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Ten-year surveillance study of ventilator-associated pneumonia at a tertiary care center in Lebanon

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ABSTRACT

Background: Ventilator-associated pneumonia (VAP) is associated with significant adverse outcomes in critically-ill patients admitted to the Intensive Care Unit (ICU). Systematic data from Lebanon on VAP are not available and large epidemiological studies from the region are scarce.
Methods: We conducted a retrospective study over a 10-year period at the American University of Beirut Medical Center (AUBMC), a tertiary referral center in Lebanon in order to describe the incidence, microbiology, and temporal trends of VAP in the medical/surgical ICU.
Results: A total of 162 patients developed VAP over the study period and the overall incidence of VAP was 7.9 per 1000 ventilator-days. There was a statistically significant decrease over time in the incidence of VAP, from 13.1 in 2008 to 1.1 per 1000 ventilator-days in 2017. Multidrug-resistant (MDR) *Acinetobacter* spp. was the predominant pathogen, both in early- as well as late-onset VAP, followed by *Pseudomonas aeruginosa*.
Conclusions: Following significant efforts from the Infection Control and Prevention Program, a considerable reduction in the incidence of VAP was achieved at AUBMC. The predominance of MDR *Acinetobacter* spp. should be taken into consideration when deciding on empirical therapy in patients with VAP.
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Introduction

Hospital-acquired infections carry a huge burden. Ventilator-associated pneumonia (VAP) is the second most common hospital acquired infections in the intensive care unit (ICU) and is associated with significant morbidity and mortality [1–3]. VAP is defined as pneumonia that develops at least two calendar days after introduction of mechanical ventilation (MV). It is associated with increased cost of care and leads to a substantial financial burden. Many hospitals have implemented evidence-based strategies to prevent VAP [3]. One of the most effective preventive strategies is the adoption of the ventilator bundle advocated by the Institute for Healthcare Improvement (IHI) among other bundles to prevent hospital acquired infections [4].

Very few studies have been published from the Middle East on the epidemiology of VAP [5–9]. The aim of this study is to review and analyze the incidence and epidemiology of VAP in an adult medical/surgical ICU setting at a tertiary care center in Lebanon over 10 years.

Methods

Definitions

All hospitalized patients who required mechanical ventilation for more than 2 calendar days were eligible for enrolment in the study if they fulfilled the definition of VAP based on the definitions of the Centers for Disease Control and Prevention (CDC) National Healthcare Safety Network (NHSN) [10]. This definition was periodically subject to multiple revisions and updates to facilitate standardization. Accordingly, VAP was defined as pneumonia occurring more than two calendar days after the onset of MV, fulfilling a combination of radiologic, clinical and laboratory criteria. VAP was labeled as "early-onset" when it developed in the first four days of MV, and "late-onset" when it is manifested after the fourth day

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of MV [11]. In 2013, NHSN published a strategic document affecting the definitions of VAP and adopted an algorithm for adult patients grouped under Ventilator Associated Events (VAE) [12]. The new algorithm was intended to improve the consistency and credibility of the surveillance definition by capturing more general and objective measures of events occurring in patients on MV.

Study setting

The study is a single center retrospective study of all adult ICU patients who developed VAP between 2008 and 2017 at the American University of Beirut Medical Center (AUBMC). AUBMC is a 386-bed academic tertiary care center, and is considered to be a referral center at the national and regional levels. The hospital has an infection control team (ICT) comprised of physicians, a hospital epidemiologist, and practitioners with more than 20 years of experience, in addition to an advanced clinical microbiology laboratory. The study was conducted at the adult 12-bed ICU. This medical-surgical ICU admits a widespread mix of high-risk patients with multiple comorbidities, as well as oncology patients and patients undergoing major surgical procedures. Patients with war-related injuries from neighboring countries are also admitted to this unit.

Study subjects

Patients were recruited prospectively during the daily ICT surveillance rounds throughout the study period. Adult patients who were mechanically ventilated for more than two calendar days were considered for inclusion in the study. Patients were excluded when MV was initiated after the onset of pneumonia. The need for informed consent was waived for both the prospective data collection and the retrospective analyses. For all patients, demographic and clinical data were collected such as age, gender, admitting diagnosis, underlying condition, invasive procedures or devices, and/or surgical procedures within the last three months. VAP data were collected on daily basis by the ICT during their daily rounds on all ICU patients as per the CDC/NHSN definitions. Microbiological findings for all respiratory specimens were also recorded. The sources of respiratory isolates included sputum, deep tracheal aspirates (DTA) and bronchoalveolar lavage (BAL) specimens. They were identified using the disk diffusion method based on the Clinical and Laboratory Standards Institute (CLSI) breakpoints and the matrix-assisted laser desorption/ionization time-of-flight (MALDI-TOF) when it became available in 2016. Data was saved using a local electronic system that was tailored for ICPP to assist data entry and analysis, and in the International Nosocomial Infection Control Consortium (INICC) registry of which AUBMC was a member [13].

Benchmarking

VAP rates were benchmarked against the NHSN reports. In addition, they were compared to the periodic INICC benchmarks as this was generated from hospitals across the world with settings similar to AUBMC. INICC checklists were also used to monitor and measure the ICU compliance with the bundles. Furthermore, ventilator utilization ratio (VUR: total number of ventilator-days divided by the total number of patient-days) was calculated to measure the use of ventilators during the study period and was benchmarked against NHSN and INICC reports.

Results

A total of 162 patients diagnosed with VAP between 2008 and 2017 were included in the study contributing 20,634 ventilator-days and 31,031 patient-days (Table 1). The majority of VAP episodes were identified as late-onset (90%).

Table 1
Population characteristics of 162 patients with VAP.

	No.	Percent
Male gender	95	58.6%
Age ≥ 60 years	100	61.7%
Admitting ICU		
Medical ICU	79	48.8%
Surgical ICU	83	51.2%
Onset of VAP		
Early onset ≤ 4 days	17	10.5%
Late onset > 4 days	145	89.5%

VAP = ventilator-associated pneumonia; ICU = intensive care unit.

The overall VAP rate was 7.8 per 1000 ventilator-days (range between a minimum rate of 1.1 per 1000 ventilator-days in 2017 and a maximum of 15.8 per 1000 ventilator-days in 2010). VAP rates in ICU were consistently higher than NHSN rates and lower than INICC rates from 2008 till 2012 (Table 2). VURs ranged from 0.61 to 0.76 (overall = 0.26). VAP rates showed a decrease from 13.1 in 2008 to 1.1 per 1000 ventilator-days in 2017 with a reduction rate of 91.6% (Fig. 1). This decrease was statistically significant with a correlation coefficient of 0.83 and a p-value of 0.003.

VAP occurred in 83 medical and 79 surgical ICU patients. In 156 out of 162 VAP episodes, the infection was microbiologically documented, and only 6 episodes were based solely on clinical diagnosis. Gram-negative organisms were predominant among all isolated pathogens (95.4%). A single pathogen was isolated in 63% of cases while the remaining infections were polymicrobial. The most commonly incriminated pathogen was *Acinetobacter baumannii* (32.6%), followed by *Pseudomonas aeruginosa* (16.5%) and *Escherichia coli* (27, 12.4%). The vast majority of *A. baumannii* isolates (90.1%) were multi-drug resistant (MDR), as defined by resistance to one or more drugs in three or more classes of antibiotics. All the MDR Acinetobacter isolates were resistant to carbapenems. Among the Enterobacteriaceae, 15% were extended-spectrum beta-lactamase producing with no cases of carbapenem-resistant Enterobacteriaceae. *A. baumannii* was the predominant pathogen in both early- and late-onset VAP and was even slightly more common in early-onset VAP. Other Gram-negative organisms such as *P. aeruginosa*, *E. coli*, and *Klebsiella pneumoniae* tended to be more common in late-onset VAP (Table 3). Only 4.6% of VAP was due to *Staphylococcus aureus*, of which 70% were methicillin-resistant.

Discussion

This is, to our knowledge, the only epidemiologic surveillance study of VAP in the region that includes data extending over a decade. The overall incidence of VAP in our study is 7.8 per 1000 ventilator-days. Data from the region about the incidence of VAP is variable. For example, a one year prospective surveillance study from Egypt found a rate of 7.5 per 1000 ventilator-days [14]. In another report from Saudi Arabia, the VAP rate over a six-year period ranged from 19.1 in 2003 to 6.3 per 1000 ventilator-days in 2009, with an overall rate of 15.9 per 1000 ventilator-days [5]. Moreover, one of the few multicenter studies on VAP from the Gulf Cooperation Council (GCC) included data from Oman, Bahrain, and Saudi Arabia, showing a rate of 4.8 per 1000 ventilator days [6].

We did not observe a change in VUR over the study period despite the adoption of the ventilator bundle in 2012. We were able to document, however, a statistically significant decrease in the incidence of VAP over time. This came as a result of the implementation of multiple strategies by ICPP. Following the identification of an of MDR Acinetobacter outbreak in the ICU in 2009 [15], the

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Table 2
Year-specific VAP rates and VURs at AUBMC (2008–2017).

Year	VAP rate[a]	NHSN rate[a]	INICC rate[a]	VUR[b]	NHSN VUR[b]
2008	28/2142 (13.1)	2.9	19.8	2142/2812 (0.76)	0.44
2009	20/1790 (11.2)	2.0	16.5	1790/2677 (0.67)	0.43
2010	31/1965 (15.8)	1.8	16.5	1965/2726 (0.72)	0.44
2011	15/1760 (8.5)	2.1	13.1	1760/2897 (0.61)	0.41
2012	14/1957 (7.2)	1.6	13.1	1957/3125 (0.63)	0.38
2013	9/1840 (4.9)	–	–	1840/2954 (0.62)	–
2014	10/1927 (5.2)	–	–	1927/2912 (0.66)	–
2015	17/2169 (7.8)	–	–	2169/3264 (0.66)	–
2016	15/2358 (6.4)	–	–	2358/3777 (0.62)	–
2017	3/2726 (1.1)	–	–	2726/3887 (0.70)	–
Overall	162/20,634 (7.9)	–	–	20,634/31,031 (0.66)	–

VAP = ventilator-associated pneumonia; VUR = ventilator utilization ratio; NHSN = National Healthcare Safety Network; INICC = International Nosocomial Infection Control Consortium.
Empty cells indicate the years where ventilator-associated events pooled mean rates are not yet available.
[a] Number of VAP episodes/1000 ventilator-days.
[b] Number of ventilator-days/number of patient-days.

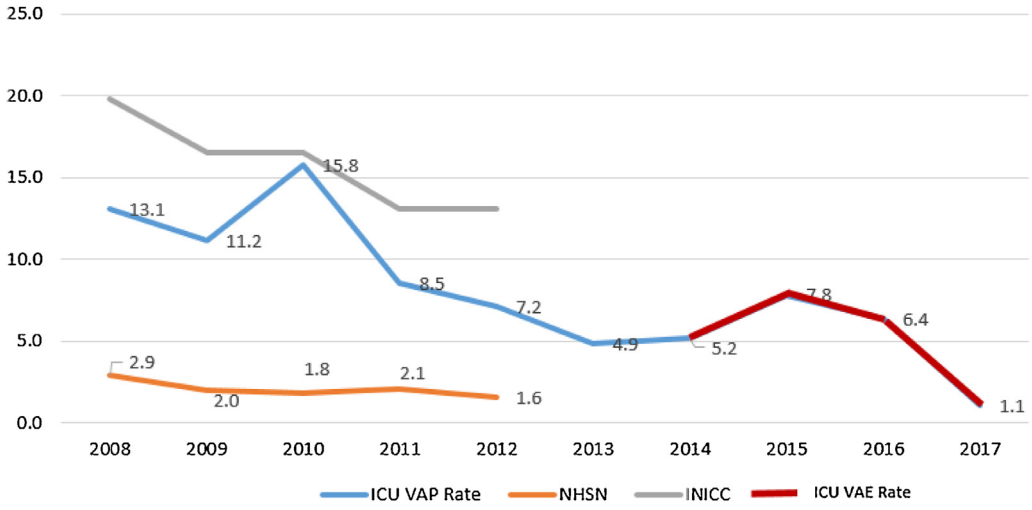

Fig. 1. VAP/VAE rates in ICU from 2008 till 2017 benchmarked against NHSN and INICC rates*. *Correlation = −0.83; p-value = 0.003.

Table 3
Distribution of identified pathogens in patients with early-onset vs. late-onset VAP.[a]

Organism	All VAP cases (n = 218)	Early-onset VAP (n = 20)	Late-onset VAP (n = 198)
Acinetobacter baumannii	71 (32.6)	8 (40.0)	63 (31.8)
Pseudomonas aeruginosa	36 (16.5)	2 (10.0)	34 (17.2)
Escherichia coli	27 (12.4)	1 (5.0)	26 (13.1)
Klebsiella pneumoniae	18 (8.3)	0	18 (9.1)
Stenotrophomonas maltophilia	13 (6.0)	1 (5.0)	12 (6.1)
Enterobacter spp.	11 (5.0)	1 (5.0)	10 (5.1)
Staphylococcus aureus	10 (4.6)	2 (10.0)	8 (4.0)
Serratia marcescens	8 (3.7)	0	8 (4.0)
Proteus mirabilis	8 (3.7)	0	8 (4.0)
Citrobacter spp.	5 (2.3)	2 (10.0)	3 (1.5)
Burkholderia cepacia	3 (1.4)	1 (5.0)	2 (1.0)
Others	8 (3.7)	2 (10.0)	6 (3.0)

VAP = ventilator-associated pneumonia.
All numbers indicate no. (%).
[a] More than one isolate could be recovered from a single patient; therefore the number of isolates exceeds the number of VAP episodes.

ICT intensified its presence in the ICU and the unit was closed for four months for renovation works. Direct and anonymous observations of all staff and visitors were applied, culminating in the installation of video surveillance cameras and training of dedicated nursing staff, which led to an increase in the compliance with hand hygiene. In addition to applying the VAP bundle uniformly on all ICU patients since 2009, ICU staff were continually educated about and involved in infection prevention efforts through daily interactions and monthly mandatory sessions. Educational sessions were also given to inhalation therapists in response to positive screening cultures from ventilators and non-invasive respiratory equipment. Other interventions included an active surveillance strategy in the ICU, whereby baseline screening cultures were obtained from patients upon admission to ICU, and contact precautions were applied until the screening cultures revealed the absence of an MDR organism. Screening cultures were subsequently repeated on a weekly basis. New methods for cleaning and disinfection in ICU were adopted including the use of new disinfectant solutions, the introduction of air decontamination by hydrogen peroxide after discharge of patients infected or colonized with MDR pathogens

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and deep cleaning of medical devices, equipment, and environment. Only one trained team from the Housekeeping Department was tasked with the implementation of all these changes. All findings from ICT were communicated to managers and unit directors.

Over the years, despite a drop in VAP rate, Gram-negative infections continued to predominate with *Acinetobacter* spp. and *P. aeruginosa* being the two most common causative agents (32.6% and 16.5% respectively). This is similar to data from Saudi Arabia from 2003 till 2009 (26.5% and 21.7%) [8] and from a one-year surveillance study from Egypt from 2011 till 2012 (30.2% and 17.6%) [14]. A 16 month-study from Tunisia also reported that *Acinetobacter* spp. was the second most commonly isolated pathogen in VAP (29%) after *P. aeruginosa* [16]. On the other hand, studies from the United States have shown a different epidemiology of VAP, with *S. aureus* and Enterobacteriaceae as predominant pathogens [17–20]. This has important implications on the applicability of treatment guidelines published by international societies in our setting, namely as it pertains to the selection of empirical therapy.

Acinetobacter spp. was the most common organism encountered in both early-onset as well as late-onset VAP, with a slight preponderance in early-onset VAP (40.0% vs. 31.8%). Although *Acinetobacter* spp. has been traditionally associated with late-onset VAP, data have been accumulating on the rising importance of this pathogen in early-onset VAP [21]. In one recent epidemiological study in 15 ICUS in China, *Acinetobacter* spp. accounted for 52.7% of all positive cultures. On subgroup analysis, the authors found that in early-onset VAP, there was a sizable proportion of *Acinetobacter* spp. of around 40%, all of which were MDR.

Most of our Acinetobacter VAP were MDR and all of them were carbapenem-resistant. These results are similar to studies from neighboring countries. A recent report analyzing patients with *Acinetobacter* VAP from the MAGICBULLET trial (Clinical trial.gov NCT01292031) has also found that a large number of *Acinetobacter* spp. isolated from VAP from Italy, Greece, and Spain were MDR with carbapenem resistance of 97% [22].

Our study has limitations, the foremost being that it is a retrospective single-center study. Other factors that might have affected the reported rates are the changes in definitions and the introduction of VAE as an outcome. One could argue that the more recent numbers do not include the less severe ventilator-associated respiratory infections (VARI).

Conclusions

VAP rates in our study were similar to international studies and studies from the region. *A. baumannii* and *P. aeruginosa* continue to be the most commonly isolated VAP pathogens, unlike several studies from the United States and Northern Europe. Such analysis is helpful in guiding clinicians to initiate appropriate empiric treatment for mechanically-ventilated patients in our ICU setup, particularly in early-onset VAP. We demonstrated a significant decrease in VAP rates with the implementation of aggressive infection control measures which proved to be effective in the prevention of device-associated infections in general, and VAP in particular.

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Competing interests

None declared.

Ethical approval

Not required.

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