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THE INCIDENCE OF NOSOCOMIAL URINARY TRACT INFECTIONS: KENYATTA NATIONAL HOSPITAL - INTENSIVE CARE UNIT

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Abstract

Urinary tract infections (UTIs) are the most common nosocomial infections in both acute care settings and long-term care facilities. Each year millions of urethral catheters are put in place in these facilities across the United States. In the acute care settings a vast majority of UTIs occur in patients with temporary urinary catheters. Nosocomial catheter-associated urinary tract infections (NCAUTIs) have been one of the major problems in the Intensive care unit (ICU) and have contributed to the mortality and morbidity of the patients. Efforts to contain the problem have resulted in the introduction of guidelines to reduce the incidence and prevalence of the nosocomial UTI. Such measures have been implemented in the developed world; unfortunately the developing countries have not duplicated the same. This was a descriptive cross-sectional study. Urine samples were collected and analyzed in the laboratory for growth of microorganisms to determine the incidence of NCAUTIs. The findings of the study indicate that the Incidence of NCAUTI was determined to be **18%** with the common isolated microorganism being Escherichia coli. It recommended that there was need for judicious use of antibiotics to prevent drug resistance and that a procedure and policy on the management of a patient with a urinary catheter should be developed and made available for use in the ICU.

Key Words: incidence, nosocomial infections, catheter associated UTI, ICU

Introduction

Hospital acquired infections (nosocomial infections), urinary tract infections in particular, continue to complicate the clinical course of critically ill patients and consequently, to create substantial economic and human costs (Tasota et al., 1998; Leone et al., 2004). Although nurses are aware of infection control measures, inconsistent application of these measures continue to occur. Inadequate infection control practices by health care personnel, is of particular concern because, one third of nosocomial infections are preventable (Tasota et al., 1998). These nosocomial infections are caused by various microorganisms.

Nosocomial UTIs can be a source of 10% to 15% of nosocomial bloodstream infections. In 1992 the CDC estimated that more than 900,000 nosocomial UTIs occurred in the United States and as many as 35,000 cases of bacteremia secondary to nosocomial catheter-associated UTIs occur annually. Even though the crude fatality rate was estimated to exceed 30%, the mortality rate attributed specifically to bacteremic UTI in one large retrospective study was 12.7%. According to this estimate attributable to mortality, as many as 4,500 deaths occur in the USA from nosocomial UTIs but most of these deaths may occur in patients with serious underlying disease process (Burke &Yeo, 2004).

It has been observed that these urinary catheters are associated with a number of complications such as urinary tract infections, which account for 40% of all hospital acquired infections (Burke & Yeo, 2004). Therefore, the aim of this study was to determine the incidence of nosocomial catheter-associated urinary tract infection in the ICU and also find out the microorganisms commonly isolated as causative organisms for nosocomial catheter-associated urinary tract infections at Kenyatta National Hospital's Intensive care unit.

Materials and Methods

Study Area

The study was conducted at the Kenyatta National and Referral Hospital's Intensive care Unit. Kenyatta National Hospital (KNH) is the largest hospital in Kenya. It is situated about 3kms from Nairobi city centre. It is built on approximately 304 acres of land.

The average bed occupancy rate is 94% but in medical, orthopedic and pediatric wards the rate goes to 210%. (Micheni, J., 2004)

KNH has the largest critical care unit with a capacity of 20 beds. It is multidisciplinary and admits patients of all ages. The major reason for admission in ICU arises from severe injuries as a result of mainly road traffic accidents and assaults. The average monthly admission is at 104 patients (ICU and HDU Admission records), with a mortality rate close to 40% of the total admission in the last six months of 2005 (ICU/HDU mortality meeting).

Study Population

All patients admitted to the ICU and passed the inclusion criteria were recruited in the study. There were 104 patients admitted on average every month (ICU/HDU admission records).

Study Design

This was a cross-sectional descriptive, that is, a study that aims to describe the relationship between diseases (or other health-related states) and other factors of interest as they exist in a specified population at a particular time, without regard for what may have preceded or precipitated the health status found at the time of the study

Selection of Study Subjects

i) Sample size

The number of patients to be recruited in the study was determined using Fisher's formula :

$$n = \frac{(z)2\, p(1 - p)}{d2}$$

where n = Required sample size

z = Standard Normal Deviate at 95% level of confidence (=1.96)

p = Estimated prevalence of NCAUTIs (p= 9.6%) (Leone et al 2003)

d = Degree of precision set at +5%. (Fisher et al., 1993)

Substituting the values in the above formula, a sample size of 133 patients was to be recruited. Due to the high turnover rate of patients due to discharge or mortality and also the time period of the study, a sample size of 90 patients, which was 68% of the calculated sample size was achieved and was analyzed in this study.

ii) Sampling method

The patients were recruited consecutively in the study given that they were not many and considering the critical nature of the patients whereby most of them died, were discharged a few hours after admission or did not pass the inclusion criteria. This was done continuously for a period of three months.

Inclusion and Exclusion Criteria

a) Inclusion criteria

- Patients who consented to participation
- Patients with indwelling urinary catheters introduced at admission or within the first 12 hours of admission
- Patients not catheterized upon admission but later in the course of their hospitalization are catheterized

b) Exclusion criteria

- Patients who or whose relatives declined to sign consent
- Already catheterized patients referred to the ICU
- Those with positive cultures in the first sample collected
- Those already diagnosed with a urinary tract infection at admission

Data Collection

The data collection instrument was a laboratory culture tool for recording information about each of the patients.

Data Collection Method

The patient's urine samples were collected as per the procedure below. This was carried out by the principle investigator after obtaining informed consent from the patients or the next of kin.

Sample collection, transport and storage

Two urine specimens were taken from one hundred and thirty-three (133) patients with indwelling urinary catheters admitted to the ICU. First and second urine specimens were taken within the first twelve (12) hours and seventy-two (72) hours of a patient's admission. The area was cleared of all items and a sterile towel lay down on the patient. Afterwards the investigator gowned and put on sterile gloves and after disinfecting the rubber catheter collecting port using a gauge 23 sterile needle and 10ml syringe, collected the urine sample. The sample was transferred into a universal bottle and coded.

The sample was then transferred to the laboratory and analyzed within the first two hours of collection.

In cases where it was not possible to undertake any tests immediately the specimens were refrigerated at 2-40 C (in order to minimize the multiplication of organisms in the sample) until they were inoculated and processed.

The findings were entered on a form. The cultures were identified by standard microbiology techniques . Antibiotic sensitivity was performed on all isolates by NCCLS protocol.

The urine sample collection was an ongoing activity for a period of three months, until the targeted sample size was achieved.

Pre-testing of the Study Tool

The study tool was pre-tested at Mater Hospital's ICU, for correction and appropriateness. After the pre-test, necessary adjustment were effected on the tools for their effectiveness and efficiency for data collection.

Data Processing and Analysis

The data collected was cleaned, coded and prepared for analysis, which was done by use of computer software Statistical Package for Social Scientists (SPSS) version 11.5 and Epi/Info. Epi/info was used for calculating odds ratio (a measure of the strength of association). A biostatistician was involved at various stages as need arose for authentication and credibility of the analysis process.

Dissemination of Results

The information from the interpreted data was prepared for presentation in the School of Nursing (U.o.N) and Kenyatta National and Referral Hospital's ICU.

Ethical Considerations

The proposal was forwarded to the KNH Research and Ethical committee for review and approval in order to carry out the study at the institution.

Confidentiality of the responses was emphasized all through. The findings of the study were made available to the participating departments.

Consent for participation was sought from the patients selected for the study and where this was not possible (for example in the cases of unconscious patients), from their relatives or the Nursing officer in charge of the unit. The patients under the age of 18 years admitted in the unit, informed consent was obtained from the parent or the guardian whose name appears in the official documents for the patient, at the hospital. The respondents were informed of the benefits and the implications of the study

Permission was also sought from the directors of clinical services to authorize the study to be conducted at the KNH's ICU and Mater Hospital.

Results

One hundred and eighty (180) urine samples were collected from the ninety patients recruited in the study. Two samples were collected from each patient.

Socio-demographic characteristics

There were 241 admissions to the ICU/ HDU during the three months of data collection of which 90 patients were recruited in this study, 49(54.4%) were males and 41 (45.6%) females (Table 1).

The oldest patient recruited in the study was 85 years while the youngest was a nine months old baby, mean age of 34 years (SD= 21.26).

Most of the patients, 18 (20%), were in the 21 – 30 age group. 11 (12.2%) patients were more than sixty years and 12 (13.3%) were less than ten years.

All the patients required mechanical ventilation for respiratory support on admission. During this period, the ICU mortality was estimated at 40.6%, the average bed occupancy was 100% and the Median duration of hospitalization was 5.48 days.

Table 1
Social Demographic Factors of the Patient

Characteristics	Frequency n	Percentage %
Gender		
Male	49	54.4
Female	41	45.6
Total	**90**	**100**
Age Distribution in years		
< 10	12	13.3
11 – 20	14	15.3
21 – 30	18	20.0
31 – 40	15	16.7
41 – 50	11	12.2
51 – 60	9	10.0
> 60	11	12.2
Total	**90**	**100**

Diagnosis Upon ICU Admission

Table 2 illustrates that, a majority of the patients, thirty five (35) representing 38.9%, had a working medical diagnosis of severe head injury, followed by those with cardiovascular disorders, metabolic disorders, obstetric emergencies, burns, motor neuropathy and gastrointestinal disorders respectively. All the patients required mechanical ventilation for respiratory support on admission.

Table 2
The Diagnosis upon ICU Admission

Characteristic	**Frequency** n	**Percentage** %
Diagnosis on ICU admission		
Severe Head Injury	35	38.9
Cardiovascular disorder	20	22.2
Metabolic Disorder	8	8.9
Obstetric Emergencies	8	8.9
Burns	7	7.8
Motor Neuropathy	7	7.8
Gastro intestinal Disorder	5	5.6
Total	**90**	**100**

Drugs Patient was Commenced on Upon ICU Admission

Figure 1 illustrates the distribution of antibiotics the ninety patients were on upon

collection of the urine samples; a majority of them were on antimicrobial therapy (91%), and/ or prescribed in combination with steroid therapy (9%).

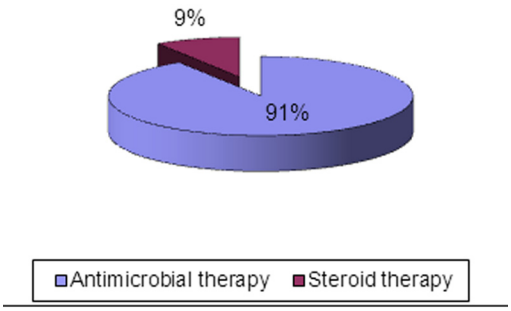

Figure 1
Drugs Prescribed upon Sample Collection

Duration of Catheter Stay

Figure 2 illustrates the duration of catheter stay of a majority of the recruited study subjects was 3 - 5 days (56%). Twenty six patients (28.9%) had their temporary catheters in situ for more than seven days.

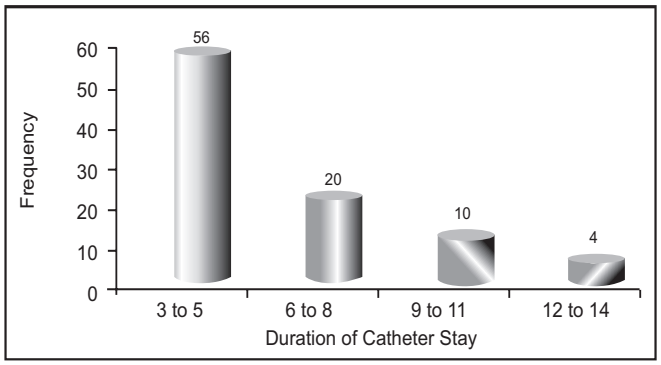

Figure 2
Duration of Catheter Stay
Mean stay = 5.48 days, SD = 2.877, Range (Maximum = 14, Minimum = 3)

Incidence of Microorganisms Isolated

Figure 3 below illustrates the Incidence of culture positive growth of microorganisms after three days of catheterization with a temporary indwelling catheter. 16 (17.8%) out of 90 patients had positive culture growth of microorganisms. The rest 74 (82.2%) had no growth. These were hospital acquired as the patients did not have the growth on admission.

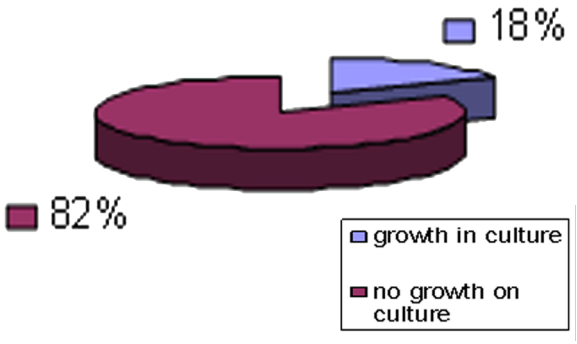

Figure 3
Incidence of Nosocomial Urinary Tract Infection

Types of Micro-organisms Isolated

Figure 4 illustrates the microorganism isolated in order of frequency, whereby *Escherichia coli* was mostly isolated (27%) and *Citrobacter freundii* and *Enterococcus spp.* were the least (4.5%). The others were as follows: *Klebsiella pnuemoniae* (18%), *Staphylococcus epidermidis* (13.6%), *Pseudomonas aeruginosa* (13.6%), *Candida albicans* (9%) *and Proteus spp.* (9%).

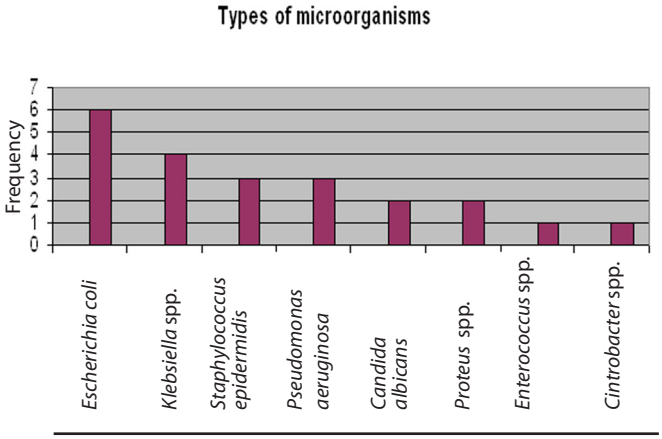

Figure 4
Type of Microorganism Isolated

Table 3 illustrates the characteristics of the sixteen patients with positive culture growth. Their ages ranged from 9 to 73 years with a mean age of 34 years (SD = 18.8). Six patients were less than 40 years and nine were more than 40 years. The male patients were only 6 (37.5%) whereas the female patients were 10 (62.5%). The medical diagnosis upon ICU admission was also spread almost evenly for each type of condition.

Table 3
Characteristics of Patients who Developed Positive Culture Growth after Three Days

Characteristics	Frequency n	Percentage %
Age Distribution		
< 10	2	12.5
11 – 20	2	12.5
21 – 30	3	18.8
31 – 40	4	25.0
41 – 50	1	6.3
51 – 60	3	18.8
> 60	1	6.2
Total	**16**	**100**
Sex		
Male	6	37.5
Female	10	62.5
Total	**16**	**100**
Diagnosis on ICU admission		
Head Injury	4	25.0
Burn Injury	3	18.8
Motor Neuropathy	3	18.8
Cardiovascular Disorder	3	18.8
Obstetric Disorder	3	18.8
Total	**16**	**100**

Relationship Between Microbial Growth and Patient Characteristics

a) Age Vs Culture Growth

The relationship between the patients' age and growth of microorganism in their urine was not statistically significant. (p = 0.73). (Table 4 below)

b) Gender Vs Culture Growth

The female patients were 2.3 times more likely to get the urinary tract infection than their male counterparts (OR = 2.3) (p = 0.13). (Table 4 below)

c) Duration of Catheter Stay Vs Culture Growth

Those who stayed with the urinary catheter for more than a week had a numerically higher chance of developing the urinary tract infection than those who stayed for less than one week (OR = 1.62), although this was also not statistically significant (p =0.40). (Table 4 below)

Table 4
Relationship Between Microbial Growth and Patient Characteristics

Characteristics	No Growth, n (%)	Growth, n (%)	OR (95% CI)	X2	*P- Value*
Age in Years					
< 10	10 (11.1)	2 (2.2)			
11 – 20	12 (13.3)	2 (2.2)			
21 – 30	15 (16.7)	3 (3.3)			
31 – 40	11 (12.2)	4 (4.4)	-	3.58	0.73
41 – 50	10 (11.1)	1 (1.1)			
51 – 50	6 (6.7)	3(3.3)			
> 60	10 (11.1)	1 (1.1)			
Total	**74 (82.2)**	**16 (17.8)**			
Sex					
Male	43 (47.8)	6 (6.7)			
Female	31(34.4)	10 (11.1)	2.3 (0.68, 8.12)	2.25	0.13
Total	**74 (82.2)**	**16 (17.8)**			
Catheter Stay					
Less than 1 Week	54 (60.0)	10 (11.1)			
More than 1 Week	20 (22.2)	6 (6.7)	1.62 (0.45, 5.75)	0.70	0.40
Total	**74 (82.2)**	**16 (17.8)**			

Results of Logistic Regression Analysis

To determine the effect of each variable independent of the others, logistic regression analysis was done. Table 5 illustrates the results. Only catheter stay and use of steroids were found to have a statistically significant effect on microorganism growth in the patient.

Table 5

Logistic Regression Analysis on Patient's Social Demographic Factors against Microorganism Growth

Variable	Regression Coefficient (B)	Standard Error (S.E)	Wald's Statistics*(or X2)*	Degrees of Freedom	Significance	95% Confidence Interval Lower | Upper
Age of the Patient	-0.007	0.018	0.142	1	0.706	0.959 1.029
Sex	0.762	0.721	1.117	1	0.291	0.522 8.793
Diagnosis	0.324	0.199	2.654	1	0.103	0.936 2.040
Duration of Catheter stay	0.269	0.123	4.780	1	0.029	1.028 1.665
Anti-microbial	-1.824	22.272	0.007	1	0.935	0.000 1.5x108
Steroids	-2.914	0.818	1 2 . 7 0 1	1	0.000	0.011 0.269

Sensitivity Analysis of Antibiotics Tests on the Microorganisms Isolated

Table 6

Sensitivity Analysis of the Microorganisms Isolated

Microorganisms	Co-Amoxiclav		Gentamicin		Ciprofloxacin		Cefuroxime		Amikacin		Nitrofurantoin		Piperacillin		Meropenem	
Sensitivity Outcome	**S**	**R**	**S**	**R**	**S**	**R**	**S**	**R**	**S**	**R**	**S**	**R**	**S**	**R**	**S**	**R**
E. coli **(6)**	3	3	3	3	4	2	4	2	5	1	6	-	6	-	6	-
K. pneumoniae **(4)**	1	3	1	3	2	2	-	4	2	2	3	1	4	-	4	-
P. aeruginosa **(3)**	*	*	3	0	3	0	*	3	0	*	*	*	3	-	3	0
Proteus **spp. (2)**	2	-	-	2	-	2	1	1	1	1	1	1	2	-	2	-
Enterococcus **spp. (1)**	1	-	-	1	1	-	1	-	1	-	1	-	1	-	1	-
Citrobacter freundii **(1)**	-	1	-	1	-	1	-	1	-	1	1	-	1	-	1	-
S. epidermidis **(3)**	2	1	1	2	2	1	1	2	2	1	1	-	3	-	3	-

Table 6 illustrates the sensitivity of the microorganisms isolated to the commonly prescribed drugs in ICU. Most of the microorganisms are resistant to the antibiotics usually prescribed on admission.

Klebsiella pneumoniae, *P. aeruginosa* and *Citrobacter* spp. showed resistance to common antibiotics but 100% sensitivity to Piperacillin and Meropenem. Sensitivity was demonstrated when Co-Amoxiclav, Nitrofurantoin and Amikacin were tested on *E. coli* and *S. epidermidis* but not *Klebsiella pneumoniae* and *P. aeruginosa*. All the microorganisms were resistant to Gentamicin except *E. coli.*

NB:

** Drug was not tested on Microorganism*

S- Sensitivity of the isolated microorganism to the commonly used antibiotics

R- Resistance of the isolated microorganism to the commonly used antibiotics

Discussion

A majority of the patients recruited in the study were males of all ages having a working diagnosis of severe head injury. It was established that all the patients were commenced on an antimicrobial, steroid, analgesic, sedation or a combination of any of these drugs on admission. This made it difficult to control for usage of these drugs in the study as they caused some degree of immunosuppression, making the patients susceptible to UTI, on the other hand, the patients could not be denied medication as this would be unethical. Upon collection of the urine samples, all of the patients were on antibiotic therapy. As a unit routine all the patients admitted to the ICU were commenced on a first line antibiotic therapy that included beta lactams like Penicillin, Amoxyllin, Co-amoxiclav combined with Gentamicin. Some patients received second generation Cephalosporins (Cefuroxime and Ceftazidime), Metronidazole (antimicrobial) and steroids (Dexamethasone and Hydrocortisone). These drugs can compromise the patient's immunity and likely to make them susceptible to acquiring infections (Baron et al., 1994).

Incidence

This study also established the incidence rate of nosocomial CAUTI (outcome measure) after three days of catheterization with a temporary indwelling catheter to be 18% (n= 16). These were hospital acquired as the patients did not have the infection on admission to ICU. This is similar with the results of Sujijantararat et al., (2005) in their study on nosocomial UTI and nursing – sensitive quality indicators in a Thai hospital, who found the incidence in various wards to range between 15% and 47.6%, on average 31.68%. Similarly, in a study done by Marc et al. (2004) determined the incidence of urosepsis to be 16% in the ICU population. In a study by Erbag et al. (2003) to determine the incidence and risk factors for nosocomial urinary tract infections in ICU, established a rate of 23.6%. The high incidence of 18% in our setup could be attributed to by the poor catheter management by the medical staff and also the poor staffing ratios. This has been alluded to by the study done by Sujijantararat et al. (2005), who came up with similar findings.

Microorganisms Isolated

In this study, twenty-two (22) bacterial isolates were obtained that caused the nosocomial CAUTI in order of frequency include; E. coli (27%), *Klebsiella pneumoniae* (18%), *S. epidermidis* (13.6%), *P. aeruginosa* (13.6%), *C. albicans* (9%), *Proteus* spp. (9%), *Enterococcus* spp (4.5%) and *Citrobacter freundii* (4.5%). Similar findings were established by Mwamba, (2005), who isolated the following microorganisms; *E. coli* (37.5%), Proteus mirabilis (12.5%), *Klebsiella pneumoniae* (12.5%), *Pseudomonas aeruginosa* (12.5%), *Enterococcus* (18%) and *Acinetobacter* spp (6.25%). Similar findings were obtained in one Tunisian hospital to determine the prevalence of hospital-acquired infection, they reported the most frequently isolated organisms were Gram-negative rods (80.8%) (Kallel et al., 2005).

Relationship Between Microbial Growth and the Patient Characteristics

E. coli is the most prevalent microorganism isolated and was prevalent among the female patients. This could be due to the close proximity of the urethral catheter to the anal passage. If the patient is not cleaned properly, (that is, poor catheter management) and on time after a bowel action, then the bacteria is likely to colonize the entry site of the catheter. It was also established that the female patients showed more susceptibility to getting the infection than their male counterparts although the difference is not statistically significant.

On the relationship between microbial growth and the duration of catheter stay, it was determined that the patients who stayed with a catheter for more

than a week had numerically higher chance of developing an infection but the difference was not statistically significant.

Logistic Regression Analysis

The study also further analyzed the findings to determine the effect of each variable independent of the others hence logistic regression analysis was done and the findings indicated that the longer the duration of catheter stay the greater the incidence of NCAUTI. Similarly, the patients who were on steroid therapy had a higher incidence of NCAUTI. Therefore these two variables each, independently significantly influenced the positive growth of microorganisms in the patients.

Sensitivity Patterns of the Bacterial Isolates

It was established that some of the bacteria isolated were resistant to the commonly prescribed and readily available antibiotics in the unit. *Klebsiella pneumoniae, P. aeruginosa* and *Citrobacter freundii* showed resistance to commonly prescribed antibiotics but 100% sensitivity to Amikacin, Piperacillin and Meropenem. Sensitivity was demonstrated when Co-amoxiclav, Nitrofurantoin and Amikacin were tested on *E.coli, Proteus spp.* and *S. epidermidis* but not *Klebsiella pneumoniae* and *Pseudomonas aeruginosa*. In the event that a patient gets infected by *Klebsiella spp., P. aeruginosa* and *Citrobacter spp,* then an extended spectrum antibiotic should be prescribed for example, piperacillin.

This study established that all the bacterial isolates were resistant to Gentamicin hence it would not be advisable to prescribe the drug in the event of a NCAUTI. All microorganisms were sensitive to amikacin, piperacillin and meropenem. Similar results were reported by Mwamba (2005) in his study on UTIs at KNH.

This study established the trend that more microorganisms are gaining resistance to commonly prescribed antibiotics and this is worrying as the broader spectrum drugs are more expensive and usually not available in the hospital pharmacy.

Conclusions

This study deduced the following conclusions:

1. The incidence of nosocomial catheter associated urinary tract infections in the ICU/HDU is at 18%.
2. The most common microorganisms solated from the positive urine cultures were; *Escherichia coli* (27%), *Klebsiella pneumoniae* (18%), *Stapylococcus epidermidis* (13.6%), *Pseudomonas aeruginosa* (13.6%), *Candida albicans* (9%)*, Proteus spp.* (9%), *Enterococcus spp* (4.5%) and *Citrobacter freundii* (4.5%).
3. The bacteria isolated on culture studies were resistant to the commonly prescribed and readily available antibiotics in the unit.
4. All microorganisms were sensitive to Piperacillin and Meropenem.

Recommendations

This study therefore recommends the following:

1. There is need for update/ refresher courses on infection control and prevention measures on urinary tract infections at the Intensive care Unit.
2. There is need for judicious use of anti-biotics in the management of NCAUTI to prevent multidrug resistant UTIs
3. There is need for more studies to be done with regards to the prevention of urinary tract infections, the healthcare personnel's level of practice and in other hospitals to be able to get a more generalizable picture.

References

Baron, E.J., Peterson, L.R., & Finegold, S.M. (1994). *Bailey and Scott's textbook of diagnostic microbiology. (*9th ed.) St. Louis Missouri: Mosby Inc.

Burke, J .P., & Yeo, T.W. (2004). Nosocomial urinary tract infections In mayhall, C.G. (*ed) Hospital epidemiology and infection control. (*3rd ed). Pp. 267 – 270. Philadelphia: Lippincott Williams and Wilkins.

Erbag, H., Yalcin, A. N., Serin S., Turgut, H.,Tomatir, E. & Cetin, B. (2003). Nosocomial infections in intensive care unit in a Turkish University Hospital: A 2-year survey*Intensive Care Medicine 29*(9), 1482-8

Fisher, A. A., Laing, J. E., Stoeckel, J. E., & Townsend, J. W. (1993) *Handbook for Family Planning Operations Research Design*. (2nd ed). New York: Population Council.

Geheb, M. (1993). *Principles and practice of medical intensive care.* Philadelphia: W. B Saunders Company.

Kallel, H., Bahoul, M., Ksibi, H., Dammak, H., helly. H., Hamida. C. B., Chaari, A., Rekik, N. & Bouaziz, M. (2005). Prevalence of hospital acquired infection in a Tunisian Hospital. *Journal of Hospital, Infection 59*(4), 343-347.

Kibet, A. (2001). Patterns of urinary tract infections at the KNH's Intensive Care Unit. [Unpublished MMed. Thesis]

Leone, M., Albanese, J., Gavnier F, Sapin, C. Barrau, K, Bimar, M. C., & Martin, C.. (2003). Risk factors of nosocomial catheter-associated urinary tract infection in a polyvalent Intensive care unit *Intensive Care Medicine, 29(*6), 929-32

Leone, M., Garnier, F., Dubuc, M., Bimar, M. C., & Martin, C. (2001). Prevention of nosocomial urinary tract infection in ICU patients – Comparison of effectiveness of two urinary drainage systems. *CHEST, 120,* 220-224

Leone, M., Garnier, F., Avidan, M. & Martin, C. 2004). Catheter associated urinary tract infections in Intensive Care Units. *Microbes and Infection. 6,*1026-1032

Micheni, J. (2004) Infection control program presentation- Kenyatta National Hospital. [Unpublished article]

Mwamba, P.M. (2005). 'The prevalence of nosocomial urinary tract infections in patients with indwelling urinary catheters at Kenyatta National Hospital.'[Unpublished MMed. Thesis]

Tasota, F. J., Fisher, E. M., Coulson, C. F., & Hoffman, L. A.. (1998). Protecting ICU patients from nosocomial infections: Practical measures for favorable outcomes. *Critical Care Nurses, 18*, 54-67

Vincent, J., Bruining, H., & Nicolas- Chanoin, M. (1995). *Journal of the American Medical Association. 274*(8), 639 – 644

Waithaka, P. M. (2005). Infection control and prevention practices in public maternity units in Kenya. [Unpublished MPH Thesis]

Warren, J. W. (1997). Catheter-associated urinary tract infections. *Infec Dis Clin North Am 11*, 609-622.