PREVALENCE OF VENTILATOR ASSOCIATED PNEUMONIA IN INTENSIVE CARE UNIT OF HOSPITAL UNIVERSITY SAINS MALAYSIA

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Introduction: Ventilator Associated Pneumonia (VAP) is the most common complication of patient who are receiving mechanical ventilation. VAP is associated with increase morbidity and mortality.

Objectives: The aim of this study was to identify the prevalence of VAP in ICU and secondly to ascertain the risk factors associated with VAP.

Patients and Methods: This was an observational study conducted in ICU HUSM. Patient admitted into ICU and who were ventilated was reviewed for VAP and the risk factor associated with VAP. Total duration was from January 2010 to December 2009.

Results: A total of 194 patients fulfilled the criteria and was followed up till discharge. It was found that the VAP rate per 1000 ventilator days were

higher than global VAP rates (19.57 days). Significant risk factors associated with VAP was, duration of ventilation (OR 1.073), DM (OR 2.182), transfer out of ICU (OR 1.402) and continuous sedation (OR 2.978). Primary pathogen involved in VAP in HUSM ICU was *Acinobacter sp.*

Conclusion: The prevalence rate of VAP in HUSM was significantly higher than global VAP rates. The significant risk factors were duration of ventilation, Diabetes Melittus, transfer out of ICU and continuous sedation.

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TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OFABBREVIATIONS

ARDS	Acute Respiratory Distress Syndrome
CDC	Centre for Disease Control and Prevention
CI	Confidence Level
COAD	Chronic Obstructive Airway Disease
DM	Diabetes Mellitus
HUSM	Hospital University Sains Malaysia
ICU	Intensive Care Unit
NG	Nasogastric
OR	Odds ratio
VAP	Ventilator Associated Pneumonia

ABSTRAK

Kelaziman Jangkitan Paru-paru akibat ventilasi dalam Unit Rawatan Rapi Hospital University Sains Malaysia.

Pengenalan VAP merupakan satu komplikasi yang biasa berlaku kepada pesakit yang menerima ventilasi mekanikal. Kajian ini bertujuan untuk mencari kadar, akibat dan risiko VAP dalam HUSM.

Metodologi Ini merupakan satu kajian pemerhatian yang dikendalikan dalam ICU HUSM. Pesakit diperhatikan untuk faktor risiko, tempoh penginapan dan akibat VAP. Kajian dijalankan dari Januari hingga Disember 2009.

Keputusan Sejumlah 194 orang pesakit yang bersesuaian kriteria telah diikuti sehingga genap lepas dari ICU. Umur purata pesakit ICU ialah 47.53 tahun dan purata lamanya tinggal di ICU adalah 10.94 hari. Ia telah didapati yang kadar VAP setiap 1000 hari ventilasi adalah lebih tinggi daripada kadar-kadar VAP global(19.57 hari). DM meningkatkan risiko untuk menjangkit VAP dengan OR 2.182. Tambahan pula, factor pemindahan daripada ICU (OR 1.402) dan ubat penenang berterusan (OR 2.978) penting secara statistik ($p<0.05$) sebagai punca untuk VAP. *Acinobacter* sp. merupakan patogen utama dalam sample BAL pesakit VAP.

Kesimpulan Kadar VAP dalam HUSM telah didapati lebih tinggi daripada kadar-kadar global. VAP meningkatkan tempoh penginapan dan dikaitkan dengan DM, pemindahan daripada ICU dan ubat penenang berterusan. Patogen utama dalam VAP HUSM adalah *Acinobacter* sp.

ABSTRACT

Prevalence of Ventilator Associated Pneumonia in Intensive Care Unit Hospital University Sains Malaysia.

Introduction VAP is a common complication of patient who are receiving mechanical ventilation. This study aims to provide background prevalence, consequences and risk factors of VAP in HUSM.

Methodology This was an observational study conducted in ICU HUSM. Patients were reviewed for background and interventional risk factors, length of stay and outcome. The study was conducted from January until December 2009.

Result A total of 194 patient fulfilled inclusion criteria and was followed up until discharge from ICU. Mean age of ICU patient was 47.53 years and mean duration of stay was 10.94 days. It was found that the VAP rate per 1000 ventilator days were higher than global VAP rates (19.57 days). DM poses additional risk for developing VAP with OR 2.182. Additionally intervention risk factor, transfering out of ICU (OR 1.402) and continuous sedation (OR 2.978) were statistically significant ($p<0.05$) for VAP development. *Acinobacter* sp. was found to be dominant pathogen from BAL of VAP patient.

Conclusion VAP rates in HUSM was found to be significantly higher than global rates. VAP lead to increase length of stay and is associated with DM, transfer out of ICU and continuous sedation. The main pathogen involved in HUSM VAP was *Acinobacter* sp.

Keywords Ventilator Associated Pneumonia, Prevalence, Risk Factor, BAL

4.0 Discussion

Intensive Unit Care is the epitome of acute critical care. Most physicians would agree that the best level of care in a hospital should and is available in the intensive care unit. The critical problem is ICU has limited resources in terms of physical infrastructure such as beds and ventilator, and as well with man power. VAP is associated with ICU increase morbidity and mortality. Thus eliminating or at least reducing VAP is vital in optimizing ICU resources.

This study was conducted to determine the level of VAP in Hospital University Sains Malaysia. The aim was to identify possible links and causes of VAP. It stands to serve either to protect current ICU management or identify potential loop holes.

4.1 Demongraphic Data

Demographic data of the patients shows a deposition for male patient (60%) compared to female (40%). Similar demographic proportion of gender has been described in both local and international ICUs.

The mean age of the patients were 47.53 years with mode age group of 60-69 years. This proportion of patients is similar with patient population in general hospitals of Malaysia, but differs from those of international ICU which have a higher mean age 62.30 years.

Demographical, the data statistically suggest that HUSM ICU patient does not differ from that of local hospital but differ from those of foreign hospital in terms of population age. This agreement allowed the assumption prevalence rate of VAP between HUSM and local hospital would not be due to age and sex. Assumption between HUSM and foreign hospital must take into account age and sex as potential risk factors.

4.2. VAP prevalence

The prevalence rate in HUSM was found to be 20% and VAP rate per 1000 ventilator days stood at 19.57. This rates when compared to local hospital VAP rates were significantly similar, NAAICU reported VAP rate per 1000 ventilator days at 15.4. When compared to foreign hospital (9.4%), HUSM VAP rates were significantly higher.

VAP rates from a review in 2006 stood at 26.3% (Gopal Katherason et al, 2006). Despite a reduction of 30% from 26.3% to 20% over the duration of 2 years, this reduction could have been more drastic.

Targeted reduction policy on VAP rates in ICU has been shown to be able to reduce VAP rates by 50% and in some centers able to achieve 0% VAP (Winkley et al 2010). Targeted reduction or goal directed intervention comprise of dedicated regimental implementation of VAP bundle, regular professional reminder and education, daily VAP monitoring and goal re-evaluation. Currently

HUSM does not have a targeted reduction policy. VAP bundles are not strictly implemented, professional education does not always translate to practice, and VAP monitoring is done periodically. Partial VAP bundle implantation may have contributed to the rate of 20% compared to VAP rate prior to VAP bundle practice 60%.

VAP patient in HUSM also has an increase in ICU stay, mean duration of 21.2 days compared to non-VAP patient with 13.7 days. This increase length of stay of 8 days is echoed in other VAP studies.

The length of hospital stay was not followed up in this study. Although it can be assumed that the length of hospital stay also could increase. Further follow up in this patient population can be done to identify if there was statistically significant increase length of stay.

The expected cost of care can be calculated during the ICU stay

Patient X increase duration X cost expected per day VAP= expected cost

38 X 8.3 X RM15000-RM40000 = RM 2,166,000 to RM 12,616,000

This additional cost of care for VAP patient increased the cost of HUSM ICU by RM2mil- RM12mil. This cost includes cost of treatment, equipment and manpower.

In terms of bed and ventilator, 256 days of ventilator days were lost. Approximately a ventilator day was lost per every day of the year, which means another patient could have benefited from ICU admission and support.

Outcome of patient with VAP was a mortality rate of 36.8% and non-VAP patient 31.4%. Significant testing showed odds ratio 0.785 and p-value 0.525, which means VAP did not increase the mortality rate of patient in HUSM ICU. In contrast VAP classically has been attributed with increased mortality rate of over 20%. Recent studies done in the United States of America showed contrast result in terms of mortality. Studies done in a community hospital showed a significant increase 45.7% p= 0.004 (Emad H. Ibrahim et al, 2001) but a large database showed no increase, mortality 30.5% p=0.713 (Jordi Rello et al, 2002).

Several explanations can attribute to this. First HUSM ICU does not enforce stringent ICU admission criteria. Thus patient admitted could possible initially have a high morbidity and mortality. This would lead to mortality dilution of the results causing the result of no difference in mortality rate. Future investigation can resolve this issue by risk stratification of patient using APACHE III or SAP II and readjusting the mortality rate.

Another issue is the usage of antibiotics. If the general ICU pathogen strain and sensivity involved in VAP is known, and targeted antibiotic sensivity

treatment is initiated early, the mortality of VAP could have been reduced. Current antibiotic regime in sepsis management in HUSM is cause-targeted initially followed by de-escalation. Treatment of suspected VAP is currently is from either carbapenem, beta lactamase group or polymyxin depending on the onset of VAP. As pathogen involved in VAP in HUSM is primary *Acinobacter* sp. susceptible to polymyxin, current practice might had lead to reduce mortality.

Despite the lack of evidence between VAP and mortality, prevention of VAP should still take precedence. Other issue proven statistically as increase ICU stay provide significant reason to act more aggressively. The economical and clinical importance cannot be underestimated as prevention is possible. Aggressive VAP bundle implementation with future prevalence screening would show if VAP rate is reduce. Price-tagging treatment management might also increase awareness of cost effective prevention rather than cost effective treatment. This would help the finance department to assist in prevention rather than withholding high cost treatment especially antibiotics during times of budget constraint.

4.3 Risk Factors

Risk factors were analysed within three components, demographic risk, background risk and intervention risk factors. Initial Odd Ratio were analysed using simple logistic regression and significant risk factors were reanalysed using multiple logistic regression to attained Adjusted Odd Ratio due to interaction between risk factors.

4.3.1. Demographic Risk Factor

Factors which were analysed were age of the patient, sex of the patient and the duration of ICU stay. Age and sex showed no significant risk towards VAP. On the other hand, duration of ventilation showed an increase risk for VAP (OR 1.072). This in term signify a 7% risk of developing VAP per day of ventilation.

Studies such as Emad et al (2001) and Kollef (1993) produced similar results in non significant Odd Ratio for sex and age towards VAP. Result from Jordi Rello et al (2002) in the other hand showed significant risk associated with male population and elderly patient. Multiple other studies also showed similar contrast in result and general consensus is age and sex may pose increase risk when other risk factors are present.

Duration of ventilation has been repeatedly shown as a risk factor for VAP. Donald E Craven (2006) showed a risk ratio of 3% per day. Marin H. Kollef (1993) showed an Odds ratio of 3.65 ($p<0.001$) when patient was ventilated more than 5 days.

In other words duration of ventilation is a significant risk for developing VAP individually. Logically, attempts to reduce the need of ventilation will result in the reduction of VAP. Balance between early extubation and risk of failed

weaning or extubation have been evaluated (MacIntyre et al, 2001). A weaning protocol helps in the decision of weaning and reduces risk of reintubation. Weaning protocols consist of weaning index and step down weaning procedure. Weaning protocols are not fool-proof, but are especially useful in streamlining process of extubation. Presence of a weaning protocol, also ensure junior medical staff are aware of the need of weaning early and alert them of red flags of possible failure. The benefit of weaning protocol has been proven to reduce ventilator duration with no increase risk of complication. Implementation of weaning protocol thus would reduce ventilation duration and subsequently reduce risk of patient developing VAP.

4.3.2 Background Risk Factors

In this study of background risks several setbacks were met. Two risk factors could not be statistically analysed due to complete one sided data. The two data were burn and immunocompromised patients. No burn patients fit the inclusion criteria during the period of the study. This was partial due to the fact that burn patient were initially ventilated in separate burn unit unless occupancy was full in the burn unit. A small number of patients were found to be immunocompromised during the study.

Simple logistic regression revealed Diabetis Mellitus (DM) as a significant risk factor. DM had a risk factor of 200% or doubled the odds ratio for developing VAP compared to a non-DM patient. Multilogistic study continued to

show that DM remained a risk for VAP. Result from several other studies also supported this relation between VAP and DM.

Diabetes mellitus is attributed to several reduction in host defence mechanisms. DM is known to reduce mucociliary motility, increase risk of reflux, increase gastric sphincter weakness, reduce gastric motility, decrease white blood cell activity, poor wound healing and reduce local microperfusion. DM thus not only increased risk of colonization but also reduces the host response towards infection.

Compared to the other background factors, DM risk towards VAP may be due to this combined activity of increase colonization and reduce defence mechanism. Other risk factors either caused reduce host defence or increase risk of colonization. Taken this into account, diabetic patients have a high susceptibility to develop VAP in ICU ventilation setting. Patient with diabetes which are ventilated should have a lower threshold to be diagnosed and treated as VAP.

4.3.3 Intervention Risk Factors

Intervention risk factors were documented as patient care progressed. Statistic analysis of the 7 risk factor initially showed only 1 significant risk factor. Subsequent multilogistic regression adjustment showed 2 significant risk factors.

Transfer out of ICU either for diagnostic or therapeutic intervention was statistically significant with Odd ratio of 1.403 or 40% increase risk. Transferring of patient is technically and physically stressful for the patient and health care provider. It requires movement of patient which could cause dislodgement of organism into the ETT in terms of aspiration and also biofilm separation. Vigorous ambubagging may cause barotraumas, ETT migration and induction of organism into the airway. Another cause would be breathing circuit left exposed in the ICU during the absence of the patient. This is a potential source of entrance for bacteria as the circuit end is no longer attached to the patient. Subsequently the bacteria will be transferred to the patient when ventilation resumes. Whereas in circuit change, which showed no significant risk for VAP, as the circuit is replace with new tubing which are sterile.

Continuous sedation was also found to be statistically significant with p= 0.034, OR 2.978. This is congruent with other study. The cause of this increase risk is due to the relation between sedation and prolonged ventilation. In the presence of continuous sedation, the duration of ventilation is increased to 140 hours compared with intermittent sedation of 70 hours. Marin H. Kollef et al (1993) showed an increase of 70 hours and John P. Kress et al (2002) showed 58 hours. This significant increase in ventilation days correlates with the increase risk of VAP and duration of ventilation.

Currently the management in HUSM ICU has embarked on sedation holiday rather than the traditional continuous sedation. Sedation holiday aims to withhold sedation for a time period everyday to a level acceptable for the patient condition. Sedation holiday is important as prolonged effect of sedation which include lethargy, muscle weakness, loss of cohesiveness and disorientation all lead to slower extubation. Protocol driven sedation holiday have been shown to be effective and does not increase risk of unplanned extubation. Current management should continue with sedation holiday as the benefits are statistically significant. Improvement such as a protocol for sedation and sedation holiday should be implemented to reap this benefit.

Other factors such as circuit change and prior antibiotics were not statistically significantly. Literature on both these factor are divided, with some being a risk reduction while others being risk additive. Further evaluations on these factors are not forthcoming as practice of circuit change has evolved from change when soiled rather than routine time based change. Data for additional risk where traditionally based on time based change. Circuit change when soiled has been proven to be safe and does not lead to contamination of circuit by new organism for infection. In this study no routine circuit change was done, and only soiled circuit were replace. As there is no significant statistic, this practice cannot be validated.

Antibiotic usage has been implicated in increase risk of VAP by inducing more high risk bacteria. This however account for late onset VAP, proper

antibiotic usage should reduce early onset VAP. As the practice of prior antibiotic is primary the discretion of referring department to ICU, advisory on usage cannot be controlled. Divided result on benefit and risk due to VAP also lead to poor support against this practice. Additionally withholding antibiotic solely to prevent VAP is not advisable as risk of mortality from delayed antibiotic administration for sepsis is significant 10% every hour of delay.

Nasogastric(NG) tube insertion has been associated with VAP in several studies. NG tube is suspected to cause sinus infection which is a possible source of VAP. Also the NG in several studies have been shown to increase risk of aspiration. On the other hand NG tube have benefits such as the ability to decompressed the stomach, early feeding, and increase gut motility, which are protective against VAP. Thus in this study, both risk and protective effect of NG tube negated each other. Current practice in HUSM ICU is for early insertion of NG tube followed by feeding. Since this does not statistically increase risk of VAP the practice should proceed for other benefits of early feeding.

Usage of paralytic agents was found not significant as a risk factor, but OR showed a protection against VAP. Although p value was > 0.005 it was less than 0.01, thus may still be significant clinically. This is incongruent with other findings which suggest paralytic agents as risk for VAP. Specific for this study 80% of the patient that were on paralysis agent were found to be under plastic reconstructive surgery patient that were paralysed to preserved free flap post

operatively. Paralysis was continued for 24-48 hours and taper off after that duration. This short duration of paralysis probably did not increase risk of VAP. In fact most patient from this subset did not develop VAP. The possible explanation for this observed protective factor, maybe due to the intensive hourly monitoring post operatively to ensure flap viability and not due to paralysis agent per se. This close care and management probably translated to better care and strict adhere to hand washing protocol. Most of this patient from this subset was primary ASA 1-2 preoperative. This suggested a healthier group of a patient compared to general admission which composed of sepsis or trauma patient.

4.4 BAL sampling

A total of 38 VAP patients were identified during the study, of which 25 BAL sample was obtained. This was a 65.7% of the VAP patients. Pathogen yield from the BAL showed a predominance of *Acinobacter sp. Acinobacter sp.* has been implicated as a late onset VAP causative organism. Research by Donald E. Kraven et al reviewed the pathogen involved with VAP which is divided into early onset VAP which were likely community acquired and responsive to treatment, and late onset VAP which organism were hospital acquired with resistant pattern and subsequently harder to treat. This late onset VAP were labelled as high risk infection due to the increase mortality and morbidity.

The result of 70% of total BAL sample showed *Acinobacter sp.* which were multiresistant. Multiresistant *Acinobacter* sp. are most likely *Acinobacter Baumannii.* This primary organism has been implicated clinically in HUSM ICU as cause of several outbreak.

When compared to other local data, this pattern is different as the local ministry of health VAP organism was basically *Klebseilla sp.* This difference is crucial as early targeted antibiotics should cover *Acinobacter*, rather than *Klebseilla*. Transferred health care practitioner to HUSM ICU must be made aware of this, so that proper antibiotic will be initiated during suspected VAP cases.

BAL sampling does not increase specificity nor sensivity during the diagnosis of VAP, but is important during targeted treatment. BAL sample provided actually organism involved in VAP and helps in de-escalation of antibiotics. Thus from this study, management of HUSM ICU should cover late onset VAP suspected patient with an anti-Acinobacter antibiotic such as Polymyxin and Sulperazone. This is in line with current practice, and therefore should be continued. The possible benefit for further investigation is the correlation between BAL sampling and trachea aspirate sampling to provide early organism diagnosis. This would then reserved BAL sampling for second pathogen isolation when early antibiotic targeted trachea aspirate fail to show signs of improvement.

5.0 Limitation

Several limitations were present in this stud

1. Criteria of VAP were solely on CDC NNIS criteria which were acceptable but not a Gold standard criteria.

2. Clinical diagnosis was done by solely by the researcher and may be bias.

3. Patients were not risk stratified during admission for correlation of mortality and morbidity.

4. Two background risk factors failed to provide adequate sample for statistic calculation.

5. BAL sample was limited towards stable VAP patient.

6.0 Recommendation

A few recommendations for future management of VAP:

1. Survey of VAP should be made a key index performance benchmark.

2. VAP bundle protocol should be implemented stringently.

3. Diabetic patient should have a low index for VAP.

4. Sedation protocol should be implemented strictly.

5. Weaning patient from mechanical ventilation as soon as possible.

6. Transport facilities and care during transportation should be emphasized.

7. Current practice of nasogastric tube for feeding should be continued.

8. Current practice of circuit change when soiled should be continued.

9. Current practice of antibiotic coverage of *Acinobacter* should be continued.

7.0 Summary and Conclusion

This study was able to fulfil the objective set forth at the start. We were able to answer the question outlined by the study.

The study was able to determine the VAP prevalence of ICU HUSM was 19.57 per 1000 ventilator days. This was significantly higher than global current VAP rates but was similar with local prevalence.

Risk Factor attributed to VAP was identified, duration of ventilation (OR 1.073), Diabettes Melittus (OR 2.182), transfer out of ICU (OR 1.402) and continuous sedation (OR 2.978).

Primary pathogen involved in VAP in HUSM ICU was *Acinobacter sp.*

1.0 INTRODUCTION AND LITERATURE REVIEW

1.1 Ventilator Associated Pneumonia (VAP)

"*Inflammation of the lung parenchyma due to infection causes which is not present or incubating at the time of initiation of mechanical ventilator support and develops >48 hours after the initiation of the support"* VAP as defined by ATS/IDSA.

Ventilator Associated Pneumonia (VAP) is one of the most common infection to occur in Intensive Care Unit (ICU) (Nasia Safdar et al, 2005). Up to 27% of patient in ICU are documented to acquire VAP. Prevalence rate of VAP in United States of America range from 9.3% to 15.0 %, Europe 8.0% to 28.0 %, and Asia 2.0 to 40.0%. Malaysia VAP rate range from 5.7% to 51.7% have been documented. This represents a common picture of VAP occurrence globally. Traditionally VAP rates were documented as percentage of VAP per ventilated patients. Recently it has been proposed that VAP rates to be documented as VAP per 1000 ventilated days. This change was supposedly due to better accurate presentation of VAP. Currently VAP rates are still being reported in both methods and remain in transitional period.

VAP is also the highest mortality associated infection with rates up 90% mortality in some centers. This mortality rate has somewhat reduce to 50% in recent times due to better understanding and awareness of ventilator bundle for ventilated patient. VAP increases the length of ICU and hospital stay from 4 to

14 days. The length of ventilated days are purposely increased by 8 days. This increase length of stay and also associated additional care to ventilated patient is estimated to increase the cost of health care by RM 15 000 to RM 60 000 per patient (Steven M. Koenig et al, 2006). More than cost, VAP depletes the limited resources within an ICU especially beds and ventilators. This is especially important in Malaysia where ICU beds are scarce and outside ICU critical care is severely limited. Shortage of ICU beds has been a national concern, requiring proactive management from the Ministry of Health by close documentation of ICU availability and pooling of regional ICU beds for better efficiency. The ministry does acknowledge the importance of VAP and has been closely monitoring VAP rates within all ministry hospitals.

VAP although commonly coined by most doctors, remains a challenge in prevention, diagnosis and treatment of the disease. Multiple guidelines have been drawn up by several major healthcare groups such as Centre for Disease Control and Prevention (CDC) which includes VAP bundle care for prevention. Malaysia's Ministry of Health, National Committee on National Audit on Adult ICU (NAICU) initiated since 2003 has strategically and persistently included VAP as part of the audit. NAICU both advise and gather audits from local ICU and produce a yearly report and recommendation. NAICU also advice and outline VAP bundle for local hospitals. Currently, the VAP bundle is neither encompassing nor enforced as it is an advisory.

To date the diagnosis of VAP remain a challenge mainly because there is no gold standard for the diagnosis of VAP. As of such, several criteria for diagnosis of VAP have emerged over the years. To diagnosis of VAP, several approaches have been suggested. Among those advocated are:-

a) Clinical Judgement
b) Pathology analysis
c) Biomarkers

VAP was initially a diagnosis of clinical judgment, pioneered by *Johanson et al* in 1972. He combined both radiology findings and clinical features to support his diagnosis of VAP.

Johanson Criteria

a) Presence of a new or progressive radiographic infiltrate.
b) Plus at least two or three clinical features:
    - Fever >38°C
    - Leukocytosis or leucopenia
    - Purulent secretions

This criteria for VAP, although established in 1972, became the reference for future VAP diagnosis. Later criteria continued the pattern combining both radiograph and clinical judgment in the diagnosis of VAP. Two other criteria are currently in use, *Clinical Pulmonary Infection Score* (CPIS) and

Centre for Disease Control and Prevention *National Nosocomial Infection Surveillance (NNIS)*.

Clinical Pulmonary Infection Score (CPIS)

- Temperature

  0 point : 35.5-38.4°C

  1 point : 38.5-38.9°C

  2 point : <36 or >39°C

- Blood leukocyctes (cells/µL)

  0 point : 4000-11000

  1 point : <4000 or >11000

  2 point : >500 band forms

- Oxygenation (PaO_2/FiO_2)

  0 point : PaO_2/FiO_2 > 240 or ARDS

  2 point : PaO_2/FiO_2 < 240 and no evidence of ARDS

- Pulmonary radiography

  0 point : no infiltrate

  1 point : diffuse or patchy infiltrates

  2 point : localized infiltrare

- Tracheal secretions (score)

  0 point : <14

  1 point : >14

  2 point : purulent sputum

- Culture of tracheal aspirate

0 point : minimal or no growth

1 point : moderate or more growth

2 point: moderate or greater growth

NNIS criteria

- Radiology

  Two or more serial chest radiograph with at least 1 change:-

  - New or progressive and persistent infiltrate
  - Consolidation
  - Cavitation

- Clnical

  At least 1 of the following

  - Fever (>38°C) with no other recognized cause
  - Leukopenia (<4000WBC/mm^3) or leukocytosis ≥12,000 WBC/mm^3)
  - For adults ≥70 years old, altered mental status with no other recognized cause

  At least 2 of the following

  - New onset of purulent sputum, or change in character of sputum, or increased respiratory secretions, or increased suctioning requirements
  - New onset or worsening cough or dyspnea or tachypnea
  - Rales or bronchial breath sounds

- Worsening gas exchange (e.g. O_2 desaturations [eg $PaO_2/FiO_2 \leq 240$], increased oxygen requirements or increased ventilation demand)

This three criteria scoring for VAP each has been reviewed and tested for both sensivity and specificity. Sensivity is important as it provides the pickup rate of the disease, and specificity provides the true positive. Achieving both high rates for sensivity and specificity have been difficult, often one or the other have been traded for improvement of the latter. Plus criteria set have to be easily reproduced and generally commonly investigated.

Table 1.1: Sensivity and specificity of VAP diagnosis criteria (Alvaro et al 2008).

	Sensivity (%)	Specificity (%)
Johanson	69	75
CPIS (varies)	72	85
CDC NNIS	84	69

Johanson criteria has the lowest pickup rate, thus potentially risking 31% patient being undetected and untreated. Both sensivitiy and specificity for CPIS is not consistent in literature review This is due to different cut off point of CPIS as VAP, certain researches using 5, others 6, leading to sensivity of 30 to 83% and specificity of 17% to 80%. CDC NNIS criteria remain consistent with the

most patient in the studies, with a pickup rate of 84% but less specific at only 69%. This leaves less patient being under diagnose but at risk for increase over treatment. Although CDC NNIS criteria has not become a global benchmark reference for VAP, most researches adopt CDC NNIS criteria in VAP diagnosis. CDC NNIS thus is fast becoming a platform for comparison and exchange of information on VAP despite fallibility of a lower specifity.

Other approaches to VAP diagnosis which is pathology analysis relies on quantitative cultures obtained from different methods. Methods employed include specimens from trachea aspirate and specimens from bronchoscopy using both blind and direct visual sampling. Compared to clinical diagnosis, pathology analysis does not increase the accuracy of diagnosis. The advantage provided by pathology analysis is the presence of positive growth and identification of the causative organism. This then provides the target for specific antibiotics.

Biomarkers as tools of diagnosis in VAP are still in their infancies. Certain biomarkers already found to be of limited use are endotoxin concentration and elastin fibers. While others, are promising but yet to be fully research such as C-reactive protein, procalcitonin and soluble triggering receptor expressed on myeloid cells (sTREM)-1.