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Comparison of Carbapenem Resistance among Clinical and Soil Isolates of *Acinetobacter baumannii* in Baghdad

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Abstract:

In Iraq and globally, the increasing prevalence of carbapenem-resistant *Acinetobacter baumannii* (CRAB) is a serious public health concern. This article examines clinical and soil isolates of CRAB from Baghdad. Seventy-three clinically confirmed CRAB isolates were obtained from various sources, along with 17 soil isolates from Baghdad. The isolates were identified and their antibiotic resistance determined using the VITEK II system. Molecular identification of the isolates carried out using 16S rRNA and blaOXA-51 genes. According to PCR results, all clinical and soil isolates carry the blaOXA-51 carbapenem resistance gene as a housekeeping gene. Carbapenem susceptibility testing of the clinical isolates showed that 52 isolates (71.23%) were imipenem-resistant, and 54 isolates (73.97%) were meropenem-resistant. In contrast, nine soil isolates (52.94%) were resistant to imipenem, and ten isolates (58.82%) were resistant to meropenem. Over all, a significant proportion of clinical and environmental *Acinetobacter baumannii* isolates are resistant to carbapenems. This suggests the need to update guidelines regarding the use of these antibiotics in healthcare facilities to prevent the development of resistance. The rate of antibiotic resistance in *Acinetobacter baumannii* isolates as well as, their sources of infection requires further investigation.

Keywords: *Acinetobacter baumannii*, carbapenems, blaOXA-51, Beta-lactam, 16S rRNA.

Note: The research is based on a PhD dissertation.



Introduction:

Acinetobacter baumannii is one of the most common causes of hospital-acquired infections. It is an obligate aerobic, Gram-negative, non-motile, rod-shaped bacterium. Its risk in hospitals is heightened due to a combination of its virulence and high antibiotic resistance (Morris *et al.*,2019; Shelenkov *et al.*,2023). The World Health Organization has classified *Acinetobacter baumannii* as a high-priority bacterial pathogen. Infections caused by this bacterium include urinary tract infections, meningitis, bacteremia, respiratory tract infections, wound infections, and surgical site infections (Anwer.,2024). In addition to hospitals, these bacteria can be found in the human environment, such as moist soil, ponds, water treatment plants, wastewater, and in humans, animals, and food products. These environmental strains often possess antibiotic resistance mechanisms, including carbapenems and broad-spectrum beta-lactamases (ESBLs), and thus may constitute important environmental reservoirs of resistance elements that can evolve into clinically relevant strains (Wong *et al.*,2017; Mussa and Abdul-Latif.,2024). Real concern about *Acinetobacter baumannii* as a dangerous pathogen, particularly in wounds, emerged after the 2003 US invasion of Iraq, especially among wounded soldiers and civilians, following reports of a "hidden enemy" they called Iraqibacter (Dewachi.,2019).

The second part is explaining the parts of the research as it can be divided into introduction and the main job, the methodology, the results, the discussion and all parts that are significant for the research and the researcher will mention them.

Penicillins, cephalosporins, carbapenems, and monobactams are targets of resistance in *Acinetobacter baumannii* via beta-lactamase. Because beta-lactams mimic their substrates, they bind to penicillin-binding proteins. Beta-lactams that inhibit these proteins disrupt cell wall metabolism. Due to their structural similarity to a class of polypeptides found in peptidoglycan, they inhibit peptide translocation, the final stage of peptidoglycan synthesis. Based on sequence patterns and differences in hydrolysis mechanisms, beta-lactamases that catalyze the hydrolysis of beta-lactam antibiotics can be classified into four classes: A, B, C, and D (Sauvage *et al.*,2008; Tooke *et al.*,2019). *Acinetobacter baumannii*

exhibits broad-spectrum resistance to antibiotics through chromosomally transgenic genetic components and possesses the ability to survive for extended periods on hospital surfaces and many medical devices (Abdul-Latif and Mussa ., 2025). The resistance of *Acinetobacter baumannii* to carbapenems and penicillin is attributed to class A beta-lactamases. Through point mutations, these beta-lactamases can develop broad-spectrum activity against antibiotics or a narrow spectrum. Extended-spectrum beta-lactamases (ESBLs), on the other hand, are capable of degradation and can be inhibited by clavulanic acid. Furthermore, plasmids and other mobile genetic components contribute to their widespread dissemination among Gram-negative bacteria (Ghafourian *et al.*,2015; Kyriakidis *et al.*,2021). Also, class D beta-lactamases, also known as carbapenem-degrading class D beta-lactamases (CHDLs) or oxylinases (OXA), are class A and C beta-lactamases that are serine-dependent. Furthermore, clavulanic acid, sulbactam, and tazobactam do not typically block class D beta-lactamases (Antunes and Fisher.,2014). *blaOXA-51*, *blaOXA-23*, *blaOXA-24*, *blaOXA-58*, *blaOXA-143*, and *blaOXA-235* are among the many *blaOXA* genes. Both chromosomes and plasmids contain the genes that encode these enzymes. Furthermore, previous research has shown that overexpression of *OXA-23* or *OXA-51* is the main cause of carbapenem resistance in clinical isolates of *Acinetobacter baumannii* (Wong *et al.*,2019). In this article, and as a result of the increasing resistance of *Acinetobacter baumannii* to antibiotics, a comparison was made between clinically obtained isolates and soil isolates of *Acinetobacter baumannii* in terms of their resistance to carbapenems antimicrobials.

2. Martial and methods:

2.1 Isolates collection:

Ninety-six clinical source samples representing respiratory tract infections, urinary tract infections, and bacteremia were collected, and 73 clinical isolates were confirmed as *Acinetobacter baumannii*. Additionally, 17 isolates were confirmed out of 40 samples collected from the soil surrounding hospitals. Soil samples were collected from the root zone at a depth of 15–30 cm from seven random locations within hospitals in Baghdad. One gram of soil sample was dissolved in 9 mL of

sterile distilled water. One mL of the resulting solution was then diluted in another 9 mL of sterile distilled water to prepare a 10^{-2} soil dilution. Sequential dilutions (10^{-1} , 10^{-2} , 10^{-3} , 10^{-4} , 10^{-5}) were repeated. We took 0.1 ml of soil dilution (10^{-3} - 10^{-5}) and cultured it on CHROM® agar as a selective medium for *Acinetobacter baumannii*, along with blood agar and MacConkey agar (Omolola.,2007).

2.2 Identification the isolates:

The isolates were identified using biochemical tests, including catalase, oxidase, citrate consumption tests, and IMVIC tests, in addition to using the VITEK 2 system with an ID-Gram negative bacteria card (ID-GNB). In addition, the isolates were molecularly identified using *16S rRNA* and *blaOXA-51* by DNA extraction and conventional polymerase chain reaction, and the PCR products were analyzed using agarose gel electrophoresis.

Table (1): Sequences of primers used in this study.

Name	Sequence 5'-3'	Size bp	Temp	References
<i>16S rRNA</i>	F: 5'-CAGCTCGTGTCTGAGATGT-3' R: 5'-CGTAAGGGCCATGATGACTT-3'	150	53°C	(Higgins <i>et al.</i> ,2004).
<i>blaOXA-51</i>	F: 5'TAATGCTTTGATCGGCCTTG-3' R: 5'-TGGATTGCACTTCATCTTGG-3'	353	54°C	(Joshi <i>et al.</i> ,2017).

2.3 Antibiotics susceptibility test:

The antibiotic susceptibility test card AST-N222 (ASTC) is used in the integrated VITEK II system to measure the minimum inhibitory concentration (MIC) of isolated bacteria. The card has 64 slots and can accommodate between 18 and 20 antibiotics. According to the manufacturer's instructions, the device monitors changes in turbidity caused by bacterial growth.

2.5 Statistical analysis:

Microsoft® Excel 2016 used to analyze the data for current study.

3. Results and Discussion:

3.1 isolates detection

Conventional polymerase chain reaction (PCR) was used to detect the *16S rRNA* gene, which is useful for classifying the species of *Acinetobacter baumannii*, and to confirm the identity of the studied

isolates using the VITEK II system (Lee *et al.*,2014). (Figure 1) shows the PCR amplification sizes (150 base pairs). PCR is a reliable method for identifying this bacterium in clinical laboratories compared to other methods (Esaa *et al.*,2016). According to the results, 90 (66.17%) soil and clinical isolates of *Acinetobacter baumannii* were confirmed out of a total of 136 isolates.

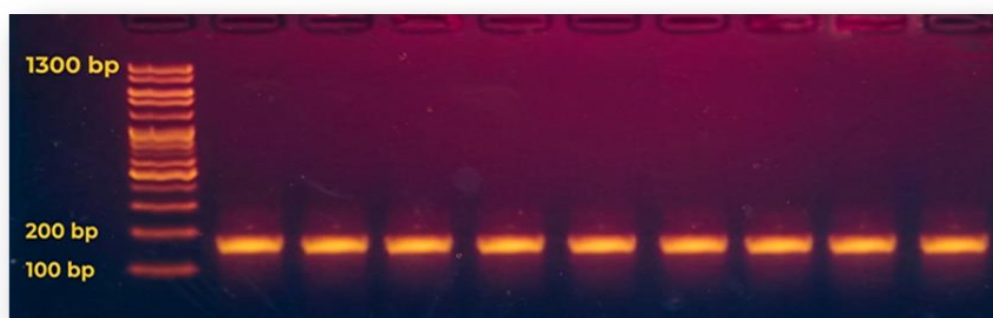


Figure (1): Fragmentation of the 16S rRNA gene of *Acinetobacter baumannii* samples on a 1.5% agarose gel resembling the tracks of the PCR products consisting of 150 base pairs.

On the other hand, the results of the polymerase chain reaction (PCR) showed that clinical and soil samples of *Acinetobacter baumannii* bacteria carry the *blaOXA51* gene, a key gene often responsible for carbapenem resistance, as shown in (Figure 2).

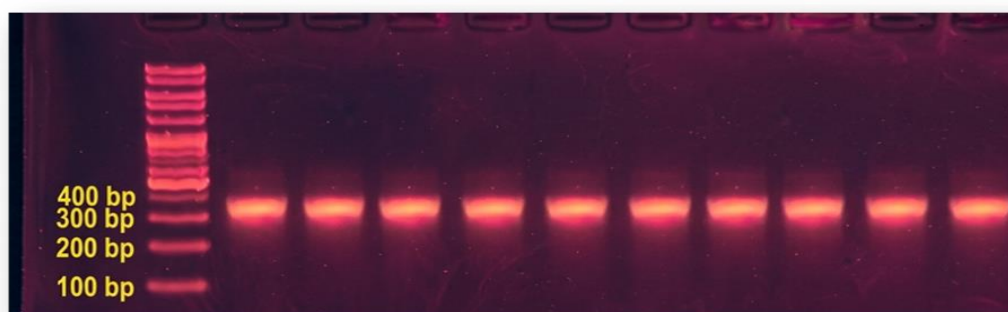


Figure (2): The amplification of the *bla-oxa51* gene of *Acinetobacter baumannii* samples was fractionated on a 1.5% agarose gel electrophoresed Lines resemble 353 bp PCR products.

Clinical and soil isolates of *Acinetobacter baumannii* were examined in this study using the VITEK II system. Although biochemical systems like VITEK II are affected by culture conditions, they are among the most widely used phenotypic techniques for identifying *Acinetobacter species* (Wang *et al.*,2014). *Acinetobacter baumannii* can also be identified using a number of genetic techniques, as demonstrated in this study, due to the limitations of phenotypic methods. One of the most common genetic techniques for identifying bacterial species isolated from environmental or clinical sources, such as *Acinetobacter baumannii*, is 16S rRNA gene sequencing (Lee *et al.*,2014). In this study, 16S rRNA PCR was crucial for identifying *Acinetobacter baumannii* isolates, particularly those isolated from soil.

3.2 Carbapenem susceptibility:

Clinical and soil isolates showed high resistance to carbapenems. Of the 73 confirmed clinical isolates, 52 (71.23%) were resistant to imipenem and 54 (73.97%) to meropenem. In contrast, 9 (52.94%) of the 17 soil isolates were resistant to imipenem and 10 (58.82%) to meropenem, as shown in (Figure 3).

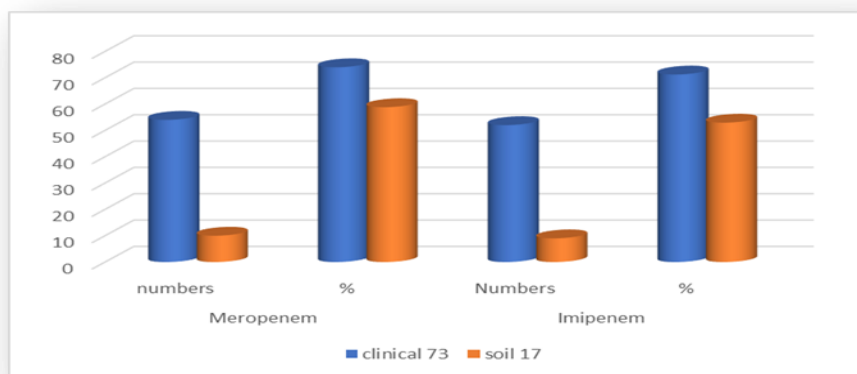


Figure (3): Carbapenem susceptibility using Vitek2, clinical and soil isolates of *Acinetobacter baumannii*.

Regarding other beta-lactam antibiotics, clinical isolates showed near-complete resistance to ceftriaxone, with 66 out of 73 isolates (90.41%) exhibiting resistance. For ampicillin-sulbactam, significant resistance was

observed among clinical isolates, with 61 isolates (83.56%) showing resistance. Soil isolates also exhibited resistance to ceftriaxone, with 14 out of 17 isolates (82.35%) showing resistance, and to ampicillin-sulbactam, with 11 isolates (64.70%) showing resistance, as illustrated in (Figure 4).

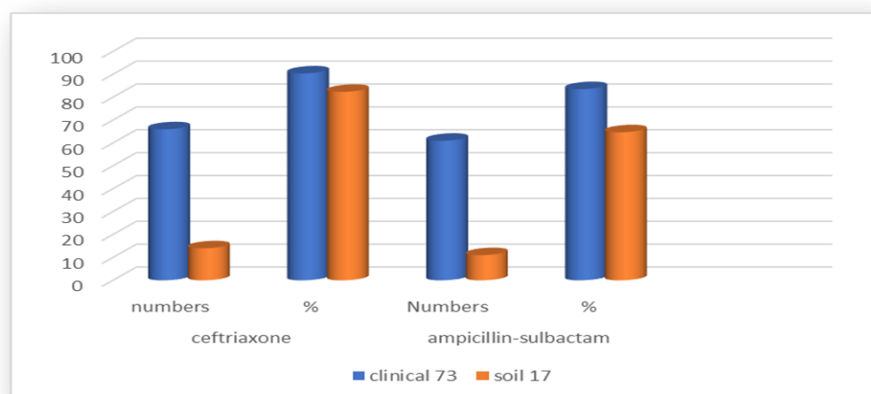


Figure (4): Sensitivity ratio to Ceftriaxone and Ampicillin-sulbactam using Vitek 2 for clinical and soil isolates of *Acinetobacter baumannii*.

Carbapenems are essential antibiotics in the treatment of severe hospital-acquired infections (HAI) and patients with multidrug-resistant (MDR) bacteria, particularly *Acinetobacter baumannii*. However, the increasing number of carbapenem-resistant bacteria worldwide poses a significant health threat (Nguyen *et al.*,2021). Multidrug resistance (MDR) has been commonly documented among *Acinetobacter* species in previous research. A 2022 study in Baghdad revealed that nearly half of the isolates exhibited resistance to imipenem. The ability of *Acinetobacter baumannii* to develop broad-spectrum antibiotic resistance may be influenced by its relatively low permeability to antibiotics and the accumulation of numerous resistance genes resulting from repeated exposure to environmental factors (Rheama and Ibrahim.,2022).

These resistance factors mentioned above may have contributed to the high prevalence of carbapenem resistance in the isolates studied in this research, with resistance rates reaching alarming levels in both soil and clinical isolates. An Iraqi study published 12 years earlier, found that 68.57% of *Acinetobacter baumannii* isolates were resistant to imipenem



and meropenem, a similarly high percentage (Hamed.,2014). Similarly, another study showed that clinical isolates exhibited high resistance to meropenem and imipenem, at 92.31% and 96.15%, respectively, with low sensitivity to these antibiotics in soil isolates (Hassan and Khider.,2020). The prevalence of these carbapenem-resistant bacteria among hospital staff, patients, and the general public is determined by the bacteria's ability to grow on medical equipment and hospital infrastructure. Outbreaks caused by carbapenem-resistant bacteria have been documented in civilian hospitals in the USA, Canada, South America, Europe, Africa, the Middle East, Southeast Asia, and Australia (Hamidian and Nigro.,2019).

Given the limited number of soil isolates in this study and their source within the hospital environment, the transfer of resistance genes is likely due to severe contamination of the hospital environment with *Acinetobacter baumannii*. A previous study indicated that 30% of the soil isolates were meropenem-resistant (Kadham.,2022). It is also noteworthy that sources reporting the prevalence of antibiotic-resistant *Acinetobacter baumannii* in soil in general, and in hospital garden soils in particular, are scarce, although previous studies have indicated that hospital wastewater and medical waste are frequently contaminated with this type of bacteria (Dekic *et al.*,2020). CRAB infection rates have been found to reach up to 50% in large referral hospitals in South and Southeast Asia, particularly in intensive care units. Furthermore, hospital wastewater provides a suitable environment for this bacterium and a potential pathway for its spread to the environment (such as soil). This poses a serious risk to human health (Mecik *et al.*,2024).

The current study demonstrated a high rate of resistance to other antibiotics in both clinical and soil isolates. This poses a growing risk, given the resistance of these isolates to a wide range of available antibiotics. Previous studies indicated that 91.6% of isolates were resistant to ceftriaxone, which is consistent with the findings of the current study. In recent years, World Health Organization (WHO) reports have highlighted the need for new antibiotics for 12 pathogens, including *Acinetobacter baumannii* (Mohammed *et al.*,2022). *Acinetobacter baumannii* is considered a reservoir of resistance genes in hospitals, and

the results of this study confirm this belief. The wide variety of antibiotic uses, both experimental and therapeutic, in hospitals is likely the reason for the high rates of resistance found in this study. Multidrug-resistant strains arise as a result of this selective pressure, and these strains may produce genes that encode resistance mechanisms. This may explain the presence of resistant isolates in the environment and outside hospital walls (Perez *et al.*,2007; Hanifah *et al.*,2011; Mohammed *et al.*,2022).

4. Conclusion:

Acinetobacter baumannii is a major opportunistic pathogen. One possible explanation for its ability to cause prolonged outbreaks is its ease of dispersal in the environment, allowing it to infect or colonize patients and survive for several days. According to this study, a significant proportion of clinical and soil isolates of *Acinetobacter baumannii* exhibited antibiotic resistance.

5. Recommendations:

New guidelines on antibiotic use in healthcare facilities are needed to prevent the development of antibiotic resistance. Antibiotic use must be rational. Environmental control must also be implemented consciously through proper waste and wastewater management, particularly from hospitals, and by taking measures such as thorough handwashing and equipment sterilization to stop the spread of *Acinetobacter baumannii* in hospitals. The level of antibiotic resistance in isolates of this bacterium and the identification of sources of contamination and infection require further research.

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مقارنة مقاومة الكاربابينيم بين العزلات السريرية وعزلات التربة من بكتريا
Acinetobacter baumannii في بغداد.

مستخلص البحث:

يعد الانتشار المتزايد لبكتريا *A. baumannii* المقاومة للكاربابينيم (CRAB) مصدر قلق للصحة العامة. تقارن هذه المقالة بين عزلات *A. baumannii* السريرية وعزلات التربة في بغداد. تم الحصول على 73 عزلة سريرية مؤكدة من مصادر مختلفة، بالإضافة إلى 17 عزلة تربة. تم تحديد العزلات ومقاومتها للمضادات الحيوية باستخدام نظام VITEK II. أُجريَ التحديد الجزيئي للعزلات باستخدام جيني *blaOXA-51* و *16S rRNA*. وفقًا لنتائج تفاعل البوليميراز المتسلسل (PCR)، تحمل جميع العزلات السريرية وعزلات التربة جين مقاومة الكاربابينيم *blaOXA-51* كجين مرجعي. أظهر اختبار حساسية الكاربابينيم للعزلات السريرية أن 52 عزلة (71.23%) مقاومة للإيميبينيم، و54 عزلة (73.97%) مقاومة للميروبيينيم. في المقابل، أظهرت تسع عزلات من التربة (52.94%) مقاومة للإيميبينيم، وعشر عزلات (58.82%) مقاومة للميروبيينيم. ووفقًا لهذه الدراسة، فإن نسبة كبيرة من عزلات بكتريا *A. baumannii* السريرية والبيئية مقاومة للكاربابينيم. وهذا يُشير إلى ضرورة تحديث الإرشادات المتعلقة باستخدام هذه المضادات الحيوية في مرافق الرعاية الصحية لمنع تطور هذه المقاومة.

الكلمات المفتاحية: *Acinetobacter baumannii*, Carbapenems, *blaOXA-51*, Beta-lactam, *16S rRNA*

ملاحظة : هل البحث مستل من رسالة ماجستير او اطروحة دكتوراه ؟ نعم : ✓ كلا :