Distribution, Optimum Detection Time and Antimicrobial Susceptibility Rates of the Microorganisms Isolated from Blood Cultures over a 4-year Time Period in a Turkish University Hospital and a Review of the International Literature

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This study retrospectively examined 8986 blood cultures from patients over a 4-year time period in an eastern Turkish university hospital to determine the detection times and distribution of isolated microorganisms using the automated BACTEC™ 9050 and BACTEC™ 9120 systems. A total of 1914 (21.3%) blood cultures contained pathogenic microorganisms and 252 (2.8%) positive cultures were considered contaminated. Of all the cultures, 18 (0.2%) were false positives and 224 (2.5%) were false negatives. In cultures containing pathogenic microorganisms, Gram-positive and Gram-negative bacterial isolation rates were 436 (22.8%) and 1440 (75.2%), respectively, and yeasts (all Candida sp.) were found in 38 (2.0%) cultures. Coagulase-negative staphylococci occurred in 936 (48.9%) cultures and Staphylococcus aureus occurred in 302 (15.8%) cultures. The mean detection time for all of the pathogens was 21 h and Brucella spp were isolated within 10 days. This study helps in understanding the epidemiology of the region and in providing positive therapeutic approaches. A review of the international literature helps to place this understanding into a global context.

KEY WORDS: Infectious disease; Pathogenic bacteria; BACTEC™; Blood cultures; Turkey

Introduction
Most pathogenic microorganisms occur in the blood during the course of infectious diseases. The presence of viable bacteria within the bloodstream is known as bacteraemia whereas the condition septicaemia is a systemic disease caused by the presence and persistence of pathogenic
Microorganisms isolated from blood cultures in a Turkish hospital

microorganisms and their toxins within the blood.1 Pathogenic microorganisms can cause septicemia by directly entering the circulatory system, or they may enter as a result of injury to capillary endothelial cells in the course of systemic infections. This latter, indirect, means can equally be considered as a cause of septicemia.2 The mortality rate related to bacteraemia depends on the number and type of microorganisms and also the age of the patient; rates are low in patients < 20 years of age and high (up to 49%) in those aged > 50 years.3 Mortality rates from septicemia were reported to be > 40% in hospitalized patients.3–5

Despite recent developments, such as nucleic acid probes, polymerase chain reaction (PCR), and other molecular techniques for microbiological diagnosis, blood cultures still remain the most practical and reliable method for the diagnosis of infections in the bloodstream.6 Blood cultures are one of the most important tools used by medical staff in the field of clinical microbiology. Rapid isolation and identification of microorganisms in blood samples enables selection of the most appropriate treatment, which is critically important for reducing the mortality rate.6

The fact that microorganisms can be present in blood, either constantly or temporarily, presents a dangerous situation for every organ in the body. Microorganisms entering the bloodstream can result in severe sequelae, such as shock, organ failure and disseminated intravascular coagulation (DIC), which can lead to a high mortality rate.7–9

Gram-positive and Gram-negative bacteria, such as Escherichia coli, Klebsiella pneumoniae, Enterobacter spp, Proteus spp, Pseudomonas aeruginosa, Bacteroides spp, group D streptococci, Staphylococcus aureus, S. epidermidis, S. pneumoniae, Propionibacterium spp, other streptococci and Salmonella spp are the most frequently isolated bacteria from blood cultures.2 The development of automated blood culture systems in recent years has reduced the isolation period necessary for the detection of microorganisms, and has particularly increased the speed of diagnosis of fungal infections.5,7,10

The aim of the present study was to determine the detection times and the distribution of bacteria and yeasts isolated from blood samples using the BACTEC™ 9050 and BACTEC™ 9120 automated systems over a 4-year period in a Turkish university hospital.

Patients and methods

BLOOD SAMPLES

This study analysed blood samples for culture from patients referred by local clinics to the Microbiology Laboratory of Yüzüncü Yıl University (Van, Turkey) between January 2002 and December 2005. For each patient, blood samples were collected into two separate bottles. Samples from adults (5 – 10 ml) were placed into BACTEC™ Plus Aerobic/F blood culture bottles (Becton Dickinson, Franklin Lakes, NJ, USA) and those from children (0.5 – 5 ml) were placed into BACTEC™ Peds Plus/F blood culture bottles (Becton Dickinson). All of the phlebotomies were performed with peripheral sticks, and the blood samples were drawn by a clinician at the patient’s bedside after cleaning the skin with 70% isopropyl alcohol and applying 10% povidone–iodine for 1 min.

BLOOD CULTURE

Following collection, the blood samples were incubated in BACTEC™ 9050 or BACTEC™ 9120 automated blood culture instruments
(Becton Dickinson) until flagged as positive or for up to 5 days. If there was suspicion of brucellosis or fungaemia, the incubation period was extended to 14 days. When blood cultures became positive, the broth was Gram-stained and sub-cultured onto sheep blood agar (Difco™, Becton Dickinson) and eosin methylene blue agar plates (Difco™, Becton Dickinson). No anaerobic blood culture bottles were used or evaluated in the present study.

**MICROORGANISM IDENTIFICATION**

When growth was detected, the bacteria were identified using Sceptor (Becton Dickinson) identification panels and yeasts were detected using conventional microbiological procedures as well as the Mycotube test kit method (BBL™ Diagnostics, Becton Dickinson). Identification of *Brucella* spp was performed by measurement of hydrogen sulphide urease production and dye tests.4 *Brucella* polyvalent antisera from the Refik Saydam Hygiene Center, Ankara, Turkey were used to confirm the diagnosis of *Brucella* spp.

Cultures in which skin flora, such as coagulase-negative staphylococci (CNS), *Streptococcus* spp, diphtheroid bacilli and *Bacillus* spp, were detected were regarded as contaminated.4 CNS and other common skin flora were considered to be pathogens only if one or more of the following criteria were fulfilled: (i) the organism was recovered from two or more cultures; (ii) the clinical significance of the presence of these pathogens was obvious; and (iii) the patient had an indwelling vascular catheter or prosthetic device.

When a blood culture bottle was flagged as positive but no microorganisms were seen on Gram-stained smears and no growth was observed on the agar plates, it was defined as a false-positive blood culture. When a blood culture bottle was flagged as negative, but microorganisms were seen on Gram-stained smears and growth was observed on the agar plates, it was defined as a false-negative blood culture.

**ANTIMICROBIAL SUSCEPTIBILITY TESTS**

Antimicrobial susceptibility tests were performed using Sceptor panels, but the susceptibility testing of bacteria not included in Sceptor panels, such as *Brucella* spp, were performed by conventional disc diffusion.

**Results**

A total of 8986 blood cultures were analysed and, of these, 1914 (21.3%) were positive for pathogenic microorganisms. The distribution of positive cultures according to the therapy area of the clinic that provided the blood samples is presented in Table 1. Among the pathogenic microorganisms, 436 (22.8%) were Gram-positive cocci, 1440 (75.2%) were Gram-negative bacilli and 38 (2.0%) were yeasts (all of which were *Candida* spp). There were 936 (48.9%) cultures with CNS, 302 (15.8%) with *S. aureus*, 60 (3.1%) with *Brucella* spp and 616 (32.2%) with other pathogens. The distribution and antimicrobial susceptibility rates of *S. aureus* and CNS are presented in Table 2, those of *Streptococcus* spp and *Enterococcus* spp are presented in Table 3 and Gram-negative bacteria are presented in Table 4.

The mean detection times for Gram-positive bacteria, Gram-negative bacteria and yeasts were 19, 16 and 24 h, respectively. The mean detection time for all microorganisms was 21 h. Yeasts and *Brucella* spp were isolated within 10 days. Of all the blood cultures (n = 8986) determined, 252 (2.8%) were regarded as being contaminated, and 18 (0.2%) were false
negatives and 224 (2.5%) were false positives.

Discussion

The development of automated blood culture systems has increased the rates of bacterial isolation and reduced the detection time. Improvements in the technology and instrumentation of these automated blood culture systems have also resulted in increased reliability of output data. The present study analysed a total of 8986 blood cultures, 21.3% of which were found to contain pathogenic microorganisms, giving a positive result using the BACTEC™ 9050 and BACTEC™ 9120 automated culture instruments. Of these positive cultures, 75.2% comprised Gram-negative bacteria, 22.8% comprised Gram-positive bacteria and 2.0% comprised yeast cells. Positive cultures were mainly isolated from the following clinics: paediatrics, reanimation and internal medicine. Özyurt et al.\textsuperscript{11} found that the clinics that produced the most blood cultures were intensive care units, internal medicine and paediatrics departments, which was consistent with the findings of the present study.

The isolation rate of positive blood cultures was found to be 21.3% in the present study which lies between rates of 4.8% and 26% previously reported by other studies in Turkey\textsuperscript{11 – 14}. The mean detection time for all pathogens in the present study was 21 h which is similar to the 23 h obtained by Cockerill et al.\textsuperscript{15}. For yeasts, the mean detection time in the present study was 24 h, which is in contrast with that of 41 h reported by Smith et al.\textsuperscript{16} In studies in which the BACTEC™ 9240 system was used, pathogens were detected in 87 – 90.2% of samples within the first 24 h.\textsuperscript{17,18}

The false-positive rates in blood cultures have been reported to vary from 0.4% to 3.4%, and false-negative rates have varied from 0.02% to 0.5%.\textsuperscript{11,16,19 – 22} Comparable rates of 2.5% and 0.2%, respectively, were found in the present study.

In previous years, Gram-negative bacteria were most commonly encountered in blood cultures however, more recently, Gram-positive bacteria have become the more

<table>
<thead>
<tr>
<th>Therapy area of clinic</th>
<th>(n)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paediatrics</td>
<td>466</td>
<td>24.3</td>
</tr>
<tr>
<td>Reanimation</td>
<td>366</td>
<td>19.1</td>
</tr>
<tr>
<td>Internal medicine</td>
<td>312</td>
<td>16.3</td>
</tr>
<tr>
<td>General surgery</td>
<td>294</td>
<td>15.4</td>
</tr>
<tr>
<td>Infectious disease</td>
<td>174</td>
<td>9.1</td>
</tr>
<tr>
<td>Obstetrics and gynaecology</td>
<td>136</td>
<td>7.1</td>
</tr>
<tr>
<td>Orthopaedics</td>
<td>68</td>
<td>3.6</td>
</tr>
<tr>
<td>Urology</td>
<td>46</td>
<td>2.4</td>
</tr>
<tr>
<td>Chest disease</td>
<td>24</td>
<td>1.3</td>
</tr>
<tr>
<td>Neurology</td>
<td>14</td>
<td>0.7</td>
</tr>
<tr>
<td>Physical therapy and rehabilitation</td>
<td>8</td>
<td>0.4</td>
</tr>
<tr>
<td>Brain and neurosurgery</td>
<td>6</td>
<td>0.3</td>
</tr>
<tr>
<td>Total</td>
<td>1914</td>
<td>100</td>
</tr>
</tbody>
</table>

\textsuperscript{TABLE 1: The distribution of positive cultures according to the therapy area of the clinic that provided the blood samples (\(n = 1914\))}
TABLE 2: Distribution and antimicrobial susceptibility rates (%) of *Staphylococcus aureus* and coagulase-negative staphylococci in 1914 pathogen-positive blood samples

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>%</th>
<th>VA</th>
<th>CLF</th>
<th>CIP</th>
<th>GN</th>
<th>TMP/SMZ</th>
<th>CLN</th>
<th>RIP</th>
<th>TET</th>
<th>OX</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Staphylococcus aureus</em>, % (n)</td>
<td>302</td>
<td>16</td>
<td>100</td>
<td>89</td>
<td>87</td>
<td>90</td>
<td>69</td>
<td>78</td>
<td>58</td>
<td>67</td>
<td>40</td>
</tr>
<tr>
<td>Coagulase-negative staphylococci, % (n)</td>
<td>936</td>
<td>49</td>
<td>100</td>
<td>83</td>
<td>79</td>
<td>73</td>
<td>62</td>
<td>83</td>
<td>64</td>
<td>69</td>
<td>32</td>
</tr>
</tbody>
</table>

VA, vancomycin; CLF, chloramphenicol; CIP, ciprofloxacin; GN, gentamicin; TMP/SMZ, trimethoprim–sulphamethoxazole; CLN, clindamycin; RIP, rifampicin; TET, tetracycline; OX, oxacillin.

TABLE 3: Distribution and antimicrobial susceptibility rates (%) of *Streptococcus* spp and *Enterococcus* spp in 1914 pathogen-positive blood samples

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>%</th>
<th>VA</th>
<th>CLF</th>
<th>GN</th>
<th>CLN</th>
<th>OF</th>
<th>CEF</th>
<th>AMP</th>
<th>P</th>
<th>ER</th>
<th>TIC</th>
<th>STP</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Streptococcus</em> spp, % (n)</td>
<td>96</td>
<td>5</td>
<td>100</td>
<td>92</td>
<td>–</td>
<td>75</td>
<td>99</td>
<td>97</td>
<td>93</td>
<td>95</td>
<td>75</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><em>Enterococcus</em> spp, % (n)</td>
<td>38</td>
<td>2</td>
<td>100</td>
<td>–</td>
<td>92</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>95</td>
<td>–</td>
<td>–</td>
<td>100</td>
<td>87</td>
</tr>
</tbody>
</table>

VA, vancomycin; CLF, chloramphenicol; GN, gentamicin; CLN, clindamycin; OF, ofloxacin; CEF, cefotaxime; AMP, ampicillin; P, penicillin; ER, erythromycin; TIC, teicoplanin, STP, streptomycin.
**TABLE 4:**
Distribution and antimicrobial susceptibility rates (%) of the most frequently detected Gram-negative microorganisms in 1914 pathogen-positive blood samples

<table>
<thead>
<tr>
<th>Microorganism</th>
<th>n</th>
<th>%</th>
<th>AMC, % (n)</th>
<th>CRO, % (n)</th>
<th>TZP, % (n)</th>
<th>MEM, % (n)</th>
<th>FLR, % (n)</th>
<th>AK, % (n)</th>
<th>GN, % (n)</th>
<th>TET, % (n)</th>
<th>CLF, % (n)</th>
<th>IP, % (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Escherichia coli</em></td>
<td>96</td>
<td>5</td>
<td>50 (48)</td>
<td>72 (69)</td>
<td>95 (91)</td>
<td>100 (96)</td>
<td>82 (79)</td>
<td>96 (92)</td>
<td>73 (70)</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><em>Klebsiella spp</em></td>
<td>96</td>
<td>5</td>
<td>35 (34)</td>
<td>55 (53)</td>
<td>95 (91)</td>
<td>100 (96)</td>
<td>88 (84)</td>
<td>92 (88)</td>
<td>69 (66)</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><em>Salmonella spp</em></td>
<td>42</td>
<td>2</td>
<td>76 (32)</td>
<td>100 (42)</td>
<td>–</td>
<td>100 (42)</td>
<td>100 (42)</td>
<td>–</td>
<td>100 (42)</td>
<td>–</td>
<td>–</td>
<td>–</td>
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<tr>
<td><em>Enterobacter cloacae</em></td>
<td>42</td>
<td>2</td>
<td>–</td>
<td>95 (40)</td>
<td>69 (29)</td>
<td>100 (42)</td>
<td>90 (38)</td>
<td>74 (31)</td>
<td>62 (26)</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><em>Acinetobacter spp</em></td>
<td>56</td>
<td>3</td>
<td>38 (21)</td>
<td>25 (14)</td>
<td>96 (54)</td>
<td>96 (54)</td>
<td>91 (51)</td>
<td>79 (44)</td>
<td>61 (34)</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><em>Serratia spp</em></td>
<td>22</td>
<td>1</td>
<td>–</td>
<td>95 (21)</td>
<td>95 (21)</td>
<td>91 (20)</td>
<td>95 (21)</td>
<td>100 (22)</td>
<td>86 (19)</td>
<td>81 (286)</td>
<td>98 (347)</td>
<td>89 (315)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>354</td>
<td>18</td>
<td>38 (135)</td>
<td>66 (233)</td>
<td>81 (286)</td>
<td>98 (347)</td>
<td>89 (315)</td>
<td>78 (277)</td>
<td>73 (257)</td>
<td>96 (34)</td>
<td>96 (34)</td>
<td>96 (34)</td>
</tr>
</tbody>
</table>

AMC, amoxicillin/clavulanic acid; CRO, ceftriaxone; TZP, piperacillin–tazobactam; MEM, meropenem; FLR, fluoroquinolone; AK, aminocillin; GN, gentamicin; TET, tetracycline; CLF, chloramphenicol; IP, imipenem.
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commonly encountered form.\textsuperscript{11,23} Data accumulated from other studies show that Gram-positive bacteria were isolated from blood cultures at rates of 27 – 78%, and Gram-negative bacteria at rates of 20 – 64%, hence are consistent with the findings of the present study.\textsuperscript{13,14,23 – 28}

Until recently, CNS isolated from blood cultures were considered to be contaminants, however these bacteria are now accepted to be the causative agents in 1 – 56% of patients with sepsis.\textsuperscript{12,13,29 – 31} In the present study, CNS were found in 48.9% of positive cultures. The present study found a 15.8% detection rate of \textit{S. aureus}, well within the 2 – 43.6% range of rates reported elsewhere.\textsuperscript{12 - 14,22} Previous studies have reported that CNS with nosocomial origins were increased, and this is consistent with the present study.\textsuperscript{7,32,33} Some studies that are similar to the present study have declared that CNS with nosocomial origins were greatly increased.\textsuperscript{7,32,33} \textit{S. aureus}, CNS and Gram-negative bacilli were the most commonly detected organisms in blood cultures analysed in the present study, consistent with findings by Özyurt \textit{et al.}\textsuperscript{11} The percentage distribution rates of the microorganisms most frequently isolated from blood cultures in studies performed in Turkey and other countries are presented in Table 5.\textsuperscript{11 – 14,26,27,34 – 40}

It is generally accepted that a contamination rate of > 3% of total blood cultures in a study indicates a problem with the method. The contamination rate in the present study was 2.8% which lies within the accepted contamination value and is low in comparison with contamination rates of 1.21 – 13.6% reported by other studies.\textsuperscript{11,13,16,21,22}

Mortality from fungal infections in intensive care units is reported to be 38 – 75% and, in recent years, there has been an increase in the rates of fungal infections with nosocomial origins.\textsuperscript{41 – 43} Most of these involve \textit{Candida} spp, of which 48% of are \textit{Candida albicans}.\textsuperscript{41} Previous studies have reported that the detection rate of \textit{Candida} spp in blood cultures varies from 1.8% to 12.5%.\textsuperscript{11,13,14,27,35} The detection rate for \textit{Candida} spp in the present study was 2.0%. Lark \textit{et al.}\textsuperscript{44} found that infection rates with \textit{Candida} spp have the highest crude mortality rate (67%), followed by those due to \textit{E. coli} and CNS.

It has recently been reported that staphylococci have become more resistant to methicillin and oxacillin,\textsuperscript{22,30} and the present study found that resistance to oxacillin was 60% for \textit{S. aureus} and 68% for CNS. Methicillin-resistant \textit{S. aureus} detection rates of 0.6 – 43.0% have been reported in Sweden, Belgium, Greece, Ireland, the UK and Israel, and vancomycin resistant enterococcus detection rates of 0 – 21.2% have been reported for Switzerland and Ireland.\textsuperscript{45} Other studies have reported oxacillin resistance rates of 4 – 66% for \textit{S. aureus} and 55 – 86% for CNS.\textsuperscript{22,26 – 28,33,45,46} In a study by Dorobâţ \textit{et al.},\textsuperscript{46} \textit{S. aureus} resistance rates were 38.9% for gentamicin and 27.7% for ciprofloxacin and erythromycin.\textsuperscript{46} Various researchers have reported that resistance to vancomycin is 7 – 21% for \textit{S. aureus} strains\textsuperscript{26,47} and 1.4 – 11% for CNS.\textsuperscript{26,27} In contrast, some researchers have reported no resistance of CNS and \textit{S. aureus} strains to vancomycin in concordance with the findings of the present study.\textsuperscript{27,34,46} Similarly we found no resistance to vancomycin for staphylococci and enterococci. Some previous reports have also failed to show vancomycin resistance in enterococci,\textsuperscript{26,27,34} however two different studies reported vancomycin resistance rates to enterococci to be 6.1% and 0.4 – 10.3%.\textsuperscript{45,48}

The frequent administration of \textit{β}-lactam antibiotics, broad-spectrum cephalosporins and quinolones in hospitals creates an environment in which multi-drug resistant microorganisms can flourish.\textsuperscript{49} Gram-
**TABLE 5:** Distribution rates (%) of the microorganisms most frequently isolated from blood cultures in different studies performed in Turkey and across the world

<table>
<thead>
<tr>
<th>Microorganism</th>
<th>Köksal et al.(^1)</th>
<th>Gülsamast et al.(^1)</th>
<th>Yüce et al.(^1)</th>
<th>Mamishi et al.(^2)</th>
<th>Cornejo-Juárez et al.(^3)</th>
<th>Blahová et al.(^4)</th>
<th>Wu et al.(^5)</th>
<th>Klaerner et al.(^6)</th>
<th>Cockerill et al.(^7)</th>
<th>Pittet et al.(^8)</th>
<th>Valles et al.(^9)</th>
<th>Fluit et al.(^10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coagulase-negative staphylococci</td>
<td>–</td>
<td>–</td>
<td>49.6</td>
<td>9.2</td>
<td>48.4</td>
<td>12.7</td>
<td>19</td>
<td>16</td>
<td>35.7</td>
<td>9</td>
<td>18</td>
<td>24.4</td>
</tr>
<tr>
<td><em>Staphylococcus aureus</em></td>
<td>–</td>
<td>–</td>
<td>15.0</td>
<td>13.9</td>
<td>16.7</td>
<td>18.3</td>
<td>13</td>
<td>–</td>
<td>17.2</td>
<td>11</td>
<td>17.5</td>
<td>17.6</td>
</tr>
<tr>
<td><em>Escherichia coli</em></td>
<td>–</td>
<td>14</td>
<td>11.6</td>
<td>11.3</td>
<td>21</td>
<td>18.6</td>
<td>13.3</td>
<td>–</td>
<td>13.7</td>
<td>12.3</td>
<td>–</td>
<td>20</td>
</tr>
<tr>
<td><em>Streptococcus</em> spp</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>1.7</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><em>Enterococcus</em> spp</td>
<td>–</td>
<td>4</td>
<td>3.6</td>
<td>1.4</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>4.8</td>
<td>10</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><em>Candida</em> spp</td>
<td>5</td>
<td>–</td>
<td>1.8</td>
<td>12.5</td>
<td>–</td>
<td>–</td>
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<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><em>Klebsiella</em> pneumoniae</td>
<td>–</td>
<td>10</td>
<td>4.0</td>
<td>3.3</td>
<td>8.5</td>
<td>9</td>
<td>11.4</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>6.5</td>
</tr>
<tr>
<td><em>Salmonella</em> spp</td>
<td>–</td>
<td>2.2</td>
<td>–</td>
<td>4</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
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<tr>
<td><em>Enterobacter cloacae</em></td>
<td>–</td>
<td>–</td>
<td>1.2</td>
<td>0.7</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>17</td>
<td>–</td>
<td>–</td>
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</tr>
<tr>
<td><em>Acinetobacter baumannii</em></td>
<td>–</td>
<td>20</td>
<td>3.3</td>
<td>10.4</td>
<td>–</td>
<td>–</td>
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<td>–</td>
<td>–</td>
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</tr>
<tr>
<td><em>Serratia marcescens</em></td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>3.3</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>6.5</td>
<td>–</td>
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</table>
negative bacteria, which are highly resistant to broad-spectrum antibiotics, constitute one of the most important problems in therapeutic practice in Turkey and other countries. Many studies have, therefore, suggested that ampicillin, amoxicillin/clavulanic acid and cephalotin have become ineffective, particularly against Enterobacter spp and Klebsiella spp. Jones et al. reported that Enterobacter spp resistance rates to the β-lactam antibiotics ceftriaxone and piperacillin–tazobactam were 18.5% and 21.6%, respectively. Enterobacter spp have the highest susceptibility rates to gentamicin and ciprofloxacin. Köksal and Samasti reported resistance rates to amoxicillin/clavulanic acid in E. coli and Enterobacter–Klebsiella strains to be 32% and 72%, respectively.

Esel et al. reported that the susceptibility rates of E. coli and Klebsiella spp to amoxicillin/clavulanic acid were 69.2% and 55.9%, respectively, those of E. coli, Klebsiella spp and Acinetobacter spp to ciprofloxacin were 75%, 64.7% and 52.4%, respectively, and the susceptibility of Acinetobacter spp to imipenem was 57.1%. Susceptibility rates of E. coli to ceftriaxone were reported by several studies as follows: 50%, 86%, 62% and 98.6%. Moreover, Mamishi et al. reported that the susceptibility rates of Klebsiella spp and Enterobacter spp to ceftriaxone were 47% and 67%, respectively. In the present study, the susceptibility rate to ceftriaxone was 25% for Acinetobacter spp and E. coli was 25% and 72%, respectively. In the study by Findik et al., the susceptibility rates of E. coli strains were found to be 100% to meropenem, 91% to amikacin and 81% to ciprofloxacin. Köksal and Samasti reported similar rates of 100% to meropenem, 97% to amikacin and 82% to ciprofloxacin. Jones et al. reported a susceptibility of Klebsiella spp to ceftriaxone of 96.4%. In the present study, the most effective antibiotics against E. coli were meropenem (100%), amikacin (96%) and piperacillin/tazobactam (95%). The resistance rates of E. coli, Klebsiella spp and Acinetobacter spp to fluoroquinolone were 18%, 12% and 9%, respectively, suggesting that considerable care should be taken to avoid excessive administration of these antimicrobial agents.

In the treatment of these microorganisms, the present study found that carbapenems were the most effective.

While Yüce et al. found that resistance to carbapenem and amikacin was 2% for Acinetobacter spp, rates of 4% and 21% for meropenem and amikacin, respectively were found in the present study. A previous study by Dorobat et al. showed imipenem and ciprofloxacin as the most effective agents against Enterobacteriaceae (89.2%). Orrett and Changoor reported that ciprofloxacin and ceftriaxone were among the most effective agents against Klebsiella spp and Enterobacter spp.

Our current findings and those reported by other studies suggest that CNS are the most frequently isolated microorganisms isolated from blood cultures taken within a hospital setting. The isolation frequencies of S. aureus and Gram-negative bacteria vary and the antimicrobial susceptibility rates of CNS, S. aureus and Gram-negative bacteria vary. It is essential, therefore, that blood cultures which can assist clinicians in the diagnosis and treatment of infections should be performed routinely and that each hospital should be aware of the prevalence of pathogens in their setting. This should enable clinicians to develop rational treatment regimes, including administration of the most appropriate antibiotics.

Conflicts of interest
The authors had no conflicts of interest to declare in relation to this article.
Microorganisms isolated from blood cultures in a Turkish hospital

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52 Diekema DJ, Pfaffer MA, Jones RN, et al: Survey of bloodstream infections due to gram-negative...


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