

Risk factors for nosocomial carbapenem-resistant *Klebsiella* infections

Nozokomiyal karbapenem dirençli klebsiella enfeksiyonlarında risk faktörlerinin incelenmesi

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ABSTRACT

Objectives: This retrospective case-control study aims to evaluate the clinical outcomes of patients diagnosed with nosocomial carbapenem-resistant *Klebsiella* infection (CRK), identify risk factors of this infection, and determine mortality rate.

Patients and methods: The study group consisted of 54 patients (23 males, 31 females; mean age 53.05±11.3 years, range, 18 to 82 years) diagnosed with CRK infection between January 2014 - July 2018. The control group was randomly selected among patients matched for gender who were hospitalized within the same period (±15 days) and had nosocomial infection but without CRK growth in cultures.

Results: Nosocomial CRK infection was most prevalent among the intensive care unit (90.75%). Mechanical ventilation, tracheostomy, presence of nasogastric tube, central venous catheter, elderly age (≥65 years), H2 receptor antagonist treatment, total parenteral nutrition, hospitalization within the past six months, antibiotic use within three months prior to CRK infection, and use of more than two antibiotic groups were identified as risk factors for development of CRK infection. Total mortality rate of the patient group was 31.48%.

Conclusion: In order to prevent spread of nosocomial CRK infections, which has gradually narrowing treatment options, there is a need for further prospective multicenter studies on reducing invasive procedures and inappropriate antibiotic use, identifying correctible risk factors, and taking necessary corrective measures.

Keywords: Carbapenem-resistant *Klebsiella* infection, mortality, nosocomial infection, risk factors.

ÖZ

Amaç: Bu retrospektif olgu-kontrol çalışmasında, nozokomiyal karbapenem dirençli *Klebsiella* (KDK) enfeksiyonu olan hastaların klinik sonuçlarının değerlendirilmesi ve bu enfeksiyon için risk faktörlerinin saptanması ve mortalite oranının belirlenmesi amaçlandı.

Hastalar ve yöntemler: Ocak 2014 - Temmuz 2018 tarihleri arasında nozokomiyal KDK enfeksiyonu saptanan 54 hasta (23 erkek, 31 kadın; ort. yaş 53.05±11.3 yıl; dağılım 18-82 yıl) çalışma grubunu oluşturdu. Kontrol grubu, aynı dönemde (±15 gün) ve serviste yatışı bulunan, cinsiyet uyumlu, nozokomiyal enfeksiyonu olan ancak alınan kültürlerinde KDK üremesi olmayan hastalardan randomize olarak seçildi.

Bulgular: Nozokomiyal KDK enfeksiyonu en sık (%90.75) yoğun bakım ünitelerinde idi. Mekanik ventilasyon, trakeostomi, nazogastrik tüp varlığı, santral venöz kateter varlığı, ileri yaş (≥65 yıl), H2 reseptör antagonist tedavisi, total parenteral beslenme, son altı ayda hastanede yatış öyküsü, KDK enfeksiyonu öncesi üç aylık dönemde antibiyotik kullanımı, ikiden fazla grup antibiyotik kullanımı KDK enfeksiyonu gelişiminde risk faktörü olarak saptandı. Hasta grubunda toplam mortalite oranı %31.48 idi.

Sonuç: Tedavi seçenekleri kademeli daralan nozokomiyal KDK enfeksiyonlarının yayılımının önlenmesi, mümkünse invaziv girişimlerin ve uygunsuz antibiyotik kullanımlarının azaltılması, düzeltilebilir risk faktörlerinin saptanması ve gerekli düzeltici önlemlerin alınması konularında ileriye dönük çok merkezli çalışmalara ihtiyaç duyulmaktadır.

Anahtar sözcükler: Karbapenem dirençli *Klebsiella* enfeksiyonu, mortalite, nozokomiyal enfeksiyon, risk faktörleri.

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Klebsiella strains are gram-negative microorganisms that may lead to serious clinical manifestations, and may cause infections such as bloodstream infections (BSI), urinary tract infections (UTI), and intraabdominal abscesses especially when hospital-acquired and in immunosuppressive patients. Infections caused by *Klebsiella* bacteria that produce carbapenemase are occurring more and more frequently with increased carbapenem use, invasive procedures, and number of immunosuppressive patients. Relevance of these infections is gradually increasing worldwide as well as in our country due to rapid spread of resistance, nosocomial outbreaks, limited number of antibiotic treatment options, increased mortality and morbidity rates, and treatment costs.^[1,2] While carbapenem resistance of *Enterobacteriaceae*, in which *Klebsiella* is a member of, used to be defined as resistance to third generation cephalosporins (ceftriaxone, cefotaxime, ceftazidime), and either doripenem, meropenem or imipenem, the update to guidelines in 2015 added ertapenem resistance to the definition and removed the condition of cephalosporin resistance.^[3]

One study that investigated carbapenemase types in European countries in 2014 and 2015 reported that carbapenem-resistance *Klebsiella* spp. identified in our country was endemic for carbapenemases, regional spread for NDM-1 type (New Delhi metallo-beta-lactamase-1) carbapenemases, and nosocomial outbreaks for VIM.^[4] This emphasizes the importance of developing strategies to identify risk factors for *Klebsiella* type bacterial infections, protection, and prevention against nosocomial spread of these microorganisms. This retrospective case-control study aims to evaluate the clinical outcomes, identify risk factors, and determine mortality in patients diagnosed with nosocomial carbapenem-resistant *Klebsiella* (CRK) infection.

PATIENTS AND METHODS

This study was planned as a retrospective case-control study to identify risk factors associated with development of nosocomial CRK infection, and determine mortality in inpatients who were hospitalized between January 2014 - July 2018. The patient group consisted of 54 patients (23 males, 31 females; mean age 53.6±11.3 years;

range, 18 to 82 years) who had CRK growth in microbiological cultures and were diagnosed with nosocomial infection according to our hospital's Infection Control Committee (ICC) surveillance data. Patients aged ≥18 years were included in the study regardless of admission diagnoses and gender differences. The control group was randomly selected from patients who were hospitalized within the same period (±15 days), of the same gender, and same nosocomial infection diagnoses as the patient group, but without CRK growth in microbiological cultures. A control patient corresponded to each patient. Patient and control groups were compared according to risk factors and mortality.

In patients who were admitted twice for the same factor, only the first infection episode was included in the study. The study protocol received approval from the Kütahya Evliya Çelebi Training and Research Hospital Ethics Committee (September 11, 2018; TUEK 141-2018 GOKAEK/7-47). Informed written consent was obtained from all study participants. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Potential risk factors

Hospital database discharge reports, ICC nosocomial infection surveillance forms, microbiological cultures, and antibiogram results of patients who were diagnosed with nosocomial *Klebsiella* infection according to the hospital's ICC and registered to the National Hospital Infections Surveillance System (Inflin) were retrospectively evaluated. Data including admission diagnoses, chronic renal failure, diabetes mellitus, immunosuppression, malignancy, history of cerebrovascular accident, history of surgery, additional disease such as trauma, invasive procedures (Foley catheter, catheter, mechanic ventilation, etc.), hospital length of stay, duration until development of nosocomial infection, antimicrobial treatments before and during nosocomial infection, Charlson comorbidity indexes (Table 1), and mortality were assessed. Collected data was transferred to forms for evaluation.

Microbiological examination

Identification and antibiotic sensitivity tests of *Klebsiella* spp. strains grown in cultures

Table 1. Charlson Comorbidity Index^[5]

Comorbidity	Weighted score*
Diabetes mellitus, myocardial infarction, congestive heart failure, peripheral vascular disease, chronic respiratory disease, dementia, cerebrovascular disease, connective tissue disease, peptic ulcer, mild liver disease	1
Leukemia/lymphoma, multiple myeloma, hemiplegia, nonmetastatic solid tumor, moderate-severe renal failure, diabetes mellitus (end organ damage)	2
Moderate-severe liver failure	3
Metastatic solid tumor; AIDS	6

* Total score was calculated by adding each comorbidity as points. One point is added for every 10 years past the age of 40 (e.g. 50-59 years: 1 point, 60-69 years: 2 points); AIDS: Acquired immune deficiency syndrome.

were done in the microbiology laboratory of our hospital using the VITEK® 2 (BioMérieux, Marcy l'Etoile, France) automated system. According to EUCAST (The European Committee on Antimicrobial Susceptibility Testing) minimum inhibitory concentration (MIC) values, years in which infections caused by *Klebsiella* spp. strains occurred in our hospital were assessed according to recommended MIC values and CRK-suspected strains were taken into reevaluation with E-test.^[5]

Definitions of infection types

Nosocomial infections are defined as infections that develop within 48 hours after hospital admittance. The current CDC (Centers for Disease

Control and Prevention) diagnostic criteria were used for nosocomial infection diagnosis.^[6,7]

Statistical analysis

Statistical analysis was performed with the SPSS version 16.0 (SPSS Inc., Chicago, IL, USA) statistical package program. Quantitative data was expressed as mean \pm standard deviation (SD) and categorical data as number (n) and percentage (%). Pearson chi-square test and Fisher's exact chi-square test methods were used in comparison of groups of categorical variables, while Student's t-test was used for testing continuous variables. All

Table 2. Distribution of carbapenem-resistant *Klebsiella* spp. growth according to hospital units

	n	%
Intensive care unit	49	90.75
Internal ICU	19	35.19
Surgical ICU 1	10	18.52
Surgical ICU 2	5	9.25
Neurology ICU 1	4	7.42
Emergency ICU	4	7.42
General ICU	3	5.55
Cardiovascular surgery ICU	2	3.70
Neurology ICU 2	1	1.85
Burn ICU	1	1.85
Non-ICU wards	5	9.25
General surgery	2	3.70
Neurosurgery	1	1.85
Internal medicine	1	1.85
Medical oncology	1	1.85
Total	54	100

ICU: Intensive Care Unit.

Table 3. Nosocomial infection type

	n	%
Bloodstream infection	23	42.60
Central venous catheter related BSI	18	33.35
Laboratory-confirmed BSI	5	9.25
UTI	17	31.48
Catheter-related UTI	13	24.06
Symptomatic UTI	4	7.42
Pneumonia	6	11.12
Ventilator-related pneumonia	4	7.42
Clinically diagnosed pneumonia	1	1.85
Non-specific pneumonia	1	1.85
Surgical site infection		
Primary superficial SSI	5	9.25
Primary deep incisional SSI	3	5.55
Other	2	3.70
Decubitus ulcer infection	1	1.85
Burn infection	1	1.85
Soft tissue infection	1	1.85
Total	54	100

BSI: Bloodstream infection; UTI: Urinary tract infection; SSI: Surgical site infection.

Table 4. Demographic, microbiological, and clinical data of patient and control groups

	Patient group (n=54)			Control group (n=54)			p
	n	%	Mean±SD	n	%	Mean±SD	
Mean age (year)			53.05±11.3			47.09±12.18	NS
Gender	23	42.60		25	46.29		NS
Male							
≥65 age	16	29.63		5	9.25		<0.05*
Infection length*			25.0±18			25.0±18	
Hospitalized unit (ICU)	49	90.75		49	90.75		NS
Primary bacteremia	23	42.60		17	31.48		NS
Secondary bacteremia	8	14.81		5	9.25		NS
Hospitalization within past 6 months	42	77.77		13	24.07		<0.001*
Hospitalization within past 3 months	13	24.07		5	9.25		NS
Transfer from another hospital	3	5.55		2	3.70		NS
Nursing home resident	12	22.22		5	9.25		NS
Surgical procedure within past month	9	16.66		2	3.70		NS
Urologic procedure within past 3 months	3	5.55		4	7.42		NS
Blood transfusion	17	31.48		9	16.66		NS
H2 receptor antagonist use	38	70.37		23	42.60		<0.05*
Mechanical ventilation	42	77.77		27	50		<0.05*
Central venous catheter	44	81.48		28	51.85		<0.05*
Urinary catheter	49	90.74		45	83.33		NS
Peritoneum dialysis catheter	2	3.70		1	1.85		NS
Nasogastric catheter	16	29.63		6	11.12		<0.05*
Tracheostomy	12	22.22		2	3.70		<0.05*
Chest drain	2	3.70		1	1.85		NS
Abdomen drain	3	5.55		2	3.70		NS
Gastrostomy	3	5.55		5	9.25		NS
Total parenteral nutrition	28	51.85		13	24.07		<0.05*
Colostomy	3	5.55		4	7.42		NS
Cystostomy	2	3.70		1	1.85		NS
Nephrostomy	1	1.85		0	0		NS
Endoscopy/colonoscopy	3	5.55		5	9.25		NS
Bronchoscopy	2	3.70		1	1.85		NS
Antibiotic use within 3 months prior to infection	49	90.75		38	70.37		<0.05*
Cephalosporin use	32	59.25		22	40.74		NS
Anti-pseudomonal penicillin use	16	29.62		13	24.07		NS
Quinolone use	16	29.62		8	14.81		NS
Glycopeptide use	7	12.96		4	7.42		NS
Carbapenem use	12	22.22		5	9.25		NS
Anaerobic effective antibiotic use	13	24.07		9	16.66		NS
Use of more than one group antibiotics	28	51.85		23	42.60		NS
Use of more than two groups antibiotics	12	22.22		2	3.70		<0.05*
Antifungal treatment	4	7.42		2	3.70		NS
Mortality (n), (>28 days)	17	31.48		5	9.25		<0.05*

SD: Standard deviation; * Statistically significant; NS: Not Significant,

significance tests were two-way and *p* value of less than 0.05 was considered statistically significant in two-way analyses.

RESULTS

Nosocomial infections that developed in inpatients hospitalized in our hospital's wards between January 2014 and July 2018 were investigated and 54 patients with infection of CRK origin were included in the study, comprising the nosocomial CRK study group. A total of 54 patients who met criteria listed above were included in the control group. Nosocomial CRK infection according to distribution over years is as follows: six cases in 2014, six cases 2015, 21 cases in 2016, 18 cases 2017, and three cases in the first seven months of 2018. Nosocomial CRK infections were most common in intensive care unit (ICU) patients (90.75%; n=49), while the rest were only five inpatients in wards other than the ICU (9.25%) (Table 2).

According to distribution of nosocomial CRK infections, 23 patients (42.6%) had BSI and 17 patients (31.48%) UTI (Table 3). Carbapenem-resistant *Klebsiella* infection growth was present in blood culture in 25 patients (46.29%), urine in 10 (18.51%), catheter blood in eight (14.81%), wound in six (11.12%), tracheal aspirate in four (7.42%), and sputum in one patient (1.85%). According to EUCAST MIC values, of the isolated strains, 24 had resistance to only imipenem, 11 decreased susceptibility to imipenem, and 16 resistance to ertapenem, imipenem, and meropenem. *Klebsiella* spp. strains isolated from three patients were susceptible to meropenem and imipenem and resistant to ertapenem. Isolated *Klebsiella* strains were generally susceptible to aminoglycosides (amikacin 72%, gentamicin 57%, tobramycin 32%). Colistin resistance was found in only one patient. Colistin resistance had not been confirmed or investigated with agar microdilution.

Table 5. Comorbidities of patient and control groups

Comorbidity	Patient group (n=54)		Control group (n=54)		<i>p</i>
	n	%	n	%	
Diabetes mellitus	25	46.29	14	25.92	<0.05*
Solid organ malignancy	5	9.25	9	16.66	NS
Hematologic malignancy	3	5.55	4	7.42	NS
Chemotherapy/radiotherapy	8	14.81	13	24.07	NS
Chronic liver failure	3	5.55	5	9.25	NS
Hypertension	42	77.77	38	70.37	NS
Chronic heart failure	16	29.62	14	25.92	NS
Chronic respiratory disease	12	22.22	15	27.77	NS
Neurologic disease/sequela	25	46.29	18	33.33	NS
Trauma	2	3.70	1	1.85	NS
Burn	1	1.85	1	1.85	NS
Chronic renal failure	13	24.07	5	9.25	NS
Acute renal failure	3	5.55	5	9.25	NS
Chronic diarrhea	8	14.81	2	3.70	NS
Decubitus wound presence	14	25.92	12	22.22	NS
Hemodialysis	5	9.25	5	9.25	NS
Immunosuppressive treatment	3	5.55	2	3.70	NS
Human immunodeficiency virus infection	0	0	0	0	NS
Organ transplantation	2	3.70	1	1.85	NS
Steroid use	8	14.81	5	9.25	NS
Charlson comorbidity index use ≥ 6	39	73.9	23	26.1	NS

* Statistically significant; NS: Not significant.

According to demographic characteristics of the patients, 31 were female (57.4%), 23 were male (42.6%), and mean patient age was 53.05 ± 11.3 (18-82) years. According to risk factors for CRK infection: prevalence of ≥ 65 age ($p=0.007$), hospitalization within the past six months ($p<0.001$), H2 receptor antagonist use ($p<0.05$), mechanical ventilation ($p<0.05$), central venous catheter presence ($p<0.05$), nasogastric catheter presence ($p<0.001$), tracheostomy presence ($p<0.05$), total parenteral nutrition ($p<0.05$), antibiotic use within three months before CRK infection ($p<0.05$), and use of more than two groups antibiotics ($p<0.05$) were found significantly high (Table 4). All patients who developed CRK infection underwent combination treatment. Six patients developed colistin-induced nephrotoxicity. In the CRK infection group, mortality occurred in 17 patients (31.7%) in less than 28 days, which was significantly higher compared to the control group.

According to comorbidities of the patient and control groups, diabetes mellitus was significantly more prevalent among the CRK group ($p<0.05$). Mean Charlson index was calculated as 3.75 ± 1.95 in the event of nosocomial infection; this value was 4 ± 1.9 in the patient group and 3.5 ± 2.0 in the control group. There was no statistically significant difference between the groups according to mean Charlson index scores (Table 5).

DISCUSSION

Klebsiella spp. strains are observed in 3-8% of all nosocomial bacterial infections, and are most commonly reported to cause urinary tract infection, pneumonia, and primary bacteremia.^[8,9] Throughout the study period, a total of 253 patients (199 carbapenem-susceptible, 54 carbapenem-resistant) developed nosocomial *Klebsiella* spp. infection. Carbapenem resistance of these *Klebsiella* strains that caused these infections was found as 21.3%. However, this rate only reflects the results of patients who developed nosocomial infection. Over the last 10 years, there is an increased number of reports of carbapenem resistance associated with *Klebsiella* spp. strains in Europe. While resistance rate was 7.3% according to 2014 data, there is an increased number of reports especially from Greece, Romania, and Italy (62.3%, 32.9%, and 31.5%, respectively).

These CRK strains are often reported to be susceptible to only tigecycline, colistin and/or aminoglycoside groups.^[10] One study conducted in our country found that CRK strains were resistant to all antibiotics except for tigecycline and polymyxin.^[11] Ozger et al.^[10] investigated 434 nosocomial *Klebsiella* strains and detected ertapenem resistance in 115 of them (26.5%). Ertapenem resistance was detected in 34.1% of strains isolated from intensive care, and 10.1% of strains isolated from other wards. Although there are studies that report carbapenem resistance does not surpass 5% among Enterobacteria strains, there are also reports that carbapenem resistance of *Klebsiella pneumoniae* strains have surged from 5 to 20% within one year.^[12,13]

The control groups of most studies in the literature on the risk factors of CRK infection consist of patients with carbapenem-susceptible *Klebsiella* infection.^[14-17] To avoid possible bias, the control group of this study was randomly selected among patients without CRK infection.

In recent years, as in the rest of the world, with the increasing number of invasive procedures in our country, CRK strains that can cause various hospital infections have become an important problem with the gradually decreasing treatment options. Both host-related and environmental risk factors that may cause infections, and especially nosocomial endemics, have been described. There is a limited number of studies in the literature about risk factors for nosocomial CRK infection. These studies have stated age and gender were not significant variables.^[17] However, one study in our country found that age was a risk factor for CRK infection.^[18] While there was no difference according to gender in our study, age of the CRK group was statistically older. We believe this may be attributed to increased comorbidity and hospitalization of elderly patients.

Some studies report that ICU stay increases risk of nosocomial CRK infection by up to 3.36-17.4 times.^[19-22] Papadimitriou-Olivgeris et al.^[22] reported CRK colonization in 13% of ICU patients and that ICU patients should be transferred to other wards as soon as possible. The literature also reports CRK colonization developed in 70-75% of patients who stayed in ICU.^[23,24] Kofteridis et al.^[23] reported ICU stay was an independent risk factor for CRK infection/

colonization. In our study, nosocomial CRK infection was most common among ICU patients (n=49; 90.7%) and there was no statistically significant difference between the cases and control groups according to the hospitalization service.

The literature reports many comorbid diseases are risk factors for CRK infection. Foremost, these include: transplantation (organ and stem cell), severe disease, chronic/acute renal failure, neurologic disease, immunosuppressive treatment, and steroid use.^[14-17,19-21,25] In our study, chronic renal failure and comorbid diabetes mellitus were found to be risk factors. While one study found systemic steroid use wasn't a risk factor for CRK infection,^[26] another study found it was a preventive factor.^[23] Our study found immunosuppressive treatment and steroid use as risk factors.

There are studies in the literature that report invasive procedures and medical treatments were especially risk factors for development of CRK infection. Esen and Leblebicioglu^[25] conducted a daily point-prevalence study and reported urinary catheter, nasogastric catheter, intubation, tracheostomy, central venous catheter, mechanical ventilation, and emergency surgical procedures significantly increased risk of nosocomial infection. Budak et al.^[26] listed use of invasive devices, total parenteral nutrition, and transfusion of blood products as risk factors. Yigit et al.^[27] reported history of surgical procedure, urinary catheter, invasive procedures, and prolonged mechanical ventilation were risk factors for CRK development. In a meta-analysis by Liu et al.,^[20] central venous catheter, tracheostomy, mechanical ventilation, and total parenteral nutrition were listed as interventional risk factors. Hyle et al.^[28] reported central venous catheter and Falagas et al.^[12] reported tracheostomy and nasogastric catheter use were independent risk factors. Akgul et al.^[16] reported tracheostomy, urinary catheter, central venous catheter, nasogastric catheter, total parenteral nutrition, mechanical ventilation procedures, and emergency operation as risk factors and emphasized that it may be caused by insufficient antisepsis, lack of proper timing of surgical prophylaxis administration, and increased complications due to emergency operation. In our study, use of H2 receptor antagonists, mechanical ventilation, presence of central venous catheter

(CVC), nasogastric catheter, tracheostomy and total parenteral nutrition were determined as risk factors for CRK.

There are studies which report prolonged hospitalization as a risk factor for *Klebsiella* infection/colonization.^[15,16,22,29] Mean infection time of CRK infections in our study was 25.0 (12.75-40.0) days, which was significantly longer compared to the control group.

Many studies in the literature list antibiotic use as a risk factor for CRK infection.^[14-17,19,20,22,30] However, there are studies that report the contrary.^[25,31,32] Liu et al.^[20] reported quinolone, aminoglycoside, carbapenem, glycopeptide, and antipseudomonal penicillin, Falagas et al.^[12] and Hussein et al.^[14] reported carbapenem, Zhang et al.^[29] carbapenem, glycopeptide, and quinolone, Wu et al.^[33] carbapenem and glycopeptide, Akgul et al.^[16] carbapenem, colistin, piperacillin, and tazobactam, and Dizbay et al.^[18] imipenem and cefoperazone use within three months before infection, and Zarakolu et al.^[32] reported antibiotic use within three months before infection, especially only imipenem, were risk factors for CRK infections. In our study, correlation between CRK infection and antibiotic use three months prior to infection was also statistically significant. However, there was no statistically significant difference between groups according to antibiotic groups.

The mortality of nosocomial CRK infection ranges from 40-50% especially in patients who develop bacteremia.^[34-37] A majority of deaths are reported to occur within two weeks of infection onset, and cancer patients have high mortality rates, especially within the first 30 days.^[38] McGregor et al.^[37] reported that high Charlson comorbidity index was associated with increased infection risk and was an important predictive factor for mortality. Zarakolu et al.^[32] indicated that there was no statistical significance in Charlson score, Glasgow Coma Scale (GCS), and Acute Physiology And Chronic Health Evaluation II (APACHE II) scores in patients with CRK infection-related mortality, but that The Simplified Acute Physiology Score (SAPS) II score was significantly higher in both single-variable and multiple variance analyses. Qureshi et al.^[38] found 28-day mortality rate as 39% in patients who developed CRK bacteremia. Combination

treatment was also reported as an independent protective factor for survival. Tumbarello et al.^[39] reported 30-day mortality rate as 41.6% and reported lower mortality in those who received *in vitro* effective combination treatment. Viale et al.^[40] stated monotherapy increased mortality, while Balkan et al.^[41] reported that combination treatments including colistin reduced mortality. In our study, there was no statistically significant difference between the two groups according to Charlson indexes. Twenty-eight-day mortality was 31.4% in patients who developed CRK infection, and there was no significant difference between the two groups.

Prevention and nosocomial spread of CRK infections, which are difficult to manage and costly, should be prevented. Following CDC guidelines,^[3] standard measures, hand-washing hygiene, surveillance, contact isolation, environmental cleaning and disinfection, quarantine and/or cohort of patients with CRK infection/colonization, separating these patients from caregivers, restricting patient admission to the unit with infection if necessary, and antibiotic management measures are recommended.

Study limitations

The retrospective study design, and the fact that records accessed from the database was already evaluated were among the limitations of the study. Carbapenem resistance was only evaluated with VITEK and E-test when necessary and was not confirmed with molecular methods.

Conclusion

In order to prevent spread of nosocomial CRK infections, which has gradually narrowing treatment options, there is a need for further prospective multicenter studies on reducing invasive procedures and inappropriate antibiotic use, identifying correctable risk factors, and taking necessary corrective measures.

Declaration of conflicting interests

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