Antimicrobial Sensitivity of *Pseudomonas aeruginosa* to Aztreonam, Amoxicillin, Erythromycin, Carbenicillin, Norfloxacin, Chloramphenicol, Gentamycin and Azithromycin after Exposure to Radiation Emitted from Radioactive Sources, Lasers and Exposure to Magnetized Water

Nebras Rada Mohammed

College Dentistry, Ibn Sina University of Medical and Pharmaceutical Sciences, Baghdad, Iraq

**Abstract:**

**Objective:** The aim of this study to assess the sensitivity of *P. aeruginosa* for ATM, AML, E, CAR, NOR, CL, CN and AZM after exposure to radiation emitted from radioactive sources, Lasers and exposure to magnetized water.

**Study design:** Cross-sectional in descriptive study design with case–control in analytical study design

**Backgrounds:** *P. aeruginosa* gram-negative bacteria occasion distinct kinds of contagion including epidermis, optics, ears, respiratory tract, urinary tract, intestines derived sepsis, soft tissues, skeleton and joint contagion. Radiation including ionizing and non-ionization depending on the energy of the radiated particles emitted Alpha, Beta and Gamma rays from different radioactive sources.

**Methodology:** Study populations and bacterial deposition and identification of *P. aeruginosa*. Exposure *P. aeruginosa* to radiation at different times and doses. Antimicrobial susceptibility test for ATM, AML, E, CAR, NOR, CL, CN and AZM after exposure to radiation emitted from radioactive sources, Lasers and magnetized water.

**Results:** After exposing *P. aeruginosa* to the Na$^{23}$, CO$^{60}$, Cs$^{137}$ and Sr$^{90}$ radioactive source without or without aluminum for (1,2,3) hr., the bacteria were examined for antibiotics and the results are high sensitivity to NOR, ATM, CAR. As well as, exposure to Nd: YAG laser in (10, 20) min. with exposure to magnetized water which show high sensitive to NOR and ATM antibiotics.

**Conclusions:** The radioactive sources, Nd: YAG laser and magnetic water have a strong effect on bacteria and their sensitivity to antibiotics, so that their sensitivity rate increased very significantly compared to before exposure. The most effective antibiotics in killing bacteria after exposure are Aztreonam, Norfloxacin, Carbenicillin and Gentamycin (ATM, NOR, CAR and CN).

**Keywords:** Antibiotics, Irradiation, MDR.

**Introduction**

*Pseudomonas* gram-negative bacteria is rod appearance and an opportunistic pathogen give rise to different kinds of infection inclusive of epidermis, optics, ears, respiratory tract, urinary tract, intestinal-derived sepsis, soft tissue infections, skeleton and joint contagions (Aghamollaei, et al. 2015), occasion illness in

---

This work is licensed under a Creative Commons Attribution 4.0 International License. The license permits unrestricted use, distribution, and reproduction in any medium, on the condition that users give exact credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if they made any changes.
impaired immune system patients; also, patients of suppressing the immune response of individual therapy like patients tribulation of cystic fibrosis, burn, injury, AIDS and cancer. It is naturally reluctant to diverse antibacterial drugs (Pereira, & Cardoso, 2014).

The development of multidrug-resistant (MDR) strains in burns units has turned into a great problem in the control of infections in order that have been impedance for multidrug with diverse of impedance technicality (Japoni, et al., 2006). The carbapenems inclusive imipenem and meropenem appear substantial therapeutic for dangerous infections by *P. aeruginosa* (Lister, Wolter, & Hanson, 2009). This pathogen turns into impedance to the carbapenems via modulating and combining diverse intrinsic technicality like down-regulation or deprivation of porins (Picão, et al., 2012).

Radiation is predominating believed as the ionizing or non-ionizing rely on the power of the eradiated mote. Ionizing rays emanate extra than 10 eV to ionize mote with molecules and fracture the bonds. Ionizing rays is radioactive matter which emanate α, β or γ rays, composed of helium nuclei, electrons or positrons and photons. Another provenances inclusive X-rays of medical radiography checking of particles which comprise the secondary cosmic beams that are output after primary cosmic beams react with Earth’s atmosphere (Yanagida, 2016). Acoustic radiance can be represented as ultrasound and gravitational radiance (Ryan, 2012).

**Methodology**

**Study Design**

Cross-sectional for descriptive study design and Case-control study design rely in this research for analytical study design (Figure 1).

**Inclusion and Exclusion Criteria**

The treatise was inclusive if first, the clinical specimens were possessed from patients indicate to Iraqi hospitals. Second, standard antibiotic susceptibility testing methods depending to CLSI rules were utilized. Third, MDR-*P. aeruginosa* was defined as isolate resistant against antibiotics belonged to at least three various classes, particularly aminoglycosides, carbapenems and fluoroquinolones.

![Figure 1. Plan Study Design for this Seek](image_url)

The treatise was also excluded if first, consideration export in language English. Second, treatise designed another than case-control and cross-sectional. Third, *P. aeruginosa* secluded of clinical specimens and fourth, depend on applied standard, the quality of treatise was renowned as qualified.

**Study Populations and Bacterial Isolates**

The entire of specimens one-hundreds of *P. aeruginosa* of patients allowable in Baghdad infirmary in 2023-2024 that identify via
traditional biochemical tests based to Ismail et al., (2012).

**Exposure* P. aeruginosa to Radiation Emitted from Radioactive Sources, Lasers and Exposure to Magnetized Water**

*P. aeruginosa* grown was carried out rely to Ismail et al., (2012) with various modification, cultured in Nutrient broth at 37° C for 24 h, subsequently centrifuged at five-thousands rpm till ten minutes. The pellet was pendent of normal saline and comparison with MacCflrand 0.5, subsequently exhibition one ml of suspension to radiance released of various radioactive provenance, lasers and magnetized water with comparison of control collection (wanting exhibition to radiance), every run was carried out in duplicate and injected in Trypton soy agar.

The equation of ratio of homicide:

\[
\text{Ratio of homicide } \% = \frac{\text{Control} - \text{treated}}{\text{Control}} \cdot 100 
\]

(1)

**Antibiotic Susceptibility Test**

*P. aeruginosa* isolates were examined for their sensitivity to various antibiotics via disk diffusion procedure (Perilla, et al., 2010). Outcomes were registered by measuring the inhibition zone (in millimeters) and explicated depending to Clinical and Laboratory Standard Institute (CLSI) (2020).

The sensitivity of *P. aeruginosa* were specified via disk diffusion method as follows:

The procedure depending to Kirby- Bauer disc diffusion process was carried out as follows:

1- MH medium was utilizing for this experience. The medium was cooled to 45–50°C and take by loop 4–5 colonies were transmitted to a tube included five ml of BHI broth then brood at 37°C till its turbidity standard with liken to McFarland standard tube No. 0.5.

2- Within fifteen minutes of check the consistency of the inoculum by swab into the standardized bacterial suspension and streak the surface of MH plate. The tray was pliable to stay on a flatness and level surface undisturbed for 3 to 5 minutes to permit sucking of put overabundant.

3- Put the antibiotic disks on the medium through fifteen minutes the injected plates were brood at 37°C for 18 hr. in an inverted placement.

4- Next brood the inhibition of the entire zones was prominent metric via utilizing a ruler. The terminus point, mensuration to the close millimeter was liken with zones of inhibition specified resistant or sensitive by CLSI.

**Results and Discussion**

**Study Populations and Bacterial Isolates**

One- hundred bacterial isolates were exposed to different radioactive sources including CO\textsuperscript{60}, Na\textsuperscript{23}, CS\textsuperscript{137} and Sr\textsuperscript{90}. Also, exposed to radiation emitted from the laser at different time (20, 30) min. as well as, exposure to magnetized water in (8, 10) ml.

**Exposure* P. aeruginosa to Radiation Emitted from Na\textsuperscript{23}, Cs\textsuperscript{137}, CO\textsuperscript{60} and Sr\textsuperscript{90} Radioactive Sources**

*P. aeruginosa* is one of the main pathogens causing hospital-acquired infections. It can readily evolve antibiotic resistance during chromosomal mutations via horizontal conquest of resistant determinants. The rising propagation of multidrug resistant (MDR) or extensively-drug-resistant (XDR) *P. aeruginosa* isolates is related with the dissemination of the so-called high-risk-clones like ST175. Infections raised by MDR/XDR suitable empiric and critical antimicrobial therapy (Ruiz-Garbajosa, & Cantón, 2017).

Multidrug-resistant *P. aeruginosa (MDR P. aeruginosa)* cause simultaneous resistance versus various category of antibiotics is of fundamental significant to health-care settings worldwide (Hirsch, & Tam, 2010; Vaez, Salehi-Abargouei, & Khademi, 2017).
Table 1. Type of Exposure of *P. aeruginosa* to Na\(^{23}\), Cs\(^{137}\), CO\(^{60}\) and Sr\(^{90}\) Radioactive Sources with Sensitivity and Resistance of Different Antibiotics

<table>
<thead>
<tr>
<th>No.</th>
<th>Type of exposure</th>
<th>ATM (10)</th>
<th>CAR (100)</th>
<th>AML (25)</th>
<th>NOR (10)</th>
<th>CN (10)</th>
<th>E (15)</th>
<th>CL (30)</th>
<th>AZM (15)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Na(^{23})/ 10 µCi through 3 hr. without Aluminum</td>
<td>26</td>
<td>20</td>
<td>0</td>
<td>33</td>
<td>21</td>
<td>11</td>
<td>0</td>
<td>17</td>
</tr>
<tr>
<td>2</td>
<td>Na(^{23})/ 10 µCi through 2 hr. without Aluminum</td>
<td>30</td>
<td>25</td>
<td>0</td>
<td>36</td>
<td>23</td>
<td>8</td>
<td>0</td>
<td>17</td>
</tr>
<tr>
<td>3</td>
<td>Na(^{23})/ 10 µCi through 1 hr. without Aluminum</td>
<td>26</td>
<td>21</td>
<td>0</td>
<td>33</td>
<td>23</td>
<td>10</td>
<td>0</td>
<td>18</td>
</tr>
<tr>
<td>4</td>
<td>Cs(^{137})/ 1 µCi through 3 hr. without Aluminum</td>
<td>30</td>
<td>22</td>
<td>0</td>
<td>33</td>
<td>25</td>
<td>0</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>5</td>
<td>Cs(^{137})/ 10 µCi through 3 hr. with Aluminum</td>
<td>33</td>
<td>25</td>
<td>0</td>
<td>36</td>
<td>25</td>
<td>8</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>6</td>
<td>Cs(^{137})/ 10 µCi through 2 hr. with Aluminum</td>
<td>30</td>
<td>23</td>
<td>0</td>
<td>36</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>Cs(^{137})/ 1 µCi through 1 hr. without Aluminum</td>
<td>30</td>
<td>25</td>
<td>0</td>
<td>33</td>
<td>23</td>
<td>0</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>8</td>
<td>Cs(^{137})/ 10 µCi through 1 hr. without Aluminum</td>
<td>33</td>
<td>23</td>
<td>0</td>
<td>36</td>
<td>25</td>
<td>0</td>
<td>0</td>
<td>19</td>
</tr>
<tr>
<td>9</td>
<td>Cs(^{137})/ 10 µCi through 1 hr. with Aluminum</td>
<td>30</td>
<td>25</td>
<td>0</td>
<td>33</td>
<td>23</td>
<td>0</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>10</td>
<td>Cs(^{137})/ 10 µCi through 3 hr. with Aluminum</td>
<td>33</td>
<td>26</td>
<td>0</td>
<td>36</td>
<td>25</td>
<td>0</td>
<td>0</td>
<td>19</td>
</tr>
<tr>
<td>11</td>
<td>Cs(^{137})/ 10 µCi through 3 hr. without Aluminum</td>
<td>30</td>
<td>25</td>
<td>0</td>
<td>36</td>
<td>23</td>
<td>0</td>
<td>0</td>
<td>14</td>
</tr>
<tr>
<td>12</td>
<td>Cs(^{137})/ 1 µCi through 2 hr. with Aluminum</td>
<td>33</td>
<td>25</td>
<td>0</td>
<td>33</td>
<td>22</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>13</td>
<td>Cs(^{137})/ 10 µCi through 2 hr. without Aluminum</td>
<td>30</td>
<td>23</td>
<td>0</td>
<td>33</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>14</td>
<td>Sr(^{90})/ 1 µCi through 1 hr.</td>
<td>26</td>
<td>23</td>
<td>0</td>
<td>33</td>
<td>22</td>
<td>0</td>
<td>0</td>
<td>19</td>
</tr>
<tr>
<td>15</td>
<td>Sr(^{90})/ 1 µCi through 2 hr.</td>
<td>30</td>
<td>25</td>
<td>0</td>
<td>33</td>
<td>22</td>
<td>0</td>
<td>0</td>
<td>18</td>
</tr>
<tr>
<td>16</td>
<td>Control (CLSI)</td>
<td>23-29</td>
<td>18-24</td>
<td>----</td>
<td>22-29</td>
<td>17-23</td>
<td>----</td>
<td>----</td>
<td>----</td>
</tr>
</tbody>
</table>

After exposing *P. aeruginosa* to the Na\(^{23}\) radioactive source without aluminum for (1, 2, 3) hr., the bacteria were examined for antibiotics and the results were as follows:

Very high sensitivity to antibiotics E and AZM at all times. As well as a very high sensitivity to the antibiotic NOR when exposed to (1, 3) hr. It is also very sensitive to ATM and CAR antibiotics when exposed to 2 hr. as shown in Table 1 and Figure 2.

The results of exposing *P. aeruginosa* to the radioactive source CO\(^{60}\) in the presence and absence of aluminum and at different times (1, 2, 3) hr. which were tested for antibiotics with showed a very high sensitivity to the antibiotic ATM for all bacteria exposed to the radioactive source and its sensitivity to CAR when exposed to a radioactive source CO\(^{60}\)/1 µCi without aluminum for 1 hr. as well as, CO\(^{60}\)/10 µCi in the presence of aluminum for 3 hr. as shown in Table 1 and Figure 3.
Figure 2. *P. aeruginosa* to Na\textsuperscript{23} Radioactive Sources with Sensitivity and Resistance of Different Antibiotics

Figure 3. *P. aeruginosa* to Co\textsuperscript{60} Radioactive Sources with Sensitivity and Resistance of Different Antibiotics
The results of exposing \( P. \) aeruginosa to the radioactive source \( \text{Cs}^{137} \) showed a very high sensitivity to the antibiotic ATM and NOR at different times (1, 2, 3) hr. in the presence and absence of aluminum. Also, very high sensitivity to CN when exposed to \( \text{Cs}^{137}/10 \) µci during 1 hr. without aluminum and 3 hr. in the presence of aluminum. In addition to its very high sensitivity to AML during exposure to \( \text{Cs}^{137}/10 \) µci for 1 hr. in the presence of aluminum and 3 hr. without aluminum and to \( \text{Cs}^{137}/1 \) µci for 2 hr. in the presence of aluminum as shown in Table 1 and Figure 4.

The results in Table 1 and Figure 5 show a very high sensitivity to the antibiotic NOR when exposed to the radioactive source \( \text{Sr}^{90}/1\text{mci} \) within (1.2) hr.. Also very high sensitivity to ATM and CAR antibiotics when exposed to \( \text{Sr}^{90}/1\text{mci} \) in 2 hr.

Radioactive dissolution radionuclide degeneration procedure usually deserts the product nuclide in an agitated power state, energy as gamma irradiation (L’Annunziata, 2007).

A prior study by Vaez, et al., (2018) utilizing random impact pattern, the raise happening of MDR \( P. \) aeruginosa was predestined 58%. The highest and lowest predominance of MDR \( P. \) aeruginosa were distinguished in Tehran (100%) and Zahedan (16%) respectively. The elevated resistance average was contra ceftazidime (50%) and amikacin (50%).
Exposure *P. aeruginosa* to Radiation Emitted from Nd:YAG Laser

Technicality resistance of antimicrobial agents confined uptake with efflux inclusive drug inactivation and alterations in targets. All *P. aeruginosa* take possession the amp C gene for the inductive chromosomal β-lactamase, over-expression of the enzyme outcomes of a spontaneous mutation in the regulatory gene, amp R. This has existed specially where dense dependence has been requiring on ceftazidime therapy. Though the enzyme is naturalistic located in the periplasm, it has been revealed in the sputum through antipseudomonal therapy (Giwercman, et al., 1990).

The results in Table 2 and Figure 6 show a very high sensitivity to the NOR antibiotic for *P. aeruginosa* exposed to an Nd:YAG laser in (10, 20) min. It is also very sensitive to the antibiotic ATM when exposed to the laser for 10 min.

A preceding study by Aghamollaei, et al., (2015) were twenty of *P. aeruginosa* were examined for antibiotics sensitivity at cross eighteen antibiotics utilizing disc diffusion methods. Examinations for antibiotic susceptibility was achieved via agar streaking procedure on MHA, especially at cross the beta-lactam antibiotics performed by penicillin inclusive piperacillin, ticarcilline and carbenicillin.

<table>
<thead>
<tr>
<th>No.</th>
<th>Type of exposure</th>
<th>ATM (10)</th>
<th>CAR (100)</th>
<th>AML (25)</th>
<th>NOR (10)</th>
<th>CN (10)</th>
<th>E (15)</th>
<th>CL (30)</th>
<th>AZM (15)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Nd:YAG Lasers for 10 min.</td>
<td>30</td>
<td>22</td>
<td>0</td>
<td>36</td>
<td>26</td>
<td>0</td>
<td>0</td>
<td>16</td>
</tr>
<tr>
<td>2</td>
<td>Nd:YAG Lasers for 20 min.</td>
<td>26</td>
<td>23</td>
<td>0</td>
<td>33</td>
<td>23</td>
<td>0</td>
<td>0</td>
<td>14</td>
</tr>
<tr>
<td>3</td>
<td>Control (CLSI) ATCC® 27853 (American Type Culture Collection)</td>
<td>23-29</td>
<td>18-24</td>
<td>----</td>
<td>22-29</td>
<td>17-23</td>
<td>----</td>
<td>----</td>
<td>----</td>
</tr>
</tbody>
</table>

Figure 5. *P. aeruginosa* to Sr⁹⁰ Radioactive Sources with Sensitivity and Resistance of Different Antibiotics
**Exposure** *P. aeruginosa* to Magnetized Water

Antibiotic-resistant determinants are dominating spread during mobile genetic elements like plasmid and integron. Integrons are genetic structures able to apprehend genes, consisting of preserved segments and a mutable region between the preserved segments (El Zowalaty, et al., 2015; Chen, et al., 2009).

The results in Table 3 and Figure 7 show a very high sensitivity to the antibiotic NOR and ATM of *P. aeruginosa* exposed to magnetic water (8, 10) ml within 1 hr, as well as its sensitivity to the antibiotic CN when exposed to magnetic water (10) ml for 1 hr.

Alterations in targets technicality of resistance outcomes from mutational alterations in target enzymes that result in conservation of their pivotal role in cell metabolism, however resistance to the effect of eclectic inhibition via antibiotics. In *P. aeruginosa* it is utmost usually performed with the quinolones during mutation in the gyrA gene encoding the A subunit of the target enzyme, DNA gyrase (Akasaka, et al., 2001).

### Table 3. Type of Exposure of *P. aeruginosa* to Magnetized Water with Sensitivity and Resistance to Different Antibiotics

<table>
<thead>
<tr>
<th>No.</th>
<th>Type of exposure</th>
<th>ATM (10)</th>
<th>CAR (100)</th>
<th>AML (25)</th>
<th>NOR (10)</th>
<th>CN (10)</th>
<th>E (15)</th>
<th>CL (30)</th>
<th>AZM (15)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Magnetized water / 8 ml through 1hr.</td>
<td>30</td>
<td>23</td>
<td>0</td>
<td>36</td>
<td>23</td>
<td>8</td>
<td>0</td>
<td>17</td>
</tr>
<tr>
<td>2</td>
<td>Magnetized water / 10 ml through 1hr.</td>
<td>30</td>
<td>22</td>
<td>0</td>
<td>33</td>
<td>25</td>
<td>0</td>
<td>0</td>
<td>19</td>
</tr>
<tr>
<td>3</td>
<td>Control (CLSI ATCC® 27853)</td>
<td>23-29</td>
<td>18-24</td>
<td>----</td>
<td>22-29</td>
<td>17-23</td>
<td>----</td>
<td>----</td>
<td>----</td>
</tr>
</tbody>
</table>

*Note: The table shows sensitivity levels for different antibiotics at various exposure conditions.*
Conclusions

The radioactive sources, Nd:YAG laser and magnetic water have a strong effect on bacteria and their sensitivity to antibiotics, so that their sensitivity rate increased very significantly compared to before exposure.

The most effective antibiotics in killing bacteria after exposure are Aztreonam, Norfloxacin, Carbenicillin and Gentamycin (ATM, NOR, CAR and CN).

Ethical Approval

All examination protocols were confirmed by the College of Ibn Sina Universty for Medical and Pharmaceuticals Sciences. All screening was achieved following the confirmed guidelines.

Financial Support and Sponsorship

There was no financial disclosure.

Conflicts of interest

The authors declare that there are no conflicts of interest.

Acknowledgments

Researcher Dr. Nebras Rada Mohammed PhD, in Biotechnology with a Genetic Engineering, Molecular Genetics and Protein Engineering, a scientist, expert, researcher, creator, inventor, writer, written and author, editor-in-chief of the Journal of Articles and Inventions in the American Goidi Journal, teaching, lecturer at the University College of Al-Turath University college, a Bachelor's degree in Microbiology and a Master's degree in Molecular Biology in Microbiology from Al-Mustansiriya University, an arbitrator, international resident and consultant In medical laboratories, an expert in medical laboratories and a holder of the title of a scientist project, an arbitrator, a distinguished publisher, a silver supporter of scientific platforms, a chairman of a committee in a scientific society, receiving accolades from international intellectual property, the Best Arab Woman Award 2020, also the Best Community Personality Award, the Best Research Award.
2019, also the Best Research Award 2020 and an American Award For the invention of 2020 by the American Goidi the World Investment Commission in America, holds the title of the best distinguished inventor in the world by the World Investment Commission in America and holds the first places in the world for inventions presented in the world from the American Goidi, the world investment commission in America. The Edison Prize, The Pascal Prize, The creativity award, the scientific medal and the Everest medal for innovation, creativity for inventions from USA.

References


