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Device-associated infection rates in Adult Intensive Care Units in Catalonia: VINCat Program findings

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A B S T R A C T

Hospital-acquired infections are a leading cause of morbidity and mortality, especially in the intensive care unit (ICU). Surveillance of device-associated infections plays a major role in infection control programs. In 2006, the Surveillance Program of Nosocomial Infections in Catalonia (VINCat Program) was started, with the major aim of reducing infection rates through a process of active monitoring.

The study period comprised calendar years 2008 (with 21 ICUs participating), 2009 (with 21 ICUs participating), and 2010 (with 28 ICUs participating). Each participating hospital was required to have an infection control team made up of at least one physician, an infection surveillance nurse, and a microbiology laboratory. Hospitals were classified into three groups according to their size. Central venous catheter-associated bloodstream infection (CVC-BSI) and ventilator-associated pneumonia (VAP) were chosen as the device-associated infections to analyze. Incidence rates of device-associated infections were calculated by dividing the total number of device-associated infection (VAP or CVC-BSI) days by the total number of days use for the relevant device.

Mechanical ventilation use ranged from 0.10 to 0.85 days (overall, 0.35), and central venous catheter use ranged from 0.18 to 0.98 days (overall, 0.65). Incidence rates of VAP ranged from 7.2±3.7 to 10.7±9.6 episodes of VAP/1000 ventilator days. Incidence rates of CVC-BSI ranged from 1.9±1.6 to 2.7±2.0 episodes of CVC-associated bloodstream infection/1000 central venous catheter days.

The implementation of the VINCat Program allowed monitoring of nosocomial device-associated infections in ICUs in Catalonia and enabled corrective measures in ICUs with increased incidences of device-associated infections.

Tasas de infección asociada a dispositivos artificiales en las unidades de cuidados intensivos de Cataluña: resultados del Programa VINCat

Palabras clave:
Infección nosocomial
Unidad de cuidados intensivos
Neumonía asociada a ventilación mecánica
Bacteriemia relacionada con catéter intravascular

R E S U M E N

Las infecciones intrahospitalarias se asocian a una elevada morbilidad y mortalidad, especialmente las que ocurren en las unidades de cuidados intensivos (UCI). La vigilancia de las infecciones asociadas a dispositivos artificiales es una parte fundamental en los programas de control de infección. En el año 2006, se instauró el Programa de Vigilancia de Infección Nosocomial en Catalunya (Programa VINCat), con el principal objetivo de reducir la tasa de infección intrahospitalaria a través de un proceso de vigilancia activa de las infecciones.

Se incluyeron los pacientes ingresados durante los años 2008 (21 UCI participantes), 2009 (21 UCI participantes) y 2010 (28 UCI participantes). El requisito que se exigía a cada hospital que participaba en el programa era tener un equipo de control de infección formado por al menos un médico, una enfermera de

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control de infección y un laboratorio de microbiología. Los hospitales fueron clasificados en tres grupos de acuerdo con su tamaño. La bacteriemia relacionada con el catéter venoso central (B-CVC) y la neumonía asociada a la ventilación mecánica (NAV) fueron las infecciones relacionadas con dispositivos artificiales escogidas para el análisis. La densidad de incidencia de las infecciones relacionadas con dispositivos artificiales se calculó dividiendo el número de infecciones relacionadas con el dispositivo artificial (B-CVC o NAV) por los días totales de utilización del dispositivo artificial correspondiente (catéter o ventilación mecánica).

El porcentaje de utilización de ventilación mecánica osciló entre el 10 y el 85% (media del 35%), y el de utilización de catéter venoso central osciló entre el 18 y el 98% (media del 65%). La densidad de incidencia de NAV osciló entre 7.2 ± 3.7 y 10.7 ± 9.6 episodios de NAV/1.000 días de ventilación mecánica. La densidad de incidencia de B-CVC osciló entre 1.9 ± 1.6 y 2.7 ± 2.0 episodios de B-CVC /1.000 días de catéter venoso central.

La implantación del Programa VINCat ha permitido conocer y monitorizar las infecciones relacionadas con dispositivos artificiales en las UCI de Cataluña y detectar aquellas UCI con mayor incidencia en las que puedan adoptarse medidas correctoras para reducir las infecciones asociadas a dispositivos artificiales.

Introduction

Hospital-acquired infections (HAI) occur in 5% to 10% of patients admitted to hospitals and remain a leading cause of morbidity and mortality.[1] The endemic rates of HAI vary markedly between hospitals and between areas of the same hospital. Patients in intensive care units, representing 8% to 15% of hospital admissions, suffer a disproportionately high percentage of HAI compared with patients in non-critical care areas.[2-8] Patients admitted to ICUs account for 45% of all hospital-acquired pneumonias and bloodstream infections (BSIs), even though critical care units comprise only 5% to 10% of all hospital beds.[3] The severity of underlying disease, invasive diagnostic and therapeutic procedures that breach normal host defenses, contaminated life-support equipment, and the prevalence of resistant microorganisms are critical factors in the high rate of infection in ICUs.[9]

Surveillance of health care-associated infections, especially in high-risk hospital settings such as ICUs, has become an integral feature of infection control in most health systems. Standards for institutional surveillance have been adopted in the United States,[10] the United Kingdom,[11] Australia,[12] Canada,[13] and Germany.[14] Developing countries with fewer institutional resources have also developed systems to ascertain the incidence of device-associated infections in ICUs, such as the International Nosocomial Infection Control Consortium.[15]

In Spain, various surveillance systems for HAI have been used since the 1990s. In general, the most widely-used program has been the EPINE (Study of Prevalence of Nosocomial Infections in Spain), in which more than 200 public and private hospitals participate each year.[16] Moreover, since 1994 a specific HAI surveillance program has been used to report device-associated infections acquired during the ICU stay. This program, the ENVIN-UCI (National Surveillance Study of Nosocomial Infection in the ICU) currently involves more than 100 Spanish ICUs.[17]

In 2006, the Surveillance Program of Nosocomial infections in Catalonia (VINCat Program) was launched, with the main objective of reducing nosocomial infection rates by continuous active monitoring. The VINCat Program has six major monitoring objectives: overall nosocomial infection and process indicators, catheter-related bloodstream infections, surgical infections, device-related nosocomial infections in ICUs, specific multidrug-resistant microorganisms, and hospital consumption of antibiotics.

This article reports the initial findings on device-related infections in ICUs collected by hospitals participating in the VINCat Program between January 2008 and December 2010.

Methods

Setting

Data for this study were collected between January 2008 and December 2010. Most participating ICUs joined the VINCat Program in 2008, with 21 ICUs participating during the first two years and 28 ICUs participating in 2010. Hospitals participating in the VINCat Program were classified into three categories: large hospitals (>500 beds), medium-sized (between 200-500 beds) and small (<200 beds).

To participate in the VINCAT Program, each hospital needed an infection control team made up of a physician, an infection surveillance nurse, and a microbiology laboratory. The person responsible for active surveillance in each ICU was preferably an intensivist with extensive experience in infections or a member of the infection control team.

We recorded daily the use of invasive devices. Patients with more than one central venous catheter were recorded as a single day of central venous catheter use. We determined the rates of ventilator-associated pneumonia and central venous catheter-associated BSI. Patient confidentiality was protected and patient identity was available only to the individual hospital's infection control team.

The reference values used in the VINCat Program were chosen on the basis of data from national surveillance studies of nosocomial infection in ICUs in the ENVIN-UCI Program and the quality standard recommended by the Spanish Critical Care Society (SEMICYUC). For VAP, the standard was <12 episodes per 1000 ventilator-days, and for central venous catheter-associated BSI the standard was <4 episodes per 1000 central venous catheter-days.

Definitions

The definitions of central venous catheter-associated BSI and VAP used in the VINCat Program were the standardized definitions used for ICU nosocomial infection research programs in the European Union (ENVIN-HELICS Program)[18] and United States (National Nosocomial Infection Surveillance System or NNISS Program).[10]

For ventilator-associated pneumonia we used the definitions of the ENVIN-HELICS Program.[18] In mechanically-ventilated patients with underlying heart or pulmonary disease, VAP was diagnosed when findings suggestive of pneumonia were present on two or more serial chest X-rays or CT-scans. In patients without underlying cardiac or pulmonary disease, VAP was diagnosed when findings suggestive of pneumonia were present on a single chest X-ray or CT-scan, provided at least one of the following criteria were met: fever >38º C in the

absence of other causes or leukopenia (<4000 white blood cells (WBC)/mm^3) or leukocytosis (≥12,000 WBC/mm^3), together with at least one of the following three criteria: new onset of purulent sputum, change in the character of sputum, cough, dyspnea or tachypnea, suggestive auscultation, or worsening gas exchange.

VAP was classified according to the microbiological findings:

PN1: *a)* Positive quantitative culture from bronchoalveolar lavage (BAL) (≥10^4 colony forming units (CFU)/ml) or ≥5% of cells obtained from BAL containing intracellular bacteria on direct microscopic exam, or *b)* protected specimen brush (≥10^3 CFU/ml), or distal protected aspirate (≥10^3 CFU/ml).

PN2: Quantitative culture of lower respiratory tract specimen (tracheal aspirate) (≥10^6 CFU/ml).

PN3: *a)* Positive blood culture not related to another source of infection, or *b)* positive growth in pleural fluid culture, or *c)* pleural or pulmonary abscess with positive needle aspiration, or *d)* evidence of pneumonia on histologic examination of lung tissue, or *e)* positive identification of viruses or microorganisms specific to pneumonia.

PN4: Positive sputum culture or non-quantitative tracheal aspirate.

PN5: No positive microbiology.

Central venous catheter-associated bloodstream infection (BSI) was defined as the detection of growth of bacteria, yeasts or fungi in at least one set of cultures of blood drawn from a peripheral vein (or microorganisms that colonize normal skin, such as coagulase-negative staphylococci, for which at least two sets of positive blood cultures were required), associated with clinical manifestations of infection (fever, chills and/or hypotension) and no apparent source of bacteremia in a patient with a central venous catheter and one or more of the following:

1. Semiquantitative culture (>15 CFU/catheter segment) or quantitative culture (>10^3 CFU/catheter segment) with detection of the same microorganism in the peripheral blood culture (within the same species and, if possible, with a similar susceptibility pattern).

2. The same microorganism was detected in both peripheral and central venous catheter blood cultures, a ≥5:1 difference in the bacterial count between the blood from any central venous catheter and blood from a peripheral vein.

3. Earlier time to positivity of blood cultures (>2 h) obtained from the distal lumen of a central venous catheter compared with cultures obtained from a peripheral vein.

4. Presence of purulent secretion or inflammation at the insertion point or anywhere along the subcutaneous route of the tunnel of a venous catheter of any kind, especially when the same microorganism found in the blood cultures is found in cultures of secretion.

5. Resolution of clinical signs and symptoms after the removal of a central venous catheter and/or the administration of appropriate antibiotic therapy (acceptable when none of the other criteria are met). The clinical diagnosis of central venous catheter-associated BSI requires the presence of signs of phlebitis (induration, pain or inflammation at the insertion point or anywhere along the subcutaneous trajectory of the catheter).

Statistical analysis

We calculated the device utilization rates by dividing the total number of device days by the total number of ICU patient days. We calculated the rates of ventilator-associated pneumonia and central venous catheter-associated BSI per 1000 device-days by dividing the total number of episodes of the relevant nosocomial infection by the total number of days the relevant device was used and multiplying the result by 1000. Data are expressed as means and standard deviations; we also report the medians and interquartile ranges of the incidence rates of ventilator-associated pneumonia and central venous catheter-associated BSI.[19]

Results

Characteristics of the study sample

During the three years of the study, 21 ICUs in the first two years and 28 ICUs in the last year provided prospectively collected surveillance data. In the first two years, 8 hospitals were classified as large (>500 beds), 10 as medium-sized (between 200-500 beds), and 3 as small (<200 beds). In the third year, 9 hospitals were classified as large, 14 as a medium-sized, and 5 as small.

Device use ratio

Device use varied widely among ICUs and along the study period: mechanical ventilation, ranged from 0.10 to 0.85 days (overall, 0.35) and central venous catheter from 0.18 to 0.98 days (overall, 0.65).

Ventilator-associated pneumonia

In 2008, the overall rate was 9.1 (range 0-19.3) episodes per 1000 ventilator days, in 2009 the overall rate was 7.2 (range 0-13.1) episodes per 1000 ventilator-days, and in 2010 the overall rate was 10.7 (range 0-41) episodes per 1000 ventilator-days. Rates of VAP also varied widely with hospital size (Table 1). Rates fulfilled the standard recommended by the VINCat Program (<12 episodes per 1000 ventilator-days) in 88% of the ICUs in the large hospitals, in 78% of the ICUs in the medium-sized hospitals, and in 75% of the ICUs in the small hospitals. Table 2 shows pooled means and key percentiles of the distribution of incidence rates of VAP and ventilator utilization ratios by hospital size in the study of 2010, when 28 ICUs participated.

Central venous catheter-associated bloodstream infection

In 2008, the overall rate was 2.7 (range 0-6.8) episodes per 1000 central venous catheter-days, in 2009 the overall rate was 2 (range 0-4.6), episodes per 1000 central venous catheter-days, and in 2010 the overall rate was 1.9 (range 0-6.5) episodes per 1000 central venous catheter-days (Table 3). Rates fulfilled the standard recommended by the VINCat Program (<4 episodes per 1000 central venous catheter-days) in 81% of the ICUs in the large hospitals, in 88% of the ICUs in the medium-sized hospitals, and in 75% of the ICUs in the small hospitals. Table 4 shows the pooled means and key percentiles of the distribution of incidence rates of central venous catheter-associated BSI in the study of 2010.

Discussion

HAIs are associated with substantial morbidity and attributable mortality. HAIs also increase healthcare costs.[20-22] An integrated infection control program that includes surveillance of HAIs can reduce the incidence of HAIs by 30%.[23]

Table 1
Incidence rate of ventilator-associated pneumonia during the three years of the study by hospital size

Episodes of VAP/1000 ventilator-days			
	2008	2009	2010
Hospital size			
>500 beds	9.0±3.7	7.8±2.6	7.7±2.0
200-500 beds	9.1±5.6	6.3±4.4	11.0±10.1
<200 beds	8.1±4.1	8.9±4.3	15.4±15.3
Overall	8.8±4.8	7.2±3.7	10.7±9.6

VAP: ventilator-associated pneumonia.

Table 2
Pooled means and key percentiles of the distribution of ventilator-associated pneumonia rates, per 1000 ventilator-days, and ventilator utilization ratios by ICU size in the study of 2010

				Percentile				
	No. of units	Pooled mean DUR	Pooled mean VAP rate	10th	25th	50th Median	75th	90th
Hospital size								
>500 beds	9	0,57	7.7	5.4	6.1	8.5	9.2	9.5
200-500 beds	14	0,32	11.0	2.7	4.3	7.9	13.6	21.9
<200 beds	5	0,49	15.4	3.9	9.6	10.8	15.7	30.8
Overall	28	0,43	10.7	3.2	6.0	8.7	11.0	20.2

DUR: device utilization ratio; VAP: ventilator-associated pneumonia.

Table 3
Incidence rates of central venous catheter-associated bloodstream infection during the three years of the study by hospital size

Episodes of CVC-associated bloodstream infection/1000 CVC days			
	2008	2009	2010
Hospital size			
>500 beds	3.2±2.0	2.1±0.9	2.5±1.4
200-500 beds	2.0±1.8	2.1±1.7	1.7±1.2
<200 beds	5.3±1.1	1.5±1.3	2.0±2.7
Overall	2.7±2.0	2.0±1.3	1.9±1.6

CVC: central venous catheter.

Nosocomial infection surveillance programs should monitor device-associated infections in the ICU because the ICU is the health care setting with the most vulnerable patients, who have the heaviest exposure to invasive devices and the highest rates of HAIs.

This is the first report showing device-associated infections rates in ICUs participating in the VINCat Program. The overall rate of device-associated infections in the participating ICUs fulfills the standards recommended in the VINCat Program. Moreover, although the device utilization ratio was similar to that reported in other countries, the rates of device-associated infections reported in the VINCat Program were similar to or lower than those reported in the ENVIN or other international studies of ICU-acquired infections[1,5,24] (Table 5).

However, the differences found in the rates of device-associated infections in ICUs in different-sized hospitals is also noteworthy. Indeed, although more than 70% of the ICUs participating in our study reported device-associated infection rates below the standard proposed for the VINCat Program, the highest percentage of ICUs with incidence rates of device-associated infections above the proposed standards was found in the group of smaller hospitals. These findings differ from those reported in the ENVIN Program, in which the highest infection rates were observed in hospitals with more beds and were attributed to the higher complexity of patient care.[24] The device utilization ratios in the ICUs participating in the VINCat Program also differ from those reported by the ENVIN Program, where a low ratio of device use was found in smaller hospitals. In VINCat hospitals, the use of mechanical ventilation in small hospitals is higher than its use in medium-sized hospitals, and the use of central venous catheters was similar in ICUs in small and medium-sized hospitals (Table 6). Therefore, our results show that there is room for improvement in our hospitals, and particularly in the smaller ones.

Although the objective of nosocomial infection control programs is to eliminate nosocomial infection, achieving this goal is complicated. In a recent paper, Rosenthal et al. describe the results of a study in 98 ICUs in the countries belonging to the International Nosocomial Infection Control Consortium (INICC), with 9.2 episodes of central venous catheter-associated BSI per 1000 catheter-days and 19.5 episodes of VAP per 1000 ventilator-days.[25] These rates are three and five times as high, respectively, as those reported during the same period in ICUs in the U.S.[26] The rates are even higher in developing countries.[15] Our results demonstrate that the incidence rate of device-associated infections in the ICUs in hospitals in Catalonia is acceptably low, even though the rate of use of devices in our ICUs is similar.

In recent years, the use of care bundles for the prevention of nosocomial infections has achieved a significant reduction in these device-associated infections, mainly in central venous catheter-related BSI.[27,28] At the start of our study, in 2008, the incidence rate of central venous catheter-associated BSI was slightly above 2.5 episodes per 1000 catheter-days. In the same period, the mean incidence rate in the hospitals participating in the ENVIN Program was around 5 episodes per 1000 catheter-days. In 2009, the "Bacteremia Zero" Program was introduced in most Spanish ICUs. This program – to prevent catheter-related bacteremia based on the application of care bundles at the time of catheter insertion and during post-insertion – achieved a significant decrease in the

Table 4
Pooled means and key percentiles of the distribution of central venous catheter-associated BSI rates, per 1000 central venous catheter-days, and central venous catheter utilization ratios by ICU size in the study of 2010

				Percentile				
	No. of units	Pooled mean DUR	Pooled mean CVC-BSI rate	10th	25th	50th,Median	75th	90th
Hospital size								
>500 beds	9	0.88	2.3	0.7	1.3	2,3	3.2	4.3
200-500 beds	14	0.65	1.7	0.1	0.8	1.9	2.2	3.5
<200 beds	5	0.63	2.0	0.0	0.0	1.2	2.4	4.9
Overall	28	0.71	1.9	0.0	0.8	1.9	2.6	4.1

BSI: bloodstream infections; CVC-BSI: central venous catheter-associated bloodstream infection; DUR: device utilization ratio; ICU: Intensive Care Unit.

Table 5
Comparison of device use and rates of device-associated infection in the intensive care units in the VINCat Program and other nosocomial infection surveillance programs

Variable	U.S. NNISS ICUs 1992-2004	INICC ICUs 2002-2005	Spain ENVIN-UCI 2010	VINCat Program 2010
Rate of device use	0.43 (0.23-0.62)	0.38 (0.19-0.64)	0.50 (0.35-0.60)	0.43 (0.32-0.57)
Mechanical ventilation	0.57 (0.36-0.74)	0.54 (0.22-0.97)	0.79 (0.62-0.90)	0.71(0.63-0.88)
CVCs				
Rate per 1000 device days	5.4 (1.2-7.2)	24.1 (10.0-52.7)	11.48 (7.5-13.5)	10.7 (3.2-20.2)
VAP	4.0 (1.7-7.6)	12.5 (7.8-18.5)	2.93 (1.2-4.0)	1.9 (0.0-4.1)
CVC-BSI				

CVCs: central venous catheters; CVC-BSI: central venous catheter bloodstream infections; ENVIN-UCI: Estudio Nacional de Vigilancia de la Infección Nosocomial en las Unidades de Cuidados Intensivos; INICC: International Nosocomial Infection Control Consortium; NNISS: National Nosocomial Infection Surveillance System; VAP: ventilator-associated pneumonia.

Table 6
Comparison of rates of device use and hospital acquired infections in the intensive care units in the VINCat Program and ENVIN-UCI Program by hospital size in 2010 reports

	ENVIN-UCI 2010 report				VINCat Program 2010 report			
Hospital size	Rate of MV use	Rate VAP	Rate of CVC use	Rate CVC-BSI	Rate of MV use	Rate VAP	Rate of CVC use	Rate CVC-BSI
>500 beds	0.50	13.5	0.78	4.0	0.57	7.7	0.88	2.3
200-500 beds	0.44	13.5	0.73	2.4	0.32	11.0	0.68	1.7
<200 beds	0.35	7.5	0.62	1.2	0.49	15.4	0.65	2.0

CVC: central venous catheter; CVC-BSI: central venous catheter bloodstream infections; ENVIN-UCI: Estudio Nacional de Vigilancia de la Infección Nosocomial en las Unidades de Cuidados Intensivos; MV: mechanical ventilation; VAP: ventilator-associated pneumonia.

incidence of these infections. The effect of this prevention program was also detected in our results: the incidence of catheter-related BSI decreased from 2.7 episodes per 1000 catheter-days in 2008 to 1.9 episodes per 1000 catheter-days in 2010.

Some infection control programs, like the U.S. Centers for Disease Control and Prevention's NNNIS have been running for many years. Others, however, are more recent and the number of participating hospitals has increased with time. The ENVIN Surveillance System, considered the reference standard in Spanish ICUs, has been operating since 1994, and more than 100 hospitals now voluntarily report nosocomial infection data annually. The VINCat Program uses the same definitions used by the ENVIN in the surveillance of nosocomial infection in ICUs, and after only a few years in operation, it has gathered annual data from 28 Catalan ICUs, providing a realistic view of nosocomial infection in ICUs in Catalonia.

Some limitations of our study must be taken into account. First, it is a multicenter study, which makes it difficult to ensure the uniformity of diagnoses, despite using well-established definitions. However, the two device-associated infections considered in our analysis are those with the lowest interobserver variability. Second, there is great variability among centers, especially for the rates of VAP. Nevertheless, grouping hospitals by size attenuates these differences, and allows a more accurate picture of the reality in our hospitals. Third, the information obtained by the VINCat Program is still insufficient; recording information about the microorganisms that cause nosocomial infections and antibiotic resistance patterns will provide even more useful information.

In conclusion, the implementation of a program for monitoring and control of nosocomial infection in ICUs in Catalonia provides an objective view of the current situation in our hospitals. By recruiting more centers and providing continuous training we should be able to homogenize the definitions and ensure that the rates are even more reliable. Similarly, our results will allow us to take corrective measures in the ICUs with higher rates of infection.

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Conflicts of Interest

All authors declare that they have no conflicts of interest in this article.

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