Evaluatin of cytotoxic activity in fecal filtrates 
from patients with Campylobacter jejuni or 
Campylobacter coli enteritis

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Title of Army Project Order: Studies of the Outer Membrane Proteins 
of Campylobacter Jejuni for Vaccine Development

Approved for public release; distribution unlimited

Campylobacter, Vaccines, Biotechnology, ID, Diseases, 
RAD I, lab animals, Volunteers

Unclassified Unclassified Unclassified Unlimited
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Evaluation of cytotoxic activity in fecal filtrates from patients with *Campylobacter jejuni* or *Campylobacter coli* enteritis

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1. SUMMARY

We sought to determine the prevalence of cytotoxic activity in fecal filtrates from persons with *C. jejuni* or *C. coli* enteritis. Stool specimens were collected from 20 persons with *C. jejuni* or *C. coli* enteritis, 20 persons with acute diarrheal illnesses of other causes, and 9 healthy, asymptomatic persons. Fecal filtrates were then incubated with Chinese hamster ovary (CHO) or HeLa cells. The fecal filtrate from 1 of the 20 (5%) persons with *Campylobacter* enteritis was cytotoxic for HeLa cells at a titer of 1:40, and 10 (50%) were cytotoxic for CHO cells at maximum titers of 1:20. Cytotoxic activity for CHO cells at a median titer of 1:20 was also present in 40% of the fecal filtrates from persons with diarrhea due to causes other than *Campylobacter* enteritis, and in 33% of filtrates from healthy, asymptomatic persons. The observed low level of cytotoxicity in fecal filtrates from all patient groups studied likely resulted from non-specific factors, unrelated to the pathogenesis of *Campylobacter* enteritis.

2. INTRODUCTION

Although *Campylobacter jejuni* and *C. coli* are important causes of diarrheal illness worldwide, the pathophysiologic mechanisms whereby these organisms cause human disease remain poorly understood [1]. Cytotoxic activity has been demonstrated in culture supernatants of *C. jejuni* and *C. coli* grown in vitro [2–7], but the in vivo relevance of these observations is not clear. We therefore sought to detect cytotoxic activity in fecal filtrates from persons with *Campylobacter* enteritis. Fecal filtrates from persons with diarrhea due to other causes and from asymptomatic healthy persons were tested as controls.

3. MATERIALS AND METHODS

3.1. Patients studied

The following three groups of persons were studied: (1) 20 consecutively diagnosed patients with *C. jejuni* or *C. coli* enteritis; (2) 20 patients...
with acute enteritis, from whose stool cultures C. jejuni or C. coli were not isolated; and (3) 9 asymptomatic healthy persons. For each C. jejuni or C. coli-infected patient identified (group 1), the next patient to submit a stool specimen to the Microbiology Laboratory for culture was selected as a control (group 2). Upon preliminary identification of Campylobacter sp. by darkfield microscopy, stool specimens were promptly frozen at -20°C, and were stored at -70°C for 1 to 10 months.

3.2. Determination of cytotoxicity

Stool specimens were suspended in phosphate-buffered saline (pH 7.2) at a ratio of 1:3, centrifuged at 3000 × g for 30 min, and the supernatants passed through a 0.22 μm filter. HeLa and Chinese hamster ovary (CHO) cells were cultured in modified Eagle's medium (Flow, McLean, VA) or F-12 medium (Gibco, Grand Island, NY), respectively, containing 10% fetal bovine serum. Serial two-fold dilutions of fecal filtrates were prepared using tissue culture media as diluents, and were mixed in final concentrations of 1:10 to 1:320 with freshly trypsinized cells in concentrations of 2 × 10⁴ cells/mL. Dilutions of fecal filtrates that caused rounding of greater than 50% of cells within 24 h were defined as showing a cytotoxic effect. All samples were tested at least in duplicate. The protein concentrations of fecal filtrates were determined using a BCA protein reagent kit (Pierce, Rockford, IL). As controls for detection of cytotoxic activity, culture supernatants were prepared from Shigella dysenteriae type 1, strain 60R, non-01 Vibrio cholerae, strain 84-74, and non-toxin-producing Escherichia coli, strain 84-169.

3.3. Statistical methods

Proportions were compared by using a one-tailed Fisher exact test. Numerical values were compared by using a two-tailed Student's t-test.

4. RESULTS

4.1. Microbiology

Of the 20 patients with Campylobacter enteritis, 11 were infected with C. jejuni, 7 were infected with C. coli, and 2 were infected with strains that were no longer available for speciation. Fever, fecal erythrocytes, and fecal leukocytes were present in 55%, 85%, and 90%, respectively, of the patients with Campylobacter enteritis. Of the 20 asymptomatic control patients, one was infected with Cryptosporidium, and one had C. difficile toxin activity detected in stool. No pathogen was identified in the remaining 18 patients by the routine diagnostic techniques employed.

4.2. Cytotoxicity of fecal filtrates and bacterial culture supernatants

Culture supernatants from three bacterial strains were tested as controls; supernatant from S. dysenteriae type 1 was cytotoxic for HeLa cells at a titer of 1:10, 240, supernatant from non-01 Vibrio cholerae was cytotoxic for CHO cells at a titer of 1:2560, and supernatant from a non-toxigenic E. coli was not cytotoxic for CHO or HeLa cells. The fecal filtrate from 1 of the 20 (5%) patients with Campylobacter enteritis was cytotoxic for HeLa cells at a titer of 1:40, and 10 (50%) of these filtrates were cytotoxic for CHO cells at titers of 1:10 to 1:20 (Table 1). Elongation of CHO cells in response to the fecal filtrates was not observed. The fecal filtrates from C. jejuni and C. coli-infected persons did not differ significantly in rates of cytotoxicity. The presence of fever, fecal

<table>
<thead>
<tr>
<th>Population studied</th>
<th>HeLa</th>
<th>CHO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Campylobacter enteritis</td>
<td>20</td>
<td>1 (5)</td>
</tr>
<tr>
<td>Diarrhea of other causes</td>
<td>2 (10)</td>
<td>8 (40)</td>
</tr>
<tr>
<td>Healthy, asymptomatic</td>
<td>9</td>
<td>0 (0)</td>
</tr>
</tbody>
</table>

* Cytotoxic activity for HeLa and Chinese hamster ovary (CHO) cells was defined as rounding of greater than 50% of cells in a dilution of 1:10 or higher.
Table 2

Relationship between protein concentration and cytotoxin activity of fecal filtrates

<table>
<thead>
<tr>
<th>Population studied</th>
<th>Characteristics of fecal filtrates (mean ± SEM)</th>
<th>Protein Concentration (mg/mL)</th>
<th>Protein Ratio</th>
<th>Protein Concentration (mg/mL)</th>
<th>Protein Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Campylobacter enteritis (n = 20)</td>
<td>Filtrates toxic for CHO cells</td>
<td>7.8 ± 0.966</td>
<td>1.6 ± 0.201</td>
<td>20 ± 2.0</td>
<td>20 ± 2.0</td>
</tr>
<tr>
<td></td>
<td>Filtrates toxic for HeLa cells</td>
<td>4.1 ± 0.674</td>
<td>3.0 ± 0.495</td>
<td>6.2 ± 1.80</td>
<td>2.9 ± 1.62</td>
</tr>
<tr>
<td></td>
<td>Filtrates toxic for CHO or HeLa cells</td>
<td>2.4 ± 0.406</td>
<td>5.5 ± 0.754</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Healthy, asymptomatic (n = 9)</td>
<td>All filtrates</td>
<td>3.1 ± 0.683</td>
<td>2.9 ± 0.470</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* The protein concentration of filtrates is expressed in mg/mL.
* For each fecal filtrate with cytotoxic activity, the reciprocal value of cytotoxin activity was divided by the protein concentration to obtain a cytotoxin-protein ratio.
* A patient with known C. difficile enteritis was excluded from this analysis.
* Single case.
* No cases identified.

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Single case.

No cases identified.

erythrocytes, or fecal leukocytes in these patients was not associated with the cytotoxicity of fecal filtrates. The cytotoxic activity in fecal filtrates also was not related to the interval between the onset of symptoms and the collection of fecal specimens or to the duration of storage of fecal filtrates at -70°C. Fecal filtrates from 2 of the 20 (10%) symptomatic control patients were cytotoxic for HeLa cells at titers of 1:10 or 1:20, and 7 (35%) were cytotoxic for CHO cells at titers of 1:10 or 1:20 (Table 1). In addition, the fecal filtrate from a patient with C. difficile enteritis was cytotoxic for CHO cells at a titer of 1:160. The fecal filtrates from 3 of the 13 healthy asymptomatic persons were cytotoxic for CHO cells at titers of 1:10 or 1:20; none were cytotoxic for HeLa cells. Thus, the prevalence of cytotoxic activity for CHO or HeLa cells in fecal filtrates from C. jejuni or C. coli-infected persons was not significantly different from the prevalence in fecal filtrates from persons with diarrhea of other causes (P = 0.5), or fecal filtrates from healthy, asymptomatic persons (P = 0.25) (Table 1).

4.4. Ratios of cytotoxin titer to protein concentration

We hypothesized that fecal filtrates with significant cytotoxin activity might contain disproportionately high ratios of cytotoxin activity to protein concentration. Therefore, a cytotoxin titer-protein concentration ratio was determined for each fecal filtrate by dividing the reciprocal titer of cytotoxin activity by the protein concentration of the specimen. The highest ratio (177) was detected in the fecal filtrate from a patient with C. difficile enteritis, an illness known to be toxin-mediated. Of the filtrates that were cytotoxic for CHO cells, those from patients with Campylobacter enteritis had a lower mean titer-protein ratio than those from the other two populations studied (Table 2). Therefore, using this method of standardization, we were unable to demonstrate significantly increased cytotoxin activity in fecal filtrates from patients with Campylobacter enteritis compared to controls.

5. DISCUSSION

Among non-immune populations, infections with C. jejuni or C. coli produce febrile illnesses in which diarrheal stools frequently contain leukocytes and blood [8]. Cytotoxins have been proposed as virulence determinants whereby C. jejuni and C. coli may cause inflammation. Culture supernatants from 32% to 100% of C. jejuni and C. coli strains isolated from humans are cytotoxic for cultured CHO, HeLa, or Vero cells [2-7], but the...
significance of low titers of cytotoxin produced in vitro remains unclear. One possibility is that in vitro conditions used for growth of the bacteria are suboptimal for toxin production, and that in vivo growth conditions are necessary for maximal production of toxin. Cytotoxin activity has previously been demonstrated in the feces of patients infected with C. difficile or enterohemorrhagic strains of E. coli [9,10]. We hypothesized that if cytotoxin were important in the pathogenesis of Campylobacter enteritis, cytotoxin activity might similarly be detectable in the stools of Campylobacter--infected patients.

In a Malaysian study, low-titer cytotoxic activity for HeLa cells was detected in the fecal filtrates from 5 of 19 (26%) C. jejuni-infected persons; however, filtrates from control subjects were not examined [5]. In this study, we have also detected cytotoxic activity in fecal filtrates from patients with Campylobacter enteritis, but the prevalences and titers of cytotoxic activity in fecal filtrates from patients with Campylobacter enteritis, persons with diarrhea of other causes, and healthy asymptomatic persons were not significantly different.

The lack of high-titer cytotoxic activity in fecal filtrates from patients with Campylobacter enteritis is consistent with the low levels of cytotoxicity observed in culture supernatants of C. jejuni of C. coli after in vitro growth [2-7]. The lack of consistently detectable cytotoxicity production by these Campylobacter species in vitro or in vivo, and the lack of a consistent neutralizing antibody response to cytotoxins in infected persons [2,4] suggest that Campylobacter enteritis is not solely a cytotoxin-mediated disease. Alternatively, current testing methods may be inadequate to demonstrate the activity of cytotoxins produced by C. jejuni and C. coli.

ACKNOWLEDGEMENTS

We thank Alison O’Brien and Theodore Puck for providing HeLa and CHO cells, and Gayle O’Malley, Stanley Mirrett, and L. Barth Reller for assistance in identification of patients. Supported in part by the Thrasher Research Fund, the U.S. Army Medical Research and Development Command, and the Medical Research Service of the Veterans Administration. T.L.C. is an Associate Investigator of the Veterans Administration.

REFERENCES