signs and symptoms depending on Migration.

The Author's experience in the pathological side of tropical medicine was responsible for the interest he has taken in this variety of intestinal parasite. It was at post-mortem work that he began to appreciate the danger of harbouring Ascaris Lumbricoides, for he found in several cases that death had been directly caused by the migration of the worm. This section therefore is dealt with at considerable length in order that his original observations should be brought forward in detail.
Why does the Ascaris leave the Jejunum to set out on pilgrimages to unknown regions of the body? Our knowledge of the Round Worm's habits and movements within the human body is very scanty.

We do know that sometimes they leave the human body during feverish conditions of their host, and sometimes they escape prior to his death; one might then surmise that some intolerable situation had been created in the intestine (of which the worms were aware) which made future life there impossible, and that this migration was merely an endeavour to escape from an awkward situation; but this does not explain why two or three worms will migrate through the bile ducts into the lobes of the liver, leaving behind them in the small intestines three or four dozen of their species leading, apparently, their usual comfortable existence. One cannot credit those which migrate with a greater sagacity than their neighbours.

The occurrence of disease in the walls of the small intestine might be thought to provide a sufficient reason for the parasite to leave its home, but this is not apparently so. The Author has repeatedly found Ascarides in large numbers leading their parasitic existence in the intestine in spite of advanced typhoid, tuberculous (and dysenteric
and dysenteric ulceration of the adjacent intestinal wall; and conversely he has observed migration of the worm to occur when little or no pathological change was apparent in the intestinal mucous membrane.

It may be said that the curious tendency exhibited by Round Worms (as mentioned on page 7 of this thesis) to insert themselves through narrow openings may be alone responsible for their wanderings, and so, finding themselves in unusual surroundings, it may be that they blindly follow on.

Migration of the worm from the intestine is much more common than is generally supposed. It is not easy to collect figures to show adequately the frequency of migration among those infected. Worms which wander into the stomach and are ejected by vomiting may cause little harm, and those which wander down into the rectum are normally passed in the faeces. These two routes are undoubtedly the commonest, but are entirely missed in post-mortem work, as no pathological changes are produced.

The Author found in Singapore that out of about one thousand infected cadavers, ante-mortem migration had occurred in eleven cases, and very serious pathological effects had been produced in each instance. This constitutes a proportion of 1.1 per cent.

It is necessary to distinguish ante- from post-mortem migration. The writer has observed Round Worms emerging from the mouth of a dead body as it lay on the post-
mortem table, and on another occasion saw a living worm between the buttocks, having just escaped from the anus. In the same way they wander after death of their host by internal paths to certain organs within the body, encountering no resistance save the anatomical obstructions of the part. He has found a living Ascaris in one of the smaller branches of the bronchial tree, but no pathological change in the lung tissues was discoverable. This is the mode of distinction that ante-mortem migration causes serious pathological change, while post-mortem migration causes none.

The eleven Singapore cases were divided as follows:—7 to the liver, 3 to the peritoneal cavity, 1 to the lung.

In four of these cases the pathological lesions resulting from the migration produced the death of the patient; in six of them the lesions were of such severity that even had the associated condition from which they died been recovered from, their ultimate recovery had been rendered impossible; in the remaining case the associated condition was altogether predominant.

The literature on the subject of migration of the Ascaris Lumbricoides, which is very scanty, records isolated examples of migration to most unexpected places; these cannot but be regarded as forming some of the curiosities
Curiosities of Medicine. Middle-ear disease resulting from migration up the Eustachian tube may be cited as a type. They are so rare as to require here only a passing notice.

The relationship between the number of worms which migrate and the number in the gut do not appear constant. The Author's experience is that the majority remain in the small intestine and only a few wander away—for example, in one case 46 Round Worms were found in the gut and two in the bile ducts; in another 6 were present in the intestine and 1 in the peritoneal cavity. This is not always so; however, for in one case twelve worms were found in the peritoneal cavity and only three in the gut. Sometimes worms migrate in different directions in the same subject; thus, in one case recounted above an Ascaris was found free in the peritoneal cavity and two were found in the bile ducts, while over forty occupied the small intestine.

The general pathological effects of migration naturally vary according to the part invaded by the worm, and to the degree of interference with the natural functions of the part..

Migration to the Stomach.

The stomach is probably the commonest site of migration, but it is seldom that serious harm results.

The Author believes that Ascarides are not as a rule
retained in the stomach for any great length of time, owing to the reflex act of vomiting. He has seen only two post-mortem examples of worms lying in the stomach, and these had probably migrated there after the death of the host.

Children are usually seized suddenly and without previous gastric disturbance with a desire to vomit, and the Round Worm is voided. It is not always so, however, and considerable abdominal discomfort may precede the vomiting. The following case is cited as an example of this:

"Evelyn Adams, aet. 8 yrs., a nervous, irritable child, but otherwise in apparently good health, was seized three hours after a meal with vomiting and severe pain in the upper region of the abdomen. The left hypochondriac and epigastric region were semi-rigid and markedly tender. The temperature was normal and the pulse 102 per minute. The pain and vomiting continued for about an hour and ceased on the expulsion by the mouth of an Ascaris (six inches long). Microscopic examination of the stools shewed a marked Round Worm infection."

Of an even more severe and prolonged gastric type are some of the cases recounted in Round Worm literature— even gastric ulcer has been simulated. The only explanation
tion for such cases of prolonged indigestion is that the Round Worm can and does -- though rarely -- live in the cardiac end of the stomach for long periods. It is remarkable that they are not dissolved by the gastric juice, as would undoubtedly be the fate of dead worms. The living Ascaris is said to give off oxygen and so neutralise the solvent. "It is wise in the tropics to remember Ascariasis as a possible source of confusion in the diagnosis of gastric ulcer and other digestion troubles". (Manson).

Some patients do not vomit in spite of an Ascaris in their stomach. The writer has seen worms said to have been withdrawn from the mouth or nose, the patient stating that until he felt a tickling in the throat he had felt perfectly fit and well.

There seems no reason to suppose that permanent injury to the gastric mucosa can be caused by Round Worms. The child vomits them, is soon better, and does not complain of any after effects.

Migrations to the Liver.

The Ascaris is able to enter the duodenal orifice of the Bile Duct, and move up the Bile channels to the smaller radicals within the liver.

It seems astonishing that a worm 5 m.m. in diameter can pass through so narrow an opening, and one so difficult to dilate. The Author believes that the Ascaris has to elongate itself to a very thin diameter before the passage
can be accomplished, and may have to use some force in effecting an entry. Mertens has described a dead worm found in the faeces of a jaundice case, which showed about its middle a constriction mark, — presumably death had overtaken it while half in and half out of the Bile Duct, the mark being caused by the tight Duodenal Orifice.

Mertens himself has suggested that the Common Bile Duct must first be dilated by the previous passage of gallstones but in the cases about to be described no evidence of gallstone formation could be detected at the post-mortem examination.

The chief difficulty must be that of entry, for having gained the lower channels, the upper automatically dilate from the obstruction to the flow of bile.

The Author has encountered the Ascariis in almost all branches of the Bile Ducts. Large ones may pass no further than the hepatic ducts, while small thin ones reach far into the liver substance. A worm's ultimate position must depend on its own diameter and on the calibre of the duct which contains it.

There are two distinct varieties of pathological change initiated in the bile passages by a migrating worm.

1) Obstruction to the flow of bile.
2) Inflammatory Changes.

1) The Bile channels are a blind alley, with an entrance but no exit, and the alley becomes narrower the further the worm progresses. The entrance to the alley is so narrow that one would expect its complete occlusion as the worm passes through.
passes through. When it reaches the wider dimensions of the Common Bile Duct complete occlusion would not be so likely, and when it reaches the smaller biliary channels it would tightly cork the duct and totally prevent the outflow of bile from that part of the liver which the duct drains.

Jaundice and pale stools should therefore occur at some stage of the clinical case, but such was not the Author's experience. In only one case was there a faint icteric tinge and in no case was there a noticeable change of colour in the faeces. One might explain the absence of the symptoms of biliary obstruction by saying the obstruction was never complete - or if complete (as when the worm is passing through the duodenal opening) it rapidly becomes incomplete either by the dilatation of the duct wall or by the worm itself moving higher up the bile channel; (a worm in the right hepatic duct would not interfere with the flow of bile from the left.)

The duct wall dilates partly from the increased pressure of bile within, and partly from weakness caused by inflammation. The worm carries along from the intestine pyogenic organisms which it distributes along its track and which find in stagnating bile a medium suitable for their growth.

2) Secondary inflammatory changes occur very soon therefore after the worm has entered the biliary channels, too soon probably for infection to have occurred through the bloodstream.

At first the walls of the ducts become inflamed (catarrhal cholangitis) but suppuration rapidly ensues, the weakened
walls become more dilated, ulcerated and thickened, and the septic process rapidly spreads along the ducts to its subdivisions within the liver, giving rise to a diffuse suppurative condition of the bile passages (suppurative cholangitis) and the formation of little collections of pus in the biliary channels (biliary abscesses). The condition is very rapid, and the death of the unfortunate host occurs within a short time. In the Author's experience the infective process rapidly outstrips the effects of obstruction, and he doubts if biliary cirrhosis ever has time to occur in cases of obstruction of the bile duct by Round Worms.

The following short account of a case shows clearly these pathological changes:

"Ho Soon Ku, aged 26 yrs., a Chinese coolie, was diagnosed dysentery probably of mixed type, as the Amoeba was found in the stools and the clinical features of the case resembled the bacillary variety. The liver was enlarged--its lower border being one finger's breadth below the costal margin--and liver abscess was suspected."

"The patient committed suicide by hanging himself from the roof by a rope round his neck."

"Post-mortem Appearance."

"Acute bacillary ulcers and a few Amoebic ulcers of dysentery were scattered throughout the large intestine, the coats of which were thickened and markedly congested."

"In the liver two macerated Round Worms were
were discovered in the right hepatic duct, extending into the right lobe of the liver. A diffuse suppurative condition of all the bile passages has occurred; the ducts and their extensions in the liver were dilated, their walls thickened and ulcerated, and they contained pus mixed with bile. Pus had collected to form many small but distinct biliary abscesses in the liver radicles beyond the site of the obstruction (corresponding with dilated suppurating ducts). The gall bladder and ducts were not distended, but showed signs of Catarrhal Cholecystitis. The prevertebral abdominal glands were enlarged. Forty six Round Worms were found in the intestine.

All the organs were congested—the left side of the heart was contracted and empty; death was primarily due to suffocation.

Extension to the Gall Bladder.

Dilatation of the Cystic Duct and Gall Bladder not uncommonly follows obstruction in the common bile duct, and allows of the passage of the worm to the gall bladder. Normally the cystic duct admits a No. 5 catheter, but its mucous membrane is thrown into folds forming a spiral arrangement in such a way as to render the passage of a probe along it a difficult if not impossible procedure.
procedure. It is therefore obvious that previous dilatation of this duct is essential before migration of the worm along it can ensue.

A sufficient dilatation of both cystic duct and gall bladder may result from the passage of a gallstone, but in such cases one would naturally expect that the age and sex of the patient, the medical history and the pathological appearance would afford some evidence of Cholelithiasis. In the following case no history of gallstone colic was obtained, and no evidence of gallstone formation could be detected at the post-mortem examination of the parts, yet the gall bladder and cystic ducts were widely dilated.

Obstruction of the common bile duct especially at the junction of the cystic and hepatic ducts may give rise to the distension required, the gall bladder filling with mucous and the cystic duct dilating. If now the worm moves higher up the biliary passages the obstruction is relieved and the gall bladder and duct evacuate their contents into the duodenum — but the necessary dilation has been established. There is now no anatomical obstruction to the passage of a second worm to the gall bladder, with its subsequent septic infection.

The following case is cited to shew the steps of
the process, although no parasites were found in the
gall bladder itself.

"Tan Hai Ng, act. 25 yrs., a Chinese coolie, "was admitted to hospital a few hours prior to "his death."

"Fever, with daily rigors and abdominal "pain for the last ten days was all the his-"tory which could be elicited from his friends; "his temperature on admission was 102°F., pulse "130 per minute; respirations 20 per minute. "His conjunctivae were slightly jaundiced, his "liver and spleen enlarged; his gall bladder "was palpable. Urine contained a trace of al-
"bumen. He was semi-conscious, but soon passed "into complete coma."

"Post-mortem Examination."

"The liver was found to be enlarged. A "depressed cicatrix on its upper surface indi-"cated an old gumma; some fibrous tags bound "the organ to the diaphragm. The bile ducts "were dilated and suppurative throughout the "whole organ, but more marked in the larger "ducts. One living worm was found in the right "branch of the hepatic duct and in the common "bile duct; the duodenal opening of the latter "was normal in size, and no obstruction could "be detected. The cystic duct was much dilated, "its walls thickened and suppurating. The gall
"bladder was extremely dilated, its walls thickened, suppurative, and bound by adhesions to the abdominal wall and the small gut. The spleen was enlarged, its capsule thickened and tense, and on section its black colour and prominent malpighian bodies indicated an old malarial condition."

"Four Round Worms occupied the small intestine. The lungs were congested and their bases oedematous; the kidneys were congested and the urine contained bile as well as albumen."

**Extension to the Pancreas.**

If the pancreatic duct is obstructed by a worm lying in the common bile duct it also will become dilated by the damming back and subsequent bacterial infection of the secretion; a further extension of the septic process to the sub-divisions of the duct within the pancreas will result in a diffuse suppurative pancreatitis, and little pancreatic abscesses may be found here and there throughout its substance.

In all the cases of migration to the liver seen by the Author, no instance of actual migration to the pancreas had occurred, and beyond a slight catarrh of the duct of Wirsung close to its duodenal orifice in one case, the pancreas and its ducts were healthy.

**Extension to neighbouring parts.**

A septic process in the liver, gall bladder and (pancreas
pancreas may result in a still further extension from these organs to parts in their neighbourhood.

Peritonitis, either local or general, is perhaps the most common; adhesions between the gall bladder and the peritoneum have already been mentioned (on page 34) and may end, when adhesions have formed with the bowel, in complete intestinal obstruction.

Abscesses of the liver may give rise to a sub-diaphragmatic abscess which may penetrate the diaphragm and enter the lung (as in one case mentioned below); or an abscess of the pancreas may result in a peri-renal abscess, or in one which follows the psoas muscle into the iliac region.

In the following case an abscess was established in the right half of the vault of the diaphragm by a biliary abscess on the upper surface of the right lobe of the liver, and it extended through the diaphragm to the lung, pleural cavity and pericardial sac before death ensued. As this case is unique, a full account of the post-mortem changes is recounted.

"Lim Yeo Tee, aet. 6 yrs., male, of Chinese parentage, died 2-3-14; post-mortem 2-2-14. "External appearance extremely emaciated."

"Abdominal and Digestive Organs."

Liver:—both hepatic ducts and the common bile duct each contained a Round worm and three or four smaller worms were seen lying in the
Case V.—D, round worm in branch of bile duct. S, site of subphrenic abscess, having burst in two places through the diaphragm into lower lobe of right lung. N marks the place behind which larger abscess burst into pericardium. R, abscess in liver. Heart shows purulent pericarditis.
"smaller branches of the bile ducts. Both "right and left lobes of the liver were the "seat of a suppurative cholangitis, with one "large and several small bile stained abscesses; "two of these on the upper surface of the right lobe had given rise to a large sub-phrenic abs-
"cess. This had ruptured through the diaphragm in two places, (plate 1), causing two large "abscesses in the lowest lobe of the right "lung. Leading into the main abscess in the "right lobe of the liver was the pointed end "of an Ascaris Lumbricoides."
"Peritoneum:—showed localised peritonitis "where the sub-phrenic abscess was shut off from "the general peritoneal cavity. Otherwise it "was normal."
"Gall bladder:—contained a little bile;"
"Pancreas:—slight catarrh of duct of Wirsung "for about an inch from the duodenal orifice."
"Spleen:—peri-splenic adhesions made its re-
"moval difficult; its cut surface was dark "chocolate in colour, being evidence of old "malarial infection. Sixty Round Worms occu-
"pied the small intestine."
"Respiratory System;"
"Right Lung:—An abscess of the size of a hen's "egg was present in the lowest lobe of the "lung; the walls were soft, yellowish in "
"colour, irregular and suppurating, and another small abscess was separated by a thin partition of lung tissue from the main abscess; each communicated with the sub-phrenic abscess by a separate opening through the diaphragm; the smaller abscess had burst posteriorly into the pleural cavity causing pyo-pneumothorax, and the larger abscess had opened through its apex into the pericardial sac, giving rise to a purulent pericarditis. (Plate 1.)

"Right pleura:--a right-sided pyopneumothorax had occurred, about two ounces of blood-stained pus being present. The point of invasion of the sub-phrenic abscess through the diaphragm to the right lung had been shut off from the pleural cavity by adhesion."

"Left Lung:--was congested and base oedematosus."

"Left Pleura:--shewed a few adhesions at the base."

Circulatory System:--

"Pericardial sac was full of pus. The abscess of the right lung had penetrated the sac by a small perforation on the right side. (Plate 1.) The heart shewed the typical shaggy coat of purulent pericarditis; its muscle was friable but the endocardium was normal."
"Genito-urinary System."
"The kidneys were congested, and the urine contained albumen."

"Nervous System."
"Brain examined and no abnormality found."

"Certified Cause of Death."
"Suppurative Cholangitis due to Ascaris Lumbricoides and in sequence:—
(a) Hepatic Abscess.
(b) Sub-phrenic Abscess.
(c) Abscess of the Lung.
(d) Pyopneumothorax.
(e) Suppurative Pericarditis."

Clinical Features.

It is not proposed to do more than briefly describe the outstanding clinical features in these cases of Round Worm migration to the biliary channels.

One would expect in the early stages that the clinical features would resemble those produced by other foreign bodies in this situation, e.g., a gall stone. This was not the case. Attacks of biliary colic did not occur. The Chinese coolie class, from which the Author drew this experience, do not come under medical observation as a rule until the disease has advanced sufficiently to prohibit work. Each of the cases had continued to work at hard coolie labour until a day or two before
before admission to hospital, yet all were suffering from high fever and other signs of septic poisoning when first seen in the hospital waiting room. A history of biliary colic was not elicited from any one of them, and while under observation in hospital no attack of biliary colic occurred. Other writers have had a different experience. Martens quotes a case in which a diagnosis of Ascarides in the bile ducts was made during the life of the patient because of attacks of biliary colic which ceased after the expulsion of three Round Worms in the stools. The Author believes that the irritation of the mucous membrane of the bile ducts by this form of parasite is not so great as that occasioned by a calculus—possibly because in the one case the duct contracts on a soft resilient structure, in the other case on a hard, firm stone; if attacks of biliary colic do occur they are probably less severe and less typical than the acute crises of gall-stone obstruction.

It is said that sometimes gall-stones may cause no symptoms; it is certain that Round Worms in the biliary channels must cause symptoms always, if only as a result of the inflammatory conditions of the bile passages which automatically follow its migration. The earliest inflammatory change must be a catarrh of the mucous membrane of the ducts followed by a suppurative condition along the biliary channels. There are clinically no sharp lines of demarcation between non-suppurative inflammation of these channels on the one hand and (suppurative.
suppurative cholangitis and biliary abscesses on the other, and the stages were not so distinguished in any of the above cases.

Rigors and remittent fever occurred in all, the fever reaching as high as a hundred and three, or a hundred and four, with a daily variation of two or three degrees.

The liver was enlarged in each case and could be felt below the costal margin and was tender. Some rigidity of the muscles of the upper part of the abdomen was present, but jaundice was not a constant sign and was only observed in one case. The faeces were invariably well stained with bile, which is perhaps surprising, but it must be remembered that a total obstruction of the larger duct by a Round Worm is very rare.

Vomiting and diarrhoea were present, the former a persistent and distressing feature occurring in all the cases.

A high leucocytosis was present in every instance, but the eosinophilia commonly associated with Round Worm infection was apparently lost in the number of polymorphonuclears present.

Albumen was present in very small amount in the urine, and doubtless depended on the febrile condition.

Pain was rarely complained of until the last stages of the disease, but the Chinaman is much more tolerant of pain than his European brother. Tenderness on pressure over the liver region was elicited from the first. In two of the cases the spleen was enlarged, but evidence
of old-standing malarial infection complicated that issue.

A markedly positive glycogen reaction was found in the white blood corpuscles of the only case tested.

A comprehensive study of the clinical features of these cases of Round Worms in the bile ducts is not possible in this thesis, nor are the many manifestations of the spread of the septic process from the liver to the gall bladder, pancreas, peritoneum and adjacent structures; they naturally vary in each case according to the size and extent of the organ invaded.

**Migration to the Peritoneal Cavity.**

It is readily seen that if Round Worms can enter the peritoneal cavity, serious damage must result. The Author has seen four cases exemplifying peritoneal infection. The human intestine is a potential tube constructed to hold all sorts of foreign bodies, and has naturally no direct communication with the peritoneal cavity. A traumatic rupture of the gut wall as a result, for example, of violence, will thus provide an easy gateway of entrance to the migrating worm; short of this, however, it is not easy to see how entrance can be effected. The Author found Round Worms in the peritoneal cavity in three cases of typhoid fever and in one case of an apparently healthy bowel. Perforation of the wall of the intestine by disease such as typhoid fever, tuberculous condition of the gut, duodenal ulcer, appendicitis and other intestinal diseases may be necessary before worms can gain access to the cavity, but in the one case
Case II.—S, round worm in common bile duct turned on itself. R, open end of colon, showing end of a round worm. N, two round worms having penetrated the mesentery, A being three inches long, B four inches.
case referred to no such perforation could be found; the worms must have had some gateway of entrance, of course, but there was no apparent disease of the intestinal mucosa.

It is naturally difficult to obtain proof of the ability of the lumbricoid worm to pierce a healthy intestinal wall; it is not sufficient to have found them in the peritoneal cavity and to have failed to find disease in the gut. But in the case about to be recounted the round worm is actually shown embedded in the layers of the mesentery (see photograph 2), and the writer considers from that that the worm has powers of penetration which are not generally recognised. The mesentery is much thinner than the intestinal wall and is softer, but there are times, especially in disease, when the intestinal wall is thinned out and almost friable, and he believes that the Ascaris can and does penetrate through to the peritoneal cavity; a necrosed appendix, and ulcerated peyers patch, a duodenal ulcer, are probably all permeable.

The peritoneum in the vicinity of the perforation tends to shut off the latter from the peritoneal cavity by forming adhesions, but the process occupies some twenty-four or forty-eight hours; ample time therefore is available for the Ascaris to pass through the aperture and wander away through the greater or lesser sacs of the peritoneum to all sorts of remote corners.

The peritoneal cavity does not appear to be a (healthy
healthy habitat for an Ascaris to live in, for they die there quickly. The Author found that the worms had died in the peritoneal cavity in three out of the four cases prior to the death of the host, and were usually surrounded by a little pool of pus.

Peritonitis (either local or general) is the necessary sequel to round worms in the peritoneal cavity. Septic organisms are carried by them from the intestinal canal and distributed along their course. In one case the Author was able to trace the track of the worm by the inflammatory reaction in the peritoneum, but this is unusual. General peritonitis is almost invariably caused, and virulent foci of septic infection are found in the vicinity of dead and macerated worms; these foci may be hidden away in remote corners (as for example in the neighbourhood of the spleen) and may become shut off by adhesions to form localised abscesses in any part of the abdominal cavity to which the worm migrates. Another virulent focus of septic infection is usually to be found around the perforation of the gut; again this may be shut off from the peritoneal cavity by adhesions, and worms have been found lying in the abscesses so formed (e.g. appendicular abscesses).

The following three cases, which came under the notice of the writer, illustrate well the possible pathological conditions which can be produced:

Case i. Pow Swee, about 40 years of age, a Chinese merchant, was found dead in a house. He had
received a blow over the hypo-gastrium which, by squeezing a loop of the bowel against the vertebral column, had caused his death. The laceration was an inch and a half long, was situated at the lower end of the jejunum, and, starting close to its mesenteric attachment, extended to one third of the lumen. Through this tear intestinal contents had passed readily into the peritoneal cavity. The mucosa was otherwise perfectly healthy. Forty-six worms were found inside the gut and eight in the peritoneal cavity, of which four were dead and shrivelled, three were alive and free, and one was alive and had burrowed its way deeply into the great omentum. The peritoneal cavity contained two to three pints of a blood-stained fluid, and white flakes of lymph lay between the coils of the duct.

Case II. Lam Ke Lew, twenty-six years of age, a Chinese rickshaw puller, died during the third week of typhoid. At the post-mortem the Peyer's patches of the gut were seen to be ulcerated, and about six inches from the ileo-caecal valve a typhoid ulcer had perforated. Four round worms were present in the intestinal canal and one dead and shrivelled was found in the peritoneum. The point of perforation had been surrounded
and partially shut by a thin layer of fibrinous exudate. Marked general peritonitis was present, about eight ounces of a turbid yellowish fluid occupying the peritoneal cavity. The dead worm (which was four inches long) lay in a pool of pus about two inches away from the perforation. The most virulent focus of septic infection in the whole peritoneal cavity was in the vicinity of the worm, and around the perforation of the gut was a small abscess shut off by adhesions from the general peritoneal cavity.

In the next case the Author could not determine the route by which the worms had entered the peritoneal cavity.

Case iii. Ah Chin, aged 2 years, a Chinese boy, was a week in hospital before he died. He had a very severe attack of pneumonia in both lungs and had vomited round worms on several occasions, as well as passing them in his stools. The Author did not see the case during life, but carried out the post-mortem examination of the body.

On opening the abdomen a condition of general peritonitis was discovered. Some twelve worms were present in the peritoneal cavity, round each of which the peritonitis was more pronounced. One worm had formed a localised abscess in the region of the spleen, and three
had penetrated the layers of the mesentery and had become partially embedded in it. (Plate 2) Page 42. Careful search was made along the whole length of the bowel for an opening, but no perforation could be found.

Some fifty-five worms occupied the small intestine and one, turned on itself, had blocked the bile duct. (Plate 2) The liver was the seat of suppurative cholangitis, with numerous small abscesses throughout its substance, in one of which two parasites were found coiled up.

The general appearance of the peritonitis suggested the probability of infection from the worms themselves, but their means of entry into the peritoneal cavity could not be discovered. There was no sign of intestinal disease such as typhoid fever, appendicitis, duodenal ulceration, tubercle, etc.

**Migrations to other parts.**

(a) Migration to the appendix is not unknown; medical literature records several cases in which an operation for appendicular abscess has revealed the presence of round worms in the pus.

(b) Migration to the lungs is also possible via the oesophagus, larynx and bronchus; this is rare.

The Author has seen in Kadamara an Ascaris in one
of the smaller branches of the right bronchus—an example of post-mortem migration.

The sensitive mucous membrane of the larynx, trachea and bronchi would induce in health the most violent spasms of coughing if a round worm passed down them, but if for any reason the mucous membrane of these passages were rendered insensitive or the reflex action of coughing was in any way interfered with (as by paralysis of the superior laryngeal nerve or by coma), the round worm can pass to the small divisions of the bronchi during the life of the patient. Such cases are on record, and one came under observation.

Pathu Muthu, aged 23 years, a Tamil coolie, died from acute nephritis, with marked effusions into the sub-cutaneous tissues, peritoneum, pericardium and pleura. He had been unconscious from Uraemia for several days before his death.

It was found at the post-mortem that both lungs were in an oedematous state, and basal pneumonia was present at both bases. Lying in one of the smaller branches of the right bronchus and obstructing it was the dead body of an Ascaris; the bronchiial tree was somewhat dilated on the distal side of the obstruction and secretions had accumulated there. Irregular areas of collapse were noted in the vicinity, and on the surface these looked dark
in colour, depressed, and on section firm and of a dark red colour.

A number of round worms were found in the intestinal canal. Death was due to nephritis.

(d) Mechanical effects.

The direct effect of Ascarides on the wall of the apparently intact intestine is very little. The Author has frequently examined the intestinal mucosa of the Jejunum against which round worms had lain, and never saw the least sign of irritative change; were it not for the frequency of abdominal pain as a symptom amongst those infected, he would not believe that intestinal irritation occurs. Adults frequently describe a gnawing pain in the oesophagus, but children are less exact, and seldom complain of more than a vague abdominal discomfort.

The chief mechanical effects of the worms are produced when they clump themselves together to form a solid mass. In the intestine the result is intestinal obstruction. The two examples of this mass formation as seen by the writer were discovered at post-mortem; in both cases the clumps were small and had not blocked the lumen of the gut completely, the one was in the ileum and the other in the caecum; quite possibly both had occurred after the patient was dead. A number of fatal cases have been reported, however, in which a mass of Ascarides had caused a complete blockage of the alimentary canal, and others, not fatal, in which the obstruction was low down and had been relieved by rectal enemata, the obstructing
mass coming away.

This mass formation is not always confined to the gut, and may be adopted by worms which have migrated. Such a case was reported in the Deut. Med. Woch. (4-12-02). The patient, a boy of eight years, died from suffocation caused by a convoluted mass of worms partially blocking the entrance of the oesophagus and obstructing the larynx.

In concluding these observations on the signs and symptoms associated with round worm infection, the Author must make a note as to the mental outlook of infected subjects. It was extraordinary how anxious were his English patients to free themselves from this parasite, and how worried they were during the process of treatment. Slight abdominal discomfort became a definite gnawing pain in the abdomen as soon as they were aware of carrying worms. Headaches and incontinence rather suddenly developed, and their general mental attitude did not change until assured that they no longer harboured the parasite.
Diagnosis.

So many and various are the clinical manifestations of ascarisis that it is fortunate there is in the stools of every infected patient a ready means of diagnosis. Every female worm of mature age lays eggs, which can be seen in the faeces of its host by a microscopic examination. Many practitioners imagine that it is necessary for an Ascaris to be voided before a diagnosis can be made with certainty, but such is not the case. The finding of ova in the stools is absolute proof of round worms in the intestinal canal.

The method of examination is simple. Take a very small sample of faeces on the end of a match and place it on a glass slide; dilute it with one drop of water and mix it well; place a cover slip upon the specimen and examine it under the microscope with a 1/23th lens. Before very long the ova, if present, will be seen. To make quite sure that none are present, two or three slides should be examined, each specimen being taken from different parts of the faeces. If the faeces are already fluid, dilution is unnecessary. With a little practice the examination occupies only a few minutes. The writer found that where one sample of faeces proved negative subsequent stools never gave a positive result.

It is possible that a male Ascaris can be the only one harboured, but the Author has never had such an experience; every case brought for treatment because of
vomiting or of passing a worm in the stools was invariablelly examined in the above manner, and he cannot recollect a single instance in which the ova were not discovered.

There are various methods of concentrating the ova so as to facilitate diagnosis; although ingenious they are unnecessary. So many ova are found in the average infected stool that if, after examining a few slides none are found, in all probability there are no worms in the intestine.

When examining the contacts of infected patients the simplicity and rapidity of stool examination is of great value. Confusion between the egg of the Ascaris and of other types of intestinal parasites is practically impossible if one remembers the description of the former; the bile-stained albuminous covering, the knobbed or mammilated exterior, the oval shape and the size are diagnostic, and if there is any doubt about one specimen, others can be easily found and confusion avoided. The hook worm's eggs are easily distinguished, the chitinous shell being line-like and continuous and not nearly so thick. The eggs of the tricocephalus dispar when once seen are never forgotten, and are very much smaller, are darker and plugged at both ends. Local experience will guide the observer as to the type of egg likely to be found in the neighbourhood.

The percentage of eosinophiles in the blood may
also be used as a diagnostic measure. Eosinophilia is of course common to a variety of diseases, amongst them being helminthiasis. It is rather a tedious method of arriving at what is only an approximate diagnosis. Five hundred white blood corpuscles at least must be counted, and preferably more. Nothing less than an eosinophilia of 6% can be regarded as a positive result. The Author made several observations upon its value, and in three or four cases in which round worms were known to be in the intestine an eosinophilia was not discovered. He found the method to be of value amongst patients who refuse to find specimens of their faeces for examination (as occurred amongst the Chinese servants of one infected family in the Author's practice), and also as a preliminary test for those unduly sensitive. With the three or four exceptions mentioned above, the writer found the blood changes a constant feature of Ascariasis, and used it in his observations on the soldiers' children of Biakan Mati. (See page 3).

Certain parts of the tropics are more notorious for ascaridian infection than others. There are parts of India, for example, in which this worm infects the alimentary tract of almost all the children; and parts of China in which almost all the coolies are said to be infected. (e.g. Tchenton, N. China—86%.) Where these local propensities are known and the variety of symptoms
produced by the ascaris are realised, diagnosis is often established by watching the effect of treatment. In the same way, the knowledge of infection in one member of a family will give the clue to the cause of the many little maladies of the others, and several examples of family infections have already been mentioned in this thesis.

It must be confessed that, apart from examination of the faeces and of the blood, and of a judicious application of the knowledge of local conditions, a diagnosis of Ascariasis is difficult, if not impossible. The condition of the tongue (described on page 19), the convulsions of young children, the reflex manifestations, are all common to many other forms of intestinal irritation. The feverish states (described on pages 16 and 17) are similarly produced by Dengue fever, sandfly fever and a whole host of other maladies. The clinical pictures of cholangitis, chole-cystitis, peritonitis and appendicular abscess as presented in these pages shewed no one single symptom indicative of an Ascaridian origin. There is but one infallible sign of Ascariasis, and that is the presence of ova in the faeces of the host.

The writer is convinced that the routine microscopic examination of the stools in every case in the tropics is a very necessary procedure. It is not, unfortunately, a frequent practice. The general practitioner considers that it is an examination requiring the special knowledge of an expert, whereas the technique is simple, the expert knowledge easily attained and the labour involved (comparatively
comparatively trifling. By a routine microscopic examination of the stools the ova of most other intestinal parasites would be revealed (e.g. ankylostomes and hook worms), the presence of intestinal protozoa would be noted (e.g. the entamoeba histolytica), and the state of the digestion would be indicated. In such a disease as dysentery the presence of the Ascaris will frustrate the best attempts at treatment until they are first got rid of. Typhoid conditions show an astonishing improvement after the Ascaris is expelled. All the obscure symptoms recounted in this thesis would not have existed long had a routine examination of the faeces been the practice.
Treatment.

A few remarks on the treatment necessary to expel the Ascaris will conclude these observations, for the object of the thesis, being the experiences of an investigator into the effects produced on the human body by the Ascaris Lumbricoides, is now complete.

The necessity of early diagnosis demands equally necessary early treatment. Where ova are found in the faeces, then there are adult worms behind in the intestine. No time should be lost in their expulsion, for one per cent. migrate and do irreparable mischief. The Author's usual practice was to exhibit Santonin and to test its efficacy in each case by examining the stools microscopically. He found that three or four courses of the drug were necessary before all the worms had been passed and no more eggs were to be seen. Other drugs did not appear to be any more expeditious.

Santonin is said to have occasionally a bad effect on the patient, producing yellow vision, yellow urine, and sometimes a condition of delirium—but the Author has used the drug repeatedly without meeting with any of these ill effects. Perhaps it is as well to warn the parents that yellow vision and yellow urine are possible, but that an accompanying purgative will prevent them. Twelve hours' starvation is a good prelude to treatment, getting rid of the bulky food stuffs, and the writer invariably gave a good dose of Castor Oil the night before the treatment commenced. He usually directed that the patient...
tea about 4 p.m. should be the last meal of the day, and that Castor Oil should be administered about 7 p.m. Powdered Santonin is a convenient preparation, and being tasteless is easily given spread on a piece of bread and butter. Two or three grains should be given to the child first thing in the morning for three successive mornings. On the evening of the last day the writer usually gave a dose of Pulv. Rhei Co. to clear the intestinal tract of worms and powder. Subsequent courses should follow at about three days' interval.

Santonin treatment is quite efficacious for adults as well, but a larger dose is required—from three to five grains given in the same way.

Adults more often than children require treatment for other parasites as well, and Oil of Chenopodium will eliminate ankylostomes, strongyloides intestinales and whip-worms as well as Ascarides. Once again its efficacy must be watched by the microscopic examination of the stools. Dr. Guthrie, of the John Hopkins Hospital, advocated its use in the following way:—Epsom Salts (1 oz) and a liquid diet commencing at 5 p.m. on the first day of treatment; Epsom Salts (1 oz) and a continuation of the liquid diet on the second day; and three doses of Oil of Chenopodium (min. 16) at two-hourly intervals commencing at 6 a.m. on the third day; at 12 noon Castor Oil (1 oz) and Chloroform (min. 48) is administered. The Author has used the method with success, but in so far
as the Ascaris Lumbricoides was concerned, Oil of Chenopodium did not impress him as being more efficient than Santonin. There are other anthelmintics occasionally used, of which Turpentine is perhaps the most common; it is, however, very unpleasant to take, especially when given with Castor Oil.

Rectal enemata are sometimes useful, notably when a large number of worms are harboured.

Very little can be said about the treatment necessary for round worms which have migrated from the intestinal canal, notably to the liver and to the peritoneum. Operative measures must be adopted, the nature of which depends entirely on the site. It is obvious that round worms passing outside the intestinal canal are beyond the reach of anthelmintics.

The Author has endeavoured to present a strong case for the early diagnosis and prompt treatment of this variety of intestinal parasite, and to expel the fallacy that Round Worms do little harm to the unfortunate host who harbours them.

( E H D. )
Conclusions

1) That Infection by Ascaris lumbricoides is much more frequent in the tropics than is usually supposed.

2) That English Subjects seldom harbour more than a dozen round worms.

3) That Asiatics often harbour many more—70 and over.

4) That Ascariasis is often a family infection, being passed from one infected child to the other.

5) That other modes of infection are uncooked vegetables, polluted water, sandy floorings to houses, etc.

6) That observations amongst the soldiers stationed at Singapore did not reveal a single case.

7) That observations amongst 26 soldiers' children in Singapore revealed 13 infected, of whom 6 had never complained of any symptoms.

8) That observations amongst the native classes in Singapore revealed an Ascaris infection in 10 per cent. of the total native population.

9) That Ascaris lumbricoides is not always a harmless visitor, for it produces serious disease in 1% of all those infected.

10) That the signs and symptoms produced by it are in part due to a toxin manufactured by the worm and absorbed by its host.
Conclusions--2

11) That the toxic effects are a constant blood change, and a less constant febrile condition.
12) That the Ascaris produces in its human host certain reflex phenomena, mostly of the nervous type, and possibly as a result of intestinal irritation.
13) That the Ascaris migrates from its normal habitat in the intestine in at least 11% of all those infected, causing pathological lesions of great severity.
14) That the commonest site of migration is to the stomach and lower bowel, and next in frequency to the liver, to the gall bladder, and to the peritoneal cavity.
15) That migration to the stomach usually ends by the worm being vomited without causing much damage, and that to the lower bowel similarly ends by the worm being passed in the faeces.
16) That migration to the liver necessarily results in cholangitis and possibly cholecystitis owing to the spread of septic infection along the bile ducts.
17) That migration to the peritoneal cavity necessarily results in peritonitis.
18) That migration to the appendix produces appendicitis and appendicular abscess.
19) That migration to the lung via the air passages is possible in states of coma.

20) That Ascarides, by clumping, can obstruct the intestine, and after migration can equally obstruct normal channels such as the air passages.

21) That the mentality of patients harbouring Ascarides becomes curiously depressed after they are aware of the fact.

22) That the presence of Ascaris Lumbricoides in a human intestine is easily diagnosed by examining the faeces under the microscope for the eggs of the worm.

23) That the alteration in the blood caused by the worm is also produced by other forms of intestinal parasitism, and therefore only furnishes an approximate diagnosis.

24) That a routine examination of the stools by the microscope should constitute a part of the physical examination of all tropical patients.

25) That the clinical signs and symptoms of Ascariasis are so varied that reliance upon them as a means of diagnosis cannot be placed.

26) That Santonin is an easy, reliable anthelmintic and suffices in all ordinary cases as a means of expelling the worms.
27) That oil of Chamomium is useful to expel not only the Ascaris but several other varieties of helminthes which may be harboured.

28) That prompt treatment to expel the worms is as necessary as early diagnosis, and that the efficacy of treatment should be judged by the absence or presence of ova in the stools.

29) That it is not generally recognised that the Ascaris Lumbricoides is responsible for serious ill-health in one per cent. of all those infected.

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The Ascaris Lumbricoides

Literature.

Fr. Guermonprez

Affections sympathétiques multiples causées par la présence des ascarides lumbricoïdes dans l'intestin. Journal des Sciences Médicales de Lille 1880.

Bosquet

Helminthes dans le foie. Thèse de Paris 1904.

Leuckart

Die menschlichen Parasiten.

Moser und Paiper

Thierische Parasiten 1894. In spezielle Pathologie und Therapie.

Tonnelle


André

Sahatchiëff Montpellier 1908.

Guéart

Arch de Parasit. v.QII, No.1, p.70, 1900.

Gallet de Santarre

Cas de diarrhée dysenteriforme d'origine ascaridienne amm d'hyg et de med colon. Paris 1913, xvi, p.452-454.

B.C.S. Gupta

A case of infantile convulsions due to Ascarides. Indian Medical Gazette 1913, XIVQII, 32.
Literature 2.

Naumann
"Mittheilungen über das Verkommen des Ascaris Lumbricoidees, etc. in Kindesalter Wien, Klin. Rundsch. 1913 XXXVII, 387, 401, 436, 451, 467, 483.

Weinberg & Julien

H. Alston

Bergmann

Chansaen

Drasche

Hillyer
Death from the irritation of Ascarides. Lancet 1892 ii. 773.

Law R.

Lowry
Ein Fall von Auswanderung von Ascaris Lumbricoidees (aus
Lowry (continued)

Macphail

MacSwiney S.V.

Stringfield C.P.

Dass

Stewart

Hehir

Stewart F.H.

Commes C.H.

Clapier N.

Leger (Marcel)

Pozze W.D.

Garcia (Faustino)

Bowman (T.B.) and Saylor (P.D.)

Wharton (Lawrence D.)

Burge (W.E.) and Burge(E.L.)
Literature—5

Baliliano (Arturo)


de Vello (Freliano)


Masters (Walter E.)


Parriana (Decio)


Shinamura (T.) and Fujii (H.)


Sinton and Baily (J.D.)


Glines (W.A.)


McGannan (Alexius)

Nagahama (M.)

Takaki (Y.)

Paulian (Demetre Em.)

Hall (Maurice C.) & Foster (Winthrop N.)

Hall (Maurice C.)

Steber

Heiner (Victor C.)

Perret (J. Maxim) and Simon (H. Theodore)
Tanami (K.)

A simple method of concentrating parasite eggs.

Cochran (Samuel)


Fort (A.C.)