Ventilator-associated pneumonia in an academic intensive care unit in Johannesburg, South Africa

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Background. Ventilator-associated pneumonia (VAP) has an estimated incidence of 10 - 41.5 events per 1 000 ventilator days in developing countries, and carries high mortality. Little is known about the incidence and outcomes of VAP in Johannesburg, South Africa.
Objectives. To describe VAP in a tertiary public hospital in Johannesburg, assess the microbiological pathogens associated with VAP (both early and late), and outline the outcomes of these patients.
Methods. The study was a retrospective record review of patients admitted to the Helen Joseph Hospital intensive care unit (ICU) between March 2013 and January 2016.
Results. VAP developed in 24/842 ventilated patients (2.9%; 95% confidence interval (CI) 1.8 - 4.2), with an incidence of 23 events per 1 000 ventilator days, during the study period. Of these patients, one-third (29.2%) died and 70.8% were discharged from the ICU. Late-onset VAP (onset ≥5 days after intubation, incidence 45.8%) was associated with higher mortality (54.6%) than early-onset VAP (onset within 4 days after intubation, incidence 54.2% and mortality 7.7%). Commonly isolated organisms were *Klebsiella pneumoniae*, *Acinetobacter baumannii* and *Pseudomonas aeruginosa.* There was a trend towards an increased risk of multidrug-resistant organisms with late-onset VAP (adjusted relative risk 2.26; 95% CI 0.92 - 5.57; p=0.077) and airway access through a tracheostomy (relative risk 1.68; 95% CI 0.78 - 3.57).
Conclusion. The study showed a low to moderate incidence of VAP of 23 events per 1 000 ventilator days. A tracheostomy and late-onset VAP were associated with infection by drug-resistant organisms. The mortality rate was 29.2% in this setting, with a seven-fold increase in mortality with late-onset VAP.
Keywords. Ventilator-associated pneumonia, VAP, early onset, late onset, South Africa.

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Study synopsis
What the study adds. This study helps to improve understanding of the incidence of ventilator-associated pneumonia in South Africa, a low- to middle-income country, and the commonly encountered causative pathogens. It indicates the importance of a short intensive care unit (ICU) stay as a target outcome for prevention of nosocomial infections and other complications.

Implications of the findings.
The study:
- reinforces the importance of preventive mesures in the ICU and keeping up to date with the evidence in the field
- highlights the importance of knowing local microbial resistance patterns in order to develop precise antibiograms
- shows the need for research in ICU care for people of advanced age, and the impact that admission rationing has on our ICU populations.

Ventilator-associated pneumonia (VAP) has an estimated incidence of 8 - 28% (10 - 41.5 per 1 000 ventilator days) in low- and middle-income countries (LMICs).[1-3] VAP carries high mortality, with rates ranging from 24% to 50%, and as high as 76% in LMICs.[4,5] Internationally, it has been difficult to delineate the true prevalence of VAP owing to multiple challenges in the diagnosis of this condition, central to which is the lack of a gold standard for diagnosis and therefore no standardised diagnostic criteria,[3] although the Johanson criteria are the most widely accepted. The Clinical Pulmonology Infection Score (CPIS), the US Centers for Disease Control criteria and the Hospitals in Europe

Link for Infection Control through Surveillance criteria have been used in clinical, research and public health environments.[1,4,6] Features of VAP overlap with other common conditions in the intensive care unit (ICU) environment such as acute respiratory distress syndrome (ARDS), atelectasis, other ICU infections, and ventilator-associated tracheobronchitis (VAT). VAT has the potential to develop into VAP in 30% of cases.[3] Patient characteristics such as advanced age (>65 years), male sex and smoking, increased mechanical ventilation time and prolonged mechanical ventilation, disorders of consciousness and head trauma, burns, comorbidities (coronary heart disease, diabetes, pre-existing pulmonary disease/chronic obstructive pulmonary disease, HIV infection, and multiple organ system failure), prior antibiotic therapy, invasive operations and gene polymorphisms are currently the internationally recognised independent risk factors associated with VAP.[7,8] Non-modifiable treatment-related risk factors include the necessity for neurosurgery, monitoring of intracranial pressure, reintubation, and transportation out of the ICU.[8]

The well-established risk factors for multidrug-resistant (MDR) organisms are prior intravenous antibiotic use (within 90 days), septic shock, ARDS preceding VAP (a high index of suspicion is required to make a diagnosis in this situation), ≥5 days of hospitalisation prior to VAP, and acute dialysis prior to VAP.[1,5,9,10] The pathogenesis of pneumonia stems from invasion of the lower respiratory tract and lung parenchyma by micro-organisms.[3,4]

The two most important contributors to VAP are biofilm establishment within the tube lumen (endotracheal tube/tracheostomy), and microaspiration of secretions, particularly subglottic and above the tube cuff.

The presence of the tube in the trachea alters the natural defence mechanisms, thus allowing microaspiration and for the aspirated particles to pass into the lower respiratory tract. The tube biofilm is pushed further down the respiratory tract by the ventilator cycles and serves as a nidus for infection. Host factors, particularly immunosuppression (which could be multifactorial with critical illness), play a major role.[6]

The common micro-organisms isolated in VAP are Gram-negative bacilli, accounting for 60% of cases in studies in the developed world and 41 - 92% in the developing world.[2,5,6,11] Of these, *Pseudomonas aeruginosa* is the leading organism, followed by *Acinetobacter* species, *Proteus mirabilis*, *Escherichia coli*, *Klebsiella* species and *Haemophilus influenzae*.[11]

Gram-positive cocci account for a substantial proportion of cases, with *Staphylococcus aureus* accounting for 20% of cases in the developed world. Gram-positive cocci in total make up 6 - 58% of cases in LMICs. VAP occurring ≥5 days after intubation is most likely to be associated with resistant organisms, i.e. carbapenem-resistant Enterobacteriaceae, vancomycin-resistant *Enterococcus*, methicillin-resistant *S. aureus* (MRSA), and *Pseudomonas* and *Acinetobacter* species, and with prior exposure to antibiotics.[9,11-14]

Prevention of VAP is based on trying to mitigate the modifiable risk factors and intervene in the main pathogenic factors mentioned above. Historically, care bundles had four care interventions, namely daily sedation holds, bed head elevation, gastric ulcer prophylaxis and oral care. The version of care bundles commonly employed was updated in 2010 and includes oral hygiene with adequate antiseptic, subglottic aspiration, and endotracheal tube cuff monitoring.[4,15-17] Supplementary to the bundles of care are appropriate humidification of inspired air, deep-vein thrombosis prophylaxis, suctioning of secretions, and appropriate tubing management (such as avoiding unnecessary circuit tubing changes).[17,18] These bundles have shown some effectiveness in VAP prevention. Several studies have shown that nursing care education is key to VAP prevention.[17] The 2016 clinical practice guidelines from the Infectious Diseases Society of America and the American Thoracic Society recommend that each ICU should develop its own antibiogram to refer to, based on local antimicrobial resistance patterns.[4]

A paucity of data pertaining to the prevalence of VAP in South Africa (SA), including information on the most common organisms causing this disease, hampers guideline development, especially for the adult population.[19] The aim of the present study was to describe VAP in a tertiary public hospital ICU in Johannesburg. Specifically, we sought to: (*i*) determine the incidence of ventilator-associated pneumonia in the ICU; (*ii*) assess the microbiological pathogens associated with both early-onset VAP (defined as occurring within 4 days after intubation) and late-onset VAP; (*iii*) determine the outcome of patients diagnosed with VAP in the ICU; (*iv*) estimate the time from admission (intubation and ventilation) to development of VAP; and (*v*) determine factors associated with MDR organisms.

Methods

Design and study population

A retrospective record review was performed of patients admitted to the Helen Joseph Hospital ICU in Johannesburg between March 2013 and January 2016, a period of 1 006 days. Data were collected following approval by the University of the Witwatersrand Human Research Ethics Committee (ref. no. M190124). To be eligible for inclusion in the study, patients had to be ≥18 years old. Patients who developed pneumonia within 48 hours of admission, patients admitted with a diagnosis of pneumonia, patients with ARDS, and mechanically ventilated patients who died within 48 hours of admission were excluded.

Setting

The 10-bed multidisciplinary ICU comprises 10 isolation cubicles and is separated into two 5-bed sections. The nurse-to-patient ratio is 1:1 and the doctor-to-patient ratio 1:2. The unit has two washbasins at the entrance of each section, with handwashing detergent at each bedside trolley and at the unit entrance. The infection control team supervises the handwashing.

Data collection

All patients admitted to the ICU were recorded in a patient register with their corresponding diagnoses, both provisional and definitive. Patients who were diagnosed with VAP by the end of their ICU stay, as entered on the Helen Joseph Hospital ICU patient database, were identified and their records were retrieved from the hospital records. These records were further filtered to those that fitted the definitions below.

VAP was defined as pneumonia occurring in mechanically ventilated patients ≥48 hours after initiation of intubation and ventilation. Multidrug resistance was defined as resistance to at least one agent in three or more antimicrobial classes, as per National Health Laboratory Service microbiological testing.

Data collected included demographics, clinical data, measures taken to prevent hospital-acquired infections, investigations performed (blood, radiology, tracheal aspirate), disease severity at the onset of VAP, and the management approach employed.

Data from medical records were captured in Excel 2013 (Microsoft, USA) and exported into Stata 14.2 (StataCorp, USA) for analysis. Descriptive statistics were used to describe individuals admitted to the ICU who developed VAP. Medians and interquartile ranges (IQRs) were used for continuous variables, while frequencies and percentages were used for categorical data. Methods of analysis for the specific objectives are described below.

1. The incidence of VAP in the ICU was determined as number of patients who developed VAP divided by the total number of ICU admission days. This was presented as the number of patients who developed VAP per 1 000 ICU admission days, with a 95% confidence interval (CI). The number who developed VAP was obtained from the database of VAP patients, while aggregated ICU data were used to obtain the number admitted to the ICU.
2. To assess the microbiological pathogens associated with VAP, both early and late, the proportions of VAP patients who had different organisms detected on tracheal aspirates and blood specimens were determined as frequencies and proportions and presented by early or late VAP status.
3. The outcome of patients diagnosed with VAP in the ICU was determined as proportions of all patients with VAP, and also by early or late VAP status.
4. The time from admission (intubation and ventilation) to development of VAP was determined as the number of days between admission and VAP diagnosis, and presented as medians with IQRs.
5. Factors associated with the detection of MDR organisms from tracheal aspirates or blood specimens were determined by univariable and multivariable binomial regression analysis. Variables that had a p-value <0.2 in univariable analysis were included in the multivariable analysis. The estimate of the relative risks (RRs) associated with the different factors was reported with a 95% CI.

Results

Incidence of VAP

During the study period, a total of 1 185 patients were admitted to the ICU. Of the admitted patients, 842 (71.1%) were ventilated, and of those who were ventilated, 24 (2.9%; 95% CI 1.8 - 4.2) had a diagnosis of VAP by the end of their ICU stay. These cases of VAP occurred over a period of 1 006 admission days, which equates to 23 events per 1 000 days, assuming that there was at least one ventilated patient in the ICU every day during this period.

Description of patients who developed VAP and frequently occurring factors in patients who developed VAP

Of the 24 patients who developed VAP, 18 (75.0%) were male (Table 1). The median (IQR) age was 40 (29 - 62) years. The majority of the patients who developed VAP were admitted from casualty and medical wards, with diagnoses of trauma or medical conditions on admission to the ICU. Table 2 compares surgical v. medical conditions on admission. The median (IQR) length of stay in the ICU was 12 (9 - 15) days, with a median time on antibiotics of 7 (7 - 8) days. Acute Physiology and Chronic Health Evaluation (APACHE II) scores were available for 11/24 (45.6%) of the patients, of whom 5 (45.5%) had scores ≥24 and 6 (54.5%) scores <24.

The median (IQR) time from intubation and ventilation to VAP diagnosis was 3 (2 - 5.5) days. An analysis of factors revealed that advanced age was not a significant risk factor in our cohort, while male gender, prolonged ventilation time and the presence of comorbidities, including being HIV positive, were common risk factors.

Table 1. Demographic and clinical characteristics of patients who developed VAP during their ICU admission (*N*=24)

Characteristic	*n* (%)*
Age (years), median (IQR)	40 (29 - 62)
Male	18 (75.0)
One or more comorbidities	7 (29.2)
Admission source	
Emergency/casualty	12 (50.0)
Medical inpatients	8 (33.3)
Surgical inpatients	2 (8.3)
Other	2 (8.3)
Diagnoses at ICU admission	
Medical	11 (45.8)
Trauma	9 (37.5)
Surgical	3 (12.5)
Missing	1 (4.2)
Airway access at admission	
Endotracheal tube	20 (83.3)
Tracheostomy	4 (16.7)
Indication for ventilation	
Respiratory failure	8 (33.3)
Airway protection	13 (54.2)
Anaesthesia	3 (12.5)
Head of bed elevated	24 (100)
Adequate sedation provided	23 (95.8)
Oral care provided	24 (100)
Antacid provided	24 (100)
HIV status	
Positive	7 (29.2)
Negative	9 (37.5)
Unknown	8 (33.3)
White blood cell count (× 109 cells/L), median (IQR)	12.8 (8.8 - 17.8)
Length of stay in ICU (days), median (IQR)	12 (9 - 15)
Time on antibiotics (days), median (IQR)	7 (7 - 8)
APACHE II score	
<24	6 (25.0)
≥24	5 (20.8)
Missing/unavailable	13 (54.2)

VAP = ventilator-associated pneumonia; ICU = intensive care unit; IQR = interquartile range; APACHE II = Acute Physiology and Chronic Health Evaluation.
*Except where otherwise indicated.

Microbiological pathogens associated with early and late VAP

The most frequently isolated pathogens were the Gram-negative bacilli (*P. aeruginosa*, *Klebsiella pneumoniae* and *Acinetobacter baumannii*), comprising 56.6% of all isolates, with both blood cultures and tracheal aspirates being positive for similar organisms in many patients. The other Gram-negative bacilli isolated were *E. coli*, *Stenotrophomonas maltophilia*, *Citrobacter koseri* and *P. mirabilis*, which made up 13.3% of all positive tracheal aspirates, bringing the total percentage of Gram-negative bacilli isolated to 69.9%. Table 3 shows the distribution of micro-organisms causing early-onset VAP v. late-onset VAP.

In univariate analysis, there was a trend towards an increased risk of MDR organisms with airway access through a tracheostomy (RR .68; 95% CI 0.78 - 3.57), being admitted to the ICU during the period 2013/2014 (RR 1.96; 95% CI 0.86 - 4.49), and late-onset VAP (RR 2.36; 95% 0.95 - 5.88). In the adjusted analysis, the trend towards an increased risk of MDR organisms remained with late-onset VAP (adjusted RR (aRR) 2.26; 95% CI 0.92 - 5.57; p=0.077) and admission during the period 2013/2014 (aRR 1.89; 95% CI 0.81 - 4.42; p=0.140). Airway access via a tracheostomy is still considered an independent risk factor despite the multivariate analysis outcomes shown in Table 4.

Outcomes of patients with VAP

Of the patients who had VAP, 29.2% died, while the remainder were discharged from the ICU. Late-onset VAP was associated with much higher mortality (54.6%) compared with early-onset VAP (7.7%) (p=0.018, χ^2 test).

Table 2. Medical v. surgical conditions associated with VAP in the ICU

Diagnosis	Medical	Trauma or surgery	Total
Acute exacerbation of COPD	1		1
Acute weakness (GBS/myasthenia)	2		2
Bowel obstruction (sigmoid stricture)		1	1
Head injury		1	1
Heart failure	1		1
Hyperglycaemic hyperosmolar state	1		1
Iatrogenic pulmonary oedema	1		1
Meningitis	1		1
Motor vehicle accident		1	1
Myocardial infarction	1		1
Organophosphate poisoning	3		3
Perforated peptic ulcer		1	1
Polytrauma		2	2
Postoperative		1	1
Stab chest		1	1
Traumatic brain injury		4	4
Not recorded	1		1

VAP = ventilator-associated pneumonia; ICU = intensive care unit; COPD = chronic obstructive pulmonary disease; GBS = Guillain-Barré syndrome.

Table 3. Micro-organisms associated with early-onset v. late-onset VAP

Organism	All patients (N=24), n (%)	Late VAP (n=11), n (%)	Early VAP (n=13), n (%)
Acinetobacter baumannii	6 (20.0)	4 (23.5)	2 (15.4)
Candida albicans	1 (3.3)	0	1 (7.7)
Citrobacter koseri	1 (3.3)	1 (5.9)	0
Escherichia coli	1 (3.3)	0	1 (7.7)
Enterobacter	1 (3.3)	1 (5.9)	0
Haemophilus influenzae	3 (10.0)	0	3 (23.1)
Klebsiella pneumoniae	6 (20.0)	5 (29.4)	1 (7.7)
Mycobacterium tuberculosis	1 (3.3)	1 (5.9)	0
Proteus mirabilis	1 (3.3)	0	1 (7.7)
Pseudomonas aeruginosa	5 (16.7)	4 (23.5)	1 (7.7)
Staphylococcus aureus	3 (10.0)	1 (5.9)	2 (15.4)
Stenotrophomonas maltophilia	1 (3.3)	0	1 (7.7)
Total micro-organisms isolated	30	17	13

VAP = ventilator-associated pneumonia.

Table 4. Factors associated with the identification of an MDR organism (*N*=24)

Variable	*n/N* (%) with MDR organism	Univariable RR (95% CI)	*p*-value	Multivariable aRR (95% CI)	*p*-value
Age ≥50 years			0.429		
No	4/10 (40.0)	1.00		-	-
Yes	8/14 (57.1)	1.42 (0.59 - 3.52)		-	-
Sex			0.999		
Female	3/6 (50.0)	1.00		-	-
Male	9/18 (50.0)	1.00 (0.40 - 2.57)		-	-
Has comorbidity			0.668		
No	9/17 (52.9)	1.00		-	-
Yes	3/7 (42.9)	0.81 (0.31 - 2.17)		-	-
HIV positive			0.151*		
No	6/9 (66.6)	0.93		-	-
Yes	5/7 (71.4)	1.07 (0.82 - 3.68)		-	-
Unknown	3/8 (37.5)			-	-
Admission period			0.112*		0.140
2015/16	5/14 (35.7)	1.00		1.00	
2013/14	7/10 (70.0)	1.96 (0.86 - 4.49)		1.89 (0.81 - 4.42)	
Airway access			0.188*		0.456
ETT	9/20 (45.0)	1.00		1.00	
Tracheostomy	3/4 (75.0)	1.68 (0.78 - 3.57)		0.75 (0.36 - 1.58)	
Ventilation indication			0.692		
Other	5/11 (45.5)	1.00		-	-
Airway protection	7/13 (53.9)	1.18 (0.52 - 2.74)		-	-
Diagnosis at ICU admission			0.686		
Other	7/13 (53.9)	1.00		-	-
Medical	5/11 (45.5)	0.84 (0.37 - 1.95)		-	-
Onset of VAP			0.064*		0.077
Early	4/13 (30.8)	1.00		1.00	
Late	8/11 (72.7)	2.36 (0.95 - 5.88)		2.26 (0.92 - 5.57)	

MDR = multidrug resistant; RR = relative risk; CI = confidence interval; aRR = adjusted relative risk; ETT = endotracheal tube; ICU = intensive care unit; VAP = ventilator-associated pneumonia.
*Significant (p<0.2).

Discussion

In this review of VAP in the public sector, there were 1 185 admitted patients (1.17 admissions per day), and 71.1% of these were ventilated (0.84 ventilated admissions per day). The ICU has <14 beds, and would generally be classified as a small ICU.

The overall average length of stay in this unit during the study period was 11 days for patients with VAP, which is similar to the 13-day average observed in other parts of the world.[20] The ICU in the study has a rapid turnover as a result of high demand, with occupancy at any given time ~90%.

The absolute percentage of patients who were diagnosed with VAP in the unit was 2.9% of all ventilated patients. The incidence was 23 events per 1 000 ventilator days, assuming that there was at least one ventilated patient in the unit every day. The estimated incidence of VAP in the developing world varies widely from 10 to 41.5 episodes per 1 000 ventilator days,[2] so our figure falls on the low end of the average, although even lower numbers have been reported in ICUs with a heterogeneous population like ours.[21] Our relatively low incidence could be attributed to a few possible factors. There is strict adherence in the unit to care bundles to reduce complications such as VAP. The diagnosis of VAP at the time of the study was largely based on the CPIS, which has a high inter-observer variability in its calculation, limiting its diagnostic impact.[6,19,22] Subtle cases may therefore have been missed.

The possibility of underdiagnosing VAP is also a consideration, especially as postmortem studies evaluating the effectiveness of clinical criteria for VAP diagnosis show that these criteria have a 69% sensitivity.[22] Studies to determine whether care bundles do indeed prevent VAP are equivocal for the most part.[16] The main factor resulting in the success of care bundles is dedication of the nursing teams, as these are the professionals who ensure continuous adherence to the interventions.[17] As shown in Table 1, the minimum requirements of head elevation, adequate sedation, antacids and oral care, which was the recommended bundle at the time of the study, were adhered to at least 95.8% of the time. Inhaled antibiotics are not used in the ICU studied, so we cannot comment on the effectiveness of this strategy in the prevention and management of VAP.

Male sex (75.0% of patients) was a dominant characteristic. We identified comorbidities in 29.2% of the cohort, excluding HIV infection. These comorbidities differed so widely that none of them can be specifically identified as associated with the development of VAP.

Immunosuppression has been described as an independent risk factor, and 29.2% of the patients were HIV positive.[8] The average length of ICU stay in this patient group was 11 days, with up to 6 ventilator days before VAP diagnosis, each day of ventilation increasing the possibility of developing VAP.[8]

Advanced age did not play a role in our cohort, as the median age was 40 years. A significant contributor to this finding may be that 37.5% of the patients were trauma patients, who tend to be relatively young. A previous SA study found no association between age and the development of VAP, with a mean age of 55 years.[19] In the context of an LMIC with a limited number of critical care beds, the concern whether ICU admission rationing plays a role in the number of patients of advanced age in our ICU could be an area of further research.[23]

The present study shows that longer duration of admission was associated with late VAP and therefore with infections with MDR organisms (Fig. 1). The average time to late VAP diagnosis was 6 days. The prevalence of early and late VAP was 54.2% and 45.8%, respectively. However, it must be kept in mind that the leading indication for a tracheostomy in ICU patients is prolonged intubation, for a period of at least 10 days. These patients had therefore been admitted for longer than 10 days more than the time it took to develop MDR VAP in association with a tracheostomy.

Gram-negative bacilli were isolated more frequently in the late-onset VAP group than in the early-onset group. Over three-quarters (83.3%) of the VAP patients had an organism isolated on respiratory specimens (tracheal aspirates), while 45.8% were blood culture positive. This finding is in keeping with observations throughout the world, including previous findings in the SA context, with Gram-negative bacilli making up ~60% of all isolates in VAP patients.[5,6,11,19]

The most common organism isolated in early-onset VAP was *H. influenzae* (23.0%), consistent with findings around the world.[24] In the present study, *H. influenzae* was isolated in early-onset VAP only. This finding is in accordance with the knowledge that prior antibiotic exposure is not a risk factor for respiratory infection with *H. influenzae*. The majority of patients with early-onset VAP would be expected to have had no prior antibiotic exposure. Rello *et al.*[24] noted in 1992 that patients with *H. influenzae* infection were co-infected with Gram-positive cocci, which was confirmed in the present study, where two-thirds of the patients with *H. influenzae* infection were co-infected with *S. aureus*.

S. aureus also made up 10.0% of all organisms isolated, two-thirds of which were from tracheal aspirates. A third of these isolates were MRSA. In LMICs, *S. aureus* accounts for between 6% and 58% of VAP cases, with high-income countries (HICs) recording an average of 20%. The findings of the present study fall within the expected range for HICs.[2,11] The isolates from early-onset VAP samples were methicillin sensitive, attesting to the fact that such patients would have had limited healthcare and antibiotic exposure prior to the diagnosis of VAP. MRSA was associated with late-onset VAP.

The least common infections were *Mycobacterium tuberculosis* and fungal, comprising 1 case (3.3%) each. The mycobacterial infection occured in the setting of HIV. It is important to note that *M. tuberculosis* is not a typical causative organism for VAP, and it may represent the reactivation of latent TB as a result of immune paresis from acute illness. *Candida albicans* was the single fungal organism isolated, and this low prevalence is comparable to findings elsewhere in the world, with figures of 0.9% in the USA and up to 7% in LMICs being reported.[11]

In the present cohort, many patients with MDR organisms had number of days in the hospital prior to VAP and possible previous intravenous antibiotics as risk factors, as these patients were in the late VAP group. As shown in Fig. 1, the average number of days for the diagnosis of late VAP was 6 days. In addition to the above, airway access via a tracheostomy was identified as another possible risk factor for MDR organisms. These findings have been discussed above. There has been conflicting evidence as to whether tracheostomies are protective against or predispose to VAP.[23,25]

VAP carries high all-cause mortality, with rates ranging from 24% to 50%, and the present study is within this range at 29.2%, not very different from a previous SA report of 37.5% mortality.[1,4,19] The outcome of patients who were discharged from the ICU once they were transferred to the general ward is beyond the scope of this study. Late-onset VAP is associated with seven times higher mortality than early VAP. This is probably due to two issues, one being that a long duration of stay in the ICU of 6 days (average days to late VAP) is an indirect indication of severe illness. Secondly, as shown above, more resistant organisms were isolated in the late VAP group, making managing these patients even more difficult and highlighting the importance of differentiating early from late VAP.

This study was a retrospective review, and as such accurate record keeping is a concern, as demonstrated by a large number of data points missing, particularly with regard to disease severity. The absence of a control arm for the assessment of risk factor prevalence meant that only the prominent characteristics in this cohort known to be risk factors could be highlighted.

Conclusion

This study showed a low to moderate prevalence of VAP of 23 events per 1 000 ventilator days. Late-onset VAP and airway access via tracheostomy were associated with infection with drug-resistant organisms. The study also showed a VAP mortality of 29.2%, with

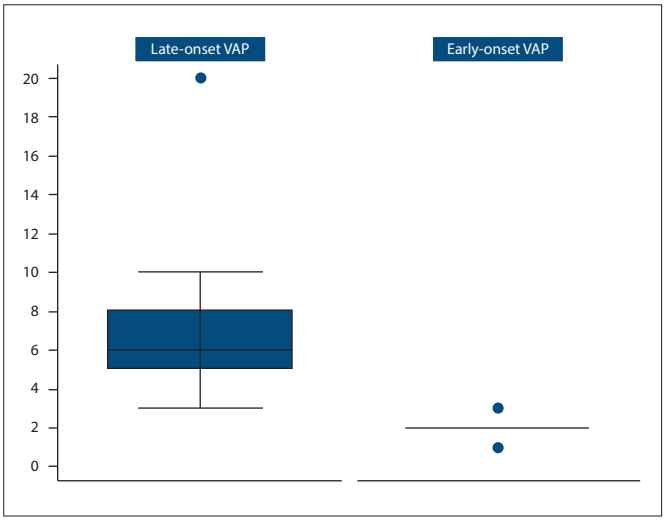

Fig. 1. Time from intubation to diagnosis in early- and late-onset VAP. The line in the shaded box for late-onset VAP and the line between the dots for early-onset VAP depict the medians (6 and 2 days).

the majority of deaths associated with late VAP, highlighting the importance of implementing preventive measures. A causative organism was isolated on culture in most cases, from tracheal aspirates or blood or from both, with Gram-negative bacilli being the most common. Clinicians are encouraged to develop antibiograms for their ICU units to guide empirical treatment.

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