

BLOODSTREAM INFECTIONS AMONG PATIENTS USING CENTRAL VENOUS CATHETERS IN INTENSIVE CARE UNITS

Eni Rosa Aires Borba Mesiano¹
Edgar Merchán-Hamann²

Mesiano ERA, Hamann EM. Bloodstream infections among patients using central venous catheters in intensive care units. Rev Latino-am Enfermagem 2007 maio-junho; 15(3):453-9.

Central Venous Catheters (CVC), widely used in Intensive Care Units (ICU) are important sources of bloodstream infections (BSI). This prospective cohort epidemiological analytical study, aimed to infer the incidence of BSI, the risk factors associated and evaluate the care actions related to the use of these catheters in seven ICU in the Federal District - Brasília, Brazil. From the 630 patients using CVC, 6.4% developed BSI (1.5% directly related to the catheter and 4.9% clinic BSI). The hospitalization term was 3.5 times greater among these patients. Different modalities of catheter insertion and antiseptic substances use were observed. Time of CVC permanence was significantly associated to infection incidence ($p < 1 \times 10^{-8}$) as well as the right subclavian access and double-lumen catheters. Patients with neurological disorders and those submitted to tracheotomy were the most affected. We suggest the organization of a "catheter group" aiming to standardize procedures related to the use of catheters in order to reduce the hospitalization term and hospital costs.

DESCRIPTORS: cross infection; intensive care units; prevention and control

INFECCIÓN DE CORRIENTE SANGUÍNEA EN PACIENTES CON CATÉTER VENOSOS CENTRAL EN UNIDADES DE CUIDADO INTENSIVO

Los catéteres venosos centrales (CVC) utilizados principalmente en unidades de cuidados intensivos - UCIs, son importantes fuentes de infección de la corriente sanguínea (ICS). Este estudio epidemiológico analítico, de corte prospectivo, enfoca la incidencia de ICS, factores de riesgo asociados y medidas asistenciales relacionadas con el uso de estos catéteres en 7 UCIs del Distrito Federal. Del total de 630 pacientes con CVC, 6,4% presentaron ICS (1,5% relacionado al catéter y 4,9% ICS-Clinica). El tiempo de hospitalización fue 3,5 veces mayor para este grupo de pacientes. Fueron observadas diferentes conductas con relación a la inserción de catéteres y al uso de antisépticos. El tiempo de permanencia del CVC estuvo asociado a la incidencia de infección ($p < 1 \times 10^{-8}$) así como a la punción en la vena subclavia derecha y al catéter de doble lumen. Pacientes neurológicos y con traqueotomía fueron los más afectados. Se sugiere la formación de un "grupo de catéter", destinado a estandarizar el uso de los catéteres, para de esta forma, se reduzca el tiempo de hospitalización y los costos hospitalarios.

DESCRIPTORES: infección hospitalaria; unidades de terapia intensiva; prevención & control

INFEÇÕES DA CORRENTE SANGUÍNEA EM PACIENTES EM USO DE CATETER VENOSO CENTRAL EM UNIDADES DE TERAPIA INTENSIVA

Os cateteres venosos centrais (CVC), utilizados, principalmente em unidades de terapia intensiva-UTIs, são importantes fontes de infecção da corrente sanguínea (ICS). Este estudo epidemiológico analítico, tipo coorte prospectiva, enfoca a incidência de ICS, fatores de risco associados e ações assistenciais relacionadas ao uso desses cateteres em 7 UTIs no Distrito Federal. Dos 630 pacientes com CVC, 6,4% apresentaram ICS (1,5% relacionadas ao cateter e 4,9% ICS-Clinica). A permanência de internação foi 3,5 vezes maior para esse grupo de pacientes. Observou-se condutas diversificadas com relação à inserção dos cateteres e o uso de anti-séptico. O tempo de permanência do CVC mostrou-se associado à infecção ($p < 1 \times 10^{-8}$), assim como à punção em veia subclávia direita e a cateter de duplo-lúmen. Pacientes neurológicos e os traqueostomizados foram os mais acometidos. Sugere-se a formação de um grupo de cateter, para padronizar rotinas relacionadas ao uso dos cateteres no intuito de reduzir o período de internação e os custos hospitalares.

DESCRIPTORES : infecção hospitalar; unidades de terapia intensiva; prevenção & controle

¹ Doctoral Student in Health Sciences University of Brasília; Technical Consultant of the General Management of Saneantes - GGSAN/ANVISA; ² PhD, Professor University of Brasília, Health Sciences School, Collective Health Department

INTRODUCTION

Intravascular catheters are essential in modern medicine, particularly at intensive care units (ICUs). However, they constitute an important source of primary blood stream infection. Approximately 150 million catheters are punctured every year at hospitals and clinics in the United States, more than 5 million of which are central venous catheters⁽¹⁾. As a result of technological advances, venous access is maintained longer and used more frequently, hence entailing an increased number of infections related to this procedure. The hospitals from the National Nosocomial Infection Surveillance System (NNISS) of the Centers for Disease Control and Prevention (CDC) in the United States have published blood stream infection (BSI) rates at intensive care units, which range from 4.9 at cardiothoracic intensive care units and 11.9 at trauma units, per 1,000 central catheters-day, for the period from 2002-2004⁽²⁾. Before, the NNISS had already published a rate of 3.48 per 1,000 discharges. Argentinean data register 2.92% of these infections⁽³⁾.

Infection risk related to vascular access is associated with the access location, the inserted solution, the experience of the professional who performs the procedure, dwelling time, type and catheter handling, among others⁽⁴⁾. These factors constitute important strategic points for actions to prevent these infections.

Although the incidence of blood stream infection is lower than of other hospital infections (HI) like lung, urinary tract and surgical site infections, blood stream infections are important because they are a cause of substantial morbidity, mortality and increased hospital costs⁽³⁻⁴⁾. North American data register an extended hospitalization period, ranging from 6.5 to 22 days⁽⁵⁾. A study in Argentina found a cost surplus of \$4888 and an extension of the hospitalization period by 11.9 days per blood stream infection episode⁽³⁾.

This study aims to calculate the incidence and risk factors associated with blood stream infections caused by Central Venous Catheters (CVC) at intensive care units from hospitals in the Single Health System (SUS) hospital network of the Federal District, Brazil. In addition, this research intends to contribute to the elaboration of actions to prevent and control blood stream infections in patients using central

venous catheters, as well as to achieve the rational use of this procedure.

PATIENTS AND METHODS

We carried out an epidemiological-analytic prospective cohort study in a clinical environment, including all patients, independently from the baseline pathology, type of ICU, medication use etc., admitted at 7 adult intensive care units from hospitals in the Federal District, in the period from February 21st to December 26th 2003. The presence of any earlier infection was not considered either, due to the criterion used to diagnose the blood stream infection, which could not be related to another infection focus.

Study participants were all adult patients hospitalized at these intensive care units who used a central venous catheter for more than 24 hours, to administer solutions, medication and hemoderivative drugs. At that moment, the ICUs were studied in general, without taking into account their type. The study involved ICUs with medical, surgical or mixed clinical patients. All central venous catheters used were made of polyurethane. Only patients who were hospitalized and used a catheter for less than 24 hours were excluded, as mentioned above. We carried out a pretest with 40 patients from an intensive care unit of another hospital from the Federal District, used for this goal only, during a 30-day period, and made the necessary adjustments in the data collection instrument. These patients were not included in the definitive study.

The collected data were registered by the researcher in individual files with the daily evolution, from the patient's entry at the intensive care unit until his/her discharge or transference. Discharge was considered to be the moment when the patient was sent to another place outside the hospital of origin and transference when the patient was sent to a unit in the same hospital. In this case, the patient was followed for two more days.

This study was observational, with the researcher's full dedication, and also benefitted from the ICUs physical proximity, three of which were located at the same hospital. Factors like: access location, catheter dwelling time and number of lumens, hospitalization time, among others,

were registered. The catheter insertion technique and the professional who carried out the procedure were not assessed, as a large majority of the patients were catheterized at the emergency units. Peripheral blood cultures were carried out in all patients with a fever or other signs of infection. The catheters were removed when their use had become unnecessary, in case of obstruction or accidental loss, and submitted to cultures (semi-quantitative in five intensive care units and quantitative in the rest). To obtain the diagnosis of blood stream infection, a technique was used with the catheter in place, without the need to remove it.

This article reports initial results of a larger project, aimed at assessing the incidence of infections in patients at the mentioned intensive care units, and was approved by the Institutional Review Board from the Federal District Health Secretary (SES-DF).

The criteria recommended by the CDC⁽⁶⁾ were used for the diagnosis. Catheters with negative results of microorganism cultures were considered sterile. Clinical Blood Stream Infection (C-BSI) was diagnosed when the patient presented at least one of the signs or symptoms without another identified cause: fever (temperature $\geq 38^\circ$ C), pain, erythema or heat of the involved vascular site and >15 Colony Forming Units (CFU), isolated from the tip of the intravascular catheter, and blood culture with a negative result or not accomplished. Catheter-Related Blood Stream Infection (CR-BSI) occurred when the patient presented the above criteria associated with positive blood culture, with the same microorganism isolated from the catheter tip.

STATISTICAL ANALYSIS

Data were analyzed using EPI INFO, version 6.2. Frequency tables were used to summarize the diagnoses of patients using a catheter, according to gender and catheter dwelling time. The percentage of patients with blood stream infection, with or without a risk factor, was compared using Fisher's Exact test or Pearson's Chi-Square test. We calculated the Relative Risk (RR), a 95% Confidence Interval and the associated p-value. The significance level was $p < 0.05$. Mean/median tests (Student's t and Kruskal-Wallis) were carried out to check for differences in

the numerical variables between patient groups, maintaining the same significance level.

RESULTS

During the study period, 1,165 patients were hospitalized at the 7 intensive care units, 1,006 of whom (49.4% female and 50.6% male) remained hospitalized at these units for more than 24 hours. The mean age was 48 ± 20.5 years and the median 47 years; the mean stay in hospital lasted 11.5 ± 15 days and the median 6 days. In the total group (1,006), 630 (62.6%) used a central venous catheter, 40.8% of whom were women and 59.2% men, who constituted the final study population (RR=1.64; 95% CI=1.41-1.90; $p=1 \times 10^{-8}$).

Among the 630 patients who used a central venous catheter, 40 (6.4%) presented blood stream infection, 9 (1.5%) of which catheter-related and 41 (4.9%) clinical. The difference observed in the incidence of blood stream infection (57.5% female and 42.5% male cases) was not statistically significant (RR=0.84; 95% CI=0.58-1.21; $p=0.30$). On the other hand, the presence of infection significantly increased the duration of the patients' stay at the ICUs, with a mean stay of 40.3 days, approximately 3.5 times longer than patients without infection, with a mean stay of 11.5 days (Kruskal-Wallis test; $p < 1 \times 10^{-8}$). Definitely, this increase in the duration of hospitalization is directly related with the severity of the patient's case, and not only with the presence of infection.

No catheter inserted in another unit was changed when the patient was admitted at the intensive care unit, except on one occasion, when the catheter was changed using the guide wire. None of the ICUs had an established Catheter Commission. As these hospitals had a medical residence program, usually, the procedure was carried out by the resident physicians, supervised by the physician responsible for the unit. Only one of the ICUs referred its patients for catheterization at the Surgery Center. Despite the absence of standardized routines for all ICUs, in all punctures, the physicians used surgical gloves, mask, cap and gown.

There exists a consensus about the benefits of using chlorhexidine dressings, although 70% alcohol and 10% alcoholic PVPI also protect against infection. In this study, we observed the lack of standardization of the antiseptic agent used on the puncture site, both

at the time of catheter installment and dressing replacement. In most cases, PVPI was used and, if absent, cleaning was done using physiological serum. This lack of standardization did not allow us to assess the use of antiseptic agent as a risk factor for blood stream infection.

The dressing used on the puncture site should be permeable to water steam, comfortable for the patient and easy to handle for health professionals and/or patients. It can be transparent or using gauze fixed with adhesive tape. The advantage of transparent dressings is that they permit the visualization of the insertion orifice, promote a barrier against dirt and that changes are less frequent, as they favor constant assessment by health professionals. There is no consensus about infection risk and its association with intravascular catheter dressings. What is important is that the gauze dressing should be replaced whenever humid, dirty or loose. In the catheters followed in this study, the dressings of the insertion site were replaced by nurses every 48 hours or whenever necessary, in line with the above orientations, using sterile gauze and the available antiseptic agent. The site was protected with sterile gauze and adhesive tape. As the used antiseptic agent was not standardized, dressing change could not be assessed either as a risk factor for infection.

Among the complications related to the CVC, 45.4% of the patients presented fever, 3.5% pneumothorax, 2.5% presence of secretion on the insertion site and 1% accidental catheter loss. All 40 patients who developed blood stream infection had a temperature $\geq 38^{\circ}\text{C}$.

Table 1 – Frequency distribution of patients with and without infection, according to catheter dwelling time, at 7 ICUs from the SUS network in the Federal District, 2003

Catheter dwelling time	Infection		No infection		Total	
	N	%	N	%	N	%
1 to 7	1	2,5	307	52*	308	48,9
8 to 14	7	17,5	155	26,2	162	25,7
15 to 21	7	17,5	70	18,9	77	12,2
More than 21	25	62,5*	58	9,8	83	13,2
Total	40	6,4	590	93,7	630	100

p<0.05

It is observed in Table 1 that 62.5% of the patients with blood stream infection used a CVC for more than 21 days. The difference was highly significant from a statistical perspective when

comparing the catheter dwelling time with the presence of infection ($p < 1 \times 10^{-8}$). More than half (52%) of the patients who did not present infection used a CVC for up to 7 days.

Table 2 – Frequency distribution of patients with and without infection according to catheter insertion site, at 7 ICUs from the SUS hospital network in the Federal District, 2003

Catheter insertion site	Infection		No infection		Total	
	N	%	N	%	N	%
Left femoral vein	0	0	4	0,7	4	0,6
Right femoral vein	0	0	0	0	0	0
Left arm	0	0	1	0,2	1	0,2
Right arm	0	0	0	0	0	0
Left jugular vein	3	7,5	1	0,2	4	0,6*
Right jugular vein	7	17,5	44	7,5	51	8,1*
Left subclavian vein	10	25*	130	22	140	22,2
Right subclavian vein	20	50*	410	69,5	430	68,2
Total	40	6,4	590	93,7	630	100

(*) p<0.05

Table 2 registers that 68.2% of the catheters were inserted in the right subclavian vein, which can justify the incidence of 50% of BSI when this access was used, and 75% when adding the access through the left subclavian vein. The occurrence of infections was very considerable when the right and left jugular vein were used.

We found a higher blood stream infection coefficient in patients were neurological pathologies (30%), followed by heart diseases (17.5%). The remainder was distributed in smaller percentages: patients with gastro-intestinal (12.5%), respiratory (12.5%), orthopedic (10%), kidney (7.5%), gynecological-obstetric (5%) and infectious pathologies (5%).

Table 3 – Frequency distribution of patients with and without infection according to number of lumens in the catheters, at 7 ICUs from the SUS hospital network in the Federal District, 2003

Number of lumens	Infection		No infection		Total	
	N	%	N	%	N	%
Single lumen	6	15	129	21,9	135	21,4
Double lumen	34	85*	460	78	494	78,4
Triple lumen	0	0	1	0,2	1	0,1
Total	40	6,4	590	93,7	630	100

(*) p<0.05

Table 3 presents the frequency of blood stream infection and the number of lumens used in the central venous catheter. Although the lumen is

considered a risk factor for blood stream infection, we found no statistical difference when comparing patients who used a central venous catheter and displayed infection with the number of lumen in the used catheter (p=0.93). We observed a preference for using double lumen catheters (78.4%) and higher infection levels (85%) when this type of catheter was used.

Table 4 – Frequency distribution of patients with and without infection according to used invasive procedures, at 7 ICUs from the SUS hospital network in the Federal District, 2003

Presence of risk factors	Infection	No infection	RR	CI	P-value
	%	%			
Respirator	87,5	79,1	1,3	1.16-1,49	0,0061
Orotracheal tube	87,5	78,1	1,3	1.16-1,49	0,0059
Blood transfusion	77,5	45,8	1,9	1.60-2,31	0
Thoracic drain	20	26,8	0,9	0.50-1,76	0,833
Tracheotomy	77,5	16,3	4,9*	3.68-6,60	0
Double lumen catheter hemodialysis	30	10,2	2,9*	1.75-4,85	0
Phlebotomy	27,5	8,1	2,5	1.45-4,22	0,0016
Total parenteral nutrition	10	4,4	3,0*	1.26-7,21	0,01251

(*) p<0.05

In Table 4, we observe that most of the invasive procedures used in the patients at the 7 ICUs revealed to be associated with the blood stream infection, with a high level of statistical significance. In tracheotomy patients, a relative risk (RR) of 4.93 is observed, followed by the use of total parenteral nutrition and double lumen catheter for hemodialysis, with an RR of 3 and 2.9 respectively.

Table 5 – Frequency distribution of patients with blood stream infection according to infectious agent, at 7 ICUs from the SUS hospital network in the Federal District, 2003

Infectious agent	Infection	
	N	%
Gram-negative	<i>Pseudomonas aeruginosa</i>	13 32,5*
	<i>Acinetobacter baumannii</i>	7 17,5
	<i>Klebsiella pneumoniae</i>	1 2,5
Gram-positive	<i>Staphylococcus aureus</i>	14 35*
	<i>Staphylococcus coagulase negativa</i>	3 7,5
Fungus	<i>Cândida albicans</i>	2 5
Total	40	100

(*) p<0.05

As to infectious agents (Table 5), gram-positive *Staphylococcus aureus* and gram-negative *Pseudomonas aeruginosa* stand out as the most frequently isolated microorganisms, with 35% and

32.5%, respectively. However, in the general sum, gram-negative organisms were more prevalence, which goes against other publications⁽⁷⁻⁸⁾.

Forty-five percent (18) of the patients with blood stream infection were transferred to other units in the same hospital; 40% (16) died due to a cause that was not specified as related to the infection. In the remaining group, 5% (2) were referred to other institutions and 10% (4) remained at the ICU until the end of the study.

DISCUSSION

Although it is acknowledged that central venous catheters are important for patients, they entail a predisposition to infectious complications⁽⁹⁾. In this study, the 6.4% infection rate we found was associated with the duration of hospitalization, catheter dwelling time, location in the right subclavian vein, use of double lumen catheter and the concomitant presence of tracheotomy, parenteral nutrition catheter and double lumen catheter for hemodialysis.

These findings are in line with other studies that appoint the duration of the catheterization as a risk factor for blood stream infection⁽¹⁾. Effective measures to reduce the risk associated with catheter dwelling include the cautious indication of catheter use, as well as a well trained team for their insertion, maintenance and removal^(4,10).

Other studies, including this one, found an extension of the hospitalization period due to the incidence of blood stream infection⁽¹⁰⁾. The extension of the hospital stay in itself favors an increased risk of infection, the reduced availability of beds and the increase of hospital costs, among others.

When the catheter is inserted in an emergency situation, this can lead to the breaking of asepsis techniques, besides the risk of traumatic vessel injuries. In these cases, the catheter should be changed as quickly as possible. However, with respect to the frequency of central catheter replacement, no advantage has been observed in terms of infection reduction. The programmed routine replacement, using the guide wire or a new puncture, is not indicated because it does not reduce infection rates⁽⁵⁾.

The protection barrier is cheap and should be considered a standard practice in the insertion of all catheter types, as it favors infection control. When

the central venous catheter is inserted by specific teams or duly trained staff, infection rates are reduced, as tissue damage decreases and the use and permanence of the CVC is reduced, with a clear advantage in the cost/benefit assessment⁽⁵⁾. In this study, we alert to the importance of the team's autonomy to implant a change in the professionals' behavior, and the need for support from hospital managers. It is highlighted that the NNISS found higher BSI rates in large teaching hospitals (more than 500 beds).

As opposed to other references⁽⁸⁾, this study found a higher incidence of infection in subclavian vein catheterizations. However, catheterization of the femoral vein is associated with a higher risk of infectious and thrombosis complications than the subclavian vein in ICU patients⁽¹¹⁾. It is also associated with higher rates of mechanical complications like arterial puncture and hematoma⁽¹²⁾. Despite a lower risk of complications caused by the insertion, jugular vein catheters concur for the highest probability of developing infection⁽¹²⁾. In a study carried out in children, the most used catheter insertion site was the internal jugular vein, followed by the subclavian vein⁽⁹⁾.

Central catheters can be inserted peripherally, by means of a puncture in the cephalic or basilic vein as, favored by the lower colonization, oiliness and humidity of the antecubital fossa, they provide for easy maintenance and longer dwelling time and present lower infection rates than non-implantable central catheters. These routes can be an option for the procedure, also due to the high contamination probability of the catheter inserted in the subclavian and jugular veins, due to the drainage of respiratory secretion found in patients using orotracheal tubes and tracheotomies which, in this study, represented important risk factors for infection. Venous dissection should be avoided because of the higher risk of infection than puncture, due to tissue trauma and because there is no appropriate catheter for this procedure⁽⁸⁾.

As to the choice of the catheter type with respect to the number of lumens, the need and/or severity of the patient's case should be assessed, as well as the number of medications and nutritional support. References indicate that each lumen increases handling by 15 to 20 times per day⁽⁵⁾. A randomized study in patients using subclavian vein catheters for more than a week for an incidence level of 2.6% of blood stream infection for single lumen, against 13.1%

for triple lumen catheters⁽¹³⁾. However, generally, it are the most severe patients who are hospitalized at ICUs, most frequently use multi-lumen catheters and, consequently, present greater infection risks. In this study, we found higher usage and, consequently, higher incidence levels of infection in case of double lumen catheters.

Gram-positive *Staphylococcus aureus* and coagulase-negative *Staphylococcus* are the organisms most frequently involved in vascular access infections, mainly in patients whose immune system is compromised and have used a catheter for a long time. *Candida spp* has revealed to be an important and emerging pathogen in recent years, increasing its participation in blood stream infections⁽⁵⁾. Probably, this occurrence is partially related with the indiscriminate use of last-generation antimicrobial agents and with the increased use of CVC.

Studies appoint that the health team's education can be the most important measure to prevent complications deriving from the use of central venous catheters⁽¹⁰⁾. Hand washing is highlighted as a primordial measure to prevent hospital infections. Therefore, in combination with the sensitization of the professional team, adequate conditions need to be favored to carry out the procedure.

We consider the following study limitations: realization at ICUs with distinct peculiarities, each of which with different risks of acquiring HI; the presence of multiple teams for catheter insertion and the non standardization of criteria for the duration of its use. The use of the total number of patients using CVC and not of patients per day and catheters per day to calculate the indicators, which would help to control for the variation in the patient's stay at the ICU, was also considered a limiting factor.

Culture of the catheter tip through the semi-quantitative method helps to distinguish between infection and contamination, providing for a more specific diagnosis of catheter-related sepsis. However, the quantitative method can be used through vigorous shaking in the culture medium or through ultrasonic treatment, in order to increase the specificity of the diagnosis⁽⁸⁾. Using qualitative techniques to diagnose catheter-related infections is not recommended, as one single contaminating microorganism can lead to a positive culture⁽⁸⁾.

Although outside the scope of this study, the economic problems the hospitals faced at the time of the study have definitely contributed to the patients' greater exposure to infection risks. In this period,

antiseptic agents, antibiotics and hand washing products were frequently lacking.

We hope that these results will stimulate the implantation of BSI prevention actions, such as the creation of the Catheter Group to standardize catheter insertion, maintenance and withdrawal routines, besides orientations for cautious catheter use and care professionals' adherence to the standardized protocols for catheter care. Another important factor is the incorporation of knowledge into hand washing practices, which will favor the reduction of infections in general, and not only of blood stream infections.

It is important to carry out specific studies per ICU type, as the duration of the patients' stay at these units varies and, consequently, catheter dwelling times, leading to variations in the infection rates related to the invasive procedures. In this sense, we agree with the orientation that, in order to prevent hospital infection, both physiopathology and epidemiology should be kept in mind⁽¹⁴⁾. Therefore, accompanying historical series of infection occurrence

is recommendable in order to apply hospital infection control and prevention measures. The elaboration of incidence density indicators, using the number of central venous catheters-day, will help to control for the patient's permanence time at the ICU. Although there does not exist an acceptable value for hospital infections, Argentinean data register 2.92% of catheter-related blood stream infections in medical/surgical and cardiology⁽³⁾ ICU patients, that is, with similar characteristics to this study.

ACKNOWLEDGEMENTS

To the Directors and professionals at the ICUs, Laboratories and File Sector of the hospitals that participated in the study: *Hospital Regional da Asa Norte, Hospital Regional de Sobradinho, Hospital Regional da Asa Sul, Hospital de Base do Distrito Federal (3 adult ICUs), Hospital Universitário de Brasília and Hospital das Forças Armadas.*

REFERENCES

1. McGee DC, Gould MK. Preventing complications of central venous catheterization. *N Engl J Med* 2003 Mar; 348:1123-33.
2. Centers for Disease Control and Prevention. National Nosocomial Infections Surveillance(NNISS) System report, data summary from January 1992-hybe 2004m. *Am J Infect Control* 2004; (32):470-85.
3. Rosenthal VD, Gusman S, Migone O, Crnich CJ. The attributable cost, length of hospital stay, and mortality of central line-associated bloodstream infection in intensive care departaments in Argentina: A prospective, matched analysis. *Am J Infect Control* 2003; 31:475-80.
4. Fernandes AT, Ribeiro NF. Infecção do Acesso Vascular. In: Fernandes AT, Fernandes MA, Ribeiro N F, organizadores. *Infecção Hospitalar e suas Interfaces na Área da Saúde*. São Paulo (SP): Atheneu; 2000. p. 556-79.
5. Associação Paulista de Estudos e Controle de Infecção Hospitalar. *Infecção Relacionada ao uso de Cateteres Vasculares*. São Paulo (SP):APECIH; 2005.
6. Centers for Disease Control and Prevention. Guideline for the Prevention of Intravascular Catheter-Related Infections. *MMWR* 2002; 51(RR-10):1-29.
7. O'Grady NP, Alexander M, Dellinger EP, Geberding JL, Heard SO, Maki DG, et al. Guidelines for the prevention of intravascular catheter-related infection. *MMWR* 2002; 34:1362-8.
8. Marangoni D, Santos M. Infecção Hospitalar e seu Controle. In: Coura JR, editor. *Dinâmica das Doenças Infecciosas e Parasitárias*. Rio de Janeiro (RJ): Guanabara-Koogan; 2005. p. 435-59.

9. Carrara D. Influência do Sistema Fechado de Infusão Venosa sem Agulha na Incidência das Infecções de Corrente Sangüínea(ICS) em Crianças Operadas no INCOR –HC-FMUSP.[tese]. São Paulo (SP): Faculdade de Medicina/USP; 2004.
10. Higuera F, Rosenthal VD, Duarte P, Ruiz J, Franco G, Safdar N. The effect of process control on the incidence of central venous catheter-associated bloodstream infections and mortality in intensive care units in México. *Crit Care Med* 2005; 33(9):1-6.
11. Merrer J, De Jonhghe B, Golliot F, Lefrant J, Raffy B, Barre E, et al. Complications of femoral and subclavian venous catheterization in critically ill patients. *JAMA* 2001 August; 286(6):700-7.
12. Slonim AD, Singh N. Nosocomial Bloodstream infection and cost. *Crit Care Med* 2001; 29(9):1849.
13. Clark C, Christoff N, Watters VA, Sparks W, Snyder P, Grant JP. Use of triple lumen suclavian catheters for administration of total parenteral nutrition. *J Parenter Enteral Nutr* 1992; 16(5):403-7.
14. Richtmann Rosana. Infecções da Corrente Sangüínea e Relacionadas a Dispositivos Intravasculares. In: Rodrigues EAC, Mendonça JS, Amarante JMB, Alves MB Filho, Grinbaum RS, Rictmann R. *Infecções Hospitalares: Prevenção e Controle*. São Paulo (SP): Savier; 1997. p. 191-208.