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Research Article

Prevalence and antimicrobial resistance of *Klebsiella pneumoniae* isolated from catheter-associated urinary tract infections in Minia University Hospitals, Egypt

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Abstract

Introduction and aim of the work: *k. pneumoniae* is an important cause of hospital acquired infections as urinary tract infections (UTIs) especially catheter-associated urinary tract infections (CAUTI) that account for 70% of UTI. The aim of this study is to access prevalence of *K. pneumoniae* among catheter-associated UTIs in hospital setting with regards to antimicrobial susceptibility pattern. **Subjects and Methods:** 192 catheterized patients with symptoms of UTI were enrolled in the study; from whom urine specimens were collected. Urine culture was done on MacConkey agar, colonies more than 10^5 CFU/ml are further identified for isolation of *k. pneumoniae* species and antimicrobial susceptibility testing was performed using disk diffusion method. **Results:** *k. pneumoniae* was isolated from 30.7% of inpatients with CAUTI; 94.9% of *K. pneumoniae* isolates showed multidrug resistance. Absolute resistance was recorded against imipenem while amikacin showed the least resistance (42.4%). **Conclusion:** Increased rates of multidrug resistant *K. pneumoniae* isolated from CAUTI which is considered a major health problem facing patients in hospitals and better antibiotic polices should be followed including avoiding exaggerated use of antimicrobial agents.

Keywords: UTI, *K. pneumoniae*, Multidrug resistant

Introduction and the aim of the work:

Urinary tract infections (UTIs) are responsible for 23% of infections in the intensive care unit (ICU) and 12.9% of infections linked to healthcare, with catheter-associated UTIs (CAUTIs) accounting for about 70% of UTIs [(1)]. Within 30 days of being admitted to the hospital, the frequency of CAUTIs approaches 100%. They arise 3–10% of the time every day after catheterization [(2)].

Klebsiella pneumoniae is a gram-negative rod of the Enterobacteriaceae family that can be found in a variety of environments, including waste fluids, plant leaves, soil, and the intestines of mammals [(3,4)]. *Klebsiella pneumoniae* is considered a major cause of hospital- and community-acquired urinary tract infections [(5)]. Klebsiella pneumoniae has been identified as the third most frequent cause of hospital acquired infections (HAIs) in Egypt (16.7%), following *Streptococcus pneumoniae* (22.5%) and *Pseudomonas aeruginosa* [(6)]. This bacterium can create a biofilm on invasive medical devices e.g. urinary catheters, which can result in infections related to health care, especially in the urinary systems [(3)]. Factors like polysaccharide capsule, fimbriae, lipopolysaccharides contribute to initial stages and maturation of biofilms while iron metabolism and siderophores production play role in regulation of biofilms in *klebsiella pneumoniae* [(7)].

According to US Centers for Disease Control and Prevention (CDC) guidelines, a patient

must have an indwelling urinary catheter for more than two days, exhibit one or more signs or symptoms, such as fever, suprapubic tenderness, or costovertebral angle tenderness, and have a urine culture that contains more than 10^5 CFU/mL of a single bacterial species in order for the infection to be classified as a CAUTI [8].

Bacterial culture and subsequent antibiotic sensitivity testing are typically used to identify the antibiotic treatment regimen against *K. pneumoniae* [9]. Appropriate antibiotic regimens, such as third-generation cephalosporins, quinolones, imipenem, or aminoglycosides, should be administered either alone or in combination for a minimum of 14 days to patients who have contracted *K. pneumoniae* in hospitals [10]. The most popular antibiotic option for treating carbapenem-resistant *K. pneumoniae* in recent decades has been polymyxins. colistin (Polymyxin E) is often the "last resort" treatment for MDR *K. pneumoniae* infections since it is frequently the only antibiotic that produces adequate minimum inhibitory concentrations (MIC) and serum levels. It is yet clear that antimicrobial combinations are better than monotherapy when treating infections caused by MDR *K. pneumoniae*. Combination therapy reduces death rates, according to retrospective research [11].

The aim of this study is to access prevalence of *K. pneumoniae* among catheter-associated UTIs in healthcare settings and determine its antimicrobial susceptibility pattern and its clinical distribution.

Materials and methods

Study design:

This is a cross-sectional study that was carried out at the Microbiology and Immunology department, Faculty of Medicine, Minia University in the period from May 2023 to November 2024. Urine specimens were collected from 192 catheterized patients admitted in different departments of Minia University Hospitals (Anaesthesia, stroke, nephrology, hepatology and chest Intensive care units (ICU)) in order to isolate *Klebsiella pneumoniae*. Inclusion criteria included adult patients (≥18y) who had no history of receiving antibiotics in the last 48 hours prior to specimen collection and meets criteria of catheter associated urinary tract infections (CAUTIs) according to guidelines published by the US Centers for Disease Control and Prevention (CDC) [8]. Full medical History of each patient was recorded including cause of admission, age, gender, and residence, relevant clinical data and investigations.

Specimen collection:

For a patient with an indwelling catheter that has been in place for more than two weeks; the catheter was replaced with new one while obtaining the urine specimen. If indwelling catheter has been in place for less than two weeks; urine was aspirated using needless sampling report of the indwelling catheter with a sterile syringe [12]. Urine specimens were collected in a sterile, dry and wide necked container and were transported immediately to Bacteriology laboratory in Medical Microbiology and Immunology Department; the specimens were processed at once.

Specimen processing:

Urine culture was done from urine specimens on MacConkey agar from **(oxoid, UK)** using calibrated loop technique [13]; lactose fermenting colonies with colony count more than 10^5 CFU/ml were further tested for identification of *k. pneumoniae* isolates by biochemical tests (sugar fermentation test, Indole production test, Methyl red test, Voges Proskauer test, citrate and urease tests and motility test) [14].

Antimicrobial Susceptibility Testing:

Antimicrobial susceptibility of the isolates was determined by disc diffusion method according to the Clinical Laboratory Standard Institute [15] guidelines. The following 10 antimicrobial discs from (**Biogram-India** and **Biomaxima-Poland)** were selected for testing according to CLSI guidelines [15], Amoxicillin-Clavulanate (AMC) 30 µg, Cefazolin (CZ) 30 µg, cefoxitin (FOX) 30µg, Ceftriaxone (CTR) 30µg, Imipenem (IMP) 10 µg, Levofloxacin (LE) 5 µg, Ciprofloxacin (CIP) 5 µg, Amikacin (AK) 30 µg, Sulphamethoxazole Trimethoprim (SXT) 25 µg and Nitrofurantoin (F) 300 µg.

Ethical approval of the study:
The Faculty of Medicine board approved the study's conduct (MUFMIRB Approval No 736:4:2023). All adult patients gave their written informed consent to take part in the study.

Statistical analysis:
All data were entered into a Microsoft excel worksheet, and statistical analysis was performed using SPSS for Windows version 19.0 (IBM, USA). Quantitative variables are described in terms of mean, standard deviation (SD) and range. Frequency of qualitative variables were described as number (no.) and percentage (%).

Results

Out of 192 catheterized patients enrolled in the study; *Klebsiella pneumoniae* was isolated from 59 patients with an isolation rate of 30.7%. *K. pneumonia*e was most frequently isolated from Anaesthesia ICU with a percentage of 36.1% (48/133), followed by stroke ICU (25%; 5/20), Nephrology ICU (19.2%; 5/26) and Hepatology ICU (11.1%; 1/9) while no *k. pneumoniae* isolates were recovered from Chest ICU.

Regarding characteristics of patients from whom *K. pneumoniae* isolates were retrieved (Table 1), 61% of them were males (36/59) and 39% were females (23/59) with an age ranging from 18 to 89 years with a mean of 52.9±19.65 years. UTI was suspected in catheterized patients if patient had fever, suprapubic or flank pain, hematuria or turbid urine in collection bag. Chronic diseases were reported in 32.2% of patients (19/59). Total leucocytic count was high more than 11.000/mm in 55.9% of patients (33/59).

Marked antimicrobial resistance was observed among *k. pneumoniae* isolates (figure 1). None of isolates was susceptible for cefazolin and imipenem. The highest resistance was observed against Amoxicillin-clavulanic (89.9%) and Ceftriaxone (84.7%) followed by Trimethoprim/Sulfamethoxazole (79.7%) and Nitrofurantoin (72.9%). Moderate resistance was recorded for Ciprofloxacin (64.4%), Cefoxitin (62.7%) and Levofloxacin (55.9%). The least resistance was for Amikacin (42.4%). Multidrug resistant strains represents 56/59 (94.9%) of isolated *k. pneumoniae* strains; MDR was defined as antimicrobial resistance to at least one antimicrobial drug in three or more antimicrobial categories [(16)].

Table 1: Characteristics of study patients

Characteristic		Number (N) Total=59	Percentage (%)
Age	**Mean±SD**	**52.89±19.65**	
	Range	**18-71**	
Gender	**Male**	**36**	**61.0%**
	Female	**23**	**39.0%**
Department	**Anaesthesia ICU**	**48**	**81.4%**
	Stroke ICU	**5**	**8.5%**
	Hepatology ICU	**1**	**1.7%**
	Nephrology ICU	**5**	**8.5%**
Chronic diseases	**yes**	**19**	**32.2%**
	No	**40**	**67.8%**
TLC	**High**	**33**	**55.9%**
	Normal	**26**	**44.1%**

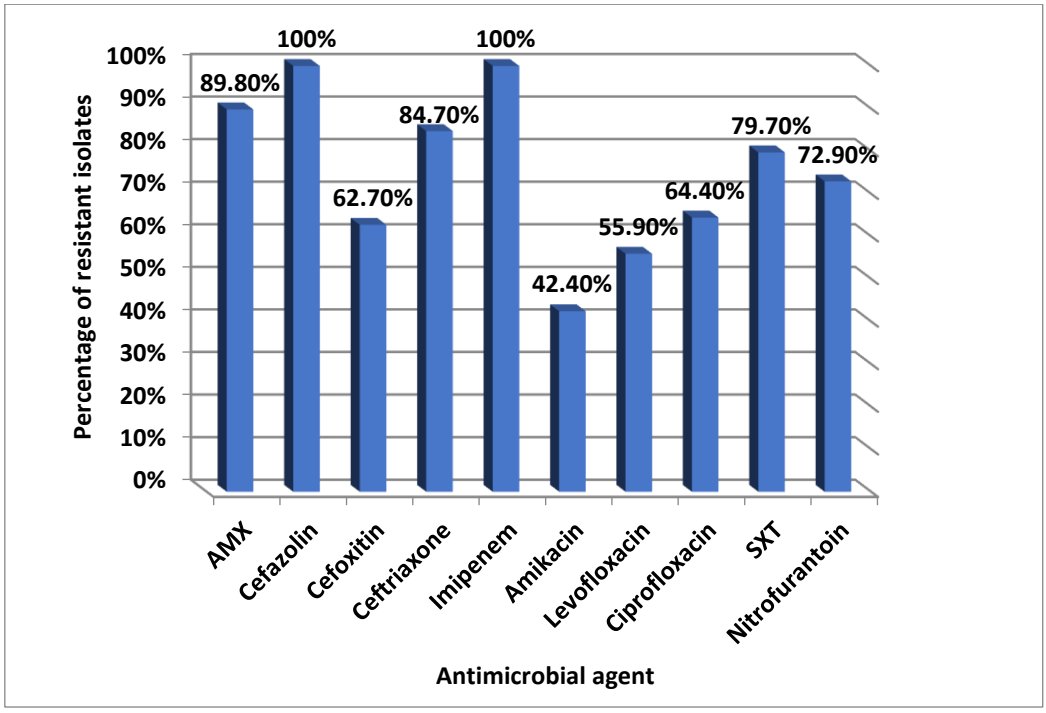

Figure 1: Antimicrobial resistance among *K. pneumoniae* isolates

Discussion

Few studies have been conducted on catheter-associated urinary tract infections (CAUTIs) caused by *K. pneumoniae*, despite the fact that the bacteria have recently become more significant in infections at a variety of locations, including the lung, biliary tract, and urinary tract.

In our study, the rate of isolation of *k. pneumoniae* from urine was 30.7% which align with Jalil and Al Atbee et al., who reported *k. pneumoniae* in urine with a rate of 31.7% [17]. However, another study by Regmi et al., reported lower rate of *k. pneumoniae* isolation from urine (12.42%) [18].

It has long been known that urinary catheterization is a significant risk factor for UTIs related to healthcare. Among the most frequent nosocomial infections, CAUTIs are also thought to be one of the most frequent side effects of indwelling urinary catheters [1]. A study by Gillen et al., [19] and Eghbalpoor et al., [20] found that women's shorter and broader urethras were an independent risk factor for CAUTIs. However, Liu et al., [1] didn't find the same relevance in their study.

Unlike other studies, ours found that over half of the patients (61%) with *K. pneumoniae* CAUTI were male. This could be explained by their underlying or functional urethra blockage, which may require catheterization as they age. This can alter the urine's microbial environment, leading to the production of biofilms and the growth of bacteria that are resistant to drugs.

Marked antimicrobial resistance was observed among *K. Pneumoniae* isolates. Our research reported complete resistance to Cefazolin and Imipenem. However, an Egyptian study by Al-Baz et al., [6] and another study by Nirwati et al., [21] reported lower Imipenem resistance (25.4%). The variety in imipenem resistance levels may be the consequence of careful carbapenem therapy selection, which preserves the sensitivity of these drugs [6].

Cefoxitin resistance in our study was (62.7%) that is close to a study by Al-Baz et al., [6] who reported resistance in 71.8%. However, our results are comparable with complete resistance reported by khairy et al., [22].
Ceftriaxone had high resistance which reached (84.7%), that is in alignment with other

Egyptian studies by Al-Baz et al., [6] and Aamir et al., [23] who also reported high resistance to Ceftriaxone in a rate with 93% and 92% respectively. However, another study by Jalil and Al Atbee et al., found lower resistance rate (31.6%)[17]. The excessive use of third-generation cephalosporins as an empirical treatment for nosocomial infections in Egyptian hospitals may be the cause of the increasing resistance to these medicines.

As regarding Trimethoprim-Sulphamethoxazole resistance in our study; 79.7% of *k. pneumoniae* isolates show resistance. Our study agreed with Jalil and Al Atbee et al., who found 71.7% resistance [17].

Also, Amoxicillin-Clavulanic acid showed high resistance in our study; we found 89.9% of *k. pneumoniae* isolates were resistant. which is in alignment with Morsi et al., [24] who reported Amoxicillin-Clavulanic resistance in 88% , however another Egyptian study by Al-Baz et al., [6] reported lower resistance to Amoxicillin-Clavulanic as 78.2%.

Regarding resistance to Nitrofurantoin, we found 72.9% of *k. pneumoniae* isolates resistant to Nitrofurantoin which is comparable to complete resistance reported by Al-Baz et al.,[6]

Moderate resistance was reported in our study for Ciprofloxacin (64.4%) which is higher than that reported by Jalil and Al Atbee et al., who found 36.8% of *k. pneumoniae* isolates resistant [17]. Regarding Levofloxacin resistance; we found 55.9% of *k. pneumoniae* isolates resistant that is comparable with studies by Al-Baz et al., [6] and Jalil and Al Atbee et al., [17] who reported different percentage.

The least resistance rate in our study was for Amikacin (42.4%) which agree with Al-Baz et al., who reported Amikacin resistance in 43% of isolates [6]. However, another study by Aamir et al., [23] reported higher Amikacin resistance 60% and a study by Nirwati et al., [21] found lower Amikacin resistance 4.8%. In our research 94.9% of *k. pneumoniae* isolates were MDR that is consistent with other Egyptian study by khairy et al., who reported 100% of isolates were MDR [22].

Conclusion

Our study showed increased rate of *k. pneumoniae* species isolated from CAUTI patients with high resistance to commonly used antibiotics and MDR rate reached 94.9%. New alternative treatment approaches should be considered and investigated in order to replace the current ineffective therapies.

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