Diagnosis of Invasive Amebiasis by Enzyme-Linked Immunosorbent Assay of Saliva To Detect Amebic Lectin Antigen and Anti-Lectin Immunoglobulin G Antibodies

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Saliva from subjects with amebic liver abscess (ALA), acute amebic colitis, asymptomatic infection with Entamoeba histolytica or Entamoeba dispar, and uninfected controls was tested by enzyme-linked immunosorbent assay (ELISA) for the presence of E. histolytica galactose-inhibitable lectin antigen and salivary immunoglobulin (Ig) antibodies to a recombinant cysteine-rich lectin-derived protein (LC3). Salivary lectin antigen was found in 65.8% of subjects with acute colitis, compared to 22.2% of those convalescent from ALA, 10.0% with asymptomatic E. histolytica infection, 9.8% with E. dispar infection, and 2.6% of controls (subjects from the United States and study patients with nonamebic diarrhea) (P < 0.001 for each compared to values for subjects with colitis). Salivary anti-LC3 IgG antibodies were found in 92% of ALA patients regardless of duration of illness and in 83.3% of colitis patients who were symptomatic for at least 7 days (P < 0.001 compared to other study groups). Serum anti-LC3 IgG antibodies were detected in 56.3% of subjects with acute colitis, 100% of subjects with ALA or prolonged colitis, 45% of subjects with asymptomatic E. histolytica infection, 32.3% of subjects with E. dispar infection, and 23.4% of diarrhea controls. In comparison to ELISA for serum anti-LC3 IgG antibodies, the salivary lectin antigen assay is a more sensitive and specific test for acute amebic colitis. Detection of salivary anti-LC3 IgG antibodies by ELISA is an effective means for the diagnosis of ALA and prolonged cases of amebic colitis.

Entamoeba histolytica infection most commonly results in asymptomatic colonization. While invasive amebiasis presents as amebic colitis or amebic liver abscess (ALA) (18). Currently, diagnosis requires skilled microscopy and a variety of serologic methods. Infection by E. histolytica, but not Entamoeba dispar, elicits a serum antiamebic immunoglobulin (Ig) antibody response (19). LC3 is a recombinant cysteine-rich portion of the E. histolytica galactose-inhibitable lectin’s 170-kDa subunit (23). Anti-LC3 IgG and IgA antibodies are found in serum and anti-LC3 IgA antibodies in saliva and stool of subjects with invasive amebic disease or asymptomatic E. histolytica infection (4, 23). The recombinant LC3 protein is immunogenic and effective as a subunit vaccine against experimental E. histolytica infection in a gerbil model (23). Early during the course of invasive amebiasis, detection of serum lectin antigen (2, 4) and anti-LC3 IgM antibodies (3, 22) is helpful in diagnosis. Seroconversion with antiamebic IgG antibodies occurs after 1 week of invasive disease symptoms and is diagnostic (1, 15, 19, 22).

Differentiation of E. histolytica from E. dispar in stool is accomplished by culture and zymodeme analysis (21), recognition by species-specific monoclonal antibodies (16), and DNA hybridization (6). However, detection of E. histolytica intestinal infection does not differentiate invasive disease from noninvasive colonization. Detection of amebic antigen (2, 4, 8) and antiamebic antibodies in either serum (1, 3, 19) or other body fluids, like saliva (4, 5, 9), plays a critical role in establishing the diagnosis and differentiating asymptomatic E. histolytica infection from invasive amebiasis.

Analysis of saliva can provide useful information for a wide range of diseases and is a good alternative to collection of venous blood, as it has some of the features of plasma and urine (12). Salivary antibody responses have been studied in a variety of infectious diseases; salivary IgG antibodies were found to have varied sensitivity for detection of infection by Toxoplasma gondii (10), Schistosoma mansoni (7), Helicobacter pylori (11), and hepatitis A Virus (13).

The goal of our study was to determine whether detection by enzyme-linked immunosorbent assay (ELISA) of salivary lectin antigen and salivary anti-LC3 IgG antibodies will be effective in diagnosis of invasive amebiasis, differentiating it from noninvasive E. histolytica intestinal infection.

MATERIALS AND METHODS

Study populations. In the outpatient clinic of the Tropical Medicine Department at El-Hussein University Hospital, Cairo, Egypt, saliva samples were obtained from 38 patients with acute diarrhea who had stool ELISA positive for E. histolytica lectin and occult fecal blood (32 patients symptomatic for <7 days and 6 symptomatic for more than 1 week), 16 patients with acute diarrhea who were positive for E. histolytica fecal lectin but without occult blood, 7 subjects positive for E. dispar fecal lectin, and 29 patients with acute diarrhea who had negative stool antigen studies for E. histolytica or E. dispar. In South Africa, saliva was obtained from 36 ALA patients 1 week after treatment with metronidazole, 4 subjects with asymptomatic E. histolytica infection, and 24 individuals with E. dispar colonization. ALA cases were diagnosed by sonography and absence of aspiration, while asymptomatic E. histolytica and E. dispar colonization were identified by stool culture and zymodeme analysis. Control saliva was collected from 48 employees of the University of Minnesota without any history of amebic infection or a recent visit to an area of endemic amebiasis. Five milliliters of saliva was collected from each subject and kept on ice for up to 2 h before being stored at −70°C. All samples were shipped frozen in dry ice to the United States. The present studies were approved by the Institutional Review Boards at the Uni-
ELISA for determination of salivary 170-kDa lectin antigen. Flat-bottomed microtiter polystyrene ELISA plates (96 wells; Corning Glass Works, Corning, N.Y.) were coated with monoclonal antibody 3F4 (1.6 μg/well), which is specific for epitopes present in both E. histolytica and E. dispers, in coating buffer (80 ml of 0.2 M Na₂CO₃ and 170 ml of 0.2 M NaHCO₃). Nonreactive sites were blocked with 1% BSA in coating buffer. Saliva samples were mixed in an equal volume of phosphate-buffered saline (PBS) containing 2 mM phenylmethylsulfonyl fluoride (United States Biochemical Corp., Cleveland, Ohio) and added at 100 μl/well for incubation for 2 h at room temperature or overnight at 4°C. Alkaline phosphatase-conjugated goat antihuman IgG (which recognizes all epitopes of E. histolytica and E. dispers) was added in a concentration of 0.5 μg/ml at 100 μl/well of a 1:1,000 dilution in PBS–Tween–1% BSA. Plates were washed five times with PBS–Tween. Nonreactive sites were blocked with 1% BSA in coating buffer for 2 h at room temperature. Saliva was mixed in an equal volume of PBS containing 2 mM phenylmethylsulfonyl fluoride and added at 100 μl/well for incubation for 2 h at room temperature or overnight at 4°C. Wells were washed (with PBS–Tween), and alkaline phosphatase-conjugated goat antihuman IgG antibodies, diluted in PBS–Tween–1% BSA (1:15,000), were added at 100 μl/well for incubation at room temperature for 2 h. Plates were washed 2 to 3 times with PBS–Tween and a developing solution (1 M diethanolamine and 1 mM MgCl₂ [pH 9.8] with p-nitrophenyl phosphate disodium [1 mg/ml]) was added. The reaction was developed in the dark for 2 h at room temperature, and the degree of color change (optical density at 405 nm) was measured in an ELISA plate reader (Bio-Rad microplate reader; Benchmark, Hercules, Calif.). Results were corrected for nonspecific background by subtracting the optical density of paired wells not coated with a primary antibody but otherwise subjected to the identical procedure. Each sample was studied in duplicate. We have previously demonstrated the lack of cross-reactivity of these antibodies with other parasitic antigens (2, 4).

ELISA for detection of salivary anti-LC3 IgG antibody. Flat-bottomed microtiter polystyrene ELISA plates (96 wells; Costar, Cambridge, Mass.) were coated with polyclonal rabbit anti-LC3 IgG (0.2 μg/well) by incubating overnight in buffer (80 ml of 0.2 M Na₂CO₃ and 170 ml of 0.2 M NaHCO₃). Plates were washed five times with PBS–Tween. Nonreactive sites were blocked with 1% BSA in coating buffer for 2 h at room temperature. Amebic colitis subjects were more likely to have positive assays for salivary lectin antigen, compared to 9.8% of those with E. dispers infection, 10% of those with noninvasive E. histolytica infection, and 6.4% with E. dispers infection, 10% with asymptomatic E. histolytica infection, and none of 48 American controls (P < 0.005, for each). Salivary anti-LC3 IgG antibodies were less frequently found in subjects with acute amebic colitis (<7 days in duration) and nonamebic diarrhea (for both, P < 0.001 compared to ALA patients and patients colitis for longer than 7 days, respectively) (Table 1).

To summarize in Table 2, ELISA for detection of serum anti-LC3 IgG antibodies was a more sensitive test for diagnosis of acute amebic colitis (56% positive compared to 18.4%; P < 0.05), but had a higher level of false-positive results during E. dispers infection (32% positive) and nonamebic diarrhea (62% positive; P < 0.05 compared to saliva anti-LC3 IgG antibodies). This is most likely due to the high levels of background positive antiamebic IgG in areas of endemicity due to frequent asymptomatic E. histolytica infections (7).

Sensitivity, specificity, and predictive values of ELISA for detection of salivary antigen and anti-LC3 IgG antibodies in comparison with serum anti-LC3 IgG antibody response. As summarized in Table 2, ELISA for detection of salivary 170-kDa lectin antigen demonstrated a 65.8% sensitivity and a 97.4% specificity, with a 92.3% positive predictive value and a 91.5% negative predictive value for diagnosis of acute amebic colitis. In contrast, ELISA for detection of salivary anti-LC3 IgG antibodies in convalescent ALA patients demonstrated 92% sensitivity and a 97.4% specificity, with a 94.3% positive predictive value and a 96.2% negative predictive value. In patients with amebic colitis who are symptomatic for more than one week, ELISA for salivary anti-LC3 IgG antibodies had 83.3% sensitivity and a 97.4% specificity, with a 71.4% positive predictive value and a 98.7% negative predictive value. Salivary 170-kDa lectin detection showed an improved diagnostic capability compared to ELISA for serum anti-LC3 IgG antibodies, which had 56.3% sensitivity and a 76.6% specificity, with a 50% positive predictive value and an 80.8% negative predictive value.

**RESULTS**

**Salivary 170-kDa adherence lectin.** Table 1 summarizes the mean of ELISA readings for detection of lectin antigen and anti-LC3 IgG antibodies in saliva and anti-LC3 IgG antibodies in serum for all subjects studied. None of the U.S. controls had positive assays for salivary lectin antigen, compared to 9.8% of those with E. dispers infection, 10% of those with noninvasive E. histolytica infection, and 6.4% of those with nonamebic diarrhea (no significant differences between these groups; P > 0.1). Amebic colitis subjects were more likely to have positive assays for salivary lectin (65.8%), compared to those convalescent for ALA (22.2%) (P < 0.001) or any of the control groups (P < 0.001 for each compared to colitis). ALA patients were more likely to be positive than U.S. controls (P = 0.002), but their results were not significantly different from subjects with nonamebic diarrhea (P = 0.176). E. dispers infection (P = 0.301), or noninvasive E. histolytica infection (P = 0.436).

**Salivary anti-LC3 IgG antibody response.** As summarized in Table 1, anti-LC3 IgG antibodies were found in the saliva of 92% of all ALA subjects and in 83.3% of patients with amebic colitis who were symptomatic for a week or more (compared to 6.4% with E. dispers infection, 10% with asymptomatic E. histolytica infection, and none of 48 American controls [P < 0.005, for each]). Salivary anti-LC3 IgG antibodies were less frequently found in subjects with acute amebic colitis (<7 days in duration) and nonamebic diarrhea (for both, P < 0.001 compared to ALA patients and patients colitis for longer than 7 days, respectively) (Table 1).

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**DISCUSSION**

There is a broad spectrum of interest regarding the study of secretory IgA antibody responses resulting from amebic infections. Most investigators have studied salivary antiamebic IgA
antibodies for determination of possible protective immunity or for use as a diagnostic tool (4, 5, 9). Recently, the diagnostic efficacy of salivary antiamebic IgA antibodies was studied in amebic colitis patients, ALA patients, and asymptomatic cyst carriers (4). Investigators reported finding salivary antiamebic IgA antibodies in 90 to 100% of Mexican subjects with amebic carriers (4). Investigators reported finding salivary antiamebic antibodies for determination of possible protective immunity or for use as a diagnostic tool (4, 5, 9). Recently, the diagnostic efficacy of salivary antiamebic IgA antibodies was studied in amebic colitis patients, ALA patients, and asymptomatic cyst carriers (4). Investigators reported finding salivary antiamebic IgA antibodies in 90 to 100% of Mexican subjects with amebic carriers (4). Investigators reported finding salivary antiamebic antibodies for determination of possible protective immunity or for use as a diagnostic tool (4, 5, 9). Recently, the diagnostic efficacy of salivary antiamebic IgA antibodies was studied in amebic colitis patients, ALA patients, and asymptomatic cyst carriers (4). Investigators reported finding salivary antiamebic antibodies in 90 to 100% of Mexican subjects with amebic carriers (4).

In summary, ELISA for salivary anti-LC3 IgG antibodies was a highly specific and sensitive diagnostic test for identifying patients with ALA and amebic colitis (duration of symptoms, ≥7 days). Detection of salivary adherence lectin antigen is an effective tool for use in early diagnosis of invasive amebiasis, before the appearance of serum or salivary antiamebic IgG antibodies.

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REFERENCES


TABLE 2. Statistical analysis of salivary lectin and anti-LC3 IgG antibody test results and comparison to ELISA for serum anti-LC3 IgG antibodies

<table>
<thead>
<tr>
<th>Value</th>
<th>Amebic colitis (&lt;1 wk)</th>
<th>Amebic colitis (&gt;1 wk)</th>
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<tr>
<td></td>
<td>Sal. lectin</td>
<td>Sal. IgG</td>
<td>Serum IgG</td>
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<td>Negative predictive (%)</td>
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</tbody>
</table>

* Specificity, sensitivity, and positive and negative predictive values are expressed in percentages according to the definition described in Materials and Methods. Analyses were carried out using salivary (Sal.) lectin and IgG and serum IgG from patients with amebic colitis (divided into those with symptoms lasting less than 1 week and those with symptoms lasting more than 1 week) and patients with ALA.


