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Progress of Study on Waterborne Giardiasis

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Abstract: Giardia was a cosmopolitan enteric protozoan with a very wide host range, including domestic and wild animal species, as well as human beings. The parasite transmitted by the water route including drinking water sources and has become the most frequently identified cause of waterborne disease. The most prominent symptoms of giardiasis were diarrhoea, abdominal pain, nausea, vomiting, flatulence, and fever. Taxonomy, epidemiology, detection methods of Giardia were presented in this paper. The objectives would be to provide early warning system to permit the possibility for fast response in a risk situation in order to prevent outbreaks of giardiasis through drinking water in the human population.

Keywords: Waterborne; Giardiasis; Drinking Water Sources

水源性贾弟虫病(giardiasis)研究进展

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摘　要：贾弟虫(*Giardia*)是一种世界性分布的体内寄生原生动物，可感染家畜、野生动物和人类。该虫可通过饮用水源等水体传播，其所导致的贾弟虫病(giardiasis)是最频发的水源性疾病之一，典型症状是腹泻、腹痛、反胃、呕吐、胃胀和发烧。本文综述了贾弟虫的分类、流行病学和检测方法等，目的是提出疾病预警系统，建立快速响应机制，以防止饮用水中贾弟虫病爆发。

关键词：水源性；贾弟虫病；饮用水源

1. 引言

1681 年，Van Leeuwenhoek 首次发现了一种寄生虫，后来为了纪念 Giard 教授而将其命名为贾第虫(*Giardia*)[1]。贾弟虫是一种原生动物，可导致胃肠疾病，呈世界性分布，约有 90%贾弟虫病(giardiasis)通过水体(水库、井水、河水、湖泊、娱乐用水和泳池水等)传播，导致人类、家畜和野生动物发病，并常与隐孢子虫(*Cryptosporidium*)并发[2-4]。人或动物饮用含动物粪便的水,即可能感染贾弟虫病[5]。贾弟虫是人类胃肠病最常见的原虫病原，尤其是在农村地区可导致群体性发病事件，每年约有 5 万人口因水源性疾病而死亡[6-10]。因此，贾弟虫病的研究显得十分重要。

本文综述了水源性贾弟虫病的国内外研究概况包括：分类地位、种类、流行病学和检测方法等，以期为我国贾弟虫研究提供一定的理论基础。尤其是在饮用水源方面，能全面了解贾弟虫的生物学、遗传学特性和流行病学，找到去除方法，为我国建立有效的贾弟虫监测手段，制定水源地管理措施，保护水质安全和人群健康提供科学依据。

2. 分类地位及种类

按早期简单的形态学系统发生分析，贾第虫隶属于肉足鞭毛门(Sarcomastigophora)、鞭毛虫亚门(Mastigophora)、动鞭毛纲(Zoomastigophorea)、双滴虫

目(Diplomonadida)、六鞭毛虫科(Hexamitidae)[11]。后来，按遗传学、形态学等综合分析，贾弟虫隶属于后滴虫门(Metamonada)、多鞭毛虫亚门(Trichozoa)、双滴纲(Trepomonadea)、挛虫亚纲(Diplozoa)、贾弟虫目(Giardiida)、贾弟虫属(Giardiidae)[12]。目前，主要有 6 种贾第虫：*G. duodenalis* (*intestinalts*, *lamblia*)、*G. agilis*、*G. muris*、*G. psittact*、*G. ardeae* 和 *G. micrott*[13]。

3. 流行病学

3.1. 贾第虫的生物学特性

贾第虫是一类寄生于人类和动物肠道的原生动物。在人体中，可寄生于小肠、胆囊，主要在十二指肠，可引起腹痛、腹泻和吸收不良等症状，为人体肠道感染的常见寄生虫之一[14]。

蓝氏贾第虫(*G. duodenalis*)的生活史，包括营养体和孢囊两个阶段[15]。营养体主要见于十二指肠，孢囊主要见于大肠和粪便中。大小长约 12~15 μm，宽约 6~8 μm。营养体通过纵向二分裂进行繁殖，通过孢囊感染新的宿主。孢囊呈卵圆形，大小长约 8~12 μm。由于种类不同，贾第虫的直径大小也不等，一般为 7~10 μm.。孢囊壁厚度为 0.3~0.5 μm，电镜照片显示其由含有颗粒的细丝组成。在脱囊后，有机体要经历 5~30 分钟的原浆移动，因此，每个孢囊会产生两个营养体。一般认为，蓝氏贾第虫致病量为 50~100 个孢囊，但也有 10 个或者更少孢囊致病的报道[16]。蓝氏贾第虫可通过动物传播，尤其是饮用水源中的水生动物。

3.2. 贾第虫的传播及危害

贾弟虫的孢囊可通过粪便在人与人、动物与人之间传播，也可通过水体(饮用水、娱乐用水和泳池水等)和食品传播[17-19]。

贾弟虫在粪便中可以存活 12~19 天，症状出现在感染后 1~75 天，尤其是 6~15 天内[20,21]。最典型的症状是腹泻、瘦弱、腹痛、反胃、呕吐、肠胃气胀和发烧。一般情况下，贾弟虫病是急性的，在 2~4 周即可自愈。贾弟虫可影响营养吸收，导致儿童减缓生长[22]。研究表明，贾弟虫主要影响内脏中酶(乳糖酶和二糖酶)的活性，破坏粘膜表面，使细菌在小肠内过度滋生[23,24]。目前，贾弟虫导致腹泻和吸收不良的机制还不是十分清楚[25]。与细菌等原因导致的水源性疾病相比，由贾第虫引起的疾病具有暴发次数多、暴发比例高、致病人数多、致死率高和治疗效果差等特点[26]。

3.3. 贾第虫病暴发情况

截止到 2004 年，全球已有 100 多起介水贾弟虫病爆发报道[17]。2008~2009 年间，美国福罗里达州、新汉普郡和芬兰诺基亚因饮用水受污染，而引起贾弟虫病爆发[27,28]。2004 年，在挪威发生了最大的一次饮用水中贾弟虫病爆发事件，当时导致了 1500 人受感染[29]。

贾弟虫病爆发的主要原因是水处理措施缺失或处理不彻底[17]。有些地区的贾弟虫含量很高，就需要有相应的检测手段和制定相应的卫生标准，采取各种措施控制疾病爆发。饮用水源中贾弟虫病很常见，原因可能是因为家畜和雨季等带来的贾弟虫，因源头过滤不充分而进入饮用水源造成的[30]。除了源水可被贾弟虫污染外，自来水管网和蓄水池中的水都有可能因动物粪便、渗流、消毒不彻底等原因被污染[17,31,32]。因此，贾弟虫的水源性途径不容忽视[33]。

3.4. 贾第虫的来源

饮用水源地周边有大量的牛、羊等牲畜,它们的排泄物中含有大量的贾弟虫孢囊，是水体中贾弟虫污染的主要来源。在很多国家包括西班牙、比利时、丹麦、葡萄牙、巴西、澳大利亚和加拿大等国家，已从动物体内分离出蓝氏贾弟虫的不同基因型，主要来自于山羊、绵羊、牛、猪和马体内[34-39]。因此，有必要限制水源附近牲畜的活动，以防止动物牲畜粪便进入水体，限制贾第虫病的水源性传播。除水源附近的家养牲畜外，北美洲和西班牙的野生动物(麝鼠、海狸、海狸鼠和水獭等)粪便也含有贾第虫孢囊，同样会污染水质。调查显示，有 6.8%~75.2%的贾第虫病流行事件是由上述野生动物引起的[40-43]。研究发现，水鸟的粪便中也含有蓝氏贾弟虫[44,45]。贾第虫的孢囊在随粪便排出宿主体内后，不需要经历成熟期，即可直接感染新的宿主[46]。贾第虫在水体和土壤环境中可存活数月，同时有研究表明，贾第虫孢囊在冬季低温情况下会被破坏，失去致病力[47]。

3.5. 贾第虫的去除

生活污水、含有动物粪便的城市或农村的地表径流流入地表水，都可以导致水体污染。贾弟虫的孢囊大小为 8~12 μm，个体较小，很容易通过堤坝土壤的过滤作用而去除[48]。研究表明，贾弟虫的孢囊可通过沙滤和硅藻土过滤而去除[49]。因此，过滤作用在去除贾弟虫孢囊的水处理过程中是非常关键的步骤。目前，在美国和欧洲，都已通过改进滤膜(微细过滤、超滤、纳滤和逆渗透)来提高贾弟虫孢囊的去除率[50,51]。

动物感染实验表明，贾弟虫的孢囊对紫外线非常敏感，通过紫外线对水进行消毒处理，可去除蓝氏贾弟虫[52]。但是，Li 等证明，有些蓝氏贾弟虫的营养体在暴露低量紫外线后仍可存活[53]。这一结果提示，水厂在采用紫外照射处理饮用水时一定要达到相应的标准,以确保彻底去除蓝氏贾弟虫。

氯或氯胺消毒法是去除水源性病原体的常用方法，但是该法对贾弟虫的处理效率并不高[54]。臭氧消毒是去除原生动物最有效的方法，但是该法在低温条件下去除效率会降低，要求的 Ct(contact time)值也较高[55,56]。各种消毒法的综合运用，可比单独使用在去除贾弟虫方面更有效[57]。值得注意的是，化学消毒剂的使用量不宜过高,因为这些物质可在水中发生反应，生成各种化合物如亚硝酸盐和亚氯酸盐等影响人体健康[58]。

4. 检测方法

主要通过采集水样、分离孢囊和检测分析三步骤对贾第虫进行检测。首先需确保适宜的取样量，如果取样量太小可能会导致无法检出贾第虫，取样量太大又会造成不必要的浪费。一般来讲，贾第虫在水体中会长期存在，其含量主要受水源地周边的耕地径流和污水排放影响[59]。

将采集的水样采用化学絮凝法和过滤法(滤膜或滤筒)，对贾第虫孢囊进行初步分离。采取梯度离心和免疫磁分离(IMS)的综合技术，可有效地分离和纯化孢囊。后来，经过改进的 IMS 技术自 2001 年一直被美国环保局(USEPA)应用至今[60]。近些年来，免疫荧光分析方法(IFA 或 IFT)已经作为检测环境样品中蓝氏贾弟虫的标准方法，该法比传统方法检测更快速、简便，可靠性更高[61]。除此之外，美国环保局 1623 方法和 ISO 15533 方法都是检测贾第虫孢囊的特异性方法[60]。目前，应用较多的快速检测贾第虫的方法是 Filta-Max xpress，该法分过滤和淘洗、离心浓缩、免疫磁珠分离和染色镜检几个步骤，尤其是在淘洗阶段时间很短，较其它方法相比，样品的处理量大大提高，减少了劳动量，有效提高回收率[62]。这些方法可用于检测地表水、地下水、矿泉水、泳池水和娱乐用水等水体中的贾第虫。虽然这些方法具有很多优势，但却不能定种，不能确定贾第虫的种系发生。近几年，分子生物学技术尤其是 PCR 和 RFLP 技术的综合应用，使得贾第虫检测的灵敏度更高，可确定种系发生。PCR 法可确定贾第虫的种类和基因型，但同时也具有检测成本高、易污染等的缺点[63]。

5. 我国贾第虫的研究概况

我国对贾弟虫的研究较少，尤其是饮用水源地中的贾弟虫的报道更少。虽然在有些地区饮用水中检出贾弟虫[62,64-66]，但因其含量很低，至今尚未爆发大规模疾病。目前，我国尚未建立对贾弟虫病疫情检测和监控系统。

6. 结论

基于目前形势，有必要采取综合有效的措施(污染防治、水源地管理和水处理技术)来保护水源地水质，防止水体污染，尤其是贾第虫污染。传统的水处理技术主要包括絮凝、沉淀(或浮选)及物理和化学消毒法等。目前，廉价、简单和敏感性强的 LAMP 技术结合 DNA 检测技术，可有效检测水中贾第虫[67]。应用该方法可对水质贾第虫污染提出风险预警，有关部门可提前做出反应，研究解决办法，可有效防止水体贾第虫污染和预防人群疾病爆发。WHO 最近将贾第虫病列为忽略病害，但仍有很多国家对贾弟虫病的认识不够，没有了解其危害性。尤其是很多国家水资源供应不足，更加深了人们对公众健康问题的重视。调查显示，很多地区正在发生由于无计划的都市化而导致当地水资源过度开发，污水的违规排放而导致水质恶化问题。此外，气候条件等恶化都是贾弟虫病爆发的原因[68]。

开展对贾第虫基因组的研究，可了解其来源、传播途径和致病特点。将来，通过遗传学了解贾第虫的

感染性、致病性和毒性等机理是研究重点，解决这些问题对去除贾第虫具有十分重要的意义。此外，了解贾第虫的生物学特性也是非常关键的。有关部门也应该制定相应有效的水源地管理措施和水处理技术，以降低贾第虫病的发病率。在过去的十年，采用了分子技术对贾第虫研究，但还是没有解决上述问题，因此，可能需要采取多种方法结合起来进行研究。

目前，贾弟虫病的发病率在全球逐渐增加已是不可忽视的问题。有些发达国家采取了有效措施控制疾病发生，但水质仍然是最普遍的问题。很多国家忽视了贾第虫对饮用水及水生生态系统的威胁，未来一段时间应该以分子技术为主要研究手段，研究贾第虫的基因型，以解决水源污染问题。水质的常规监测和科学研究，对控制贾第虫病的传播也具有极其重要的作用。

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