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Major article

Effectiveness of a multidimensional approach to reduce ventilator-associated pneumonia in pediatric intensive care units of 5 developing countries: International Nosocomial Infection Control Consortium findings

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Background: Ventilator-associated pneumonia (VAP) is one of the most common health care–associated infections in pediatric intensive care units (PICUs). Practice bundles have been shown to reduce VAP rates in PICUs in developed countries; however, the impact of a multidimensional approach, including a bundle, has not been analyzed in PICUs from developing countries.

Methods: This was a before-after study to determine rates of VAP during a period of active surveillance without the implementation of the multidimensional infection control program (phase 1) to be compared with rates of VAP after implementing such a program, which included the following: bundle of infection control interventions, education, outcome surveillance, process surveillance, feedback on VAP rates, and performance feedback on infection control practices (phase 2). This study was conducted by infection control professionals applying the National Health Safety Network's definitions of health care–associated infections and the International Nosocomial Infection Control Consortium's surveillance methodology.

Results: During the baseline period, we recorded a total of 5,212 mechanical ventilator (MV)-days, and during implementation of the intervention bundle, we recorded 9,894 MV-days. The VAP rate was 11.7 per 1,000 MV-days during the baseline period and 8.1 per 1,000 MV-days during the intervention period (relative risk, 0.69; 95% confidence interval, 0.5-0.96; $P = .02$), demonstrating a 31% reduction in VAP rate.

Conclusions: Our results show that implementation of the International Nosocomial Infection Control Consortium's multidimensional program was associated with a significant reduction in VAP rate in PICUs of developing countries.

Ventilator-associated pneumonia (VAP) has long been associated with excess hospital length of stay (LOS),[1-3] increased hospital costs,[4] and increased attributable mortality.[1,3] The extreme vulnerability of children hospitalized in pediatric

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intensive care units (PICUs) has been highlighted in previous studies.[3]

VAP is one of the most common device-associated health care–associated infections (DA-HAIs) in critical care settings.[5] VAP contributes to overall mortality in PICUs[6] and is the leading cause of death among DA-HAIs.[6,7] However, in the particular context of developing countries, knowledge regarding DA-HAIs is scant, and there is an insufficient recognition of the importance of surveillance for measuring infection risks, outcomes, and processes in PICU patients. To address this deficiency, the International Nosocomial Infection Control Consortium (INICC) has conducted an outcome and process surveillance program specifically designed for PICUs in developing countries since 2002.[8,9] The INICC program has revealed 3- to 5-fold higher rates of DA-HAIs in the PICUs of hospitals in limited-resource countries compared with PICUs of hospitals in the developed world.[3,7,10-22]

Society for Health Care and Epidemiology of America and Infectious Diseases Society of America guidelines describe many different interventions for preventing VAP in PICUs.[23] These interventions are categorized based on existing scientific evidence, theoretical rationale, applicability, and potential economic impact. However, there is little robust evidence to guide the choice of interventions to implement in an effort to decrease VAP rates.[24] Studies conducted in INICC member hospitals have validated outcome and process surveillance and performance feedback of infection control practices as effective tools for reducing and controlling DA-HAIs in.[25-31]

The purposes of the present study were to examine the effect of the INICC's multidimensional infection control program—comprising a bundle of infection control interventions, education, outcome surveillance, process surveillance, feedback on VAP rates, and performance feedback on infection control practices—on reducing the incidence of VAP in the PICUs of 8 INICC member hospitals in 5 developing countries, and to advance the study of the specific impact of this preventive strategy on VAP rates in limited-resource countries.

METHODS

Setting and study design

The study was carried out in 8 PICUs of 8 INICC member hospitals in 5 developing countries: Colombia, El Salvador, India, the Philippines, and Turkey. Six of the participating hospitals were academic institutions, and 2 were private hospitals. Each hospital had been actively participating in the INICC surveillance program for at least 14 months, with an infection control team composed of a medical doctor with formal education and background in internal medicine, infectious diseases, and/or hospital epidemiology and an infection control professional.

This study was performed in 2 phases: phase 1 (baseline period) and phase 2 (intervention period).

Intervention period

The intervention period was initiated after 7 months of participation in the INICC surveillance program. The multidimensional infection control program (Phase 2- Intervention period) includes the following: (1) bundle of infection control interventions, (2) education, (3) outcome surveillance, (4) process surveillance, (5) feedback of VAP rates, and (6) performance feedback of infection control practices.

INICC methodology

The INICC surveillance program includes 2 components: outcome surveillance (DA-HAI rates and consequences) and process surveillance (adherence to hand hygiene and other basic preventive infection control practices).[8] At the hospitals, investigators were required to complete outcome and process surveillance forms, which were sent to the INICC headquarters office in Buenos Aires for analysis each month.

Outcome surveillance

The INICC surveillance program applies methods and definitions for DA-HAI developed by the US Centers for Disease Control and Prevention for the National Nosocomial Infection Surveillance System/National Health Safety Network program.[32,33] INICC methods have been adapted to the setting of developing countries, taking into consideration these countries' differing socioeconomic status and specific limitations.[8]

Outcome surveillance includes rates of central line–associated bloodstream infection (CLABSI), VAP, and catheter-associated urinary tract infection (CAUTI) per 1,000 device-days; microorganism profile; bacterial resistance; LOS; and mortality in the PICU.

Process surveillance

In INICC member hospitals, preventive strategies are based on simple, inexpensive, evidence-based measures, including education, outcome surveillance, process surveillance, feedback on DA-HAI (VAP, CLABSI, CAUTI) rates, and performance feedback.[25-31] Process surveillance includes compliance rates for hand hygiene practices and specific infection control measures for the prevention of CLABSI, CAUTI, and VAP.[8,25-31]

Process surveillance is designed to monitor compliance with easily measurable key infection control measures, such as hand hygiene. Hand hygiene compliance by health care workers (HCWs), based on the frequency of performing hand hygiene when clearly indicated, is monitored by the hospital's infection control practitioner during randomly selected 1-hour observation periods 3 times a week. Although HCWs know that hand hygiene practices are regularly monitored, they are not actually informed of the exact moments that the observations take place.[8,25-31]

Performance feedback

The concept of using performance feedback of outcome surveillance and process surveillance as a control measure in hospitals with limited resources is based on its proven effectiveness in previous studies within INICC.[25-31] On a monthly basis, after processing the hospitals' surveillance data, the INICC headquarters team prepares and sends to each participating hospital a final report on its institutional rates of DA-HAIs, microorganism profile, bacterial resistance, LOS, and mortality in the PICU, as well as data on compliance with hand hygiene, central line, and urinary catheter care and VAP preventive measures.

To provide feedback to PICU staff, charts providing a running tally of rates of DA-HAIs compiled by the INICC headquarters team are reviewed at monthly staff meetings and posted in a prominent location in the PICU.

Bundle components

Our bundle included the following interventions:

1. Conduction of active surveillance for VAP[34]
2. Adherence to hand hygiene guidelines[35]
3. Maintenance of patients in a semirecumbent position (30-45° head of bed elevation)[36]
4. Daily assessment of readiness to wean and use of weaning protocols[37]
5. Regular oral care with an antiseptic solution[38]
6. Use of noninvasive ventilation whenever possible, minimizing the duration of ventilation[23]
7. Preference for orotracheal intubation over nasotracheal intubation[39]

Table 1
Characteristics of participating PICUs

	PICUs, n	PICU patients, n
Country		
Colombia	2	620
El Salvador	1	1145
India	2	2014
Philippines	1	252
Turkey	2	308
Type of hospital, n (%)		
Academic teaching	6 (75)	2631 (61)
Private community	2 (25)	1708 (39)

8. Maintenance of endotracheal cuff pressure of at least 20 cm H_2O[40]
9. Removal of condensate from ventilator circuits,[23] keeping the ventilator circuit closed during condensate removal[41]
10. Changing of the ventilator circuit only when visibly soiled or malfunctioning[42]
11. Avoidance of gastric overdistention[43]
12. Avoidance of histamine receptor 2—blocking agents and proton pump inhibitors[44]
13. Use of sterile water to rinse reusable respiratory equipment.[23]

We perform direct observation of hand hygiene compliance, duration of the ventilation, and ventilation ratio use, using a structured observation tools at regularly scheduled intervals.[8]

Definitions

We applied the National Health Safety Network's definitions for VAP.[33] VAP is indicated in a patient being mechanically ventilated with a chest radiograph showing new or progressive infiltrate, consolidation, cavitation, or pleural effusion. The patient also must meet at least one of the following criteria: new onset of purulent sputum or change in character of sputum, organism cultured from blood, or isolation of an etiologic agent from a specimen obtained by tracheal aspiration, bronchial brushing or bronchoalveolar lavage, or biopsy.[33]

Statistical methods

Patients' characteristics in the baseline and intervention periods in each PICU were compared using Fisher's exact test for dichotomous variables and the unmatched Student *t* test for continuous variables. Relative risk (RR) ratios with 95% confidence intervals (CIs) were calculated for comparison of rates at baseline and during the subsequent intervention period.

RESULTS

Throughout the study period, 4,339 patients, hospitalized for a total of 29,209 days in 8 PICUs, with a total of 15,106 mechanical ventilator (MV)-days, were enrolled in the study (Tables 1 and 2). Patient characteristics, including age, sex, underlying diseases, and previous infections, were similar in the baseline and intervention phases (Table 2). Hand hygiene compliance rates improved significantly, and MV use and the duration of MV decreased significantly (Table 3).

The VAP rate was 11.7 VAPs per 1,000 MV-days at baseline and 8.1 per 1,000 MV-days during the intervention period (RR, 0.69; 95% CI, 0.50-0.96; $P = .0286$). These results demonstrate a 31% reduction in VAP rate (Table 4).

The microorganism profile is shown in Table 5.

DISCUSSION

Patients undergoing MV are at considerable risk for developing a DA-HAI, particularly VAP. The occurrence of VAP is associated with increased LOS,[1-4] excess health care costs,[4] and increased attributable mortality.[1,3,45] Unfortunately, many health care institutions in developing countries lack basic infection control programs, and most caregivers in these countries are unaware of their institutional rates of VAP.[3,7,10-22]

Table 2
Characteristics of patients at baseline and during the intervention period

	Baseline	Intervention	RR	95% CI	*P* value
Months, n	7	21.1 (range, 7-52; SD, 15.1)			
Patients, n	1272	3067			
MV-days, n	5212	9894			
Bed-days, n	9113	20,096			
Sex, n (%)					
Male	710 (56)	1802 (59)	1.05	0.97-1.15	.2471
Female	548 (43)	1260 (41)			
Underlying disease, n (%)	15 (1)	29 (1)	0.80	0.43-1.50	.4865
Renal failure, n (%)	15 (1)	29 (1)	0.80	0.43-1.50	.4865
Hepatic failure, n (%)	7 (1)	6 (0.2)	0.36	0.12-1.06	.0520
Cardiac surgery, n (%)	35 (3)	58 (2)	0.69	0.45-1.05	.0780
Abdominal surgery, n (%)	21 (2)	33 (1)	0.65	0.38-1.13	.1222
Thoracic surgery, n (%)	8 (1)	19 (1)	0.99	0.43-2.25	.9713
Trauma, n (%)	33 (3)	53 (2)	0.67	0.43-1.03	.0650
Previous infection, n (%)	109 (9)	260 (8)	0.99	0.79-1.24	.9247

Reducing DA-HAIs has been identified as an important priority in many hospitals.[46] The effectiveness of implementing an integrated infection control program focused on DA-HAI surveillance was demonstrated approximately 30 years ago, as demonstrated by US studies showing that the incidence of DA-HAI can be reduced by as much as 30%, and that a related reduction in health care costs is feasible as well.[47]

VAP is largely preventable, and researchers have documented the effectiveness of various preventive interventions, including hand hygiene,[35] semirecumbent positioning,[36] early endotracheal tube removal,[40] and maintenance of endotracheal cuff pressure and continuous subglottic suctioning.[48]

The benefits of multidimensional infection control programs have been demonstrated in numerous studies that stressed educational interventions.[25-31,49,50] Such positive results may be short-lived without regular reinforcement, however. Likewise, surveillance of DA-HAI rates should not be expected to lead to reduced rates of selected DA-HAIs unless the data collected are used for improving patient care practices.[25-31] As a result, buttressing educational efforts with regular feedback in the form of monthly incidence rates of DA-HAIs may provide the maximum benefit.[25-31]

Control VAP requires not just one measure, but rather a culture change involving the entire PICU team (doctors, nurses, and respiratory therapists).[23] We have shown that implementation of the INICC multidimensional infection control approach—comprising an intervention bundle, education, outcome surveillance, process surveillance, feedback on VAP rates, and performance feedback—resulted in significantly reduced VAP rates over the study period. This is the first study in PICUs in developing countries to document a reduction in VAP rates in these settings, associated with the implementation of this type of infection control approach.

A weakness of this study lies in the fact that our results cannot be generalized to all PICU patients from developing countries. In addition, the higher rates of hand hygiene compliance after intervention might have been affected by the "Hawthorne effect." Nonetheless HCW's reactions to observations were reduced, because they were actually performed unobtrusively at randomly selected schedules. We are aware that we might not be able to sustain our current VAP rates indefinitely, but our goal is to sustain

Table 3
Process surveillance, hand hygiene compliance, and MV use

	Baseline period	Intervention period	RR (95% CI)	*P* value
Hand hygiene compliance, % (n)	48.9% (427/873)	67.1% (1017/1516)	1.37 (1.22-1.54)	.0001
MV use ratio, mean (95% CI)	0.57 (0.56-0.58)	0.49 (0.48-0.50)	0.86 (0.83-0.89)	.0001
MV duration, mean ± SD	4.10 ± 7.6	3.23 ± 3.23	-	.0016

Table 4
Outcome surveillance, VAP rates

	Baseline period	Intervention period	RR (95% CI)	*P* value
No. of VAPs	61	80		
No. of MV-days	5212	9894		
VAP rate per 1000 MV-days	11.7	8.1	0.69 (0.50-0.96)	.0286

Table 5
Outcome surveillance, VAP-related microorganisms

Isolated microorganisms	Baseline period	Intervention period
Acinetobacter spp, n (%)	3 (21)	2 (18)
Escherichia coli, n (%)	1 (7)	2 (18)
Enterobacter spp, n (%)	1 (7)	0
Pseudomonas spp, n (%)	8 (57)	16 (55)
Staphylococcus aureus, n (%)	0	1 (9)
Stenotrophomonas spp, n (%)	1 (7)	0

a nearly perfect compliance with the ventilator bundle and maintain PICU team motivation for VAP prevention.

The improvement shown in INICC member hospitals is motivating for HCWs, who are provided with simple and inexpensive preventive strategies. We expect that this will continue to increase the acceptance of infection control programs in all INICC member hospitals, leading to significant reductions in DA-HAI rates. For this reason, any hospital worldwide may participate in the INICC network, which was created in response to the crucial need to significantly prevent, control, and reduce DA-HAIs and their adverse consequences in developing countries. In the INICC, investigators are freely provided with training and methodological tools to conduct outcome and process surveillance, and, through the publication of these confidentially collected data, relevant scientific evidence-based literature is fostered as well.

References

1. Rosenthal VD, Udwadia FE, Munoz HJ, Erben N, Higuera F, Abidi K, et al. Time-dependent analysis of extra length of stay and mortality due to ventilator-associated pneumonia in intensive care units of ten limited-resources countries: findings of the International Nosocomial Infection Control Consortium (INICC). Epidemiol Infect; 2011:1-7.
2. Barnett AG, Beyersmann J, Allignol A, Rosenthal VD, Graves N, Wolkewitz M. The time-dependent bias and its effect on extra length of stay due to nosocomial infection. Value Health 2011;14:381-6.
3. Rosenthal VD, Maki DG, Jamulitrat S, Medeiros EA, Todi SK, Gomez DY, et al. International Nosocomial Infection Control Consortium (INICC) report, data summary for 2003-2008, issued June 2009. Am J Infect Control 2010;38: 95-104.
4. Rosenthal VD, Guzman S, Migone O, Safdar N. The attributable cost and length of hospital stay because of nosocomial pneumonia in intensive care units in 3 hospitals in Argentina: a prospective, matched analysis. Am J Infect Control 2005;33:157-61.
5. Richards MJ, Edwards JR, Culver DH, Gaynes RP. Nosocomial infections in combined medical-surgical intensive care units in the United States. Infect Control Hosp Epidemiol 2000;21:510-5.
6. Garrouste Orgeas M, Timsit JF, Soufir L, Tafflet M, Adrie C, Philippart F, et al. Impact of adverse events on outcomes in intensive care unit patients. Crit Care Med 2008;36:2041-7.
7. Rosenthal VD. Health care–associated infections in developing countries. Lancet 2010;377:186-8.
8. Rosenthal VD, Maki DG, Graves N. The International Nosocomial Infection Control Consortium (INICC): goals and objectives, description of surveillance methods, and operational activities. Am J Infect Control 2008;36:e1-12.
9. Lynch P, Rosenthal VD, Borg MA, Eremin SR. Infection control in developing countries. In: Jarvis WR, editor. Bennett and Brachman's hospital infections. Philadelphia [PA]: Lipppincott Williams & Wilkins; 2007. p. 255.
10. Guanche-Garcell H, Requejo-Pino O, Rosenthal VD, Morales-Perez C, Delgado-Gonzalez O, Fernandez-Gonzalez D. Device-associated infection rates in adult intensive care units of Cuban university hospitals: International Nosocomial Infection Control Consortium (INICC) findings. Int J Infect Dis 2011;15:e357-62.
11. Madani N, Rosenthal VD, Dendane T, Abidi K, Zeggwagh AA, Abouqal R. Health care–associated infections rates, length of stay, and bacterial resistance in an intensive care unit of Morocco: findings of the International Nosocomial Infection Control Consortium (INICC). Int Arch Med 2009;2:29.
12. Salomao R, Rosenthal VD, Grimberg G, Nouer S, Blecher S, Buchner-Ferreira S, et al. Device-associated infection rates in intensive care units of Brazilian hospitals: findings of the International Nosocomial Infection Control Consortium. Rev Panam Salud Publica 2008;24:195-202.
13. Rosenthal VD. Device-associated nosocomial infections in limited-resources countries: findings of the International Nosocomial Infection Control Consortium (INICC). Am J Infect Control 2008;36:S171.e7-171.e12.
14. Rosenthal VD, Maki DG, Mehta A, Alvarez-Moreno C, Leblebicioglu H, Higuera F, et al. International Nosocomial Infection Control Consortium report, data summary for 2002-2007, issued January 2008. Am J Infect Control 2008; 36:627-37.
15. Cuellar LE, Fernandez-Maldonado E, Rosenthal VD, Castaneda-Sabogal A, Rosales R, Mayorga-Espichan MJ, et al. Device-associated infection rates and mortality in intensive care units of Peruvian hospitals: findings of the International Nosocomial Infection Control Consortium. Rev Panam Salud Publica 2008;24:16-24.
16. Mehta A, Rosenthal VD, Mehta Y, Chakravarthy M, Todi SK, Sen N, et al. Device-associated nosocomial infection rates in intensive care units of seven Indian cities: findings of the International Nosocomial Infection Control Consortium (INICC). J Hosp Infect 2007;67:168-74.
17. Leblebicioglu H, Rosenthal VD, Arikan OA, Ozgultekin A, Yalcin AN, Koksal I, et al. Device-associated hospital-acquired infection rates in Turkish intensive care units: findings of the International Nosocomial Infection Control Consortium (INICC). J Hosp Infect 2007;65:251-7.
18. Rosenthal VD, Maki DG, Salomao R, Moreno CA, Mehta Y, Higuera F, et al. Device-associated nosocomial infections in 55 intensive care units of 8 developing countries. Ann Intern Med 2006;145:582-91.
19. Moreno CA, Rosenthal VD, Olarte N, Gomez WV, Sussmann O, Agudelo JG, et al. Device-associated infection rate and mortality in intensive care units of 9 Colombian hospitals: findings of the International Nosocomial Infection Control Consortium. Infect Control Hosp Epidemiol 2006;27:349-56.
20. Ramirez Barba EJ, Rosenthal VD, Higuera F, Oropeza MS, Hernandez HT, Lopez MS, et al. Device-associated nosocomial infection rates in intensive care units in four Mexican public hospitals. Am J Infect Control 2006;34:244-7.
21. Rosenthal VD, Guzman S, Crnich C. Device-associated nosocomial infection rates in intensive care units of Argentina. Infect Control Hosp Epidemiol 2004; 25:251-5.
22. Rosenthal VD, Guzman S, Orellano PW. Nosocomial infections in medical-surgical intensive care units in Argentina: attributable mortality and length of stay. Am J Infect Control 2003;31:291-5.
23. Coffin SE, Klompas M, Classen D, Arias KM, Podgorny K, Anderson DJ, et al. Strategies to prevent ventilator-associated pneumonia in acute care hospitals. Infect Control Hosp Epidemiol 2008;29(Suppl 1):S31-40.
24. Apisarnthanarak A, Pinitchai U, Thongphubeth K, Yuekyen C, Warren DK, Zack JE, et al. Effectiveness of an educational program to reduce ventilator-associated pneumonia in a tertiary care center in Thailand: a 4-year study. Clin Infect Dis 2007;45:704-11.
25. Rosenthal VD, Maki DG, Rodrigues C, Alvarez-Moreno C, Leblebicioglu H, Sobreyra-Oropeza M, 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.
26. Rosenthal VD, Guzman S, Crnich C. Impact of an infection control program on rates of ventilator-associated pneumonia in intensive care units in 2 Argentinean hospitals. Am J Infect Control 2006;34:58-63.
27. Rosenthal VD, Guzman S, Safdar N. Reduction in nosocomial infection with improved hand hygiene in intensive care units of a tertiary care hospital in Argentina. Am J Infect Control 2005;33:392-7.
28. 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 Mexico. Crit Care Med 2005;33:2022-7.
29. Rosenthal VD, Guzman S, Safdar N. Effect of education and performance feedback on rates of catheter-associated urinary tract infection in intensive care units in Argentina. Infect Control Hosp Epidemiol 2004;25:47-50.
30. Rosenthal VD, McCormick RD, Guzman S, Villamayor C, Orellano PW. Effect of education and performance feedback on handwashing: the benefit of administrative support in Argentinean hospitals. Am J Infect Control 2003; 31:85-92.
31. 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.
32. Emori TG, Culver DH, Horan TC, Jarvis WR, White JW, Olson DR, et al. National nosocomial infections surveillance system (NNIS): description of surveillance methods. Am J Infect Control 1991;19:19-35.
33. Horan TC, Andrus M, Dudeck MA. CDC/NHSN surveillance definition of health care–associated infection and criteria for specific types of infections in the acute care setting. Am J Infect Control 2008;36:309-32.
34. Tablan OC, Anderson LJ, Besser R, Bridges C, Hajjeh R. Guidelines for preventing health care–associated pneumonia, 2003: recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee. MMWR Recomm Rep 2004;53:1-36.
35. Boyce JM, Pittet D. Guideline for hand hygiene in health-care settings: recommendations of the Healthcare Infection Control Practices Advisory Committee and the HIPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. Am J Infect Control 2002;30:S1-46.
36. Dellinger RP, Vincent JL. The Surviving Sepsis campaign sepsis change bundles and clinical practice. Crit Care 2005;9:653-4.
37. Burns KE, Adhikari NK, Meade MO. Noninvasive positive pressure ventilation as a weaning strategy for intubated adults with respiratory failure. Cochrane Database Syst Rev; 2003:CD004127.
38. Tantipong H, Morkchareonpong C, Jaiyindee S, Thamlikitkul V. Randomized controlled trial and meta-analysis of oral decontamination with 2% chlorhexidine solution for the prevention of ventilator-associated pneumonia. Infect Control Hosp Epidemiol 2008;29:131-6.
39. Holzapfel L, Chastang C, Demingeon G, Bohe J, Piralla B, Coupry A. A randomized study assessing the systematic search for maxillary sinusitis in nasotracheally mechanically ventilated patients: influence of nosocomial maxillary sinusitis on the occurrence of ventilator-associated pneumonia. Am J Resp Crit Care 1999;159:695-701.
40. Rello J, Sonora R, Jubert P, Artigas A, Rue M, Valles J. Pneumonia in intubated patients: role of respiratory airway care. Am J Resp Crit Care Med 1996;154: 111-5.
41. Kollef MH. Prevention of hospital-associated pneumonia and ventilator-associated pneumonia. Crit Care Med 2004;32:1396-405.
42. Stamm AM. Ventilator-associated pneumonia and frequency of circuit changes. Am J Infect Control 1998;26:71-3.
43. Heyland DK, Drover JW, MacDonald S, Novak F, Lam M. Effect of postpyloric feeding on gastroesophageal regurgitation and pulmonary microaspiration: results of a randomized controlled trial. Crit Care Med 2001;29:1495-501.
44. Cook DJ, Reeve BK, Guyatt GH, Heyland DK, Griffith LE, Buckingham L, et al. Stress ulcer prophylaxis in critically ill patients: resolving discordant meta-analyses. JAMA 1996;275:308-14.
45. Heyland DK, Cook DJ, Griffith L, Keenan SP, Brun-Buisson C, Canadian Critical Trials Group. The attributable morbidity and mortality of ventilator-associated pneumonia in the critically ill patient. Am J Respir Crit Care Med 1999;159: 1249-56.
46. Assanasen S, Edmond M, Bearman G. Impact of 2 different levels of performance feedback on compliance with infection control process measures in 2 intensive care units. Am J Infect Control 2008;36:407-13.
47. Hughes JM. Study on the efficacy of nosocomial infection control (SENIC Project): results and implications for the future. Chemotherapy 1988;34: 553-61.
48. Valles J, Artigas A, Rello J, Bonsoms N, Fontanals D, Blanch L, et al. Continuous aspiration of subglottic secretions in preventing ventilator-associated pneumonia. Ann Intern Med 1995;122:179-86.
49. Boyce JM, White RL, Spruill EY, Wall M. Cost-effective application of the Centers for Disease Control guideline for prevention of nosocomial pneumonia. Am J Infect Control 1985;13:228-32.
50. Gaynes RP, Solomon S. Improving hospital-acquired infection rates: the CDC experience. Jt Comm J Qual Improv 1996;22:457-67.