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To Study The Etiological Factors With Special Reference To Its Antibiogram In Ventilator Associated Pneumonia (Vap) In Icu Patients At A Tertiary Care Centre, Uttar Pradesh

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ABSTRACT

BACKGROUND: The most prevalent nosocomial infection that raises morbidity and mortality in patients in the intensive care unit (ICU) is ventilator-associated pneumonia (VAP).

AIM: This study aims to identify the etiological factors and analyze their antibiogram which causes VAP in the ICU patients.

MATERIAL & METHODS: This was a Prospective study carried out in the Department of Microbiology for a period of 1 year i.e, March 2023 to March 2024 at a tertiary care hospital, UP. Endotracheal aspirates were obtained from 176 patients who were admitted to medical intensive care unit (ICU). All the clinical suspected sample of VAP were sent to the department of microbiology. All the isolates were identified to species level and antimicrobial susceptibility test were performed using Kirby bauer disk diffusion method. Processing of samples were done using latest CLSI guidelines 2023.

RESULTS: In the present study out of 176 suspected cases 39.2% were acquired VAP. Of which males and females were 59.4% and 40.5% respectively. Maximum number of cases belongs to the age group of 46-55(30.43%). There were 56(81.15%) were GNB and 18.84% were GPC. Among GNB, Acinetobacter baumanii was most predominant accounting for 44.64% followed Pseudomonas aeruginosa (25%). Among GPC, S.aureus was the most frequently isolated. Out of the 56 Gram negative isolates, 4 out of 8 E.coli and 2 out of 7 Klebseilla spp were ESBL producers. Among 25 Acinetobacter baumanii 17 were Carbapenem resistant. Out of the 11 isolates of S.aureus, 3 were MRSA and only one was observed to be MSSA.

CONCLUSION: Understanding locally widespread organisms and the nature of susceptibility to antibiotics will assist to limit the formation of multidrug resistant strains in hospital setting and suggest the best empirical antibiotic therapy for VAP.

KEYWORDS: Intensive care unit(ICU), VAP, Nosocomial infection, Antibiogram, Endotracheal aspirates, Acinetobacter baumanii.

INTRODUCTION

Hospital acquired pneumonia also known as nosocomial pneumonia, is defined as the onset of pneumonia symptoms more than 48 hours after admission to the hospital. Ventilator associated pneumonia (VAP) is a type of nosocomial pneumonia that occurs more than 48–72 hours after endotracheal intubation and receiving mechanical ventilation in ICU. VAP occurs in 9–27% of all intubated patients [1] .
Incidence of VAP in ICUs (Intensive Care Unit) ranges from 8% to 28% in intubated mechanically ventilated patients [2].

The use of mechanical ventilation in patients with respiratory failure has modernized the management of critically ill patients. Ever since its first description in the 1950s, the use of ventilators has increased several folds [3].

According to the American Thoracic Society, VAP is defined as "pneumonia occurring more than 48 hours after the initiation of endotracheal intubation and mechanical ventilation."[4].It is the inflammation of lung parenchyma caused by infectious agents not present or incubating at the time mechanical ventilation was started [5].VAP is a subgroup of healthcare-associated infections and it is a critical device-associated infection (DAI) observed in an intensive care unit (ICU) setting. It is one of the leading causes of death contributing to morbidity and mortality in ventilated patients [6].
The most common mechanism of acquiring VAP is by micro aspiration of oral and pharyngeal flora into the lower respiratory tract. Other potential routes are less common, such as haematogenous spread of bacteria from distant foci of infection like catheter-related bloodstream infections, from the hospital environment, hands of health care workers or contaminated respiratory equipment, bronchoscopes, medical aerosols, water or Air [7].

The etiologic agents of VAP depends on various factors such as the population of patients in an intensive care unit, duration of hospital stay, and prior antimicrobial therapy. Even with the advances of antimicrobial regimen, VAP continues to be an important cause of morbidity and mortality in ICU patients. VAP requires a rapid confirmation of diagnosis for early and appropriate instillation of therapy as inadequate antibiotic treatment on patient's prognosis may lead to emergence of multidrug-resistant (MDR) pathogens [8].
The most frequently isolated pathogens from patients with VAP are gram-negative bacteria, namely Acinetobacter baumannii, Pseudomonas aeruginosa, Klebsiella pneumoniae, and Escherichia coli, and gram-positive bacteria, such as methicillin-resistant Staphylococcus aureus (MRSA) reported from hospitals in western as well as Indian literature [9-12].
The incidence of VAP has been observed to vary considerably from study to study. In early studies in the 1990s, it was reported to be 16.5% by Papazian et al., in France [13]. In later years, Al Dorzi et al., during 2003 to 2008, reported VAP in 14.5% of patients [14]. Recent Indian studies conducted by Joseph et al [15]. showed the incidence of VAP to be 18%. A similar study conducted by Dey et al. reported an incidence of 45.4%[15]. In the western literature. VAP rates varied from 6 to 52% [5,9,16]. Indian studies indicate an overall incidence rate of 9 to 58% [11,15,17]. It is also observed that surgical ICUs have higher rates of VAP compared to the medical ICUs [10].
The aim of this study was to identify the etiological factors associated with Ventilattor associated pneumonia and analyze their Antibiogram admitted in the ICU of tertiary care hospital, Uttar Pradesh.

MATERIAL & METHODS

This was a 12 month Prospective study, in which a total 176 Endotracheal secretions were collected from the Pneumonia suspected patients admitted in ICU. The study was carried out in the Department of Microbiology with collaboration with the Anesthesiology Department.

Inclusion criteria: Patients above 18 years of age , who were on mechanical ventilation for more than 48 hours were included in the study.

Exclusion criteria: Patients with respiratory disease like cystic fibrosis, pneumonia and patient's already on antibiotic therapy were excluded from this study.

Ethical clearance: Ethical clearance was duly obtained from the ethical committee.

Sample Collection: The Endotracheal Secretions or aspirates were collected from the patients on ventilator. The samples were immediately taken to the microbiology laboratory for processing.

Sample Processing: A smear was made using a loopful of sample and gram stain were performed. Then smear was examined under microscope for the presence of polymorphnuclear cells an bacteria. A quantitative culture were performed on MacConkey agar and blood agar. Culture plates were incubated for 24 hrs at 37 ^{0}C. A colony count of ≥104 colony-forming unit/mL (cfu/mL) was recorded significant [18,19] and counts less than this were considered insignificant. Plates showing significant growth were further studied for gram stain and colony morphology.
Species identification were done using standard bacteriological methods.

Antimicrobial susceptibility testing: Kirby–Bauer disk diffusion method on Mueller–Hinton agar according to Clinical and Laboratory Standards Institute (CLSI) guidelines [18].

Statistical analysis: Qualitative data were represented in the form of frequency and percentages. SPSS Version 22 was used for the statistical analysis.

RESULTS

In the present study a total of 176 suspected cases of pneumonia patients in ICU were studied in which only 69 were diagnosed with ventilator associated pneumonia(VAP). Among 69 confirmed cases, 41(59.4%) were males and 28 (40.5%) were females.as given in table 1. The prevalence of VAP in our study was observed to be 39.2%.
In our study VAP was more predominant in the age group of 46-55 (30.43%), followed by age group 56-65(26.08%), 36-45 (13.04%) and less number of patients were belong to age group 15-25(4.34%) as shown in table 2.
Of of the 69 isolates, 56(81.15%) were Gram negative bacteria and 13(18.84%) were gram positive bacteria. Among gram negative bacilli, Acinetobacter baumanii found to be most predominant accounting for 44.64% followed by Pseudomonas aeruginosa (25%), E.coli (14.28%), Klebseilla pneumoniae (8.92%), Klebseilla oxytoca(3.57%) and Proteus spp(3.57%).
Among gram positive cocci, Staphylococcus aureus was the predominant accounting for 53.84% followed by MRSA(23.07%), Enterococcus faecalis(15.38%) and MSSA(7.69%). as shown in table 3.

Antimicrobial susceptibility pattern

Of of the 11 isolates of S.aureus, 3 were MRSA and only one was MSSA observed . All the S.aureus isolates were Sensitive to Vancomycin, Teicoplanin and Linezolid and six were resistant to Gentamycin, Ciprofloxacin, while three were resistant to Erythromycin. All MRSA were resistant to Ciprofloxacin, Erythromycin and only one were resistant to Gentamycin and Clindamycin.

Out of the 56 Gram negative isolates, 4 out of 8 E.coli and 2 out of 7 Klebseilla were ESBL producers. Among 25 Acinetobacter baumanii 17 were Carbapenem resistant. Antibiogram of gram negtive bacilli were given in table 4 and Gram positive cocci were given in 5.

TABLE 1: GENDER WISE DISTRIBUTION OF VAP CASES.

GENDER	FREQUENCY	PERCENTAGE(%)
MALE	41	59.4
FEMALE	28	40.5
TOTAL	**69**	**100**

In this table it was observed that, ventilator associated pneumonia was found more in males (59.4%) than in female patients (40.5%).

TABLE 2: AGE WISE DISTRIBUTION OF VAP CASES.

AGE OF VAP PATIENTS	FREQUENCY	PERCENTAGE(%)
15-25	3	4.34
26-35	9	13.04
36-45	12	17.39
46-55	21	30.43
56-65	18	26.08
>65 years.	6	8.69
TOTAL	**69**	**100**

In this table it was observed that, maximum number of VAP cases were found in the age group of 46-55(30.43%) and only 4.34% of VAP cases were found 15-25 years of age group.

TABLE 3: DISTRIBUTION OF MICROBIAL ISOLATES AMONG VAP PATIENTS.

MICROORGANISM	FREQUENCY	PERCENTAGE(%)
GNB(n=56)		
Acinetobacter baumanii	25	44.64
Pseudomonas aeruginosa	14	25
E.coli	8	14.28
Klebseilla pneumoniae	5	8.92
Klebseilla oxytoca	2	3.57
Proteus spp	2	3.57
GPC(n=13)		
Staphylococcus aureus	7	53.84
MRSA	3	23.07
MSSA	1	7.69
Enterococcus faecalis	2	15.38
TOTAL	**69**	**100**

In this table it was observed that, Among gram negative bacilli A.baumanii was predominant and found to be 44.64% and in casse of GPC, S.aureus was predominant and found to be 53.84%.

TABLE 4: SENSITIVITY PATTERN OF GRAM NEGATIVE BACILLI.

	A. Baumani (n=25)	P. Aeruginosa (n=14)	Klebseilla (n=7)	E. Coli (n=8)	Proteus (n=2)
AMIKACIN	11(44%)	10(71%)	5(71.4%)	6(75%)	2(100%)
GENTAMYCIN	12(48%)	12(85.7%)	6(85.7%)	7(87.5%)	1(50%)
NETILMYCIN	11(44%)	11(78.5%)	4(57.1%)	4(50%)	2(100%)
TOBRAMYCIN	13(52%)	12(85.7%)	5(71.4%)	7(87.5%)	2(100%)
CEFTAZIDIME	5(20%)	10(71%)	2(28.5%)	2(25%)	1(50%)
CEFEPIME	4(16%)	11(78.5%)	4(57.1%)	5(62.5%)	2(100%)
CEFOPERAZONE-SULBACTUM	11(44%)	9(64.2%)	3(42.8%)	4(50%)	2(100%)
PIPERACILLIN-TAZOBACTUM	17(68%)	14(100%)	6(85.7%)	7(87.5%)	2(100%)
CIPROFLOXACIN	9(36%)	11(78.5%)	2(28.5%)	3(37.5%)	2(100%)
IMIPENEM	6(24%)	12(85.7%)	7(100%)	7(87.5%)	2(100%)
MEROPENEM	6(24%)	12(85.7%)	7(100%)	7(87.5%)	2(100%)
COLISTIN	25(100%)	14(100%)	7(100%)	8(100%)	0(0%)

TABLE 5: SENSITIVITY PATTERN OF GRAM POSITIVE COCCI.

	S.aureus(n=11)
VANCOMYCIN	100%(11)
TEICOPLANIN	100%(11)
LINEZOLID	100%(11)
CLINDAMYCIN	27.2%(3)
PENICILLIN	0%(0)
GENTAMYCIN	54.5%(6)
CEFOXITIN	27.2%(3)
CEFAZOLIN	27.2%(3)
AMOXICILLIN-CLAVULANATE	36.3%(4)
CIPROFLOXACIN	54.5%(6)

DISCUSSION

VAP is caused by a wide spectrum of bacterial pathogens. It may be polymicrobial and in immunocompromised hosts may be of viral or fungal etiology [5].

Early diagnosis and prompt administration of empirical antimicrobial therapy has been shown to have significant positive effect on mortality from hospital acquired pneumonia. The microbiological evidence prior to the instillation of treatment of VAP avoids unwanted over-treatment of colonizers from pathogens. There are investigative techniques like invasive bronchoscopy for biopsy and protective specimen brush from the site of infection that are highly specific for diagnosing VAP. However, they are invasive in nature and expensive but quantitative ETA culture showed similar results as that of invasive methods and it is affordable and noninvasive. Irrespective of what method was employed for the collection of sample for culture (bronchoscopic or endotracheal aspiration), some studies have shown that those patient outcomes were similar [20].

The overall incidence of VAP was observed to be 39.2% in our study. This value falls under the range of 15-58% as reported by other investigators.[21] The incidence was slightly higher than the incidence of reported in a study of 37 patients on ventilator therapy which was 37% [22]. Even higher incidence rates were reported in other studies with 45.4% [23] and even as high as 73% [24]. This was probably because of the shorter duration or the smaller sample size of the study.

Patients belonging to the age group of 46-60 years in our study showed highest incidence of VAP in patients exposed to mechanical ventilation for more than 48 hours and this correlated with data from other studies [25].The incidence of VAP was higher in males (59.4%) compared to females

(40.5%) which correlated with other studies [26]. A study conducted by Dey et al.[27] showed that a significantly higher VAP was acquired in 46- to 60-year age-group. Old age, underlying chronic lung disease, and previous antibiotic exposures were associated with a higher risk for developing VAP reported in studies [28,29].

There were 69 bacterial isolates found in the current study. These included 56 (81.15%) gram-negative organisms and 13 (18.84%) gram positive microorganisms. In a meta-analysis of VAP in adults from developing countries, Arabi et al.[30] reported that 41 to 92% of VAP episodes were caused by gram-negative bacilli, while 6 to 58% by gram-positive cocci. A study by Chandrakanth et al.[31]in 2009 reported that gram negative organisms account for 89% of VAP. Chawla et al.[32] in their study also found that 87% of patients with VAP had gram negative organisms. The gram-negatives constituted 36.6%. Worldwide data indicate that in Western countries gram-positive organisms predominate. Potential reasons include the use of indwelling catheters, local environmental conditions, and the administration of specific antibiotic agents, especially as prophylaxis. As per Indian studies, gram-negative organisms are the major cause of VAP. This can be linked with colonization of the gut and exposure to antimicrobials. The critically ill patients get colonized exogenously or endogenously with hospital flora within 24–48 hours of hospitalization and the oral flora shifts to apredominance of hospital microbial flora, i.e., aerobic gramnegative pathogens. Pulmonary aspiration of these oropharyngeal contents increases the risk for infection. Also, critically ill patients are on broad-spectrum empirical antibiotics, which cause selection pressures on these colonizers for the emergence of resistant strains of gram-negative pathogens [33,34].

The common organisms isolated from cases with VAP in our study were A. baumannii followed by P. aeruginosa and E.coli. Al-Dorzi et al.[14] from Saudi Arabia during 2003 to 2008 reported that A. baumannii was the most commonly cultured microorganism (19%), causing VAP. In a prospective study conducted by Joseph et al.,[15] in 2006–2007, A. baumannii (21.3%) and P. aeruginosa (21.3%) were the most common gram-negative bacteria associated with VAP and S. aureus (14.9%) was the most common gram-positive organism. Similar findings were reported by Dey et al.,[27] Rajasekhar et al.,[35] and Goel et al.,[36] where A. baumannii was the commonest organism causing VAP followed by P. aeruginosa.

Colonization of the respiratory tract with Acinetobacter spp., Pseudomonas spp., and MRSA may have originated from endogenous sources, such as the oropharynx or the stomach, or from exogenous sources, such as contaminated respiratory instruments, infective aerosols from the ICU environment, and contaminated hands and apparel of the healthcare workers. These act as vehicles of transmission. Handwashing is the single most effective measure of preventing transmission. Also, many of our VAP patients had risk factors for acquiring multidrug-resistant organisms (MDROs), such as advanced age, underlying immunosuppression chronic renal failure, diabetes mellitus, acquired immunodeficiency syndrome, and on immunosuppressants—exposure to broadspectrum antibiotics in preceding 3 months, increased severity of illness, previous multiple hospitalizations, and prolonged duration of invasive mechanical ventilation [4,5,37].

It was observed in our study, that antibiotic resistance in gram negative bacilli were increasing. In our study, A.baumanii shows only 24% sensitivity towards cabapenems, 20% sensitivity towards ceftazidime, and 16% towards cefepime. Balkhy et al.[38] studied 248 isolates of A. baumannii and found that 83 to 88% isolates were resistant to aminoglycoside group of antimicrobials, 60–71% to carbapenems like imipenem and meropenem, 86–89% to third-generation cephalosporins, and 86% to the fluoroquinolones.Sievert et al.[39]reported data from US hospitals in 2009 and 2010 and found that 63.4% of Acinetobacter isolates were resistant to aminoglycosides and piperacillin–tazobactam and 61.2% to the carbapenems.

The susceptibility of P.aeruginosa in our study was highest towards colistin (100%), Piperacillin-tazobactum(100%), and 85.7% towards imipenem and meropenem. Balkhy et al.[38] found that P. aeruginosa had 31% resistance to carbapenems, 27–28% to third-generation cephalosporins, and

13–25% to aminoglycosides. Sievert et al. [39] reported that P. aeruginosa isolates showed 11.3% resistance to amikacin, 19.1% to piperacillin–tazobactam, 28.4% to cefepime and ceftazidime, 32.7% to ciprofloxacin/levofloxacin, and 30.2% to Imipenem/ Meropenem.
All S. aureus isolates were susceptible to Vancomycin, Teicoplanin, and Linezolid, and 27.2% were MRSA. Balkhy et al.[38]found that all isolates of S. aureus were susceptible to Vancomycin and 42% of isolates were Methicillin-resistant strains.
The findings in the current study were consistent with these studies. It was observed that multidrug resistance is increasing gradually in hospital isolates, particularly in case of Acinetobacter spp., P. aeruginosa, K. pneumoniae, and S. aureus. A number of studies in the literature also indicate a gradual increase in the emergence of antibiotic-resistant microorganisms in VAP patients.
Studies from Indian hospitals from International Nosocomial Infection Control Consortium have shown that MDR P. aeruginosa was the most common bacterial isolate in VAP patients [40] which inevitably resulted in the increased use of carbapenems that might have contributed to the emergence of MDR nonfermentative gram negative bacilli, mainly A. baumannii.
There are very few antimicrobials in the pipeline and there is an urgent need to change the approach from "treatment" to "prevention." Robust antimicrobial stewardship programs involving pharmacists, physicians, and other healthcare providers to optimize antibiotic selection, dose, and duration thereby increasing the efficacy in targeting causative pathogens for the best clinical outcome are the way forward.

CONCLUSION

In our study, 81.15% gram negative bacilli were responsible for ventilator associated pneumonia, of which Acinetobacter baumanii was the most predominant bacteria and had a high resistant rate among all antibiotics except Colistin. Understanding locally widespread organisms and the nature of susceptibility to antibiotics will assist to limit the formation of multidrug resistant strains in hospital setting and suggest the best empirical antibiotic therapy for VAP.

Declarations:
Conflicts of interest: There is no any conflict of interest associated with this study

Consent to participate: We have consent to participate.

Consent for publication: We have consent for the publication of this paper.

Authors' contributions: All the authors equally contributed the work.

REFERENCES

1. Gupta A, Agrawal A, Mehrotra S, Singh A, Malik S, Khanna A. Incidence, risk stratification, antibiogram of pathogens isolated and clinical outcome of ventilator associated pneumonia. Indian J Crit Care Med. 2011; 15(2):96-101.
2. Safdar N, Crnich CJ, Maki DG. The pathogenesis of ventilator associated pneumonia: Its relevance to developing effective strategies for prevention. Respir Care. 2005; 50:725-39.
3. Lassen HCA. The epidemic of poliomyelitis in Copenhagen, 1952. Proc R Soc Med. 1954; 47(1):67–71.
4. Kalil AC, Metersky ML, Klompas M, Muscedere J, Sweeney DA, Palmer, et al. American Thoracic Society: Infectious Diseases Society of America. Guidelines for the management of adults with hospital acquired, ventilator associated and healthcare associated pneumonia. Am J Respir Crit Care Med. 2005 ;171(4):388–416.

5. Chastre J, Fagon JY. Ventilator associated pneumonia. Am J Respir Crit Care Med. 2002; 165(7):867–903. Kalanuria AA, Zai W, Mirski M. Ventilator associated pneumonia in the ICU. J Crit Care 2014; 18(2):208.
6. Chastre J, Fagon JY. Ventilator-associated pneumonia. Am J Respir Crit Care Med. 2002; 165:867-903.
7. Trouillet JL, Chastre J, Vuagnat A, Joly-Guillou M, Combaux D, Dombret M et al. Ventilator-associated pneumonia caused by potentially drug resistant bacteria. Am J Respir Crit Care Med. 1998; 157:531-9.
8. Davis KA. Ventilator associated pneumonia: a review. J Intensive Care Med. 2006; 21:211–226.
9. Rakshit P, Nagar VS, Deshpande AK. Incidence, clinical outcome and risk stratification of ventilator-associated pneumonia: A prospective cohort study. Indian J Crit Care Med. 2005; 9(4):211–216.
10. Gupta A, Agrawal A, Mehrotra S, Singh A, Malik S, Khanna A. Incidence, risk stratification, antibiogram of pathogens isolated and clinical outcome of Ventilator associated pneumonia. Indian J Crit Care Med. 2011; 15(2):96–101.
11. Bonell A, Azarrafiy R, Huong VTL, Viet TL, Phu VD, Dat VQ, et al. A systematic review and meta-analysis of ventilator-associated pneumonia in adults in Asia: an analysis of national income level on incidence and etiology. Clin Infect Dis. 2019; 68(3):511–518.
12. Papazian L, Bregeon F, Thirion X, Gregoire R, Saux P, Denis JP, et al. Effect of ventilator associated pneumonia on mortality and morbidity. Am J Respir Crit Care Med. 1996; 154(1):91–97.
13. Balkhy HH, El-Saed A, Maghraby R, Al-Dorzi HM, Khan R, Rishu AH, et al. Multi drug-resistant versus sensitive Acinetobacter baumannii ventilator associated pneumonia at a tertiary care centre: characteristics, microbiology and outcomes. Am J Respir Crit Care Med. 2012; 18:50–53.
14. Joseph N, Sistla S, Dutta T, Badhe A, Parija S. Ventilator associated pneumonia in a tertiary care hospital in India: incidence and risk factors. J Infect Dev Ctries. 2009;3(10):771–777.
15. Wałaszek M, Różańska A, Wałaszek MZ, Wójkowska-Mach J, The Polish Society of Hospital Infections Team. Epidemiology of ventilatorassociated pneumonia, microbiological diagnostics and the length of antimicrobial treatment in the Polish Intensive Care Units in the years 2013–2015. BMC Infect Dis. 2018;18:308.
16. Gadani H, Vyas A, Kar AK. A study of ventilator-associated pneumonia: Incidence, outcome, risk factors and measures to be taken for prevention. Indian J Anaesth 2010;54(6):535–540.
17. Winn W Jr, Allen S, Janda W, Koneman E, Procop G, Schreckenberger P, et al. Koneman's colour atlas and textbook of diagnostic microbiology. 6th ed. Lippincot; 2006.
18. Wu CL, Yang DI, Wang NY, Kuo HT, Chen PZ. Quantitative culture of endotracheal aspirates in the diagnosis of ventilator-associated pneumonia in patients with treatment failure. Chest. 2002;122(2):662– 668.
19. Ruiz M, Torres A, Ewig S, Marcos MA, Alcon A, Lledo R, et al. Noninvasive versus invasive microbial investigation in ventilator associated pneumonia: Evaluation of outcome. Am J Respir Crit Care Med. 2000;162:119-25.
20. Morehead RS, Pinto SJ. Ventilator-associated pneumonia. Arch Intern Med. 2000;160:1926-36.
21. Gadani H, Vyas A, Kar AK. A study of ventilatorassociated pneumonia: incidence, outcome, risk factors and measures to be taken for prevention. Indian J Anaesth. 2010;54(6):535-40.
22. Dey A, Bairy I. Incidence of multidrug-resistant organisms causing Ventilator associated pneumonia in a tertiary care hospital: A nine months' prospective study. Ann Thorac Med. 2007; 2:52–7.

23. Rajasekhar T, Anuradha K, Suhasini T, Lakshmi V. The role of quantitative cultures of non-bronchoscopic samples in ventilator associated pneumonia. Indian J Med Microbiol. 2006; 24:107-13.
24. Jakbrittu R.P, Boloor R. Characterisation of aerobic bacteria isolated from endotracheal aspirate in adult patients suspected ventilator associated pneumonia in a tertiary care center in Mangalore. Saudi J Anaesth. 2012; 6(2):115–19.
25. Sharma P.C, Raut S.S, More S.R, Rathod V.S, Gujar V.M. J of evolution of med and dental sci. 2012; 1(3):192-7.
26. Dey A, Bairy I. Incidence of multidrug-resistant organisms causing ventilator associated pneumonia in a tertiary care hospital: a nine months' prospective study. Ann Thorac Med 2007; 2(2):52–57.
27. Torres A, Carlet J. Ventilator-associated pneumonia. European Task Force on ventilator-associated pneumonia. Eur Respir. J 2001; 17(5):1034–1045.
28. O'Grady NP, Murray PR, Ames N. Preventing ventilator-associated pneumonia: does the evidence support the practice? JAMA. 2012;307(23):2534–2539.
29. Arabi Y, Al-Shirawi N, Memish Z, Anzueto A. Ventilator-associated pneumonia in adults in developing countries: a systematic review. Int J Infect Dis. 2008;12(5):505–512.
30. Chandrakanth C, Anushree, Vinod A. Incidence of ventilator associated pneumonia. Int J Med Clin Res. 2010;1(2):11–13.
31. Chawla R. Epidemiology, etiology and diagnosis of hospital acquired pneumonia and ventilator associated pneumonia in Asian countries. Am J Infect Control. 2008; 36(4 Suppl.):93–100.
32. Rahal JJ, Urban C, Segal-Maurer S. Nosocomial antibiotic resistance in multiple Gram negative species: experience at one hospital with squeezing the resistance balloon at multiple sites. Clin Infect Dis. 2002; 34(4):499–503.
33. Gottesman BS, Carmeli Y, Shitrit P, Chowers M. Impact of quinolone restriction on resistance patterns of Escherichia coli isolated from urine by culture in a community setting. Clin Infect Dis. 2009;49(6):869–875.
34. Rajasekhar T, Anuradha K, Suhasini T, Lakshmi V. The role of quantitative cultures of non bronchoscopic samples in ventilator associated pneumonia. IJMM. 2006; 24(2):107–113.
35. Goel V, Hogade SA, Karadesai SG. Ventilator associated pneumonia in a medical intensive care unit: microbiological aetiology, susceptibility patterns of isolated organisms and outcome. Indian J Anasth. 2012; 56(6):558–562.
36. Divatia JV, Pulinilkunnathil JG, Myatra SN. Nosocomial infections and ventilator-associated pneumonia in cancer patients. Oncol Crit Care. 2019; 1419–1439.
37. Balkhy HH, El-Saed A, Maghraby R, Al-Dorzi HM, Khan R, Rishu AH, et al. Drug-resistant ventilator associated pneumonia in a tertiary care hospital in Saudi Arabia. Ann Thorac Med. 2014; 9(2):104–111.
38. Sievert DM, Ricks P, Edwards JR, Schneider A, Patel J, Srinivasan A, et al. Antimicrobial resistant pathogens associated with healthcareassociated infections: summary of data reported to the National Healthcare Safety Network at the Centers for Disease Control and Prevention, 2009–2010. Infect Control Hosp Epidemiol 2013; 34(1):1– 14.
39. Mehta Y, Jaggi N, Rosenthal VD, Rodrigues C, Todi SK, Saini N, et al. Effectiveness of a multidimensional approach for prevention of ventilator-associated pneumonia in 21 adult intensive-care units from 10 cities in India: findings of the International Nosocomial Infection Control Consortium (INICC). Epidemiol Infect. 2013; 141(12):2483–2491.