



# Infection-Related Ventilator-Associated Complication and Possible Ventilator-Associated Pneumonia among Mechanically Ventilated Patients of Adult Medical and Surgical Intensive Care Units

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## Abstract

### Keywords

- ▶ ventilator-associated events
- ▶ infection-related ventilator-associated complication
- ▶ possible ventilator-associated pneumonia
- ▶ Centers for Disease Control and Prevention-National Healthcare Safety Network (CDC-NHSN)
- ▶ adult medical and surgical intensive care units

**Objective** An observational study was conducted to evaluate (1) the incidence rates of infection-related ventilator-associated complication (IVAC) and possible ventilator-associated pneumonia (PVAP) among mechanically ventilated patients of adult medical and surgical intensive care units (ICUs) and (2) the pathogen distribution in patients with PVAP.

**Materials and Methods** The IVAC and PVAP rates of medical and surgical ICUs, between July 1, 2017, and June 30, 2021, per 1,000 mechanical ventilator (MV) days were calculated. The significance of difference in IVAC and PVAP rates between medical and surgical ICUs was calculated. The level of significance was set at less than 0.05.

**Results** MV utilization ratios of adult medical and surgical ICUs were 0.32 and 0.26, respectively ( $p < 0.001$ ). About 8 and 7 episodes of IVAC and 14 and 6 episodes of PVAP were reported from adult medical and surgical ICUs, accounting for IVAC rates of 3.17 and 1.8 per 1,000 MV ( $p > 0.05$ ) and PVAP rates of 2.46 and 1.59 per 1,000 MV days in medical and surgical ICUs, respectively ( $p > 0.05$ ). *Acinetobacter baumannii* complex either singly or in combination was isolated in 11/20 PVAP cases.

**Conclusion** IVAC and PVAP were more in medical compared with surgical ICUs. The most common pathogen in patients with PVAP was *A. baumannii* complex. More studies are warranted to monitor the significance of ventilator-associated event on patient outcomes.

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## Introduction

Surveillance of ventilator-associated pneumonia (VAP) continues to be challenging in intensive care unit (ICU) settings and has been a debated issue since long. Prior to 2013, the surveillance of VAP was based on a combination of clinical signs, chest radiography, and microbiological data.<sup>1</sup> This definition has since been found to be neither sensitive nor specific for VAP, and hence, was deemed unsuitable for surveillance purposes. In 2013, the Centers for Disease Control and Prevention–National Healthcare Safety Network (CDC-NHSN) developed new surveillance definitions for surveillance of ventilator-associated events (VAEs) in adult medical and surgical ICUs in an attempt to promote surveillance in a uniform and consistent manner.<sup>2</sup> In the CDC-NHSN three-tiered VAE algorithm, ventilator-associated conditions (VACs) are defined by an increase of more than 3 cm of H<sub>2</sub>O from daily minimum positive end-expiratory pressure (PEEP) or an increase of more than 20% in the fraction of inspired oxygen (FiO<sub>2</sub>).<sup>2</sup> Infection-related VAC (IVAC) is defined by VAC with inflammatory signs and use of new antibiotics for more than 4 days, and possible VAP (PVAP) is defined by IVAC with microbiological evidence of pneumonia.<sup>2</sup> This definition was adopted at our adult and medical surgical ICUs for routine surveillance of VAE. We undertook an observational study over 4 years with aim to evaluate the following: (1) the incidence rates of IVAC and PVAP among mechanically ventilated patients of adult medical and surgical ICUs and (2) the pathogen distribution in patients with PVAP.

## Method

In this study, patients admitted to various adult medical and surgical ICUs, between July 1, 2017, and June 30, 2021, and had at least 4 days on mechanical ventilation were included. The mechanical ventilator (MV) utilization ratio of medical and surgical ICUs was calculated. The IVAC and PVAP rates of medical and surgical ICUs, per 1,000 MV days were calculated. Patients requiring progressive increases in FiO<sub>2</sub> or PEEP from intubation without subsequent stabilization were excluded.

Patients who succumbed within 2 calendar days of MV were also excluded. Three-tier VAEs algorithm according to the definition of CDC-NHSN was implemented and VAE Calculator, version 7.0 was used for VAE stratification. To make a diagnosis of IVAC, first, VAEs were captured by using CDC-designed software in which the lowest FiO<sub>2</sub> and the lowest PEEP of all invasively ventilated patients were listed. Endotracheal aspirate (ETA)/bronchoalveolar lavage (BAL) were collected as per protocol. ETA and BAL were subjected to Gram staining and semiquantitative culture. Presence of greater than or equal to 25 neutrophils and less than or equal to 10 squamous epithelial cells on sputum microscopy was considered as significant. Significant growth in respiratory samples was stratified as follows: endotracheal aspirate (ETA) 10<sup>5</sup> CFU/mL, bronchoalveolar lavage (BAL) 10<sup>4</sup> CFU/mL. Patients with IVAC or PVAP were not mutually exclusive. For example, patients in the PVAP group were all included in IVAC.

## Results

The MV utilization ratio of adult medical and surgical ICUs was 0.32 and 0.26, respectively ( $p < 0.001$ ). Eighteen and 7 episodes of IVAC were reported from adult medical and surgical ICUs, accounting for IVAC rates of 3.17 and 1.8 per 1,000 MV ( $p > 0.05$ ). Fourteen and 6 episodes of PVAP were reported from adult medical and surgical ICUs accounting for PVAP rates of 2.46 and 1.59 per 1,000 MV days in medical and surgical ICUs, respectively ( $p > 0.05$ ). A single pathogen was isolated in 15 out of 20 cases of PVAP, whereas rest of the five cases had two pathogens. Extensively drug-resistant (XDR) *Acinetobacter baumannii* complex and *Klebsiella pneumoniae* (retaining susceptibility to only tigecycline and colistin) either singly or in combination were isolated from 15 out of 20 cases. *Pseudomonas aeruginosa*, either singly or in combination, was isolated from 6 out of 20 cases. Multi-drug-resistant *Escherichia coli* and *Proteus mirabilis* were isolated from one case each. The total MV days, MV utilization ratio, incidence rates of IVAC and PVAP, and mortality among mechanically ventilated patients of adult medical and surgical ICUs is depicted in ►Table 1. The variables are denoted as  $n$  (%) and compared by using the chi-square

**Table 1** Total MV days, MV utilization ratio, incidence rates of IVAC and PVAP, and mortality among mechanically ventilated patients of adult medical and surgical ICUs

	Medical intensive care unit	Surgical intensive care unit	p-Value
Total MV days	5,671	3,762	< 0.001
Total patient days	17,597	14,448	
MV utilization ratio	0.32	0.26	
Total IVAC (n)	18	7	> 0.05
IVAC/1,000 MV days	3.17	1.8	> 0.05
Total PVAP (n)	14	6	
PVAP/1,000 MV days	2.46	1.59	
Total death in patients who developed IVAC or PVAP	13 (72.2%)	2 (28.5%)	< 0.05

Abbreviations: ICU, intensive care unit; IVAC, infection-related ventilator-associated complication; MV, mechanical ventilator; PVAP, possible ventilator-associated pneumonia.

test. *p*-Value of 0.05 or lower was used to ascertain statistical significance.

## Discussion

In our study, the incidence rates of IVAC and PVAP were higher in medical ICUs compared with surgical ICUs, though the difference was not statistically significant. In a recent Indian study, more VAE cases (62.1%) were reported from medical ICU as compared with surgical ICU.<sup>3</sup> On further stratification of the VAE cases, incidences of VAC and IVAC was almost similar in medical and surgical ICUs; however, the incidence of PVAP between medical ICU (9.1/1,000 ventilator days) as compared and surgical ICU (1.45/1,000 ventilator days), was statistically significant ( $p=0.0044$ ).<sup>3</sup> Our IVAC and PVAP rates over 4 years is less than that reported by Sharma et al as well as from other international studies by Apisarnthanarak et al and Dallas et al.<sup>3,4,7</sup> In a study from Thailand, incidence of VAP in the medical ICU was higher compared with the surgical ICU (20.6 cases per 1,000 ventilator-days vs. 5.4 cases per 1,000 ventilator-days).<sup>4</sup> In few studies from western countries, the incidence rates of IVAC and PVAP have been reported to be more in surgical ICUs compared with medical ICUs. In a previous large-scale, retrospective cohort study conducted at a tertiary, academic center in 2013, the proportion of IVACs ranged from 29% in medical units to 42% in surgical units.<sup>5</sup> Another study from Japan, also reported higher incidences of three VAEs subtypes (VAC, IVAC, PVAP) in ICUs with large proportion of surgical patients.<sup>6</sup> In a study from United States by Dallas et al, surgical ICU patients had higher rates of VAP compared with medical ICU patients (13.6 per 1,000 ventilator-days vs. 4.8 per 1,000 ventilator-days).<sup>7</sup> In our study, MV utilization ratio in medical ICUs was significantly higher compared with surgical ICUs ( $p < 0.001$ ). This could be one of the reasons of higher infectious complications in adult medical ICUs. In our study, IVAC and PVAP were associated with increased risk of mortality, and mortality was significantly higher in medical ICUs compared with surgical ICUs. In a recently published study, the hospital mortality among patients with all three VAEs subtypes (VAC, IVAC, PVAP) was more than three times of those with non-VAEs.<sup>8</sup> In our study, XDR *A. baumannii* complex (retaining susceptibility to only tigecycline and colistin) either singly or in combination were isolated from 11 out of 20 cases. Similar to our findings, the most common pathogen in patients with PVAP was *A. baumannii*, in the study by He et al.<sup>8</sup> A notable finding of our study was total absence of Gram-positive organisms as causative agent of VAP, whereas in a previous study, *Staphylococcus aureus* was isolated from 29% of cases.<sup>5</sup> This study helps to give a preliminary idea regarding the incidence and microbiological etiologies of infectious complications of mechanical ventilation. We would like to highlight the limitations of our study. Our findings are based on data from one tertiary hospital, which may not be generalizable to other settings.

Multivariate models adjusted for age, sex, unit type, and other risk factor analysis, as well as inclusion of controls (selected from among ventilated patients for at least the number of days as matched to cases as per days to VAE onset) could have helped us calculate the attributable mortality risk. More Indian studies are warranted to monitor VAE and its clinical significance on patient outcomes.

## Authors' Contributions

B.B. contributed to the conceptualization, methodology, formal analysis, resources, data curation, writing - original draft, writing - review and editing, supervision, and project administration. A.M. contributed to the data curation, writing - review and editing, supervision, and project administration. J.S.K. contributed to resources, supervision, and project administration. J.J. contributed to methodology and project administration. J.R., J.B., C.S., R.P., and M.K. contributed to formal analysis, data curation, and writing - review and editing.

## Note

The work was presented as chaired poster in the XVII Annual Conference of Hospital Infection Society of India. HISICON 2021. The study was approved by the Institute Ethics Committee, Number T-EM-F/Micro/16/27.

## Conflict of Interest

None declared.

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