ANTIMICROBIAL AGENTS AND CHEMOTHERAPY, Feb. 2005, p. 798–800 Vol. 49, No. 2
0066-4804/05/$08.00+0 doi:10.1128/AAC.49.2.798–800.2005

Test Characteristics of Perirectal and Rectal Swab Compared to Stool Sample for Detection of Fluoroquinolone-Resistant *Escherichia coli* in the Gastrointestinal Tract

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Received 17 September 2004/Returned for modification 19 October 2004/Accepted 23 October 2004

Among 63 patients enrolled in a prospective cohort study of gut colonization with fluoroquinolone-resistant *Escherichia coli*, the sensitivity of perirectal swab compared to stool sample was 90% (95% confidence interval [CI], 70 to 99%) and the specificity was 100% (95% CI, 91 to 100%). For rectal swab, the sensitivity was 90% (95% CI, 68 to 99%) and the specificity was 100% (95% CI, 91 to 100%).

Resistance to many antimicrobial drugs has increased significantly among gram-negative bacilli (GNB) in recent years (5, 6, 9, 10). GNB colonizing the gastrointestinal (GI) tract serve as both the reservoir for the person-to-person spread of resistant bacteria and the likely source for subsequent clinical infection in colonized individuals (4). Timely and accurate identification of patients with GI tract colonization with resistant GNB is thus critical.

Currently, the culture of a stool sample is considered the "gold standard" for identification of GI tract colonization with resistant GNB. However, for both infection control programs and research studies, this approach is often infeasible or impractical. Thus, hospital epidemiologists and researchers often rely on perirectal or rectal swabs to identify patients colonized with resistant organisms (1, 2, 8). Despite the widespread use of these approaches, no data exist describing their sensitivity and specificity for detection of resistant GNB compared to the gold standard of stool sample.

We conducted this study to determine the test characteristics (i.e., sensitivities and specificities) of perirectal and rectal swabs, and we used stool sample as the gold standard. This is the first study to investigate this issue for GNB. We specifically focused on detection of GI tract colonization with fluoroquinolone (FQ)-resistant *Escherichia coli* (FQREC).

The study was performed at two hospitals within the University of Pennsylvania Health System: (i) The Hospital of the University of Pennsylvania, an academic tertiary care medical center with 625 patient beds; and (ii) Presbyterian Medical Center, a 344-bed urban community hospital. This study was reviewed and approved by the Committee on Studies Involving Human Beings of the University of Pennsylvania.

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(This work was presented in part at the 44th Interscience Conference on Antimicrobial Agents and Chemotherapy, Washington, D.C., 31 October 2004.)

We conducted a cross-sectional study of subjects enrolled in an ongoing prospective cohort study. This larger cohort study, in which all hospitalized patients were eligible to participate, investigated the incidence of new GI tract colonization with nosocomial FQREC. Over a 12-month period, all study subjects enrolled in the ongoing cohort study, for which a perirectal swab, rectal swab, and stool sample were collected within the same 24-hour period, were included in our study. A rectal swab was not required for neutropenic subjects; hence, neutropenic subjects were included if a perirectal swab and stool sample were collected within the same 24-hour period. Study subjects known to be FQREC colonized were oversampled to ensure that they accounted for at least 25% of the study cohort. The same research nurse collected perirectal and rectal swabs from all subjects. Stool samples were requested and collected by clinical nursing staff for all subjects for whom perirectal and rectal swabs had been obtained. Each subject was included only once.

To detect *E. coli* isolates with even low-level FQ resistance ($\geq$0.125 μg/ml), all patient samples were inoculated to MacConkey agar plates supplemented with levofloxacin at a concentration of 0.125 μg/ml. For stool samples, a swab was used to plate the sample. Plates were streaked for isolation of colonies and incubated at 37°C in atmospheric air supplemented with 5 to 10% CO_2. Plates were checked for growth at 24 and 48 h. Colonies suspected of being *E. coli* were subcultured and all oxidase-negative colonies with the appropriate colony morphology were definitively identified by using a semiautomated VITEK 2 identification and susceptibility system (bioMérieux, Inc.) (7). Broth enrichment cultures were not performed. To estimate the fecal concentration of FQREC, the numbers of colonies on plates from stool samples were noted. No quantitative cultures were performed. Of note, all microbiological tests for this study were performed by two individuals.

Sensitivities and specificities of perirectal and rectal swabs were calculated with 95% binomial confidence intervals (CIs) based on the stool sample gold standard. Sensitivity was defined as the number of samples with a positive culture for FQREC from a perirectal or rectal swab and stool sample divided by the total number of samples with a positive culture from stool sample. Specificity was defined as the number of samples with a negative culture for FQREC from a perirectal or rectal swab and stool sample divided by the total number of samples with a negative culture from stool sample. Agreement was defined as the total number of samples with a positive result from both perirectal and rectal swabs plus the total number of samples with a negative result from both perirectal and rectal swabs divided by the total number of samples with both perirectal and rectal swab results. All statistical calculations were performed by using STATA version 8.0 (Stata Corp., College Station, Tex.).

A total of 63 subjects were enrolled in the study. A perirectal swab, a rectal swab, and a stool sample were obtained from 59 of these subjects. Rectal swabs were not obtained from four subjects with neutropenia. The median age of subjects was 61 years (range, 21 to 96 years) and 31 subjects (49%) were male. Twenty-one subjects (33%) were Caucasian, 35 subjects (56%) were African-American, and 7 subjects (11%) were of unknown race.

Of the 63 subjects from whom both a stool sample and a perirectal swab were obtained, 21 had stool samples which were positive for FQREC. Of these subjects, 19 (90%) also had a positive perirectal swab (Table 1). Of 42 subjects with a negative stool sample, 42 (100%) also had a negative perirectal swab.

Of the 59 subjects with both a stool sample and rectal swab, 20 had a stool sample which tested positive for FQREC. Of these, 18 (90%) also had a positive rectal swab (Table 1). Of the 39 subjects with a negative stool sample, 39 (100%) also had a negative rectal swab. Finally, of the 59 subjects from whom both perirectal and rectal swabs were obtained, there was 100% agreement in the results with these two techniques.

All but two positive stool cultures had >100 colonies per plate. The remaining two positive cultures each had fewer (<5) colonies per plate. Notably, these were the same two samples which tested negative with both perirectal and rectal swab cultures.

These results demonstrate that both perirectal and rectal swab approaches have excellent sensitivity and specificity for detection of GI tract colonization with FQREC. In addition, there was complete agreement between the results of perirectal and rectal swabs. Finally, our results also suggest that perirectal and rectal swabs are most likely to fail to identify FQREC when the concentration of such organisms in the stool is very low.

No previous studies, to our knowledge, have examined the sensitivities and specificities of perirectal and rectal swabs for the detection of fecal colonization with resistant GNB. Indeed, the only two studies that have addressed the issue of detection of GI tract colonization with resistant pathogens by different surveillance methodologies have focused on vancomycin-resistant enterococci (VRE). One study of 82 paired rectal and perirectal swabs obtained from 13 patients noted that the sensitivity of perirectal swab (with stool culture as the gold standard) was 83% and the specificity was 87% (11). A more recent study evaluated 35 stool samples from 13 patients known by stool culture to be colonized with VRE, and found a sensitivity of 58% for rectal swab (3). The likelihood of the rectal swab being positive was significantly greater when the concentration of VRE in the stool culture was higher.

TABLE 1. Test characteristics of perirectal and rectal swab

Test characteristic	Result (%) for test indicated (95% CI)	
	Perirectal swab (n = 63)	Rectal swab (n = 59)
Sensitivity	90 (70 to 99)	90 (68 to 99)
Specificity	100 (91 to 100)	100 (91 to 100)

The ability to accurately identify subjects colonized with antimicrobial-resistant organisms is critical for the following reasons: (i) to identify the prevalence of resistance at an institution, (ii) to enable to infection control programs to identify targets for intervention (e.g., identifying cohorts, establishing contact precautions), and (iii) for research studies seeking to more clearly elucidate the risk factors for GI tract colonization with these pathogens. Perirectal and rectal swabs are frequently used both in infection control and in research endeavors to identify patients colonized with resistant GNB. Our data support the use of these sampling methods, specifically for identification of FQREC. Our finding of 100% agreement between the results of perirectal and rectal swabs is also important since perirectal swabs are thought to be safer to perform in neutropenic patients and may be more acceptable to patients (11).

This study has several potential limitations. Although this is the largest study to date to address this issue (and the first to focus on GNB), the sample size was small, limiting the ability to calculate narrow confidence intervals for the estimates of sensitivity and specificity. In addition, although there were markedly greater numbers of colonies of fecal FQREC in subjects with concordant swab and stool samples compared to the two patients with discordant results, our method of stool culture (i.e., using a swab to plate the stool) may have introduced some variability in our assessment of fecal FQREC concentration. Finally, our study was conducted in a large tertiary care medical center and a smaller urban community hospital; therefore, the results may not be generalizable to other institutions.

In conclusion, we found that perirectal and rectal swab techniques have excellent sensitivity and specificity for detection of GI tract colonization with FQ-resistant *E. coli*, supporting their use for both infection control and research endeavors.

This work was supported by Public Health Service grant RS1/CCR320627-01 of the Centers for Disease Control and Prevention (Ebbing Lautenbach). Eli N. Perencevich and Joshua P. Metlay were supported by Research Career Development Awards from the Health Services Research and Development Service of the Department of Veterans Affairs. This study was also supported in part by an Agency for Healthcare Research and Quality (AHRQ) Centers for Education and Research on Therapeutics cooperative agreement (U18-HS10399).

We thank Carol Imperatrice and Andrea Worrall for their excellent work in microbiological evaluation of study samples.

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