Impact of selective digestive decontamination without systemic antibiotics in a major heart surgery intensive care unit

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ABSTRACT

Purpose: The incidence density of ventilator-associated pneumonia (VAP) is higher in patients undergoing major heart surgery than in other populations, despite the introduction of bundles of preventive measures, because many risk factors are not amenable to intervention. Selective digestive decontamination (SDD) has been shown to be efficacious for decreasing the frequency of VAP, although it has not been incorporated into the routine of most intensive care units. The objective of our study was to evaluate the efficacy of SDD without parenteral antibiotics for preventing VAP in a major heart surgery intensive care unit.

Methods: We compared the incidence of VAP before the introduction of SDD (17 months) and during the 17 months after the introduction of SDD and examined its ecologic influence.

Results: The rates of VAP in the overall population before and during the intervention were 16.26/1000 days and 6.80 episodes/1000 days of mechanical ventilation, respectively ($P = .01$). The rates of VAP in the 173 patients remaining under mechanical ventilation > 48 hours after surgery were, respectively, 25.85/1000 days of mechanical ventilation versus 12.06 episodes/1000 days of mechanical ventilation ($P = .04$). We found a significant reduction in the number of patients with multidrug-resistant microorganisms ($P = .01$) in the second period of the study.

Conclusions: Our study shows that SDD without parenteral antibiotics can reduce the incidence of VAP in high-risk patients after major heart surgery, with no significant ecologic influence. (J Thorac Cardiovasc Surg 2018;156:685-93)

SDD digestive solution and oral paste.

Central Message

Our study evaluates the efficacy of SDD without parenteral antibiotics for preventing VAP in an MHS ICU and its ecologic influence.

Perspective

We found that SDD without parenteral antibiotics can reduce the incidence and delay onset of VAP in high-risk patients after MHS. The presence of MDR microorganisms had no ecologic influence on the MHS-ICU. In our opinion, SDD should be systematically applied to all patients requiring MV > 48 hours after MHS.

See Editorial Commentary page 694.

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Ventilator-associated pneumonia (VAP) is the most frequent infection in patients admitted to intensive care units (ICUs). It is associated with high morbidity and mortality, prolonged hospital stay,¹⁻³ and increased health care costs.⁴⁻⁶ The main pathogenic mechanism underlying lung infection in VAP is aspiration of contaminated secretions of the upper respiratory tract into the lungs.⁷⁻⁹

Measures for preventing VAP can be nonpharmacologic and pharmacologic. The latter group includes oral hygiene with chlorhexidine and selective digestive decontamination

Scanning this QR code will take you to a supplemental video for the article.

Abbreviations and Acronyms

ICU	= intensive care unit
MDR	= multidrug resistant
MHS	= major heart surgery
MV	= mechanical ventilation
SDD	= selective digestive decontamination
VAP	= ventilator-associated pneumonia
XDR	= extensively drug resistant

(SDD) with antimicrobial agents.¹⁰⁻¹² Despite its efficacy,^{11,13,14} SDD has not been incorporated into the routine of most ICUs, mainly because of the fear of inducing bacterial resistance.¹⁵⁻¹⁷

In patients undergoing major heart surgery (MHS), the incidence density of VAP is higher than in other populations¹⁸ despite the introduction of bundles of preventive measures because many risk factors are not amenable to intervention.¹⁹

Our study assessed the influence of SDD in an MHS-ICU in which other preventive measures had been already introduced. We used only topical antimicrobial agents and evaluated the long-term influence of SDD on the isolation of multidrug-resistant (MDR) microorganisms in the MHS-ICU population (Video 1).

MATERIALS AND METHODS

Hospital Setting and Patients

Our institution is a general referral hospital with 1550 beds and approximately 50,000 admissions per year. More than 500 MHS procedures are performed annually in our Department of Cardiovascular Surgery, which is a large referral unit.

Study Design

This was a prospective, interventional study. All consecutive patients from April 2012 to January 2015 received prevention of VAP as the standard of care. The preintervention period went from April 2012 to August 2013. From September 2013 to January 2015 we introduced, on top of the standard care, SDD. Preintervention patients were used as nonconcurrent controls to analyze the ecologic influence of SDD on the MHS-ICU. We compared also the incidence of VAP before the introduction of SDD (17 months) and during the 17 months after introduction.

The bundle of measures for prevention of pneumonia in the MHS-ICU during the study period (before and during of introduction of SDD), included aspiration of subglottic secretions using a TaperGuard Evac endotracheal tube (Mallinckrodt, St Louis, Mo), cuff pressure maintained at 20 to 30 mm Hg and monitored continuously, semirecumbent position (30°–45°), and oral hygiene with chlorhexidine. The antibiotic prophylaxis for surgery consisted of 2 g cefazolin given immediately before surgery and every 8 hours thereafter for a total of 3 doses (patients who were allergic to cefazolin received 1 g vancomycin twice daily, up to 2 doses). All patients received prophylaxis for gastrointestinal ulcers with proton pump inhibitors. A nasogastric tube was only placed in patients intubated longer than 24 hours who required enteral nutrition or gastric emptying.

VIDEO 1. Selective digestive decontamination after major heart surgery. Video available at: [http://www.jtcvsonline.org/article/S0022-5223\(18\)30725-6/fulltext](http://www.jtcvsonline.org/article/S0022-5223(18)30725-6/fulltext).

SDD was systematically applied to patients who remained under mechanical ventilation (MV) for more than 48 hours. It was also anticipated and started after 24 hours of MV in patients who fulfilled 1 or more of the following criteria: open sternum due to bleeding, hemodynamic instability, ventricular assist device due to cardiogenic shock, and/or neurologic damage type I.

Tracheostomy was not an exclusion criterion. All patients received oral hygiene with 0.12% chlorhexidine every 6 hours followed by SDD oral paste and digestive solution every 6 hours. Our SDD paste was composed of nystatin, tobramycin, vancomycin, and colistin. The digestive solution contained only colistin, nystatin, and tobramycin.

We did not administer systemic antibiotics as part of the procedure. SDD was stopped at the end of MV or in tracheostomy patients at discharge from the ICU. No surveillance cultures were performed during the study due to the poor predictive value of those cultures in our own institution.²⁰

Primary End Point

The primary end point of the study was the reduction in the incidence density of VAP.

Secondary End Points

The secondary end points were length of ICU stay, days of MV, mortality rate, cost of antimicrobial drugs during the ICU stay, and ecologic influence on the MHS-ICU population (ie, emergence of antimicrobial resistance, superinfection, and *Clostridium difficile* infection).

Follow-up

Physicians from the Departments of Anesthesia and Infectious Diseases monitored patients daily to check for the presence of infection. The infection control team is multidisciplinary and comprises physicians and nurses from the ICU, microbiologists, infectious diseases specialists, and health care workers from the Department of Preventive Medicine. All data of patients undergoing MHS are regularly and prospectively collected in a database, both before and after the introduction of the SDD.

The Ethics Committee of our institution (Hospital Gregorio Marañón) approved the study (code 10/15) and waived the need for informed consent

because we followed the recommendations of the guidelines for the prevention of VAP.

Sampling in Patients With Suspected Lower Respiratory Tract Infection

Sampling of the lower respiratory tract in patients with suspected VAP was by endotracheal aspiration, protected specimen brushing, or both. When aspiration was unproductive, we irrigated with 5 mL Ringer's lactate solution. Secretions obtained by endotracheal aspiration were collected in a Lukens specimen container (Sherwood Medical, Tullamore, Ireland). A sample was considered positive with bacterial counts $\geq 10^4$ CFU/mL for each microorganism obtained using endotracheal aspiration and $\geq 10^3$ CFU/mL for each microorganism obtained using protected specimen brushing.

All microorganisms were identified using standard methods, and antimicrobial susceptibility was determined according to Clinical and Laboratory Standards Institute recommendations.

Demonstration of VAP

Patients ventilated for > 48 hours were diagnosed with VAP based on the presence of new and/or progressive pulmonary infiltrates on the chest radiograph plus ≥ 2 of the following criteria: fever > 38.5°C or hypothermia < 36°C, leukocytosis $\geq 12 \times 10^9/L$, purulent tracheobronchial secretions, and a $\geq 15\%$ reduction in arterial oxygen tension/fraction of inspired oxygen according to the definitions of the Centers for Disease Control and Prevention.²¹ Patients with a clinical pulmonary infection score higher than 6 were also considered to have pneumonia.²² The isolation of 1 or more pathogenic microorganisms

in significant bacterial counts was required to confirm the diagnosis of VAP. Rate of pneumonia was defined as the number of episodes of pneumonia per days of exposure to mechanical ventilation (ie, incidence density).

The definition for diagnosis of tracheobronchitis was identical to that of VAP in the absence of pulmonary infiltrates. To exclude colonization, patients with tracheobronchitis had to present fever or hypothermia, leukocytosis, purulent tracheobronchial secretions, or a reduction in arterial oxygen tension/fraction of inspired oxygen of $\geq 15\%$ not attributable to other causes.^{23,24}

Unless other evidence was available, we considered as nonpathogenic the isolation (at any concentration) of the following microorganisms in lower respiratory secretions: viridans-group streptococci, coagulase-negative staphylococci, *Neisseria* spp, *Corynebacterium* spp, and *Candida* spp.

Ecologic Influence on the MHS-ICU

To assess the ecologic influence of SDD on the MHS-ICU population, we compared data from the Department of Microbiology during the 2 study periods, including the proportion of MDR microorganisms (ie, carbapenemase-producing gram-negative bacteria, MDR, or extensively drug-resistant [XDR] *Pseudomonas aeruginosa*, and methicillin-resistant *Staphylococcus aureus* isolates).

Statistical Analysis

Relationships between baseline variables were evaluated before and after implementation of SDD. Baseline comparisons between groups were established by clinical relevance (using the variables of interest according to clinical criteria) following the Consolidated Standards of Reporting

FIGURE 1. Consort diagram of population of study. MHS, Major heart surgery; OR, operating room; MV, mechanical ventilation; SDD, selective digestive decontamination.

Trials Normative for Publication. The qualitative variables appear with their frequency distribution. The quantitative variables are summarized as mean $\pm$ standard deviation and median and interquartile range if the distribution was skewed. Continuous variables were compared using the *t* test for normally distributed variables or median test for nonnormally distributed variables. The χ^2 or Fisher exact test was used to compare categorical variables.

The incidence rates of VAP (event/1000 days of MV) were compared between the groups.

A multivariate logistic regression model adjusted for age, reintubation, days of MV, and SDD was used to assess the influence of SDD in VAP and results were reported as odds ratio and 95% confidence interval (CI). Time to event was analyzed with the Cox model and is reported as a hazard ratio and 95% CI. Both models were adjusted by the following variables: age, reintubation, days of MV, and SDD. There was no adjustment for multiplicity in the determination of statistical significance. All statistical tests were 2-tailed. Statistical significance was set at $P < .05$ for all the tests. The statistical analysis was performed using SPSS 12.0 (IBM-SPSS Inc, Armonk, NY), and STATA 11.0 (StataCorp LLC, College Station, Tex).

RESULTS

Study Population

We compared the results obtained before the intervention (April 2012-August 2013) and during the intervention

(September 2013-January 2015). Throughout the study period, 1258 patients underwent MHS (629 per period). Of those, 173 patients (13.8%) remained under MV for ≥ 48 hours and constitute the base of our study: 92 pre-intervention controls and 81 SDD patients. SDD was started after 48 hours of MV in 59 patients and after 24 hours of MV in 22 high-risk patients according to our criteria (Figure 1).

Both populations (cases and control) were comparable according to age, sex, underlying conditions, European system for cardiac operative risk evaluation score, and acute physiology and chronic health evaluation score. The underlying conditions and surgical variables of both populations are compared in Tables 1 and 2. The mean $\pm$ standard deviation European system for cardiac operative risk evaluation score of both groups was comparable (10.1 ± 2.9 before the intervention vs 9.4 ± 4.2 after the intervention; $P = .25$).

Overall Population

When the overall population was analyzed, we found no significant differences in days of MV, length of ICU

TABLE 1. Baseline characteristics and surgical variables of the study patients

	Before SDD (n = 629)	During SDD (n = 629)	P value
Preoperative			
Age, y	67 (57-76)	67 (56-75)	.27
Sex, F/M	256/373	235/394	.23
Underlying conditions			
Myocardial infarction	75 (11.9)	76 (12.1)	.93
Congestive heart failure	69 (11.0)	65 (10.4)	.72
ACVA	55 (8.7)	38 (6.0)	.06
Chronic obstructive pulmonary disease	78 (12.4)	75 (11.9)	.79
Diabetes mellitus	156 (24.8)	177 (28.1)	.18
Peptic ulcer disease	10 (1.6)	9 (1.4)	.81
Peripheral vascular disease	40 (6.4)	36 (5.7)	.63
Risk, EuroScore (logistic)	10.1 ± 11.7	9.4 ± 4.2	.25
Previous cardiac surgery	91 (14.5)	92 (14.6)	1.00
Shock	9 (1.4)	7 (1.1)	.80
Severe reduction of LVEF	45 (7.1)	47 (7.5)	.82
Severe pulmonary hypertension	68 (10.8)	57 (9.1)	.30
Type of surgery			
Valve replacement	275 (43.7)	272 (43.2)	.86
CABG	146 (23.2)	178 (28.2)	.03
Mixed (valve and CABG)	69 (10.9)	61 (9.6)	.45
Transplantation	13 (2.2)	19 (3.0)	.35
Congenital	10 (1.6)	17 (2.7)	.29
Surgical data			
CPBT, min	132.3 ± 59.6	142.0	.18
Aortic crossclamp time, min	77.5 ± 40.6	76.6 ± 41.6	.72
Intra-aortic balloon during surgery	42 (7.0)	50 (8.5)	.33

Values are presented as median (interquartile range), n (%), or mean $\pm$ standard deviation. SDD, Selective digestive decontamination; ACVA, acute cerebrovascular accident; EuroSCORE, European system for cardiac operative risk evaluation; LVEF, left ventricular ejection fraction; CABG, coronary artery bypass grafting; CPBT, cardiopulmonary bypass time.

TABLE 2. Primary and secondary end points before and after selective digestive decontamination in the overall population of a major heart surgery intensive care unit

	Before (n = 629)	During (n = 629)	P value
(VAP + tracheobronchitis)/1000 d of MV	19.74	9.28	.01
Episodes of VAP	28	11	.008
VAP/1000 d of MV	16.26	6.80	.01
Episodes of tracheobronchitis	6	4	.52
Tracheobronchitis/1000 d of MV	3.48	2.47	.83
Total time MV, d	1722	1616	–
Time on MV, d	2.7 ± 6.4	2.5 ± 5.5	.61
Time on MV, d	1 (1-1)	1 (1-1)	.69
Reintubation MV > 48 h	34 (5.6)	35 (5.6)	.99
Length of ICU stay, d	4 (3-7)	5 (3-7)	.82
Transfusion	384 (50.2)	381 (49.8)	.86
Units transfused	2 (0-3)	1 (0-3)	.90
Episodes of bacteremia/1000 admissions	55.0	41.47	.23
Episodes of candidemia/1000 admissions	1.2	2.24	1.0
Episodes of CDAD	5 (7.9)	8 (13.6)	.31
Cost of antimicrobial drugs during the ICU stay/1000 admissions, €	213.3 ± 208.4	211.9 ± 169.0	.98
Mortality	51 (8.1)	45 (7.2)	.52

Values are presented as n, mean ± standard deviation, median (interquartile range), or n (%). VAP, Ventilator-associated pneumonia; MV, mechanical ventilation; ICU, intensive care unit; CDAD, *Clostridium difficile*-associated diarrhea.

stay, mortality, or incidence of other infections between the first period (no SDD) and the second period (SDD) (Table 1).

The incidence density of lower respiratory tract infections (combination of VAP and tracheobronchitis) was 19.74 and 9.28 before and during the intervention, respectively ($P = .01$) (Table 2). The rates of VAP before and during the intervention were 16.26/1000 days and 6.80 episodes/1000 days of MV, respectively ($P = .01$) (Table 2). The rates of tracheobronchitis before and during the intervention were 3.48 and 2.47/1000 days of MV, respectively ($P = .83$) (Table 2).

We recorded 47 episodes of bacteremia (55.0/1000 admissions) before the intervention and 37 episodes (41.47/1000 admissions) during the intervention ($P = .23$). In the case of candidemia we recorded 1 episode (1.2/1000 admissions) and 2 episodes (2.24/1000 admissions), respectively ($P = 1.0$).

High-Risk Population (Patients Ventilated > 48 Hours)

Table 3 shows that the characteristics of high-risk patients (MV > 48 hours) in both periods of time (with and without SDD) were comparable.

The incidence density of lower respiratory tract infections (combination of VAP and tracheobronchitis) in this high-risk population was 31.39 before the intervention and 14.25 during the intervention ($P = .01$) (Table 4).

Of 92 high-risk patients, the rates of VAP before and during the intervention were 25.85/1000 days and 12.06 episodes/1000 days of MV, respectively ($P = .04$). Episodes of tracheobronchitis/1000 days of MV before and during the intervention were 5.54 versus 2.19, respectively ($P = .41$) (Table 4).

The median days of MV in the long-term population before and during the intervention was, respectively, 6.0 (range, 4-14.7 days) and 6.0 (range, 3-15.0 days) ($P = .96$). The episodes of VAP occurred significantly later in patients receiving SDD (day 6 [range, day 3-11] vs day 5 [range, day 3-14.5]; $P = .01$).

The etiology of VAP during both periods is detailed in Table 5. We only found significant differences in episodes of VAP caused by *P aeruginosa* between both periods: 13 versus 3 episodes ($P = .03$).

In a multivariate regression model analysis adjusted for age, reintubation, days of MV, and SDD, we found that SDD was an independent protective factor for the development of VAP (odds ratio, 0.33; 95% CI, 1.13-0.76; $P = .01$). When we analyzed the VAP during the period of mechanical ventilation, the hazard ratio was 0.73 (CI, 0.54-0.98; $P = .04$), adjusted for age and reintubation.

We were not able to find significant differences in ICU stay, mortality, or other infections in either the overall population or the at-risk population (patients ventilated > 48 hours) (Table 4).

TABLE 3. Baseline characteristics and surgical variables of patients undergoing major heart surgery on mechanical ventilation for > 48 h

	Before SDD (n = 92)	During SDD (n = 81)	P value
Patients (%)	14.6	12.9	.36
Preoperative			
Age, y	72.5 (61.5-78.0)	68.0 (59.0-76.0)	.06
Sex, F/M	36/56	34/47	.70
Underlying conditions			
Myocardial infarction	12 (13.0)	11 (13.6)	.91
Congestive heart failure	18 (19.6)	14 (17.3)	.70
Central nervous system—ACVA	11 (12.0)	10 (12.3)	.93
Chronic obstructive pulmonary disease	12 (13.0)	12 (14.8)	.73
Diabetes mellitus	26 (28.3)	20 (24.7)	.59
Peptic ulcer disease	2 (2.2)	2 (2.5)	.89
Peripheral vascular disease	10 (10.9)	3 (3.7)	.07
Risk, EuroSCORE	18.9 ± 17.3	15.4 ± 17.1	.18
Severe pulmonary hypertension	18 (19.5)	15 (18.5)	.87
Type of surgery			
Valve replacement	37 (40.2)	32 (39.5)	.92
CABG	11 (12.0)	14 (17.3)	.32
Mixed (valve and CABG)	17 (18.5)	17 (21.5)	0.67
Transplant	4 (4.5)	6 (7.4)	.42
Surgical data			
CPBT, min	157.6 ± 80.3	156.1 ± 91.1	.90
Aortic crossclamp time, min	87.5 ± 57.5	75.2 ± 58.3	.16
Intra-aortic balloon during the surgery	14 (15.6)	26 (32.1)	.01

Values are presented as median (interquartile range), n, n (%), or mean ± standard deviation. SDD, Selective digestive decontamination; ACVA, acute cerebrovascular accident; EuroSCORE, European system for cardiac operative risk evaluation; CABG, coronary artery bypass grafting; CPBT, cardiopulmonary bypass time.

Cost of Antimicrobial Agents During ICU Stay

Cost of antimicrobial drugs during the ICU stay per 1000 admissions, before and after the intervention, were €213.30 and €211.90 ($P = .98$), respectively.

Ecologic Influence of the Implementation of SDD in the MHS-ICU

To assess the ecologic influence of the introduction of SDD on the MHS-ICU, we analyzed several parameters in

TABLE 4. Primary and secondary end points before and after selective digestive decontamination in the high-risk population (mechanical ventilation [MV] > 48 h) of a major heart surgery intensive care unit

	Before (n = 92)	During (n = 81)	P value
(Tracheobronchitis+VAP)/1000 d of MV	31.39	14.25	.01
Episodes of VAP	28	11	.01
VAP/1000 d of MV	25.85	12.06	.04
Episodes of tracheobronchitis	6	2	.20
Tracheobronchitis/1000 d of MV	5.54	2.19	.41
Total time of MV	1083	912	.10
Time on MV, d	6 (4-14.7)	6 (3-15)	.96
Reintubation	27 (29.3)	23 (28.4)	.85
Length of ICU stay, d	12.5 (7-24.5)	13 (8-27.5)	.24
Transfusion	77 (86.5)	71 (89.9)	.50
Units transfused	4 (2-6.7)	5 (2-8)	.08
Episodes of CDAD	3 (6.8)	6 (17.6)	.13
Mortality	32 (34.8)	21 (25.9)	.20

Values are presented as n, n (%), or median (interquartile range). VAP, Ventilator-associated pneumonia; MV, mechanical ventilation; ICU, intensive care unit; CDAD, *Clostridium difficile*-associated diarrhea.

TABLE 5. Microorganisms isolated during episodes of ventilator-associated pneumonia before and during selective digestive decontamination

	Before (n = 28)	During (n = 11)	P value
Methicillin-susceptible <i>Staphylococcus aureus</i>	1	2	.91
<i>Haemophilus influenzae</i>	4	0	.16
<i>Enterobacteriaceae</i>	15	5	.06
<i>Pseudomonas aeruginosa</i>	13	3	.03
Virus	1	1	.53

the whole population admitted to the MHS-ICU before and after the intervention.

Table 6 shows data obtained from the Department of Microbiology on the incidence per 1000 MHS/ICU admissions according to several parameters. We found no significant differences in the number of patients with ≥ 1 isolates of gram-negative carbapenemase-producing gram-negative bacteria or number of patients with ≥ 1 methicillin-resistant *S aureus* isolates.

We found a significant reduction in the number of patients with ≥ 1 isolates of MDR or XDR *P aeruginosa* ($P < .001$) during the second period (Table 6). The number of patients with ≥ 1 MDR microorganism was 18 and 10 ($P = .10$) for each period, respectively.

DISCUSSION

In a busy MHS-ICU, the implementation of SDD without parenteral antibiotics in the high-risk population remaining under MV for more than 48 hours, reduced the rate of VAP

and delayed its appearance. This intervention did not promote the emergence of antibiotic resistance, neither in the high-risk population nor in the overall population. We were not able to demonstrate a significant influence on mortality in the overall population.

VAP is the most frequent infection after MHS, with incidence rates ranging from 5.7% to 21.6%,² although incidence can reach 46% in high-risk patients, who must remain under MV for more than 48 hours.¹⁹ The effect of SDD with topical antibiotics (with or without parenteral antibiotics) remains open to debate²⁵⁻²⁷; however, this measure was associated with a reduction in mortality in a recent meta-analysis.^{13,28}

Most data on the efficacy of SDD are obtained from general ICUs, as opposed to MHS-ICUs.^{11,16,29} Our data also confirm the efficacy of SDD in this specific group of patients.

Although the major concern regarding SDD is the potential selection of drug-resistant microorganisms, several meta-analyses did not confirm this fear. In those series, data on resistant microorganisms were obtained over short periods of time and mainly in the exposed population.^{15,17,29-33}

Our study shows that MDR organisms causing colonization or infection did not appear in the overall population of our MHS-ICU and were collected over a relatively long period of observation. In fact, we found that the number of patients with ≥ 1 isolates of MDR or XDR *P aeruginosa* decreased during the period when SDD was used and that the number of other MDR bacteria did not increase.

We decided not to use parenteral antibiotics because our group had previously shown that even short courses of no

TABLE 6. Ecologic influence of selective digestive decontamination

	April 2012-August 2013 (before)	September 2013-January 2015 (after)	P value
Total admissions for major heart surgery	854	892	.59
ICU length of stay, d	5362	5610	.59
Number of samples with any bacteriological request from intensive care unit	531	505	.06
Number of samples with ≥ 1 bacterial isolates*	307	217	<.001
Number of patients with ≥ 1 bacterial isolates*	103 (12.0)	85 (9.5)	.12
Number of patients with ≥ 1 MRSA isolates*	3 (0.3)	1 (0.1)	.59
Number of patients with ≥ 1 linezolid-resistant <i>Staphylococcus aureus</i> isolates*	—	—	NA
Number of patients with ≥ 1 isolates of MDR or XDR <i>Pseudomonas aeruginosa</i> *	9 (1.0)	0 (0)	.01
Number of patients with ≥ 1 isolates of ESBL-producing <i>Enterobacteriaceae</i> *	6 (0.7)	9 (1.0)	.66
Number of patients with ≥ 1 isolates of gram-negative carbapenemase-producing gram-negative bacteria*	1 (0.19)	1 (0.1)	1.47
Number of patients with ≥ 1 isolates of MDR or XDR <i>Acinetobacter baumannii</i> *	—	—	NA
Number of patients with ≥ 1 MDR microorganisms*	18 (2.1)	10 (1.1)	.15

ICU, Intensive care unit; MRSA, methicillin-resistant *Staphylococcus aureus*; NA, not available; MDR, multidrug-resistant; XDR, extensively drug-resistant (from PMID 21793988); ESBL, extended-spectrum beta-lactamase. *Number of episodes (episodes per 1000 admissions).

more than 3 days of intravenous linezolid caused an increase in the number of linezolid-resistant *Staphylococcus* spp isolates (coagulase-negative staphylococci and *S aureus*) in our MHS-ICU.³⁴

The effect of SDD on bacteremia is particularly interesting. Bacteremia acquired by patients in the ICU is associated with high attributable mortality, especially in those undergoing MV or who have pneumonia as the source of bacteremia.³⁵ We observed a decreasing trend in the frequency of bacteremic episodes during the second period, although the differences did not reach statistical significance.

Our study is limited by the fact that we enrolled only the population undergoing MHS; therefore, our data cannot necessarily be extrapolated to other ICU populations. The design of our study did not include concurrent controls and a Hawthorne effect cannot be excluded with this design.

CONCLUSIONS

We found that SDD without parenteral antibiotics can reduce the incidence and delay onset of VAP in high-risk patients after MHS. SDD had no ecologic influence on the incidence of MDR microorganisms in the MHS-ICU. In our opinion, SDD should be systematically applied to all patients requiring MV > 48 hours after MHS.

Conflict of Interest Statement

Authors have nothing to disclose with regard to commercial support.

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Key Words: prevention, ventilator-associated pneumonia, selective digestive decontamination, nosocomial pneumonia

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