Incidence of ventilator-associated pneumonia: Egyptian study

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Background Despite different ICU admission causes, ventilator-associated pneumonia (VAP) is still a common cause of mortality and morbidity in intubated patients and impedes obvious progression in diagnostic modalities and management of these infections.

Aim of study The aim of this study was to estimate VAP incidence in Tanta University Hospitals ICUs.

Settings and design This was a crossover observational study.

Patients and methods This was a one-year study (April 2015 to March 2016), including patients on invasive ventilation who developed VAP, with evaluation of admission and ventilation causes, isolation of causative organisms, and study of used antibiotics and ventilation modes.

Statistical analysis Data were statistically analyzed using the SPSS software for Windows (IBM SPSS Statistics 21.0).

Results It is a statistics based study aimed to trace infection incidence in national hospital ICUs. Among 222 admitted patients, only 38.4% fulfilled the criteria of VAP. Admission was because of cardiovascular impairment, cardiac arrest, respiratory failure, or head trauma. The ventilation mode at VAP time was assisted control (75%) and synchronized intermittent mandatory ventilation (25%). The minimum intubation period was 7 days, whereas the maximum period was 37 days. Isolated organisms were Pseudomonas (37.5%), Klebsiella (25%), Staphylococcus (20.8%), and methicillin-resistant *Staphylococcus aureus* (4.2%). The antibiotics used were amikacin, imipenem, vancomycin, levofloxacin, ceftazidime, and teicoplanin (29, 25, 21, 12.5, 8.3, and 4.2%, respectively). The minimum period of antibiotic used was 5 days, whereas the maximum period was 35 days. The highest incidence of VAP occurred in February, whereas the lowest incidence occurred in July.

Conclusion The incidence of VAP is still high and varies according to the intubation cause and period, and the underlying morbidity. More efforts must be made to prevent, diagnose, and manage infection early and properly to reduce patient suffering and to reduce the burden on the serving hospitals.
Egypt J Bronchol 2019 13:258–266
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Introduction

Although invasive mechanical ventilation is not an easy to take decision for some patients, it is a method of keeping a patient alive by adequate tissue oxygenation to support the body during the treatment course in the ICU [1].

Patients are admitted to the ICU for many reasons either related to pulmonary diseases such as acute respiratory failure and massive pneumonia or other causes such as neuromuscular diseases, after major surgeries, shock, or post-arrest [2]. Invasive mechanical ventilation (MV) is used as a cornerstone in the treatment plan of these patients [3].

Despite the different ICU admission causes, the mortality rates in intubated patients are still higher than those who do not need ventilator support [4].

Ventilator-associated pneumonia (VAP) is pneumonia that develops 2–3 days after endotracheal intubation; the patient must have new or progressive radiological infiltrate, infection alerts (e.g. fever, white blood cell count change), altered sputum characters, and isolation of a causative organism, all together to diagnose VAP [5].

VAP is still one of the most common hospital-acquired infections that are encountered in ICU patients despite the recent progress in diagnostic modalities and management advances of these infections [6].

Pneumonia is usually mild or low in severity if it occurs in the early period of invasive ventilation and the organisms are most responsive to the antibiotics administered, whereas after a few days (late onset), pneumonia is more severe in its course, with fewer organisms responding to antibiotics and increased rate of morbidity and mortality among those with late onset infection [7].

The incidence of VAP in ICUs in developed countries differs significantly from that in developing ones ICUs [8]; this is because of many reasons such as the prudent use of specific antibiotics, better management of possible risk factors, and good prophylactic measures to decrease hospital-acquired infections.

To identify the problem is the first step in problem solving.

Aim of the work

This is one of the first studies in Tanta University Hospital that attempted to explore VAP incidence in ICUs of the hospital and to identify the possible causative organisms and to clarify possible risk factors.

Patients and methods

The study duration was 12 months, from April 2015 to March 2016. It included patients who were admitted to ICUs (chest and anesthesia units) and subjected to invasive MV (crossover observational study).

They were included in the study as they had one or more of the following: no previous hospital admission, not intubated or tracheotomized for the first 48 h of admission, radiological chest infiltration, body temperature higher than 38°C, either white blood cells more than 12.000 or less than 4.000/mm^3, purulent airway secretion, and positive bacterial culture for airway secretion or blood.

Patients were excluded if they developed pneumonia within the first 48 h of admission or developed later acute respiratory syndrome and also if they did not fulfill any of the previously mentioned inclusion criteria.

All patients were subjected to the following: assessment of history, clinical general and local chest examination, chest radiology, arterial blood gases using GASTAT-602i, Techno Medical blood gas analyzer system, erythrocyte sedimentation rate, complete blood count, liver and kidney functions, and tracheal aspirate (using a new catheter to be introduced in the tube for suction, and using 3–5 ml injectable normal saline to enable secretion suction), and then subjected to a bacteriologic examination by stain and culture (to be considered quantitatively acceptable for culture if they had less than 10 epithelial cells/low-powered field). Also, the onset of VAP and duration of ICU stay were recorded, along with a regular recording of patients' vital signs, oxygen saturation, patient position, and ventilator modes used.

Patients were intubated and ventilated using an e-Vent-Medical (Event Medical Ltd, Galway, Ireland), Inspiration Ventilator System (Event Medical LTD, 60 Empire Dr Lake Forest CA, USA)(SN: 200W030259) and GE Healthcare ventilator (General Electric Company, GE, Finland)).

Informed consent was obtained from patients and/or patients' relatives for the procedure/treatment and for usage of their medical data in the present study.

Tanta University Ethics Committee approved the study protocol.

Statistical analysis

All data were statistically analyzed using the SPSS software for Windows (IBM SPSS Statistics 21.0). *P* values less than 0.05 were considered significant.

Results

The present study was initiated with 222 patients who were admitted to ICUs; only 125 patients were intubated because of the need for MV, but only 48 (38.4%) of 125 patients fulfilled the criteria of VAP.

Thirteen (27.08%) of 48 patients were in chest ICU and 35 (72.92%) of 48 patients were in anesthesia ICU. The age of the patients ranged between 38 and 87 years, mean 60.54±10.42. Also, there were more men than women (Table 1).

Cardiovascular impairment was the most common cause of patients' admission in ICU, whereas respiratory failure was the least common cause of patients' admission (Table 2).

In terms of the development of VAP in relation to the duration of ventilation, 28 (58.33%) patients developed VAP during 15 days or more of MV, whereas 20 (41.67%) patients developed VAP during less than 15 days of MV.

Two (4.2%) patients had unilateral pneumonia, whereas 46 (95.8%) patients had bilateral pneumonic patches.

Body temperature and pulse increased significantly with time after the development of VAP because of infection, but blood pressure decreased (Table 3).

Table 1 Sex distribution of patients on mechanical ventilation in ICU

	n (%)
Male	32 (66.7)
Female	16 (33.3)

At the first 3 days of ventilation, some blood investigations showed no significant differences, whereas others changed significantly (Table 4).

There were significant differences between the first 3 days of ventilation in terms of arterial blood gases (Table 5).

Twenty-two patients were subjected on the first day of MV to assisted control mode and 26 patients began their MV under the synchronized intermittent mandatory ventilation mode, but on the first day of VAP, 36 patients were on the assisted control mode (Table 6).

All the parameters in patients under ventilation changed significantly from the first to the second day of MV compared with the first day of VAP (Table 7).

Nineteen (39.6%) patients developed VAP within 5 days of MV, and this was called early-onset VAP, whereas most patients, 29 (60.4%), developed VAP after the first 5 days of MV and this was called late-onset VAP (Table 8).

Gram-positive organisms were the most common causative ones for VAP (52.6%) within the first 5 days of ventilation and pseudomonas was the least common causative organism (15.8%) for VAP. However, after these 5 days, Pseudomonas was the most common (51.7%) causative organisms in patients with VAP undergoing ventilation (Table 8).

Patients with VAP were classified according to the causative organisms and varied between positive and negative organisms (Table 9).

Pseudomonas gram-negative organism was responsible for infection in 37.5% of cases in all patients with VAP, whereas the staphylococcus gram-positive organism was isolated from 20.8% of VAP patients. Methicillin-resistant *Staphylococcus aureus* (MRSA) was the least isolated organism among VAP patients (Table 9).

Pseudomonas was the most isolated organism from VAP patients with respiratory failure secondary to chronic obstructive pulmonary disease (COPD), whereas in patients with respiratory failure secondary to asthma, Klebsiella and gram-positive staph. were the most commonly isolated organisms in those patients with VAP (Table 10).

Patients with VAP had received intravenous antibiotics according to culture and sensitivity tests and (Table 11).

The durations of prescribed antibiotics were different from one patient to another according to the isolated organisms, duration of MV, hospital stay period, and patient response (Table 12).

The maximum period of antibiotics used was 35 days and the maximum duration of MV was 37 days.

Table 2 Causes of admission in chest and anesthesia ICU

	Chest ICU [n (%)]	Anesthesia ICU [n (%)]	Total [n (%)]
Respiratory failure (chronic obstructive pulmonary disease)	6 (12.5)	0 (0)	6 (12.5)
Respiratory failure (bronchial asthma)	7 (14.6)	3 (6.25)	10 (20.85)
Head trauma	0 (0)	8 (16.7)	8 (16.7)
Cardiopulmonary arrest	0 (0)	10 (20.8)	10 (20.8)
Cardiovascular impairment	0 (0)	14 (29.2)	14 (29.2)

Table 3 Temperature, pulse, and blood pressure recordings on the first day of mechanical ventilation and on the first day of ventilator-associated pneumonia

	First day of MV	First day of VAP	t-Test	P value
Body temperature (°C)				
Range	36.3–37.5	38.5–39.5	32.933	0.001*
Mean±SD	36.98±0.29	38.99±0.31		
Pulse (beats/min)				
Range	80–98	110–130	90.986	0.001*
Mean±SD	88.0±5.61	121.08±4.64		
Systolic BP (mmHg)				
Range	100–180	80–140	34.008	0.001*
Mean±SD	124.58±22.4	102.08±14.58		
Diastolic BP (mmHg)				
Range	60–110	50–100	18.517	0.001*
Mean±SD	79.58±13.20	67.92±13.36		

BP, blood pressure; MV, mechanical ventilation; VAP, ventilator-associated pneumonia. * $P<0.005$, significant.

Table 4 Laboratory investigations in the first day of MV and on the first day of VAP

	First day of MV	First day of VAP	*t*-test	*P* value
Creatinine (mg/dl)				
Range	0.5–1.5	0.6–1.3	5.109	0.026*
Mean±SD	0.81±0.25	0.92±0.19		
Urea (mg/dl)				
Range	12–124	22–120	0.083	0.774
Mean±SD	57.54±32.19	59.33±28.56		
Serum bilirubin (mg/dl)				
Range	0.4–5.6	0.6–6.0	0.963	0.329
Mean±SD	1.13±1.1	1.35±1.1		
SGPT (units/l)				
Range	10–270	14–290	0.478	0.491
Mean±SD	39.13±56.15	47.42±61.25		
SGOT (units/l)				
Range	13–215	7–230	0.398	0.530
Mean±SD	46.0±55.88	53.5±60.55		
Serum albumin (g/dl)				
Range	2.1–3.9	2.0–3.2	10.955	0.001*
Mean±SD	3.08±0.51	2.77±0.39		
HB (g/dl)				
Range	7.7–13.0	7.8–11.9	7.112	0.009*
Mean±SD	10.24±1.34	9.54±1.23		
RBCs (cells/mcl)				
Range	2.5–4.6	2.7–4.3	5.356	0.023*
Mean±SD	3.52±0.57	3.29±0.39		
PLT (cells/mcl)				
Range	140–255	150–240	0.396	0.531
Mean±SD	195.96±29.34	192.29±27.75		
WBCs (cells/mcl)				
Range	4.2–10.3	13.2–22.2	69.417	0.001*
Mean±SD	7.83±1.76	18.01±2.37		

HB, hemoglobin; MV, mechanical ventilation; PLT, platelets; RBCs, red blood cells; SGOT, serum glutamic-oxaloacetic transaminase; SGPT, serum glutamic-pyruvic transaminase; VAP, ventilator-associated pneumonia; WBCs, white blood cells. *$P < 0.005$, significant.

Table 5 Arterial blood gas analysis on the first day of mechanical ventilation, the second day of mechanical ventilation, and on the first day of ventilator-associated pneumonia

	First day of MV	Second day of MV	First day of VAP	*F* test	*P* value	P_1	P_2	P_3
PCO_2								
Range	32–108	24–70	15–70	8.266	0.001*	0.004*	0.001*	0.881
Mean±SD	60.46±26.34	46.88±15.15	44.88±18.13					
PO_2								
Range	72–96	87–95	62–87	65.651	0.001*	0.004*	0.001*	0.001*
Mean±SD	87.42±7.07	91.58±1.77	73.17±7.93					
SO_2								
Range	81–96	92–98	65–91	29.533	0.001*	0.001*	0.001*	0.001*
Mean±SD	90.13±4.78	95.17±1.97	79.0±7.95					
HCO_3								
Range	21–32	21–30	13–32	0.088	0.915	0.999	0.921	0.939
Mean±SD	26.13±3.65	26.08±2.33	25.79±5.91					

F test: between first and second days of MV and first day of VAP. MV, mechanical ventilation; VAP, ventilator-associated pneumonia. P_1: first day and second day of MV. P_2: first day of VM and first day of VAP. P_3: second day of MV and first day of VAP. *$P < 0.005$, significant.

In terms of the ratio of VAP mortality, the survival rate in ventilated patients was higher [28 (58.3%) patients] than that among the patients who died [20 (41.7%) patients]. Moreover, most nonsurvivors had isolated Pseudomonas organisms from their respiratory secretions (25%; Table 13).

There were different variations in VAP incidence in relation to each month of the year; in January and February, the highest incidence of VAP (12.5%) was observed, whereas in July and October, the lowest incidence of VAP (4.1%) was observed (Table 14).

Table 6 Mode of ventilation on the first day of mechanical ventilation, the second day of mechanical ventilation, and on the first day of ventilator-associated pneumonia

AC or SIMV	First day of MV	Second day of MV	First day of VAP
AC [n (%)]	22 (45.8)	6 (12.5)	36 (75.0)
SIMV [n (%)]	26 (54.2)	42 (87.5)	12 (25.0)
Total [n (%)]	48 (100.0)	48 (100.0)	48 (100.0)
χ^2			
χ^2		38.025	
P value		0.001*	

AC, assistant control; MV, mechanical ventilation; SIMV, synchronized intermittent mandatory ventilation (volume controlled); VAP, ventilator-associated pneumonia.

Table 7 Some ventilator parameters on the first day and the second day of mechanical ventilation, and on the first day of ventilator-associated pneumonia

	First day of MV	Second day of MV	First day of VAP	F test	P value	P_1	P_2	P_3
RR								
Range	12–15	12–15	12–16	12.510	0.001*	0.260	0.003*	0.001*
Mean±SD	13.63±1.0	13.25±0.93	14.42±1.49					
TV								
Range	450–550	450–550	500 –600	6.248	0.003*	0.955	0.005*	0.012*
Mean±SD	497.92±30.87	500.0±32.62	520.83±41.04					
FiO_2								
Range	40–40	40–40	40–70	31.771	0.001*	1.0	0.001*	0.001*
Mean±SD	40±0.0	40±0.0	49.17±11.27					
PaO_2/FiO_2								
Range	180–240	22 –337.5	114.2–217.5	20.677	0.001*	0.352	0.001*	0.001*
Mean±SD	218.54±17.68	228.76±54.03	154.16±26.07					

FiO_2, fraction of inspired oxygen; MV, mechanical ventilation; PaO_2/FiO_2, ratio of arterial oxygen partial pressure to fractional inspired oxygen; RR, respiratory rate; TV, tidal volume; VAP, ventilator-associated pneumonia. P_1: first day and second day of MV. P_2: first day of VM and first day of VAP. P_3: second day of MV and first day of VAP. *$P<0.005$, significant.

Table 8 Causative organisms in early-onset (<5 days) and late-onset (>5 days) ventilator-associated pneumonia

Organism	n (%)
Early onset (<5 days)	19 (39.6)
Gram-positive staph	10/19 (52.6)
No growth	6/19 (31.6)
Pseudomonas	3/19 (15.8)
Late onset (≥ 5 days)	29 (60.4)
Pseudomonas	15/29 (51.7)
Klebsiellia	12/29 (41.4)
MRSA	2/29 (6.9)

MRSA, methicillin- resistant *Staphylococcus aureus*.

Table 9 Number of patients developed ventilator-associated pneumonia in relation to the type of organisms

Type of organism	n (%)	Total (N=48) (%)
Gram-positive staph	12/48 (25)	–
Staphylococcus	10/12 (83.3)	20.83
MRSA	2/12 (16.7)	4.17
Gram-negative bacilli	30/48 (62.5)	–
Pseudomonas	18/30 (60)	37.5
Klebsiella	12/30 (40)	25
No growth	6/48 (12.5)	–
Total	48 (100)	–

MRSA, methicillin- resistant *Staphylococcus aureus*.

Discussion

Patients who are admitted to ICU; are exposed to different infection types including pneumonia, irrespective of the cause of ICU admission, but those who are subjected to MV are at risk of developing VAP with different organisms that may differ according to the underlying cause required MV.

The present study is one of the first epidemiology trials in Tanta University Hospitals to track the incidence of VAP in chest and anesthesia ICUs and to explore the magnitude of this problem as a complication of MV and the possible causative organisms and antibiotics

that were used, in addition to the response to these antibiotics.

According to the data of the present study, the incidence of VAP was 38.4% in all the ICUs studied. This was lower than that obtained by Ahmed *et al.* [9] in their study of VAP in three ICUs and reported an incidence of VAP of 58.2%. Also, in another study by Song *et al.* [10] to study the incidence of VAP in both medical and surgical ICUs in tertiary China hospital for 18 months, they found an incidence of VAP of 26.85%. This difference between the studies may be because of variation in the recording system in these hospitals or because of

Table 10 Causes of mechanical ventilation in relation to the organism causing ventilator-associated pneumonia

	No growth	Gram-negative bacilli (Pseudomonas)	Gram-negative bacilli (Klebsiella)	Gram-positive staph (MRSA)	Gram-positive staph
Respiratory failure, COPD [n (%)]	4 (8.3)	2 (4.2)	0 (0.0)	0 (0.0)	0 (0.0)
Respiratory failure, asthma [n (%)]	0 (0.0)	2 (4.2)	4 (8.3)	0 (0.0)	4 (8.3)
Head trauma [n (%)]	2 (4.2)	4 (8.3)	2 (4.2)	0 (0.0)	0 (0.0)
Cardiopulmonary arrest [n (%)]	0 (0.0)	4 (8.3)	4 (8.3)	0 (0.0)	2 (4.2)
Cardiovascular impairment [n (%)]	0 (0.0)	6 (12.5)	2 (4.2)	2 (4.2)	4 (8.3)
χ^2					
χ^2		34.521			
P value		0.005 (significant)			

COPD, chronic obstructive pulmonary disease; MRSA, methicillin- resistant *Staphylococcus aureus*.

Table 11 Types of antibiotics used to treat ventilator-associated pneumonia (according to culture and sensitivity test)

Antibiotics	n (%)
Amikacin	14 (29.2)
Broad spectrum (levofloxacin)	6 (12.5)
Ceftazidime	4 (8.3)
Imipenem	12 (25)
Tecoblanin, linozolid	2 (4.2)
Vancomycin	10 (20.8)
Total	48 (100)

Table 12 Duration of used antibiotics for ventilator-associated pneumonia, duration of mechanical ventilation, and duration of stay in ICU

	Minimum duration (days)	Maximum duration (days)	Mean	SD
Antibiotic duration	5	35	18.75	8.39
MV duration	7	37	17.88	7.25
ICU duration	7	37	22.38	9.0

MV, mechanical ventilation.

Table 13 Number of nonsurvivors with ventilator-associated pneumonia in relation to the organism causing ventilator-associated pneumonia

	No growth	Gram-negative bacilli (Pseudomonas)	Gram-negative bacilli (Klebsiella)	Gram-positive staph (MRSA)	Gram-positive staph	Total
Non survivors [n (%)]	0 (0)	12 (25)	6 (12.5)	2 (4.2)	0 (0)	20 (100%)

MRSA, methicillin- resistant *Staphylococcus aureus*.

Table 14 Number of patients with ventilator-associated pneumonia in relation to studied months

	January	February	March	April	May	June	July	August	September	October	November	December
VAP [n (%)]	6 (12.5)	6 (12.5)	5 (10.4)	4 (8.3)	5 (10.4)	4 (8.3)	2 (4.1)	3 (6.25)	2 (4.1)	3 (6.25)	5 (10.4)	3 (6.25)

VAP, ventilator-associated pneumonia.

anti-infection measures and avoidance of risk factors that are followed by the health team to decrease the incidence of VAP.

The age of the patients in the present study ranged between 38 and 87 years, mean 60.54±10.42; this may be because of old age, with higher incidences of VAP, or may have been because the majority of patients had underlying comorbidities and risk factors such as COPD and cardiac impairment.

In the present study, VAP was more common in men (66.7%) than in women (33.3%); this may be explained by the high prevalence of COPD and cardiac impairment among men than women, and these two

diseases were the most commonly recorded causes of ICU admission and for MV.

These findings were in agreement with those of Sharpe *et al.* [11], who found that VAP was common in men (79%) than women (21%) among ventilated patients because of trauma. Also, Goel *et al.* [12] recorded a higher incidence of VAP in their study in men than women (69.81 vs. 30.19%).

The duration of MV varied in the present study; 58.33% of patients had undergone ventilation for more than 15 days, whereas 41.67% had undergone ventilation for less than 15 days. The higher percentage may be attributed to the higher risk of infection during

the prolonged intubation period because of incubation of organisms in ventilator circuits, nebulizers, or humidifier systems; therefore, efforts should be made to reduce the risk of VAP by reducing the period of intubation.

Previous findings were in agreement with those of Badr et al. [13], who studied VAP in neonates and found that the incidence of infection increased when the period of intubation was prolonged. In another relative study by Gadani et al. [14] carried out to study the incidence of VAP and risk factors, it was concluded that period of intubation was one of the risk factors of VAP, with a higher incidence of infection (73%) in intubated patients for a period of about 96 h than those who were intubated for less than 96 h (27%). Elgazzar [15] concluded in his study that longer duration of MV is a reliable predictor of poor outcome and mortality in MV COPD patients with acute and chronic respiratory failure.

In the present study, 9.6% of patients were categorized under early-onset VAP and 60.4% under late-onset VAP. These results were lower than those obtained by Golia et al. [16], who stated that 44.23% of patients were grouped as having early-onset VAP and 55.77% as having late-onset VAP. However, in another relative study of risk factors of VAP, patients were classified according to the onset of VAP and found that 27% of patients had early-onset VAP, whereas 73% of the patients studied had late-onset VAP.

In terms of the organisms isolated in the present study, gram-positive organisms were the most commonly isolated organism (52.6%) in early-onset VAP, followed by Pseudomonas (15.8%), whereas in late-onset VAP, Pseudomonas was the most commonly isolated organism (51.7%), followed by Klebsiella (41.4%).

In a survey study by Restrepo et al. [17] of 496 patients over 3 years, *Staphylococcus aureus* was the most common etiological agents for early-onset VAP (44.0%), whereas gram-negative bacilli (e.g. *Haemophilus influenza*) was common in late-onset VAP (84.3%). In contrast, MRSA incidence in late-onset VAP patients was 25.3 versus 18% in early-onset VAP patients.

In another limited study, Golia et al. [16] found that among the 59 VAP cases, *Pseudomonas aeruginosa* was the most commonly isolated organism causing both early-onset and late-onset VAP (33.33 and 34.29%, respectively), followed by *Escherichia coli* 15 (25 and

25.71%, respectively) and *Acinetobacter baumanii* (12.5 and 14.29%, respectively).

As an overall analysis for causative organisms isolated from all patients in the present study; *P. aeruginosa* was responsible for 37.5%, *Klebsiella pneumonia* was 25%, *S. aureus* was 20.83%, and MRSA was 4.17%.

Countless studies have focused on the causative microbes responsible for pneumonia in ICU and ventilated patients. In a survey study in Iran on the most prevalent bacterial isolates in surgical ICU, Hashemi et al. [18] reported that *Acinetobacter baumannii* were the most commonly present in VAP patients (24.6%), followed by *P. aeruginosa* (20.2%) and *Enterobacter* spp. (13.0%).

An American study by Jones et al. [19] reported that *P. aeruginosa* had the highest rate (27%), followed by *S. aureus* (20%) and *Acinetobacter* spp. (14%) as causative organisms of pneumonia in ventilated patients.

A relative surveillance study for VAP incidence was conducted in 73 hospitals in Asia by Chung and his team [20]; *Acinetobacter* spp. (33.5%) was the most commonly isolated pathogen from VAP patients, followed by *P. aeruginosa* (23.9%), *K. pneumoniae* (15.4%), and *S. aureus* (13.8%).

Ahmad et al [21] studied VAP aetiology in admitted patients in one of Pakistan hospital ICU and reported that causative organisms were MRSA (40%), followed by Enterobacteriaceae (22%), *K. pneumonia* (30%), and *Enterobacter cloacae* (10%).

In terms of the organisms isolated in relation to the cause of ventilation, in a recent study, Pseudomonas (4.2%) was the most common organism in COPD ventilated patients, Klebsiella (8.3%) in asthmatic patients, Pseudomonas and Klebsiella in postcardiopulmonary arrest patients by the same percentage (8.3%), and Pseudomonas was the main organism in patients with cardiovascular impairment (12.5%).

Another study about the relation of causative organisms to different ICU admission causes, Rello [22] concluded that *H. influenza* and *Moraxella catarrhalis* were the main findings in COPD patients, *P. aeruginosa* and *S. aureus* infections were predisposed by cystic fibrosis while trauma and neurologic patients were risky for *S. aureus*.

Many studies were carried out to trace and explore the causative organisms in early-onset and late-onset VAP in intubated patients, and the relation between isolated

pathogens and the underlying risk factors, and the causes of MV. However, their results were different from each other and from those of the present study because of the differences in the countries in which the studies were carried out, the hospitals in which the patients were admitted, type of ICU and cause of ICU admission, and the time and cause of invasive ventilation.

In the present study, the antibiotics used varied between patients; amikacin was the most commonly used antibiotic (29.2%), followed by vancomycin (20.8%), levofloxacin (12.5%), and ceftazidime (8.3%).

Although antibiotics are important in patient management according to the pathogen isolated, the antibiotics used are not unique in all patients; they are prescribed according to the suspected organism, patient comorbidities in addition to the primary underlying disease, and local epidemiology.

In a relevant Egyptian study by Abd El-Kader [23] in the Emergency Hospital at Mansoura University, the most commonly used antibiotics in VAP patients were ciprofloxacin, followed by ampicillin–sulbactam, fusidic acid, erythromycin, and imipenem.

Djordjevic *et al.* [24] reported in their survey study that ceftazidime was the most used antibiotic that isolated bacteria were sensitive to, followed by piperacillin–tazobactam, meropenem, and imipenem. In the present study, the mean MV period was 17.88 ±7.25 days, whereas the mean hospital stay duration period was 22.38±9.0 days; these are actually long periods of hospital stay and care for patients that can affect patient outcome statistics, and also place a burden on the healthcare system budget and financial plan.

Actually, VAP prolongs ICU and hospital stay of the patients. So; many countries make hard to shorten patients' hospital stay and improve their management, and if possible, to protect them against infections and management of risk factors, predisposing them to morbidity and mortality, and avoid misuse of antibiotics to decrease the cost and to prevent drug resistance among virulent pathogenic organisms.

Ranjit and Bhattarai [25] reported in their study of the VAP group a longer duration of hospital stay (29±17.8 days) and also a longer duration of MV (18.88±7.7 days).

In the present study, the survival rate was high (58.3%) in relation to not surviving (41.7%); this may be because of less hygienic precautions followed by the healthcare team.

In a study by Yasmen and colleagues, the death rate among ventilated patients was high, 68.2%, whereas among survivors it was 31.8%, which was more relevant to that of the present study.

Bozorgmehr and colleagues also reported a lower survival rate (21.05%), whereas the mortality rate was 78.95%. However, in the study carried out by Ali *et al.* [26], the mortality rate was low (23.6%) compared with that of the present study.

One of this study limitations was the few number of involved IC units which decreased the number of studied patient and also had effect on the results; more patients from different hospitals and tertiary units should be enrolled in the study.

Another limitation was that the use of combined antibiotics in comparison with a single antibiotic was not studied. Antibiotics should be studied with correlation to culture and sensitivity before and after these drugs usage.

Another limitation is the insufficient study of the MV period and hospital stay duration in relation to the cause of ventilation and type of antibiotics used and their duration, which should be clarified in detail in further studies.

Conclusion
Pneumonia is a frequent complication that is encountered by physicians in ICU patients irrespective of the cause of admission.

VAP is a severe infection that should be managed early or even prevented to lower morbidity and mortality.

Identification of risk factors, causative organisms causing VAP in addition to detection of antibiotics sensitivity are all essential steps to manage VAP and to decrease patient suffering in addition to decrease financial burden for both patient and healthcare system.

Conflicts of interest
There are no conflicts of interest.

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