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Implementation of central venous catheter bundle in an intensive care unit in Kuwait: Effect on central line-associated bloodstream infections

Mona F. Salama[a,e,*], Wafaa Jamal[b,c], Haifa Al Mousa[d], Vincent Rotimi[b,c]

[a] *Infection Control Department, Mubarak Al Kabeer Hospital, Jabriya, Kuwait*
[b] *Microbiology Unit, Mubarak Al Kabeer Hospital, Jabriya, Kuwait*
[c] *Department of Microbiology, Faculty of Medicine, Kuwait University, Kuwait*
[d] *Infection Control Directorate, Ministry of Health, Kuwait*
[e] *Department of Microbiology and Medical Immunology, Faculty of Medicine, Mansoura University, Mansoura, Egypt*

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Summary Central line-associated bloodstream infection (CLABSIs) is an important healthcare-associated infection in the critical care units. It causes substantial morbidity, mortality and incurs high costs. The use of central venous line (CVL) insertion bundle has been shown to decrease the incidence of CLABSIs.

Our aim was to study the impact of CVL insertion bundle on incidence of CLABSI and study the causative microbial agents in an intensive care unit in Kuwait.

Surveillance for CLABSI was conducted by trained infection control team using National Health Safety Network (NHSN) case definitions and device days measurement methods. During the intervention period, nursing staff used central line care bundle consisting of (1) hand hygiene by inserter (2) maximal barrier precautions upon insertion by the physician inserting the catheter and sterile drape from head to toe to the patient (3) use of a 2% chlorohexidine gluconate (CHG) in 70% ethanol scrub for the insertion site (4) optimum catheter site selection. (5) Examination of the daily necessity of the central line.

During the pre-intervention period, there were 5367 documented catheter-days and 80 CLABSIs, for an incidence density of 14.9 CLABSIs per 1000 catheter-days.

* Corresponding author at: Infection Control Unit, Mubarak Al Kabeer Hospital, Ministry of Health, PO Box 715, 40158 Mishref, Kuwait. Tel.: +965 25312029.

E-mail address: mfodamd@yahoo.com (M.F. Salama).

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After implementation of the interventions, there were 5052 catheter-days and 56 CLABSIs, for an incidence density of 11.08 per 1000 catheter-days. The reduction in the CLABSI/1000 catheter days was not statistically significant ($P = 0.0859$).
This study demonstrates that implementation of a central venous catheter post-insertion care bundle was associated with a reduction in CLABSI in an intensive care area setting.

Introduction

Central venous catheters (CVCs) are increasingly used in inpatient and outpatient settings to provide long-term venous access. CVCs disrupt the integrity of the skin, leading to bacterial and/or fungal infections. Infection may spread to the bloodstream (bacteremia) with the possibility of consequent hemodynamic changes and organ dysfunction (severe sepsis), leading to death.

Approximately 90% of catheter-related bloodstream infections (CRBSIs) occur with CVCs [1]. Forty-eight percent of intensive care unit (ICU) patients have CVCs, accounting for 15 million central venous catheter-days per year in ICUs. Studies of catheter-related bloodstream infections (CRBSIs) suggest that they are among the most common healthcare-associated infections (HAI) and that they appear to control the underlying severity of the illness [2]. A report in 2013 by the Center for Disease Control and Prevention (CDC) National Health Safety Network (NHSN) indicates that CRBSI in ICUs ranges between 0.9 and 2.4 (mean 1.1) per 1000 catheter days in major teaching medical/surgical ICUs, which matches our ICU classification [3]. The pooled rate of CLABSI that was reported by the International Nosocomial Infection Control Consortium (INICC) is 4.9/1000 catheter days according to their 2014 report. This is nearly 5-fold higher than the rate reported from comparable US ICUs that was included in their last report. The INICC study was conducted from January 2007 to December 2012 in 503 intensive care units in Latin America, Asia, Africa, and Europe. Using the Center for Disease Control and Prevention's (CDC) U.S. National Healthcare Safety Network (NHSN) definitions for device-associated health care-associated infections, the authors collected data from 605,310 patients who were hospitalized in ICUs over 3,338,396 days [4]. Other studies have reported significant increases in the attributable mortality for these infections [5,6] as well as remarkable increases in the hospital length of stay and hospital cost [7,8]. It has been estimated that between 500 and 4000 US patients die annually because of bloodstream infections [9].

According to Eggimann et al. [10], a comprehensive infection control program including the meticulous sterile insertion technique and post-insertion care was associated with a 67% reduction in CLABSI incidence at a single center. In support of the 5 Million Lives campaign in the US, the Institute for Healthcare Improvement (IHI) (http://www.ihi.org/ihi) recommends that all ICUs should implement a central line bundle in an attempt to reduce the incidence of CLABSI to zero [11]. The concept of ''bundles'' that was developed by the IHI was to help healthcare providers more reliably deliver the best possible care for patients undergoing particular treatments with inherent risks. A bundle is a structured method of improving the processes of care and patient outcomes: a small, straightforward set of evidence-based practices—generally three to five—that, when performed collectively and reliably, have been proven to improve patient outcomes [12]. The science supporting the bundle components is sufficiently established to be considered the standard of care.

The purpose of this study was to evaluate the effectiveness of a ''Central Venous Line bundle'' (CVLB) implementation in our main ICU on the outcome of CLABSI and to establish the causative microorganisms.

Subjects and methods

Setting

The study was conducted between January 2010 and February 2012 in the main ICU of a general teaching hospital, a Ministry Of Health-run hospital affiliated with the Health Sciences Center of Kuwait University. The adult medical—surgical ICU consists of 2 wings with a capacity of 23 beds that are structurally identical and an occupancy rate of 100% at all times. It operates an open-staffing model with 3 beds in isolation rooms in each wing. Because this was considered to be a quality improvement study, we did not submit it for ethical approval by the Ministry of Health.

Design

This is a 26-month prospective cohort study that was conducted in 2 phases, a pre-intervention period to establish base-line total HCAI and CLABSI from January 2010 to January 2011 and a post-interventional period to measure HCAI and CLABSI from February 2011 to February 2012. The rates of HCAI and CLABSI were calculated per 1000 patient days and central line days, respectively. Patients fulfilling the criteria of the definition of HCAI were included in our study to calculate the total rate/1000 patient days, and from these, our focus was on patients with CLABSI to calculate the rate/1000 CVC days in both intervals.

Surveillance program

Infection surveillance was implemented for all patients who were admitted to the ICU with a stay longer than 48 h during the period from January 1, 2010, to February 29, 2012. The Center for Disease Control and Prevention (CDC) definitions of nosocomial infections [13] and the standard surveillance methods of the National Health Safety Network (NHSN) were used, as previously described [14]. The infection control team performed surveillance that involved ICU daily rounds, microbiology reviews and chart reviews. Kuwait National Health Surveillance System (KNHSS) worksheets were used. The following data were collected: patient's name, file number, age, nationality, bed number, admission date, diagnosis, duration of ICU stay, duration that the catheter was in place, and the isolated organism(s) from blood. CLABSI is a laboratory-confirmed bloodstream infection (LCBI) where the central line (CL) was in place for >2 calendar days on the date of the event, with the day of device placement being Day 1, and the CL was in place on the date of the event or the day before. The CLABSI rate was calculated as the number of all CLABSI per 1000 CVC days.

The number of patients with one or more central lines of any type was collected daily and was summed to calculate the number of catheter-days for each period of analysis. The catheter dwell time was defined as the number of days between catheter insertion and the onset of CLABSI symptoms. If a patient had a catheter *in situ* on the day of admission, that date was used as the insertion date. The catheter utilization proportion was calculated by dividing the number of catheter days by the number of patient-days for each time period.

Surveillance was conducted by a well-trained infection control team. They reviewed the medical record of every patient who had a positive blood culture by using a standard data collection form. Each case was then reviewed by the Infection Control Physician to ensure that it met the case definition. The reporting of all bloodstream infections was performed per 1000 patient catheter days.

Microbial identification

Bacteria were cultured using standard microbiological methods. They were identified by conventional methods according to the Kirby-Bauer disk diffusion technique and the VITEK 2 system (bioMérieux, Marcy, l'Etoile, France). The results of antibiotic susceptibility testing for the isolated microbes causing CLABSI were interpreted according to the recommendations of the Clinical Laboratory Standard Institute (CLSI) [15,16].

CVC bundle of care

A CVC insertion bundle was implemented in February 2011 in the main ICU; the bundle insertion procedure consisted of (1) hand hygiene by the inserter; (2) maximum barrier precautions, including the donning of sterile gloves, gowns, caps and masks by the physicians who inserted the catheter before beginning the procedure and a head-to-toe sterile drape of the patient during insertion; (3) use of a 2% chlorhexidine gluconate (CHG) in 70% ethanol scrub at the insertion site; (4) optimal catheter site selection with avoidance of the femoral vein for central venous access in adult patients; and (5) daily examination of the necessity of the central line. Physicians were trained in the aseptic technique for CVC insertion by presentations that were carried out by the infection control team at the beginning of the rotation. Nursing staff were empowered to halt the procedure if a break in sterile technique was observed, and they were tasked with monitoring compliance with the insertion bundle. For recording overall compliance for the central line, it was ''ALL OR NONE'', that is, even if one element of the bundle was missing on the day of inspection, the case would not be in compliance with the bundle. The central lines were check, but not the patients. In addition, the central

Table 1 Characteristics of patients with CLABSI comparing pre-intervention and post-intervention periods.

Patient characteristics	Before intervention	After intervention	*P* value
Mean length of stay	31.78	41.39	0.02523
Male (%)	66.25	53.57	0.135669
Mean age	57.9	59.16	0.687256
Percentage of deaths	20	17.86	0.628929
Site of central venous catheter			0.015037
Internal Jugular	50	24	
Subclavian	31	39	
Femoral	7	8	
Days' duration of CVC	**30.025**	**40.16**	**0.013849**

CLABSI, central line associated bloodstream infection; CVC, central vascular catheter.
The entries in bold correspond to the mean duration of CVC insertion in days in the pre and post intervention periods, showing significant lower duration of catheter insertion period after the bundle implementation.

line days rather than patients were counted. The Infection Control Team entered the main ICU three times per week to spot-check all patients with central lines and assess them for compliance with the CVLB.

Compliance measurement calculations

Compliance with each individual bundle element was calculated with a special form by dividing the total number of patient central line days compliant to the given element by the total number of patient central line days examined for compliance with the element (%). Total CVL bundle compliance was also calculated using the following equation:

$$\frac{\text{Total number of patient-days compliant with combined 5 central line bundle} \times 100}{\text{Total number of patient catheter-days examined for combined 5 central line bundle}}$$

Statistical methodology

Data were collected, coded and entered into an IBM compatible computer, using SPSS version 19 for Windows. The entered data were checked for accuracy and then for normality using the Kolmogorov—Smirnov test. Qualitative variables were expressed as a number and percentage, while the quantitative variables were expressed as the mean (X) and standard deviation (S).

The following statistical tests were used: (1) The χ^2-test was used as a non-parametric test of significance for comparison between the distribution of two qualitative variables and (2) Fisher's exact test was used as a non-parametric test of significance for comparison between the distribution of two qualitative variables whenever the χ^2-test was not appropriate. Fisher's exact test gives a *P*-value directly. A 5% level was chosen as being statistically significant.

Results

The characteristics of patients with CLABSI during the pre- and post-intervention periods re summarized in Table 1. There was no significant difference among the studied criteria among patients in both the pre- and post-intervention periods, except for the duration of catheter insertion and the mean length of stay, which were significantly increased during the pre-intervention period (Table 1).

Compliance with the different elements of the CVL insertion bundle showed fluctuation throughout the period of observation (Table 2). During the pre-intervention period from January 1, 2010, to January 31, 2011, there were 7161 patient-days and 5367 documented catheter-days, with a total of 80 reported CLABSI episodes, for an incidence density of 14.9 CLABSIs/1000 catheter days and a catheter utilization proportion of 0.75. After implementation of the interventions (February 1, 2011 to February 29, 2012), there were 6474 patient-days and 5052 catheter-days with a total of 56 reported CLABSI episodes for an incidence density of 11.08 per 1000 catheter days. The reduction in the CLABSI/1000 catheter days was not statistically significant ($P = 0.0859$) (Table 3). The catheter utilization proportion was 0.79. In this study, the number of reported episodes of health care-associated CLABSI was equal to that of the causative microorganisms (Table 4). There was a reported decrease in Gram-negative microorganisms causing CLABSI during the post-intervention period (except for *Stenotrophomonas maltophilia*), which were not frequently isolated even before the CVL bundle implementation (Table 4).

Table 2 Central venous line bundle compliance rates (%) from February 2011-February 2012 in the main intensive care unit.

Bundle element	Compliance rates (%) in the month of												
	February 2011	March 2011	April 2011	May 2011	June 2011	July 2011	August 2011	September 2011	October 2011	November 2011	December 2011	January 2012	February 2012
Total central line days	108	169	80	136	137	139	131	145	158	92	110	127	96
1. Hand hygiene by inserter	94.44	80.47%	97.5%	91.91%	97.08%	99.28%	92.36%	97.93	97.46	100	100	100	95.83
2. Maximal barrier precautions upon insertion	92.59	75.73%	83.75%	77.20%	85.40%	92.08%	92.36%	94.48	98.10	90.21	84.54	98.42	92.7
3. Chlorhexidine (2% in 70% isopropyl alcohol) skin antisepsis upon insertion	73.14%	76.33%	97.5%	91.91%	97.08%	99.28%	92.36%	97.93	100	100	98.18	98.42	88.54
4. Optimal catheter site selection (with avoidance of the femoral vein for central venous access in adult patients)	91.66%	79.28%	83.75%	83.08%	90.51%	98.56%	92.36%	95.86	96.83	97.82	100	100	97.91
5. Daily review of line necessity with prompt removal of unnecessary lines	83.33%	67.45%	83.75%	73.52%	88.32%	92.08%	89.31%	95.17	95.56	97.82	95.45	94.48	98.95
Total	61.11%	57.39%	66.25%	51.47%	71.53%	84.17%	82.44%	92.41	89.87	90.21	80.9	91.33	77.08

Table 3 CLABSI rates in the main intensive care unit before and after implementation of bundles.

Infection	Before intervention	After intervention	*P* value
CLABSI/1000 CVL days	14.9	11.08	0.0859
Central line days	5367	5052	0.339554
Patients' days	7161	6474	0.08261

HCAI, healthcare associated infection; CLABSI, central line associated bloodstream infection; CVL, central venous line

Discussion

The implementation of CVL bundles of care was initiated in our main ICU in February 2011 as a measure for healthcare improvement. Compliance with the CVL bundle elements showed fluctuations throughout the period of observation and was attributed to periods of low nurse: patient ratios, resulting in a lack of compliance. The noticeable low compliance with the CVLB during March, April and May 2011 coincided with periods of reported high CLABSI/1000 catheter days of 18.04, 14.07, 16.85, respectively.

Chlorhexidine gluconate (2% in 70% isopropyl alcohol) was used for skin antisepsis upon insertion of central line catheters instead of povidone iodine, which was used in other areas of the hospital where the CVL bundle was not yet implemented. Our findings demonstrate that implementation of a CVL insertion care bundle was associated with a decrease in the total CLABSI/1000 central line days from 14.9 to 11.08 infections; however, the difference was not statistically significant ($P = 0.0859$). It is important to note that during the month of June 2011, no healthcare associated CABSI were reported; this could be attributed to the period following the introduction of hand hygiene observational and educational campaigns that were conducted in May 2011 [17]. One study conducted by Rosenthal el al. addressed that the education, performance feedback, and outcome and process surveillance of CLABSI rates significantly improved infection control adherence, reducing the CLABSI incidence by 54% and the number of CLABSI-associated deaths by 58% in INICC hospitals during the first 2 years [18].

The number of CLABSIs in our ICU that were caused by multidrug-resistant (MDR) organisms decreased from 80 organisms in the pre-implementation period to 56 in the post-implementation period with CVL bundles of care; this finding is in agreement with a previous study that showed that the overall infection rates decreased with an improvement in CRBSIs in all of the ICUs that participated [19]. Although the proportion of Gram-negative organisms did not change significantly in that study, there was a significant decrease in the proportion of Gram-positive infections [19]. In a study similar to ours, 9938 central line days were included from a total of 1395 central venous catheters, demonstrating that the average number of CLABSI per 1000 catheter days decreased from 5.0 to 0.90 ($P < .001$) after the initiation of CVC bundle intervention [20]. Further studies that were considered to be multimodal, multidisciplinary, hospital-wide training strategies in successfully reducing CLABSI suggested that a clinically relevant reduction of hospital-wide CLABSI was reached with a comprehensive, multidisciplinary and multimodal quality improvement program including aspects of behavioral change and key principles of good implementation practice [21,22].

However, our results were somewhat different from those in the study conducted by Guerin et al. [23], which demonstrated a significant

Table 4 Microorganisms implicated in central line associated bloodstream infection in the main intensive care unit before and after implementation of bundles.

Microorganism	Before intervention	After intervention
Klebsiella pneumoniae	12	8
Acinetobacter baumannii	14	10
P. aeruginosa	21	14
E. coli	5	2
Enterococcus faecalis	4	1
Candida spp.	4	3
S. epidermidis	3	5
Proteus mirabilis	3	1
MRSA	2	1
Stenotrophomonas maltophilia	4	5
Serratia marcescens	4	2
Enterobacter cloacae	4	3
Citrobacter koserii		1
Total CLABSI	80	56

P value 0.081206.
CLABSI, central line associated bloodstream infection.

association between the implementation of a CVC post-insertion care bundle and a reduction in CLABSI. We achieved the same type of noticeable decrease in CLABSI that was demonstrated by this group, who reported an incidence density of 5.7 CLABSIs per 1000 catheter-days pre-intervention and 3 CLABSIs, for an incidence density of 1.1 per 1000 catheter-days after implementation of the interventions.

In the main ICU of our hospital, CLABSI are among the most commonly reported healthcare associated infections (HCAI), accounting for 34.1%, and 42.3% of the total HCAI reported in 2010 and 2011, respectively. Our surveillance data indicated an ongoing high incidence density of CLABSI in relation to the HCAI from other sites that led us to review each case for clues regarding the underlying reason for the high incidence. We found no commonalities in physician staff, services, admission diagnoses, or pathogens. We noted that the median *in situ* time between catheter insertion and onset of infection was 14 days, which led us to suspect that events occurring after insertion might be responsible for the infections.

Compliance with sterile technique at the time of CVL insertion was not sufficient by itself to prevent CLABSI because the insertion of a CVC results in the ongoing presence of a foreign body traversing the cutaneous barrier. Part of the limitations of this study was that meticulous post-insertion site care to prevent CLABSI was not included in this study. As we carried out staff education and reinforcement of proper CVL care after insertion, along with careful cleaning of the hub before each access, this might have contributed, in part, to the reduction in infection incidence that was noted in our study. The elements of post-insertion care, including hand hygiene, chlorhexidine for site cleansing [24], chlorhexidine-impregnated sponges [25] and attention to decontamination of access ports with each use [26], were reinforced in our hospital. In spite of these post-insertion care measures, the results of our study showed a non-significant reduction in the total reported CLABSI before and after CVL bundle implementation, which suggests that reducing the CLABSI rates in an ICU setting is a complex process that probably involves other factors in addition to CVL bundle implementation alone. This should be an area for further research in the future when we will start the implementation of catheter maintenance bundles of care in addition to the currently implemented insertion bundle. This study was also limited by the absence of data with regards to the extra costs that were attributable to CLABSI in addition to the inclusion of a single adult ICU.

Conclusion

CLABSI are expensive, common, and potentially fatal. Reduction in the CLABSI rate at our institution coincided with the implementation of the CVL bundle. Our current series demonstrates a noteworthy decrease, albeit a non-statistically significant decrease, in the rate of CLABSI, a benefit that was sustained throughout the study. From our study, it can be inferred that the broad use of CVLB will significantly reduce the cost and morbidity of CLABSIs; thus, the adoption of CVLB nationwide is highly recommended.

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Competing interests

None declared.

Ethical approval

Not required.

References

[1] Mermel LA. Prevention of intravascular catheter-related infections. Ann Intern Med 2000;132:391—402.

[2] Climo M, Dickema D, Warren DK, Herwaldt LA, Perl TM, Peterson L, et al. Prevalence of the use of central venous access devices within and outside of the intensive care unit: results of a survey among hospitals in the prevention epicenter program of the Centers for Disease Control and Prevention. Infect Control Hosp Epidemiol 2003;24: 942—5.

[3] Dudeck MA, Edwards JR, Allen-Bridson K, Gross C, Malpiedi PJ, Peterson KD, et al. National Healthcare Safety Network report, data summary for 2013. Device-associated Module. Am J Infect Control 2015;43(3):206—21.

[4] Rosenthal VD, Maki DG, Mehta Y, Leblebicioglu H, Memish ZA, Al-Mousa HH, et al. International Nosocomial Infection Control Consortium (INICC) report, data summary of 43 countries for 2007—2012. Device-associated module. Am J Infect Control 2014;42:942—56.

[5] Sheretz RJ, Ely EW, Westbrook DM, Gledhill KS, Streed SA, Kiger B, et al. Education of physicians-in-training can decrease the risk of vascular catheter infection. Ann Intern Med 2000;132:641—8.

[6] Warren DK, Quadir WW, Hollenbeak CS, Elward Am Cox MJ, Fraser VJ. Attributable cost of catheter-associated bloodstream infections among intensive care patients in a nonteaching hospital. Crit Care Med 2006;34:2084—9.

[7] Warren DK, Cosgrove SE, Diekema DJ, Zuccotti G, Climo MW, Bolon MK, et al. A multicenter intervention to prevent

catheter-associated bloodstream infections. Infect Control Hosp Epidemiol 2006;27:662—9.
[8] Warren DK, Zack JE, Mayfield JL, Chen A, Prentice D, Fraser VJ, et al. The effect on an education program on the incidence of central venous catheter-associated bloodstream infection in a medical ICU. Chest 2004;126:1612—8.
[9] Soufir L, Timsit JF, Mahe C, Carlet J, Regnier B, Chevret S. Attributable morbidity and mortality of catheter-related septicemia in critically ill patients: a matched, risk-adjusted, cohort study. Infect Control Hosp Epidemiol 1999;20:396—401.
[10] Eggimann P, Harbarth S, Constantin MN, Touveneau S, Chevrolet JC, Pittet D. Impact of a prevention strategy targeted at vascular-access care on incidence of infections acquired in intensive care. Lancet 2000;355:1864—8.
[11] Pronovost P, Needham D, Berenholtz S, Sinopoli D, Chu H, Cosgrove S, et al. An intervention to decrease catheter-related bloodstream infections in the ICU. N Engl J Med 2006;355:2725—32.
[12] Resar R, Pronovost P, Haraden C, Simmonds T, Rainey T, Nolan T. Using a bundle approach to improve ventilator care processes and reduce ventilator-associated pneumonia. Jt Comm J Qual Patient Saf 2005;31:243—8.
[13] Horan TC, Andrus M, Margaret A. CDC/NHSN Surveillance definition of health care-associated infection and criteria for specific types of infections in the health care setting. Am J Infect Control 2008;36:309—32.
[14] Centers for Disease Control and Prevention National Healthcare Safety Network Manual. Patient safety component protocol; 2008, January. Available from: http://www.cdc.gov/nhsn/PDFs/pscManual/4PSC_CLABScurrent.pdf [accessed 09.12.09].
[15] Barrow GI, Feltham RKA. Cowan and steel's manual for the identification of medical bacteria. 3rd ed. Cambridge: Cambridge University Press; 1993.
[16] Clinical Laboratory Standards Institute (CLSI). Performance standards for antimicrobial susceptibility testing. 24th Informational Supplement. Document M100-S24. Wayne, PA: CLSI; 2014.
[17] Salama MF, Jamal WJ, Al Mousa H, Al-AbdulGhani KA, Rotimi VO. The effect of hand hygiene compliance on hospital-acquired infections in an ICU setting in a Kuwaiti teaching hospital. J Infect Publ Health 2013;6:27—34.
[18] Rosenthal VD, Maki DG, Rodrigues C. et al: Impact of International Nosocomial Infection Control Consortium (INICC) strategy on central line-associated bloodstream infection rates in the intensive care units of 15 developing countries. Infect Control Hosp Epidemiol 2010;31:1264—72.
[19] Kim JS, Holtom P, Vigen C. Reduction of catheter-related bloodstream infections through the use of a central venous line bundle: epidemiologic and economic consequences. Am J Infect Control 2011;39(8):640—6.
[20] Galpern D, Guerrero A, Tu A, Fahoum B, Wise L. Effectiveness of a central line bundle campaign on line-associated infections in the intensive care unit. Surgery 2008;144(4):492—5.
[21] Marra AR, Cal RG, Durao MS, Correa L, Guastelli LR, Moura Jr DF, et al. Impact of a program to prevent central line-associated bloodstream infection in the zero tolerance era. Am J Infect Control 2010;38(6):434—9.
[22] Rosenthal VD, Guzman S, Pezzotto SM, Crnich CJ. Effect of an infection control program using education and performance feedback on rates of intravascular device-associated bloodstream infections in intensive care units in Argentina. Am J Infect Control 2003;31:405—9.
[23] Guerin K, Wagner J, Rains K, Bessesen M. Reduction in central line-associated bloodstream infections by implementation of a postinsertion care bundle. Am J Infect Control 2010;38:430—3.
[24] Marschall J, Mermel LA, Classen D, Arias KM, Podgorny K, Anderson DJ, et al. Strategies to prevent central line-associated bloodstream infections in acute care hospitals. Infect Control Hosp Epidemiol 2008;29:S22—30.
[25] Maki DG, Ringer M, Alvarado CJ. Prospective randomized trial of povidone-iodine, alcohol, and chlorhexidine for prevention of infection associated with central venous and arterial catheters. Lancet 1991;338:339—43.
[26] Timsit JF, Schwebel C, Bouadma L, Geffroy A, Garrouste-Org Pease S, et al. Chlorhexidine-impregnated sponges and less frequent dressing changes for prevention of catheter-related infections in critically ill adults: a randomized controlled trial. JAMA 2009;301:1231—41.