Infection Control & Hospital Epidemiology (2024), **45**, 994–997
doi:10.1017/ice.2024.60

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Concise Communication

Surveillance of carbapenem-resistant *Klebsiella pneumoniae* and *Escherichia coli* in perianal swab samples

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Abstract

Our study aimed to detect carbapenem-resistant *Klebsiella pneumoniae* (CRKP) and/or carbapenem-resistant *Escherichia coli* in perianal swab samples, exploring their link to bloodstream infections (BSIs) in a tertiary-care university hospital. CRKP-related BSIs ranged from 3.7% to 9.58%, emphasizing the need to understand local risk factors for effective infection control.

(Received 17 October 2023; accepted 2 March 2024; electronically published 12 April 2024)

Introduction

Surveillance strategies are crucial to early detection and effective management of carbapenem-resistant *Klebsiella pneumoniae* (CRKP) and carbapenem-resistant *Escherichia coli* (CREC) infections. Perianal swab (PAS) samples have gained attention as a noninvasive and informative method for detecting colonization with CRKP and CREC.[1]

This study aimed to investigate patients admitted to the adult intensive care unit (ICU), Hematology, and Oncology clinics, focusing on those who exhibited growth of CRKP and/or CREC in PAS samples and were subsequently diagnosed with bloodstream infection (BSI) attributed to CRKP and CREC growth in blood cultures.

Material and methods

In a 900-bed tertiary-care university hospital accredited by Joint Commission International, we analyzed CRKP and CREC isolated from PAS samples collected between April 1, 2021, and March 31, 2022, along with blood cultures obtained from symptomatic patients on the same period. All patients admitted to the adult ICU (14 beds, separated by curtains), hematology clinic (24 beds, single rooms), or oncology clinic (39 beds, 13 single rooms, 13 double rooms) during the same period underwent weekly screening with no specific exclusion criteria. CRE-positive patients are prioritized for empiric treatment according to the susceptibility results and received contact isolation. PAS samples were evaluated after incubation in Chromid® Carba Agar (Bio Merieux. France) chromogenic medium for 18–24 hours according to the color scale. Blood cultures were performed via BACTEC System.

MALDI-TOF MS was used for identification of pathogens. Antimicrobial susceptibility tests were conducted utilizing the outcomes from an automated system (Phoenix™ 100, Becton Dickinson, Sparks, MD, USA). Antimicrobial susceptibility results were evaluated in accordance with the recommendations of the European Committee on Antimicrobial Susceptibility Testing.[2] According to Centers for Disease Control and Prevention recommendations, CRKP and/or CREC were defined as having resistance to at least one of the carbapenems.[3]

BSI is defined by positive blood cultures in a patient with systemic signs of infection and can be either primary (a laboratory-confirmed BSI that is not secondary to an infection at another body site) or secondary to a documented source.[4]

Our study was performed in accordance with the ethical standards of the Helsinki Declaration, which was accepted by the World Health Community in 1975 (revised in 2013).

Results

Among the patients with positive PAS samples, there were 189 females and 152 males, with a mean age of 57.5 years.

In the adult ICU, PAS samples from 170 patients showed 42.9% CRKP positivity and 25.8% CREC positivity; in the Hematology clinic, among 288 patients, 33.6% were CRKP positive and 31.2% were CREC positive; and in the Oncology clinic, out of 390 patients, 20.7% were CRKP positive and 16.9% were CREC positive (Table 1).

Among PAS (+) patients, 18 had growth of the same organism in a blood culture (17 CRKP, one CREC) (Table 2).

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Cite this article: Çalışkan G, Eren H, Aslan F, *et al.* Surveillance of carbapenem-resistant *Klebsiella pneumoniae* and *Escherichia coli* in perianal swab samples. *Infect Control Hosp Epidemiol* 2024. 45: 994–997, doi: 10.1017/ice.2024.60

Table 1. Perianal swab (PAS) surveillance results

Adult ICU-Hematology Clinic-Oncology Clinic PAS Screening*					
Departments	Screened patients (n = number)	PAS culture (+) patients (percentage = %, (n/total n))	Only PAS positive patients with CRKP %, (n/total n)	Only PAS positive patients with CREC %, (n/total n)	PAS positive patients with both CRKP and CREC %, (n/total n)
Adult ICU	170	51.1 (87/170)	42.9 (73/170)	25.8 (44/170)	17.6 (30/170)
Hematology	288	46.1 (133/288)	33.6 (97/288)	31.2 (90/288)	18.7 (54/288)
Oncology	390	31 (121/390)	20.7 (81/390)	16.9 (66/390)	6.6 (26/390)
Total	848	40.2 (341/848)	29.5 (251/848)	28.5 (200/848)	12.9 (110/848)

*(between the dates of 01.04.2021 and 31.03.2022).

Discussion

In our study, a substantial number of patients in the adult ICU, Hematology clinic, and Oncology clinic displayed CRKP and CREC positivity in perianal swabs. These results emphasize the vulnerability of critically ill and immunocompromised patients to colonization with multidrug-resistant pathogens.

In a systematic review assessing infection risk following CRE colonization, the analysis of 1806 initially colonized patients revealed 299 clinical infections, yielding a cumulative infection rate of 16.5%. Furthermore, among the 223 previously colonized patients for whom the site of infection was reported, primary bloodstream infections were identified in 30 patients (13.4%).[5] Similarly, in a study assessing the risk of CRKP-related BSI in colonized patients, it was observed that 37 out of 353 patients (11%) developed CRKP-related BSI.[6] Kontopoulou et al. investigated 498 patients, of which 226 exhibited rectal colonization by CRKP. Among these, 48 patients (21%) developed a CRKP-related BSI. Their findings indicated a median time of 8 days from hospital admission to the detection of CRKP rectal colonization, with a subsequent median time of 4 days from colonization to the development of BSI.[7] In our study, BSI rates among patients exhibiting CRKP growth in PAS samples demonstrated variation ranging from 3.7% to 9.58%. Among the patients with PAS (+), 17 had CRKP growth in blood culture whereas only 1 had CREC growth in blood culture. Across departments, our study found a median time of 19 to 57 days from hospital admission to CRKP BSI identification and 13 to 92 days from CRKP rectal colonization to BSI onset. We believe that the disparities in bloodstream infection rates among colonized patients in the literature, as well as the variations in median times of infection development following hospitalization and PAS positivity, could stem from differences in patient cohorts and hospital wards, as well as the colonization status of patients prior to admission.

Chu et al. conducted an investigation involving a total of 1203 patients, among whom 85 were found to be colonized by CRE. Out of these, 21 patients developed CRE infections, with 13 of them progressing to CRE-related BSI. The study highlighted a heightened prevalence of intestinal CRE colonization, especially among hospitalized patients and those in ICU, indicating potential rapid horizontal transmission and strongly suggesting a correlation between intestinal colonization and the occurrence of CRE-related BSI in hospitalized patients, underlining the possibility that the infecting strains might be linked to their colonized counterparts.[8] In our study, CVC-BSIs were identified as a notable source in both the adult ICU and Hematology clinic, highlighting the importance of catheter care and infection control measures in preventing such infections. We believe that the heightened incidence of invasive procedures might be a contributing factor to this elevated (9.58%) BSI rate in adult ICU.

Xu et al. investigated 2914 patients with hematological diseases via analyzing perianal swabs. Seventy-four patients were identified with CRE, and among them, 13 (17.5%) experienced CRE-related bloodstream infections. CRKP rectal colonization was identified as an independent risk factor for CRE-related BSI and suggested that rectal swab screening could serve as an early warning for subsequent CRE-related BSI.[9] In our study, out of 288 Hematology clinic patients, 33.6% tested positive for PAS CRKP (+) and 31.2% for PAS CREC (+), with 7 patients in the CRKP group and 1 patient in the CREC group having corresponding pathogens in blood cultures. Moreover, this study highlighted the significance of monitoring intestinal CRE colonization, not just in ICU or oncologic patients, but also in individuals with hematologic diseases.

Alon et al.'s research demonstrates the effectiveness of implementing infection control measures, including maintaining a case registry, strict contact isolation, and dedicated nursing staff, in significantly reducing acquisition rates of carbapenem-resistant *Acinetobacter baumannii* (CRAB) during a hospital-wide outbreak ($p < 0.001$).[10] Although the study primarily examines CRAB, we contend that the principles of surveillance and isolation can be applicable to CRE prevention as well.

Our study has several limitations, such as its retrospective nature, the absence of an assessment regarding compliance with infection control measures, and the lack of admission samples with molecular analysis of carbapenemase types preventing determination of whether patients were colonized on admission or acquired CRE in the hospital. Additionally, the study's design primarily emphasizes epidemiological data rather than delving into the clinical aspects of the patients.

In conclusion, our findings highlight the increased susceptibility of critically ill and immunocompromised patients to multidrug-resistant pathogens, reinforcing the need for vigilant surveillance and infection control strategies. The high yield of PAS in this study supports the practice of targeted screening in high-risk units that can aid in earlier detection, providing the opportunity to apply infection control precautions to prevent transmission and potentially reduce adverse clinical outcomes.

https://doi.org/10.1017/ice.2024.60 Published online by Cambridge University Press

Table 2. Bloodstream infection (BSI) surveillance in clinics with PAS screening

Patient Number	Age (in years) and Gender	Comorbidities	Departments	PAS result	Time to positivity for PAS according to hospitalization date (in days)	BSI related to CRKP or CREC	Day of CRKP or CREC growth in blood culture according to hospitalization date	Day of CRKP or CREC growth in blood culture according to PAS CRKP (+) or PAS CREC (+) date
1	68, F	NA	Adult ICU	CRKP	16	CRKP(+)secondary BSI	21	5
2	40, F	MG, HT	Adult ICU	CRKP	4	CRKP(+)CVC-related BSI	4	0
3	58, F	PHT, Scleroderma	Adult ICU	CRKP	3	CRKP(+)CVC-related BSI	19	16
4	37, F	Hypothyroidism	Adult ICU	CRKP	19	CRKP(+)CVC-related BSI	31	13
5	75, F	HT, DM, CHF, CLL	Adult ICU	CRKP	5	CRKP(+)secondary BSI	16	11
6	48, F	Hemangioma, Surrenal adenoma	Adult ICU	CRKP	4	CRKP(+)CVC-related BSI	17	13
7	73, F	HT, NHL	Adult ICU	CRKP	18	CRKP(+)CVC-related BSI	38	20
8	31, M	ALL, DM	Hematology	CRKP	10	CRKP(+) MBI-LC BSI	13	3
9	52, M	AML, HT, CAD	Hematology	CRKP	33	CRKP(+)CVC-related BSI	125	92
10*	19, F	AML	Hematology	CREC	0*	CREC(+) CVC-related BSI	22	102
11*	19, F	AML	Hematology	CRKP	0*	CRKP(+)CVC-related BSI	11	285
12	32, M	AML	Hematology	CRKP	26	CRKP(+)MBI-LC BSI	57	31
13	53, F	AML, rectal cancer	Hematology	CRKP	10	CRKP(+)MBI-LC BSI	16	6
14	29, M	AML	Hematology	CRKP	4	CRKP(+)MBI-LC BSI	148	144
15	59, F	AML	Hematology	CRKP	4	CRKP(+)MBI-LC BSI	163	159
16	65, F	SCC, HT	Oncology	CRKP	30	CRKP(+)secondary BSI	51	20
17	54, M	Plasmacytoma	Oncology	CRKP	7	CRKP(+)secondary BSI	47	40
18	74, M	Hepatocellular carcinoma	Oncology	CRKP	48	CRKP(+)secondary BSI	98	50

F, female; M, male; NA, non-available; MG, myasthenia gravis; HT, hypertension; PHT, pulmonary hypertension; DM, diabetes mellitus; CHF, congestive heart failure; CLL, chronic lymphocytic leukemia; NHL, non-Hodgkin's lymphoma; ALL, acute lymphocytic leukemia; AML, acute myeloid leukemia; CAD, coronary artery disease; SCC, squamous cell carcinoma; CVC, central venous catheter; MBI-LC, mucosal barrier injury laboratory-confirmed.
*Patients 10 and 11 are duplicates; however, the patient has a history of recurrent hospitalizations on different dates and a positive perianal swab (PAS) culture prior to hospitalization dates.

https://doi.org/10.1017/ice.2024.60 Published online by Cambridge University Press

Acknowledgments. None available.

Financial support. None available.

Competing interests. All authors report no conflicts of interest relevant to this article.

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https://doi.org/10.1017/ice.2024.60 Published online by Cambridge University Press