



Prevention of Ventilator-Associated Pneumonia (VAP)

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Ventilator-Associated Pneumonia

Pneumonia that develops in a patient who has been mechanically ventilated for more than 48 hours



Risk factors

- Pathogenesis of VAP → prevention strategies
- Risk for VAP determined by
 - duration of exposure to the health care environment
 - presence of host factors
 - presence of treatment-related factors

(Clini Chest Med 1999, NEJM 1999, Crit Care Med 2002, JAMA 1998)



Pathogenesis

- Colonisation of the aerodigestive tract with pathogenic bacteria
- Aspiration of contaminated secretions/fluids (eg ventilator tubing condensate) into the lower airway

Pathogenesis of VAP

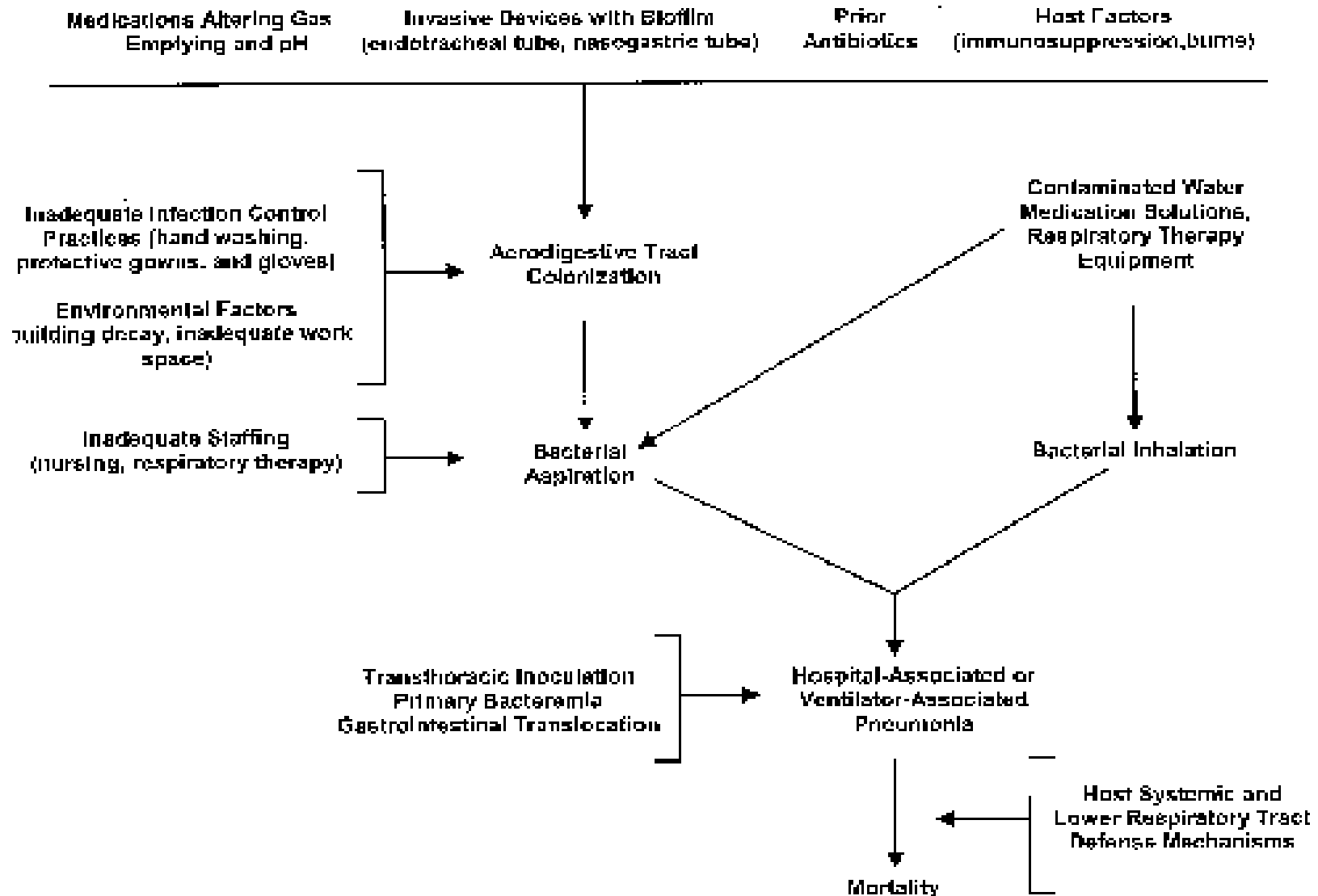


Figure 1. Pathogenesis of bacterial hospital-associated and ventilator-associated pneumonia.



Risk factors

- Modifiable
- Non-modifiable



Non-modifiable risk factors

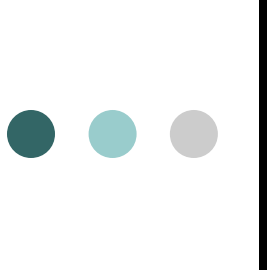
Co-morbidities

- Age- > 60 years
- Gender-male
Rello Chest 2002
- Surgery and type
Post surgical pt high risk
Albumin levels, ASAII, longer surgery, thoracic and upper abdomen,
Post op compared medical ICU: RR 2.2
Cardiothoracic surgery *Kollef Chest 1995*
- Trauma
Chastre AMJRCCM 2002, Rello Chest 2002
Cook Ann Intern Med 1998 Trauma pt face ≈ 5X greater risk of developing VAP
Head injury *Cook An Intern Med 1998*
- Reintubation
Increased risk of aspiration
47% cp 4%
92% reintubated pt cp 12% control gp *Leal-Noval CCM 2000*



Modifiable strategies

- Non-pharmacologic
 - more easily applied
 - less expensive
 - target the prevention of aspiration
- Pharmacologic
 - target the prevention of colonisation of aerodigestive tract with pathogenic bacteria



Interventions aimed at the prevention colonisation of the aerodigestive tract

- Chlorhexidine mouth rinse
- Oral hygiene and decontamination
- Hand hygiene
- Limit use of **peptic ulcer disease prophylaxis** to high risk patients
- Decolonisation of the aerodigestive tract
- Antibiotics
 - avoid unnecessary use
 - prophylactic antibiotics for high risk groups (eg trauma, severe head injury, coma, high risk surgical procedures)
- Avoid unnecessary blood transfusion
- Good glycaemic control



Interventions aimed at the prevention of aspiration

- Avoid tracheal intubation-non-invasive mask ventilation
- Shorten duration of mechanical ventilation
- Subglottic suctioning
- Avoid nasotracheal intubation
- Avoid unnecessary manipulation/changes of the ventilator circuit
- Drain ventilator circuit condensate
- Elevation of head of bed
- Avoid gastric distension
- Avoid unnecessary use of sedation/sedation vacation
- Biofilm prevention
- Discontinue nasogastric tube as soon as possible

Relationship between pathogenesis and preventive strategies for VAP

Prevention strategies

- . Avoid unnecessary antibiotic admin]
- . Avoid unnecessary SUP]
- . Oral intubation]
- . Chlorhexidine oral rinse]
- . Selective digestive decontamination]
- . Hand disinfection]

- . Avoid tracheal intubation]
- . Shorten duration of MV]
- . Avoid gastric overdistension]
- . Subglottic suctioning]
- . Avoid ventilator circuit changes/manipulation]
- . Drain ventilator circuit condensate]
- . Avoid patient transport]
- . Prevent accidental extubation]

Pathogenesis of VAP

Bacterial colonisation
(oropharynx, stomach,
sinuses)



Aspiration of contaminated
secretions/ventilator circuit
condensate/aerosol



VAP



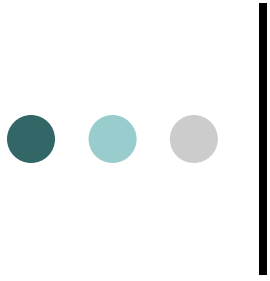


Evidence-based CPG for the prevention of VAP

Peter Dodek et al (Canadian Critical Care Trials Group)

Ann Intern Med 2004;141:305-313

- Level 1 :Concealed randomisation, blinded outcome adjudication, intention to treat analysis
- Level 2 :One of above not fulfilled
- Level 3 :Not randomised



Hand hygiene



Hand hygiene

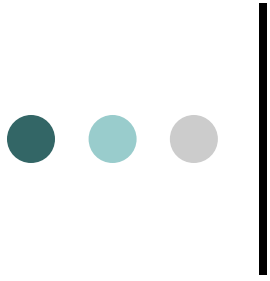
- Most important and widely recognised measure in the prevention of all nosocomial infections
- Compliance among healthcare providers unacceptably low
 - Mean compliance rate 5-81% (average 40% compliance)
 - Barriers: insufficient education, lack of facilities, attitude, heavy workload
- Before and after patient contact
- After handling patient's equipment
- Nurses need to remind themselves/staff



Hand hygiene

- 4% chlorhexidine with isopropyl alcohol
- Handrubbing with alcohol-based, waterless hand antiseptic at bedside
- Recommendation: Wash hands





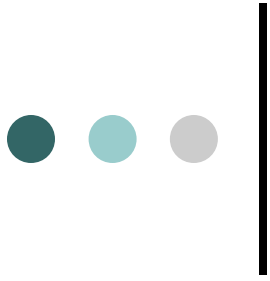
Route of Endotracheal intubation



Route of Endotracheal intubation

- 1 level 2 trial (*Holzapfel CCM 1993*), orotracheal intubation is associated with a lower incidence of VAP compared with nasotracheal intubation
- 5 level 2 trials (*Holzapfel, Salord, Michelson, Bach, Rouby*) - orotracheal intubation associated with decreased incidence of sinusitis and that incidence of VAP lower in patients who do not develop sinusitis
- Nasal obstruction by ETT or feeding tube prevents clearance of secretions from sinuses → sinusitis. Aspiration of infected secretions → VAP
- Recommend: Orotracheal route of intubation should be used when intubation is necessary

Dodek et al Evidence-based CPG for the prevention of VAP Ann Intern Med 2004;141:305-313



Frequency of ventilator circuit changes

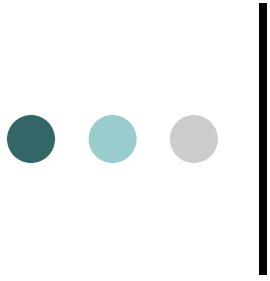


Frequency of ventilator circuit changes

- 1 Level 2 (*Kollef Ann Intern Med 1995*)
- 2 level 3 (*Dreyfuss Am Rev Respir Dis 1991, Long Infect Control Hosp Epidemiol 1996*)
- Frequency of ventilator circuit changes does not influence incidence of VAP.
- Less frequent changes of circuits not associated with harm
- More frequent changes associated with increased cost

Recommend: New circuits for each patient. Change when soiled. No scheduled ventilator circuit changes

Dodek et al Evidence-based CPG for the prevention of VAP Ann Intern Med 2004;141:305-313



Scheduled drainage ventilator circuit condensate

Scheduled drainage ventilator circuit condensate

- Contaminated condensate within circuit → Colonised by bacteria → Aspiration → VAP
- Scheduled/routine monitoring of circuits and removal of tubing condensate with proper disposal
- Reduced by the use of HME
- Scheduled drainage of condensate is recommended





Airway humidification

Heat and moisture exchanger (HME)

versus

Heated humidifier



Airway humidification HME versus Heated humidifier

- 7 level 2 trials (*Martin Chest 1990, Roustan ICM 1992, Kollef Chest 1998, Kirton Chest 1997, Boots CCM 1997, Dreyfuss AJRCCM 1995, Memish Am J Infect Control 2001*)
- HME may be associated with slightly decreased incidence of VAP
- Benefit of HME
 - less condensate formation
 - ? Bacterial filtration properties



Airway humidification HME versus Heated humidifier

- Infrequent change of HME (depends on type of HME)
- Drawback:
 - More tenacious secretions, requiring more frequent change
 - ETTs can be occluded due to the tenacity of secretions
 - On-line nebuliser/MDI

Recommend: Use HME in patients with no contraindication

Dodek et al Evidence-based CPG for the prevention of VAP Ann Intern Med 2004;141:305-313



Endotracheal Suctioning System

Open multi-use versus Closed single-use





Endotracheal Suctioning System Open versus Closed

- 2 level 2 trials (*Deppe CCM 1990, Combes ICM 2000*)
- 2 level 3 trials (*Johnson CCM 1994, Zeitoun Rev Lat Am Enfermaem 2001*)
- No effect on incidence of VAP
- 1 level 2 trial (*Kollef AJRCCM 1997*) - scheduled daily changes and unscheduled change no effect on incidence of VAP
- Benefit of closed method
 - less environmental cross contamination
 - may be more cost effective
- **Recommend: Use closed suction systems and change when clinically indicated or recommended by manufacturer**

Dodek et al Evidence-based CPG for the prevention of VAP Ann Intern Med 2004;141:305-313



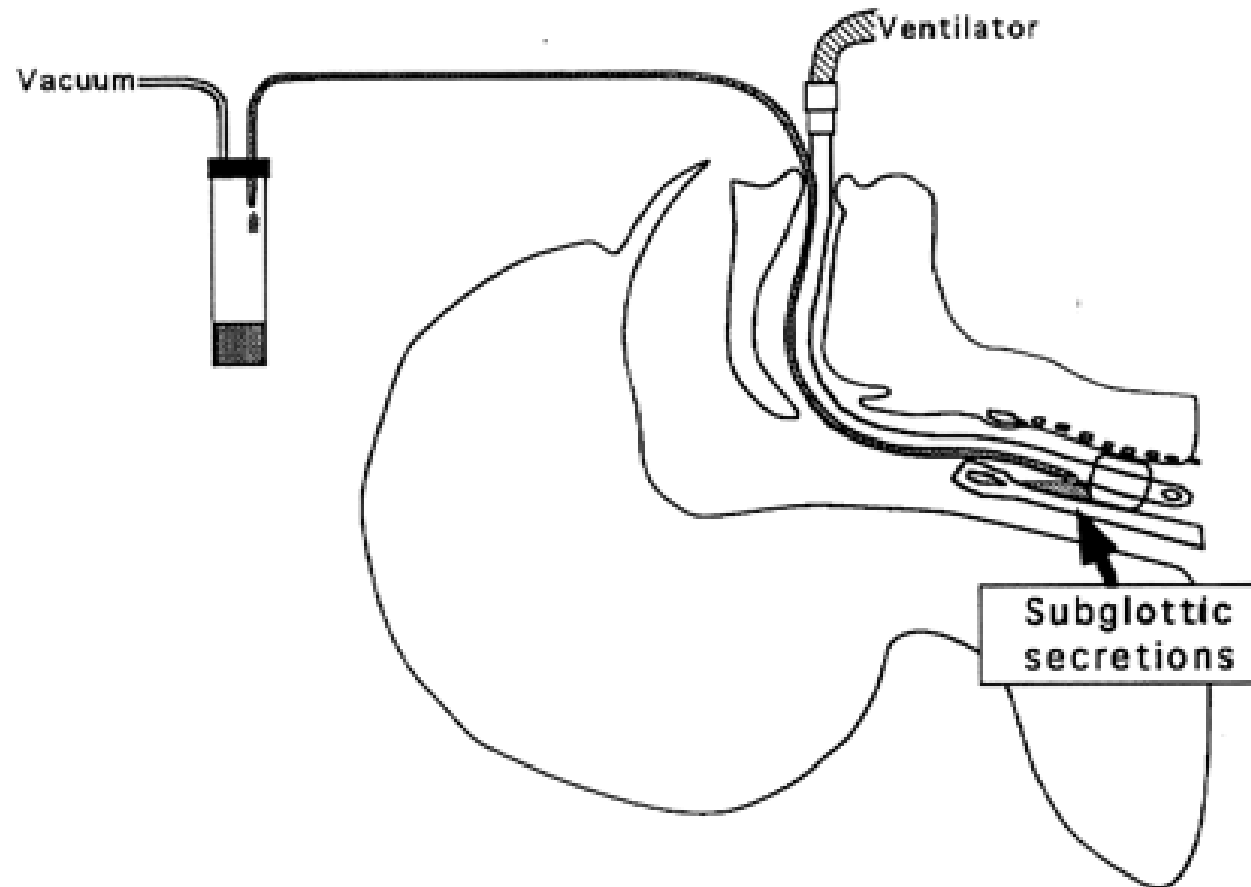
Continuous aspiration of
subglottic secretions
CASS



Continuous aspiration of subglottic secretions

- Secretions from the upper airways of intubated patients pool above the cuff of the ETT and then leak into the lower airways (demonstrated radiographically)
- The accumulation of contaminated oropharyngeal secretions above the ETT cuff may result in aspiration
- Removal of these pooled secretions through the suctioning of the subglottic region is termed CASS

CASS





CASS

- Meta-analysis of 5 studies (896 pt)
CASS effective in preventing early-onset VAP *Dezfulian Am J Med 2005*
- 4 randomised trials (past 10 yrs)
 - Impact on pneumonia mixed
 - No change in mortality
 - Significant decrease in the rate of VAP *Valles et al Ann Intern Med 1995*
 - Trend towards a decrease in VAP rate *Mahul et al ICM 1992*
 - No significant difference *Kollef et al Chest 1999*
 - All 3 trials showed a delay in the onset of pneumonia
- Disadvantage:
 - Cost
 - Lack of availability in most situations



CASS

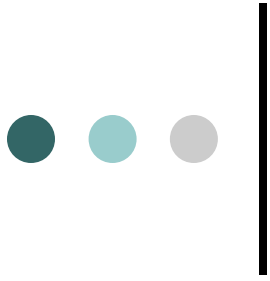
On the basis of evidence from 5 level 2 trials

(Valles, Metz, Mahul, Kollef, Smulders),

CASS is associated with decreased incidence of VAP,
especially early onset VAP

Recommend: Clinicians consider the use of CASS

*Dodek et al Evidence-based CPG for the prevention of VAP Ann Intern Med
2004;141:305-313*



Kinetic Bed Therapy



Kinetic Bed Therapy

- Kinetic or oscillating beds produce continuous rotational movement for the prevention of VAP
- Immobility in critically ill may lead to atelectasis
- Continuous rotational movements on specialised beds may improve drainage of pulmonary secretions
- 7 Level 2 and 1 level 3 trials: There was a decrease in the incidence of VAP
- Drawback:
 - Cost
 - Discomfort
 - Accidental disconnections



Kinetic Bed Therapy

- Recommend: Clinicians consider use of kinetic beds
(Cost effectiveness needs to be evaluated)



Selective Digestive Decontamination (SDD)



Selective Digestive Decontamination

- Application of topical antibiotics into the oropharynx and digestive tract to eliminate potential gram–ve organisms and yeast while preserving the indigenous flora of the gut
- Oropharyngeal and gastric decontamination
- 10 meta-analyses:
 - associated with decrease incidence of VAP and mortality
- Problems:
 - cost effectiveness unknown
 - long term risk for emergence of antibiotic-resistant bacteria

1993)

(Kollef Chest

- No recommendations due to serious concerns on the development of resistance organisms



Avoidance of Large Gastric Volumes



Avoidance of Large Gastric Volumes

- Large gastric volumes predisposes the patient to gastro-esophageal reflux and aspiration
- Several studies have found association between aspiration of gastric contents and VAP, suggesting that avoidance of gastric overdistension may reduce incidence of VAP
- Analysis of 10 studies comparing gastric with small bowel feeding (SBF)
(Heyland JPEN 2002)
 - SBF less gastro-esophageal reflux
 - 7 randomised trials: SBF associated overall reduction in pneumonia
 - No difference in mortality



Avoidance of Large Gastric Volumes

- Intermittent feeding resulted in larger gastric volumes compared to continuous feeding
- Recommendation: Avoid large gastric volumes by using the Enteral Feeding Protocol

Program Anestesiologi & Cawangan Kualiti Penjagaan Kesihatan BPP, KKM

ICU Management Protocol No. 4

ENTERAL FEEDING

General Points

1. All ventilated patients must receive a nasogastric or orogastric tube. It is preferable to use 12FG in adults. The correct position of the tube should be confirmed by 2 out of the following 3 criteria. The criteria are (i) injecting 10-20 ml of air down the tube and auscultating the epigastric area (ii) use of litmus paper and (iii) radiography.
2. Early enteral feeding should be commenced within 24-48 hours after ICU admission whenever the gastrointestinal tract is deemed to be functioning. This applies to all mechanically ventilated patients who have been adequately resuscitated and haemodynamically stable.
3. Enteral feeding for patients who have undergone recent abdominal and bowel surgeries may require prior discussion with the surgeon and ICU specialist before commencement.
4. Patients should preferably receive feeding continuously during the acute phase. They can be switched to intermittent bolus technique later.

(i) Continuous feeding

Start at 20-40ml/hr continuously. Aspirate the feeding tube every 4 hours.

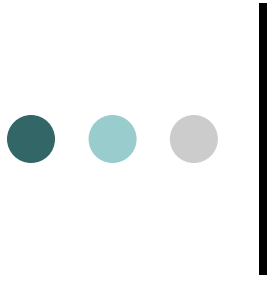
(a) If aspirate < 200ml, return all aspirate. Increase rate by 20ml/hr every 3 cycles till a flow rate that meets the caloric needs of the patient. Once target caloric needs are met, the feeds may be further diluted with water to meet the fluid requirements of the patient.

(b) If aspirate >200ml, return 200ml aspirate to patient and reduce rate by 50% of initial rate. Exclude bowel obstruction first. If there is no clinical evidence of bowel obstruction, administer prokinetic agents (see 11). Once further aspirates are < 200ml, follow (i-a). If aspirates continue to exceed 200 ml after the above has been carried out, consider the use of small bowel feeding (see 10) and elemental formulas (see 9).

(ii) Intermittent bolus feeding

Start with 50ml every 3 hours. Aspirate before every feed.

(a) If aspirate < 200ml return aspirate to patient. Increase by 50ml after every 4 feeds. Increase by 100 ml/feed every 24 hr till caloric needs are met. Once target caloric needs are met, the feeds may be further diluted with water to meet the fluid requirements of the patient.

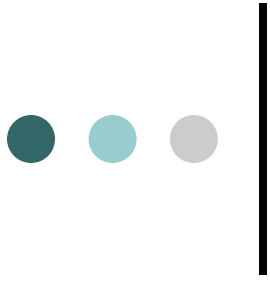


Endotracheal tube cuff pressure



Endotracheal tube cuff pressure

- Low cuff pressure predisposes to the aspiration of the oropharyngeal and gastric secretions
- Recommendation:
Routine monitoring of the endotracheal tube cuff pressure is mandatory in ICU

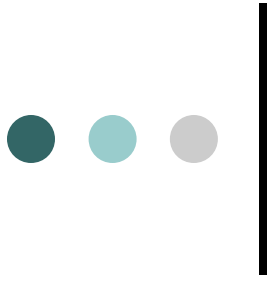


Unplanned extubation



Unplanned extubation

- Associated with increase risk of aspiration of oropharyngeal and gastric secretions
- Recommendation: Avoid unplanned extubation

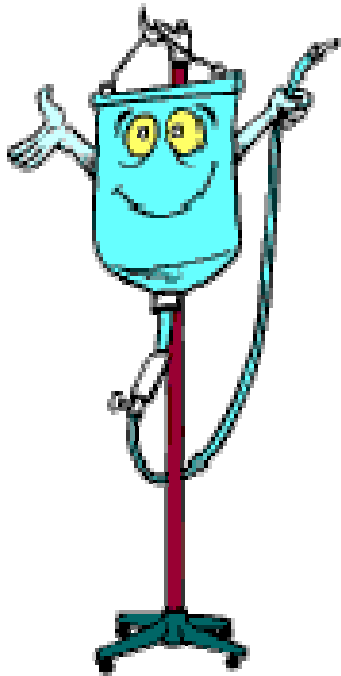


Biofilm Prevention Technology



Biofilm Prevention Technology

- Biofilms form on surfaces such as ETT when they are encountered by bacteria that settle on that surface
- Certain bacteria (*Pseudomonas* spp) appear to be more capable of forming biofilms, esp in presence of abnormal airway mucosa (cystic fibrosis)
- Use of surface coatings (impede bacterial adherence)
- Respiratory Infection Control device (silver-coated ETT)
Reduced bacterial burden in tracheal aspirates and delayed colonisation on ETT
Rello Crit Care Med 2006
- No recommendations



Blood Transfusion



Blood Transfusion



- Shown to alter host's immune system
Blajchman Transfus Med Rev 2001, Vamvakas Transfusion 1996
- Associated with serious nosocomial infections
-correlates with surgical site infections and potentiates risk for catheter-related sepsis *Tang Ann Surg 2001, Duggan Q J Med 1993*
- Independent risk factor postoperative (non-ventilator) pneumonia *Arozullah Ann Intern Med 2001*
- Retrospective study on cohort of 1717 patients
Strong correlation between transfusion practice and nosocomial infection.
Transfused patients were \simeq 6X more likely to develop a nosocomial infection *Taylor Crit Care Med 2002*



Blood Transfusion

- Transfusion of packed RBC increased risk of developing VAP

Multicentre prospective observational study of transfusion practice in ICUs in US

284 ICUs, 5000 pt, Aug 2000-April 2001(9/12)

VAP diagnosis

Utilisation of pRBC during and after ICU stay recorded

Pt followed until death, hospital discharge or up to 30 days after ICU admission

Shorr et al Red blood cell transfusion and VAP: A potential link Crit Care Med 2004;32;666-674

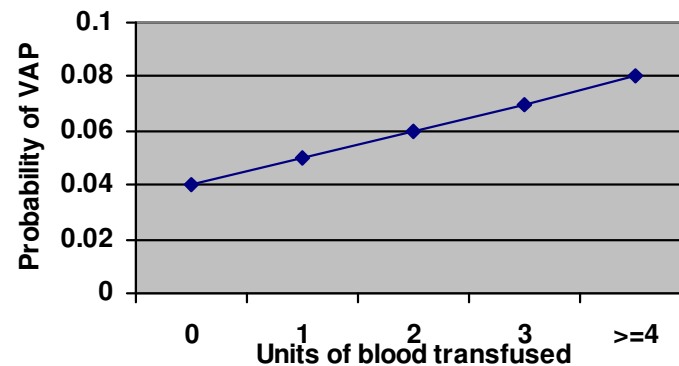
Blood Transfusion

- Transfusion of packed RBC increased risk of developing VAP

*Multivariate analysis : Transfusion independently increased risk of VAP
Male sex, post trauma, continuous sedation, type of nutritional support (early enteral nutrition, TPN)*

Effect on late-onset VAP more pronounced

Dose-response relationship between transfusion and VAP



p=0.023

Shorr et al Red blood cell transfusion and VAP: A potential link Crit Care Med 2004;32;666-674



Blood Transfusion

- Transfusion promotes cytokine release which in turn enhances various cytokine cascades
- Stored blood contain significant levels of proinflammatory cytokines
- “Transfusion-related immunosuppression”
Donor white cells serve as antigen and induce and immunomodulatory affect by altering T-cell function

Recommendation: Restrict blood transfusion



Nutritional support



Nutritional support

- Early enteral feeding associated with greater incidence of VAP
Ibrahim JPEN 2002
Shorr Crit Care Med 2004 OR2.65;95%CI 1.93-3.63
- Total Parenteral Nutrition
Shorr Crit Care Med 2004 OR 3.27;95% CI 2.24-4.75

Canadian Clinical Practice Guidelines for Nutrition Support in Mechanically Ventilated Critically Ill Adult Patients

Heyland DK, et al JPEN 2003; 27:355–373

- When considering nutrition support for critically ill patients, strongly recommend the use of enteral nutrition over parenteral nutrition
(12 level 2, 1 level 1 studies)
- Recommend early enteral nutrition (within 24-48 hours) following admission to ICU in critically ill patients
(10 level 2 studies)
- Recommend that critically ill patients receiving enteral nutrition have the head of the bed elevated to 45°
(1 level 2 study)
- In critically ill patients with an intact GI tract, recommend that parenteral nutrition not be used routinely
(5 level 2 studies)

ICU Management Protocol No. 4

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- Where feasible, enteral feeds can be administered via the closed system. Closed system refers to the "ready to hang formulas". Once connected the duration of feeding is 24 hrs. During initiation of feeding, use the open system (to reduce wastage) and where feasible, use the closed system once target feeding has been achieved.
- All patients receiving feeding must be placed in the semi-recumbent position with the head of the bed elevated to 45°. Head injured patients will have head elevated to 30°. Patients who have to be prone should be in the anti-trendelenberg position (10-20°)
- Current recommendations suggest a target energy intake of 25 kcal/kg/day and at least 1.2-1.5 g/kg/day of protein. For obese patients, use 120% of ideal body weight (IBW) or (Actual Body Weight - IBW) X 0.25 + IBW. For underweight patients, use actual body weight. Energy intake should be adjusted according to the severity and type of illness. Feeding should be administered via a stepwise gradual introduction of feeds over first 48 hrs. Avoid overfeeding.
- Use polymeric formulas (whole protein formula) for feeding.
- Peptide based or elemental formulas (eg Peptamen, Alitrac) have been shown to be useful in patients with gastrointestinal complications (short bowel syndrome, pancreatitis). However, there is insufficient evidence to demonstrate any favourable treatment effects.
- Small bowel feeding (nasojunal/nasoduodenal) can be considered for patients who are intolerant to enteral feeding (high inotropic support, continuous infusion of sedatives, or paralytic agents or with high gastric residual volumes) or in pancreatitis
- Motility agents such as IV metochlopramide 10-20mg 6-8 hourly and/or IV erythromycin 125 mg QID or 250 mg BID to be used in patients who experience feed intolerance (high gastric residuals, emesis).
- Nutrient mixtures prepared in the kitchen ("blenderised diet") should not be used as this type of feed is unbalanced, causes feeding tube occlusion and diarrhea secondary to bacterial contamination.



Intrahospital patient transport





Intrahospital patient transport

- Prospective study on 521 MV pt and impact of transporting pt out of ICU to other sites within the hospital
- 993 transports
- 52% of patients moved at least once
- 24% of transported pt develop VAP compared 4% pt confined to ICU ($p<0.001$)
- Multiple logistic regression analysis-transport out of ICU independent risk factor for VAP (OR=3.8, $p<0.001$)
- Kollef Chest 1997
- Recommendation: Avoid unnecessary transport out of ICU