Paediatric Intensive Care Unit

Prevention of Ventilator Associated Pneumonia

Staff relevant to:	Medical and Nursing staff caring for children in the PICU
Approval date:	January 2024
Version:	3
Revision due:	January 2027
Written by: Revised by:	Simon Robinson, Claire Westrope Pompa Dutta Kukreja
Trust Ref:	C43/2016

Related Guidelines and Policies:	
B54/2023	Nasogastric and Orogastric Tube Insertion in Neonates Infants Children and Young People UHL Childrens Hospital Policy
C90/2016	Feeding UHL Childrens Intensive Care Guideline

Contents

1. Introduction and who this guideline applies:

The aim of this guideline is to prevent the development of ventilator associated pneumonia (VAP) in neonates and children admitted to CICU and CPICU at University Hospitals of Leicester NHS Trust.
VAP is estimated to occur in 10-20% of mechanically ventilated patients. VAP increases the duration of mechanical ventilation, length of stay, mortality, and hospital costs.
Age less than 1 year, altered immune status, unplanned emergency intubations and reintubations, acute respiratory distress syndrome, continuous enteral feeding and use of discontinuous sedation have been associated with an increased risk of developing VAP.

1.1 Definition:

There is no gold standard definition of VAP. Traditionally, as per CDC, VAP is defined as pneumonia occurring more than 48 hours after invasive mechanical ventilation.
In 2013, CDC replaced surveillance definitions from VAP towards a broader concept of preventable conditions (both infectious and non-infectious) associated with mechanical ventilation known as Ventilator associated events (VAE) in adults.

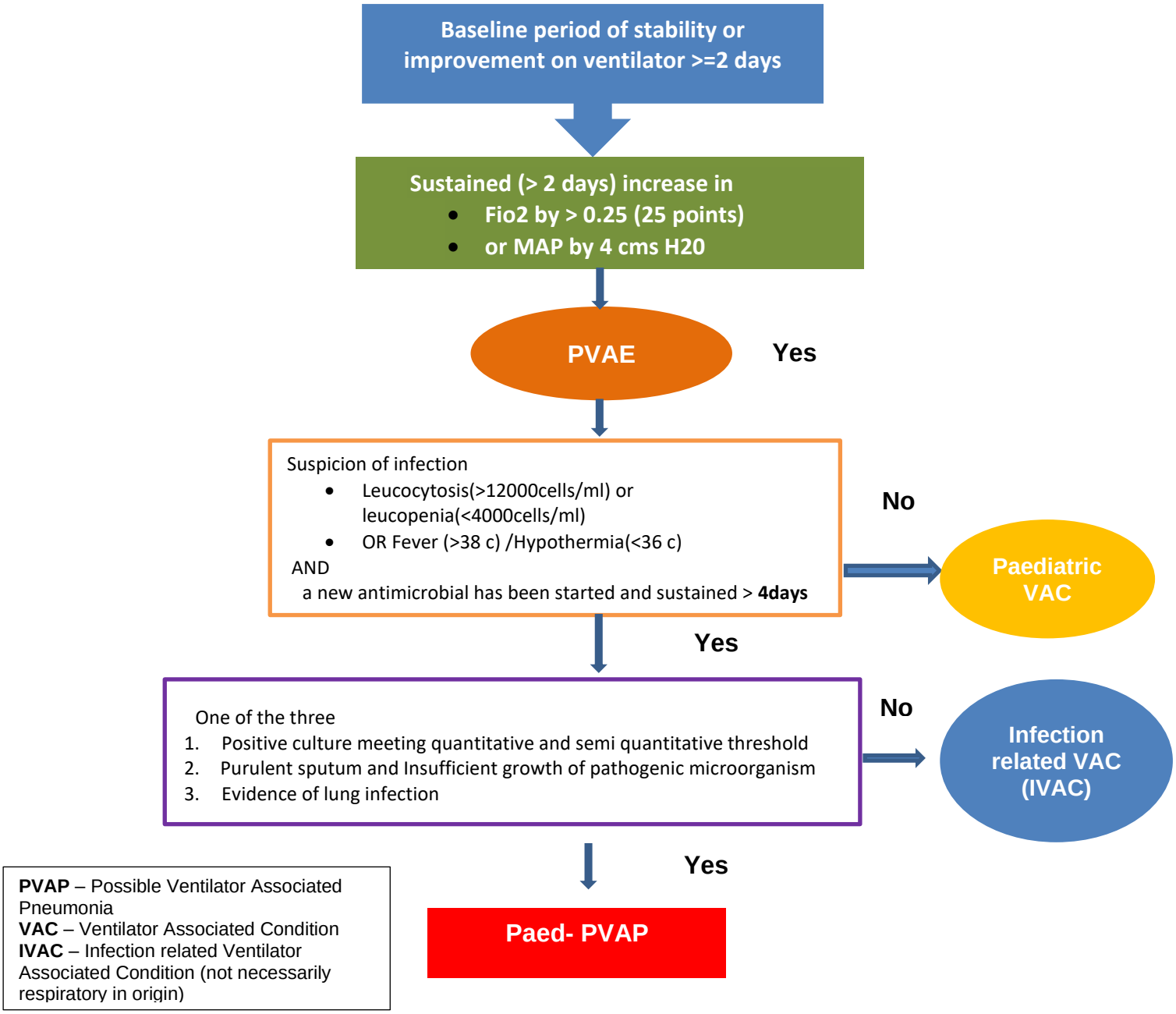
Common causes of VAE include pneumonia, fluid overload, atelectasis, ARDS etc.

Subsequent paediatric VAE (PVAE) definition criteria adopted by CDC in 2017 emerged from consensus and expert opinions. In this new definition, emphasis was placed on respiratory worsening after a period of stability or improvement on ventilator. This is specified by hypoxemia and objectified by two ventilator settings - namely Fio2 and MAP (in children). **Subjective items (such as CXR changes) were removed from this definition**.

One criticism of this model is that it may not be sensitive to clinically diagnosed ventilator associated infections and may only pick up the most severe cases. Therefore application of CDC-PVAE definitions may miss mild but clinically impactful events.

Though the new CDC definition hasn't been universally adopted in the UK, as a unit we have agreed to adopt the paed-PVAP criteria as stipulated in 2017 CDC definition.

2. Paediatric VAE criteria



- Patient must be mechanically ventilated for at least 4 calendar days to fulfil Ped VAE, and lowest MAP and lowest fio2 (maintained for >1 hr) on calendar day are used for VAE surveillance.
- The Date of event is the first day of >= 2day period on which either of the worsening thresholds of MAP or fio2 is met (NOT the date when all PEDVAE criteria have been met)
- MAP values: lowest value of MAP during a calendar day. In patients <30 days old , MAP of 0-8cm H20= 8 cm H20 , > 30 days old MAP 0-10= 10 cm H20
- Ped VAE are defined by a 14 day period and new Ped VAE cannot be identified or reported until this 14 day period has elapsed.
- Break in Mechanical Ventilation for at least one calendar day followed by reinitiation defines a new episode of MV

2.1 Microbiology

Common VAP pathogens include aerobic gram-negative bacilli (e.g., Escherichia coli, Klebsiella pneumoniae, Enterobacter spp., Pseudomonas aeruginosa, Acinetobacter spp.), gram-positive cocci (e.g., Staphylococcus aureus, including methicillin-resistant S. aureus [MRSA], Streptococcus spp.) and fungus (e.g., Candidiasis, Aspergillosis). The presence of Candida isolated from respiratory specimens is usually regarded as colonization. The diagnosis of Candida pneumonia is difficult due to the nonspecific clinical and radiological features and the lack of specific biomarkers which necessitates the histopathological demonstration of the organism for confirmation of diagnosis

Table 1: Criteria used to meet PVAP definition	
1.Significant growth of respiratory pathogens in culture	a. Endotracheal aspirate 10^5CFU/ml
	B BAL 10 4CFU/ml
	C Protected brush specimen 103 CFU/ml
	D Lung tissue 104 CFU/g
2.Insufficient growth of pathogenic microorganism plus purulent sputum	Purulent respiratory secretions >25 neutrophils and <10 sq epithelial cells per low power field
3 Evidence of Lung infection	A Pathogenic microorganism in Pleural fluid culture
	B. Positive lung histopathology:
	Abscess formation
	Consolidation foci with PMN accumulation
	Evidence of parenchymal invasion by fungi or virus
	C Positive Test for Legionella
	D Positive test for selected virus in respiratory samples [b]

2.2 Organisms that are excluded:

1. Normal respiratory flora, normal oral flora or mixed respiratory/Oral flora, isolation of commensal flora of the oral cavity or upper respiratory tract
2. The following organisms, unless identified from lung tissue or pleural fluid (where specimen was obtained during thoracentesis or within 24 hours of chest tube placement)
    - Any Candida species as well as a report of “yeast” that is not otherwise specified
    - Any coagulase-negative Staphylococcus species
    - Any Enterococcus species
3. Organisms rarely or not known to cause HAI - Blastomyces, Histoplasma, Coccidioides, Paracoccidioides, Cryptococcus, and Pneumocystis.

2.3 Summary of risk factors and preventive measures:

Prevention is based on modifying the known risk factors. In adults, VAP is believed to be caused by aspiration of oropharyngeal secretions, inhalation of contaminated aerosols, or bacterial translocation from a contaminated gastrointestinal tract. It is not known whether these same mechanisms operate in mechanically ventilated infants and children. Because the epidemiology of VAP in infants and children is not as well understood as it is in adults, many currently recommended prevention measures extrapolated from adult guidelines are based on biological plausibility and common sense.

Table 2: Risk factors & preventative measures

Risk factors	• Duration of mechanical ventilation • Medication (e.g., proton pump inhibitors, histamine 2-receptor blockers) • Enteral feeding • Re-intubation • Aspiration of secretions • Use of contaminated equipment • Presence of genetic syndrome or neurological/cardiovascular disease
Preventive measures	• Hand hygiene and Oral hygiene (as per unit policy) • Suction of respiratory secretions as per unit policy • Maintenance of endotracheal cuff pressure of at least 20 cm H2O • Semi-recumbent position • Changing of the ventilator circuit when visibly soiled • Draining ventilator condensate away • Minimizing ventilator days

2.4 Recommended prevention measures in PICU:

Hand hygiene:

Hand hygiene is an important element of preventing health-care associated infections and spread of multi-resistant pathogens. Meticulous hand hygiene must be practised.

Oral hygiene:

In the critical care setting, poor oral hygiene has been associated with increased dental plaque accumulation, bacterial colonization of the oropharynx, and higher nosocomial infection rates, particularly ventilator-associated pneumonia.[i]

Comprehensive mouth care should be used as appropriate to the age of the patient such as chlorhexidine mouth wash to decontaminate the oral cavity and foams or toothbrushes (in older children) to remove plaque and debris.

Reducing the duration of ventilation:
Early extubation should be prioritised. Clinical practice should include a daily assessment of readiness for extubation using SBT trial. Sedation breaks pose a high risk for accidental extubation, with the process of re-intubation potentially increasing the risk of developing VAP; daily sedation holidays are no longer recommended. Heavy sedation and decreased respiratory drive precludes ventilator weaning. Use of a validated sedation scoring (COMFORT B in our PICU) is recommended to avoid under or over sedation.

Positioning:
It is recommended to elevate to the head end of the bed to 30-45 for infants and children and 15-30 for neonates [ii]. Supine position is believed to contribute to micro-aspiration of both gastrointestinal contents and oral secretions

Preventing micro-aspiration of contaminated secretions:
Micro-aspirations of oral secretions is one of the biggest risk factors for VAP. Cuffed Endotracheal tubes could be beneficial in prevention considering the superior tracheal seal and its role in lowering the number of micro-aspirations. According to Kneyber et al. the endotracheal high-volume low-pressure cuffed tubes with cuff pressure monitoring could be safely used in all children.[iii] Cuff pressure should be maintained <= 20 cms H20.The risk of VAP becomes greater with reintubation .A possible explanation is aspiration of gastric contents in the interval between extubation and reintubation

Prevent contamination of equipment:
All Aspects of ETT tube care, including intubation should include good habits and practice that minimises risk of contamination (Wash Hands, Wear Apron and Gloves, Single use laryngoscope blades, protect ETT tube if problems inserting etc.

The use of aseptic techniques while performing endotracheal suction is of great importance to prevent contamination of the respiratory tract.

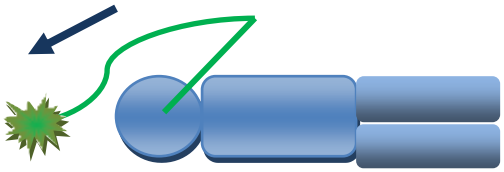
Where multi-use suction devices are used, they should be placed in a clean non-sealed plastic bag when not in use. A closed suction system is preferred because of some specific complications that result from using open system suctioning procedures, such as environmental contamination, cross infections or hypoxia. Despite this obvious disadvantage of open suction systems, no difference in VAP incidence was found utilizing either closed or open suction system.

Changing ventilator circuits and in-line suction catheters on a routine schedule is not currently recommended - instead, they should be changed when visibly soiled. However, research regarding the effectiveness of these practices in paediatric and neonatal populations is lacking.

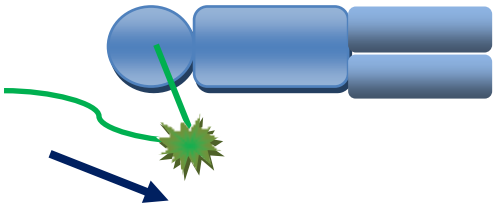
Care of the ventilator includes clearing the circuit of condensate and preventing condensate from draining into the patient's airway and washing the biofilm into the

patient's lungs – see Figure 2 below. Clearing the tubing and checking tube positioning should take place on a routine basis (e.g. every 2 hours) and before a patient is repositioned or moved for transport. This should occur without disconnecting the circuit. Heated ventilator circuits are preferred in infants and children

***Figure 2.*Positioning of Endotracheal tube and Ventilator Tubing**
- To minimise water from vent circuit entering the patient



ETT Vertical with tubing below
Minimal 'condensate' will drain into patient



ETT Connector below patient entry point
'Condensate' will drain to the connector with the ventilator tubing

Enteral feeding:
Enteral feeding can lead to regurgitation and is considered an important risk factor for VAP. Proper placement of a nasal or oral gastric tube is therefore of utmost importance as it decreases the chance of stomach contents being aspirated. By both noting what length the NG tube is inserted and regular aspiration , the risk of misplacement can be minimised and feed tolerance can be assessed [iv]Recent studies have shown that measurement of gastric residuals correlates poorly with aspiration risk and is associated with a decrease in calorie delivery.
The rate of VAP is not higher in patients who did not undergo monitoring of gastric residuals. Based on that, routine check of gastric residual volumes in asymptomatic patients receiving tube feeding is not recommended.[v]

Stress-Ulcer Prophylaxis:
Peptic ulcer prophylactics (H2 blockers and proton pump inhibitors—PPI) raise the gastric pH and can lead to increased gastric colonization with pathogenic bacteria and therefore a higher risk of acquiring VAP. Some studies have shown increased incidence of VAP with the use of acid-suppression medication, while others don't indicate any difference in the incidence of VAP, macroscopic stress ulcer bleeding and mortality whether patients treated with acid suppression medications or not .
According to the insufficient data about stress ulcer prophylaxis and VAP in the group of paediatric patients, other studies with larger numbers of patients are needed

- Omeprazole is used as SUP for critically ill children to prevent GI bleeding Omeprazole should be considered with prolonged or high doses of glucocorticoids (Dexamethasone…) or aspirin

- Omeprazole should be stopped once feeding has been established – agreement in our unit is > half of full feeds.

2.5 Surveillance:

Surveillance is standardised with the rate calculated per 1000 ventilator days. All suspected cases of pVAP should be reviewed and strictly determined in agreement with the defined criteria to ensure consistency of the data and monitoring- pVAP Rate per 1000 ventilator days.

3. Education and Training

Training and raising awareness are on-going processes. On-going awareness is promoted through the induction and continuous bedside teaching. Training is provided for medical staff during lunchtime teaching (Wednesdays) and other sessions, and at junior doctors' induction training. Nursing education is supported by the Practice Development teams, and nursing educators.

4. Monitoring Compliance

Emphasis should be put mainly on early VAP prevention, possibly by implementing "prevention bundles", together with optimal staff compliance, quick diagnostics and early treatment.

What will be measured to monitor compliance	How will compliance be monitored	Monitoring Lead	Frequency	Reporting arrangements
PVAP rates /1000 ventilator days VAP bundle compliance	Audit		Monthly	

5. Supporting References

1. https://www.cdc.gov/nhsn/pdfs/pscmanual/pedvae-current-508.pdf

2. Cocoros NM, Priebe G, Gray JE, et al. Factors associated with pediatric ventilator-associated conditions in six U.S. hospitals: a Nested Case-Control Study. Pediatr Crit Care Med. 2017;18:e536–e545.

3. Y. Pen˜a-Lo´pez, M. Campins-Martı´, M. Slo¨cker-Barrio et al. Ventilator-associated events in children: A multicentre prospective cohort study Anaesth Crit Care Pain Med 41 (2022) 101072

4. Munro CL, Grap MJ. Oral health and care in the intensive care unit: State of the science. Am J Crit Care. 2004; 13(1): 25-33

5. De Neef, Marjorie, ; Bakker, Leo M; et al . Effectiveness of a Ventilator Care Bundle to Prevent Ventilatorssociated Pneumonia at the PICU: A Systematic Review and Meta-Analysis. Pediatric Critical Care Medicine: 2019; (20): 474-480

6. Kneyber, M.C.J.; de Luca, Det al. Recommendations for Mechanical Ventilation of Critically Ill Children from the Paediatric Mechanical Ventilation Consensus Conference (PEMVECC). Intensive Care Med. 2017, 43, 1764–1780.

7. Metheny NA. Preventing respiratory complications of tube feedings:evidence-based practice. Am J Crit Care. 2006; **15**(4): 360-9.

8. Elke G, Felbinger TW, Heyland DK. Gastric residual volume in critically ill patients: a dead marker or still alive. Nutr Clin Pract 2015, 30 (1) 59 - 71.

6. Key Words

Mechanical ventilation, Ventilator associated events (VAE)

The Trust recognises the diversity of the local community it serves. Our aim therefore is to provide a safe environment free from discrimination and treat all individuals fairly with dignity and appropriately according to their needs.
As part of its development, this policy and its impact on equality have been reviewed and no detriment was identified.

CONTACT AND REVIEW DETAILS			
Guideline Lead (Name and Title) Pompa Dutta Kukreja - Consultant			**Executive Lead** Chief Medical Officer
Details of Changes made during review:			
Date	**Issue Number**	**Reviewed By**	**Description Of Changes (If Any)**
2016	**1**		
October 2019	**2**	**P Dutta**	
January 2024	**3**	Pompa Dutta Kukreja PICU Clinical practice meeting UHL Children's Quality & Safety Board	1)Definition updated 2)Use of MAP and Fio2 criteria 3) Diagnostic flow chart