ORIGINAL RESEARCH PAPER

Microbiology

HOOKWORM ANAEMIA IN CHILDREN.

KEY WORDS: Anaemia; Children; Hookworm.

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ABSTRACT

Anaemia is thought to affect the health of children in more than 900 million children worldwide. One of its main causes is parasitic infection mostly hookworm infections. Children with malnutrition are more vulnerable to parasitic infection. The hookworm infections can be seen in different stages of life and more common in young children. Laboratory diagnosis plays a crucial role in identifying the eggs from the stool samples and complete blood count to rule out anaemia from the blood samples. Timely diagnosis of anaemia and identification of hookworm eggs can improve the benefits of deworming and control of anaemia. Conclusively, personal hygiene and education is important for the control of hookworm anaemia among the children. The aim of this review is to make the better understanding of the hookworm anaemia in children which is most neglected in the developing countries. A Pub Med bases/relevant literature was search using the keywords hookworm and anaemia in children associated with parasitic infections.

Introduction:

Hookworm infections are one of the important causes of iron deficiency anaemia in children and are wide spread globally. It is also one of the most important parasitic diseases in human in terms of Disability Adjusted Life Years DAILYs, followed by Schistosomiasis, African trypanosomiasis, Chagas diseases and Leprosy.[1] Children can be infected with hookworm as young as 6 months old and higher prevalence rates are shown in the age group of 6 to 10 years [2]. Hookworm infection is more common in children, due to their behavioural pattern which may include close contact with household pets, playing with the bare foots, frequently contact with pollutes soil and less care of the hygiene. Human infection is primarily caused by two species namely Ancylostoma duodenale and Necator americanus, which belong to family Ancylostomatidae. Geographic distribution of A. duodenale is mainly in Middle East, North Africa, India, Australia and Europe. N.americanus is more common in the Western Hemisphere, Sub-Sharan, Eastern Asia and South East Asia [3]. In India, N. americanus is predominant in South India & A.duodenale in North India [4]. They are the soil-transmitted helminths (STHs) responsible for an estimated 900 million hookworm infection worldwide, N. americanus (835 million) & A.duodenale (135 million). More than 200 million people in India are estimated to be infected. Approximately, 400 million children worldwide are infected with intestinal parasites and compromised by anaemia which gives negative effects on growth, iron status, irritability & cognitive impairment to increase susceptibility to other infection and acute complications. In school going children which leads to attention deficits, learning disabilities, school absenteeism and the higher dropouts' rates [5].

Hookworm anaemia:

The infection of hookworm occurs when the adult parasites causes intestinal blood loss, which leads to cause iron deficiency anaemia. Hookworm increases the risk of anaemia in children, when there is the greatest physiological demand for iron during their growth time [6].

Hookworm anaemia is due to the iron deficiency and microcytic, hyprochromic anaemia which is due to the chronic blood loss and nutritional deficiency [7]. Iron deficiency anaemia (IDA) usually developed with prolong infection, especially with A.duodenale. However, N.americanus is more widespread worldwide; therefore it is more significant as a cause of disease burden [8]. Nutritional undertone with lead to the anaemia in children is mainly due to the deficiency of iron, folic acid, B-complex and protein [9]. Anaemia is defined by World Health Organisation (WHO) as a haemoglobin concentration below 11 g/dl for children (0.5-5 years) and 12g/dl for older children (12-15 years) [10]. Anaemia, when caused by severe iron deficiency is termed Iron deficiency anaemia (IDA). Chronic anaemia is associated with behavioural disturbance in children as a result of impaired neurological development in infants [11]. There are several factors which the amount of blood loss depends which include the number of worm load in the intestine and species involved. Among the species, A.duodenale causes more blood loss than N. americanus. It has been estimated that a single A.duodenale worm ingests about 150 µl (0.15 ml) of blood per day and N.americanus worm about 30 µl (0.03ml). Haemoglobin concentration falls as intensity of infection rises [10]. Depending on the status of host iron, a hookworm burden (intensity of infection) of 40 to 160 worms per individuals is associated with haemoglobin level before 11g per decilitres [12]. The World Health Organisation defines moderate intensity infections as those with 2000-3999 eggs per gram of feces and heavy intensity infections as those with 4000 or more eggs per gram [13].

Blood loss starts when the worm attached themselves to the intestinal mucosa, sub mucosa and contract their muscular oesophagi to create negative pressure, which suck a plug of tissue into their buccal capsule. The mouth of A.duodenale is large and teeth like structures whereas that of N.americanus has cutting plate [8]. By the action of the hydrolytic enzymes capillaries & arterioles are ruptured completely [14]. Therefore symptoms in the intestinal phase are caused by necrosis of the intestinal tissue and blood loss. Then the adult worm release anticoagulant Xa and VIIa/TF inhibitor, and a platelet agent to maintain free blood flow throughout the alimentary canal [15]. The hookworm ingests a portion of the extravasated blood and some red cells undergo lyses. The free haemoglobin is digested through the action of asparte-cysteine and metallo-haemoglobin [16]. Hookworm feeding activity also causes a loss of blood plasma and its constituents into the guts and in heavy infections hypoalbuminaemia may develop.

Table.I: Differences between the *N.americanus* & *A.duodenale* in terms of biological and host blood loss. [19,20,21,22,23]

Characteristics	N.americanus	A.duodenale
Size	Smaller and slender	Large and thick
Rate of egg production	3000-6000	10,000-20,000
Life expectancy of infective larvae, L3(days)	3-5	1
Life expectancy of adult worm (years)	3-10	1-3
Intestinal blood loss(ml) worm/day, mean(range)	0.03(0.01-0.04)	0.15 (0.14-0.30)
Number (range) of worm causing Blood loss 1ml/day	25(14-50)	5 (4-7)
Blood loss (ml/day) per 1000epg stool	1.3 (0.82-2.24)	2.2 (1.54-2.86)
Iron loss (mg/day) per 1000 epg stool	0.45	0.76
Worm burden responsible for 1000 epg stool	32	11
Lactogenic transmission	No	Yes
Oral transmission	No	Yes

Life cycle of hookworm:

Human acquire hookworm when the third-stage filariform larva or L3 in the soil either penetrate through the skin (N.americanus & A.duodenale) or when they are ingested (A.duodenale). The transmission has been reported through transmammary & in utero routes (in rare cases). The L3 stage of N.americanus, invaded the buccal epithelium, if they are ingested orally. Hookworm can live in the soil for week to precede further development of which each larva approximately 600μm in length, under the favourable conditions such as warm temperature, shade and moisture. After the penetration, the larva resumes the development and starts secrete bioactive polypeptides and proteins [17]. The important protein secreted are metalloprotease of the astacin class (containing Zinc) and ancylostoma secreted protein (cysteine rich) which believed to have a role in tissue invasion & host immunomodulation [18]. The L3 enters the subcutaneous venules, then to the right side of the heart and then to the pulmonary vasculature which goes into the lung capillaries. The larva rupture and enter the lungs parenchyma, where they ascent the alveoli, bronchioles, bronchi and trachea when they are coughed and swallowing of sputum .The L3 undergo third molt either in the migratory phase or on reaching oesophagus to form L4 and reached the small intestine to undergo final molt and develop into an adult worm which takes approximately 5-8 weeks. Intestinal blood loss begins just prior to egg production, deposition & continues for the life of the hookworm.

Risk factors:

1. Socio –economic factors:

Hookworm infections are mainly because of the contamination of food and water by the hookworm's eggs. Poor personal hygiene, household sanitation & the higher contact rates with wildlife & domestic animals reservoirs of infection are the main risk factors. It is also reported that the infection is more in the farmer's family and using widespread of faeces as a night soil fertilizers. In India, the heavily infected areas are Assam (Tea gardens), West Bengal, Bihar, Odisha, Andhra Pradesh, Tamil Nadu, Kerala and Maharashtra [4].

2. Climate & environmental factors:

Hookworm required soil for the embryonation till the infective larval stages, therefore the rate of development & survival are depending on the humidity, warm & ultra-violet light. This is the reasons for the variation of species transmission in different geographical regions. The factors influenced are rainfall, soil type and altitude [24]. The amount of rainfall (40 inches & above) is important both spatially and temporally because hookworms are unable to survive desiccation. The influence of climate on hookworm transmission was reviewed by Chandler, given that 20-30°c was optimal for transmission [25].

Diagnosis:

Specific identification and differentiation of hookworm species is important for the proper diagnosis in children in both communities and in school for monitoring the efficacy of mass & effective treatment. For the treatment purposes, the drugs of choice are similar, however the severity of anaemia differs depending on the different species & worm load in the intestine, the accuracy of diagnosis must be consider for the rational design of control strategies.

Most diagnosis of hookworm at present is based on the use of conventional microscopic method (gold standard) for the detection of eggs in the faecal samples using saline and iodine mount. Also stool concentration techniques enhance the recovery of egg from the stool samples. However, microscopic alone cannot differentiate between the hookworm eggs and other similar species like strongyloid nematodes [28].Therefore various coprocultures techniques are employed to obtain the filariform larva to differentiate between the A.duodenale & N.americanus. However the limitation of the coproculture is that, diagnosis depends on the availability of fresh stool samples; easily contamination with other microorganism and also need well trained staff to expertise it. Also various methods are used for egg count (number of eggs per gram of stool) to identify the worm burden and intensity of the infection.

To overcome all this limitation, molecular techniques is the alternative to it. It is based on their DNA sequence, in conjugation with the identification of taxonomic groupings & classifications of phylogenic relationship [12].

Complete blood count is necessary to rule out anaemia. Mean corpuscular haemoglobin concentration (MCHC) below 30% in the presence of microcytosis and hypochromic is the strong indication of definite iron deficiency and Mean corpuscular haemoglobin concentration (MCHC) between 30 and 32% in the presence of low haemoglobin should be consider for the possible cause of iron deficiency [26]. Leishman's stain preparation also can look for the presence of microcytic and hypochromic anaemia and to exclude sickle-cell anaemia.

Control measures:

Accurate surveys of the distribution & extend of infection is essential for monitoring the programs & effectiveness of the chosen strategy. For this epidemiological research are important, which led to improve understanding of how hookworm are transmitted & how their number are neglected with the host both in individuals & in communities & how the population dynamics may be distributed for purposes of control. It is also important to know the incidence rates fall as the transmission co-efficient decline with improvements in socio-economic condition, personal & environmental hygiene as well as the reduction in the number of infected person after treatment. Since the hookworm infection has the high transmission potential, it is difficult to eradicate in the communities, however because of its direct life cycle in the soil without the intermediate host and not replicate in human, transmission can be interrupted by improving personal hygiene, proper sanitation, wearing shoes & educating people and parents for the younger children's. Also, chemotherapy programmes with antelminthic drugs in school and in communities has greatly beneficial to reduce morbidity. Four antelminthic drugs are available for the treatment of hookworm: albendazole, lavamisole, amebendazole and pyramental pamoate. Albendazole & mebendazole are provided as single-dose tablets are more effective and used in most control programmes.

Conclusion:

Anaemia in children is a worldwide public health problem with the prevalence rate of 24.8% & almost half of school age children are affected. Since the hookworm infection is caused mainly due to the poverty & poor sanitation, it is important to give health-related benefit which includes personal hygiene & proper nutrition in children. Long term programme, including deworming, regular treatment & early diagnosis will contribute to the affected children.

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