

An Epidemiological Hospital Based Matched Case-Control Study to Assess the Determinants of Catheter Associated Urinary Tract Infections

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Abstract - To evaluate the risk factors related to catheter associated urinary tract infections in a tertiary care hospital. An Epidemiological matched case-control study was conducted at Social Security Hospital, Gujrainwala, Pakistan. A sample of 376 (188 cases and 188 controls by 1:1 ratio) participants of age 20-80 years was collected. Urine specimen of 5 mL from each participant was taken after 48 hours of catheterization. Cases were selected randomly, and matched by control. Chi-Square test and Logistic Regression analysis were applied to assess the relationship of variables with CAUTIs. Matched variables were not included in analysis. Factors that were observed as significant with p-value ≤ 0.05 ; no suitable condition at the time of catheterization, patient mobilization, with diabetes, less fluid intake (< 1.5 Liter) and low hemoglobin level (< 10 g/dL). Duration of catheter (≥ 7 days), no patient perineal care and no proper cleanliness in units were identified as risk factors that were highly significant with p-value < 0.001 for CAUTIs. Long duration of catheter, unsatisfactory perineal care of patients, unsatisfied cleanliness in units and diabetes were potential risk factors for CAUTI's. Well trained paramedical staff and proper care regarding cleanliness and perineal care are required to prevent and control the CAUTI's.

Index Terms- Risk Factors, Evaluate, Urinary Tract Infections, Hospital Based, Case-Control Study

I. INTRODUCTION

Urinary tract infection (UTI) is an infection of urethra, bladder, ureter or kidney, UTI is associated with lodging of urinary catheter, a device placed through urethra to drain the urine from bladder secured in place by small balloon. When urinary catheter is not properly placed there for too long, it causes infection.¹ According to the National Health care Safety Network, healthcare-associated infections (HAI) were reported 3.20%

of total patients, whereas UTIs 40% of HAIs.^{2,3}

Worldwide, UTIs are fourth common type of infection that are related to health care. A study reported approximately >93 thousand cases of UTIs in acute care hospitals in 2011.⁴ CAUTI is one of the most significant problems among acquired UTIs in hospital settings, 70-80% are linked with an indwelling urinary catheter.^{5,6} According to the Centers for Disease Control and Prevention (CDC), (15-25)% of hospitalized patients received urinary catheters during their stay. CAUTIs have been associated with increased morbidity, mortality, hospital cost and length of stay. Every year, 449334 CAUTI incidents affecting the Americans and 13,000 CAUTI-linked deaths in the United States. The morbidity rate is 2.8 times more in CAUTIs patients as compare to others⁷. Mostly studies on CAUTIs were conducted in the developed countries whereas this study was performed in public sector hospital of developing country (Pakistan). Purpose of the study was to evaluate the risk factors associated with CAUTI's in the patients of public sector hospital.

II. METHODOLOGY

Study Design

An epidemiological observational hospital-based matched case-control study was conducted to evaluate the risk factors related to CAUTIs at Social Security Hospital, Gujrainwala, Pakistan since July, 2021 to November, 2021.

Data Collection

After the approval of Institutional review board (IRB) of University of Lahore, (Reference no; REG/GRT/21/AHS-64) and hospital ethics committee, data of 376 participants were collected through pre-tested questionnaire about the factors like the history of UTIs, duration of catheterization, place of catheterization, perineal care of patients, diabetes, cleanliness in units, patient mobilization, fluid intake per day and hemoglobin level. By considering the data of certain demographic variables, i.e. age, sex, area and income. A written informed consent was taken by participants. Purpose of the study was explained to the participants and confidentiality of data was ensured. Urine specimen of 5 mL was taken from each participant to verify CAUTI by aspirating urine from the urine bag with a sterile syringe. The proper supervision of catheter insertion and removal was obtained twice a week.

Sample Size Calculation

A sample of 376 participants (188 cases and 188 controls by 1:1 ratio) was calculated. Following formula was used to estimate a sample size⁸

$$n = [(r+1)(p^*)(1-p^*)(Z_{\beta}+Z_{\alpha/2})^2]/r (p_1-p_2)^2$$

Where,

r = control to case ratio, 1 for equal number of case and control, because 1:1 control to case ratio in this study, so $r = 1$

p^* (average proportion of exposed = [proportion of exposure for people with disease (case) + proportion of exposure without the disease (Control)] / 2

$Z_{1-\beta}$ = standard normal variate = 0.84 for 80% power of the study ($1-\beta$), when type II error (β) is 20%.

$Z_{\alpha/2}$ = standard normal variate = 1.96 for level of significance (α) = 5% and 95% confidence level ($1-\alpha$)

$P_1 = 0.298$ and $P_2 = 0.175$ are proportions in cases and control for a previous study respectively.⁹

$P_1 - P_2$ = Effect size or different in proportion expected based on previous studies.

$$n = [(1+1)(p^*)(1-p^*)(0.84+1.96)^2] / (0.298-0.175)^2$$

Average Proportion for Exposed (P^*) = (proportion of exposed cases + proportion of control exposed) / 2

$$P^* = (0.298 + 0.175) / 2 = 0.237$$

$$n = [2(0.237)(0.763)(0.84+1.96)^2] / (0.298-0.175)^2$$

$$n = 187.41$$

After round off, at least 188 participants were required in each group. So, the researcher recruited 188 cases and 188 controls.

Case and Control Definition

After 48 hours of catheter insertion, whose urine culture test was showing growth $\geq 10^5$ CFU/mL urine but > 2 species of bacteria was found, that participants were selected as case group. Participants whose urine culture test was found free of microorganism growth along with catheter insertion for > 48 hours were selected as a control group.¹

Inclusion and Exclusion

Age of both (case and control) groups were between of 20-80 years. Candidates of both groups were picked by 1:1 ratio from different units (intensive care unit, neurology, urology, gynecology, surgery and postoperative wards) of same hospital. Confirmed UTI patients without catheterization and those participants who had spent > 3 weeks were excluded from this study.

Matching

Controls were matched with cases on the basis of age (± 3 years), gender, area and income (± 5000 PKR). The matched variables are shown in **Table 1**.

Statistical Analysis

The collected data were entered and analyzed through SPSS (version 22.0), initially Univariate analyses were performed for summarizing and presenting of data. The data of numerical variables were displayed through mean and standard deviation and qualitative data were shown through frequencies and percentages in **Tables (1 & 2)**. In Bivariate analysis, Chi square test was applied to assess the relationship of risk factors with CAUTI_s and unadjusted odds ratio was also calculated for the quantification of risk. In Bivariate logistic regression technique for unmatched data was also performed to compute the adjusted odds ratio (OR) at 95% confidence interval. Because both groups were matched with age, gender, area, and family income and these matched factors were not included for analysis. Whereas $p\text{-value} \leq 0.05$ was considered as significant value .

III. RESULTS

A total of 376 contributors were included in the study, of which 188 participants of control group were matched by age (± 3 years), gender, area and income (± 5000 PKR) that are listed in **Table 1** and which were excluded at the time of analysis.

Table 1. Matched characteristics of the control with cases

Variables	Total=376 <i>n</i> (%)	Case Group=188 <i>n</i> (%)	Control Group=188 <i>n</i> (%)
Age (years)	42.42 \pm 15.18	43.17 \pm 14.80	41.67 \pm 15.56
Gender			
Male	240(63.83)	120(63.83)	120(63.83)
Female	136(36.17)	68(36.17)	68(36.17)
Area			
Rural	139(36.97)	72(38.30)	67(35.64)
Urban	237(63.03)	116(61.70)	121(64.36)
Income (PKR)	31824.47 \pm 11106.32	30781.91 \pm 13150.72	32867.02 \pm 8499.03

n(%) , Mean \pm S.D

The average age of control group (41.67 \pm 15.56) was matched with case group (43.17 \pm 14.80), average age of cases was slightly more than controls. Male sex was more prevalent in both (case and control) groups with $n=120$ (63.82%) for each group. Mostly, the participants belonged to urban area with $n=116$ (61.70%) cases and $n=121$ (64.36%) controls. Income of both groups was also matched which was 30781.91 \pm 13150.72 and 32867.02 \pm 8499.03 PKR in case and control group respectively shown in **Table 1**. Mostly 85(22.61%) and 76(20.21%) patients belonged to ICU and Neurology wards of total ($n=376$) respectively shown in **Table 2**. Out of 376 participants, only 81(21.54%) patients were diabetic, 165(43.88%) had duration of catheterization ≥ 7 days, 266(70.74%) patients were done

perineal care before the insertion of catheter and 285(75.80%) had suitable condition at the time of catheterization

Table 2. Baseline characteristics of both (case and control) groups

Variables	Total=376 n (%)	Case Group=188 n (%)	Control Group=188 n (%)	χ^2	P-Value ⁺
Place of catheterization				13.98	0.016*
ICU	85(22.61)	45(23.94)	40(21.28)		
Neurology	76(20.21)	42(22.34)	34(18.09)		
Urology	55(14.63)	23(12.23)	32(17.02)		
Gynecology	58(15.43)	38(20.22)	20(10.64)		
Surgery	55(14.63)	19(10.11)	36(19.15)		
Post-Operative	47(12.05)	21(11.17)	26(13.83)		
Diabetes				11.47	<0.001*
Yes	81(21.54)	54(28.72)	27(14.36)		
No	295(78.46)	134(71.28)	161(85.64)		
Duration of catheterization (days)				16.43	<0.001*
< 7	211(56.12)	125(66.49)	86(45.74)		
≥ 7	165(43.88)	63(35.51)	102(54.26)		
Patient perineal care				11.57	<0.001*
No	110(29.26)	70(37.23)	40(21.28)		
Yes	266(70.74)	118(62.77)	148(78.72)		
Suitable condition at the time of catheterization				9.06	0.003*
No	91(24.20)	58(30.85)	33(17.55)		
Yes	285(75.80)	130(69.15)	155(82.45)		
Cleanliness in wards				15.63	<0.001*
No	139(36.97)	88(46.81)	51(27.13)		
Yes	237(63.03)	100(53.19)	137(72.87)		
Patient mobilization				4.93	0.026*
No	147(39.10)	84(44.68)	63(33.51)		
Yes	229(60.90)	104(55.32)	125(66.49)		
Fluid intake per day				11.6	<0.001*
< 1.5 Liter	181(48.14)	107(56.91)	74(39.36)		
≥ 1.5 Liter	195(51.86)	81(43.09)	114(60.64)		
Hemoglobin level				7.47	0.006*
< 10 g/dL	152(40.43)	89(47.34)	63(33.51)		
≥ 10 g/dL	224(59.57)	99(52.66)	125(66.49)		

+ Chi-square test for significance value (P-Value≤0.005 indicate the significance)

“*” indicates the statistically significance

Table 3. Association of determinants with catheter associated urinary tract infection

Variables	Unadjusted OR 95% CI	<i>P</i> - Value	Adjusted OR 95% CI	<i>P</i> - Value
	OR(Lower-Upper)		OR(Lower-Upper)	
Duration of catheter (≥ 7 days)	2.35(1.55-3.57)	<0.001	2.09(1.32-3.31)	0.002*
Place of catheterization	1.09(.97-1.23)	0.141	1.06(0.93-1.22)	0.355
Patient perineal care (No)	2.20(1.39-3.47)	<0.001	2.64(1.58-4.42)	<0.001*
Unsuitable condition at the time of catheterization	2.10(1.29-3.41)	0.003*	2.22(1.29-3.84)	0.004*
Unsatisfied Cleanliness in wards	2.36(1.54-3.64)	<0.001*	2.35(1.45-3.80)	<0.001*
No patient mobilization	1.60(1.06-2.43)	0.026*	1.88(1.16-3.06)	0.010*
Diabetes	2.40(1.43-4.03)	<0.001*	2.25(1.28-3.96)	0.005*
Less fluid intake per day (<1.5 Liter)	2.04(1.35-3.07)	0.001*	2.08(1.31-3.29)	0.002*
Low Hemoglobin level (<10 g/dL)	1.78(1.18-2.71)	0.006*	2.26(1.40-3.63)	<0.001*

OR (Odds Ratio), “*” indicates the statistically significance, CI indicates the confidence interval

237(63.03%) patients were told that they were satisfied towards ward's cleanliness and 229(60.90%) of total could move from one to another place. The patients whose fluid intake per day ≥ 1.5 Liter and Hb level ≥ 10 g/dL were 195(51.86%) and 224(59.57%) of total respectively that are expressed in **Table 2**.

Bivariate analysis was carried out to calculate the association of risk factors with CAUTI, s. Unadjusted Odds ratios (OR) at 95% confidence interval (CI) were shown in **Table 3**, duration of catheter ≥ 7 days (OR:2.35;95% CI, 1.55-3.57; $p \leq 0.001$), unsatisfactory perineal care of patient (OR: 2.20;95% CI:1.39-3.47; $p \leq 0.001$), unsuitable condition at the time of catheterization (OR: 2.10; 95% CI:1.29-3.41; $P=0.003$), unsatisfied cleanliness in wards (OR:2.36; 95% CI:1.54-3.64; $p \leq 0.001$), no patient mobilization after catheterization (OR:1.60; 95% CI:1.06-2.43; $p=0.026$), diabetes (OR:2.40; 95% CI:1.43-4.03; $p \leq 0.001$), fluid intake per day <1.5 Liter (OR:2.04; 95%CI:1.35-3.07; $p=0.001$) and Hemoglobin level <10 g/dL (OR:1.78; 95% CI:1.18-2.71; $p=0.006$) were significant risk factors for CAUTIs.

In multivariate analysis adjusted odds ratios (OR) were calculated and presented in **Table 3**, duration of catheter ≥ 7 days (OR:2.09; 95%CI:1.32-3.31), no perineal care of patients (OR: 2.64; 95% CI:1.58-4.42), unsuitable condition at the time of catheterization (OR:2.22; 95% CI: 1.29-3.84), unsatisfied cleanliness in wards (OR:2.35; 95%CI:1.45-3.80), no patient

mobilization after catheterization (OR:1.88; 95% CI:1.16-3.06), diabetes (OR:2.25; 95% CI: 1.28-3.96), fluid intake per day <1.5 liter (OR:2.08; 95% CI: 1.31-3.29) and hemoglobin level <10 g/dL (OR: 2.26; 95% CI: 1.40-3.63) were all risk factors with $P<0.05$. The place of catheterization (OR: 1.06; 95% CI: 0.93-1.22) was not associated as a risk factor with $p=0.355$. The duration of catheter ≥ 7 days, no patient perineal care, unsuitable condition at the time of catheterization, diabetes fluid intake per day <1.5 liter and hemoglobin level <10 g/dl were highly associated risk factors with significance results.

IV. DISCUSSION

A total of 378 participants (cases=188 and controls=188) were included in the study. Nine determinants were assessed for the etiology of CAUTIs. The logistic regression for the multivariate analysis technique was applied to analyze the result of these determinants that are shown in **Table 3**.

The duration of catheterization (≥ 7 days) was considered as a most important risk factor with Odds ratio (OR=2.56). A study of risk factors related to CAUTI was done by Maki and co-researchers, the study revealed that the factor “ more duration of catheterization” was 5.2 fold more risk as compare for CAUTI.¹⁰ Results of current study was supported by the findings of other researches that had a high risk of CAUTIs was also linked with the long duration of catheterization.^{11,12,13, 14}

Role of place (Unite) from which ward, catheter insertion was performed, this place was very important. Outside the operation theater, catheterization had 2-5 folds more chance to produce CAUTIs were reported in various studies.^{11,12} In another research, this likelihood was recorded 3.92 time more for CAUTIs, but was not significant with $p\text{-value}=0.079$.¹⁰

In the present study, place of catheterization was not associated to CAUTIs with $p\text{-value}=0.355$, because the participants were not only selected from post-operative unite but also other units like ICU, Neurology, Urology, Gynecology and Surgery from which data is collected.

In a study reported that the diabetic individuals had 5 times more risk to progress CAUTI than others. Positive history of diabetes was linked to promote the risk of CAUTIs that was similar to current study.¹¹ As diabetic persons have an enlarged colonization of bacteria in perineum and urine, which was supported to microbial growth. Another factor that was immunity of person with diabetes may also plays an important role. Results of above maintained research, was indicated to increase the risk of CAUTIs with diabetes history.

Before the insertion of catheter, it is compulsory to clean the perineal area with any perineal

care agent by proper protocol under the well-trained paramedic staff. The current study showing that unsatisfactory perineal care is a risk factor with adjusted OR=2.64 which is statistically significant by p-value 0.001. Results of present study were similar to a study which was conducted in Japan, according to this study patients with “no perineal care” were more prone to develop CAUTIs with p-value =0.005 as compare to perineal care.¹⁵ Unsatisfactory cleanliness in different units in hospital setting was also the most significant risk factor with p-value \leq 0.05.¹⁶

Current study revealed that immobilization was a significant determinant with p-value \leq 0.05. This study was similar to a study which was conducted at United States of American in 2003. According to this study, (39-76) % patients were showing the low risk of CAUTI with mobilization i.e. upholding posture and walking. Findings of current study indicated that keeping or increasing the mobility (transferring the positions, walking, or moving in bed) was related with a lesser risk of all types of UTIs including CAUTI.¹⁷

Fluid intake plays a significant role to prevent the CAUTIs, the urine pH, acidity and urine osmolarity can be maintained by proper fluid intake. as a consequence of less fluid intake was an increased risk of all types of UTIs.^{18,19} The results of current study was similar to the above maintained studies. Outcomes of current study indicated that “less fluid intake per day” (<1.5 liter) is a significant risk factor with p-value \leq 0.05 to increase the risk of all type of UTIs. Results of current study indicated that Low hemoglobin level (<10 g/dL) was also a risk factor with unadjusted OR=1.78 (1.18-2.71), P-value =0.006, and after adjustment OR= 2.26 (1.40-3.63) and p-value \leq 0.001, These results are similar to a study which was conducted in India, according to this study the patients with <10 hemoglobin elevated the renal parameters with >1.5 serum creatinine revealed a significant association to increase the CAUTI with p-value< 0.001.¹¹

V. CONCLUSION

After the evaluation, it was concluded that the long duration of catheter, unsatisfactory perineal care of patients, unsatisfied cleanliness in units and diabetes were potential risk factors for CAUTIs. Well trained paramedical staff, proper care regarding cleanliness and perineal care are required to prevent and control the CAUTI's.

Conflict of Interest

The authors declare that there is no conflict of interest regarding this study.

Financial Statement

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Ethical approval and informed consent

This observational case control study was approved by Institutional Review Board (IRB), University of Lahore. Punjab, Pakistan (IRB No: REG/GRT/21/AHS-64). Informed consent was confirmed by IRB.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author.

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