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Carbapenem-Resistant *Klebsiella pneumonia* Isolated from Patients Admitted in Tertiary Care Hospital in Saudi Arabia

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Authors' contributions

This work was carried out in collaboration among all authors. Author ESHK choose the topic of the study, planned the study, collected the samples, carried out the practical laboratory work, interpreted the results and revised the manuscript. Author AAA shared in clinical diagnosis of cases, collecting samples, reviewing and approving the final manuscript. Author SSAE participated in the designing of the study, obtaining the samples, participated in the interpretation of the results. All authors read and approved the final manuscript.

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ABSTRACT

Background: Carbapenem-resistant *klebsiella pneumoniae* is an emerging threat worldwide causing high rates of morbidity and mortality
Aim: To evaluate the prevalence of carbapenem-resistant *K. pneumonia (*CRKP), associated risk factors, type of infections caused by CRKP and their antimicrobial susceptibility. To evaluate Carbapenemase Detection Set (D70C) as screening test for CRKP
Place and Duration of the Study: A cross sectional study and prospective cohort study was performed from June 2019 to February 2020 in intensive care unit and medical units of Al Quwayiyah General hospital.
Methodology: 541 samples were collected from different patient sources. *Klebsiella pneumoniae* strain was only selected identified to the species level and AST was done using the Vitek-2.

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Minimum inhibitory concentration (MIC) of meropenem and imipenem was carried out. A Carbapenemase Detection Set (D70C) was used as screening test for CRKP while Modified Hodge test and multiplex PCR as confirmatory tests.

Results: A total of 132 isolates were diagnosed as Enterobacteriaceae out of 541 patient samples.78 clinical isolates *were klebsiella pneumoniae* which were collected. Out of the 78 clinical isolates CRKP were 36 (46.2%) and CSKP were 42 (53.8%).) CRKP cases aged from (18-84 years) with the median patient age 59 year. Seventeen of 36 patients (47.2%) were males. the majority of the nosocomial CRKP infections were pneumonia 12 (33.3%) followed by urinary tract infection 9 (25%). The most common associated disease was diabetes (30%) followed by renal disease (27.8%). For invasive procedures, Urinary catheter was 27(75%) and 29(69%) followed by Mechanical ventilation 25(69.4%) and 22(52.4%) in CRKP and CSKP patients respectively. Reports of PCR for the 41 isolates which sent to regional laboratory for confirmation revealed that 36 isolates had carbapenemase genes; twenty eight (77.8%) *K. pneumonia* isolates positive for *bla* OXA-48 and 5 (13.9%) isolates were positive for *bla*NDM. in 2 (5.6%) *bla* KPC were detected, one isolate contained *bla*IMP. 5 isolates contain both *bla*OXA-48 and *bla*NDM. The sensitivity of MHT was analysed to be 91.7%. (95%CI ratio 77.53% - 98.25%) and the specificity was 100% (95%CI ratio 54.07% to 100%). The positive predictive value was 100% and the Negative predictive value was 66.7% (95%CI ratio 40.36% to 85.53%). The sensitivity of Carbapenemase Detection Set (D70C) was 94.4% (81.34% to 99.32%) and the specificity was 80% (95%CI ratio 28.36% to 99.49%). The positive predictive value was 97.1% (95%CI ratio 85.46% to 99.49%).and the Negative predictive value was 66.7% (95%CI ratio 32.67% to 89.18%).

Conclusion: CRKP prevalence was 46.2% among *K. pneumoniae* isolates in Al Quwayiya General Hospital. Using invasive procedures such as urinary catheters or mechanical ventilator and misuse of antibiotics were risk factors associated with CRKP indicating that infection control guidelines and effective preventive measures should be strictly applied. It is very important to monitor and report changes in antimicrobial-resistant isolates but Carbapenemase Detection Set (D70C) has low specificity makes it less reliable and need PCR confirmation.

Keywords: Carbapenem-resistance; Klebsiella pneumoniae; modified hodge test.

1. INTRODUCTION

Enterobacteriaceae are considered as most common organisms which cause health care associated infections worldwide [1]. Increasing the incidence of these organisms leads to emergence of new antimicrobial resistant strains such as Carbapenem resistant Enterobacteriaceae (CRE). The most commonly detected CRE is carbapenem-resistant *Klebsiella pneumoniae* (CRKP) [2]. CRKP was early isolated in 1996 in North Carolina then reported all over the world, including Asia, Europe, and Australia [3].

With the presence of CRKP, physicians have very limited antibiotic choices to manage infections, as CRKP strains are also resistant to other antibiotics such as Aminoglycosides and Fluoroquinolones besides Carbapenem [4].

Carbapenem resistance in *Klebsiella pneumoniae* is due to two mechanisms: first presence of enzymes which hydrolyze carbapenems like. serine-carbapenemases and metallo-β-lactamases. Second is caused by membrane impermeability with ESBLs and AmpC production [5].

Many researchers have studied the risk factors of acquiring CRKP [6,7]. Recent reports determine the CRKP associated risk factors such as antibiotic use, ventilator use, and admission to the ICU.

The most common carbapenemases are oxacillinase-48 (OXA-48), New Delhi metallo-beta-lactamase-1 (NDM-1), Verona integron metallo-beta-lactamases (VIM), imipenemase (IMP) *and Klebsiella pneumoniae* carbapenemase (KPC) which harbor carbapenem resistance genes blaOXA-48-like, blaNDM, blaVIM, blaIMP and blaKPC respectively [8]. Phenotypic assays are included in screening carbapenemase activity, while molecular assays detects carbapenemase encoding genes [9].

The aim of the study:

1. To evaluate the prevalence of carbapenem-resistant *K. pneumonia (*CRKP), associated risk factors, type of

infections caused by CRKP and their antimicrobial susceptibility.
2. To evaluate Carbapenemase Detection Set (D70C) as screening test for CRKP.

2. MATERIALS AND METHODS

2.1 Study Design

A cross sectional study and prospective cohort study was performed from June 2019 to February 2020 in intensive care unit and medical units of Al- Quwayiyah General Hospital. 541 samples were collected from different patient sources. *Klebsiella pneumoniae* strain was selected if there is more than one type of bacteria isolated. Inclusion criteria included all patients who had clinical symptoms correlated with respiratory, urinary, blood stream, and wound infections admitted to intensive care unit and medical units after 2 days of admission or more.

Two studied groups were defined according to multiplex PCR results:

Group I contained patients infected with a CRKP strain

Group II consisted of patients infected with a carbapenem-susceptible *Klebsiella pneumoniae*. (CSKS)

Data for demographics (age and sex), risk factors (diabetes mellitus, cardiovascular disease, pulmonary disease, renal disease, hepatic disease central nervous system disease) and antibiotics administration was collected after patient permission.

2.2 Collection and Identification of Isolates

Seventy eight *K. pneumoniae* isolates were collected from various samples; from patients admitted in ICU, male medical and female medical wards. *K. pneumoniae* isolates were identified by colony morphology on blood and MacConkey's agar plates (oxoid, UK), Gram stained smears and using the Vitek-2 identification system (BioMerieux, France) by the GN card as per the manufacturer's instructions Control strains *K. pneumonia ATCC 700603 strains were used as positive control for KPC, Also, ATCC Escherichia coli 25922 was used as a negative control.*

2.3 Antibiotic Susceptibility Testing (AST)

AST was done using the Vitek-2 system (BioMerieux, France), as per the manufacturer's instructions. The antimicrobials included in the AST 220 card were ampicillin, amoxicillin-Clavulanate, trimethoprim-Sulfamethoxazole, piperacillin-tazobactam, eftazidime, imipenem, Cefepime, meropenem, amikacin, tigecycline gentamicin, and ciprofloxacin [10]

Minimum inhibitory concentration (MIC) of meropenem and imipenem was carried out for each isolate using an E-test (BioMérieux, France), which were done and interpreted according to the manufacturer's guidelines. the concentration gradient of meropenem and imipenem was between 0.0025 µg/ml to ≥32 µg/ml. Carbapenem resistance was suspected MIC was ≥2 mg/L for either imipenem or meropenem according to CLSI guidelines [11].

2.4 Screening Test for Carbapenemase

2.4.1 Phenotypic detection of KPC/MBLs enzymes and AmpC activity [8]

A Carbapenemase Detection Set (D70C) (Mast Diagnostics, Merseyside, UK) was used to identify carbapenemase (KPC/MBLs enzymes and AmpC activity) which had 4 discs:

A) 10 µg carbapenem disc),
B) carbapenem 10 µg plus MBL inhibitor disc
C) carbapenem 10 µg plus KPC inhibitor disc
D) carbapenem 10 µg plus AmpC inhibitor disc.

Interpretation: On comparison of inhibition zone of disc A to the inhibition zones of each of discs B, C, and D.

1. If disc B showed a zone difference of ≥ 5 mm from disc A, the organism was interpreted to have MBL activity.
2. If disc C showed a zone difference of ≥ 4 mm from disc A, the organism was interpreted to have KPC activity.
3. If disc C and disc D both showed a zone difference of ≥ 5 mm from disc A, the organism was interpreted to have AmpC activity

2.5 Confirmatory Test for Carbapenemase

2.5.1 Modified hodge test (MHT)

MHT test was done as recommended by the CLSI guidelines, 2012. A suspension of

ATCC *Escherichia coli* 25922 was done and adjusted to 0.5 Mac Farland's then diluted 1:10 in sterile saline. The diluted suspension was streaked on a Mueller Hinton agar plate in three directions. After 5 minutes the plate was dried then a disc of imipenem 10 µg was applied in the middle of the agar plate. Three to five colonies of the isolate were streaked in a straight line, from the disc edge up to a distance of not less than 20mm. The plates were overnight incubated at 37°C then examined the day after [12]

Interpretation: The plates were examined for the enhanced growth around the test organism, at the intersection of the streak and for a zone of inhibition.

The presence of carbapenemase production was indicated by an enhanced growth and the absence of carbapenemase production was indicated by absence of the enhanced growth.

All isolates which were positive by E test were sent to the regional laboratory to be confirmed by multiplex PCR for detection of the *bla* genes *bla*IMP, *bla*VIM, *bla*KPC, *blaOXA-48-like* and *bla*NDM-1 [13].

2.6 Statistical Analysis

Data analysis was done using SPSS version 16 software. Data was interpreted as numbers and percentages. _ Z ˝ test for 2 variables and ˝ χ^2 _(Chi square) test for more than two were used as tests of significance. P value of <0.05 was considered statistically significant.

3. RESULTS

A total of 132 isolates were confirmed to be Enterobacteriaceae out of 541patient samples.78 clinical isolates were *klebsiella pneumoniae* which were collected from different patient sources; sputum (31), urine (20), Blood/intravascular line (11), wound (10), body fluid (4) and throat (2). Out of the 78 clinical isolates CRKP were 36 (46.2%) and CSKP were 42 (53.8%). Sources from which CRKP and CSKP isolated were shown in Table (1). Twenty three CRKP isolates were isolated from patients in ICUs followed by 7 isolates from the male medical ward and 6 isolates from the female medical ward. While 24 isolates CSKP from the male medical ward, 10 isolates from the female medical ward and 7 isolates from patients in ICU.

The demographic data of patients with CRKP and CSKP are presented in Table (2) CRKP cases aged from (18-84 years) with the median patient age 59 year, 27(75%) of CRKP cases were aged over 60 years. Seventeen of 36 patients (47.2%) were males, while CSKP cases aged from (16-87 years) with the median patient age 37 years, 20(43.4%) were aged over 60 years and 25 of 42 patients (59.5%) were males. There is statistically significant difference between CRKP and CSKP regarding median age.

The most common associated disease was diabetes (30%) followed by renal disease (27.8%). For invasive procedures, Urinary catheter was 27(75%) and 29(69%) followed by Mechanical ventilation 25(69.4%) and 22(52.4%) in CRKP and CSKP patients respectively. There is statistically significant difference between CRKP and CSKP regarding length of ICU stay, nasogastric catheter and antibiotics use.

Table 3 showed that the majority of the nosocomial CRKP infections were pneumonia 12 (33.3%) followed by urinary tract infection 9 (25%). All CSKP and CPKP infections included were hospital acquired as samples collected after 48 h of admission.

Table 1. Sources of *klebsiella pneumoniae* isolates

Sources	CRKP =36	CSKP =42
Sputum	12(33.3%)	19(45.2%)
Urine	9(25%)	11(26.2%)
Blood/intravascular line	5(13.9%)	6(14.3%)
Wound	6(16.7%)	4(9.5%)
Body fluids	3(8.3%)	1(2.4%)
Throat	1(2.8%)	1(2.4%)

Table 2. Comparison of risk factors associated with carbapenemase resistance and susceptibility

Risk factors	CRKP =36	CSKP =42	OR (95% CI)	P
Male	17(47.2 %)	25(59.5 %)	1.416(0.601-3.192)	0.512
Female	19(52.8%)	17(40.5%)	1.392(0.589-3.180)	0.102
Median age	59(18-84)	39(8-87)		0.051
ICU stay per day	16(1-65)	9(3-42)		0.019*
Diabetes mellitus	12 (33.3 %)	14(33.3%)	0.531(0.043-6.128)	5.02
Renal disease	10 (27.8 %)	10(23.8%)	1.259(0.713-3.590)	0.630
Pulmonary disease	7 (19.4%)	7(16.7%)	1.528(0.153-3.817)	0.891
Cardiovascular disease	3(8.3%)	4(9.5%)	0.671(0.283-1.362)	0.468
Neurological disease	8 (22.2%)	4(9.5%)	4.291(1.127-3.761)	0.11
Mechanical ventillation	25(69.4%)	22(52.4%)	1.421(0.530-3.79)	0.571
Nasogastric catheter	17(47.2%)	7(16.7%)	3.501(1.320-9.521)	0.019*
Endotracheal tube	24(66.7%)	21(50%)	1.623(0.299-1.593)	0.441
Urinary catheter	27(75%)	29(69%)	1.663(0.762-3.910)	0.217
Central venous catheter	23(63.9%)	26(61.9%)	2.107(0.398-1.632)	0.550
Antibiotic use	34(94.4%)	23(54.8%)	2.415(1.102-5.310)	0.057*

Table 3. Nosocomial infections caused by CRKP and CSKP

Type of infection	CRKP =36	CSKP=42
Pneumonia	12(33.3%)	19(45.2%)
Urinary tract infection infection	9(25%)	11(26.2%)
Surgical site infection	6(16.7%)	4(9.5%)
Central venous catheter bacteraemia	5(13.9%)	6(14.3%)
Intra-abdominal infection	3(8.3%)	1(2.4%)
Throat infection	1(2.8%)	1(2.4%)

Table 4. showed that the resistance pattern was high among CRKP more than CSKP strains in all antibiotic groups. Among β-lactam group CRKP strains were 100% resistant to ampicillin, amoxicillin-clavaulanate, pip/taz, trimethoprim-sulfamethoxazol, ceftazidime, ceftriaxone, cefepime and aztreonam. Aminoglycosides group showed 88.9% resistance for amikacin and 94.4% resistance for gentamicin. Fluoroquinolones group showed 91.7% ciprofloxacin resistance. Carpapenem showed 100% meropenem resistance and 88.9% imipenem resistance. Of the total 78 isolates there was 41 isolates were resistant to at least one carpabenem either imipenem or meropenem. All 41 isolates had MIC ≥2 µg/mL for imipenem and meropenem.

Reports of PCR for the 41 isolates which sent to regional laboratory for confirmation revealed that 36 isolates had carbapenemase genes; twenty eight (77.8%) *K. pneumonia* isolates positive for *bla*OXA-48 and 5 (13.9%) isolates were positive for *bla*NDM. in 2 (5.6%) *bla* KPC were detected, one isolate contained *bla*IMP. 5 isolates contain both *bla*OXA-48 and *bla*NDM.

Modified Hodge test was positive in 33 (80.5%) out of 41 suspected isolates and negative in 8(19.5%) and of the 36 positive carbapenemase genes isolates detected by PCR, 33 isolates were positive by MHT. While the 5 gene negative isolates by PCR were also negative by MHT. On comparison of PCR in detection of carbapenemase genes as the golden method, the sensitivity and specificity of MHT was calculated; the sensitivity of MHT was analyzed to be 91.7%. (95%CI ratio 77.53% - 98.25%) and the specificity was 100% (95% CI ratio 54.07% to 100%). The positive predictive value was 100% and the Negative predictive value was 66.7 %(95%CI ratio 40.36% to 85.53%).

D70C test was positive in 34 (94.4%) out of 41 suspected isolates and negative in 7(17.1%) and of the 36 positive carbapenemase genes isolates detected by PCR, 34 isolates were positive by D70C test. While of the 5 gene negative isolates by PCR, 1(20%) was positive and 4(80%) was negative by D70C test. The sensitivity of Carbapenemase Detection Set (D70C) was 94.4% (81.34% to 99.32%) and the specificity was 80% (95%CI ratio 28.36% to 99.49%). The

positive predictive value was 97.1% (95 %Cl ratio 85.46% to 99.49%).and the Negative predictive value was 66.7% (95%Cl ratio 32.67% to 89.18%).

4. DISCUSSION

The emergency and spread of *K. pneumoniae* carbapenems resistance is a great danger because long time ago the last therapeutic resort or option of antibiotics to manage infections caused by multidrug-resistant gram-negative bacteria [14].

In this study out of the 78 clinical isolates CRKP were 36 (46.2%) and CSKP were 42 (53.8%). the high prevalence of CRKP also reported in European countries as Greece and Italy, where 64.7 and 29.7% of *K. pneumoniae* infections in 2017 showed respectively carbapenems resistance [15]. The incidence of CRKP infections in Turkey increased from 3.2% in 2010 to 66.9% in 2014 [16]. In Saudi Arabia Al-Zalabani et al, 2020 reported resistance of carpabenems from 37.2% to 43.1% between 2014 to 2018 [17].

In the current study CRKP cases aged from (18-84 years) with the median patient age 59 year, 27(75%) of CRKP cases were aged over 60 years. Seventeen of 36 patients (47.2%) were males, while CSKP cases aged from (16-87 years) with the median patient age 37 years, 20 (43.4%) were aged over 60 years and 25 of 42 patients (59.5%) were males. There is statistically significant difference between CRKP and CSKP regarding median age. This was in agreement with Al-Zahrani & Alasiri, 2018 [8] who reported more prevalence of CRKP in the 2 largest hospitals in the Southern province was associated with old age (54% of CRKP patients were older than 60 years) and in females more than males. This was consistent with Kofteridis et al, 2014 [18] who revealed that increasing age is a significant risk factor associated with CRKP isolation.

In this study all samples collected 48 hours after admission; the majority of these nosocomial CRKP infections were pneumonia 12 (33.3%) followed by urinary tract infection 9 (25%). Lanini et al, 2009 [19] and Lui et al, 2012 [20] also reported that respiratory tract infection is the most common infection among all studied CRKP infections, followed by urinary tract infection, Han et al,,2017 [21] also reported (53.6%) of CRKP isolates were from a respiratory source followed by 37.0% urinary source and (9.4%) from blood cultures.

Table 4. Antimicrobial resistance rate among CRKP and CSKP strains

Antimicrobial agent	CRKP=36		CRKS=42	
	No	%	No	%
Ampicillin	36	100%	42	100%
Piperacillin-Tazobactam	36	100%	4	9.5%
Amoxicillin-Clavulanate	36	100%	17	40,5%
Gentamicin	34	94.4%	14	33.3%
Trimethoprim-Sulfamethoxazole	36	100	16	38.1%
Imipenem	32	88.9%	3	7.1%
Meropenem	36	100%	5	11.9%
Ceftazidime	36	100%	12	28,6%
Ceftriaxone	36	100%	14	33,4%
Cefepime	36	100%	11	26.2%
Amikacin	32	88.9%	4	9.5%
Ciprofloxacin	33	91.7	10	23.8%
Tigecycline	0	0	0	0
Colistin	0	0	0	0
Aztreonam	36	100	18	44

Table 5. Comparison between PCR technique and MHT

MHT	PCR		
	Positive	Negative	Total
POSITIVE	33	0	33
NEGATIVE	3	5	8
TOTAL	36	5	41

Table 6. Comparison between PCR technique and D70C test

D70C test	PCR		
	Positive	Negative	Total
POSITIVE	34	1	35
NEGATIVE	2	4	6
TOTAL	36	5	41

The most associated common disease was diabetes (30%) followed by renal disease (27.8%). For invasive procedures, Urinary catheter was 27(75%) and 29(69%) followed by Mechanical ventilation 25(69.4%) and 22(52.4%) in CRKP and CSKP patients respectively. There is statistically significant difference between CRKP and CSKP regarding length of ICU stay, nasogastric catheter and antibiotics use. Similar studies also reported that concomitant diseases (renal dysfunction, neurological disorders), certain invasive procedures (mechanical ventilation, Central venous catheter, urinary catheter, nasogastric tube and dialysis), prior use of any antibiotic, and certain exposure to vancomycin, Carbapenems, Aminoglycosides, Fluoroquinolones, Glycopeptides considered as risk factors more likely to be present in patients CRKP [22,23,24]. Apparently, ages, severe accompanying diseases, and inadequate antibiotic treatment would impair the immunity and increase the risk of infection and even death [25].

In the current study the resistance pattern was high among CRKP than CSKP strains in all antibiotic groups. In β-lactam group CRKP strains were 100% resistant to ampicillin, amoxicillin-clavaulanate, pip/taz, trimethoprim-sulfamethoxazol, ceftazidime, ceftriaxone, cefepime and aztreonam. Aminoglycosides group showed 88.9% resistance for amikacin and 94.4% resistance for gentamicin. Fluoroquinolones group showed 91.7% ciprofloxacin resistance. Carpapenems showed 100% meropenem resistance and 88.9% imipenem resistance. While tigecycline and colistin showed 100% susceptibility. Han et al, 2017 [21] also revealed that all isolates of CRKP were resistant to β-lactam antibiotics, and no isolates were resistant to tigecycline. Nearly all of the isolates (> 97%) demonstrated resistance to levofloxacin, ciprofloxacin, gentamicin, and Tobramycin, while tigecycline resistance rate was low (0.7%).

Reports of PCR for the 41 isolates which sent to regional laboratory for confirmation revealed that 36 isolates had carbapenemase genes; twenty eight (77.8%) *K. pneumoniae* isolates positive for blaOXA-48 and 5 (13.9%) isolates were positive for blaNDM. in 2 (5.6%) bla KPC were detected, one isolate contained blaIMP. five isolates contain both blaOXA-48 and blaNDM. this finding was supported by Sahin et al, 2015 [26] who reported that multiplex PCR method had 99 % specificity for OXA-48 and 100% for other enzymes. Two other studies from in Saudi Arabia reported that using the multiplex PCR method lead to accurate results, also reported that OXA-48 and NDM are considered the most common carbapenemase isolated from Saudi hospitals as well as many countries in the Arabian Peninsula and these two enzymes have been previously described as major carbapenemases of *Enterobacteriaceae* in countries in the Arabian Peninsula [8,13,27].

Modified Hodge test was positive in 33 (80.5%) out of 41 suspected isolates and negative in 8(19.5%) and of the 36 positive carpabenemase genes isolates detected by PCR, 33 isolates were positive by MHT. While the 5 gene negative isolates by PCR were also negative by MHT. On comparison of PCR in detection of carbapenemase genes as the golden method, the sensitivity and specificity of MHT was calculated; the sensitivity of MHT was analyzed to be 91.7%. and the specificity was 100%. The positive predictive value was 100% while the Negative predictive value was 66.67%. Similar studies by Anderson et al, 2012 and Mathers et al, 2013 [28,29] had also evaluated the modified Hodge test for detection of CRKP revealed that the test had 100% sensitivity and specificity for detection of carbapenemase activity. Tamma et al, 2017 [30] showed that MHT had a sensitivity of 98% for detecting carbapenemase producers and 93% for OXA-48-like enzyme. The sensitivity of MHT as reported in this study was less than that of the sensitivity of the previous two studies. This could urged changes in the MHT to be more sensitive. Although the MHT is inexpensive, easy to perform, and uses available reagents in most laboratories, it is sometimes difficult to interpret and time-consuming because it needs additional 24-h growth step after AST reports obtained [31] because of these drawbacks, CLSI removed the

MHT from the CLSI M100 document in 2018, as newer phenotypic methods with more accuracy have become available [32].

The sensitivity of Carbapenemase Detection Set (D70C) was calculated to be 94.4% and the specificity was 80%. The positive predictive value was 97.1% and the negative predictive value was 66.67%. Genc et al, 2019 [33] reported the sensitivity and specificity of the Mast discs Combi-D70C were identified as 100% for both, while Ciftci et al, 2019 [34] reported low sensitivity revealing that the sensitivity and specificity of the D70C were 21.4% and 100% in detecting MBL positivity. The D70C is a screening method that was developed to identify and differentiate carbapenemases it is easy to apply and can be used in the routine laboratory to detect carbapenemase production using zone size comparison of combined disks, containing specific enzyme inhibitors. It showed acceptable discriminatory power between carbapenemase enzymes (particularly KPC and MBLs). The limitation of this test was its low specifity [8].

5. CONCLUSIONS

CRKP prevalence was 46.2% among *K. pneumoniae* isolates in Al Quwayiya General Hospital. Using invasive procedures such as urinary catheters or mechanical ventilator and misuse of antibiotics were risk factors associated with CRKP indicating that infection control guidelines and effective preventive measures should be strictly applied. It is very important to monitor and report changes in antimicrobial-resistant isolates but Carbapenemase Detection Set (D70C) has low specificity makes it less reliable and need PCR confirmation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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