ON THE LESIONS PRODUCED IN THE APPENDIX BY OXYURIS VERMICULARIS AND TRICHOCEPHALUS TRICHIURA.*

BY RUSSELL L. CECIL, M.D., AND KENNETH BULKLEY, M.D.

(From the Pathological Laboratory of the Presbyterian Hospital, New York, and the Surgical Research Fund of Columbia University.)

Plates 32-35.

The importance of intestinal parasites as the exciting cause of appendicitis was first emphasized in 1901 by Metchnikoff (1), who reported three cases of this disease due to Ascaris lumbricoides. Metchnikoff's contributions served to awaken some interest among clinicians in parasitic appendicitis, but the subject is one which, on the whole, has received very meager scientific study.

The commonest parasitic inhabitant of the appendix is Oxyuris vermicularis. Brumpt (2) found pin-worms in the appendix in 3.5 per cent. of normal cases, and in 40 per cent. of all cases of appendicitis.

Railliet's (3) figures are still higher for the same locality (Paris). He found oxyuris in 58 out of 119 cases of appendicitis examined, or 48 per cent. Hoepfl (4) found them less common in Germany, but even there he could demonstrate them in the appendix of 21 per cent. of all cases of appendicitis. In London, Still (5) found oxyuris in 19 per cent. of all normal children's appendices examined at autopsy. Trichocephalus trichiura probably ranks second in importance, but is much less frequently found. Brumpt and Lécène (6) found trichocephalus in 4 per cent. of normal adult appendices. Railliet, however, in 119 cases of appendicitis, encountered trichocephalus only once. Delsmitt (7) and Oelnitz (8) found that a large percentage of diseased appendices contained the ova of trichocephalus.

In America, the incidence of these two parasites in the appendix has not been studied. Erdman (9) noted the presence of pin-worms in 4 out of 250 cases of appendicitis in children, but it is probable that a thorough examination of the contents of the appendix under the microscope would have shown a much higher percentage.

As far as the pathology of oxyuris and trichocephalus appendicitis is concerned, it may be said that the greater part of the literature on the subject consists of clinical reports of single cases, in

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many of which there is no reference whatever to the pathological changes found. It is unnecessary to cite these cases.

Several writers (Wakefield (10), Wagener (11), and Walther (12)) have noted that the parasites were attached to the mucous membrane, but they give no descriptions of the gross or microscopic lesions produced. On the other hand, a number of case reports, such as those of Culhane (13), Martin (14), von Moty (15), Pabeuf and Dubois (16), Ashhurst (17), and Bégozin (18), contain descriptions of the histological changes found, such as superficial ulceration of the mucosa and swelling of the lymph follicles, but they fail to establish a relationship between the parasites and the changes described.

Winkler (19), Hippius and Lewinson (20), Weinberg (21), Romanovitch (22), Brumpt and Lecène (6), and Galli-Valerio (23) have all reported single cases of oxyuris appendicitis in which the parasite is shown to be the actual cause of the disease. The description in nearly every case is identical. At operation, the appendix was lying free and moderately swollen and injected. On opening the appendix, one or more parasites were found attached to the mucous membrane, which was swollen and often marked by small ecchymoses. Microscopical sections showed the worms burrowing under the mucous membrane and invading the lymph follicles. Brumpt and Lecène observed small hemorrhages about the invading parasites. Galli-Valerio's case was that of a gangrenous oxyuris appendicitis in a boy five years old. The mucous membrane showed a number of necrotic foci surrounded by zones of inflammation. In some of these foci, male oxyurides were found. The author concludes that in this case, the parasite acted as a predisposing factor, the bacteria gaining entrance through the break produced by the oxyuris. The case reported by Romanovitch is of the same character.

Unterberger (24) has reported two cases of oxyuris appendicitis, accidentally discovered at autopsy, in both of which he found the parasite invading the mucous membrane. Railliet has recently made a study of 58 appendices that contained oxyurides. While he refers to the fact that oxyuris sometimes attacks the mucous membrane, his study is almost entirely a biological one, dealing with the incidence of oxyuris appendicitis, the number of parasites and the proportion of each sex present, and their blood-sucking faculty.

In spite of the statement of Wichman (25), that trichocephalus never penetrates the intestinal mucosa, Girard (26) and Weinberg (21) have each reported a case of appendicitis in which the trichocephalus was found attached to the mucosa of the appendix. Girard's case was in a child eight years old. The appendix appeared normal externally. On the mucosa, however, two trichocephali were found, attached by their anterior extremities to the mucous membrane. Microscopically, there were no inflammatory changes except about the heads of the parasites, where an infiltration of leukocytes had occurred, and streptococci and Gram negative bacilli were present. Weinberg's case is very similar. None of the coats of the appendix showed any changes except the mucosa, which at one point had been invaded superficially by a trichocephalus. In Weinberg's case, there was no inflammatory reaction about the parasite, nor were any bacteria demonstrated in the tissue.
From this brief but fairly comprehensive review of the literature, it is apparent that there has been very little systematic study of the pathology of oxyuris and trichocephalus appendicitis, and slight effort to determine whether the presence of parasites in a diseased appendix is fortuitous, a predisposing factor, or the exciting cause of the disease.

The present report is based on a study of 148 unselected appendices of children between the ages of two and fifteen. We have also included four adult cases of oxyuris appendicitis. In this investigation, we have undertaken to determine:

1. The incidence of oxyuris and trichocephalus in the normal appendices of children.
2. The incidence of oxyuris and trichocephalus in the appendicitis of children.
3. The percentage of appendices containing these parasites in which specific lesions produced by them could be demonstrated.
4. The character of such lesions.

The material has been collected in large part from the two surgical services of the Presbyterian Hospital. The remainder, with the exception of one case, has come from other New York hospitals.

Of the 148 children's appendices examined, nineteen were normal and served as controls. They were all removed at autopsy from children who had died of various diseases. In three of the nineteen, oxyuris was present. Trichocephalus was not found in any of this series.

The remaining 129 appendices were all from operative cases, and all of them showed pathological changes. Of this series, nineteen, or about fifteen per cent., contained parasites, the oxyuris being found in seventeen, and the trichocephalus in two cases.

Our cases may be classified as follows:

<table>
<thead>
<tr>
<th>Category</th>
<th>Oxyuris</th>
<th>Trichocephalus</th>
<th>No parasites</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Acute catarrhal appendicitis (children)</td>
<td>14</td>
<td>1</td>
<td>5</td>
<td>20</td>
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<tr>
<td></td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>4</td>
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<tr>
<td>2. Chronic appendicitis</td>
<td>0</td>
<td>0</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>3. Acute suppurative appendicitis</td>
<td>0</td>
<td>0</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>4. Acute gangrenous appendicitis</td>
<td>3</td>
<td>1</td>
<td>60</td>
<td>64</td>
</tr>
<tr>
<td>5. Normal appendices</td>
<td>24</td>
<td>2</td>
<td>126</td>
<td>152</td>
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</table>

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Lesions Produced in Appendix by Oxyuris and Trichocephalus.

METHODS OF STUDY.

In most cases, we have examined the appendix in the fresh state. The condition of the serosa having been noted, the appendix was carefully opened with small probe-pointed scissors, and the contents were inspected with a hand lens. If parasites were seen, one or two of them were carefully removed, placed on a glass slide in a drop of normal salt solution, and examined under the low power of the microscope. The characteristic shape and structure of the oxyuris and trichocephalus made the identification easy. Sections for microscopical study were taken at the site of the worm or through ulcerated areas. If parasites were not seen, the mucosa of the appendix was washed off with normal salt solution, the suspension centrifuged, and the sediment examined under the low power of the microscope. In this way we were able, in several instances, to demonstrate the presence of oxyuris, where it would have otherwise escaped detection. In every case, the tissue was imbedded in paraffin, and serial sections were cut and stained with hematoxylin and eosin.

OXYURIS APPENDICITIS.

In the classification of cases given above, it will be observed that of the twenty-one cases of appendicitis associated with oxyuris, eighteen were of the acute catarrhal, and three of the acute gangrenous type. We have noted the same predominance of the catarrhal type in the cases reported in the literature. Our own cases have presented in the gross a remarkably similar appearance. Excepting the three gangrenous cases, which contained nothing characteristic, they have shown the following changes: The appendix is moderately swollen and rigid, but the serosa is smooth, pale, and glistening. The vessels of the serosa may be congested. On opening the appendix, the lumen is usually found to be filled with blood and mucus, in which can be seen writhing one or more parasites. The male oxyuris is hard to see with the naked eye. In our series, the number of worms present has varied from one to thirty-five. In eight cases the males have outnumbered the females, and in eight the females outnumbered the males. In the remaining five cases, the two sexes were equally represented. The mucosa is
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invariably swollen, pale pink in color, and appears more velvety than normally. In most cases, it is marked here and there, usually in the neighborhood of a parasite, by dark red purpuric spots, or small hemorrhagic ulcers. There is no evidence of suppuration, gangrene, or perforation. In several of our cases, we have seen pin-worms firmly attached to the mucous membrane. In two cases, living worms were seen to free themselves from the mucosa while under observation. It is of course with the microscopical changes that we have been most concerned. It will be convenient to classify the cases according to the lesions found.

1. There is the group where pin-worms, though present in the appendix, have apparently produced no lesion other than a mild catarrhal appendicitis. In the gross, the appendix is thickened and rigid and its mucosa is swollen, but the focal hemorrhages on the mucosa are absent, and no worms are seen adherent to it. Microscopically, the crypts of the mucous membrane are filled with mucus, and the keim centers of the lymph follicles are considerably enlarged. The submucosa and muscularis may show no changes. The serosa is usually normal, but it may be slightly thickened, especially in the case of adults. In some cases a few scattered polymorphonuclear leukocytes, eosinophils, and lymphoid cells have been noted in the muscularis and serosa.

In our series of seventeen cases of oxyuris appendicitis in children, we have encountered only three such cases (cases 8, 14, and 20). The four cases of oxyuris appendicitis in adults also belong to this group, though two of them also showed mild chronic changes. In all seven of these cases we have cut serials from various parts of the appendix, but with negative results as far as specific lesions are concerned.

2. In the second group, we may include those cases in which the oxyuris has punctured or invaded the mucosa, but where there has been little or no destruction of tissue. By some means or other, the parasite, usually the male, breaks through the columnar epithelium, and burrows into a lymph follicle. Such lesions may be recognized in the gross as small purpuric spots, over which the mucosa often appears intact.

Microscopically, there is extensive extravasation of blood into
the tissue and out through the ruptured epithelium into the lumen, but with it all no evidence of an inflammatory reaction. In those cases where the worm has penetrated into a follicle, a slender trail of necrotic tissue may be traced back through the serial sections to a small break in the columnar epithelium, but there is no infiltration of leukocytes about it. In case 2, there was considerable necrosis and infiltration of leukocytes about one of the parasites found in a follicle. Bacteria were, however, demonstrated in the necrotic tissue. Six of our cases belong to this group (cases 2, 3, 4, 7, 19, and 21). Beautiful examples of the puncture wound of the mucosa were demonstrated in cases 4, 7, and 21 (figures 1, 2, and 3), while in cases 2, 3, and 19, parasites were actually found in the lymph follicles (figure 4).

3. In this group, we have placed the cases showing destructive oxyuris lesions. In these there is seen more or less necrosis of the mucosa, with the formation of ulcers, which are characterized by
(a) hemorrhagic bases, (b) undermined edges, and (c) absence of inflammatory reaction about them.

The ulcers are dark red in the gross and rather shallow. Microscopically the submucosa forms the base of the ulcer which is covered with blood and necrotic tissue (figure 6). The edges of the ulcer are undermined, sometimes markedly so, when the pin-worm burrows beneath the mucosa into neighboring follicles (figure 5). In two cases (cases 1 and 9), the mucosa had been, in places, almost entirely separated from the submucosa by the extensive tunneling beneath it. About neither the ulcer nor the sinuses connected with it, have we ever seen the slightest inflammation. Five of our cases belong to this group (cases 1, 5, 9, 10, and 17). In cases 1 and 9, oxyurides were demonstrated in the ulcers.

4. The fourth group comprises the cases of gangrenous appendicitis, associated with oxyuris. Three of our cases have been of this type (cases 11, 12, and 13). In case 12, there was a perforation. Except for the presence of pin-worms in the lumen of the appendix, these three cases differed in no respect from the usual type of gangrenous appendicitis. No specific oxyuris lesions were found in this group, though several serials were cut from each case.

In cases 2 and 5, we found, in addition to the lesions already
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described, foci where the process of repair was going on. In case 5, the ulcer was still present, but reduced to a small slit, which was surrounded by granulation tissue. In case 2, we found deep in the mucosa a remarkable healed lesion, consisting of a hyaline oxyuris surrounded by a few fibroblasts, and the whole enclosed in a thick capsule of dense fibrous tissue (figure 7).

Autopsy Cases.—Oxyuris was found in three children's appendices that were removed at autopsy. These serve as controls for the clinical cases, and were studied in exactly the same way, even to the cutting of serial sections. All three appendices appeared normal in the gross. It was noticed that the lumen in these cases contained yellow feces, instead of the blood and mucus seen in the pathological cases. In no instance were the parasites attached to the mucous membrane. Microscopically, serials failed to reveal any punctures or ulcerations of the mucosa. The lymph follicles, however, showed well marked swelling of the keim centers. The other coats of the appendix were normal.

TRICHOCEPHALUS APPENDICITIS.

Our series includes only two cases of trichocephalus appendicitis, one catarrhal, the other gangrenous. The former (case 23) had, macroscopically, many of the traits of an oxyuris appendix. It was swollen and moderately congested. The mucosa was swollen, but smooth and pale. Near the base, a single whip-worm was found, firmly attached by its head to the mucosa. Microscopically, the parasite is seen burrowing along just beneath the columnar epithelium, and, like the oxyuris, producing absolutely no inflammatory reaction (figure 8). The epithelium just over the parasite has become stretched and thinned, and has lost entirely its normal structure, appearing more like an extra coat to the worm than like columnar epithelium. There are no changes in the other coats of the appendix. In the gangrenous case (case 22), the trichocephalus was attached to the mucosa, just proximal to the gangrenous portion, the tissue immediately about the parasite being sound. Microscopical sections show the parasite burrowing along beneath the epithelium in precisely the same manner observed in the catarrhal
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If the series of normal appendices be compared with that of pathological appendices, it will be observed that about the same proportion of both series (15 per cent.) contained parasites. Unfortunately, the series of control cases is so small that no definite conclusions can be drawn from it. Schloss (27) has recently investigated the incidence of intestinal parasites in healthy children on the east side of New York City, and found the oxyuris present in 7 per cent. Such a percentage, or even a smaller one, would probably represent the incidence of oxyuris in the normal appendix of children, and would more nearly agree with the figures of Still already quoted.

In considering the first group of oxyuris cases, that is, the several cases in which there was no evidence of invasion of the mucosa by the parasites, the question will naturally arise whether the worms were in any way responsible for the slight pathological changes found, for on the one hand, five out of the 152 appendices studied were cases of catarrhal appendicitis without worms, and on the other, three normal appendices, removed at autopsy, contained worms. We believe, however, that the parasites did cause the symptoms and tissue changes observed. In the first place, it is quite possible that minute puncture wounds were overlooked. It was obviously impossible to cut a serial of the entire appendix, and only in that way could the possibility of such an oversight be excluded. The hyperplasia of the lymph follicles even in the control cases suggests that the mere presence of the oxyuris in the appendix is a source of irritation to the organ, and in the absence of other etiological factors, such as kinks, strictures, foreign bodies, and bacterial infection, it is rational to suppose that the parasites were themselves the exciting agent.

It is interesting to note that all four of the cases occurring in adults belonged to this class. This may be nothing more than a coincidence, but it is possible that the appendix, after having been for years infested with the oxyuris, acquires some immunity against the parasite. At any rate, the majority (70 per cent.) of the
cases of oxyuris appendicitis in children fall into the second and third groups, in which actual injury to the mucosa is wrought by the parasites. Whether it be a slight puncture, or penetration into a lymph follicle, or extensive ulceration of the mucous membrane, the fact remains that the oxyuris has produced definite and characteristic lesions in the appendix, and that usually these are the only noteworthy changes found. The absence of inflammatory reaction about the oxyuris lesions, even in those cases where there has been extensive ulceration, has been noted by various observers in connection with other parasites. The reason for this phenomenon is not at hand, but the most probable explanation is one that would attribute it to some kind of negative chemotaxis. In this connection, it has occurred to us as remarkable that secondary bacterial infections have not oftener been associated with the oxyuris lesions. We have demonstrated such an association in only one case (case 2), but the three cases of gangrenous appendicitis may also be instances of it. The extensive gangrene present in these cases might readily have blotted out all traces of any oxyuris lesions, had they been present. We have been impressed with the rarity of healed oxyuris lesions, and have concluded that the puncture wound can probably heal without the formation of scar tissue. The encapsulated focus described in case 2 was associated with necrotic foci surrounded by leukocytes and containing bacteria. One would expect such lesions in healing to pass through the usual phases of inflammation and repair. Lesions, however, which are entirely free from inflammatory changes, might be repaired without any visible evidence of such repair having taken place. The apparently healing ulcer in case 5 had been reduced to a vertical slit, surrounded by vascular connective tissue, and no doubt would have eventually become a patch of dense fibrous tissue.

In respect to trichocephalus appendicitis, it would be impossible to draw many conclusions from a study of only two cases. From a comparison, however, of our cases with those reported by Girard and Weinberg, it is quite probable that in trichocephalus, as in oxyuris appendicitis, the lesions are confined exclusively to the mucosa. There is the same swelling of the lymph follicles, and invasion of the mucosa by the parasites. The most noticeable dif-
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ference between the invasion of the oxyuris and that of the trichocephalus is that the oxyuris penetrates deeply into the mucosa and usually enters a lymph follicle, while the trichocephalus burrows along just beneath the columnar epithelium. In case 22 of our series, it is impossible to say whether the trichocephalus was implicated in the gangrenous changes at the tip of the appendix, or whether the two lesions were entirely independent of each other. The inference is that the slight lesions produced by the parasite opened the way for bacteria and the onset of gangrenous appendicitis.

In two cases out of the entire series, we have found only the ova of parasites in the contents of the appendix, once the eggs of oxyuris, once those of trichocephalus. These cases could, of course, not be included in the cases of parasitic appendicitis, but there remained the suspicion that parasites might have been concerned in the changes noted. Both cases were of the gangrenous type.

SUMMARY AND CONCLUSIONS.

1. In a study of 129 cases of appendicitis in children, we have found that in nineteen of them (15 per cent.) the appendix contained Oxyuris vermicularis or Trichocephalus trichiura.

2. The oxyuris is much the commoner of the two parasites, occurring seventeen times, while the trichocephalus was found only twice.

3. In fifteen out of the nineteen cases, the parasites were associated with a non-suppurative catarrhal type of appendicitis. If the four cases of catarrhal oxyuris appendicitis of adults be also included, it may be said that 83 per cent. of the cases of appendicitis associated with parasites have been of the catarrhal type. In the four remaining cases, the appendix was gangrenous. The cellular changes noted in the catarrhal cases have been distension of the crypts with mucus, hyperplasia of the lymph follicles, and in some cases, the presence of a few leukocytes in the muscularis and serosa.

4. In thirteen of the nineteen cases (70 per cent.), there have been noted, in addition to the cellular changes, certain lesions in the mucosa, unquestionably produced by the parasite. Of the six cases
in which no specific lesions were demonstrated, the extensive gangrene in three of them might have obliterating specific lesions had they been present. Specific lesions were not demonstrated in any one of the four adult cases.

5. The oxyuris injures the mucosa by breaking through the lining epithelium and burrowing into the lymph follicles for a greater or less distance. Its invasion is usually accompanied by extravasation of blood into the surrounding lymphoid tissue, and its escape through the ruptured mucosa. In some cases, the oxyuris produces hemorrhagic ulcers in the mucous membrane, the edges of which are undermined and the bases formed by the submucosa. A characteristic feature of the oxyuris lesions is the absence of inflammatory reaction about them, except in those cases where there is secondary bacterial infection.

6. In some instances, the oxyuris may become encapsulated in the mucosa with fibrous tissue, and itself undergo hyaline degeneration. Such a process constitutes a healed oxyuris lesion.

7. The trichocephalus attacks the mucous membrane of the appendix in a manner similar to that described for the oxyuris, and there is the same absence of inflammation about the invading parasite. The trichocephalus, however, instead of invading a lymph follicle, shows a tendency to burrow along just beneath the columnar epithelium.

8. The conclusion to be drawn from these facts is that oxyuris and trichocephalus, when they occur in a diseased appendix, are, in most cases, the existing cause of the pathological changes found.

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CASE HISTORIES.

The appendix is 7.5 cm. in length. The serosa is smooth, pale, and glistening. Except for a slight swelling, the appendix appears normal externally.
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The lumen contains bloody mucus in which are a number of thread-worms, 14 males, 3 females. Some of the worms are adherent to the mucosa. The mucosa is swollen and marked by minute hemorrhagic foci.

Microscopical sections were cut in serials from various parts of the appendix. In all, 808 sections were made.

Microscopical Examination.—The lumen is filled with mucus in which are suspended many red blood corpuscles, considerable brown pigment, leukocytes, chiefly of the lymphoid type, and granular detritus. A few ova of trichocephalus also occur. The mucous membrane is intact in some sections. In others, it has been partially destroyed. These ulcers are lined with necrotic tissue which contains many red blood cells and a few lymphoid cells. The ulcers show a marked tendency to undermine the mucous membrane, some of them being continuous with necrotic tracts in the submucosa, which extend half way around the appendix. Lying in the ulcers and in their submucous branches are male thread-worms cut at various angles. Following these through the serials, one finds that they have gone in head first, and that they are boring their way beneath the mucosa (figure 5). The tunnels often terminate in lymph follicles, the keen centers of which are swollen and the seats of small hemorrhages. There is remarkably little inflammatory reaction about the ulcers and their branches. None of the ulcers reach the muscularis, a thin strip of hyaline submucosa invariably separating them. The muscularis, however, is infiltrated with a moderate number of eosinophils. The serosa is somewhat thickened and infiltrated at some points by eosinophils, polynuclear leukocytes, and lymphoid cells.

Diagnosis.—Hemorrhagic ulceration of the appendix by Oxyuris vermicularis; ova of Trichocephalus dispar in the lumen; acute catarrhal appendicitis.


The appendix is 6 cm. in length. The serosa is smooth and glistening, but the vessels are injected. The mucosa is pale and swollen, and dotted with small purpuric areas. The appendix contains 28 oxyurides, 19 males and 9 females. At one point near the tip, the tail of an oxyuris protrudes from the mucous membrane to a distance of 2 mm., the remainder of the worm being apparently buried beneath it.

Serial sections were cut from various parts of the appendix, mostly through the hemorrhagic foci. In all, 700 sections were examined.

Microscopical Examination.—The hemorrhagic areas correspond to points where the oxyuris has invaded the wall of the appendix. A variety of lesions are seen, exemplifying the different stages of the parasite’s invasion. In one, a male oxyuris is found curled up in a lymph follicle which as yet has suffered little or no damage from the presence of the worm (figure 4). In tracing this lesion through the serial, a diagonal tract of necrosis, just wide enough to admit the worm can be found from the break in the mucosa down to the infested follicle. Another lesion shows a male oxyuris, again in a lymph follicle, but this time surrounded by a zone of necrotic tissue, outside of which occur large numbers of polynuclear leukocytes and eosinophils and a few cocci and bacilli. A streak of necrosis connects this focus with the lumen of the appendix. At still another point, in the submucosa and surrounded by lymphoid tissue, there is seen a small focus of hyaline material surrounded by epithelioid
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cells, which are, in turn, enclosed by a dense fibrous capsule. In the midst of the hyaline area, the remains of an oxyuris can be clearly made out. The outlines of the parasite are sharp, but the structure of the worm has been in great part obliterated (figure 7).

The mucosa is intact except at those points where it has been destroyed by the invading pin-worms. The lymph follicles are swollen. The stoma about the crypts and follicles is infiltrated with large numbers of eosinophils and a few polymuclear leukocytes. The submucosa and muscularis contain many eosinophils. The serosa is thickened and infiltrated with eosinophils, lymphoid cells, and polymuclear leukocytes.

Diagnosis.—Invasion of the mucosa of the appendix by Oxyurus vermicularis; encapsulated oxyuris in submucosa; acute catarrhal appendicitis.


The appendix is 6 cm. in length. The vessels of the mucosa are injected, and the serosa is smooth. The appendix is swollen. The lumen is large and contains bloody mucus in which are seen many pin-worms, 35 in all, and only 5 males. A small part of the appendix near the tip is not opened. The mucosa is swollen and dotted with minute petechiae.

Microscopical sections were cut in serials from various parts of the appendix. In all, 1,948 sections were examined.

Microscopical Examination.—The mucosa for the most part is intact. Sections, however, through the petechiae show extensive extravasations of blood into the lymph follicles. Hemorrhagic tracts lead from these into the lumen of the appendix, the blood passing out through small breaks in the superficial epithelium. In one of these hemorrhagic tracts, a female oxyuris is seen. Another parasite is seen in the act of invading the mucosa (figure 3). The lymph follicles are considerably larger and more numerous than normally. There is some infiltration of polymuclear leukocytes and lymphoid cells about the blood vessels of the muscularis. The serosa is slightly thickened, and its vessels are engorged with blood. There is moderate infiltration of the serosa in places with polymuclear leukocytes and lymphoid cells.

Diagnosis.—Acute catarrhal appendicitis; invasion of the mucosa of the appendix by Oxyurus vermicularis.

Case 4.—M. B., male, 3 years. Operation, February 18, 1910.

The appendix is 5 cm. long. It is swollen and rigid. The serosa is injected. The lumen contains blood and mucus, and one female oxyuris. The mucous membrane is reddened and swollen. Near the tip, there is a dark hemorrhagic area over which the mucosa is apparently ulcerated.

A long serial was cut through the hemorrhagic area, and shorter ones through other parts of the appendix. Altogether, 846 sections were examined.

Microscopical Examination.—Sections through the hemorrhagic focus show, at one point, an extensive extravasation of blood, with destruction of the overlying epithelium. On either side, the hemorrhagic excavates the mucous membrane for some distance, separating the lymphoid structures from the submucosa. Mixed with the blood there is considerable granular detritus, and occasional small bits of material resembling the outer cuticle of an oxyuris. There is no inflammatory reaction about the hemorrhage. The lymph follicles
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in all parts of the appendix are swollen. The submucosa, muscularis, and serosa show no changes.

Diagnosis.—Hemorrhages from the mucosa of the appendix due to Oxyuris vermicularis; acute catarrhal appendicitis.

Case 5.—W. A., male, 14 years. Operation, February 25, 1910.

The appendix is 7 cm. in length. It is slightly swollen. The serosa is injected. The lumen contains yellow fecal material in which is found one female oxyuris. The mucosa is swollen, and in several places there are small, dark red, eroded foci that resemble ulcers.

Serials were cut from various parts of the appendix, at sites of hemorrhagic foci. In all, 366 sections were studied.

Microscopical Examination.—The only changes found in the appendix are those that occur in the mucosa. The lymph follicles are swollen, and at many points there are extensive extravasations of blood into the follicles, some of which are in direct connection with the lumen of the appendix by means of slender sinuses. Small areas of necrosis occur in some of these hemorrhages. One ulcer is found extending down into the submucosa. There is no infiltration of leukocytes, but the tissue about it is rich in young blood vessels and has the appearance of granulation tissue.

Anatomical Diagnosis.—Hemorrhagic ulceration of the appendix due to oxyuris; healing oxyuris ulcer; acute catarrhal appendicitis.

Case 6.—J. D., female, 43 years. Operation, April 6, 1910.

The appendix is 6 cm. in length. It is slender, smooth, and pale. The lumen contains 6 pin-worms, 3 male and 3 female. The mucosa is pale. No hemorrhages. No ulceration.

Serials were cut through several different points. In all, 540 sections were studied. No oxyuris ulcerations are found. The mucosa contains many eosinophils, is absent in places, but the possibility of mechanical erosion cannot be excluded. The lymph follicles are swollen. The muscularis and serosa show, in places, groups of lymphoid and plasma cells. The lumen is larger than normally.

Anatomical Diagnosis.—Oxyuris in the appendix; acute catarrhal appendicitis.

Case 7.—M. H., female, 10 years. Operation, April 21, 1910.

The appendix is 5 cm. long. It is somewhat swollen. The serosa is smooth and injected. Right at the tip, 3 oxyurides are found, 2 males and 1 female. One of the males is attached to the mucosa, but while under observation is seen to free himself. The mucosa at the tip is reddened.

A complete serial section of the tip was cut, and shorter serials from various other parts of the appendix. Altogether, 422 sections were studied.

Microscopical Examination.—The mucosa is intact, except at the point where the male oxyuris was found attached to the mucosa. In this portion of the serial, cross sections of the parasite are seen lying free in the mucosa. At one point there is a fresh break in the epithelium, through which there is pouring out blood, rich in leukocytes (figures 1 and 2). This stream can be traced to the adjacent lymph follicle, in which there has occurred an extravasation of blood. There are small hemorrhages in some of the other follicles. All the follicles are swollen. The submucosa, muscularis, and serosa show no changes.
Diagnosis.—Puncture of the mucosa of the appendix by *Oxyuris vermicularis*; acute catarrhal appendicitis.

**Case 8.**—L., female, 6 years. Operation, May 20, 1910.

The appendix is 5 cm. in length, pale, but moderately swollen. The serosa is glistening. The lumen contains a small quantity of mucus in which there is found one male oxyuris, and a dozen or more ova of oxyuris. The mucosa is swollen, but smooth and pale. No hemorrhagic foci are found.

Serial sections were cut at different points, 456 sections being studied.

**Microscopical Examination.**—The mucosa is intact except at a few points where artificial breaks are seen. The crypts are filled with mucus. The lymph follicles are considerably swollen. The muscularis and serosa are normal.

Diagnosis.—*Oxyuris* in the appendix; acute catarrhal appendicitis.

**Case 9.**—M. L., female, 8 years. Operation, June 4, 1910.

The appendix is 5.5 cm. in length. It is somewhat swollen, but the serosa is smooth and pale. The vessels of the serosa are injected. The lumen is found filled with bloody mucus in which there are found pin-worms, 2 males and 2 females, all located in the proximal half of the appendix. The lumen is large in this region, and the mucosa of the proximal half shows several small hemorrhagic ulcerations.

A serial of 96 sections was cut through one of the hemorrhagic areas.

**Microscopical Examination.**—The mucosa is covered everywhere with mucus containing many red blood cells. At one point the mucosa is absent and is partially replaced by necrotic tissue, mucus, and red blood cells. The base of this ulcer is formed by the submucosa. There is no inflammation about the ulcer. The edges of the ulcer are considerably undermined, the necrosis extending along for some distance under the mucosa (figure 6).

A male oxyuris is found in the bed of another and similar ulcer.

Diagnosis.—Hemorrhagic ulceration of the appendix due to *Oxyuris vermicularis*; acute catarrhal appendicitis.

**Case 10.**—Female, 8 years.

The appendix is 6 cm. in length. The serosa is smooth and pale. Lying on the mucosa there are 5 pin-worms, 2 males and 3 females. Under two of the worms the mucosa shows hemorrhagic ulceration. One of the other parasites is firmly attached to the mucosa.

Three serials were cut, making a total of 608 sections examined.

**Microscopical Examination.**—Sections taken through the attached parasite show an adult female oxyuris invading the mucous membrane. The parasite has entered the mucosa through a small ulcer, and has burrowed out a deep sinus under the mucous membrane. There is a moderate amount of necrotic tissue about the worm, but no inflammatory change. At another point, a recent puncture wound is found, showing incipient destruction of the epithelium. The lymph follicles are large.

Diagnosis.—Ulceration of the appendix by *Oxyuris vermicularis*; acute catarrhal appendicitis.

**Case 11.**—K. K., female, 7 years. Operation, July 13, 1910.

The appendix is 4 cm. in length. It is swollen, reddened, and covered with fibrin. There are no perforations. On opening the appendix, 14 pin-worms,
Lesions Produced in Appendix by Oxyuris and Trichocephalus.

2 males and 12 females, are found in the lumen which is distended with foul smelling pus. There is a small fecal concretion in the central part of the appendix. The mucosa of the distal three quarters is gangrenous and ulcerated. That of the proximal one quarter is smooth and pale.

Serials were cut through both the gangrenous and non-gangrenous portions, 342 sections being examined.

Microscopical Examination.—Sections through the gangrenous part show extensive destruction of the mucosa, the necrosis in places invading the submucosa and muscularis. At one point the entire wall is gangrenous. There is a dense and widespread infiltration of all the coats with polymuclear leukocytes. The serosa is thickened and infiltrated with leucocytes, and has a deposit of fibrin upon it.

Sections through the non-gangrenous portion show an intact mucosa, moderate swelling of the lymph follicles, a normal muscularis, and considerable fibrous thickening of the serosa. No evidence of invasion by oxyuris.

Diagnosis,—Oxyuris vermicularis in the appendix; acute gangrenous appendicitis.


The appendix is 7 cm. in length. The proximal third is smooth and pale. The distal two thirds is swollen, reddened, and covered with fibrin. One cm. from the tip there is a perforation which readily admits a probe. On opening the appendix, the mucosa of the proximal third appears a little congested and swollen, but otherwise normal. The mucosa of the distal two thirds is greenish gray and gangrenous. Just proximal to the perforation, the lumen of the appendix is markedly diminished by thickening of its wall. At the tip, the lumen is dilated, and contains a small concretion. One male oxyuris is found lying free near the tip.

Serials were cut from different parts, 188 sections in all.

Microscopical Examination.—The mucosa is for the most part gangrenous. At one place, the necrosis involves the entire wall. All the coats are infiltrated with leukocytes, the polymorphonuclear type predominating in the mucosa, lymphoid cells and eosinophils in the muscularis. The serosa has been converted into a thick layer of granulation tissue. At several points there are pigmented foci in the gangrenous mucosa, but no definite oxyuris lesions are found in the sections examined.

Diagnosis.—Oxyuris vermicularis in the appendix; acute gangrenous appendicitis.

Case 13.—E. M., female, 14 years.

The appendix is 6.5 cm. in length. It is swollen, reddened, and covered with fibrin. At the juncture of the middle with the distal third of the mucosa there are one male and one female oxyuris lying free. The mucosa is reddened and shows superficial ulceration. There is no perforation.

Two serials were cut, 140 sections in all.

Microscopical Examination.—The mucosa has been in large part destroyed. The necrosis extends down into the submucosa at many places. The vessels are intensely congested. At one place the necrosis involves the muscularis. The serosa is thickened, and densely infiltrated with polymorphonuclear leukocytes. There is a deposit of fibrin on the serosa.
**Diagnosis.**—Oxyuris vermicularis in the appendix; acute gangrenous appendicitis.

**Case 14.**—J. D., male, 10 years. Operation, December 15, 1910.

The appendix is 7.5 cm. in length, swollen but pale. The serosa is smooth and glistening. It contains feces, mucus, and 19 pin-worms, 7 males and 12 females. The mucosa is injected but shows no ulceration. The worms are lying free.

Several serials were cut, 640 sections being studied.

**Microscopical Examination.**—The mucosa is intact and covered with mucus. The lymph follicles are swollen. The submucosa, muscularis, and serosa show no changes. No evidence of oxyuris invasion.

**Diagnosis.**—Oxyuris vermicularis in the appendix; acute catarrhal appendicitis.

**Case 15.**—M. L., female, 54 years. Operation, January 10, 1911.

The appendix is 8 cm. in length, and moderately swollen. The serosa is smooth, pale, and glistening. It contains 6 pin-worms, 3 males and 3 females. The mucosa is swollen and injected in places, but shows no ulceration.

A serial of 456 sections was cut.

**Microscopical Examination.**—The mucosa is intact. The lymph follicles are swollen and many eosinophils occur in the mucosa. The submucosa, muscularis, and serosa are normal.

**Diagnosis.**—Oxyuris vermicularis in the appendix; acute catarrhal appendicitis.

**Case 16.**—J., male, 37 years. Operation, January 13, 1911.

The appendix is 9 cm. in length, slightly swollen, but smooth, pale, and glistening. The lumen of the appendix contains mucus and 5 pin-worms, 3 males and 2 females. The mucosa is swollen and shows small red areas, but there is no visible ulceration.

Serials were cut from five different pieces, 540 sections being examined.

**Microscopical Examination.**—The mucosa is intact, but is covered in places by a layer of mucus, granular debris, and lymphoid cells. The follicles are swollen. The submucosa, muscularis, and serosa show no changes. No oxyuris lesions are found.

**Diagnosis.**—Oxyuris vermicularis in the appendix; acute catarrhal appendicitis.

**Case 17.**—M. D., female, 15 years. Operation, February 20, 1911.

The appendix measures 8 cm. in length, and is moderately swollen. The serosa is smooth, pale, and glistening. The lumen is filled with bloody mucus. The mucosa is swollen and marked by two small hemorrhagic foci. Right at the tip of the appendix, one female oxyuris is seen lying free on the mucosa.

Serials were cut of the tip, and also through the hemorrhagic foci. In all, 808 sections were examined.

**Microscopical Examination.**—Sections through the hemorrhagic foci show that the mucosa has been in part destroyed and its place taken by necrotic tissue in which red blood corpuscles and lymphoid cells occur. The necrosis extends down to the submucosa, and undermines the mucosa which still survives. There
Lesions Produced in Appendix by Oxyuris and Trichocephalus.

are no signs of cellular infiltration or repair about these lesions. The lymph
follicles are swollen. The submucosa, muscularis, and serosa show no changes.

Diagnosis.—Hemorrhagic ulceration of the appendix produced by Oxyuris
vermicularis; acute catarrhal appendicitis.

Case 18.—R. W., female, 23 years. Operation, February 20, 1911.
The appendix is 4 cm. in length, and is moderately swollen. The serosa is
covered with fibrous tags. The wall of the appendix is somewhat thickened.
The lumen is empty, except near the tip where there is some mucus that con-
tains 3 pin-worms, 2 males and 1 female. The mucosa is slightly injected, but
smooth and glistening.

Several serials were cut, 322 sections being examined.

Microscopical Examination.—In two of the serials, the lumen of the appendix
has been completely obliterated by a new growth of fibrous tissue. In others,
the lumen survives and the mucosa is intact, but there is a deposit of mucus and
lymphoid cells on it. The lymph follicles are swollen. The submucosa is
thickened and hyaline. The muscularis is normal. The serosa is thickened and
infiltrated in places with lymphoid cells.

Diagnosis.—Oxyuris vermicularis in the appendix; chronic obliterating ap-
pendicitis; acute catarrhal appendicitis.

Case 19.—M. J., male, 5 years. Operation, February 25, 1911.
The appendix is 5 cm. in length, considerably swollen, but pale and glisten-
ing. The lumen contains a small quantity of mucus and 7 male pin-worms. The
mucosa is swollen and shows several elevated hemorrhagic areas. The wall of
the appendix is thickened.

Serials were cut at several points, 408 sections being studied.

Microscopical Examination.—Sections through one of the hemorrhagic areas
show that at one point there is extensive extravasation of blood into a lymph
follicle. The epithelium is absent over this point and the hemorrhage extends
as far as the surface. The other follicles are greatly swollen.

On another section, a male oxyuris is found coiled up in a lymph follicle.
There is no inflammatory reaction whatever about the parasite. Still another
section shows a male oxyuris penetrating the mucosa through a narrow break in
the epithelium. The submucosa and muscularis are normal. The serosa is
moderately thickened.

Diagnosis.—Invasion of the mucosa of the appendix by Oxyuris vermicularis;
acute catarrhal appendicitis.

The appendix is 7.5 cm. in length, reddened, but smooth and glistening. The
lumen contains soft yellow feces, in which are found 2 pin-worms, 1 male
and 1 female. There is a small hemorrhagic ulcer in the mucosa, just beneath
the female. Elsewhere the mucosa is smooth, but swollen and marked by several
small hemorrhages.

Several serials were cut, 710 sections in all being examined.

Microscopical Examination.—The mucosa is intact. The lymph follicles are
swollen. The submucosa, muscularis, and serosa show no noteworthy changes.
The serosa is somewhat thicker than normally. No oxyurides are found.

Diagnosis.—Oxyuris vermicularis in the appendix; acute catarrhal append-
icitis.
Case 21.—H., male, 13 years. Operation, October 7, 1911.

The appendix is 7.5 cm. in length, swollen, and injected, but the serosa glistens. A female oxyuris is found in the lumen, about 1.5 cm. from the tip, with its head buried in the mucosa. At about the mid-point of the appendix there is a small hemorrhagic ulcer. Elsewhere the mucosa is smooth, swollen, and covered with mucus.

Two serials were cut, 603 sections being examined.

Microscopical Examination.—Sections through the foci above referred to show rather extensive extravasation of blood into the swollen lymph follicles, the blood at one point pouring out into the lumen through a break in the epithelium. The submucosa, muscularis, and serosa are normal.

Diagnosis.—Puncture of the mucous membrane of the appendix (with hemorrhage) by Oxyuris vermicularis; acute catarrhal appendicitis.

Case 22.—T. L., male, 7 years. Operation, May 26, 1910.

The appendix is 5 cm. in length, swollen, rigid, intensely reddened, and covered with a fibrino-purulent exudate. Near the tip there is a small perforation surrounded by a zone of necrotic tissue. On opening the appendix, a small fecal concretion is found at about the mid-point of the organ. Proximal to the concretion, the mucosa is smooth and pale. Distal to the concretion and surrounding it, the mucosa is gangrenous. Immediately proximal to the concretion one Trichocephalus dispar is found firmly attached to the preserved portion of the mucosa.

A serial was cut through the point where the parasite was attached, another one through the gangrenous portion, 388 sections being examined.

Microscopical Examination.—Sections through the non-gangrenous part show the mucosa intact, except at one point where the superficial columnar epithelium is reflected over the cross section of a trichocephalus. There is no inflammatory change and no hemorrhage. All the lymph follicles are swollen, however. The muscularis contains many eosinophils. The serosa is congested and infiltrated with lymphoid cells. There is a deposit of fibrin on the surface.

Sections through the gangrenous part show complete destruction of the mucosa. In some places the necrosis involved the entire wall of the appendix. All coats are densely infiltrated with polymuclear leukocytes. The serosa has been converted into a thick layer of granulation tissue, on the surface of which there is a deposit of fibrin.

Diagnosis.—Invasion of the appendix by Trichocephalus trichiura; acute gangrenous appendicitis.


The appendix is 5 cm. in length. It is swollen and congested. The serosa is somewhat thicker than normally, but otherwise shows no significant changes. On opening the appendix, the mucosa is swollen but smooth. Near the base there is a Trichocephalus dispar firmly attached by its head to the mucosa. There is little or no reaction about the point of its attachment.

A serial was cut through the point where the worm was attached. Altogether, 216 sections were examined. A few sections were also taken through the tip.

Microscopical Examination.—Sections through the point of attachment of the parasite show sections of the parasite just beneath the columnar epithelium.
Lesions Produced in Appendix by Oxyuris and Trichocephalus.

One section shows the epithelium reflected over the parasite, which has apparently affected a break in the epithelium, and has then burrowed along just beneath it (figure 8). There is no inflammatory reaction about the lesion. The lymph follicles are moderately swollen. The submucosa is normal. The muscularis contains a moderate number of eosinophils. The serosa is infiltrated with lymphoid cells and eosinophils.

Diagnosis.—Invasion of the mucosa of the appendix by Trichocephalus trichiura; acute catarrhal appendicitis.

Autopsy Case 1.—B. H., male, 3 years. Cause of death, meningitis.

The appendix measures 5 cm. in length, and is slender and pale. The serosa is smooth and glistening. The lumen contains a small quantity of soft feces in which are found 3 male oxyurides. The mucosa is smooth, pale, and free from swelling.

A serial of 96 sections was cut at about the middle point.

Microscopical Examination.—The mucosa is intact. The lymph follicles are swollen. The submucosa, muscularis, and serosa are normal.

Diagnosis.—Oxyuris vermicularis in the appendix; hyperplasia of the lymph follicles.

Autopsy Case 2.—Male, 10 years. Cause of death, diphtheria.

The appendix is 8 cm. in length, slender, smooth, and pale. The serosa glistens. The lumen contains soft yellow feces, in which are seen 2 pin-worms, a male and a female. The mucosa appears normal.

A serial of 88 sections was cut at the point where the parasites were located.

Microscopical Examination.—The mucosa shows some autolysis, but there are no pathological changes. The submucosa, muscularis, and serosa are normal. The lymph follicles are large.

Diagnosis.—Oxyuris vermicularis in the appendix; hyperplasia of the lymph follicles.

Autopsy Case 3.—A., female, 3 years. Cause of death, measles.

The appendix measures 4 cm. in length. It is slender and pale, and apparently normal. The lumen contains 2 oxyurides. The mucosa shows no changes.

A serial of 108 sections was cut through a portion of the appendix lying just beneath one of the parasites.

Microscopical Examination.—The mucosa is everywhere intact. Many goblet cells are seen. The lymph follicles are large. The submucosa, muscularis, and serosa are normal.

Diagnosis.—Oxyuris vermicularis in the appendix; hyperplasia of the lymph follicles.

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FIG. 7.

FIG. 8.
8. Oelnitz, Cong. de gynéc., d’obst., et de pédiat., Nantes, 1901, Session of September 27th.
15. von Moty, Echo méd. du nord, 1902, vi, 217.

EXPLANATION OF PLATES.

PLATE 32.

Fig. 1. Case 7. Superficial puncture of the mucosa of the appendix by a male oxyuris. A small blood clot is seen protruding through a break in the mucosa. Cross sections of the oxyuris in the lumen. X 107.

Fig. 2. Case 7. The same lesion, highly magnified. The structure of the clot is well shown. X 320.

PLATE 33.

Fig. 3. Case 3. A male oxyuris, invading the mucosa. Early stage. X 107.

Fig. 4. Case 2. Invasion of a lymph follicle by a male oxyuris. Note the entire absence of inflammatory changes about the parasite. X 107.

PLATE 34.

Fig. 5. Case 1. Characteristic undermining of the mucosa by a male oxyuris. Necrosis but no inflammation. X 107.

Fig. 6. Case 9. A typical oxyuris ulcer, filled with blood and necrotic tissue. The necrosis undermines the sound mucosa for a short distance. X 107.

PLATE 35.

Fig. 7. Case 2. Hyaline oxyuris completely encapsulated by fibrous tissue. A healed oxyuris lesion. X 107.

Fig. 8. Case 23. Trichocephalus invading the mucosa. The parasite is burrowing along beneath the columnar epithelium which is shown reflected over it. No inflammatory changes. X 107.