Incidence, microbiological profile of nosocomial infections, and their antibiotic resistance patterns in a high volume Cardiac Surgical Intensive Care Unit

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ABSTRACT

Background: Nosocomial infections (NIs) in the postoperative period not only increase morbidity and mortality, but also impose a significant economic burden on the health care infrastructure. This retrospective study was undertaken to (a) evaluate the incidence, characteristics, risk factors and outcomes of NIs and (b) identify common microorganisms responsible for infection and their antibiotic resistance profile in our Cardiac Surgical Intensive Care Unit (CSICU). Patients and Methods: After ethics committee approval, the CSICU records of all patients who underwent cardiovascular surgery between January 2013 and December 2014 were reviewed retrospectively. The incidence of NI, distribution of NI sites, types of microorganisms and their antibiotic resistance, length of CSICU stay, and patient-outcome were determined. Results: Three hundred and nineteen of 6864 patients (4.6%) developed NI after cardiac surgery. Lower respiratory tract infections (LRTIs) accounted for most of the infections (44.2%) followed by surgical-site infection (SSI, 11.6%), bloodstream infection (BSI, 7.5%), urinary tract infection (UTI, 6.9%) and infections from combined sources (29.8%). Acinetobacter, Klebsiella, Escherichia coli, and Staphylococcus were the most frequent pathogens isolated in patients with LRTI, BSI, UTI, and SSI, respectively. The Gram-negative bacteria isolated from different sources were found to be highly resistant to commonly used antibiotics. Conclusion: The incidence of NI and sepsis-related mortality, in our CSICU, was 4.6% and 1.9%, respectively. Lower respiratory tract was the most common site of infection and Gram-negative bacilli, the most common pathogens after cardiac surgery. Antibiotic resistance was maximum with Acinetobacter spp.

Key words: Cardiac Surgical Intensive Care Unit; Microbiological profile and antibiotic resistance patterns; Nosocomial infection

INTRODUCTION

The Center for Disease Control and Prevention has defined nosocomial infection (NI) as a localized or systemic condition resulting from an adverse reaction to the presence of an infectious agent(s) or its toxins, without any evidence that the infection was present or incubating at the time of admission to the Intensive Care Unit (ICU). NIs are more common in patients admitted in the surgical ICU because of immobility, surgical incisions, multiple invasive monitoring lines, urinary tract infections, and the presence of invasive lines.
catheters, and mechanical ventilation. In Cardiac Surgical Intensive Care Unit (CSICU), in addition to the aforementioned issues, there are intercostal drainage tubes, long duration surgeries, hypothermia, poor nutrition, cardiac cachexia, and patients undergoing open chest management which increases the susceptibility of these patients for infections. NIs in the postoperative period not only increase morbidity and mortality, but also impose a significant economic burden on the health care infrastructure. The other factors which can prolong the stay in CSICU, and predispose the patients for NI are low cardiac output syndrome, acute kidney injury, need for increased inotropic support, need for renal replacement therapy, coagulopathies, neurological injury, and cardiopulmonary bypass (CPB) induced systemic inflammatory response. On the basis of perioperative risk factors many models have been formulated to predict the occurrence of NI after cardiac surgery.

The data on the incidence of NI among the CSICUs and the organism profiles together with the antibiotic resistance details in developing setups is scanty, more so from surgical ICUs. Such information is useful for medical audit as well as planning for preventive/corrective measures. We analyzed the incidence, risk factors, common sites, the pathogens responsible for NI and their antibiotic susceptibility profile in our cohort of cardiac surgical patients in a large CSICU.

PATIENTS AND METHODS

Study design, setting
This retrospective study was conducted in the CSICU of Cardiothoracic Vascular Surgery Department of the All India Institute of Medical Sciences, New Delhi. The CSICU has 42 beds including 8 for neonates.

Patient selection
All (neonates, infants, pediatric, and adult) patients admitted to the CSICU after elective cardiovascular surgery from January 2013 to December 2014 were studied. Detailed information was obtained from the records of all patients who developed microbiologically documented NI. In addition for comparative purposes, data on admitted patients who did not develop NI was collected for a 2-month period from November to December 2014. This was done mainly due to the consideration that data on patients admitted during a 2-month period in a high output center like ours would give enough statistical power for any comparison between infected and non-infected groups. Demographic data, intra- and post-operative information, time, and source and number of samples sent for microbiological investigations were collected. Patients with preoperative infection, on ventilator, on antibiotics before surgery, emergency operations, heart transplant recipients, and patients received on extracorporeal membrane oxygenator were excluded. Patients were categorized into valvular (valve repair/replacements), nonvalvular (coronary artery bypass grafting, aortic aneurysms, and dissections), cyanotic (all right to left shunts and univentricular hearts), acyanotic (all left to right shunts), and miscellaneous (all closed heart surgeries including patent ductus arteriosus ligation, coarctation of aorta repair, pericardiectomy, etc.).

Infection classification
NIs: Infections developed within 48 h of shifting the patients from ICU to the wards or patients who were readmitted to the ICU for infection before their hospital discharge. All infections were diagnosed on the basis of clinical suspiciousness, radiological information and were confirmed by biochemical criteria like positive cultures from different body secretions. Major infections such as lower respiratory infections (LRTIs), wound/surgical-site infections (SSIs), blood stream infections (BSIs), and urinary tract infections (UTIs) were defined as follows - LRTIs-infections involving lower respiratory tract including bronchitis, pneumonitis, and pneumonia; SSI-nonhealing wound with or without discharge involving the sternal wound and/or leg or arm (sites of graft harvesting) and culture proven pathogens from the discharge; BSI-culture proven pathogens in blood, sampled from one central, and one peripheral site; UTI – more than $10^5$ colony forming bacterial units on culture.

All biological samples were collected and sent to the microbiology laboratory as per the standard procedures. The data on the positive culture reports from different sites, the microorganisms isolated and their susceptibility to commonly used antibiotics were collected from the microbiology reports.

Clinical antibiotic protocol
All patients in the postoperative CSICU were treated with antibiotics as per the standard protocol of the unit. Those were changed to the next level of broad spectrum antibiotics in case of suspiciousness of infection and/or according to the antimicrobial susceptibility results when available.
Approval was obtained from the medical research ethics committee of the hospital.

Data analysis
The overall incidence risk of NI was calculated along with 95% confidence interval (CI). Ventilation duration, length of ICU stay, and the mortality in the two groups with and without infection were compared using Student’s t-test/Chi-square test as appropriate. A \( P < 0.05 \) was considered to be statistically significant. Analysis carried out using STATA version 12.1 (STATA corporation, Texas, USA).

RESULTS
During the period January 2013 to December 2014, a total of 7156 patients were admitted to the CSICU, out of which 6864 patients met the inclusion criteria. Review of the records of study patients indicated that NI was detected in 319 patients. Thus, the overall incidence of NI was 4.6% (95% CI: 4.2%–5.2%) during the study period. Medical data of all the 319 infected patients during the 2-year period along with the data of a comparable control pool of 572 patients during a 2-month period were analyzed. Age of the study patients varied from 1 month to 84 years. Majority (69%) were males.

Of the total 6864 patients during the 2-year period, 457 died giving an all-cause mortality during the study period as 6.7% (95% CI: 6.1–7.3%) while the mortality due to sepsis was 1.9% (95% CI: 1.5–2.2%). More than one-third (39.8%) of the patients acquiring NI died (95% CI: 34.4–45.4%) while the mortality among patients without NI was 5.0% (95% CI: 4.5–5.6%). The mortality risks were statistically significantly different between the groups with and without NI (\( P < 0.001 \)).

Comparison of the patients with and without NI indicated that the duration of ventilation (14.8 ± 13.4 vs. 12.1 ± 14.1 h, \( P < 0.001 \)) and also the length of ICU stay (13.6 ± 18.5 vs. 3.3 ± 3.1 days, \( P < 0.001 \)) were significantly higher among the infected patients than noninfected patients. Infants (<1 year of age) and patients with cyanotic heart disease were more prone to NI. CPB time was also found to be significantly higher in the infected patients but the aortic cross clamp time was not statistically different between the two groups [Table 1].

Of the 319 patients who acquired NIs, only one microorganism was detected in 228 (71%) patients, two in 71 (22%), three in 16 (5%), and four organisms in four (1%) of patients. In all, 319 patients acquired a total of 434 infections.

LRTI was the most common among all infections, occurring in 141 (44.2%) of the 319 infected patients followed by SSI in 37 (11.6%), BSI in 24 (7.5%), and UTI in 22 (6.9%) patients [Figure 1]. In the rest 95 patients (29.8%), pathogens were isolated from other sources such as tissues/vegetations, chest drainage, central venous catheter tips, and/or multiple (>1 site) sources. There was considerable variation in the isolated organisms from different sources. The most commonly detected organisms from respiratory secretions were Gram-negative bacteria such as Acinetobacter, Klebsiella, and Pseudomonas. Similarly, Escherichia coli was maximally grown from urine, whereas wound discharge/pus samples yielded mainly the Gram-positive Staphylococci. Klebsiella and Pseudomonas were the leading Gram-negative bacteria isolated from blood cultures. Figures 2 and 3 depict the distribution of various organisms detected from each type of sample for the total 319 patients with NIs.

### Table 1: Distribution of study characteristics between patients with and without nosocomial infections

| Characteristic                  | Infected (n=319) | Non-infected (n=572) | \( P \) |
|--------------------------------|-----------------|----------------------|---------|
| Age (years)                    |                 |                      |         |
| Mean±SD                        | 20.0±25.43      | 25.0±22.68           | <0.01   |
| <1 year                        | 41.8            | 12.8                 | <0.001  |
| 1-5                            | 11.9            | 15.3                 |         |
| 5-15                           | 4.4             | 16.8                 |         |
| 15-40                          | 16.0            | 25.6                 |         |
| 40-60                          | 12.9            | 17.5                 |         |
| >60                            | 12.9            | 11.9                 |         |
| CPB time* (min)                | 109.2±38.76     | 97.5±49.25           | <0.001  |
| Aortic clamp time* (min)       | 60.0±22.82      | 60.7±32.02           | 0.77    |
| Ventilation (h)                | 14.8±13.38      | 12.1±14.08           | <0.001  |
| ICU stay (days)                | 13.6±18.52      | 3.3±3.05             | <0.001  |
| Patient category               |                 |                      |         |
| Nonvalvular                    | 18.8            | 17.1                 | <0.001  |
| Valvular                       | 17.2            | 28.2                 |         |
| Cyanotic                       | 38.2            | 25.2                 |         |
| Acyanotic                      | 21.0            | 26.2                 |         |
| Miscellaneous                  | 4.7             | 3.3                  |         |
| Cyanotic                       | 38.2            | 25.2                 |         |
| Other                          | 61.8            | 74.8                 | <0.001  |

*Excluding surgeries without ACC, **Based on surgeries with CPB, Nonvalvular: CABG, Aortic aneurysms and dissections, Valvular: All valve repairs and replacements, Cyanotic: All right to left shunts and univentricular hearts, Acyanotic: All left to right shunts, Miscellaneous: All closed heart surgeries like PDA ligation, Coarctation repair and pericardectomy, etc. ACC: Aortic cross clamp, CPB: Cardiopulmonary bypass, ICU: Intensive Care Unit, PDA: Patent ductus arteriosus, CABG: Coronary artery bypass grafting.
Antibiotic resistance patterns for the isolated microorganisms are shown in Table 2 and Figure 4.

**DISCUSSION**

In the present study, we observed NI incidence of 4.6% among patients undergoing cardiac surgery during a 2-year period. This is lower than that observed 6–31% in other series[4–9] of postoperative cardiac surgical patients. The Fowler et al. study[3] found that major infections occurred in 3.51% of coronary bypass patients. Our incidence is almost similar to a study by Michalopoulos et al.[10] where the microbiologically documented NI occurred in 107 of the 2122 (5.0%) adult patients undergoing open heart surgery. One of the largest studies comprising of both surgical and medical patients (European Prevalence of Infection in Intensive Care [EPIC] study) conducted across Europe documented an infection risk of 20.6%.[11]

We observed a sepsis-related mortality rate as 1.9% and mortality among infected patients was 39.8%. Michalopoulos et al.[10] and Fowler et al.[3] documented mortality of 16.8% and 17.9%, respectively, in adult cardiac surgical patients having NI. Kelava et al.[9] documented a mortality rate of 1.5% for same day admission group of patients which is very much similar to our mortality risk.

In our study, LRTI was found to be the most common NI (44.2%) followed by SSI (11.6%), BSI (7.5%), and UTI (6.9%). The distribution of NI was more or less similar to that of Michalopoulos et al.[10] (respiratory infections 42% followed by central venous catheter-related infection 22.4%, SSI 16.8%, and UTI 7.5%). In the study conducted by Lola et al.,[7] BSI accounted for 30%, SSI for 26.7%, and LRTI for 13.3%. The predominance of respiratory tract infections is similar to the studies based on medical ICUs like EPIC II study (63.5%),[12] Chinese study (68.5%),[13] and Indian study (65.8%).[14] In our study, we found very small number of infections related to the central venous catheter (<1%) contrary to that of other studies.

![Figure 1: Depicts the source of infection in number of cases with percentage](image1)

![Figure 2: Depicts the causative microorganisms responsible for nosocomial infection and their frequency](image2)

![Figure 3: Causative microorganisms isolated from different sources](image3)

![Figure 4: Antimicrobial resistance pattern among different microbes](image4)
Table 2: Antibiotic resistance profile n (%) of microorganisms

| Drug               | Acinetobacter Resistant (%) 95% CI | Klebsiella Resistant (%) 95% CI | Pseudomonas Resistant (%) 95% CI | Escherichia coli Resistant (%) 95% CI | Enterobacter Resistant (%) 95% CI | Staphylococcus Resistant (%) 95% CI |
|--------------------|------------------------------------|---------------------------------|-----------------------------------|----------------------------------------|----------------------------------|-----------------------------------|
| Colistin           | 23/126 (18.3) (11.4-25.1)          | 3/71 (4) (0.5-9)                | 1/48 (2) (2-6)                    | 9/32 (28) (11-44)                     | 4/33 (12) (0.3-23)                | 0/9 (0)                           |
| Tigecycline        | 68/106 (64.2) (54-73)              | 3/29 (10) (1-22)                | 1/14 (7) (8-22)                   | 3/12 (25) (3-53)                      | 3/15 (20) (2-42)                  | 3/8 (37) (0-80)                   |
| Amikacin           | 98/121 (81.0) (73-88)              | 54/63 (86) (76-94)              | 38/45 (84) (73-95)                | 26/43 (60) (45-75)                    | 22/33 (66) (49-83)                | 13/37 (35) (18-51)                |
| Netilimicin        | 126/134 (94.0) (89-98)             | 69/73 (95) (89-99)              | 32/38 (84) (72-96)                | 40/47 (85) (74-95)                    | 30/34 (88) (76-99)                | 39/46 (85) (73-95)                |
| Ciprofloxacin      | 125/128 (97.7) (94-100)            | 70/76 (92) (85-98)              | 48/50 (96) (90-100)               | 48/52 (92) (84-99)                    | 31/38 (82) (68-94)                | 42/46 (91) (82-99)                |
| Levofoxacin        | -                                  | -                               | 19/22 (86) (70-100)               | 30/32 (94) (84-102)                   | 10/18 (55) (30-80)                | 3/4 (75) (0-100)                  |
| Ceftazidime        | 136/136 (100.0) (-)                | 78/78 (100) (-)                 | 53/53 (100) (-)                   | 53/53 (100) (-)                      | 38/38 (100) (-)                   | 17/17 (100) (-)                   |
| Cefotaxime         | 135/135 (100.0) (-)                | 77/77 (100) (-)                 | 33/33 (100) (-)                   | 51/51 (100) (-)                      | 37/37 (100) (-)                   | 17/17 (100) (-)                   |
| Ceferopazone-sulbactam | 70/98 (71.4) (62-80)               | 53/62 (85) (76-94)              | 22/51 (43) (29-57)                | 33/43 (77) (63-89)                    | 22/30 (73) (56-90)                | 8/14 (57) (27-86)                 |
| Piperacillin-tazobactum | 73/116 (62.9) (54-71)             | 56/73 (77) (66-86)              | 15/41 (36) (21-51)                | 25/48 (52) (37-66)                    | 24/37 (65) (48-81)                | 9/11 (82) (54-108)                |
| Imipenem           | 118/137 (86.1) (80-91)             | 68/75 (90) (83-97)              | 53/55 (96) (91-100)               | 46/54 (85) (75-94)                    | 37/38 (97) (92-102)               | 20/20 (100) (-)                   |
| Meropenem          | 104/127 (81.9) (75-88)             | 62/7 (86) (77-94)               | 43/51 (84) (73-94)                | 37/51 (72) (59-85)                    | 29/35 (83) (69-95)                | 20/22 (90) (77-103)               |
| Nitrofurantoin     | -                                  | -                               | 31/32 (97) (90-100)               | 8/10 (80) (49-110)                    | 4/4 (100) (-)                     | -                                 |
| Amoxicillin-clavulinic acid | 119/121 (98.4) (96-100)            | 15/15 (100) (-)                 | 24/25 (96) (87-104)               | 47/49 (96) (90-101)                   | 26/27 (96) (88-103)               | 17/39 (43) (27-59)                |
| Vancomycin         | -                                  | -                               | -                                 | -                                     | -                                 | 0/12 (0)                          |
| Teicoplanin        | -                                  | -                               | -                                 | -                                     | -                                 | 1/31 (3) (0-9)                    |
| Linezolid          | -                                  | -                               | -                                 | -                                     | -                                 | 21/27 (77) (61-94)                |
Our study documented a predominance of Gram-negative organisms in nosocomial ICU infections. Lola et al. demonstrated equal frequencies of Gram-positive cocci and Gram-negative bacilli from the culture results, whereas Gram-positive organisms were noted predominantly in Michalopoulos et al. study. Our profile was similar to what has been observed in the EPIC study and the EPIC II study.

In the present study, the most frequently isolated pathogens were Acinetobacter (32%) and Klebsiella (19%). Staphylococcus (60.6%) and Enterobacter species (10%) were the most common pathogens in the US report by Michalopoulos et al. Acinetobacter was responsible for most LRTI (81%) in our cohort of patients whereas it was completely absent in the study by Michalopoulos et al. Acinetobacter (26.7%) was found to be a most common Gram-negative pathogen in the cohort of patients studied by Lola et al. the same was observed in our study. Klebsiella was responsible for most of the BSIs (29%), and Staphylococcus was the most common pathogen for SSI (58%) in the present study [Figure 2] whereas Michalopoulos et al. demonstrated that bacteremia was caused by Gram-positive organisms like Staphylococci and Gram-negative organisms like Klebsiella were responsible for LRTI. E. coli was the most common bacterial cause of nosocomial UTI in our study [37%, Figure 2] which was similar to that observed in other medical ICU in India and China.

The most common isolated Acinetobacter was found to be multidrug resistant with 86% resistance to imipenem, 62% resistance to piperacillin-tazobactam, and 18% resistance to colistin. Multidrug-resistant Acinetobacter isolates varying between 62% and 70% have been reported in other studies. This Gram-negative bacterium was posing a major hurdle in our ICU as it was becoming very difficult to treat.

In the present study, E. coli was resistant to most of the commonly used antibiotics such as amoxicillin-clavulanate (96%), amikacin (60%), ciprofloxacin (92%), and cefotaxime (100%). In the Chinese study, 22.2% of E. coli isolates were sensitive to the combination of amoxicillin-clavulanate, whereas 78.8% of E. coli isolates exhibited susceptibility to the combination in EPIC II study. In addition, there was a high proportion (80%) of E. coli isolates resistant to ciprofloxacin, whereas the rate was <10% in the UK and the United States. This shows that E. coli in our setup are far more resistant to antibiotics as compared to other countries. We also found that a considerable number of Pseudomonas aeruginosa isolates were resistant to fluoroquinolones (96% to ciprofloxacin and 86% to levofloxacin) which is much higher compared to Chinese (41.3–66.9%) and the USA (30%) reports. Staphylococcus was found to be resistant to amoxicillin + clavulanate combination in 43% cases and to linezolid in 77% cases but was highly sensitive to vancomycin (same was observed by Ding et al.).

The risk of NI in the present study was comparatively less, probably because our CSICU being in the apex institute of the country follows good hand hygiene practices by the staff and doctors, stringent aseptic precautions, streamlined antibiotic policies, and infection control guidelines. A low rate of central venous catheter-related infection reflects a good aseptic care during insertion, handling in ICU, and their early removal. The high rate of LRTI in our ICU was because of risk factors such as long CPB time, longer duration of ventilation, and length of ICU stay. Moreover, our inclusion of all age group of patients in the study probably had an impact on the high rate of LRTI. NI was more common in neonates and infants having cyanotic congenital heart disease. Statistically significant difference in the CPB time and ventilation duration was observed between the groups with and without infection. There was also statistically significant increase in ICU stay and mortality in patients with NI compared to those without infection. Reduced duration of ICU stay in the uninfected group suggests the possibility of considerable savings in the hospital turnaround time, which can be used for increased services. The high mortality among the patients acquiring NI may or may not be directly due to the NIs, as it might depend on many other factors such as the underlying condition of the patient and other concomitant conditions/co-morbidities. Further specific studies on this aspect can answer whether NIs, per se, can be the cause for mortality in patients undergoing cardiac surgeries, if so their magnitude, etc. The high prevalence of antibiotic resistance is of great concern for both the clinicians and the patients, which suggests the need for appropriate antibiotic policies for prescription, procurement, and usage.
Limitations of the study
The results of the present study were based on all cases with NIIs during a 2-year period, but for comparison the cases without infections during a 2-month period only were taken. In view of this, limitations arising out of such comparison, if any, will be applicable for our results too.

CONCLUSION
We report the burden, characteristics of microbial flora, and resistance patterns of NIIs in a postoperative cardiac surgical facility in the apex medical institute of India. Literature review did not indicate such a comprehensive attempt in any cardiac surgical ICU. The overall incidence of NI was 4.6% with a notably high mortality among the infected patients. LRT was found to be the most common site for NI and Acinetobacter was the most commonly detected organism, with high resistance. The outcome of cardiac surgery with NI might deteriorate further because of the fast emerging multidrug resistant pathogens (particularly the Gram-negative bacteria).

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Conflicts of interest
There are no conflicts of interest.

REFERENCES
1. Garner JS, Jarvis WR, Emori TG, Horan TC, Hughes JM. CDC definitions for nosocomial infections, 1988. Am J Infect Control 1988;16:128-40.
2. Brown PP, Kugelmass AD, Cohen DJ, Reynolds MR, Culler SD, Dee AD, et al. The frequency and cost of complications associated with coronary artery bypass grafting surgery: Results from the United States medicare program. Ann Thorac Surg 2008;85:1980-6.
3. Fowler VG Jr., O'Brien SM, Muhlbaier LH, Corey GR, Ferguson TB, Peterson ED. Clinical predictors of major infections after cardiac surgery. Circulation 2005;112:666-75.
4. Lex DJ, Tóth R, Cserép Z, Breuer T, Sápi E, Szatmári A, et al. Microbiologically documented nosocomial infections after cardiac surgery. J Thorac Cardiovasc Surg 2014;148:1615-1621.e3.
5. Michalopoulos A, Geroulanos S, Rosmarakis ES, Falagas ME. Frequency, characteristics, and predictors of nosocomial infections in a tertiary level intensive care unit in north northern India: Epidemiology, clinical profiles and outcomes. J Assoc Physicians India 2014;62:18-21.
6. Martin CD, et al. International study of the prevalence and outcomes of infection in intensive care units. JAMA 2009;302:2323-9.
7. Ding JG, Sun QF, Li KC, Zheng MH, Miao XH, Ni W, et al. Retrospective analysis of nosocomial infections in the intensive care unit of a tertiary hospital in China during 2003 and 2007. BMC Infect Dis 2009;9:115.
8. Braden NP, Bhat SM, Ghadge DP. Nosocomial infections in the medical ICU: A retrospective study highlighting their prevalence, microbiological profile and impact on ICU stay and mortality. J Assoc Physicians India 2014;62:18-21.
9. Lex DJ, Tóth R, Cserép Z, Breuer T, Sápi E, Szatmári A, et al. Postoperative differences between colonization and infection after pediatric cardiac surgery—a propensity matched analysis. J Cardiothorac Surg 2013;8:166.
10. Mathai AS, Oberoi A, Madhavan S, Kaur P. Acinetobacter baumannii infections in a tertiary level intensive care unit in northern India: Epidemiology, clinical profiles and outcomes. J Infect Public Health 2012;5:145-52.
11. Bacakoglu F, Korkmaz Ekren P, Tasbakan MS, Basarik B, Pullukçu H, Aydemir S, et al. Multidrug-resistant Acinetobacter baumannii infection in respiratory intensive care unit. Mikrobiyol Bul 2009;43:575-85.
12. Bean DC, Krahe D, Wareham DW. Antimicrobial resistance in community and nosocomial Escherichia coli urinary tract isolates, London 2005-2006. Ann Clin Microbiol Antimicrob 2008;7:13.
13. Peterson JL, Rello J, Marshall J, Silva E, Anzueto A, Martin CD, et al. International study of the prevalence and outcomes of infection in intensive care units. JAMA 2003;302:2323-9.
14. Koleff MH, Sharpless L, Vlasnik J, Pasque C, Murphy D, Fraser VJ. The impact of nosocomial infections on patient outcomes following cardiac surgery. Chest 1997;112:666-75.
15. Xia J, Qi T, Li TL, Li J, Ren Q, et al. Nosocomial infections after cardiac surgery in infants: Incidence and risk factors. J Hosp Infect 2013;83:198-203.
16. Diogo FP, Diogo JF, Diogo JP. Antimicrobial resistance in urinary tract infection: A systematic review of observational studies. Clin Microbiol Infect 2011;17(Suppl 5):1-15.
17. Sahu, et al.: Nosocomial infections in cardiac surgical intensive care unit