Isolation of nosocomial multi-drug resistant Gram-negative bacteria from some Benghazi hospitals

Background

Resistance of bacteria to antimicrobial agents are increasingly reported in clinical and environmental samples in healthcare settings. Nosocomial infections and spread of nosocomial multi-drug resistant Gram-negative pathogens have become a worrisome subject rendering treatment options very limited. Multidrug-resistant nosocomial pathogens have been detected in the hospital environment such as Intensive Care Unit (ICU) environments. This study was undertaken to investigate the spread of nosocomial pathogens from clinical and environmental swabs collected from some ICU units in Benghazi hospitals. Methods: Three hundred six swabs were collected from patients and patients zone, the patients were admitted to different ICUs in Benghazi hospitals, the environmental swabs were from several parts of ICUs, such as: ventilators screen, floors, bedside, and O2 suppliers, both types of swabs were collected at the same time for each ICU. The swabs were cultured on MacConkey Agar supplemented with 4 mg/l of cefotaxime. Isolates were identified using standard methods. Antibiotic sensitivity testing was performed to examine the resistance of Gram-negative bacteria to different classes of antibiotics used in Libyan hospitals. Production of extended spectrum beta-lactamaeses (ESBLs) and metallo-beta-lactamases (MbLs) were also investigated to examine the mechanism of resistance in our isolates. Findings: The results demonstrated that 52 isolates were Gram-negative bacteria; others were Gram-positive bacteria. Gram-negative bacteria found in nasal swabs, and oral cavities of patients admitted to ICU units were Acinetobacter baumannii, Pseudomonas aeruginosa and Klebsiella pneumoniae. Swabs collected from the hospital environments showed that most isolates found in the hospital environment were P. aeruginosa and A. baumannii followed by
**Introduction**

Infections caused by antibiotic-resistant bacteria continue to challenge physicians; they face growing resistance among Gram-positive and Gram-negative bacteria that cause infections in the hospital and in the community settings. The most common problems of resistance occur in the hospital settings are the spread of multi-drug resistant (MDR) bacteria either as infections or spread in the hospital environment [1].

Nosocomial infection is used to refer to infections arise during or following hospital stay or after 48 h of admission. Nosocomial infection constitutes an important cause of death, as well as increasing the length of hospital stay and medical costs [2]. Microbial infections play vital roles in determining the outcome as well as the cost and duration of the hospital stay for patients admitted to intensive care units (ICU). Therefore, regular surveillance of important pathogens and their resistance pattern is mandatory [3-4]. Patients at ICUs are at risk of acquiring nosocomial infections which contribute to higher rates of morbidity and mortality. Approximately 25% of all hospital infections and 90% of outbreaks occur in ICUs, the highest incidence of MDR infection in ICUs is due to the increased use of medical instruments such as mechanical ventilators, monitoring devices, blood and urine catheters. Its high resistance is argued to the over use of broad-spectrum antibacterial agents used for ICU patients [3]. Therefore, Healthcare associated Infections (HAIs) are an important health care problem in terms of morbidities, mortalities and economic consequences world-wide [4, 5, 6].

Multi-resistant Gram-negative rods are important pathogens in ICUs, causing a high rate of mortality [7]. Patients in ICUs have a 5 to7-fold higher risk of nosocomial infection compared with other patients. This is a consequence of the impaired defense mechanism, application of invasive methods and monitoring devices, exposure to broad-spectrum antibiotics, and the colonization of resistant microorganisms [8].

ICUs where critically ill patients admitted are always considered as high risk areas, because infections with MDR organisms can be easily developed. Infections caused by MDR bacteria constitute a serious problem for intensive care patients all over
the world, which result in increasing the mortality rate [6]. Determining the optimal therapy for ICU patients requires the availability of data on the prevalence and susceptibility patterns of bacterial isolates [9-10]. A considerable number of critically ill patients, in particular those staying in ICUs, acquire different infections following hospitalization [11]. Many factors affect the risk of nosocomial infections, including underlying disease, severity of illness, length of ICU stay, and usage of invasive devices and procedures. The frequent use of broad-spectrum antibiotics results in colonization with resistant Gram-negative bacteria and consequently serious infections [11]. Due to the problem of the transmission of highly resistant strains of Gram-negative bacilli (GNB) in hospitals, and inadequate isolation of infected patients with infectious diseases and resistant micro-organisms, therapy problems occurred in many parts of the world, particularly in developing countries [5, 12, 13].

Antibiotic resistance is a major worldwide problem in ICUs in Indonesia. The excessive, and uncontrolled use of antimicrobial drugs is strongly related to the widespread of antibiotic resistant bacteria, particularly in ICUs. Many surveillance efforts have drawn attention to this phenomenon [14]. Antibiotic use is the main driving force for the development and selection of drug-resistant bacteria; as a consequence, a perfect storm has been created with regard to these infections: increasing drug resistance in the absence of new drug development [1, 12].

A range of Gram-negative organisms are responsible for hospital-acquired infections, the Enterobacteriaceae family being the most commonly identified group overall. Unfortunately, multidrug-resistant organisms, including Pseudomonas aeruginosa, Acinetobacter baumannii, and extended-spectrum β-lactamase (ESbL) producing or carbapenemase-producing Enterobacteriaceae, are being increasingly reported worldwide. Gram-negative organisms predominate as causative agents of hospital-acquired pneumonia, particularly P. aeruginosa, A. baumannii, and the Enterobacteriaceae. Several highly resistant Gram-negative pathogens namely Acinetobacter species, MDR P. aeruginosa, and carbapenem-resistant Klebsiella species and Escherichia coli are emerging as significant pathogens in both the United States and other parts of the world [1, 15, 16].

Most studies define multidrug resistance as resistance to more than two classes of antibiotics [14]. ICU is considered one of potential sources of hospital-acquired infections, even in hospitals where extensive infection prevention and control measures are routinely implemented. Pattanayaka and co-authors reported that from a study conducted on 1265 ICU patients from 75 countries in 2007, it was found that longer ICU stay is correlated with higher incidence of infection rate. Most ICU patients that acquired infections are associated with the use of invasive devices such as catheters and mechanical ventilators [17, 18].

Globally, patients in the ICU have encountered an increasing emergence and spread of antibiotic-resistant pathogens. The worldwide incidence rate is 23.7 infections per 1000 patient days. Rates of nosocomial infections range from 5% to 30% among ICU patients. Although ICUs generally comprise < 5% of all hospital beds, they account for 20% to 25% of all nosocomial infections. ICUs accommodate the most seriously ill patients in a relatively confined environment. Therefore, the highest rates of nosocomial infections are observed in ICUs, which are also the units in which the most severely ill patients are treated and in which the highest mortality rates are observed [11, 16, 19].

Bacteria resist antimicrobial agents through either inherent resistance or resistance acquired through gene mutation or transfer of genetic material [4].
Beta-lactams are the most widely used antibiotics all over the world, and resistance of bacteria to beta-lactam antibiotics has resulted in a major clinical crisis [20]. Resistance to b-lactam antibiotics often involves production of β-lactamases, other mechanisms of resistance can also result from drug efflux pumps or outer-membrane changes that decrease drug permeability. Resistance of bacteria to antibiotics is facilitated by horizontal gene transfer, plasmids and transposons, the resistance mechanisms also include drug efflux system, and antibiotic target modification [4].

The high prevalence of resistance of bacteria to penicillins, and cephalosporin drugs, including fourth generation is evident, resistance of Gram-negative bacteria to other available antimicrobial agents, including carbapenems, have been emerged [21]. Gram-negative bacteria have become increasingly resistant to antimicrobial agents due to the misuse of antibiotics that caused emergence of resistant strains. Several mechanisms were developed, it includes; the production of Extended-spectrum β-lactamases (ESβLs) and carbapenemases. It is also capable of spreading such resistance between members of the family Enterobacteriaceae and the non-fermenters by using mobile genetic elements as vehicles for such resistance mechanisms [22]. These enzymes are encoded by genes to hydrolyze all classes of β-lactams and the activity of which cannot be neutralized by β-lactamase inhibitors; it is also associated with aminoglycoside resistance genes and thus bacteria that possess Mbl genes are often co-resistant to aminoglycosides, further compromising therapeutic regimes [23].

The introduction of carbapenems into clinical practice, and the use of these drugs to treat Gram-positive and negative bacterial infections represented a great advance in decreasing the rate of serious bacterial infections caused by β-lactams resistant bacteria. This is due to the broad spectrum activities and stability to hydrolysis by most β-lactamase enzymes, which have made carbapenems the drug of choice for the treatment of infections caused by penicillin or cephalosporin-resistant, Gram-negative bacilli, particularly extended spectrum β-lactamases (ESβLs) [24]. However, in recent years, emergence of carbapenem-hydrolysing metallo-beta-lactamase (Mbl) enzymes is now increasing and spread in different parts of the world. With respect to infection with Mbl-producing strains, this mechanism represents a therapeutic problem due to their resistance to all β-lactams except monobactams. Several types of Mbl enzymes that have been identified and described in MDR pathogens are uniquely problematic due to its ability to withstand antibiotics and antimicrobial drugs, they also have the ability to inherit and acquire resistance to many drug classes via mutation to all relevant treatments [22, 25, 26]. Due to the very few studies and information on antibiotic resistance in Benghazi, this study was undertaken.

Methods and Materials

Patients

Forty-one patients were included in the study, those patients were diagnosed to have nosocomial infections and the infections were recorded after 48 to 72 hrs following their admission as defined by center for disease control [25]. They were 28 males and 13 females, their ages were between 3 days to 85 years. The patients included in this study were those patients who were admitted to the ICUs of four major hospitals in Benghazi; Benghazi Medical Center (BMC), El-Gomhoria, El-Jala and 7th of October, during March-July 2013.

Swabs collection

A total of 306 swabs (nasal and mouth swabs) were randomly collected from patients admitted to dif-
ferent ICUs in the four hospitals and also from the patient surroundings (hospital environment) from several areas, such as: bedsides, ventilator screens, floors and oxygen suppliers. The isolates were collected by sterile transport swabs impregnated in 1 ml of sterile normal saline. The swabs were labeled with the number of the patient and the date of collection and the site where swabs were taken from [22].

**Culture of isolates**

All swabs were cultured on MacConkey agar without salt supplemented with 4mg/l of cefotaxime, and were incubated aerobically at 37°C overnight to select for isolates resistant to third generation cephalosporins [27]. Mixed cultures were purified using the same culture media to obtain pure cultures.

**Bacterial Strains Used**

A modified *E. coli* HB101 (UAB190) was used as the recipient strain [rifampicin and aminoglycoside resistant and green Fluorescent protein (GFP) producing] [28].

**Identification of Bacteria**

The bacterial isolates were identified by using standard bacteriological procedures according to Clinical and Laboratory Standards Institute (CLSI) recommendations. The isolates were identified by conventional methods; microscopic morphological examination, and biochemical reaction tests to confirm the identification.

**Antibiotic Sensitivity Test (AST)**

Bacterial species vary in their sensitivity to the different chemotherapeutic and antibiotic agents. These variations and the continuously increasing number of the antimicrobial agents, necessitate the selection of the proper agent for each organism to be used for therapeutic purposes. The antibiotic sensitivity pattern of selected isolates was studied by disc diffusion method. Antibiotic sensitivity was carried out on all isolated strains of bacteria using Muller Hinton Agar with modified Kirby Bauer disc diffusion method. The susceptibility of the isolated Gram-negative bacteria were tested against imipenem (IPM 10μg), ampicillin (AMP 10μg), ceftazidime (CAZ 30μg), amikacin (AK 30μg), gentamicin (CN 30μg) using the Kirby-Bauer disc-diffusion technique as described by the CLSI [29].

**Extended Spectrum β-Lactamase (ESβL) Detection Test**

Production of ESBLs was carried out by Double Disc Synergy Test (DDST). This test was carried out to confirm the ability of the resistant isolates to produce Beta-lactamase enzymes in our isolates. The test was carried out on Muller Hinton agar with a 30mg of ceftazidime and a disk of amoxicillin–clavulanate (containing 10mg of clavulanate) positioned at a distance of 30 mm (centre to centre) [27, 30].

**Phynotypic detection of Metallo-β-Lactamases (MbLs)**

MbL-producing isolates were suspected when the isolate was resistant to imipenem. Screening and confirmation for the detection of MbL were carried out by disc potentiating test with EDTA-impregnated imipenem discs [25]. All isolates that showed resistance to imipenem were submitted to further examination for the detection of MbL production using EDTA (750μg) combined disk. The test organisms were inoculated onto plates of Mueller-Hinton agar and optical density was adjusted to 0.5 McFarland standards. A 0.5M EDTA solution was
prepared by dissolving 186.1 g of disodium EDTA 2H2O in 1000 ml of distilled water and adjusting it to pH 8.0 by using NaOH and the mixture was sterilized by autoclave. Two 10μg imipenem discs were placed on the plate and 5μl (750μg) of EDTA solution was added to one of the discs. The inhibition zones of the imipenem and imipenem-EDTA discs were compared after overnight incubation at 37°C. An increase in the zone size of at least 7 mm around the imipenem-EDTA disc was recorded as an MbL-positive isolate [25].

Conjugation experiments

Conjugation experiments were carried out using GFP E. coli as recipients. Fresh colonies of parents and recipients were grown separately in 2ml tubes containing nutrient broth media and incubated overnight at 37°C. Each isolate of parents was mated with GFP E. coli in a nutrient broth of 2:2 percents and incubated overnight at 37°C in a shaking incubator. Mated mixture was then cultured on MacConkey agar supplemented with 4mg/l of rifampicin with 4mg/l of cefotaxime and incubated overnight at 37°C [22].

Results

Patients

Of the 41 patients who stayed at ICUs, 24 (58.5%) were infected with Gram-negative bacteria during March-July 2013. The occurrence of Gram-negative infections among ICU patients in Benghazi hospitals is illustrated in Figure 1, the percentage of the infections at the hospitals was as follows; 7 cases at BMC (29.1%), 10 cases at El Gomhoria (41.7%), 4 cases at El-Jala (16.7%) and 3 cases at 7th of October (12.5%).

Among the studied patients, 17 cases (70.8%) were male and 6 cases (25%) were female. The mean age of the patients was 37.7 years (ranged between 3 days to 85 years). The mean duration of ICUs stay was 11.22 days.

Frequency of different MDR Gram-negative isolates

From the total 306 swabs obtained, 101 isolates (33%) were able to grow on MacConkey agar.
without salt that was supplemented with 4mg/l of cefotaxime. The results demonstrated that 52 (51.5%) isolates were Gram-negative bacteria, the others 49 (48.5%) were Gram-positive bacteria that grew on MacConkey agar and were excluded according to the aim of this study (Fig. 2).

Identification of MDR Gram-negative isolates

The results of the swabs collected from the hospitals are presented in table 1. The most frequent Gram-negative bacterial isolates derived from swabs were *P. aeruginosa* (48.1%), *A. bumannii* (26.9%) and *K. pneumoniae* (25%) (Table 2). The results of swabs collected from patients and patients surroundings from the 4 hospitals are shown in Figure 3. The swabs collected from nasal and mouth from patients yielded isolates belong to Gram-negative bacteria. Nasal swabs positive for Gram-negatives were 20 (38.5%), whereas positive mouth swabs were 18 (34.6%). The swabs collected from patients surroundings produced positive results of the occurrence of Gram-negative bacteria; 6 isolates found on the ventilator screens (11.5%), 3 on the floors (5.8%), 3 isolates on bed sides (5.8%) and 2 isolates on oxygen supplier (3.8%).

Antimicrobial Sensitivity Testing

The results showed that ZAK8, ZAK32 and ZAK63 were completely sensitive to antibiotics; whereas; ZAK1, ZAK54, ZAK53, ZAK55, ZAK65, ZAK68, ZAK71 and ZAK72 were sensitive to imipenem, amikacin, gentamycin and ceftazidime but showed resistance to ampicillin. The isolates ZAK24, ZAK26, ZAK29, ZAK30, ZAK39, ZAK40, ZAK45, ZAK46, ZAK47, ZAK48, ZAK54, ZAK58, ZAK60, ZAK61, ZAK64, ZAK67, ZAK73 and ZAK74 were resistant to imipenem and ceftazidime, where ZAK6, ZAK24, ZAK29, ZAK30, ZAK39, ZAK40, ZAK45, ZAK46, ZAK47, ZAK48, ZAK54, ZAK58, ZAK60, ZAK61, ZAK64, ZAK67 and ZAK74 were resistant to aminoglycosides and imipenem. ZAK6, ZAK24, ZAK29, ZAK30, ZAK33, ZAK35, ZAK39, ZAK64, ZAK73 and ZAK74 were resistant to imipenem and EDTA, while ZAK22, ZAK24, ZAK26, ZAK29, ZAK31, ZAK40, ZAK46, ZAK47, ZAK48, ZAK54, ZAK58, ZAK60, ZAK61 and ZAK67 were resistant to imipenem but showed sensitivity to EDTA.

---

**Figure 2.** Incidence of Gram-negative bacteria in ICUs.
Table 1. Gram negative bacteria isolated from clinical and non-clinical settings

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Isolate ID</th>
<th>Hospital</th>
<th>Source of Swab</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZAK1</td>
<td>A. baumannii</td>
<td>BMC</td>
<td>Ventilator screen</td>
</tr>
<tr>
<td>ZAK2</td>
<td>K. pneumoniae</td>
<td>BMC</td>
<td>Floor</td>
</tr>
<tr>
<td>ZAK4</td>
<td>A. baumannii</td>
<td>BMC</td>
<td>Nasal</td>
</tr>
<tr>
<td>ZAK6</td>
<td>A. baumannii</td>
<td>BMC</td>
<td>Nasal</td>
</tr>
<tr>
<td>ZAK7</td>
<td>P. aeruginosa</td>
<td>BMC</td>
<td>Nasal</td>
</tr>
<tr>
<td>ZAK8</td>
<td>A. baumannii</td>
<td>BMC</td>
<td>Ventilator screen</td>
</tr>
<tr>
<td>ZAK9</td>
<td>P. aeruginosa</td>
<td>BMC</td>
<td>Nasal</td>
</tr>
<tr>
<td>ZAK10</td>
<td>P. aeruginosa</td>
<td>BMC</td>
<td>Nasal</td>
</tr>
<tr>
<td>ZAK22</td>
<td>P. aeruginosa</td>
<td>BMC</td>
<td>Nasal</td>
</tr>
<tr>
<td>ZAK24</td>
<td>P. aeruginosa</td>
<td>BMC</td>
<td>Mouth</td>
</tr>
<tr>
<td>ZAK26</td>
<td>P. aeruginosa</td>
<td>BMC</td>
<td>Nasal</td>
</tr>
<tr>
<td>ZAK27</td>
<td>P. aeruginosa</td>
<td>BMC</td>
<td>Ventilator screen</td>
</tr>
<tr>
<td>ZAK29</td>
<td>A. baumannii</td>
<td>BMC</td>
<td>Mouth</td>
</tr>
<tr>
<td>ZAK30</td>
<td>P. aeruginosa</td>
<td>El Gomhoria</td>
<td>Mouth</td>
</tr>
<tr>
<td>ZAK31</td>
<td>P. aeruginosa</td>
<td>El Gomhoria</td>
<td>Nasal</td>
</tr>
<tr>
<td>ZAK32</td>
<td>P. aeruginosa</td>
<td>El Gomhoria</td>
<td>Bed side</td>
</tr>
<tr>
<td>ZAK33</td>
<td>A. baumannii</td>
<td>El Gomhoria</td>
<td>O2 supplier</td>
</tr>
<tr>
<td>ZAK34</td>
<td>K. pneumoniae</td>
<td>El Gomhoria</td>
<td>Mouth</td>
</tr>
<tr>
<td>ZAK35</td>
<td>A. baumannii</td>
<td>El Gomhoria</td>
<td>Mouth</td>
</tr>
<tr>
<td>ZAK38</td>
<td>K. pneumoniae</td>
<td>El Gomhoria</td>
<td>Mouth</td>
</tr>
<tr>
<td>ZAK39</td>
<td>A. baumannii</td>
<td>El Gomhoria</td>
<td>Nasal</td>
</tr>
<tr>
<td>ZAK40</td>
<td>A. baumannii</td>
<td>El Gomhoria</td>
<td>Mouth</td>
</tr>
<tr>
<td>ZAK41</td>
<td>K. pneumoniae</td>
<td>El Gomhoria</td>
<td>Nasal</td>
</tr>
<tr>
<td>ZAK42</td>
<td>K. pneumoniae</td>
<td>El Gomhoria</td>
<td>Mouth</td>
</tr>
<tr>
<td>ZAK43</td>
<td>K. pneumoniae</td>
<td>El Gomhoria</td>
<td>Nasal</td>
</tr>
<tr>
<td>ZAK44</td>
<td>K. pneumoniae</td>
<td>El Gomhoria</td>
<td>Mouth</td>
</tr>
<tr>
<td>ZAK45</td>
<td>K. pneumoniae</td>
<td>El Gomhoria</td>
<td>Mouth</td>
</tr>
<tr>
<td>ZAK46</td>
<td>A. baumannii</td>
<td>El Gomhoria</td>
<td>Mouth</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Isolate ID</th>
<th>Hospital</th>
<th>Source of Swab</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZAK47</td>
<td>A. baumannii</td>
<td>El Gomhoria</td>
<td>Nasal</td>
</tr>
<tr>
<td>ZAK48</td>
<td>K. pneumoniae</td>
<td>El Gomhoria</td>
<td>Floor</td>
</tr>
<tr>
<td>ZAK49</td>
<td>K. pneumoniae</td>
<td>El Gomhoria</td>
<td>Mouth</td>
</tr>
<tr>
<td>ZAK53</td>
<td>P. aeruginosa</td>
<td>El-Jala</td>
<td>Nasal</td>
</tr>
<tr>
<td>ZAK54</td>
<td>P. aeruginosa</td>
<td>El-Jala</td>
<td>Nasal</td>
</tr>
<tr>
<td>ZAK55</td>
<td>P. aeruginosa</td>
<td>El-Jala</td>
<td>Nasal</td>
</tr>
<tr>
<td>ZAK56</td>
<td>K. pneumoniae</td>
<td>El-Jala</td>
<td>Mouth</td>
</tr>
<tr>
<td>ZAK58</td>
<td>P. aeruginosa</td>
<td>El-Jala</td>
<td>Nasal</td>
</tr>
<tr>
<td>ZAK59</td>
<td>A. baumannii</td>
<td>El-Jala</td>
<td>Mouth</td>
</tr>
<tr>
<td>ZAK60</td>
<td>P. aeruginosa</td>
<td>El-Jala</td>
<td>Nasal</td>
</tr>
<tr>
<td>ZAK61</td>
<td>P. aeruginosa</td>
<td>El-Jala</td>
<td>Mouth</td>
</tr>
<tr>
<td>ZAK63</td>
<td>P. aeruginosa</td>
<td>7th of October</td>
<td>Nasal</td>
</tr>
<tr>
<td>ZAK64</td>
<td>A. baumannii</td>
<td>7th of October</td>
<td>Ventilator screen</td>
</tr>
<tr>
<td>ZAK65</td>
<td>P. aeruginosa</td>
<td>7th of October</td>
<td>Ventilator screen</td>
</tr>
<tr>
<td>ZAK67</td>
<td>A. baumannii</td>
<td>7th of October</td>
<td>Mouth</td>
</tr>
<tr>
<td>ZAK68</td>
<td>P. aeruginosa</td>
<td>7th of October</td>
<td>Nasal</td>
</tr>
<tr>
<td>ZAK71</td>
<td>P. aeruginosa</td>
<td>7th of October</td>
<td>Bed side</td>
</tr>
<tr>
<td>ZAK72</td>
<td>P. aeruginosa</td>
<td>7th of October</td>
<td>O2 supplier</td>
</tr>
<tr>
<td>ZAK73</td>
<td>K. pneumoniae</td>
<td>7th of October</td>
<td>Mouth</td>
</tr>
<tr>
<td>ZAK74</td>
<td>P. aeruginosa</td>
<td>7th of October</td>
<td>Nasal</td>
</tr>
<tr>
<td>ZAK76</td>
<td>P. aeruginosa</td>
<td>7th of October</td>
<td>Ventilator screen</td>
</tr>
<tr>
<td>ZAK77</td>
<td>P. aeruginosa</td>
<td>7th of October</td>
<td>Bed side</td>
</tr>
<tr>
<td>ZAK78</td>
<td>P. aeruginosa</td>
<td>7th of October</td>
<td>Floor</td>
</tr>
<tr>
<td>ZAK79</td>
<td>K. pneumoniae</td>
<td>7th of October</td>
<td>Mouth</td>
</tr>
</tbody>
</table>
The 14 isolates from the non-clinical settings accounted for 42.85% from ventilator screen, 21.43% from both floors and bed sides and 14.29% from O₂ suppliers. The most frequent Gram-negative isolates derived from swabs included: *P. aeruginosa* 8 (57.14%), *A. baumannii* 4 (28.57%) and *K. pneumoniae* 2 (14.29%); and three of these isolates were MBL positive strains (21.43%).

In BMC, *A. baumannii* ZAK1 swabbed from ventilator screen was resistant only to ampicillin, while *K. pneumoniae* ZAK2 swabbed from floor was resistant to gentamycin, ampicillin and ceftazidime. *A. baumannii* ZAK8 swabbed from ventilator screen was completely sensitive; and *P. aeruginosa* ZAK27 swabbed from ventilator screen was resistant only to ceftazidime.

In El Gomhoria hospital, *P. aeruginosa* ZAK32 swabbed from a bed side in the ICU was completely sensitive, except for ampicillin, while *A. baumannii* ZAK33 isolated from oxygen supplier

---

**Table 2. Frequency of different MDR Gram-negative bacterial isolates.**

<table>
<thead>
<tr>
<th>Microorganism</th>
<th>Patient swabs</th>
<th>Patient environmental swabs</th>
<th>Total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nasal</td>
<td>Mouth</td>
<td>Ventilator screen</td>
</tr>
<tr>
<td><em>A. baumannii</em></td>
<td>4</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td><em>K. pneumoniae</em></td>
<td>2</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td><em>P. aeruginosa</em></td>
<td>14</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total (%)</strong></td>
<td>20 (38.5)</td>
<td>18 (34.6)</td>
<td>6 (11.5)</td>
</tr>
</tbody>
</table>

---

**Figure 3. Incidence of MDR Gram-negative isolates from patients and ICU environments (patient zone).**
in the ICU was sensitive to amikacin; and resistant to gentamycin, ampicillin, ceftazidime and imipenem, this isolate was Mbl positive. *K. pneumoniae* ZAK48 isolated from the floor of the ICU was resistant to aminoglycides, ampicillin, ceftazidime and imipenem; and was positive for Mbl production.

In 7th October hospital; *A. baumannii* ZAK64 was isolated from ventilator screen, this strain was resistant to aminoglycides, ampicillin, ceftazidime and imipenem; and Mbl positive when tested against EDTA. *P. aeruginosa* ZAK65, ZAK76, ZAK71 and ZAK72 swabbed from the ventilator screens, bed sides and O₂ suppliers of the ICU were only resistant to ampicillin. *P. aeruginosa* ZAK77 isolated from a bed side in the ICU was only sensitive to imipenem, whereas *P. aeruginosa* ZAK78 isolated from the floor of the ICU was resistant to aminoglycides and ampicillin and sensitive to ceftazidime and imipenem and was not Mbl positive as it was sensitive to 3rd generation cephalosporins and carbapenems.

Of the 52 isolates of Gram-negative bacteria tested, 29 (55.8%) were sensitive to imipenem, 20 (38.46%) resistant and 3 (5.8%) were intermediate. Table 3 depicts the susceptibility of the different microorganisms to various antibiotics. Amikacin and imipenem were the most active antibiotics against Gram-negative bacteria. However, most of these microorganisms were resistant to gentamycin and ceftazidime.

The sensitivity of different microorganisms to common antibiotics are demonstrated in tables 4 and 5. *P. aeruginosa* were most sensitive isolates to amikacin and ceftazidime (56%) and imipenem (60%), these isolates exhibited a resistance profile

Table 3. Distribution of microorganisms according to resistance and susceptibility to antibiotics.

<table>
<thead>
<tr>
<th>Name</th>
<th>Susceptible</th>
<th>Intermediate</th>
<th>Resistant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gentamycin</td>
<td>46.2%</td>
<td>1.9%</td>
<td>51.9%</td>
</tr>
<tr>
<td><em>A. baumannii</em></td>
<td>6</td>
<td>-</td>
<td>8</td>
</tr>
<tr>
<td><em>K. pneumoniae</em></td>
<td>6</td>
<td>-</td>
<td>7</td>
</tr>
<tr>
<td><em>P. aeruginosa</em></td>
<td>12</td>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td>Amikacin</td>
<td>50%</td>
<td>9.6%</td>
<td>40.4%</td>
</tr>
<tr>
<td><em>A. baumannii</em></td>
<td>6</td>
<td>-</td>
<td>8</td>
</tr>
<tr>
<td><em>K. pneumoniae</em></td>
<td>6</td>
<td>-</td>
<td>7</td>
</tr>
<tr>
<td><em>P. aeruginosa</em></td>
<td>14</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Ampicillin</td>
<td>18.5%</td>
<td>zero</td>
<td>90.4%</td>
</tr>
<tr>
<td><em>A. baumannii</em></td>
<td>1</td>
<td>-</td>
<td>13</td>
</tr>
<tr>
<td><em>K. pneumoniae</em></td>
<td>-</td>
<td>-</td>
<td>13</td>
</tr>
<tr>
<td><em>P. aeruginosa</em></td>
<td>4</td>
<td>-</td>
<td>21</td>
</tr>
<tr>
<td>Ceftazidime</td>
<td>50%</td>
<td>zero</td>
<td>57.7%</td>
</tr>
<tr>
<td><em>A. baumannii</em></td>
<td>4</td>
<td>-</td>
<td>10</td>
</tr>
<tr>
<td><em>K. pneumoniae</em></td>
<td>4</td>
<td>-</td>
<td>9</td>
</tr>
<tr>
<td><em>P. aeruginosa</em></td>
<td>14</td>
<td>-</td>
<td>11</td>
</tr>
<tr>
<td>Imipenem</td>
<td>53.8%</td>
<td>zero</td>
<td>44.2%</td>
</tr>
<tr>
<td><em>A. baumannii</em></td>
<td>4</td>
<td>-</td>
<td>10</td>
</tr>
<tr>
<td><em>K. pneumoniae</em></td>
<td>10</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td><em>P. aeruginosa</em></td>
<td>15</td>
<td>-</td>
<td>10</td>
</tr>
</tbody>
</table>
Table 4. Frequency and percentage of microorganisms according to resistance and susceptibility to antibiotics

<table>
<thead>
<tr>
<th>Microorganism</th>
<th>Antibiogram</th>
<th>Frequency</th>
<th>Percentage %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>S</td>
<td>I</td>
</tr>
<tr>
<td>A. baumannii (n=14)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gentamycin</td>
<td></td>
<td>6</td>
<td>-</td>
</tr>
<tr>
<td>Amikacin</td>
<td></td>
<td>6</td>
<td>-</td>
</tr>
<tr>
<td>Ampicillin</td>
<td></td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Ceftazidime</td>
<td></td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>Imipenem</td>
<td></td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>K. pneumoniae (n=13)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gentamycin</td>
<td></td>
<td>6</td>
<td>-</td>
</tr>
<tr>
<td>Amikacin</td>
<td></td>
<td>6</td>
<td>-</td>
</tr>
<tr>
<td>Ampicillin</td>
<td></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Ceftazidime</td>
<td></td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>Imipenem</td>
<td></td>
<td>10</td>
<td>-</td>
</tr>
<tr>
<td>P. aeruginosa (n=25)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gentamycin</td>
<td></td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>Amikacin</td>
<td></td>
<td>14</td>
<td>5</td>
</tr>
<tr>
<td>Ampicillin</td>
<td></td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>Ceftazidime</td>
<td></td>
<td>14</td>
<td>-</td>
</tr>
<tr>
<td>Imipenem</td>
<td></td>
<td>15</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 5. Resistance rates of MDR Gram-negative isolates to antibiotics

<table>
<thead>
<tr>
<th>MDR Gram- negatives</th>
<th>Antibiotics</th>
<th>Gentamycin</th>
<th>Amikacin</th>
<th>Ampicillin</th>
<th>Ceftazidime</th>
<th>Imipenem</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. baumannii</td>
<td></td>
<td>57.1</td>
<td>57.1</td>
<td>92.9</td>
<td>71.4</td>
<td>71.4</td>
</tr>
<tr>
<td>K. pneumoniae</td>
<td></td>
<td>53.8</td>
<td>53.8</td>
<td>100</td>
<td>69.2</td>
<td>23.1</td>
</tr>
<tr>
<td>P. aeruginosa</td>
<td></td>
<td>48.0</td>
<td>24.0</td>
<td>84.0</td>
<td>44.0</td>
<td>40.0</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>52.9</td>
<td>44.9</td>
<td>92.3</td>
<td>61.5</td>
<td>44.8</td>
</tr>
</tbody>
</table>
toward ampicillin (84%). *K. pneumoniae* isolates were highly sensitive to imipenem (76.9%) and displayed the highest resistance rate to ampicillin (100%) followed by ceftazidime (69.2%). All *A. baumannii* isolates in this study were ampicillin resistant, moreover, most *A. baumannii* isolates were resistant to other antibiotics (gentamycin, amikacin, ceftazidime and imipenem).

The results of the frequency of MDR Gram-negative isolates in some of Benghazi hospitals are presented in Table 6 and Figure 4. It is clear that El Gomhoria hospital had more frequency of MDR Gram-negative isolates (34.6%), followed by BMC, 7th of October (25%), and El-Jala (15.4%). *P. aeruginosa* was the most frequent 25 (48.1%) in the four hospitals, while *K. pneumoniae* was at higher rate in El Gomhoria 9 (69.2%), whereas, in 7th of October, the rate was 2 (15.4%), the same rate of the occurrence of *K. pneumoniae* was recorded for both BMC and El-Jala hospitals, 1 (7.7%). *A. baumannii* isolates were more frequent at El Gomhoria, 6 (42.9%), followed by BMC, 5 (35.7%), 7th of October, 2 (14.3%) and El-Jala 1 (7.1%).

### Table 6. Frequency of different MDR Gram-negative isolates in Benghazi hospitals.

<table>
<thead>
<tr>
<th>Hospitals</th>
<th>Micro-organism</th>
<th>Total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><em>A. baumannii</em></td>
<td><em>K. pneumoniae</em></td>
</tr>
<tr>
<td>BMC</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>El Gomhoria</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>El-Jala</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>7th of October</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Total (%)</td>
<td>14 (26.9)</td>
<td>13 (25)</td>
</tr>
</tbody>
</table>
Screening Extended Spectrum β-Lactamase (ESβL)

The results of ESBL production showed that 23 isolates out of 52 collected from different hospitals were able to resist third generation cephalosporins in addition to the β-lactamase inhibitor. These isolates were strains from ICU patients and patients surrounding (Table 7).

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Hospital</th>
<th>Source of Swab</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. baumannii ZAK1</td>
<td>BMC</td>
<td>Ventilator screen</td>
<td>-</td>
</tr>
<tr>
<td>K. pneumoniae ZAK2</td>
<td>BMC</td>
<td>Floor</td>
<td>-</td>
</tr>
<tr>
<td>A. baumannii ZAK4</td>
<td>BMC</td>
<td>Nasal</td>
<td>-</td>
</tr>
<tr>
<td>A. baumannii ZAK6</td>
<td>BMC</td>
<td>Nasal</td>
<td>Positive for Mbo</td>
</tr>
<tr>
<td>P. aeruginosa ZAK10</td>
<td>BMC</td>
<td>Nasal</td>
<td>-</td>
</tr>
<tr>
<td>P. aeruginosa ZAK22</td>
<td>BMC</td>
<td>Nasal</td>
<td>Positive for Mbo</td>
</tr>
<tr>
<td>P. aeruginosa ZAK24</td>
<td>BMC</td>
<td>Mouth</td>
<td>Positive for Mbo</td>
</tr>
<tr>
<td>P. aeruginosa ZAK26</td>
<td>BMC</td>
<td>Nasal</td>
<td>Positive for Mbo</td>
</tr>
<tr>
<td>P. aeruginosa ZAK27</td>
<td>BMC</td>
<td>Ventilator screen</td>
<td>-</td>
</tr>
<tr>
<td>A. baumannii ZAK29</td>
<td>BMC</td>
<td>Mouth</td>
<td>Positive for Mbo</td>
</tr>
<tr>
<td>P. aeruginosa ZAK30</td>
<td>El Gomhoria</td>
<td>Mouth</td>
<td>Positive for Mbo</td>
</tr>
<tr>
<td>A. baumannii ZAK39</td>
<td>El Gomhoria</td>
<td>Nasal</td>
<td>Positive for Mbo</td>
</tr>
<tr>
<td>A. baumannii ZAK40</td>
<td>El Gomhoria</td>
<td>Mouth</td>
<td>Positive for Mbo</td>
</tr>
<tr>
<td>A. baumannii ZAK46</td>
<td>El Gomhoria</td>
<td>Mouth</td>
<td>Positive for Mbo</td>
</tr>
<tr>
<td>A. baumannii ZAK47</td>
<td>El Gomhoria</td>
<td>Nasal</td>
<td>Positive for Mbo</td>
</tr>
<tr>
<td>K. pneumoniae ZAK48</td>
<td>El Gomhoria</td>
<td>Floor</td>
<td>-</td>
</tr>
<tr>
<td>P. aeruginosa ZAK54</td>
<td>El-Jala</td>
<td>Nasal</td>
<td>-</td>
</tr>
<tr>
<td>P. aeruginosa ZAK58</td>
<td>El-Jala</td>
<td>Nasal</td>
<td>-</td>
</tr>
<tr>
<td>A. baumannii ZAK59</td>
<td>El-Jala</td>
<td>Mouth</td>
<td>-</td>
</tr>
<tr>
<td>A. baumannii ZAK67</td>
<td>7th of October</td>
<td>Mouth</td>
<td>Positive for Mbo</td>
</tr>
<tr>
<td>K. pneumoniae ZAK73</td>
<td>7th of October</td>
<td>Mouth</td>
<td>-</td>
</tr>
<tr>
<td>P. aeruginosa ZAK74</td>
<td>7th of October</td>
<td>Nasal</td>
<td>Positive for Mbo</td>
</tr>
<tr>
<td>P. aeruginosa ZAK77</td>
<td>7th of October</td>
<td>Bed side</td>
<td>-</td>
</tr>
</tbody>
</table>

Metallo-β-lactamase Detection

The frequency of MbL positive isolates in the hospitals is presented in tables 8 and 9 and 10; the highest occurrence of MbL positive isolates (10 (43.5%)), were recorded from isolates recovered from swabs collected from El Gomhoria hospital, followed by BMC 5 (21.7%) and El-Jala 7th of October (4 (17.4%)). MbL producing P. aeruginosa...
Table 8. Prevalence of MβLs in the four hospitals

<table>
<thead>
<tr>
<th>Hospital</th>
<th>IPM/EDTA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benghazi Medical Center</td>
<td>21.7%</td>
</tr>
<tr>
<td>El Gomhoria</td>
<td>43.5%</td>
</tr>
<tr>
<td>El-Jala</td>
<td>17.4%</td>
</tr>
<tr>
<td>7th of October</td>
<td>17.4%</td>
</tr>
</tbody>
</table>

Table 9. Frequency of different MβL isolates in the four hospitals

<table>
<thead>
<tr>
<th>Hospitals</th>
<th>Micro-organism</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A. baumannii</td>
</tr>
<tr>
<td>BMC</td>
<td>2</td>
</tr>
<tr>
<td>El Gomhoria</td>
<td>6</td>
</tr>
<tr>
<td>7th of October</td>
<td>2</td>
</tr>
<tr>
<td>El-Jala</td>
<td>-</td>
</tr>
<tr>
<td>Total (%)</td>
<td>10 (43.5)</td>
</tr>
</tbody>
</table>

Table 10. Frequency of different MβL isolates of various swabs

<table>
<thead>
<tr>
<th>Microorganism</th>
<th>Patient swabs</th>
<th>Patient environmental swabs</th>
<th>Total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nasal</td>
<td>Mouth</td>
<td>Ventilator screen</td>
</tr>
<tr>
<td>A. baumannii</td>
<td>3</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>K. pneumoniae</td>
<td>-</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>P. aeruginosa</td>
<td>7</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td>Total (%)</td>
<td>10 (43.5)</td>
<td>10 (43.48)</td>
<td>1 (4.34)</td>
</tr>
</tbody>
</table>
was the most frequent (40%) in El-Jala, followed by BMC (30%), El Gomhoria (20%) and 7th of October (10%). MbL producing K. pneumoniae was accounted in two isolates in El Gomhoria (66.7%) and one isolate in 7th of October (33.3%). MbL was found in 6 isolates of A. baumannii recovered from swabs collected from El Gomhoria (60%), followed by two isolates (20%) in both BMC and 7th of October.

The most MbL positive Gram-negative bacteria were from patients, 10 isolates were from nasal and mouth swabs (43.48%). MbL positive isolates found in patient zone (non-clinical settings), were lower than those found in clinical swabs. One MbL positive isolate was found in the ventilator screen (4.34%), floor (4.34%) and oxygen supplier (4.34%). The most frequent Gram-negative microorganisms found positive to MbLs were P. aeruginosa (10 (43.5%)), 10 isolates of A. baumannii (43.5%), and 3 isolates of K. pneumoniae (13%).

The resistance pattern of MbL positive and negative isolates against antibiotics clearly demonstrate that the resistance rate was higher for both MbL positive and negative isolates toward other drugs.

Conjugation Experiment

The results of conjugation experiments showed that no conjugants were recovered from the experiments, therefore, the resistance determinants did not mobilize from MDR strains to sensitive GFP E. coli as the E. coli strains were not capable of growing on MacConkey Agar supplemented with 4 mg/l of third generation cephamosporins.

Discussion

Infections caused by multidrug-resistant bacteria constitute a serious problem to patients admitted to ICUs worldwide. The mortality rates associated with multidrug-resistant bacteria in these patients are high in some intensive care units (ICUs). Surveys of the prevalence and susceptibility patterns of bacterial isolates are important in determining optimum empirical therapy for infections in critically ill patients [8]. This study provides an analysis of the transmission of MDR nosocomial pathogens among ICU patients and ICU environments. The data clearly demonstrates the emergence of MDR Gram-negative pathogens in some Benghazi hospitals, in which a total of 52 isolates were recovered for this study.

From 306 samples, only 101 multi drug resistant pathogens grew on MacConkey agar without salt supplemented with 4mg/l of Cefotaxime. Only 52 were Gram-negative bacteria (51.5%). The Gram-negative and Gram-positive pathogens were isolated from many patients admitted to ICUs in different studies [8, 16].

According to Rupp and Fey [27], observation of bacterial growth on a culture medium supplemented with a concentration of 1mg/ml of cefotaxime will detect the presence of an extended spectrum b-lactamase (ESbL) producing micro-organism [27]. This study showed that the observation of bacterial growth in 4mg/l suggests the presence of an ESbL, and these isolates were proposed by the National Committee for Clinical Laboratory Standards (NCCLS) in 1999. For all confirmed ESbL producers, the general consensus states that ESbL producers should be reported as resistant to all penicillins, cephalosporins and aztreonam regardless of routine antimicrobial susceptibility results [31].

This study showed that the most frequent MDR Gram-negative pathogens derived from samples were A. baumannii (43.5%), P. aeruginosa (43.5%), and K. pneumoniae (13%). Similar findings were obtained by Bhaumik and co-workers (2012) who found that MDR Gram-negatives were the caus-
ative agents of infection in the ICU. The isolates detected were; *K. pneumoniae* (80%), *P. aeruginosa* (79.25%) and *A. baumannii* (77.78%), similar results were also observed by Aminizadeh and Kashi and Ahmadi and co-authors [7, 8, 16].

Amikacin, ceftazidime and imipenem, as 50%, 50% and 53.8% respectively were the most active antibiotics against MDR Gram-negative pathogens. These results are in accordance with Jamshidi and collaborators, who reported a high resistance rate of *P. aeruginosa* (53.3%) and *K. pneumoniae* (38.4%) toward imipenem. In this study, the resistance rate of *P. aeruginosa* and *K. pneumoniae* to imipenem was 40% and 23.1%, respectively, the results are in agreement with Radji and co-workers and Aminizadeh and Kashi who found that the resistance to amikacin was 75.47% and 13.2% to imipenem. The results of this study are in conflict somewhat with Bhaumik and collaborators [7, 8, 10, 14].

*A. baumannii* showed the highest resistance rate (71.4%) to imipenem. Similar results were observed by Mohammadi-Mehr and Feizabadi, Aminizadeh and Kashi, and Obeidat and co-authors [7, 11, 32]. This could be explained by the ability of Acinetobacter spp. to withstand the effect of different antibiotics by the different mechanisms of resistance such as decreasing the permeability, efflux system and production of Mbls.

Some isolates showed resistance to ampicillin, this is not surprising, as ampicillin has been used for treatment long time ago, and production of beta-lactamases is expected to inactivate this type of antibiotics. These findings are similar to the findings of Mohammed-Mehr and Feizabadi [11]. The resistance rate of *P. aeruginosa*, *K. pneumoniae* and *A. baumannii* to gentamycin were 48%, 53.8% and 57.1%, respectively. These sensitivity profiles of gentamycin are comparable to the findings of Jamshidi and collaborators who documented the rate of gentamycin resistance in the same type of isolates that were 66.6%, 61% and 93.2% respectively. The increased level of resistance could be argued by the occurrence of aminoglycoside resistance genes possibly on class one integrons as approved in the study carried by El Salabi in 2011 who found endemic strains of *K. pneumoniae*, *P. aeruginosa* resistant to aminoglycosides, and positive for antibiotic resistant genes carried on class 1 integrons [10, 22].

Resistance of most isolates to ceftazidime can be explained by the production of ESbLs and Mbls. These enzymes can efficiently hydrolyze third generation cephalosporins. These results are in agreement with the results of El Salabi and co-workers, and Chouchani and collaborators who found that environmental bacteria isolated from the non-clinical settings and high touching areas in the hospitals are resistant to third generation cephalosporins. These findings are also similar to the results of Mohammadi-mehr and Feizabadi, Ahmadi and collaborators, and Ellabib and co-authors [11, 16, 22, 25].

High rate of resistance to aminoglycosides, third generation cephalosporins and carbapenems was observed among *P. aeruginosa* isolates in this study. This can be explained by the occurrence of resistance determinants, in particular the production of ESbLs and Mbls found in *P. aeruginosa* ZAK22, 24, 26, 30, 31, 60, 61, and 74 that could reflect the incidence of class 1 integrons that carry the resistance genes responsible for conferring such resistance. Similar results were observed by Ellabib and co-workers when they conducted a study on *P. aeruginosa* collected from one of Tripoli hospitals in Libya. They found that *P. aeruginosa* was resistant to ceftazidime (29.5%), amikacin (27.3%) and imipenem (13.5%), the rate of resistance of *P. aeruginosa* is higher in this study [23, 25].

This study showed that carbapenem resistant *P. aeruginosa* and *A. baumannii* was high (86.95%),
the increased resistance rate to carbapenems could be explained by the increased pressure on the use of carbapenems in Libyan hospitals, particularly in ICUs, as they are the last options of beta-lactam antibiotics available to treat Gram-negative bacterial infections, moreover, there is no systemic antibiotic policy to be applied to manage antibiotic prescription in Libyan hospitals. Another important explanation is that these strains have the ability to produce a range of enzymes to hydrolyze beta-lactam antibiotics. These enzymes include, MBLs, carbapenem hydrolyzing class D beta-lactamases (blaOXA-23, blaOXA-24, and blaOXA-58) in A. baumannii and MBLs such as balVIM, blaSPM-1, blaTMB-1, and blaNDM-1. It is worth mentioning that blaTMB-1 encoding gene was discovered in an Achromobacter xylosoxidans recovered from a swab collected from the hospital environment of the central hospital in Tripoli [33, 34]. MBL producing isolates have been reported to be an important cause of nosocomial infections. The present study was conducted to study the incidence of MBLs in bacteria isolated from patients admitted to some Benghazi hospitals. The isolates were further screened for the production of MBLs by disc potentiating testing using EDTA-impregnated imipenem discs. In this study P. aeruginosa showed resistant to imipenem was 43.5%, this study moreover showed that 21 of imipenem resistance isolates were MBL positive (91.3%). In contrast higher resistance was found by Zilberberg and co-authors. Ellabib and collaborators found that only 10.9% were MBL positive [25, 35].

References


22. El-Salabi, A. Characterisation of antibiotic resistance mechanisms in gram-negative bacteria from Tripoli and Benghazi, Libya. Thesis submitted for the degree of doctor philosophy at Cardiff University, School of Medicine, Department of Infection, Immunity and Biochemistry, 2011.


Comment on this article: http://medicalia.org/

Where Doctors exchange clinical experiences, review their cases and share clinical knowledge. You can also access lots of medical publications for free. Join Now!

Publish with iMedPub
http://www.imed.pub

JBS publishes peer reviewed articles of contemporary research in the broad field of biomedical sciences. Scope of this journal includes: Biochemistry, Biomedical sciences, Biotechnology, Microbiology, Molecular biology and Genetics. Secondary research including narrative reviews, systematic reviews, evidencebased articles, meta-analysis, practice guidelines will also be considered for publication. From time to time invited articles, editorials and review of selected topics will be published. The editorial board of JBS shall strive to maintain highest standards of quality and ethics in its publication.

Submit your manuscript here: http://www.jbiomeds.com

This article is available from: www.jbiomeds.com