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The frequency and antimicrobial resistance patterns of nosocomial pathogens recovered from cancer patients and hospital environments

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ABSTRACT

Objective: To determine the prevalence and antimicrobial resistance rates of nosocomial pathogens isolated from cancer patients and hospital environments.

Methods: A descriptive cross-sectional study was conducted between December 2010 to May 2013 at Radiation and Isotopes Centre of Khartoum, Sudan. A total of 1 503 samples (505 clinical and 998 environmental) were examined. Isolates were identified, and their antimicrobial susceptibility was determined using standard laboratory procedures.

Results: Out of 505 clinical samples, nosocomial pathogens were found as 48.1%. Among hospital environment samples, bacterial contaminants were detected in 29.7% of samples. The main microorganisms recovered from cancer patients were *Proteus* spp. (23.5%), *Escherichia coli* (22.2%), *Pseudomonas aeruginosa* (*P. aeruginosa*) (21.0%) and *Staphylococcus aureus* (20.2%). The most frequent isolates from hospital environments were *Bacillus* spp. (50.0%), *Staphylococcus aureus* (14.2%) and *P. aeruginosa* (11.5%). The proportions of resistance among Gram-negative pathogens from cancer patients were high for ampicillin, cefotaxime, ceftazidime and ceftriaxone. Moderate resistance rates were recorded to ciprofloxacin, such as 51.0% for *P. aeruginosa*, 21.7% for *Klebsiella pneumoniae* and 55.5% for *Escherichia coli*. Except *Klebsiella,* there were no significant differences ($P \geq 0.05$) of resistance rates between Gram-negative isolates from cancer patients to those from the hospital environments. The proportions of extended-spectrum β-lactamase producing isolates from cancer patients were not differ significantly ($P = 0.763$) from those collected from the hospital environments (49.2%; 91/185 *vs.* 47%; 32/68).

Conclusions: The prevalence of nosocomial infection among cancer patients was high (48.1%) with the increasing of antimicrobial resistance rates. Hospital environments are potential reservoirs for nosocomial infections, which calls for intervention program to reduce environmental transmission of pathogens.

1. Introduction

Nosocomial infection is one of the most common life-threatening complications of immunocompromised hospitalized patients [1,2]. Cancer patients are more susceptible to hospital acquired infections due to their compromised immune system, the use of invasive technologies and they being subjected to surgical operations and chemotherapy [3,4]. Bacterial infection among cancer patients is continuing to emerge as particularly destructive complications of cancer treatment [2,5]. This infection among cancer patients could happen either as endogenously from normal flora on the skin or on the operative site or exogenously from the air, hospital staff, inanimate environment and medical equipments [6,7]. Patients with cancer are highly susceptible to almost any type of bacterial infection [3]. The colonization of the potentially pathogenic microorganisms on the various inanimate surfaces presents in a clinical setup has been reported as a potential vehicle for the transmission of nosocomial pathogens [6,7].

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The emergence of bacterial strains that are resistant to commonly used antibacterial agents, has created a potential public health problem, particularly among cancer patients [2,5]. The increasing of antimicrobial resistance rates among bacterial pathogens isolated from cancer patients and hospital environments are posing new challenges [5]. Many studies have been conducted to determine the prevalence of nosocomial infections among cancer patients in developed countries and developing countries [8–10]. In Sudan, no current data available documented nosocomial infections among cancer patients. Therefore, the aim of the present study was to determine the incidence and antimicrobial resistance of nosocomial pathogens isolated from cancer patients who admitted to the Radiation and Isotopes Centre of Khartoum in Sudan. In addition, the study also analyzed the distribution of pathogens that isolated from hospital environments.

2. Materials and methods

2.1. Study design and population

This descriptive cross-sectional hospital based study was conducted during the period from December 2010 to May 2013 in Radiation and Isotopes Centre of Khartoum, Khartoum state, Sudan. The Radiation and Isotopes Centre of Khartoum is one of the main oncology centers in Sudan, providing treatment for cancer patients with radiotherapy, chemotherapy and hormonal therapy [11]. All cancer patients who attended Radiation and Isotopes Centre of Khartoum were enrolled in the study. Each patient with no proven evidence of infection at the time of admission, but developed signs of infection after at least two days of hospitalization was included in the study. Patients with proven evidence of infection at the time of admission to the hospital were excluded from the study. The study was approved by the Research Committee of the Faculty of Medical Laboratory Sciences, University of Khartoum. All patients included in this study were consented verbally before collection of samples.

2.2. Collection of samples

Clinical samples of urine (n = 325), wound pus (n = 130), blood (n = 20) and sputum (n = 30) were collected from cancer patients for the investigations of pathogenic microorganism following standard laboratory procedures [12]. Hospital specimens were collected from different moist environments, including infrastructures (n = 551), furniture (n = 232), surgical equipments (n = 123), laboratories (n = 68), kitchens (n = 24) using sterile moist cotton swabs. All the collected specimens were properly labeled and the data were collected via a questionnaire form.

2.3. Isolation and identification of bacterial species

For possible isolation of bacterial pathogens, each specimen (clinical or environmental) were inoculated onto blood agar (HiMedia, India) and MacConkey agar (HiMedia, India) plates. Then all cultured plates were incubated aerobically at 37 °C for 24 h. Blood samples were inoculated onto brain heart infusion broth and incubated at 37 °C for a period of 7–14 days. Each bacterial isolate was identified on the bases colonial morphology, Gram staining and required biochemical tests following standard laboratory methods [12].

2.4. Antimicrobial susceptibility testing

Antimicrobial susceptibility testing was performed using Kirby–Bauer disc diffusion technique on Mueller-Hinton agar medium (HiMedia, India) as recommended by the Clinical and Laboratory Standards Institute [13]. Isolates were tested for their susceptibility against different antimicrobial agents, including: amikacin (30 μg), ampicillin (10 μg), cefotaxime (30 μg), ceftazidime (30 μg), ceftriaxone (30 μg), ciprofloxacin (5 μg), gentamicin (10 μg), meropenem (10 μg) (HiMedia, India). The strain of *Escherichia coli* ATCC 25922 (*E. coli*) was used as control, and was examined each time when susceptibility testing was carried out. The test result was only validated in cases where inhibition zone diameters of the control strain within the performance range in accordance to the Clinical and Laboratory Standards Institute criteria [13].

2.5. Screening of extended-spectrum β-lactamase (ESBL) production

Gram-negative isolates recovered from cancer patients and hospital environments were screened for ESBL production by the double disc synergy test as described by Jarlier *et al*. [14]. All the isolates showed the resistance to third generation cephalosporin were examined for ESBL production. A disc containing amoxicillin/clavulanic acid (30 μg) was placed in the centre of the Mueller-Hinton agar plate, and discs containing ceftriaxone (30 μg), cefotaxime (30 μg) and ceftazidime (30 μg) were placed 30 mm distance from the disc of amoxicillin/clavulanic acid. A clear extension of the edge of the inhibition zone of third generation cephalosporin towards amoxicillin/clavulanic acid disc is interpreted as positive for ESBL production. Control strains of *Staphylococcus aureus* ATCC 25923 (*S. aureus*), *E. coli* and *Pseudomonas aeruginosa* ATCC 27853 (*P. aeruginosa*) were run at the same time on separate plates using the same turbidity as in the test organism to evaluate the conditions of the test and the potency of the discs.

2.6. Statistical analysis

The data obtained was coded and entered into the SPSS, version 16.0. The *Chi*-square test was used to test for the significant differences between the variables. $P < 0.05$ was considered as statistically significant.

3. Results

A total of 505 clinical samples collected from cancer patients (443 adults and 62 children) and 998 swab samples obtained from hospital environments were screened for the presence of bacterial pathogens. Out of the 505 clinical samples, pathogenic bacteria were detected in 48.1% (243). Of the 243 clinical isolates, 203 were recovered from adult patients and 40 from children. The majority of the isolates were from urine (n = 117), and wound pus (n = 113), with low frequency of the isolates from sputum (n = 12) and blood (n = 1) samples.

Overall the 998 swab specimens collected from hospital environments, 296 (29.7%) were yielded different bacterial species. As shown in Table 1, the most frequent microorganisms among cancer patients were *Proteus* spp. (23.5%), *E. coli*