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Impact of a multidimensional infection control approach on catheter-associated urinary tract infection rates in an adult intensive care unit in Lebanon: International Nosocomial Infection Control Consortium (INICC) findings

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SUMMARY

Objective: The objective of this study was to assess the impact of a multidimensional infection control approach for the reduction of catheter-associated urinary tract infection (CAUTI) in an adult intensive care unit (ICU) of a hospital member of the International Nosocomial Infection Control Consortium (INICC) in Lebanon.

Methods: A before–after prospective active surveillance study was carried out to determine rates of CAUTI in 1506 ICU patients, hospitalized during 10 291 bed-days. The study period was divided into two phases: phase 1 (baseline) and phase 2 (intervention). During phase 1, surveillance was performed applying the definitions of the US Centers for Disease Control and Prevention National Healthcare Safety Network (CDC/NHSN). In phase 2, we adopted a multidimensional approach that included: (1) a bundle of infection control interventions, (2) education, (3) surveillance of CAUTI rates, (4) feedback on CAUTI rates, (5) process surveillance, and (6) performance feedback. We used random effects Poisson regression to account for clustering of CAUTI rates across time-periods.

Results: We recorded a total of 9829 urinary catheter-days: 306 in phase 1 and 9523 in phase 2. The rate of CAUTI was 13.07 per 1000 urinary catheter-days in phase 1, and was decreased by 83% in phase 2 to 2.21 per 1000 urinary catheter-days (risk ratio 0.17; 95% confidence interval 0.06–0.5; $p = 0.0002$).

Conclusions: Our multidimensional approach was associated with a significant reduction in the CAUTI rate.

1. Introduction

Catheter-associated urinary tract infections (CAUTI) have been described in the scientific literature as one of the most common device-associated healthcare-associated infections (DA-HAI) developed by patients hospitalized in the intensive care unit (ICU). CAUTI acquired by critically ill patients has been associated with prolonged hospital length of stay (LOS), bacterial resistance, morbidity, and increased healthcare costs.[1,2] More recently, different published studies have shown divergence in terms of its association with excess mortality, which may be the result of confounding by unmeasured variables, i.e., lack of control for lurking factors or hidden variables during the study, such as septic shock, multiple organ failure, and ICU admission, receipt of mechanical ventilation during the first 48 h of ICU stay, use of antibiotics, and extra-urinary sepsis.[3–5]

DA-HAI rates in the ICUs of countries with limited resources are 3- to 5-times higher than rates in the ICUs of high-income countries, as reported from hospitals of the International Nosocomial Infection Control Consortium (INICC).[6]

To our knowledge, the considerable influence exerted by the socioeconomic level of a country and the type of hospital in DA-HAIs in developing countries has only been assessed in two studies.[7,8] With regard to the socioeconomic level of the country, in a study conducted in pediatric ICUs it was shown that lower-middle-income countries had higher CAUTI rates than low-income countries or upper-middle-income countries (5.9 vs. 0.6 CAUTIs per 1000 urinary catheter-days).[8]

On the other hand, it has been shown in different studies, most from developed countries, that implementing infection control programs and practice bundles is associated with a reduction in the incidence density of CAUTI; these include hand hygiene, training on care, maintenance, alternatives to indwelling catheters;[9]

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education and training on procedures for catheter insertion, management, and removal; inserting urinary catheters only when needed; removing them when not necessary;[10] maintaining unobstructed urine flow, among other interventions; and simultaneously, outcome surveillance of CAUTI rates and their consequences, process surveillance, feedback on CAUTI rates, and feedback on healthcare worker (HCW) performance.[11]

There is a pressing need for the implementation of prevention strategies and programs in the developing world.[12] We implemented a multidimensional infection control approach in an adult ICU of a hospital in Lebanon with the aim of reducing these high CAUTI rates. This approach included specific interventions for CAUTI prevention, such as a practice bundle, education, outcome surveillance, process surveillance, and feedback of CAUTI rates, as well as performance feedback for infection control practices. The implementation of the INICC multidimensional approach for CAUTI prevention is based on the recommendations and guidelines published by the Society for Health Care Epidemiology of America (SHEA) and the Infectious Diseases Society of America (IDSA) in 2008.[13]

This study is the first to analyze the particular effect of this multidimensional preventive strategy on CAUTI rates in the adult ICU setting of a Lebanese hospital. The study was carried out from November 2007 to March 2012.

2. Patients and methods

2.1. Setting and study design

This active, prospective outcome and process surveillance before–after study was conducted from November 2007 to March 2012 in a medical–surgical adult ICU of the American University of Beirut Medical Center (AUBMC), a tertiary care university hospital in Lebanon and member of the INICC. The participating ICU has an infection control team comprised of infection control professionals, and a medical doctor with a formal education and background in infectious diseases. The nurse to patient ratio in the ICU during the study period was 1:1–2.

The INICC headquarters team in Buenos Aires provided infection control teams with centralized education, data analysis, and coordination functions.

The Institutional Review Board of the hospital approved the study protocol.

2.2. Intervention period and the goal of the INICC (phase 2)

The purpose of this INICC study was to achieve the highest possible reduction in the rate of CAUTI in the participating ICU. The intervention period (phase 2) was initiated after 3 months of participation in the INICC outcome and process surveillance program, and amounted to 50 months.

The INICC multidimensional infection control approach has been described in a previous article,[14] and includes the following elements. First, the implementation of an infection prevention bundle based on the guidelines published by the SHEA and the IDSA, as modified by Lo et al.,[13] which provide evidence-based recommendations and cost-effective infection control measures that can be feasibly adapted to the ICU setting in developing countries. Second, the education of HCWs about infection prevention measures. Third, CAUTI outcome surveillance by applying the definitions for CAUTI developed by the US Centers for Disease Control and Prevention National Healthcare Safety Network (CDC/NHSN).[15,16] Fourth, CAUTI process surveillance to monitor compliance with easily measurable infection control measures, including hand hygiene performance according to the recommendations of the World Health Organization's Five Moments.[17] Fifth, feedback on CAUTI rates routinely provided to HCWs of the ICU. Sixth, performance feedback on process surveillance, which was provided particularly by reviewing and discussing chart results at monthly infection control meetings.

2.3. Definition of CAUTI

For the diagnosis of CAUTI, the patient had to meet one of two criteria. The first criterion was satisfied when a patient with a urinary catheter had one or more of the following symptoms with no other recognized cause: fever (temperature $\geq$38 °C), urgency, and suprapubic tenderness; the urine culture was positive for 10^5 colony-forming units (CFU) per ml or more, with no more than two microorganisms isolated. The second criterion was satisfied when a patient with a urinary catheter had at least two of the following criteria with no other recognized cause: positive dipstick analysis for leukocyte esterase or nitrate and pyuria ($\geq$10 leukocytes/ml).[15]

2.4. Statistical methods

Characteristics of the patients in the participating ICUs recorded at baseline and during the last 3 months of the intervention period were compared using Fisher's exact test for dichotomous variables and the unmatched Student's *t*-test for continuous variables. 95% Confidence intervals (CI) were calculated using VCStat (Castiglia). Relative risk (RR) ratios with 95% CI were calculated for comparisons of rates of CAUTI using Epi Info v.6. *p*-Values of $<$0.05 by two-sided tests were considered significant.

Further, we used Poisson regression to compare the rates of CAUTI at baseline and during the-follow up period divided into 9–24-month periods; we compared the CAUTI rates in each period with the CAUTI rate at baseline. We used random effects Poisson regression to account for clustering of CAUTI rates across time-periods. These models were estimated using Stata 11.0.

3. Results

During the whole study period, a total of 1506 patients were hospitalized during 10 291 bed-days in one ICU, amounting to 9829 urinary catheter-days.

Patient characteristics, including age, gender, device use ratio, surgical stay, cancer, endocrine diseases, and abdominal surgery conditions were similar during the two study phases (Table 1).

With regard to compliance rates, during phase 2, hand hygiene compliance remained high and was similar during the two phases. Similarly, compliance rates with the correct position of the urinary catheter (over thigh) and collection bag hanging were 100% in both phases (Table 1).

Regarding CAUTI rates, during phase 1 (baseline period), there were 306 documented urinary catheter-days. There were four CAUTIs, for an overall baseline rate of 13.07 CAUTIs per 1000 urinary catheter-days. The urinary catheter use mean was 0.96. In phase 2, merging all data of the intervention period, after the implementation of the multidimensional infection control program, there were 9523 urinary catheter-days. There were 21 CAUTIs for an incidence density of 2.21 per 1000 urinary catheter-days. The urinary catheter use mean was 0.96 as well. These results showed a CAUTI rate reduction of 83% from baseline (13.07 to 2.21 CAUTIs per 1000 urinary catheter-days; RR 0.17, 95% CI 0.06–0.5; $p = 0.0002$). The urinary catheter use mean was very similar in the two periods ($p = 0.983$).

When using Poisson regression to compare the rates of CAUTI in the two phases, divided into 9–12-month periods during the first year, we found a progressive reduction in the incidence of CAUTI, which was decreased by 72% during the third year (Table 2).

Table 1
Characteristics of patients, hand hygiene compliance, and urinary catheter care in phase 1 (baseline period) and phase 2 (intervention period) of the study

Patient characteristics	Baseline	Intervention	RR[a]	95% CI	*p*- Value
Number of patients	35	1471	-	-	-
Study period, months	3	50	-	-	-
Urinary catheter duration, mean ± SD	8.74 ± 12.3	6.5 ± 6.5	-	-	0.288
Age, years, mean ± SD	67.91 ± 17.7	62.7 ± 19.64	-	-	0.126
Male, *n* (%)	20 (57%)	898 (61%)	1.07	0.69–1.66	0.770
Female, *n* (%)	15 (43%)	572 (39%)			
Surgical stay, *n* (%)	11 (31%)	510 (36%)	1.13	0.62–2.05	0.6864
Abdominal surgery, *n* (%)	1 (3%)	73 (5%)	1.74	0.24–12.51	0.5777
Cancer, *n* (%)	3 (9%)	150 (10%)	1.19	0.38–3.73	0.7646
Endocrine diseases, *n* (%)	4 (11%)	118 (8%)	0.70	0.26–1.91	0.4866
Hand hygiene compliance, *n*/*n* (%)	134/139 (96%)	2074/2233 (93%)	0.96	0.81–1.15	0.6761
Compliance with urinary catheter on thigh, *n*/*n* (%)	268/268 (100%)	7406/7406 (100%)	1.0	0.89–1.13	1.0
Compliance with urinary catheter collection bag hanging, *n*/*n* (%)	268/268 (100%)	7406/7406 (100%)	1.0	0.89–1.13	1.0

CI, confidence interval; RR, rate ratio; SD, standard deviation.
[a] For hand hygiene the relative risks rather than rate ratios are calculated.

4. Discussion

The burden of CAUTIs in critically ill patients has been widely addressed in the scientific literature worldwide. CAUTIs have been related to prolonged hospital LOS, bacterial resistance, morbidity, and increased healthcare costs.[2]

The incidence of CAUTI is frequently underestimated in hospitals from resource-limited countries, as in many cases basic infection control programs cannot be systematically implemented. If compared with rates in developed countries, the baseline rate of CAUTI found in this study (13.07 per 1000 urinary catheter-days) was 10-fold higher than that in the USA (1.5 CAUTI per 1000 urinary catheter-days determined by the CDC/NSHN[18]) and higher than that found in the KISS study (2.5 CAUTI per 1000 urinary catheter-days).[19]

In comparison with pooled CAUTI rates from developing countries, our CAUTI baseline rate was higher than the rates measured in the Fourth International INICC Report published in 2012 (6.3 CAUTIs per 1000 urinary catheter-days).[6]

As far as we know, there has been no single study addressing the effectiveness of CAUTI prevention programs in Lebanon, and the literature on this issue is extremely scant from developing countries.[1] In a previous study conducted in Lebanon in 1997, CAUTI was the third most common nosocomial infection (18%).[20] In a study in Saudi Arabia, the CAUTI rate was 11.4, which is similar to our baseline rate of 13.07.[21]

In our study, patient characteristics, such as age, gender, device use ratio, surgical stay, cancer, endocrine diseases, and abdominal surgery conditions, as well as urinary catheter mean duration, were similar and showed similar patient intrinsic risk in both study phases.

During the implementation of the INICC multidimensional approach, hand hygiene compliance remained high and was similar in both phases. Similarly, compliance rates with the correct position of the urinary catheter (over thigh) and collection bag hanging were 100% in both phases. A multivariate analysis reviewed by Salgado et al. reported catheter care violations among the five risk factors associated with the later development of a CAUTI.[22]

During the study period, the high CAUTI rate at baseline was reduced from 13.07 to 2.21 per 1000 urinary catheter-days, showing an 83% CAUTI rate reduction and evidencing the effectiveness of the applied multidimensional approach.

Regarding the microorganism profile, we identified a predominance of *Acinetobacter spp*, *Candida spp*, and *Escherichia coli* during the two periods; this is similar to the findings of other studies conducted in Lebanon.[23]

This study has many limitations. First, our findings are not to be generalized to all ICU patients in Lebanon. However, in this study it was shown that a multidimensional approach is fundamental to understanding and fighting the occurrence of CAUTI in the ICU setting in Lebanon. Second, the 3-month baseline period may have been too short and might have led to an overestimation of the effect of the intervention. Nevertheless, during the baseline period the sample size was sufficient and the confidence intervals for the baseline rate are narrow. In addition, this length of baseline period is common in the scientific literature. Third, we did not count on the necessary resources to collect more data on process surveillance and measure compliance with all the elements included in our bundle. Therefore, we could not evaluate the implications of individual interventions or other contextual factors related to the ICU or hospital. Specifically, we were not able to perform process surveillance for the following bundle components: insertion of urinary catheters only when needed and removal when unnecessary; use of indwelling urethral catheters for perioperative and for selected surgical procedures; urine output monitoring in critically

Table 2
Catheter-associated urinary tract infection rates stratified by length of participation of the intensive care unit in the International Nosocomial Infection Control Consortium (INICC); Poisson regression analysis

Months since joining INICC	Urinary catheter days, *n*	CAUTI, *n*	Crude CAUTI rate/ 1000 urinary-catheter days	IRR accounting for clustering by ICU	*p*-Value
1–3 months (baseline)	306	4	13.07	1.0	-
4–12 months	1325	6	4.53	0.35 (0.1–1.23)	0.1
Second year	2780	7	2.52	0.2 (0.056–0.66)	0.01
Third year	2194	8	3.65	0.28 (0.84–0.92)	0.037
Fourth year	3223	0	0.0	0 (-)	0.994

CAUTI, catheter-associated urinary tract infection; ICU, intensive care unit; IRR, incidence rate ratio.

ill patients; management of acute urinary retention and urinary obstruction; assistance in pressure ulcer healing for incontinent residents; to consider other methods for management, including condom catheters or in-and-out catheterization, when appropriate; to use as small a catheter as possible; use of gloves, a drape, and sponges; a sterile or antiseptic solution for cleaning the urethral meatus; a single-use packet of sterile lubricant jelly for insertion; to insert catheters by use of aseptic technique and sterile equipment; to empty the collecting bag regularly; to avoid allowing the draining spigot to touch the collecting container; and on the cleaning of the meatal area as part of routine hygiene. These data would greatly contribute to advance our knowledge with regard to quality improvement in this setting of a hospital in Lebanon and would provide an accurate description of the successful results of our approach. Nevertheless, our main goal was to reduce the high baseline CAUTI rates found in our ICUs, and although our interventions were inexpensive, the individual evaluations would have required more allocation of time, contributing to unnecessary harm for ICU patients. Finally, we could not quantify in detail some of the non-quantifiable interventions included in our approach, such as education and training. Fortunately, as from January 2012, we have been able to collect all these process surveillance data.

In conclusion, this study is the first multicenter study to report a substantial reduction in CAUTI rates in the ICU setting of Lebanon, showing this kind of infection control approach to be successful. Although the intrinsic risk in some patients was higher during the intervention period, a multidimensional approach including improved compliance with CAUTI prevention measures resulted in significant reductions in the CAUTI incidence rate. Good as it is, it is worth highlighting that the reduction in CAUTI rates does not derive from surveillance itself. This systematically collected data should serve to guide healthcare professionals in their strategies for improving patient care practices, such as performance feedback, as demonstrated in several previous studies conducted in resource-limited countries.[14]

These preventive strategies found to be effective in the INICC ICUs of Lebanon could promote a wider acceptance of infection control programs in hospitals, leading to significant CAUTI reductions worldwide. Within the INICC network, investigators are provided with training and methodological tools to perform outcome and process surveillance, and to implement effective infection prevention programs. Furthermore, the publication of these findings contributes to the fostering of relevant scientific evidence-based literature from developing countries. For this reason, every hospital is invited to participate in the INICC project, which was set up to respond to the compelling need in the developing world to significantly prevent, control, and reduce CAUTIs and their adverse effects.

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Ethical considerations: Every hospital institutional review board agreed to the study protocol, and patient confidentiality was protected by codifying the recorded information, making it only identifiable to the infection control team.

Conflict of interest: All authors report no conflicts of interest related to this article.

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