VENTILATOR ASSOCIATED PNEUMONIA IN INTENSIVE CARE UNIT

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ABSTRACT

BACKGROUND

Knowledge of the incidence of ventilator-associated pneumonia (VAP) and its associated risk factors is imperative for the development and use of more effective preventive measures.

METHODOLOGY

We conducted a prospective cohort study over a period of 12 months to determine the incidence and the risk factors for development of VAP in critically ill adult patients admitted in intensive care units (ICUs) in Chalmeda Anand Rao Institute of Medical Sciences, Karimnagar, we included 150 patients, on mechanical ventilation for more than 48 hours. VAP was diagnosed according to the current diagnostic criteria.

RESULTS

The study cohort comprised of 150 patients of various cases of cerebrovascular accident, poisoning, neurological disorders, sepsis and others. VAP was diagnosed when a score of ≥6 was obtained in the clinical pulmonary infection scoring system having six variables and a maximum score of 12. The mean age of the patients was 40 years. Of the 150 patients, 28 patients developed VAP during the ICU stay. The incidence of VAP in our study was 18.8%. The risk factor in our study was decrease in the PaO_2/FiO_2 ratio, duration of mechanical ventilation, impaired consciousness, tracheostomy, re-intubation, emergency intubation, nasogastric tube, emergency intubation and intravenous sedatives were found to be the specific risk factors for early onset VAP, while tracheostomy and re-intubation were the independent predictors of late-onset VAP, The most predominant organisms in our study was Pseudomonas (39.2%).

CONCLUSIONS

Knowledge of these risk factors may be useful in implementing simple and effective preventive measures. Precaution during emergency intubation, minimizing the occurrence of reintubation, avoidance of tracheostomy as far as possible, and minimization of sedation. The ICU clinicians should be aware of the risk factors for VAP, which could prove useful in identifying patients at high risk for VAP, and modifying patient care to minimize the risk of VAP.

KEYWORDS

Intensive Care Unit, Risk Factors, Mechanical Ventilator, Ventilator-Associated Pneumonia.

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INTRODUCTION: Ventilator-associated pneumonia (VAP) is a nosocomial infection diagnosed in the intensive care units (ICUs). VAP is defined as pneumonia that occurs 48h or more after endotracheal intubation or tracheostomy, caused by infectious agents not present or incubating at the time mechanical ventilation was started. It can be of two types: (i) early-onset VAP which is defined as VAP that occurs within the first 4 days of ventilation, and (ii) late-onset VAP which is defined as VAP that occurs more than 4 days after initiation of mechanical ventilation.[1,2] Iatrogenic lung injury, including ventilator-associated pneumonia (VAP), is a risk influenced by severity of illness, immune function, physiological reserve and duration of invasive ventilation.[2,3]

VAP incidence is 9-27% and incidence increases with duration of mechanical ventilation.[4,5] It is most common nosocomial infection in invasive ventilation.[6,7] It ranges from 6 to 52% and can reach 76% in some specific settings.[8] Hospital acquired pneumonia (HAP) is the pneumonia after 48h or more after admission, which were not present at admission. The duration of hospital stay increases by 7-9 days per patient.[9,10] The risk of VAP is highest early in the course of hospital stay, and is estimated

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to be 3%/day during the first 5 days of ventilation, 2%/day during days 5–10 of ventilation and 1%/day after this.[11]

The clinical diagnosis based on biofilm of endotracheal tube, tracheal secretion culture, or pharyngeal secretion leakage around airway, chest X-ray changes suspected of VAP, ABG showing early decline in Pao_2/fio_2 ratio (mmHg), Fever and leucocytosis. Inspite of airway colonization and positive for pathogen in tracheal secretion without clinical findings were not suggestive of VAP.[12,13] The Clinical Pulmonary Infection Scoring (CPIS) system originally proposed by Pugin and others helps in diagnosing VAP with better sensitivity (72%) and specificity (80%). The aim of this study is to identify the risk factors, and to adopt specific protocols in intensive care unit to reduce the incidence, morbidity and mortality associated with VAP.

METHODS: The study was conducted after obtaining approval from the ethical committee of institution, written and informed consent were taken next to kin.

This prospective study was conducted over a period of 12 months, extending from August 2014 to July 2015, in an intensive care unit (ICU) of a tertiary care centre, Chalmeda Anand Rao Institute of Medical Sciences, Karimnagar. A total of 150 patients who were kept on mechanical ventilator were selected. Patients with pneumonia or positive culture from endotracheal secretions before mechanical ventilation were not included in study. Cases included were patients of age >15years, on mechanical ventilator for more than 48hours.

The data collected included the following: reason for admission; past medical history; vital signs, Age, sex, date of admission to ICU, indication of mechanical ventilation, duration of mechanical ventilation, duration of sedation, position of patient, date of initiating mechanical ventilation and mode of access to the patients' airway, i.e. orotracheal or tracheostomy, were recorded. The principal risk factor for the development of ventilator associated pneumonia is the presence of an endotracheal tube it causes an abnormal interruption between the upper airway and the trachea, bypassing the structures in the upper airway and providing bacteria a direct route into the lower airway.[14] All precautions were taken to avoid Hospital-acquired infections. Routine investigations was performed and special investigations, like culture of tracheal tube, ABG, daily chest roentgenogram, blood and urine and others like serum cholinesterase levels when needed, were performed. Sputum from the patients were collected from the tip of the suction catheter and transported to the laboratory in a sterile tube. The relevant data were recorded from medical records, bedside flow sheets, radiographic reports, and reports of microbiological studies of the patients. Patients were assessed from day of ICU stay to the final outcome. The patients fulfilling both the clinical and microbiological criteria were diagnosed to be suffering from VAP. VAP was diagnosed on clinical grounds based on the modified CPIS system [Table 1] originally developed by Pugin and others,[4] giving 0–2 points each for fever, leukocyte count, oxygenation status, quantity and purulence of tracheal secretions, type of radiographic abnormality and result of sputum culture and Gram stain. The VAP group was classified into two groups, early onset type (within 48–96 h) and late onset type (>96h). Once the clinical suspicion was established, empirical antibiotic therapy was initiated based on guidelines prescribed by the American Thoracic Society. Every 12 hourly arterial blood gas analysis were done and accordingly appropriate measures were taken.

CPIS Points	0	1	2
Tracheal Secretions	Rare	Abundant	Purulent
Leukocyte count (mm3)	>4,000 and <11,000	<4,000 and >11,000	<4,000 or >11,000+band forms
Temperature (0c)	>36.5 and <38.4	>38.5 and <38.9	>39 or <36
Pao2/fio2 ratio(mmHg)	>240 or ARDS	-	≤240 and no ARDS
Chest radiograph	No infiltrate	Diffuse infiltrate	Localized infiltrate
Culture of tracheal aspirate	Negative	-	Positive

Table 1: Clinical pulmonary infection scoring

CPIS: Clinical pulmonary infection scoring.

Statistical Analysis: The prospective cohort study was classified into two groups, early onset VAP and late onset VAP the data obtained were subjected to univariate analysis using chi-square test. The level of significance was set at $P<0.05$.

RESULTS: The study comprised of 150 patients of various cases, the mean age of the patients was 40 years, showing male predominance. Diagnosis of VAP was confirmed in 28 patients during course of treatment in ICU. The mean duration of mechanical ventilation was found to be 8 days for the non-VAP group and 14 days for the VAP group. It was analyzed in our study that those requiring prolonged ventilator support (>5 days) had a significantly higher incidence of VAP.[15] The PaO_2/FiO_2 ratio was analyzed in VAP patients and was found to be <240mmHg in 85% of the cases. In the remaining 15%, the ratio was higher (>240mmHg). Supine position and stuporous, comatose patients were found to be risk factors, having a high incidence of VAP, and proved to be statistically significant (P-value, 0.002 and 0.0026, respectively). Of the 28 patients who developed VAP, 8 patients developed early onset VAP and 20 patients developed the late onset VAP. The mortality associated with VAP was found to be 53%, compared to non VAP 46%. The mortality of the early onset type was found to be 25%. In case of the late onset type, it was found to be 65%. The most predominant organism isolated in our study was Pseudomonas (39.2%).

DISCUSSION: The endotracheal tube plays a role in the pathogenesis of VAP by elimination of natural defense mechanisms, thereby allowing the entry of bacteria by

aspiration of subglottic secretion or the formation of biofilm on the endotracheal tube. Ventilator cycling propels pathogen rich biofilm and secretions to the distal airways. The size of the biofilm and the virulence of the bacteria within it contribute to the risk of infection, but it is the host's immune response that determines whether parenchymal infection and ventilator associated pneumonia will develop.

Parameter	Non-VAP	VAP
Gender		
Male	93	21(23.6%)
Female	57	7(12.28%)
Primary Diagnosis		
CNS Disorder*	45	10
Poisoning	28	6
Respiratory Diseases	12	4
Cardiovascular Diseases	5	2
Chronic Renal Failure	4	2
Sepsis	4	2
Post op Laparotomy	6	1
Trauma	8	1
Others	38	0

Table: 2 Patient Details

VAP-Ventilator Associated Pneumonia,*CNS Disorder-Cerebrovascular accident, sub dural and extra dural haemorrhage, meningitis. Others- uncontrolled diabetes with nephropathy, severe anaemia, malignancy, malaria, ARDS.

Patients with neurological disorders in our study group were significantly predisposed for the development of VAP. These patients had impaired consciousness and inadequate cough reflexes which predisposed them for developing VAP. The incidence of VAP in our setting was 18%. The mean age of the patients was 40 years, showing male predominance. [Table 2] The incidence of VAP is 15 to 30%.[16,17] The average mean duration of mechanical ventilation for VAP patients was 14 days compared to 8 days for non VAP[table 3].[18] There is strong association between development of VAP and duration of mechanical ventilation.[19] where the incidence of VAP was 9.3% and with 10 days of mean duration of mechanical ventilation.

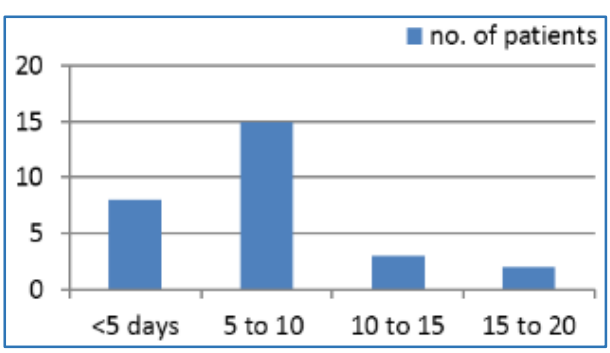

Table 3: Comparison of VAP (ventilator associated pneumonia) and duration of mechanical ventilation

By administrating proper weaning protocol the mean duration of mechanical ventilation can be effectively reduced. The duration of mechanical ventilation is strongly associated with the development of pneumonia. Therefore, strategies aimed at reducing the duration of tracheal intubation may reduce the incidence of pneumonia. Over sedation prolongs mechanical ventilation and should be avoided by careful assessment of sedation status and daily interruption of sedation if appropriate. Weaning protocols have also been shown to hasten discontinuation of mechanical ventilation.[20]

The time spend by patients on mechanical ventilator is more during weaning process[21] Spontaneous breath trial proved to be very effective as compared with the intermittent mandatory ventilation (IMV) because of the fact that IMV promotes respiratory fatigue.[22,23] Daily weaning trials and sedation holidays, When the decision is made to intubate a patient, a strategy to liberate the patient from mechanical ventilation must also be considered. Daily weaning trials and sedation holidays have been repeatedly described and validated as strategies that limit the time of mechanical ventilation.[24,25] As the risk of VAP is related to the duration of mechanical ventilation, limiting this duration makes physiologic sense though no randomized trials have shown a benefit with regards to reduction in VAP rates. A once daily trial of spontaneous breathing may be the most effective methods of weaning to recondition respiratory muscles that may have been weakened during mechanical ventilation.[26,27]

Reintubation may attribute to impaired airway reflexes after prolonged intubation and increasing the risk of aspiration contributing to increased incidence of VAP [28] and proved to be an independent risk factor in various studies.[29] In our study, the number of patients reintubated were only two in number, but one patient developed VAP. A recent case–control study also found reintubation to be a major risk factor as VAP occurred in 92% of the reintubated patients versus 12% of the control subjects.[30] As clinicians postulate weaning, they must be mindful of and balance the risks associated with re-intubation and the cumulative time of mechanical ventilation.

The presence of a nasogastric or an orogastric tube interrupts the gastro oesophageal sphincter, leading to increased gastrointestinal reflux and providing a route for bacteria to translocate to the oropharynx and colonize the upper airway. Enteral feedings increase both gastric pH and gastric volume, increasing the risk of both bacterial colonization and aspiration.[31] A significantly higher incidence of VAP in supine positioning as compared with the semi recumbent position [Table 4] because it may facilitate aspiration with simultaneous administration of enteral feeding, which may be decreased by a semi recumbent positioning matches to the outcome of the other studies when position is considered as a risk factor.[32-34] Radioactive labelled orogastric or nasogastric feeding tube proved that cumulative numbers of endotracheal counts were higher when patients were placed in the completely supine position (0°) as compared with a semi recumbent position (45°).[32,33]

	Total No. cases	VAP	%
Supine	45	13	28
Semi-Recumbent	105	15	14

Table: 4 VAP incidence in supine and semi-recumbent position

The incidence of VAP were significantly high in comatose patients.[35] May be due to the higher chances of aspiration in comatose patients. Previously it was thought that early tracheostomy might lead to better outcomes. However, a recently published meta-analysis of studies comparing early tracheostomy (performed within 7 days of intubation) and either prolonged endotracheal intubation followed by tracheostomy found that the timing of tracheostomy was not associated with a significant reduction in incidence of VAP.

For stress ulcer prophylaxis, Sucralfate is effective against VAP because it does not raise the gastric pH like H_2 receptor antagonists. Therefore, sucralfate is preferred over H_2 receptor antagonists. The PaO_2/FiO_2 ratio was observed and early drop of ratio at least 12-24 hours of ventilator support before the onset of the clinicoradiologic picture were suggestive of VAP. Thus, a decline in the PaO_2/FiO_2 ratio was found to be an early indicator of onset of VAP.

Organism	Total isolates	% of isolates	Early-onset VAP	Late-onset VAP	Survivors (%)	Non survivors (%)
Gram positive bacteria						
Staphylococcus aureus	2	7	-	2	1(50%)	1(50%)
MRSA	3	10.7	1	2	2(66%)	1(33%)
Enterococcus spp.	1	3	-	1	1(100%)	-
Gram negative bacteria						
Acinetobacter baumannii	1	3	-	1	1(100%)	-
Acinetobacter Lwoffini	1	3	-	1	1(100%)	-
Pseudomonas aeruginosa	11	39.2	4	7	3(27.2%)	8(72.7%)
Enterobacter spp.	1	3	-	1	1(100%)	-
Escherichia coli	1	3	-	1	1(100%)	-
Klebsiella pneumonia	7	25	3	4	2(28%)	4(57%)

Table 5: Causative organism in VAP-type of VAP, correlation of frequency, and associated mortality

The most common organism associated with VAP is Pseudomonas (39.2%), Klebsiella (25%), and MRSA (10.7%). [Table 5] Also, the overall mortality rate was high in the Pseudomonas group (72.7%) [Table 6]. Isolation of Pseudomonas ranges from 15 to 25%.[36,16] The infection acquired is directly correlated to the size of pathogens inoculum and the virulence of the microorganisms, and is inversely proportional to the immune competency of patient. High counts of resistant bacteria were found in the biofilm of endotracheal tube. Simultaneously, in critically ill patients, immunity response is usually compromised by systemic inflammation and underlying diseases. This three factors act together to increase the susceptibility of VAP in patients with mechanical ventilator support.

Early onset VAP in our study was found to be 28.57% while in other study it was 40%.[37] The empirical use of antibiotics not supported by results of clinical culture should be avoided to minimize development of multidrug resistant (MDR) pathogens,[38] Our study also demonstrated that early onset VAP had a good prognosis as compared with the late onset type in terms of mortality, which is also statistically significant (P=0.024) [Table 6]. Probably, the de-escalation strategy[39] fully endorsed by the American Thoracic Society, which means initiation of a broad-spectrum antibiotic and changing to a narrow spectrum after the sensitivity results are made available, will reduce inappropriate antibiotic use and subsequently, the drug resistant pathogens. Invasive bronchoscopic sample collection and quantitative sample culture reduces inappropriate antibiotic use.[40]

Outcome	Early Onset VAP (n=8)	Late Onset VAP(n=20)	Total VAP
Expired	2	13	15
Survived	6	7	13
Total	8	20	28

Table 6: Outcome of patients of ventilator associated pneumonia

The rate of mortality was less in early-onset VAP group as compared to late-onset VAP, A similar high mortality rate associated with VAP was observed in other similar studies[9,41-43] the mortality rate in VAP (53.57%) was high compared to non-VAP (44.52%) group.

Hand washing is an important but underused measure to prevent nosocomial infections.[44] According to the 2004 CDC (Center for Disease Control) guidelines, hands should be washed before and after patient contact and also in between patient contact. Chlorhexidine has been shown to be effective in the control of ventilator circuit colonization and pneumonia caused by antibiotic resistant bacteria.[45] Oropharyngeal decontamination with Chlorhexidine solution has also been shown to reduce the occurrence of VAP in patients undergoing cardiac surgery.[46] The three main ways of preventing pneumonia are to reduce colonization of the aero digestive tract with pathogenic bacteria, prevent aspiration, and limit the duration of mechanical ventilation. Best results are achieved by using various combinations (bundles that include measures such as head of bed elevation, oral cleansing with chlorhexidine, sedation holidays, weaning protocols, and care provider

education) of interventions in all mechanically ventilated patients. Recent guidance from the National Institute for Health and Clinical Excellence recommends that all bundles include oral antisepsis and nursing in the semi recumbent position.[47]

CONCLUSION: VAP is associated with significant morbidity and mortality in critically ill patients, the predominant organism isolated in our study was Pseudomonas. Multidisciplinary approach of prevention is the other important aspects of limitation like limiting the duration of mechanical ventilation, administrating proper weaning protocol, optimizing the need for intravenous sedation, semi-recumbent position and antibiotic spectrum after sensitivity results. The ICU clinicians should be aware of the risk factors for VAP, which could prove useful in identifying patients at high risk for VAP, and modifying patient care to minimize the risk of VAP.

REFERENCES:

1. Morehead RS, Pinto SJ. Ventilator-associated pneumonia. Arch Intern Med 2000;160:1926-36.
2. Di Pasquale M, Ferrer M, Esperatti M, et al. Assessment of severity of ICU-acquired pneumonia and association with etiology. Crit Care Med 2014;42:303 12. doi:10.1097/CCM.0b013e3182a272a2. [PubMed]
3. Rea-Neto A, Youssef NC, Tuche F, et al. Diagnosis of ventilator-associated pneumonia: a systematic review of the literature. Crit Care 2008;112:R56. doi:10.1186/cc6877. [PMC free article] [PubMed]
4. Davis KA. Ventilator-associated pneumonia: a review. J Intensive Care Med. 2006;21:211–26. [PubMed]
5. Chastre J, Fagon JY. State of the art: ventilator-associated pneumonia. Am J RespirCrit Care Med. 2002;165:867–903. doi: 10.1164/ajrccm.165.7.2105078. [PubMed] [Cross Ref]
6. Hunter JD. Ventilator associated pneumonia. BMJ. 2012;344:e3325. doi: 10.1136/bmj.e3325. [PubMed] [Cross Ref]
7. Afshari A, Pagani L, Harbarth S. Year in review 2011: Critical care - infection. Crit Care. 2012;16:242–247. doi: 10.1186/cc11421. [Cross Ref]
8. Koenig SM, Truwit JD. Ventilator-associated pneumonia: diagnosis, treatment, and prevention. ClinMicrobiol Rev. 2006;19:637–57. [PMC free article] [PubMed]
9. Chastre J, Fagon JY. Ventilator-associated pneumonia. Am J RespirCrit Care Med. 2002;165:867–903. [PubMed]
10. Rello J, Ollendorf DA, Oster G, et al. Epidemiology and outcomes of ventilator - associated pneumonia in a large US database. Chest. 2002;122:2121. [PubMed]
11. Cook DJ, Walter SD, Cook RJ, et al. Incidence of and risk factors for ventilator associated pneumonia in critically ill patients. Ann Intern Med. 1998;129:440. [PubMed]
12. Niederman MS. Gram negative colonization of the respiratory tract: pathogenesis and clinical consequences. SeminRespir Infect. 1990;5:173–84. [PubMed]
13. Diaz E, Rodriguez AH, Rello J. Ventilator-associated pneumonia: issues related to the artificial airway. Respir Care. 2005;50:900–6. [PubMed]
14. Kunis KA, Puntillo KA. Ventilator-associated pneumonia in the ICU: its pathophysiology, risk factors, and prevention. Am JNurs. 2003;133(8):64AA-64GG. rect route into the lower airway.
15. Apostolopoulou E, Bakakos P, Katostaras T, et al. Incidence and risk factors for ventilator-associated pneumonia in 4 multidisciplinaryintensive care units in Athens, Greece. Respir Care. 2003;48:681–8. [PubMed]
16. Kollef MH. Ventilator-associated pneumonia: A multivariate analysis. JAMA. 1993;270:1965-70. [PubMed]
17. Fagon JY, Chastre J, Vuagnat A, et al. Nosocomial pneumonia and mortality among patients in intensive care units. JAMA. 1996;275:866–9. [PubMed]
18. HinaGadani, Arun Vyas, Akhya Kumar Kar. Indian J Anaesth. Nov-Dec 2010;54(6):535–540. doi: 10.4103/0019-5049.7264
19. Cook DJ, Reeve BK, Guyatt GH, et al. Stress ulcer prophylaxis in critically ill patients. Resolving, discordant meta-analyses. JAMA. 1996;275:308–14. [PubMed]
20. Rello J, Sa-Borges M, Correa H, et al. Variations in etiology of ventilator associated pneumonia across four treatment sites: Implications for antimicrobial prescribing practices. Am J RespirCrit Care Med. 1999;160:608–13. [PubMed]
21. Ely EW, Meade MO, Haponik EF, et al. Mechanical ventilator weaning protocols driven by nonphysicianhealth-care professionals: evidence-based clinical practice guidelines. Chest 2001;120:454S-63S.
22. Esteban A, Alía I, Ibañez J, et al. Modes of mechanical ventilation and weaning: a national survey of spanish hospitals: The Spanish Lung Failure Collaborative group. Chest. 1994;106:1188–93. [PubMed]
23. Marini JJ, Smith TC, Lamb VJ. External work output and force generation during synchronized intermittent mandatory ventilation: effect of machine assistance on breathing effort. Am Rev Respir Dis. 1988;138:1169–79. [PubMed]
24. Imsand C, Feihl F, Perret C, et al. Regulation of inspiratory neuromuscular output during synchronized intermittent mechanical ventilation. Anesthesiology. 1994;80:13–22. [PubMed]
25. Brook AD, Ahrens TS, Schaiff R, et al. Effect of a nursing-implemented sedation protocol on the duration of mechanical ventilation. Crit Care Med 1999;27:2609-15.

26. Ely EW, Meade MO, Haponik EF, et al. Mechanical ventilator weaning protocols driven bynonphysician health-care professionals: Evidence-based clinical practice guidelines. Chest 2001;120:454S-63S.
27. Faulkner JA. Structural and functional adaptations of skeletal muscle. In: Roussos C, Macklem PT, editors. The thorax. Part B. of Lung biology in health and disease. New York: Marcel Dekker; 1985;Vol(29):pp1329-51.
28. Rochester DF. Does respiratory muscle rest relieve fatigue or incipient fatigue? Am Rev Respir Dis. 1988;138:516–7. [PubMed]
29. Torres A, Gatell JM, Aznar E, et al. Re-intubation increases the risk of nosocomial pneumoniain patients needing mechanical ventilation. Am J RespirCrit Care Med. 1995;152:137–41. [PubMed]
30. Kollef MH, Von Harz B, Prentice D, et al. Patient transport from intensive care increases the risk of developing ventilator associated pneumonia. Chest. 1997;112:765–73. [PubMed]
31. Leal-Noval SR, Marquez-Vacaro JA, Garcia-Curiel A, et al. Nosocomial pneumonia in patients undergoing heart surgery. Crit Care Med. 2000;28:935–40. [PubMed]
32. Ferrer R, Artigas A. Clinical review: Nonantibiotic strategies for preventing ventilator associated pneumonia. Crit Care. 2001;6(1):45-51.
33. Torres A, Serra-Batlles J, Ros E, et al. Pulmonary aspiration of gastric contents in patients receiving mechanical ventilation: the effect of body position. Ann Intern Med. 1992;116:540–3. [PubMed]
34. Orozco-Levi M, Torres A, Ferrer M, et al. Semirecumbent position protects from pulmonary aspiration but not completely from gastroesophageal reflux in mechanically ventilated patients. Am J RespirCrit Care Med. 1995;152:1387–90. [PubMed]
35. Davis K, Jr, Johannigman JA, Campbell RS, et al. The acute effects of body position strategies andrespiratory therapy in paralyzed patients with acute lung injury. Crit Care. 2001;5:81–7. [PMC free article] [PubMed]
36. Chastre J, Fagon JY. Ventilator associated pneumonia. Am J RespirCrit Care Med. 2002;165:872. [PubMed]
37. Kollef MH. What is ventilator-associated pneumonia and why is it important? Respir Care. 2005;50:714-21. [PubMed]
38. Park DR. The microbiology of ventilator-associated pneumonia. Respir Care. 2005;50:742–63. [PubMed]
39. Guidelines for the management of adults with hospitalacquired, ventilator-associated, and healthcare-associated pneumonia. Am J RespirCrit Care Med. 2005;171:388–416. [PubMed]
40. Fagon JY, Chastre J, Wolff M, et al. Invasive and noninvasive strategies for management of suspectedventilator-associated pneumonia: a randomized trial. Ann Intern Med. 2000;132:621–30. [PubMed]
41. Torres A, Puig de la Bellacasa J, Xaubet A, et al. Diagnostic value of quantitative cultures of bronchoalveolar lavage and telescoping plugged catheters in mechanically ventilated patients with bacterial pneumonia. Am Rev Respir Dis 1989;140:306-10.
42. Fagon JY, Chastre J, Domart Y, et al. Nosocomial pneumonia in patients receiving continuous mechanical ventilation: Prospective analysis of 52 episodes with use of protected specimen brush and quantitative culture techniques. Am Rev Respir Dis 1989;139:884.
43. Panwar R, Vidya SN, Alka KD. Incidence, clinical outcome and risk stratification of ventilator-associated pneumonia: A prospective cohort study. Indian J Crit Care Med 2005;9:211-6.
44. Doebbeling BN, Stanley GL, Sheetz CT, et al. Comparative efficacy of alternative hand-washing agents in reducing nosocomial infections in intensive care units. N Engl J Med. 1992;327:88–93. [PubMed]
45. Rumbak MJ, Cancio MR. Significant reduction in methicillin-resistant Staphylococcus aureusventilator associated pneumonia associated with the institution of a prevention protocol. Crit Care Med 1995;23:1200-3.
46. DeRiso AJ 2nd, Ladowski JS, Dillon TA, et al. Chlorhexidinegluconate 0.12% oral rinse reduces the incidence of total nosocomial respiratory infection and nonprophylactic systemic antibiotic use in patients undergoing heart surgery. Chest 1996;109:1556-61.
47. National Institute for Health and Clinical Excellence. Technical patient safety solutions for ventilator-associated pneumonia in adults. PSG002.2008. www.nice.org.uk/guidance/index.jsp?action=byId&o=12053.