The Most Predominant Gram Negative Bacteria in a Public Hospital

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

ABSTRACT

Aim: The aim of this study was to explore the occurrence of Escherichia coli, Klebsiella pneumoniae, Pseudomonas aeruginosa and Acinetobacter baumannii bacteria in a hospital in Al-Kharj.

Methodology: The study included the review of antibiogram results to find the number and percentage of these bacteria in 4 years, 2015-2018.

Results: The total number of bacterial cultures in the 4 years was 3327. Most of these cultures were for gram negative bacteria (81.06%). Regarding gram negative bacteria in the 4 years, the most common was Escherichia coli (represents 19.30% of the total bacteria and 23.80% of gram negative bacteria).

Conclusion: It can be concluded that the most prevalent gram negative bacteria were Escherichia coli, Pseudomonas aeruginosa and Klebsiella pneumonia. It is important to conduct more researches to know the prevalence of these bacteria, to know their resistance rate to help healthcare providers to prescribe and dispense antibiotics wisely.

Keywords: Acinetobacter baumannii; Escherichia coli; Gram negative bacteria; Klebsiella pneumonia; prevalence; Pseudomonas aeruginosa.

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1. INTRODUCTION

A worldwide increase in the number of infections caused by gram-negative bacteria has occurred in current years, with infections caused by gram-negative organisms often more prevalent than gram-positive infections in numerous settings [1]. Gram-negative bacteria cause infections including bloodstream infections, pneumonia, meningitis, and wound or surgical site infections in healthcare settings. Gram-negative infections include those caused by Pseudomonas aeruginosa, Acinetobacter, Escherichia coli and Klebsiella as well as many other less common bacteria [2].

In the United States, it is estimated that as many as 2 million patients yearly develop a bacterial infection (caused by gram positive and/or gram-negative bacteria) that is resistant to antibiotics and that more than 23,000 deaths are associated with these infections [3]. A majority of these deaths are related to gram-negative infections, particularly healthcare–acquired infections caused by extended-spectrum β-lactamase-producing Enterobacteriaceae, carbapenem-resistant Enterobacteriaceae, multidrug resistance Pseudomonas aeruginosa and multidrug resistance Acinetobacter baumannii [3]. Centers for Disease Control and Prevention reported that these multidrug resistance gram negative bacteria such as carbapenem-resistant Enterobacteriaceae and Acinetobacter spp in particular are increasing in prevalence [4].

Escherichia coli normally resides in the intestinal flora of humans and other warm-blooded animals. It is ubiquitous in the environment and has been used as an indicator of fecal contamination to assess the quality and safety of water [5]. Although most Escherichia coli strains are harmless, certain strains are pathogenic and cause several diseases such as bloody diarrhea, watery diarrhea, meningitis, urinary tract infection and sepsis which can lead to death [6,7]. Pseudomonas is a type of bacteria that is found commonly in the environment, like in water and in soil. There are many different types of Pseudomonas, Pseudomonas aeruginosa is the organism that most often causes infections in humans. It can cause infections in the lungs, blood or other parts of the body after surgery [8].

Klebsiella species rank among the top 10 bacteria causing hospital-acquired infections, and it is one of the most common bacteria isolated in the intensive care unit (ICU). Klebsiella pneumoniae is a gram-negative facultative anaerobic bacillus that is a member of the Enterobacteriaceae family. It is found in the respiratory tract and stools of about 5% of normal individuals. It is responsible for about 1% of bacterial pneumonia [9-11]. Klebsiella pneumoniae is responsible for a significant proportion of soft tissue infections, pneumonia and urinary tract infections [10]. Acinetobacter baumannii can cause infections in the blood, lungs, urinary tract, or in wounds in other parts of the body. It can also “colonize” or live in a patient without causing infections or without symptoms, especially in respiratory secretions or open wounds [12]. In the United States, Acinetobacter infections rarely occur outside of healthcare settings. However, people who have weakened immune systems or who have chronic diseases may be more susceptible [12].

These 4 bacteria are usually the most prevalent gram negative bacteria. This study aimed to explore the prevalence of Escherichia coli, Klebsiella pneumoniae, Pseudomonas aeruginosa and Acinetobacter baumannii bacteria.

2. METHODOLOGY

This retrospective study was conducted in a public hospital in Al-Kharj to explore the occurrence of the most prevalent gram negative bacteria. The study included the review of antibiogram results to find the number and percentage of these bacteria in 4 years, 2015-2018.

The data were collected from microbiology laboratory in the hospital after receiving the acceptance from the hospital management. The data were represented as frequency and percentage of gram positive and gram negative bacteria in the 4 years and frequency and percentage of the most prevalent gram negative bacteria.

This study was approved by institutional review board (IRB) committee of Saudi Ministry of Health and after receiving the acceptance from the public hospital. The study was approved with IRB log number of 18-474E.

3. RESULTS

The number of bacterial cultures in 2015 was 897. Most of these cultures were for gram
negative bacteria (81.83%). Table 1 shows the number of gram negative and gram positive bacteria in 2015.

Regarding gram negative bacteria in 2015, the most common was \textit{Escherichia coli} (represents 21.63\% of the total bacteria and 26.43\% of gram negative bacteria) followed by \textit{Pseudomonas aeruginosa} (represents 18.62\% of the total bacteria and 22.75\% of gram negative bacteria). Table 2 showed the number of \textit{Escherichia coli}, \textit{Klebsiella pneumoniae}, \textit{Pseudomonas aeruginosa} and \textit{Acinetobacter baumannii} bacteria in 2015.

The number of bacterial cultures in 2016 was 920. Most of these cultures were for gram negative bacteria (82.61\%). Table 3 shows the number of gram negative and gram positive bacteria in 2016.

Table 4 showed the number of \textit{Escherichia coli}, \textit{Klebsiella pneumoniae}, \textit{Pseudomonas aeruginosa} and \textit{Acinetobacter baumannii} bacteria in 2016. Regarding gram negative bacteria in 2015, the most common was \textit{Pseudomonas aeruginosa} (represents 19.57\% of the total bacteria and 23.68\% of gram negative bacteria) followed by \textit{Escherichia coli} (represents 16.09\% of the total bacteria and 19.47\% of gram negative bacteria).

The number of bacterial cultures in 2017 was 765. Most of these cultures were for gram negative bacteria (83.79\%). Table 5 shows the number of gram negative and gram positive bacteria in 2017.

Table 6 showed the number of \textit{Escherichia coli}, \textit{Klebsiella pneumoniae}, \textit{Pseudomonas aeruginosa} and \textit{Acinetobacter baumannii} bacteria in 2017. Regarding gram negative bacteria in 2017, the most common was \textit{Escherichia coli} (represents 19.17\% of the total bacteria and 21.68\% of gram negative bacteria) followed by \textit{Pseudomonas aeruginosa} (represents 17.39\% of the total bacteria and 20.75\% of gram negative bacteria).

The number of bacterial cultures in 2018 was 745. Most of these cultures were for gram negative bacteria (75.44\%). Table 7 shows the number of gram negative and gram positive bacteria in 2018.

Table 8 showed the number of \textit{Escherichia coli}, \textit{Klebsiella pneumoniae}, \textit{Pseudomonas aeruginosa} and \textit{Acinetobacter baumannii} bacteria in 2018. Regarding gram negative bacteria in 2018, the most common was \textit{Escherichia coli} (represents 21.61\% of the total bacteria and 28.65\% of gram negative bacteria) followed by \textit{Klebsiella pneumoniae} (represents 17.99\% of the total bacteria and 23.84\% of gram negative bacteria).

The total number of bacterial cultures in the 4 years was 3327. Most of these cultures were for gram negative bacteria (81.06\%). Table 9 shows the number of gram negative and gram positive bacteria in the 4 years.

Regarding gram negative bacteria in the 4 years, the most common was \textit{Escherichia coli} (represents 19.30\% of the total bacteria and 23.80\% of gram negative bacteria) followed by \textit{Pseudomonas aeruginosa} (represents 17.58\% of the total bacteria and 21.69\% of gram negative bacteria). Table 10 showed the number of \textit{Escherichia coli}, \textit{Klebsiella pneumoniae}, \textit{Pseudomonas aeruginosa} and \textit{Acinetobacter baumannii} bacteria in in the 4 years.

\begin{table}[h]
\centering
\begin{tabular}{l|c|c}
\hline
\textbf{Bacteria} & \textbf{Number} & \textbf{Percentage} \\
\hline
Gram negative bacteria & 734 & 81.83\% \\
Gram positive bacteria & 163 & 18.17\% \\
\hline
Total & 897 & 100.00\% \\
\hline
\end{tabular}
\caption{Number of gram negative and gram positive bacteria in 2015}
\end{table}

\begin{table}[h]
\centering
\begin{tabular}{l|c|c}
\hline
\textbf{Bacteria} & \textbf{Number} & \textbf{Percentage}\textsuperscript{*} \\
\hline
\textit{Escherichia coli} & 194 & 21.63\% \\
\textit{Klebsiella pneumoniae} & 94 & 10.48\% \\
\textit{Pseudomonas aeruginosa} & 167 & 18.62\% \\
\textit{Acinetobacter baumannii} & 78 & 8.70\% \\
\hline
\end{tabular}
\caption{Number of \textit{Escherichia coli}, \textit{Klebsiella pneumoniae}, \textit{Pseudomonas aeruginosa} and \textit{Acinetobacter baumannii} bacteria in 2015}
\textsuperscript{*}The percentage of bacteria is calculated as number of bacteria divided by the total bacteria (gram positive and gram negative bacteria) so the sum of the percentage was less than 100\%
Table 3. Number of gram negative and gram positive bacteria in 2016

| Bacteria           | Number | Percentage |
|--------------------|--------|------------|
| Gram negative bacteria | 760    | 82.61%     |
| Gram positive bacteria  | 160    | 17.39%     |
| Total               | 920    | 100.00%    |

Table 4. Number of *Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa* and *Acinetobacter baumannii* bacteria in 2016

| Bacteria                  | Number | Percentage |
|---------------------------|--------|------------|
| *Escherichia coli*        | 148    | 16.09%     |
| *Klebsiella pneumonia*    | 119    | 12.93%     |
| *Pseudomonas aeruginosa*  | 180    | 19.57%     |
| *Acinetobacter baumannii* | 100    | 10.87%     |

*The percentage of bacteria is calculated as number of bacteria divided by the total bacteria (gram positive and gram negative bacteria) so the sum of the percentage was less than 100%.

Table 5. Number of gram negative and gram positive bacteria in 2017

| Bacteria           | Number | Percentage |
|--------------------|--------|------------|
| Gram negative bacteria | 641    | 83.79%     |
| Gram positive bacteria  | 124    | 16.21%     |
| Total               | 765    | 100.00%    |

Table 6. Number of *Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa* and *Acinetobacter baumannii* bacteria in 2017

| Bacteria                  | Number | Percentage |
|---------------------------|--------|------------|
| *Escherichia coli*        | 139    | 18.17%     |
| *Klebsiella pneumonia*    | 112    | 14.64%     |
| *Pseudomonas aeruginosa*  | 133    | 17.39%     |
| *Acinetobacter baumannii* | 98     | 12.81%     |

*The percentage of bacteria is calculated as number of bacteria divided by the total bacteria (gram positive and gram negative bacteria) so the sum of the percentage was less than 100%.

Table 7. Number of gram negative and gram positive bacteria in 2018

| Bacteria           | Number | Percentage |
|--------------------|--------|------------|
| Gram negative bacteria | 562    | 75.44%     |
| Gram positive bacteria  | 183    | 24.56%     |
| Total               | 745    | 100.00%    |

Table 8. Number of *Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa* and *Acinetobacter baumannii* bacteria in 2018

| Bacteria                  | Number | Percentage |
|---------------------------|--------|------------|
| *Escherichia coli*        | 161    | 21.61%     |
| *Klebsiella pneumonia*    | 134    | 17.99%     |
| *Pseudomonas aeruginosa*  | 105    | 14.09%     |
| *Acinetobacter baumannii* | 80     | 10.74%     |

*The percentage of bacteria is calculated as number of bacteria divided by the total bacteria (gram positive and gram negative bacteria) so the sum of the percentage was less than 100%.
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Table 9. Total number of gram negative and gram positive bacteria in the 4 years (2015-2018)

| Bacteria               | Number | Percentage |
|------------------------|--------|------------|
| Gram negative bacteria | 2697   | 81.06%     |
| Gram positive bacteria | 630    | 18.94%     |
| Total                  | 3327   | 100.00%    |

Table 10. Total number of *Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa* and *Acinetobacter baumannii* bacteria in the 4 years (2015-2018)

| Bacteria               | Number | Percentage* |
|------------------------|--------|-------------|
| *Escherichia coli*     | 642    | 19.30%      |
| *Klebsiella pneumoniae* | 459   | 13.80%      |
| *Pseudomonas aeruginosa* | 585   | 17.58%      |
| *Acinetobacter baumannii* | 356    | 10.70%      |

*The percentage of bacteria is calculated as number of bacteria divided by the total bacteria (gram positive and gram negative bacteria) so the sum of the percentage was less than 100%*

4. DISCUSSION

The present study showed that gram negative bacteria were more common than gram positive bacteria and that the most prevalent gram negative bacteria were *Escherichia coli*, *Pseudomonas aeruginosa*, *Klebsiella pneumonia* and *Acinetobacter baumannii*. Rotimi et al conducted a study about the prevalence of gram negative bacteria but in intensive care units and stated that the most common bacterial isolates in Jeddah versus Kuwait intensive care units were *Pseudomonas aeruginosa* (26%, 26%), *Escherichia coli* (23%, 3%), *Klebsiella pneumoniae* (20%, 17%), inducible Enterobacteraeae group (17%, 14%), and *Acinetobacter spp.* (9%, 33%) [13]. A systematic review and meta-analysis was conducted by Aliyu et al and stated that among nursing home residents, *Escherichia coli* accounted for the largest proportion of multidrug-resistant gram-negative bacterial isolates [14]. Moreover, Zare et al reported that among gram-negative bacteria isolated from patients with urinary tract infections, the most commonly isolated bacteria in the urine included *Escherichia coli* (45%), *Enterobacter* (12%), *Klebsiella* (3.14%), and *Pseudomonas* isolates (1.22%) [15]. Additionally, saber et al and Gajdács et al reported that *Escherichia coli* has been documented to be the most common pathogen associated with urinary tract infections in many countries causing both community- and hospital-acquired UTI [16,17].

Al-Saadi et al reported that the most frequent identified bacterial species in open fractures were *Staphylococcus aureus* (23.52%) followed by *Acinetobacter spp.* (19.32%), then *Escherichia coli* (14.28%), *Pseudomonas spp* (11.76%), *Enterobacter spp.* (9.24%), *Klebsiella spp.* (6.72%) [18]. Deka et al reported that regarding gram-negative bacteria causing surgical site infection in a tertiary care hospital, *Escherichia coli* (22.4%) and *Klebsiella* species (20.6%) were the predominant isolated bacteria followed by *Staphylococcus* species (18.4%), *Pseudomonas* species (12.3%), and *Enterococcus* species (6.6%) [19]. Wen et al stated that data from the National Nosocomial Infection Surveillance System (NNISS) in mainland China indicated that *Pseudomonas aeruginosa* ranked top among pathogens identified from the lower respiratory tract, at 12.82% from 1999 to 2001, 12.31% during the period from 2002 to 2004, and 13.37% from 2005 to 2007 [20].

5. CONCLUSION

The present study showed that gram negative bacteria were more common than gram positive bacteria and that the most prevalent gram negative bacteria were *Escherichia coli*, *Pseudomonas aeruginosa*, *Klebsiella pneumonia* and *Acinetobacter baumannii*. It is important to know the prevalence of infections caused by these bacteria and also to know their resistance rate. More researches are needed to prepare stratified antibiogram that will help health care providers to prescribe and dispense antibiotics wisely.

6. LIMITATIONS

The main limitation in the study was that the diagnosis is not available so the types of infections were not identified and also the setting is not determined, for example if these cultures isolated from ICU or inpatients.
CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

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