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Detection of hypervirulent and classical type of *Klebsiella pneumoniae* and screening their resistant properties in Erbil city

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Abstract

Background and objective: *Klebsiella pneumoniae*i s an opportunistic pathogenic bacterium and is considered one of the main causes of nosocomial infection. Hypervirulent *K.pneumoniae* (hvKp) has emerged as a pathogen of global importance. The current study aimed to determine Extended-spectrum beta-lactamase, carbapenem resistance, and serum bactericidal effect among the clinical isolates and to find the relationship of the above features with antimicrobial resistance.

Methods: A total of 90 *K.pneumoniae* isolates were collected from different clinical specimens. Isolates were diagnosed using routine bacteriological methods and VITEK 2 compact system. Several phenotypic tests including string test, serum resistant, ESBL test, and Modified Carbapenem inactivation method were performed. The antibiotic resistance pattern was compared among ESBL-positive, carbapenem-resistant in both Hypervirulent (hvKp) and classical *K.pneumoniae* (cKp) isolates.

Results: The results revealed that among 90 isolates, 56.7% of the isolates were of classical *K.pneumoniae* (cKp) type within which 70.6% of them were ESBL positive, 37.3% of them were resistant to carbapenem, and 51% were resistant to serum bactericidal activity. On the other hand, 43.3% were of hvKp type within which 61.5% of them were ESBL positive, 30.8% were carbapenem-resistant and all of the hvKp were resistant to human serum. The rate of antibiotic-resistant among cKp was higher than hvKp isolates.

Conclusion: In this study, classical strains were more resistant to antibiotics and the rates of ESBL and Carbapenem resistance were higher compared to hvKp strains. but they were killed by serum bactericidal activities more rapidly.

Keywords: Hypervirulent *Klebsiella pneumoniae* (hvKp); Classical *Klebsiella pneumoniae (*cKp); Carbapenem-resistant; Extended-spectrum beta-lactamase (ESBL); Serum Resistant.

Introduction

Klebsiella pneumoniae (K. pneumoniae) is a pathogenic gram-negative microorganism that is found all over the world. It mostly affects individuals with underlying illnesses and results in hospital- and community-acquired infections.[1,2]

K. pneumoniae seems to have been the second most common causative organism of community-acquired urinary tract infections (UTI) recently.[3] Hypervirulent types of bacteria (hvKp) and classical type (cKp) are the two main pathotypes that comprise a danger to public health. cKp is the most frequent form; however, the new hvKp with hypermucoviscosity have been appeared as a clinically important infectious agent, leading to extremely invasive infections including liver abscesses for both healthy and individuals with a weakened immune system.[4] These variants, together with the observed global spread of antibiotic resistance, can produce severe community-acquired

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infections in healthy people.[5] As a result, hvKp raises public health expenses, limits antibiotic selection, and increases medical treatment failure, resulting in death and high morbidity.[6] Most of hvKp illnesses that have been documented are obtained from the population. The capability of hvKp to infect healthy individuals of any age, as well as the proclivity of an infected individual to exist with various sites of infection and/or establish subsequent metastases, are strongly indicative of hvKp infection.[7] Throughout the previous decades, the number of people infected with hvKp has significantly increased in the world.[8] Multidrug-resistant hvKp strains, particularly extended-spectrum β-lactamase-producing hypervirulent *Klebsiella pneumoniae* (ESBL-hvKp) and carbapenem-resistant hypervirulent *Kp* (CR- hvKp), have been described in various investigations in latest years,[9] which is now identified as a significant health concern.

The emergence of resistanceto carbapenems, strong broad-spectrum β-lactam drugs, is among the most alarming types of antibiotic resistance in gram-negative bacteria. Carbapenemases, which are enzymes that may hydrolyze the carbapenem β-lactam ring, making the molecule ineffective, or the creation of cephalosporins, provide phenotypical resistance to carbapenems,[10] It's crucial to distinguish between such phenotypes because carbapenem-resistant *Klebsiella pneumoniae* (CP-Kp) are linked to worse outcomes than non-CP-Kp.[11]

Therefore, this study aimed to perform a rapid identification method for cKp and hvKp, also to investigate antibiotic resistances, and differences between cKp and hvKp in ESBL, Carbapenem-resistant and human serum sensitivity in clinical samples isolated from some hospitals in Erbil city.

Methods

Bacterial Strains

A total of 90 *K. pneumoniae* isolates were recovered from different clinical specimens including sputum, urine, blood, and wound swabs in many laboratory settings from various hospitals in Erbil city between July 2021 and January 2022.

Identification and Antimicrobial Susceptibility Test

K. pneumoniae isolates were diagnosed by applying conventionally bacteriological methods including colony morphology, gram stain, catalse test, and citrate utilization, and standard procedures were used to identify the phenotypic characteristics of bacterial isolates.[12] Then, the identification and antibiotic sensitivity were confirmed by VITEK 2 compact system (bioMérieux, France). Thirteen antibiotics were used for AST analysis Piperacillin (PIP)(100µg), Pep/Tazobactum (TZP) (100/10µg), Ampicillin (AMP) (10µg), Amoxicillin/Clavulanic Acid (AMC) (20/10µg), Ciprofloxacin (CIP) (5µg), Ceftriaxone (CRO) (30 µg), Ceftazidime (CAZ) (30µg),Tri/sulfamethoxazole (SXT) (1.25/23.75µg), Gentamicin (GN) (10µg), Amikacin (AK) (30µg), Imipenem (IMP) (10µg), Meropenem (MEM) (10µg), Ertapenem (ETP) (10µg).

String test

The string test was used to identify hvKp strains from cKp strains, whenever an inoculation loop was able to stretch bacterial colonies on a blood agar plate and form a sticky string of 5 mm long, the result was considered positive. Once the length of the string was ≤ 5 mm or no string was visible, the result was considered negative.[13]

Detection of ESBL

Depending on resistance to ceftazidime, the *K. pneumoniae* isolates were shown to be ESBL screening-positive. The double -disc synergy testing (DDST) test was done with ceftazidime (CAZ 30µg) and cefotaxime (CTX 30µg) individually, as well as a combination disc of ceftazidime-clavulanic acid (CAZ/CLA and CTX/CLA 30/10µg). Whenever the inhibition zone formed by the combined action of ceftazidime or cefotaxime plus clavulanic

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acid rose by 5mm above ceftazidime or cefotaxime alone without clavulanic acid, the ESBL confirmatory test was regarded positive.[14]

Detection of Carbapenemase

Carbapenems producing *K. pneumoniae* detected briefly, by a loopful of bacteria were then mixed in a 2-mL tube of TSB. Another 1 loopful of bacteria was mixed in a 2mL tube of TSB treated with EDTA at a fixed concentration of 5mM (place 20 mL 0.5M EDTA to 2 mL TSB). Every tube included a meropenem disc, which was incubated at 35 °C for 4hrs and 15 minutes. The discs were then removed and put on freshly plated Mueller-Hinton agar plates containing 0.5 McFarland concentration of a carbapenem-susceptible *E. coli* ATCC 25922. The plates have been incubated for 16 to 20hrs at 35 °C, and the Combination of modified carbapenem inactivation method (mCIM) and EDTA- carbapenem inactivation method (eCIM) findings were analyzed.[10] If somehow the circle size is less than 19 mm, the mCIM is negative; if indeed the zone size is 6 to 15 mm, the mCIM is positive; and if tiny colonies are found within a 16 to 18-mm zone, the mCIM is then intermediate. Once the eCIM zone size widened by 5mm relative to the mCIM zone size, the strain is positive for Metallo-carbapenemase formation; whenever the increase in zone size is less than 4mm, an isolate is regarded negative for metallo-carbapenemase production.[15]

Serum Resistance Assay

Bacterial cells were then washed from BHI and resuspended in PBS to an OD_{600} after 14hrs of growth in TSB (Tryptic soy broth) media. Five healthy people's serum was collected and diluted in PBS to a fixed concentration of 40%. The same serum was thermally inactivated by incubating it at 56°C for 30 minutes. After that, bacterial suspensions were mixed with human serum or heat-inactivated serum to achieve a bacterial cell suspension of 1×10^7 CFU/ mL, and samples werethen incubated for 2 hrs at 37°C. In triplicates, viable counts got evaluated at 0 and 2 hours.[16]

Statistical Analysis

Data were analyzed using the statistical package SPSS for Windows version 25.0. Categorical variables were assessed by the Chi-square test or Fisher's exact test and a *P*-value <0.05 was considered to be statistically significant.

Results

Bacterial strains and Hypervirulence of *K. pneumoniae*

A total of 90 isolates of identified *K. pneumoniae* were identified from which 53.8% females among hvKp with 46.2% of males, However, the male percentage was 51% among classical strains which appears higher than females 49%.

The mean age of the participants was 52.6 ±18.7 years. Hypervirulent phenotypes were detected in 39 43.3% of the 90 isolates based on the findings of the modified loop test. The percentages of cKp strains isolated were 51 56.7%. There were a considerably larger number of patients with cKP. The positive string test was not correlated with gender or type of specimen (both *P* >0.05). hvKp has been isolated from different clinical specimens, urine was 58.3% the most frequent specimen followed by sputum (38.2%), blood 29.4%, and no wound swab 0%. Whereas for classical types the specimens were as follows; wound swab 100%, blood 70.6%, sputum 61.8%, Urine 41.7%. hvKp strains were found in 28.2% of young adults and 53.8% of Middle-aged adults patients and only 17.9% of elderly, in contrast, majority of cKp infected elderly 76.5%, only 7.8% and 15.7% of classical strains were found among young adults and Middle-aged adults as shown in the Table.1

Antimicrobial resistance and its correlation with ESBL and Carbapenem

The results showed that Ampicillin, Amoxicillin/Clavulanic Acid, Piperacillin, and Piperacillin/Tazobactam were the most inactive antibiotics against hvKp with resistance rates of 100%, 79.5%, 69.2% and 66.7%, respectively. However, the

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most effective antibiotics were Imipenem and Ertapenem 33.3% followed by Meropenem with a resistance rate of 35.9%, accordingly. The resistance rates to the majority of antimicrobial agents were lower in hvKp than cKp. Nevertheless, Ampicillin and Amoxicillin/clavulanic acid had higher resistance rates. Table 2 depicts the complete results of antibiotics resistance patterns of hvKp and cKp.

Table 1 Distribution of both hvKp and cKp *K. pneumoniae* according to the source of isolates.

	hvKp (n=39) No. (%)	cKp (n=51) No. (%)	Total (n=90) No. (%)	*P* value
Gender				
Male	18/39 (46.2)	26/51 (51)	44/90 (48.9)	0.650
Female	21 (53.8)	25 (49)	46 (51.1)	
Age group				
Young adults	11/39 (28.2)	4/51 (7.8)	11/90 (12.2)	<0.001
Middle-aged adults	21 (53.8)	8 (15.7)	29 (32.2)	
Elderly	7 (17.9)	39 (76.5)	50 (55.6)	
Specimen type				
Urine	21/36 (58.3)	15/36 (41.7)	36 (40)	0.063
Sputum	13/34 (38.2)	21/34 (61.8)	34 (37.8)	
Blood	5/17 (29.4)	12/17 (70.6)	17 (18.9)	
Wound swab	0/3 (0)	3/3 (100)	3 (3.3)	

Young adults 18-40, Middle-aged adults 41-65, Elderly>65

Table 2 Differences in antibiotic-resistant between hvKp and cKp.

Antibiotics	hvKp (n=39) No. (%)	cKp (n=51) No. (%)	Total (n=90) No. (%)	*P* value
PIP (100µg)	27 (69.2)	50 (98)	778 (5.6)	<0.001
TZP (100/10 µg)	26 (66.7)	37 (72)	63 (70.0)	0.546
AMP (10µg)	39 (100)	47 (92.2)	86 (95.6)	0.130
AMC (20/10µg)	31 (79.5)	35 (68.6)	66 (73.3)	0.248
CIP (5µg)	22 (56.4)	34 (66.7)	56 (62.2)	0.320
CRO (30µg)	24 (61.5)	35 (68.6)	59 (65.6)	0.483
CAZ (30µg)	30 (76.9)	39 (76.5)	69 (76.7)	0.960
SXT (1.25/23.75 µg)	18 (46.2)	36 (70.6)	54 (60)	0.019
GEN (10µg)	18 (46.2)	34 (66.7)	52 (57.8)	0.051
AMK (30µg)	19 (48.7)	37 (72.5)	56 (62.2)	0.021
IMP (10µg)	13 (33.3)	26 (51)	39 (43.3)	0.094
MEM (10µg)	14 (35.9)	21 (41.2)	35 (38.9)	0.611
ETP (10µg)	13 (33.3)	21 (41.2)	34 (37.8)	0.447

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Average resistance to antibiotics was higher among isolates that were positive for both ESBL and Carbapenem, data which is illustrated in Table 3 indicates that isolates which are ESBL positive are more resistant against antibiotics, additionally Carbapenem resistant isolates show significantly higher resistance. However, the highest resistance rates were recorded by those isolate which were both ESBL and Carbapenem resistant.

Table 3 A comparison in antibiotic resistance pattern among ESBL, Carbapenem and to both ESBL+ Carbapenem isolates.

Antibiotics	ESBL Positive (n=60) No. %	ESBL Negative (n=30) No. %	Total (n=90) No. %	*P value	Carbapenem Resistant (n=31) No. %	Carbapenem Sensitive (n=59) No. %	Total (n=90) No. %	*P value	ESBL+ Carbapenem positive (n=25) No. %	Total (n=90) No. %	*P value	Total (n=90) No. %
PIP (100µg)	54 90%	23 76.7%	77 85.6%	0.115	28 90.3%	49 83.1%	77 85.6%	0.530	22 80%	77 85.6%	0.686	77 85.6%
TZP (100/10 µg)	44 73.3%	19 63.3%	63 70%	0.329	26 83.9%	37 62.7%	63 70%	0.037	21 84%	63 70%	0.114	63 70%
AMP (10µg)	58 96.7%	28 93.3%	86 95.6%	0.598	29 93.5%	577 96.6%	86 95.6%	0.606	24 96%	86 95.6%	1.000	86 95.6%
AMC (20/10 µg)	54 90%	12 40%	66 73.3%	<0.001	24 77.4%	42 71.2%	66 73.3%	0.525	23 92%	66 73.3%	1.000	66 73.3%
CIP (5µg)	46 76.7%	10 33.3%	56 62.2%	<0.001	23 74.2%	33 55.9%	56 62.2%	0.090	18 72%	56 62.2%	0.470	56 62.2%
CRO (30µg)	44 73.3%	15 50%	59 65.6%	0.028	23 74.2%	36 61%	59 65.6%	0.211	19 76%	59 65.6%	0.693	59 65.6%
CAZ (30µg)	50 83.3%	19 63.3%	69 76.7%	0.034	25 80.6%	44 74.6%	69 76.7%	0.518	20 80%	69 76.7%	0.728	69 76.7%
SXT (1.25/23.75 µg)	36 60%	18 60%	54 60%	1.000	23 74.2%	31 52.5%	54 60%	0.046	17 68%	54 60%	0.285	54 60%
GEN (10µg)	35 58.3%	17 56.7%	52 57.8%	0.880	22 71%	30 50.8%	52 57.8%	0.066	18 72%	52 57.8%	0.070	52 57.8%
AMK (30µg)	41 68.3%	15 50%	56 62.2%	0.091	22 71%	34 57.6%	56 62.2%	0.215	19 76%	56 62.2%	0.281	56 62.2%
IMP (10µg)	32 53.3%	7 23.3%	39 43.3%	0.007	28 90.3%	11 18.6%	39 43.3%	<0.001	24 96%	39 43.3%	<0.001	39 43.3%
MEM (10µg)	29 48.3%	6 20%	35 38.9%	0.009	27 87.1%	8 13.6%	35 38.9%	<0.001	23 92%	35 38.9%	<0.001	35 38.9%
ETP (10µg)	28 46.7%	6 20%	34 37.8%	0.014	26 83.9%	8 13.6%	34 37.8%	<0.001	22 80%	34 37.8%	<0.001	34 37.8%

*It compares the association between those isolates that are both carbapenem positive and ESBL positive with each of the antibiotics, it revealed that they posses higher antibiotic resistant compared to other isolates which are only carba positive or only ESBL positive

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Phenotypic detection of KPC-Producing *Klebsiella pneumoniae*

All isolates of *K. pneumoniae* were subjected to Combination of modified carbapenem inactivation method (mCIM) and EDTA-CIM (eCIM). Out of 90 isolates of *K. pneumoniae*, the result was positive for 59 65.6% of all resistant isolates confirming the presence of significant carbapenemase hydrolyzing activity, the other 31 34.4% were negative. The results of mCIM and eCIM procedures are shown in the Table. 4, the rates of eCIM positive among Carbapenem resistant *Klebsiella pneumoniae* isolates hit 61.3%, whereas a significantly higher rate of mCIM was recorded which was 100%.

Nevertheless, antibiotic resistance within CR-Kp isolates experienced a sharp increase as well, within which the resistance against Imipenem, Meropenem, and Ertapenem raised steeply to 90.3%, 87.1% and 83.9% respectively.

Human serum resistance and its correlation with ESBL and Carbapenem

The capability of all 90 isolates to tolerate the bactericidal activity of human serum was compared. Overall, 65 72.2% of the strains were resistant, while 25 27.8% were susceptible. We observed no hypervirulent strains that were susceptible to human serum, whereas 25 49% of cKp was sensitive to bactericidal action.

The findings revealed that hypervirulent *K. pneumoniae* isolates are much more tolerant to human serum than classical bacteria. According to the results, a comparison between ESBL producers and non-ESBL producers was made between hvKp and cKp depending on their serum bactericidal activity. Serum resistance among classical ESBL producers is steeply higher than that of ESBL non-producers, while for hvKp isolates the results remain high for both ESBL producers and non-producers because none of hvkp isolates were found sensitive to human serum. So, the positive ESBL samples of cKp have a sharply higher rate 72.2% of serum resistance than negative ESBL samples 0%.

Consequently, altogether within ESBL producers of both types of strains, there is 83.3% serum resistance whereas only 50% within ESBL non-producers. Nonetheless, Carbapenem-resistant hvKp has a much higher serum resistance than Carbapenem -resistant cKp, as visualized in Figure 1.

According to statistical analysis, all ESBL-positive isolates had a considerably higher average of resistance than ESBL-negative strains (P <0.05). The combined disc test revealed that 60 66.7 % of the samples were ESBL-producing bacteria. ESBL was found in a higher proportion among cKp strains 36/51 70.6% than hvKp strains 24/39 61.5% (P = 0.36). Data is shown in Figure 2. These results indicate a significant negative association between the ESBL producer and the hvKp phenotype in these isolates. Furthermore, slightly higher carbapenem-resistant isolates were found among cKp 37.3% strains than hvKp 30.8% (P = 0.52) Data illustrated in Figure 3.

Table 4 mCIM, eCIM, and Carbapenem (Imipenem, Meropenem, Ertapenem) antibiotic resistance of Carbapenem resistant *Klebsiella pneumoniae.*

	eCIM No. (%)		mCIM No. (%)		Carbapenem Resistant (n=31)		
	Pos	Neg	Pos	Neg	IPM	MEM	ETP
CR-KP	19 (61.3)	12 (38.7)	31 (100)	0 (0)	28 (90.3)	27 (87.1)	26 (83.9)
		P value <0.001			*P* <0.001	*P* <0.001	*P* <0.001

*The result *P* value compares the significant association between each of Imipenem, Meropenem and Ertapenem antibiotics with Carbapenem resistant *Klebsiella pneumoniae,* which revealed that CR-KP isolates had a higher resistance to each of the three antibiotics.

https://doi.org/10.15218/zjms.2023.035

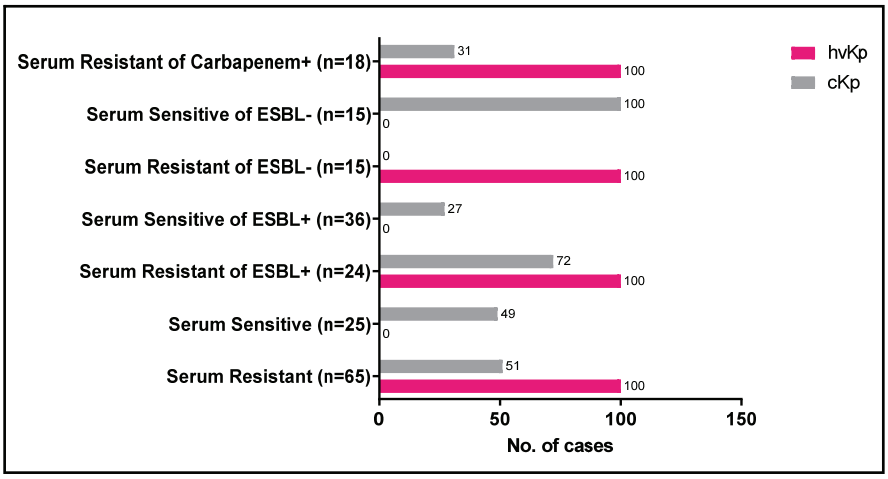

Figure 1 Differences between serum resistance and sensitivity among cKp, hvKp, ESBL producer, ESBL non-producer, and Carbapenem positive.

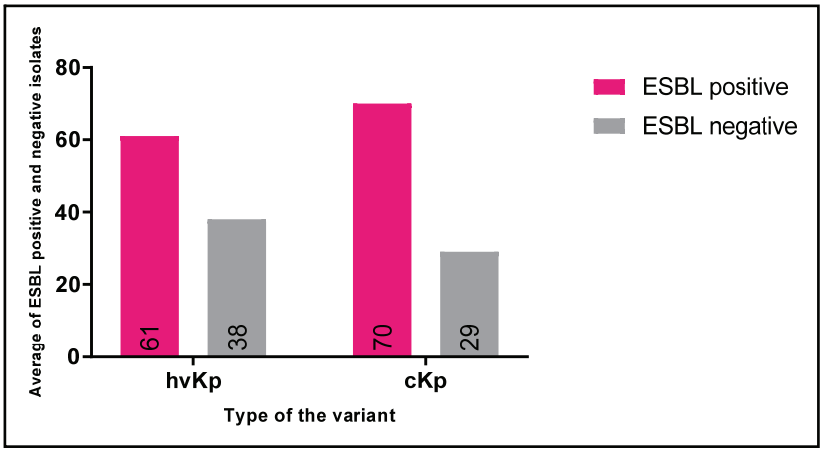

Figure 2 Average of ESBL producers and non-producers among hvKp and cKp. *P* value = 0.367

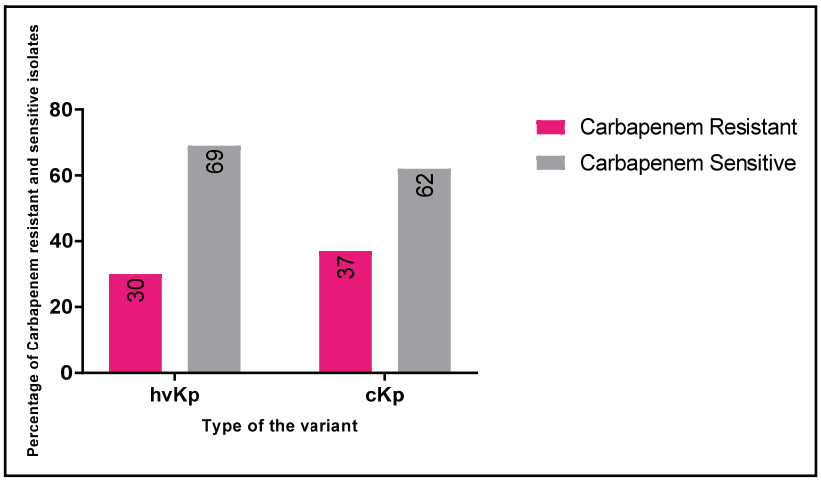

Figure 3 Differences in carbapenem-resistant and sensitivity within hvKp and cKp. *P* value = 0.521

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Discussion

The hvKp has arisen as a worldwide health concern and potentially "superbug" for clinical settings in the past few years, producing a wide range of illnesses in community patients.[17] Depending on a positive string test, 43.3% of *K. pneumoniae* were shown to be hypervirulent in the current investigation. According to our results, the rates of hvKp climbed up higher than that reported in Sudan 31.6%.[18] and those reported by Li et al. 33% in china.[19] However, both pathotypes are global pathogens, but the incidence of infections due to hvKp has been steadily increasing over the last decades in countries that comprise the Asian Pacific Rim.[20] Our data is in agreement with the study of Sanikhani et al. from last year who also reported highest rates of Urine samples for hvKp, followed by tracheal aspiration and blood.[21] However, cKp variants reported their highest percentage in wound swab 100%, lowest percentage in urine 41.7%. Contrary to our results, Other studies which have done in2019 reported that cKp were found most frequently in Urine samples 41.1%, followed by Blood 32.2%, Respiratory secretion 16.9% and wound swabs 8.8%.[22] In current study, the variant hvKp affected females more than males, which is different to the observation reported by AM parrot and coworkers (2021) who had shown the rate of isolation in female was lower than male.[23] However, according to statistical analysis, no significant association were found neither with gender nor with sample type (*P* value >0.05). *K. pneumoniae* can cause infections in all age groups, especially in the immunocompromised. Another study in China showed similarity to our results in that hvKp was more predominant among younger patients.[4] Nevertheless, hvKp would also affect elderly more readily, for instance, a study in Iran in which majority of their patients were older than 60 years of age, they found hvKp affecting the patients predominantly.[21] We applied different phenotypic procedures in this study to detect *K. pneumoniae* both hvKp and cKp. Prior research has found that hvKp isolates are more drug resistant as cKp variants, but more recent study has revealed that these strains are not only less related with resistance to antimicrobial agents, but also have much lower ESBL levels than cKp strains.[6] In consequent, those findings are inconclusive. In this investigation, hvKp variants were found to be less resistant to 13 antimicrobial agents than cKp isolates. Furthermore, ESBL was shown to have a negative relationship with hvKp (*P* = 0.36). With the exception of intrinsic resistance to ampicillin, majority of hvKp are slightly more sensitive to antibiotics compared to cKp.Similarly, In a study, all hvKp strains resisted ampicillin.[24] As a result, antibiotic resistance is less frequent in hvKps than in cKp isolates.[25] However, the percentage of resistance between the two types, hvKp and cKp, was not significantly different, contrary to predictions.

Other investigations have found that the rate of hvKp resistance is growing globally, and our findings are consistent with that.[19,26] Due to differences in geography, community, and environment, the frequency of resistant isolates and antibiotic susceptibility profiles show diverse outcomes, Nevertheless, a high resistance rate against Imipenem and Meropenem were recorded.[27]

Our findings align with the resistance pattern of multidrug-resistance in *K. pneumoniae* isolates from India with 28.5% imipenem resistance.[28] Regarding the ESBLs, despite the type of the strain, the results of the combined disc test confirmed that 60 66.7% isolates were ESBL-producing strains and this was higher than reports in Turkey (2019) which reported 47% of *Klebsiella spp*. were ESBL producers.[14] Our data was moderately higher than the research which was conducted in Iran, in which their percentage was 59%.[29] According to our research, serum-resistant bacteria are so much more common amongst ESBL-

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producing *K. pneumoniae* isolates than non -ESBL producer isolates, and more among hvKp than cKp. Similarly, other studies have shown the same.[16,30] The correlation between ESBL production with serum resistance in hvKp and cKp strains was Significant (*P*-Value <0.05), in contrast to another study which was done in China in which the correlation was non-significant.[7] Because of the enormous size of their capsule and enhanced expression of capsule-related genes, studies have indicated that hvKp would be less likely to pick up DNA from other resistant bacteria.[25] However, our findings support that the ratio of resistance between two types, hvKp, and cKp, was not significantly different. Other research has found that the frequency of hvKp resistance is growing globally.[26]

Regardless of type of the variant, in the total resistance to antibiotics, the present study discovered a strong resistance to the three antibiotics imipenem, meropenem, and ertapenem antibiotics was 43.3%, 38.9% and 37.8% respectively, and this rate was higher compared to another study conducted in Erbil a few years ago this indicates the rapid emergence and increase in resistance against carbapenems.[31] The present study reflects the growing tendency of CR-hvKp literature reports. Zhang et al. published the initial description of CR-hvKp in 2015.[32] A rapid spread of CR-hvKp literature has been recorded. Among 31 cases of Carbapenem -resistant *K. pneumoniae*, 12 of them were hvKp, the rates have increased significantly compared to the studies done over the past few years.[5] In this study we detected a higher rate of the potential carbapenemase activity 34.4% among the isolates in accordance with the results of other studies that have been carried out in different cities of Iraq and the Kurdistan region. Phenotypic results from the current study showed comparatively higher results than other studies.[31,33]

Conclusion

This study revealed that the rate of antibiotic-resistant among cKpis slightly higher than that of hvKp, but the formers are less resistant to killing activities of human serum, the majority of classical strains are killed by human serum bactericidal activities, while it affected hvKp at a very low percentage, although ESBL and Carbapenem resistance among classical strains was higher than that of hvKp. Antibiotic-resistant, ESBL positive and CR-hvKP exhibited an increasing trend recently.

Ethical Considerations

The current study was ethically approved by the ethics committee of Pharmacy college, Hawler Medical University Kurdistan-Iraq. All participants were informed about the purpose of the study.

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Competing interests

The authors declare that they have no competing interests.

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