1986

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J. Kevin Baird
ALERTAsia Foundation, jkevinbaird@yahoo.com

M. Mistrey
University of Natal

M. Pimsler
Divisions of Geographic Pathology and of Microbiology and Immunology, Department of Infectious and Parasitic Disease Pathology, Armed Forces Institute of Pathology, Washington, DC

D. H. Connor
Divisions of Geographic Pathology and of Microbiology and Immunology, Department of Infectious and Parasitic Disease Pathology, Armed Forces Institute of Pathology, Washington, DC

Am. J. Trop. Med. Hyg., 35(2), 1986, pp. 314–318

FATAL HUMAN ASCARIASIS FOLLOWING SECONDARY MASSIVE INFECTION

J. K. BAIRD, M. MISTREY,* M. PIMSLER, AND D. H. CONNOR
Divisions of Geographic Pathology and of Microbiology and Immunology, Department of Infectious and Parasitic Disease Pathology, Armed Forces Institute of Pathology, Washington, DC 20306-6000 and
**Department of Pathology, University of Natal, P.O. Box 17039, Congella 4014 Natal, Republic of South Africa*

Abstract. More than 796 *Ascaris lumbricoides* worms weighing 550 g were recovered at autopsy from a 2-year-old black South African girl. Most of the worms were taken from necrotic small intestine, but worms were also in the stomach, esophagus, intrahepatic and extrahepatic bile ducts, and gallbladder. The worms had caused torsion and gangrene of the ileum, which was interpreted as the cause of death. Worms were formalin-fixed and individually weighed. There were 796 intact worms and 112 appreciably large (>0.2 g) fragments of worms. Statistical analysis of the weights revealed 2 distinct populations of worms: 16 large worms (0.5–2.3 g) and 778 small worms (0.03–0.95 g). The difference in weight between these 2 groups of worms was significant (male and female worms treated separately; $P < 0.05$ to $P < 0.001$). These observations reveal that the patient acquired a massive and fatal infection with *A. lumbricoides* while hosting a relatively light worm burden.

Massive infection by *Ascaris lumbricoides* invariably causes serious complications that may require surgical intervention or chemotherapy.[1] The most common of these complications is intestinal obstruction of the small bowel by a bolus of worms.[2–4] A survey of 3 rural hospitals in Louisiana revealed an incidence of 2 intestinal obstructions per 1,000 patients with ascariasis.[2] Thus, ascariasis may create a serious public health problem in some areas.[2,4,5]

Ascariasis in humans is a consequence of ingestion of *A. lumbricoides* eggs containing infective larvae. The ascarid of the pig, *A. suum,* also causes ascariasis in humans. Eggs of *A. lumbricoides* develop infective larvae after deposition in appropriate soil. Ascariasis is acquired through ingestion of egg-laden soil or food. The number of eggs ingested is believed to be directly proportionate to the number of adult worms in the lumen of the small intestine approximately 60 days later. The usual number of naturally acquired adult *A. lumbricoides* per human host is less than 15.[5,6] The number of worms reported as causing intestinal obstruction varies widely—from 4 worms in a 45-day-old infant[7] to as many as 1,800 in a young woman.[8] In general, patients with serious complications have 50–500 worms. Infants and children tolerate fewer worms than fully grown people. Young children (1–5 years old) are most frequently infected because of their tendency to indiscriminately place things in their mouths.[9,10]

In reviewing 7 cases of massive infection with *A. lumbricoides,* Jung reported populations of worms that were uniformly small in size.[11] This finding suggested that the infections were acquired through ingestion of a large number of infective worms at once, or repeatedly over hours or within a day or two. Jung referred to these as "single-brood" infections. He also suggested that the uniform absence of pre-existing *A. lumbricoides* infections in the 7 patients indicated that a normal worm burden may confer protection to the host from subsequent infection, even an extraordinarily large number of secondary invaders.

In the present report we describe fatal ascariasis in a 2-year-old South African girl. Statistical analysis of the worm weights of the specimens suggests that a massive infection with *A. lum-*

Accepted 28 October 1985.

Address reprint requests to: Dr. D. H. Connor, Chairman, Department of Infectious and Parasitic Disease Pathology, Armed Forces Institute of Pathology, Washington, DC 20306-6000.

bricoides was acquired subsequent to a pre-existing infection with an ordinary number of adult worms.

CASE REPORT

Clinical findings

A 2-year-old black African girl presented clinically with malaise, abdominal distention, and nontender palpable worm boluses. She had rapid respiration (44/min), bilateral crepitations, and rapid pulse (112/min). On the previous day the child had vomited a worm. On the day of admission she began gasping, suffered respiratory failure, and died.

Autopsy findings

Autopsy 3 days postmortem revealed a massive infection with *Ascaris* worms. A total of 796 intact worms and 112 worm fragments were recovered (Fig. 1). Worms and worm fragments weighed 550 g. Many worms were in the stomach and esophagus. No worms or other obstructions were in the air passages. Solitary worms were in the intrahepatic and extrahepatic bile ducts and gallbladder. There were boluses of worms in the ileum, where they had caused volvulus and infarction. Lungs, meninges, and spleen were congested. Mesenteric lymph nodes were fleshy, and some were infarcted. There was focal peritonitis adjacent to infarcted ileum.

WORMS

Specimen preparation

Worms recovered at autopsy were rinsed with tap water and buffered formalin. Worms were stored in buffered formalin for about 3 months, and then they were individually weighed. The worms were grouped by gender and weight into jars. Each jar contained a 0.10 g weight interval of worms up to 2.4 g. Histologic and taxonomic studies were conducted according to the sex/weight groups. Selected worms were cut into segments, embedded in paraffin, cut at 5 μm, and stained with hematoxylin-eosin.

Statistical analysis

Histograms in Figures 2 and 3 illustrate the weight distributions of male and female worms.

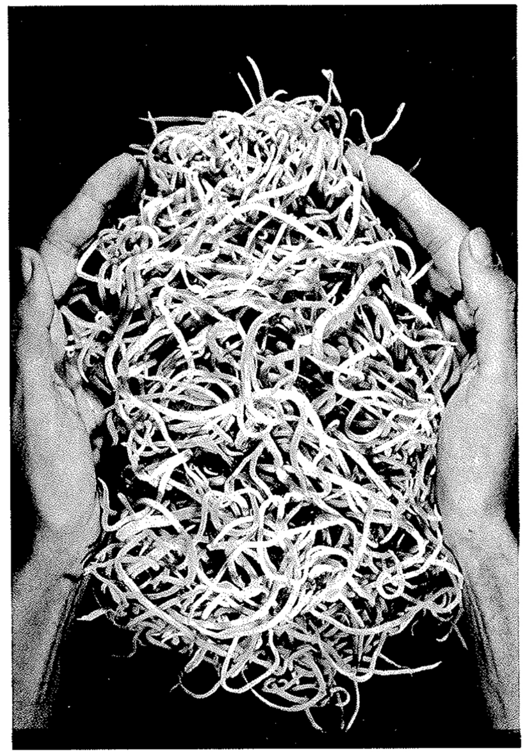

FIGURE 1. Worms recovered from necrotic small intestine, stomach, esophagus, intrahepatic and extrahepatic bile ducts, and gallbladder of a 2-year-old black South African girl.

In both figures it is evident that a small number of worms weighed appreciably more than the majority of worms. In both populations the largest worm was 6 standard deviations from the mean (see Fig. 4). An analysis of variance (ANOVA) *t*-test[12, 13] indicated that the largest worm that could be considered (with a 95% level of confidence) a member of the same population of worm weights was 0.48 g for male worms and 0.95 g for female worms. Conversely, the probability (P) that the male worm weighing 0.52 g or the 2 female worms weighing 1.10 g belong to their respective worm weight populations was less than 5%. This probability decreased with increased worm weight to much less than 0.01%. An ANOVA F-test comparing the aberrantly heavy worms as a group against the population of smaller worms (male worms <0.5 g; female worms < 1.0 g) indicated that P was again less than 5%. These results indicate that the 6 male and 10 female worms >0.5 g and >1.0 g, respectively, were significantly ($P < 0.05$) larger

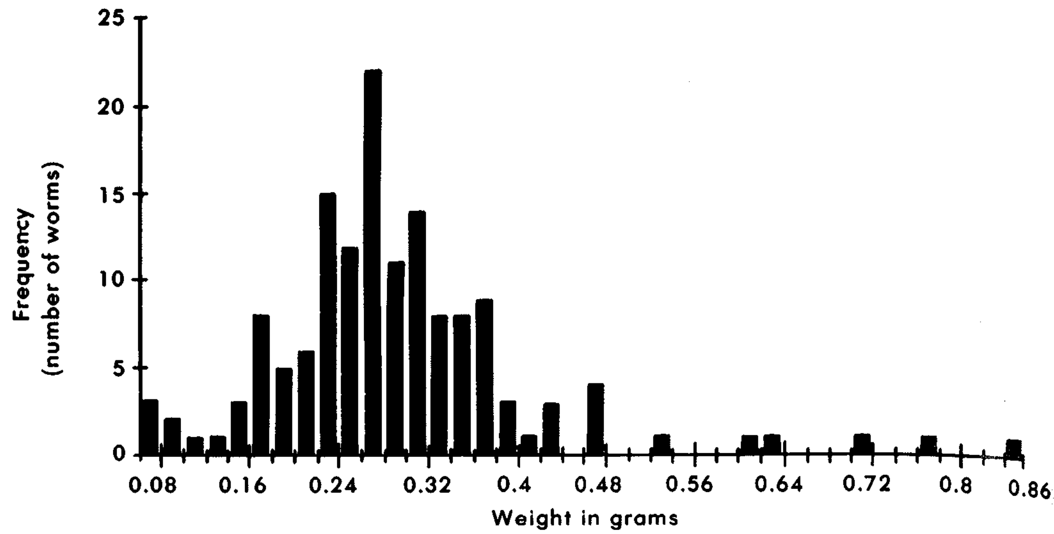

FIGURE 2. Distribution by weight of 145 male *Ascaris* worms recovered at autopsy of a 2-year-old black South African girl. Each bar represents the frequency of worms in a 0.02 g-interval weight class.

than the remaining worms. For comparison, the largest female worm was photographed with the smallest and mean weight female worms (Fig. 4).

Sexual maturity

Male worms >0.5 g were sexually mature. Female worms >1.0 g were gravid. All male worms <0.5 g were sexually mature, except for 2 of 3 worms <0.1 g. Almost all female worms <0.2 g were immature. Female worms <1.0 g and >0.2 g were mature and about two-thirds were gravid.

Taxonomy

Worms were identified as *Ascaris*.[14] We attempted to rule out *A. suum*. Examination by scanning electron microscopy of the ridges of

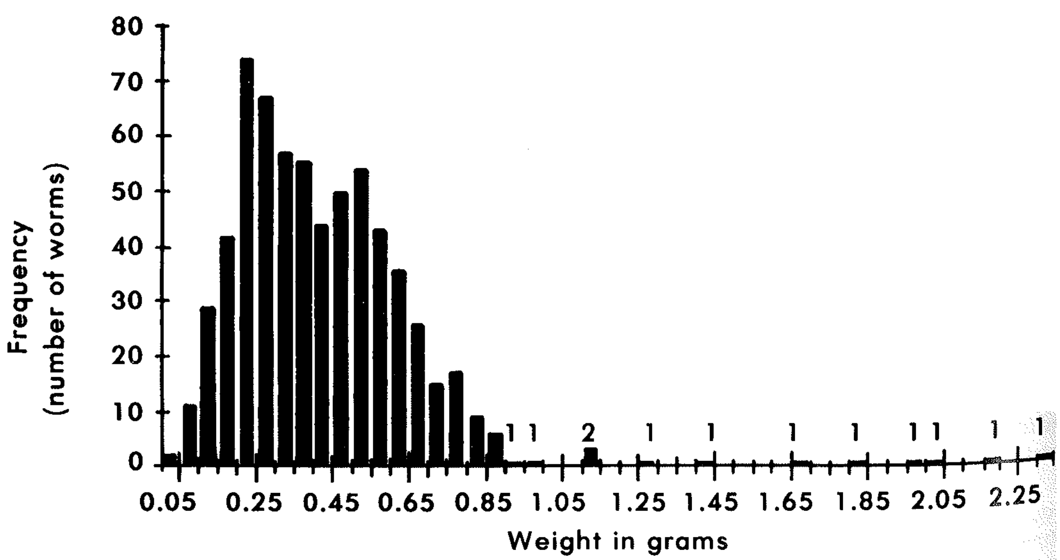

FIGURE 3. Distribution by weight of 651 female *Ascaris* worms recovered at autopsy of a 2-year-old black South African girl. Each bar represents the frequency of worms in a 0.05 g-interval weight class.

denticles on the interior aspect of the lips of these specimens failed to reveal consistent differences upon which *A. lumbricoides* could be differentiated from *A. suum.*[15–18] The criterion of denticle shape (straight vs. convex-sided) showed inconsistencies not only within the same weight class, but also on the same dentigerous ridge; both straight and convex-sided denticles were observed. The differences in denticle shape appeared to depend upon worm size; the largest worms had low, rounded nubs as denticles, whereas the smallest worms had sharp, well-defined triangular denticles. A pattern of denticle wear such as this may explain the repeated findings of consistent differences in denticle shape between *A. lumbricoides* and *A. suum.*[15–18] The ascarid of the pig is smaller and shorter-lived in humans than is *A. lumbricoides*[19] and would thus possess more triangular denticles. A similar pattern of wear was observed by scanning electron microscopy of *A. suum* of known age.[20] For lack of morphological evidence it is difficult to attribute this infection to *A. lumbricoides.* However, the fact that the ascarid of the pig reproduces poorly in humans[21] persuaded us that the worms in this little girl were *A. lumbricoides.*

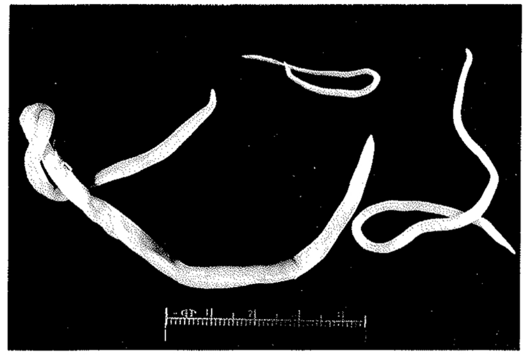

FIGURE 4. Photograph illustrating the largest, smallest, and mean weight female worms.

DISCUSSION

Massive infection with *A. lumbricoides* with a pre-existent infection has not been reported. The frequency of secondary massive infection is unknown because measurements of ascarid worm populations recovered after chemotherapy, surgery, or autopsy are rarely reported. Published descriptions of worm populations indicate that most massive infections with *A. lumbricoides* consist of a single brood of worms.

Reports of worm sizes in experimental and naturally acquired ascariasis demonstrate that individual worm populations are uniform in weight and/or length. We calculated size distributions of worm populations described elsewhere[11, 21, 22] and found the size distribution of the worms we studied to be extraordinarily wide. However, when the male and female worm populations were separated where the statistical analysis indicated, size distributions were in agreement with those of reported worm populations from humans. This indicates that most naturally acquired infections do not possess a small number of larger worms and supports our contention that the patient hosted an ordinary worm burden when she acquired her fatal infection.

The predominance of single-brood infections with human ascariasis reported by Jung[11] suggested that pre-existent infection with *A. lumbricoides* may prevent development of worms that subsequently infect the host. Similarly, studies conducted by Cort and Otto[23–25] demonstrated that chemotherapeutic clearance of established *A. lumbricoides* was rapidly followed by reinfection. Their findings indicated that although humans in endemic areas were continually ingesting infective eggs, successful development of the worms to egg-producing adult worms depended upon the absence of an established infection in the small intestine. The populations of worms studied by Jung[11] suggest that the hypothesized protective effect may be sufficient to ward off even massive infection by *A. lumbricoides.*

Why this protective effect failed in this little girl is not clear. If the protective effect of an extant worm population against subsequent invaders is mediated through the host immune system, perhaps the host in this particular instance was immunocompromised and thus open to massive infection while hosting a supposedly protective worm burden. Studies of pigs conducted by Beaver[26] demonstrate that there is precedence for multiple-brood *Ascaris* infections.

Whether the worm infection described here is rare or common is of secondary importance to the hypothesis proposed by Jung,[11] which is that the presence of a normal worm burden may serve to protect the host from subsequent life-threatening massive infection. Paradoxically, chemotherapeutic clearance of *A. lumbricoides* may predispose to massive infection with the worm. If this is true, then large scale deworming programs to alleviate malnutrition may lead to an increase in the incidence of massive infection.

ACKNOWLEDGMENTS

The authors thank Dr. Dean Gibson, HM2 David Smith (USN), and HM2 David Rainey (USN) for their assistance in the arduous task of weighing and measuring each worm.

The views of the authors do not purport to reflect the positions of the U.S. Navy, U.S. Air Force, U.S. Army or the U.S. Department of Defense.

This work was supported in part by the World Health Organization Collaborating Centre for the Histopathology of Filarial Diseases of Man.

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