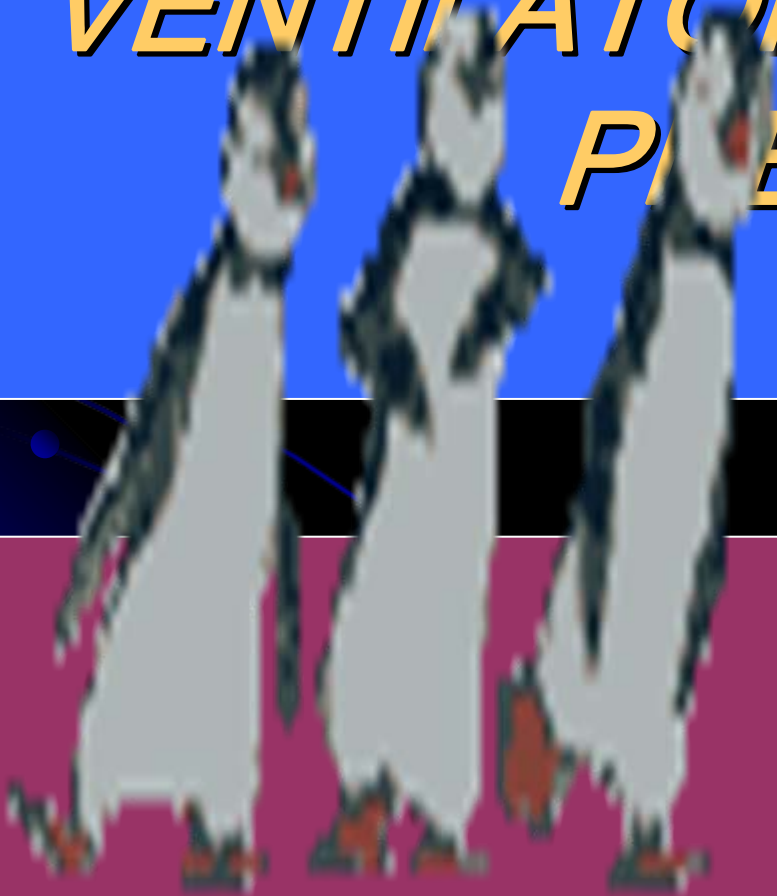


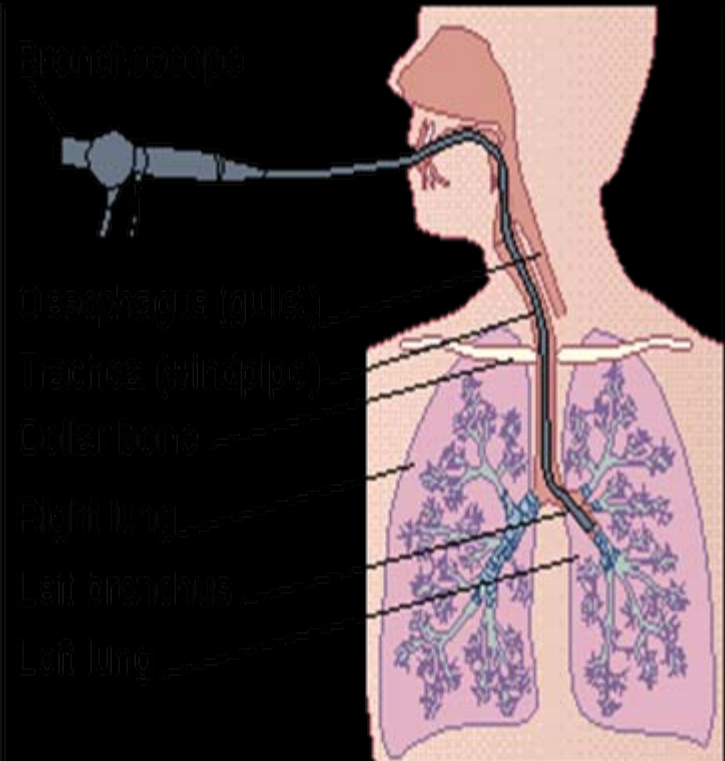
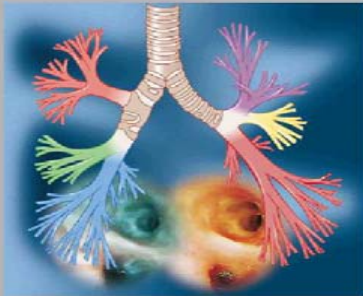
# *VENTILATOR – ASSOCIATED PNEUMONIA*



*Phunsup Wongsurakiat, MD, FCCP  
Division of Respiratory Disease and TB  
Department of Medicine, Siriraj Hospital*

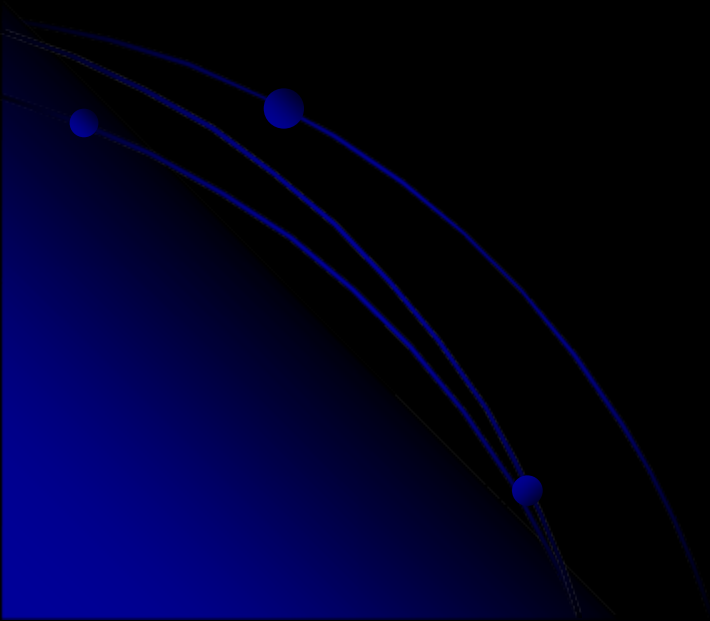
# Pneumonia

- Inflammation in lung parenchyma  
(portion of lower respiratory system distal to terminal bronchioles)



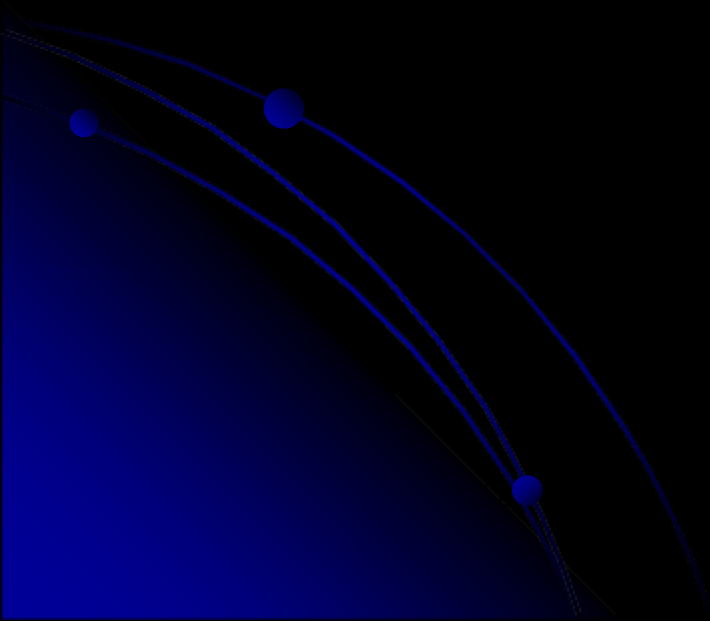
# Hospital – Acquired Pneumonia

- Pneumonia developed  $\geq 48$  hours after hospital admission



# Ventilator – Associated Pneumonia

- Pneumonia developed  $\geq$  48 hours after endotracheal intubation or tracheostomy to 48 hours after extubation





# Ventilator – associated pneumonia

How To Diagnose



# Diagnosis

## Suspected VAP

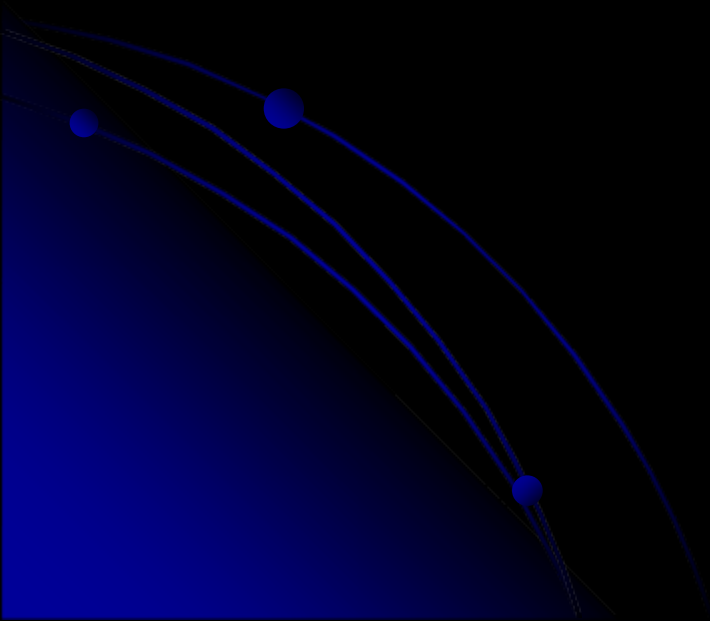
- New or progressive CXR infiltrate
- 2/3 of
  - fever  $> 38$  C
  - leukocytosis or leukopenia
  - purulent secretions

# Diagnosis

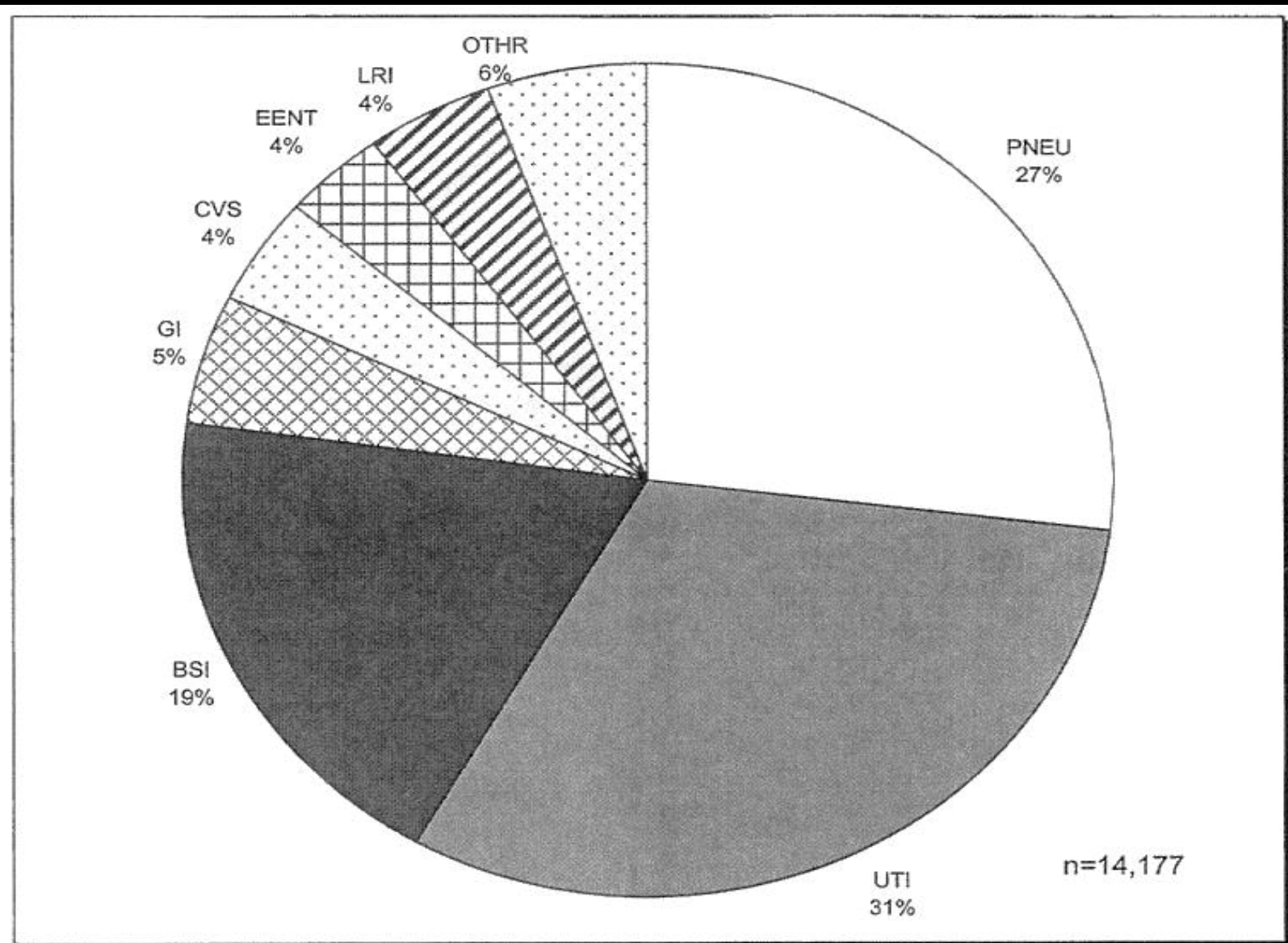
	Sensitivity	Specificity
CXR infiltrates + 2/3 of fever or leukocytosis/leukopenia or purulent secretions	69%	75%

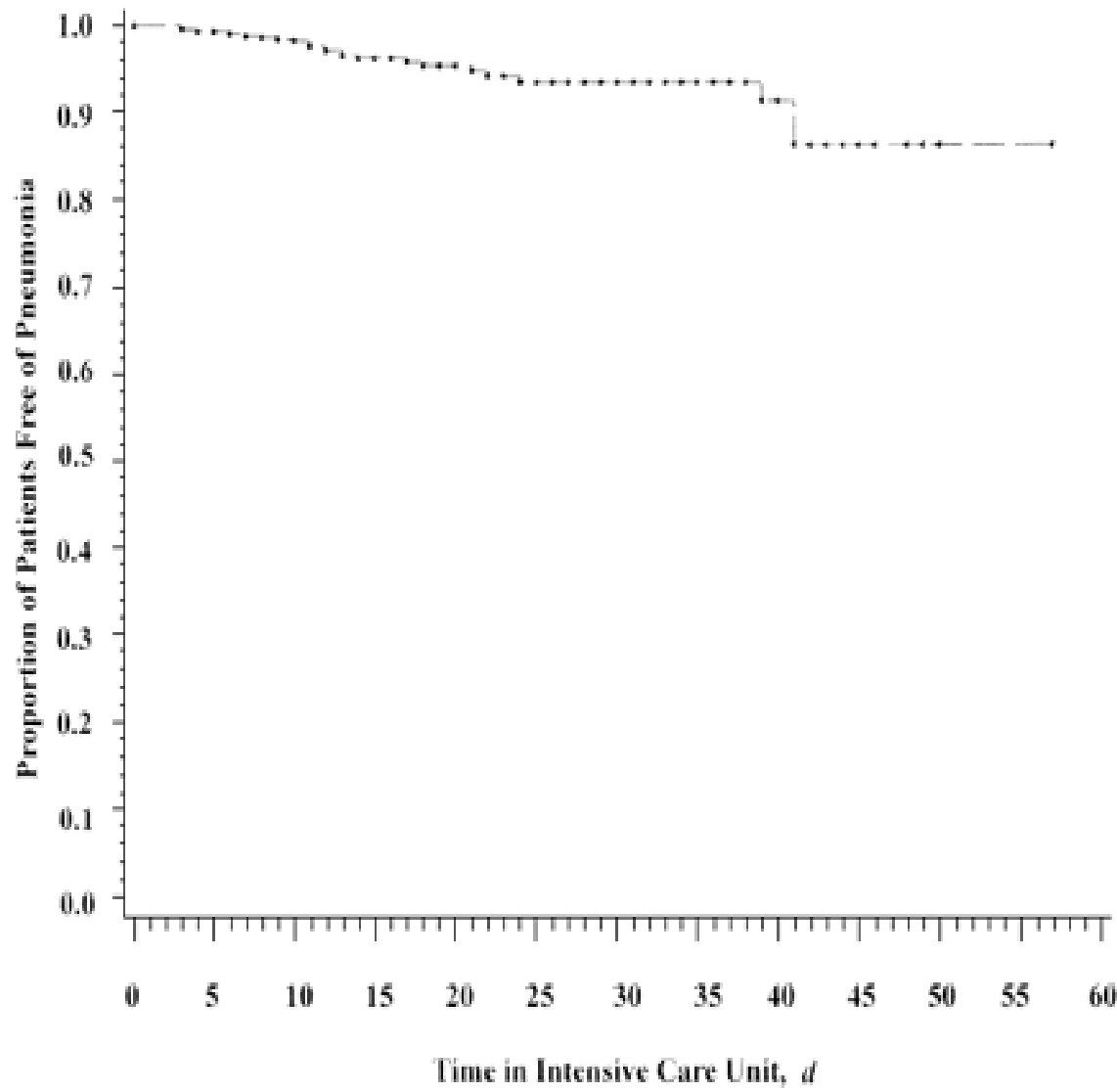


# Why Is VAP Important ?



# Site Distribution Of Nosocomial Infections In Adult Medical Intensive Care Unit Patients (1992 to 1997)





**Incidence of VAP**

< 5 days	3% / day
5 – 10 days	2% / day
> 10 days	1% / day

***Incidence of and Risk Factors for Ventilator-Associated Pneumonia  
in Critically Ill Patients***

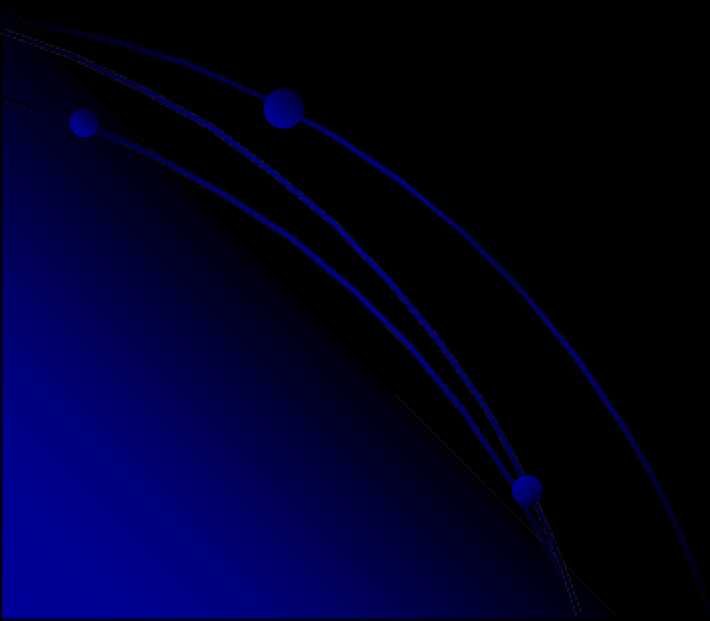
*Cook et al. Ann Intern Med 1998; 126:433*

# CRUDE MORTALITY RATES OF VENTILATOR-ASSOCIATED PNEUMONIA

First Author	Year of Publication	No, of Patients	Incidence (%)	Diagnostic Criteria	Mortality Rate (%)
Salata	1987	51	41	Clinical-autopsy	76
Craven	1986	233	21	Clinical	55
Langer	1989	724	23	Clinical	44
Fagon	1989	567	9	PSB	71
Kerver	1987	39	67	Clinical	30
Driks	1987	130	18	Clinical	56
Torres	1990	322	24	Clinical-PSB	33
Baker	1996	514	5	PSB/BAL	24
Kollef	1993	277	16	Clinical	37
Fagon	1996	1,118	28	PSB/BAL	53
Timsit	1996	387	15	PSB/BAL	57
Cook	1998	1,014	18	Clinical-PSB/BAL	24
Tejada Artigas	2001	103	22	PSB	44

# Ventilator – Associated Pneumonia

- Incidence : 17 – 18.8 / 1000 ventilator-days



# VENTILATOR-ASSOCIATED PNEUMONIA

## Mortality

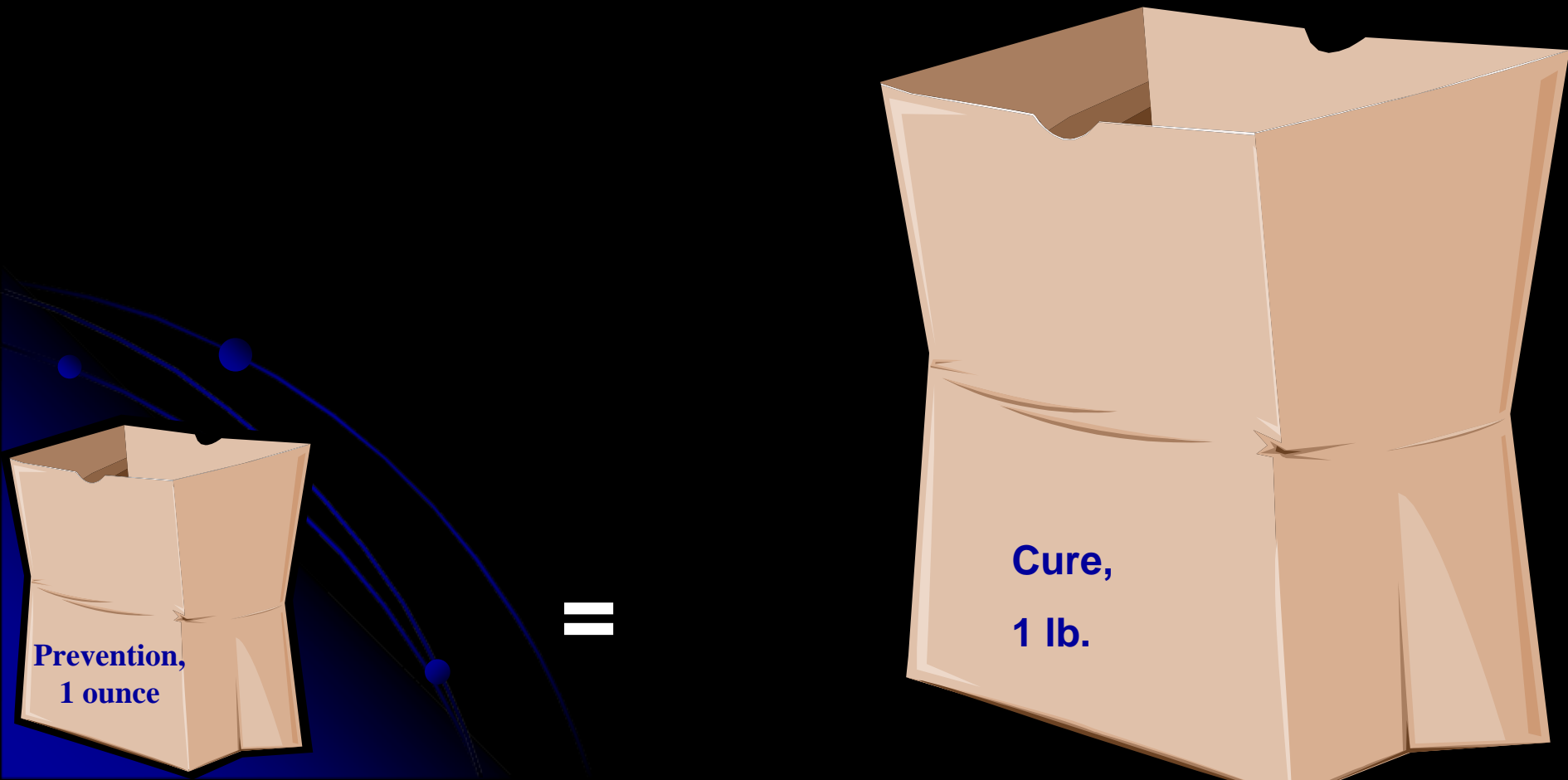
- Mortality 24 – 76%
- Risk ratios of mortality 1.7 – 4.4 over non VAP
- Attributable mortality 20 – 30%
  - Intermediate severity
  - High-risk pathogens : Pseudomonas, Acinetobacter spp.

# VENTILATOR-ASSOCIATED PNEUMONIA

## Morbidity & Cost

- Longer mechanical ventilation 4 – 32 days
- Longer hospital duration  
( Thai, 2 – 45 days)
- ↑ cost ≈ \$ 20,000 - \$ 40,000  
( Thai, 9881.64 Baht)

# *PREVENTION OF VENTILATOR – ASSOCIATED PNEUMONIA*



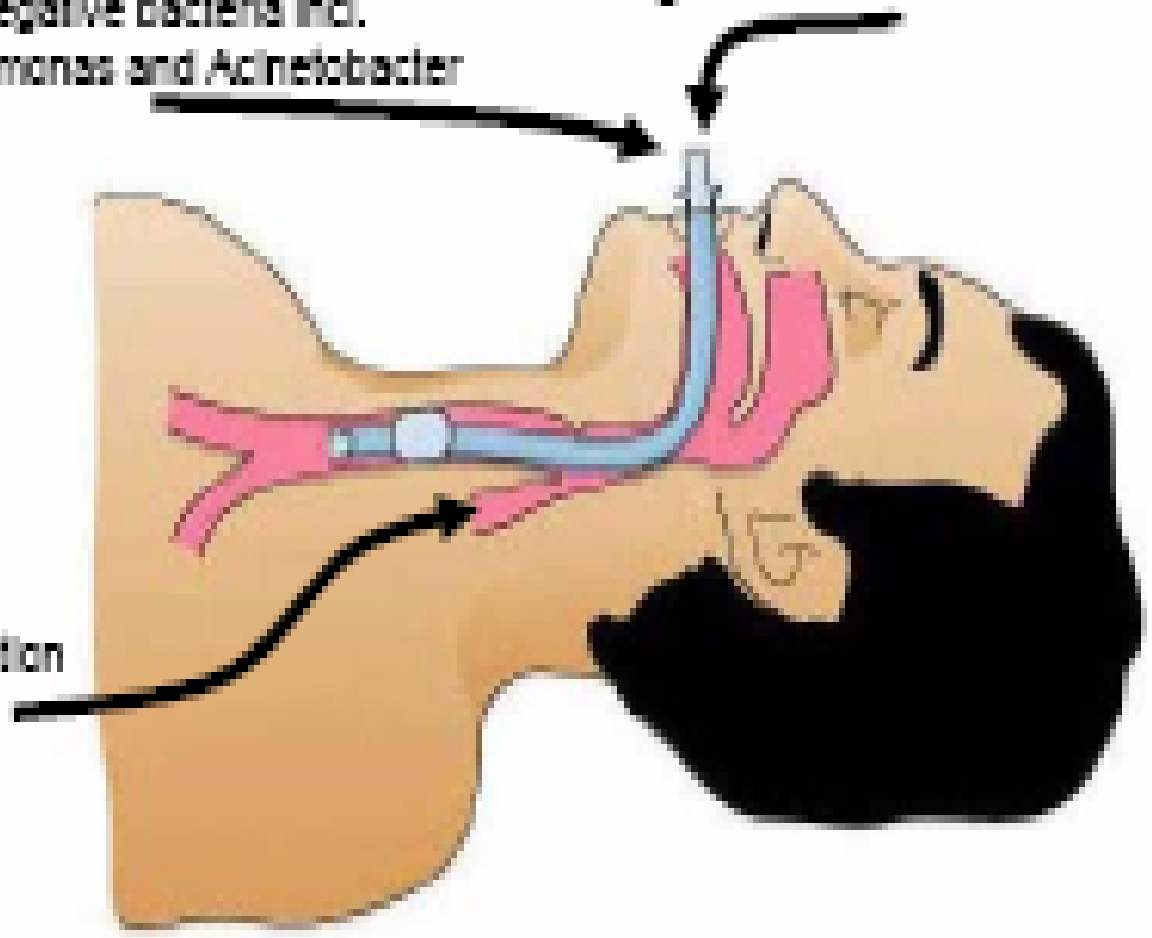


# Contaminant reservoirs in VAP

HCW: transmission of staph,  
Gram-negative bacteria incl.  
Pseudomonas and Acinetobacter

Ventilator: environmental microbes,  
Enterobacteriaceae, staphylococci,  
Legionella from humidifier

GI tract: aspiration  
of GI flora



# Ventilator – Associated Pneumonia Pathogenesis

**Bacterial Colonization**

Oropharynx, Stomach,  
Sinus



**Aspiration**

Secretions, Vent Condensate,  
Aerosol



**Ventilator – Associated Pneumonia**

Bacterial Inhalation  
Contaminated Water,  
Medication Solutions,  
Equipment



Transthoracic Inoculation,  
Bacteremia, GI Translocation



Medications altering pH

Invasive devices with biofilm  
ET tube, NG tube

Antibiotics

Host Factors

**Bacterial Colonization**  
Oropharynx, Stomach, Sinus

Inadequate infection control practices  
Hand washing, Gowns, Gloves

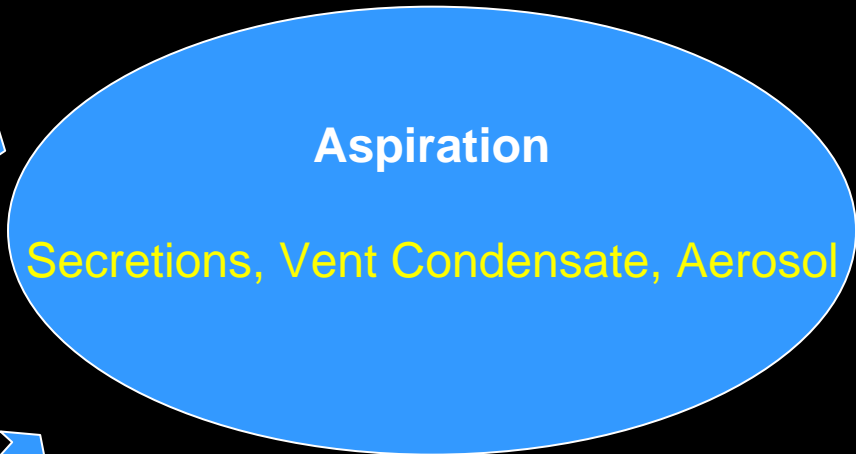


Inadequate Staffing  
Nursing, Respiratory Therapy

Low Endotracheal  
Intracuff Pressure

Supine Position

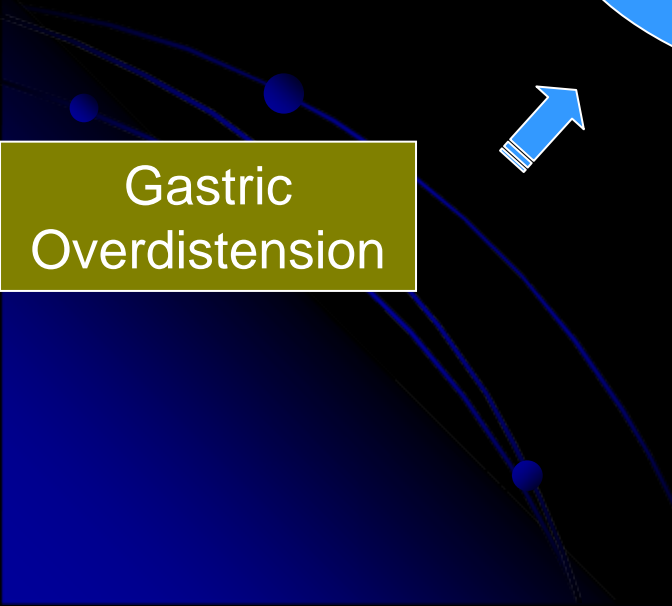
ET Tube



Gastric  
Overdistension

Accidental Extubation

Contaminated Water,  
Medication Solutions,  
Equipment



Medications altering pH

Invasive devices with biofilm  
ET tube, NG tube

Antibiotics

Host Factors

**Bacterial Colonization**  
Oropharynx, Stomach, Sinus

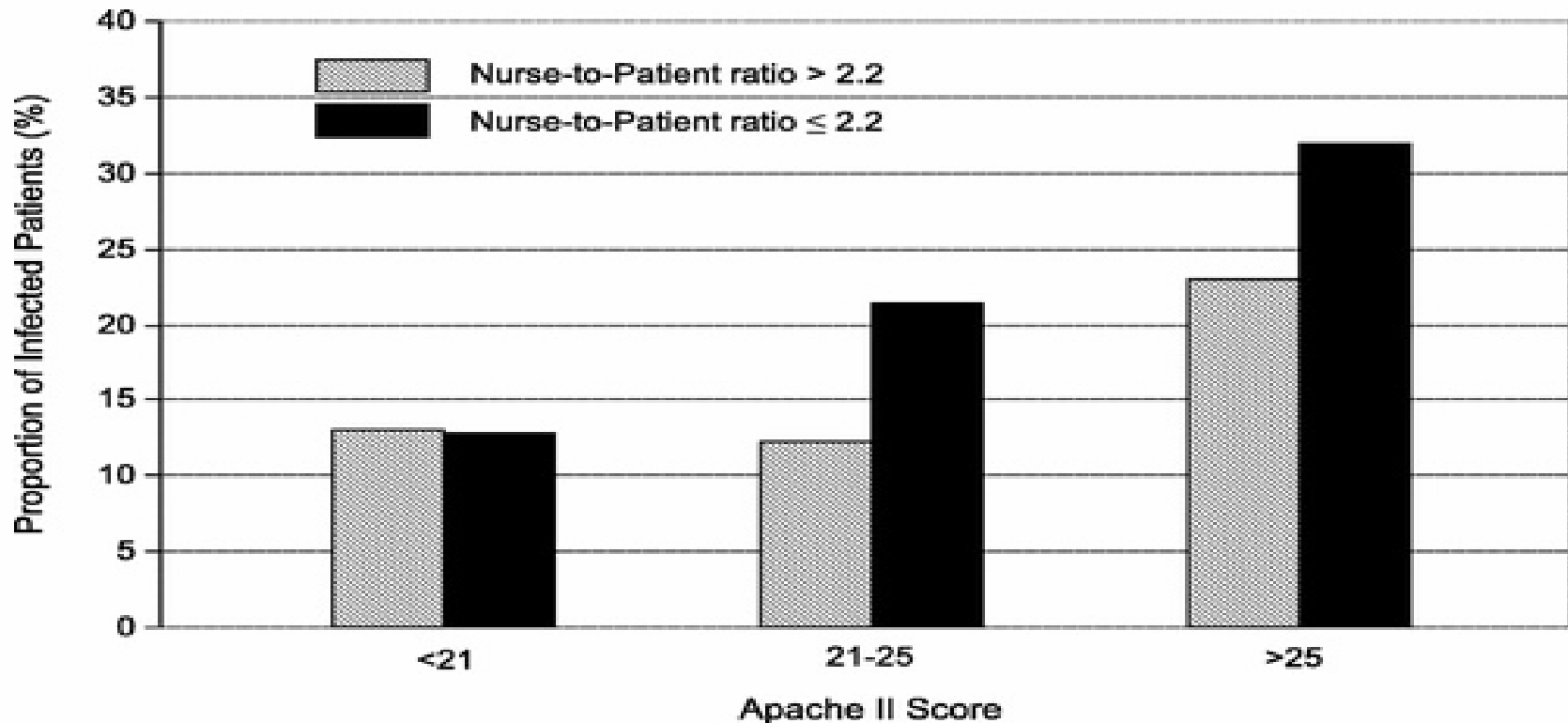
Inadequate infection control practices  
Hand washing, Gowns, Gloves



# General Prophylaxis Infection control Practices

- ✓ Effective infection control measures
  - Staff education
  - Adequate staffing
  - Compliance with hand disinfection
  - Isolation to reduce cross-infection with multidrug-resistant (MDR) pathogens
- ✓ Surveillance of ICU infections
  - Identify and quantify endemic and new MDR pathogens
  - Guide appropriate antimicrobial therapy

# The effect of workload on infection risk in critically ill patients



**Conclusions:** Staffing is a key determinant of healthcare-associated infection in critically ill patients. Assuming causality, a substantial proportion of all infections could be avoided if nurse staffing were to be maintained at a higher level



*Wash Hands*

*Prevent Spread of Microorganisms*



# Handwashing on VAP Prevention



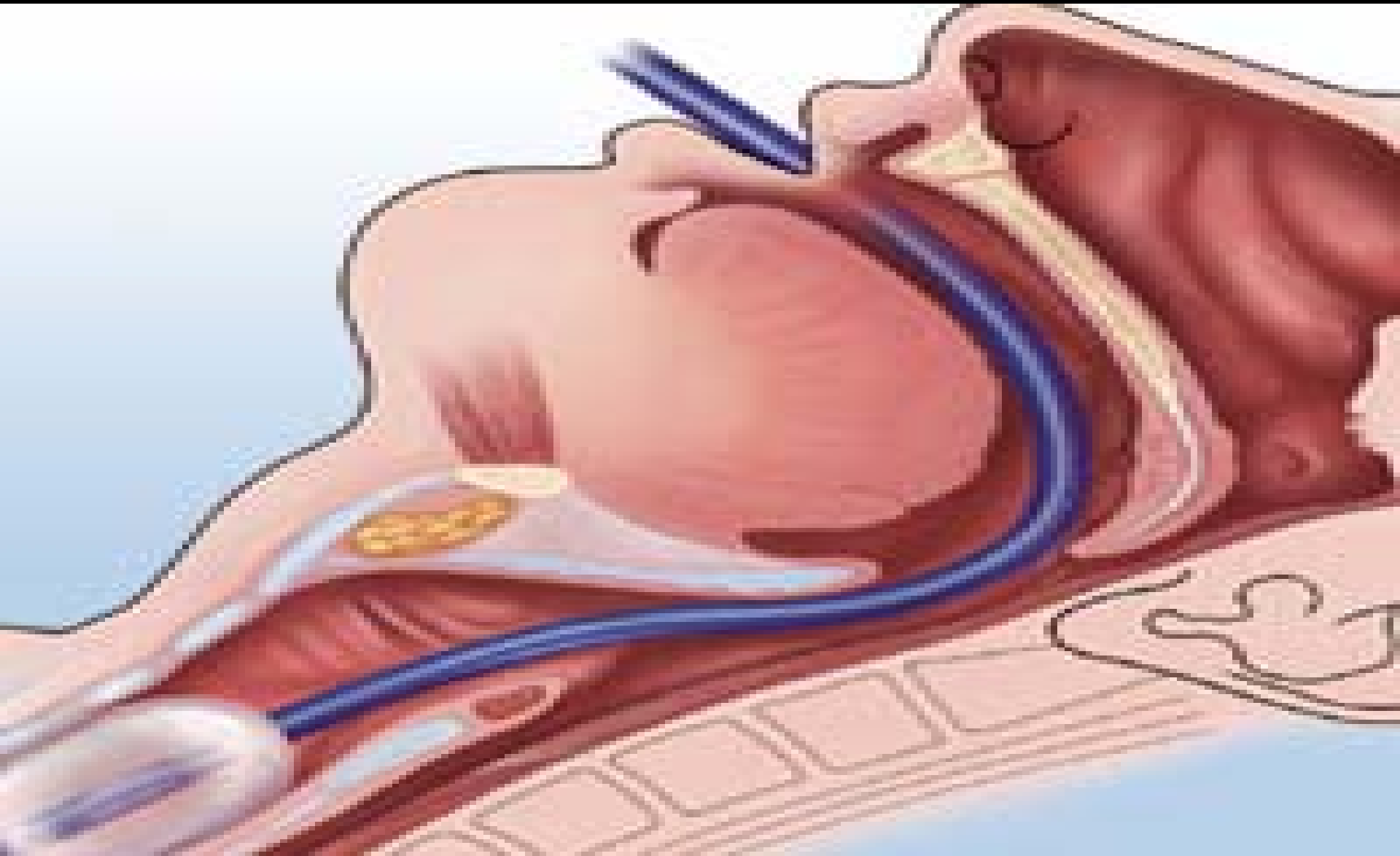
- Before and after suctioning
- Touching ventilator equipment
- Contact patients & patient environment  
(e.g. bed, table)
- Contact with respiratory secretion
- **All recommendations are level IA**

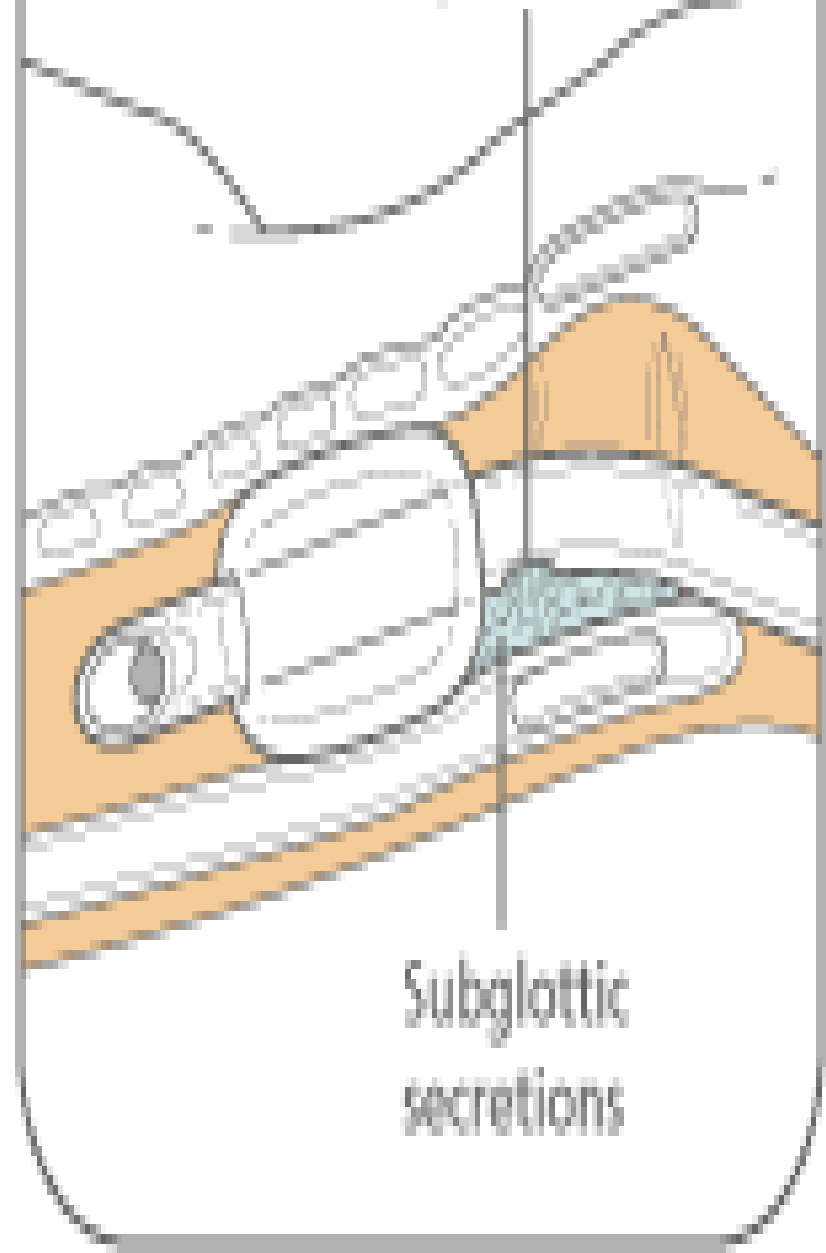
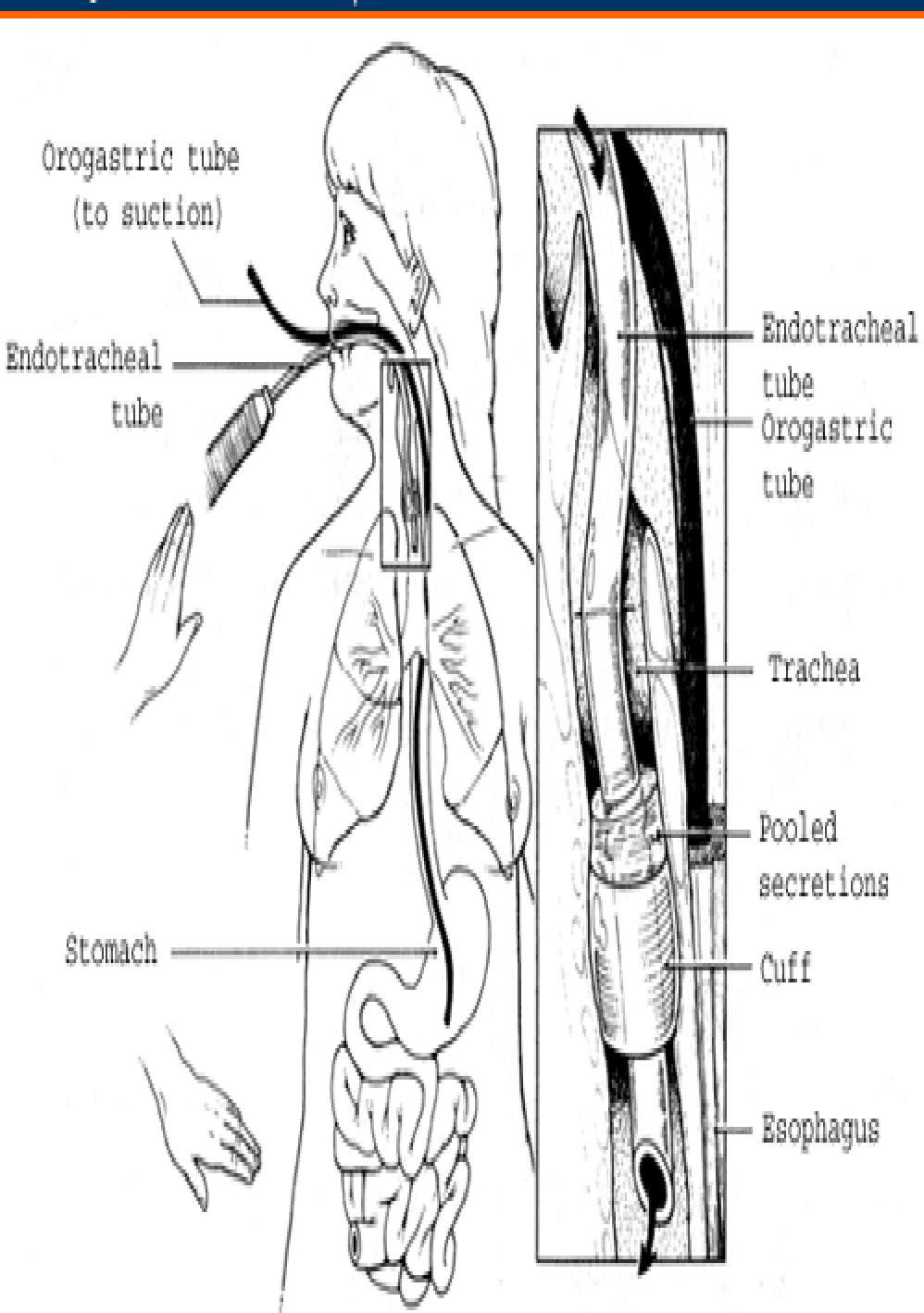
# Invasive Device

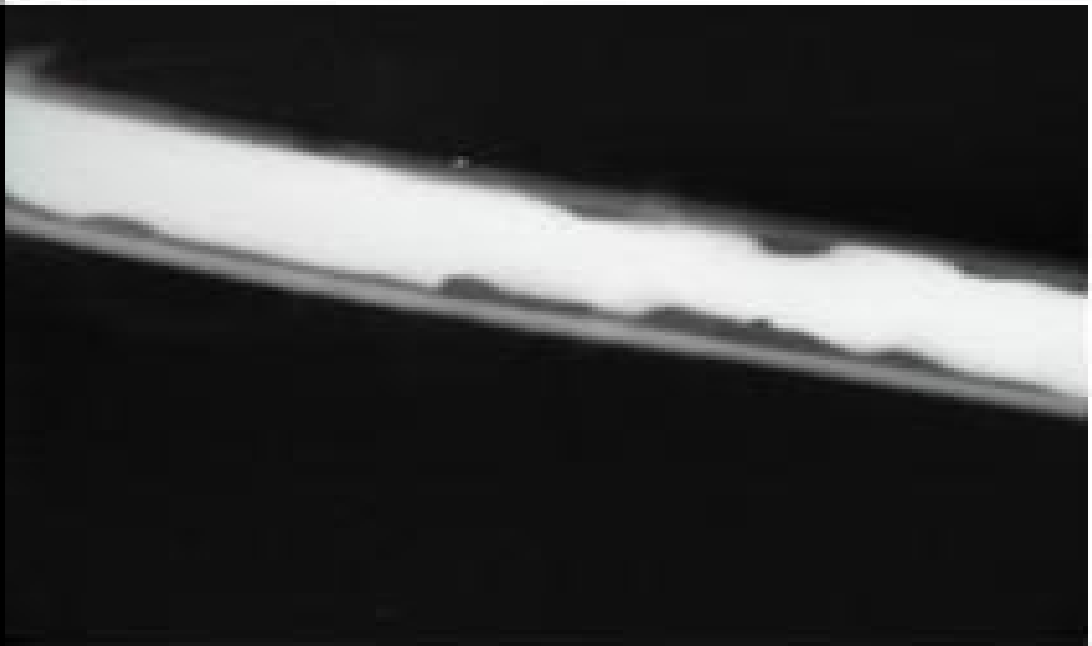
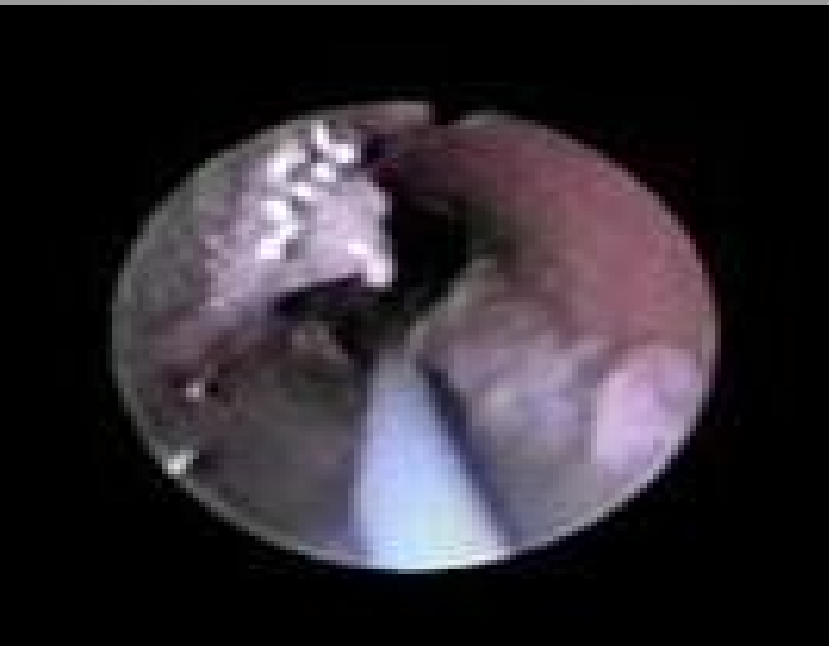
## Intubation and mechanical ventilation



# Endotracheal Tube & VAP







# Intubation

## Endotracheal tube



- Abnormal continuum between upper airway & trachea
- Establishing a subglottic reservoir of secretions rich in bacterial pathogens...
- Biofilm lines the ET tube
  - allowing distal aerosolization of particulate matter via ventilatory cycle

# Intubation

## ✓ Avoid intubation

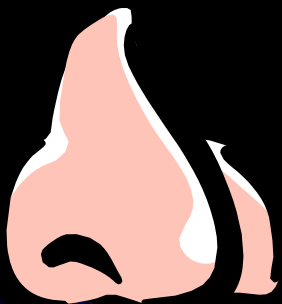
- Use noninvasive ventilation whenever possible (COPD)
- ↓ Duration of mechanical ventilation (Weaning protocol, sedation)

## ✓ Avoid Reintubation

- 8 fold higher nosocomial pneumonia
- 6-12 fold higher mortality

# Intubation

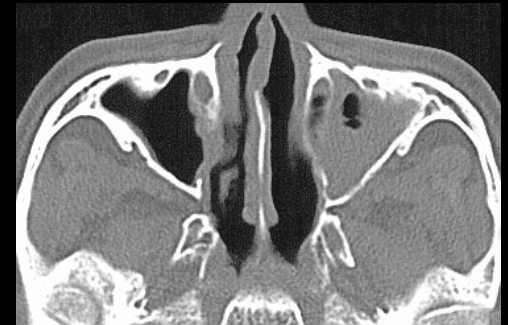
*If you have to, not in the nose...*



+



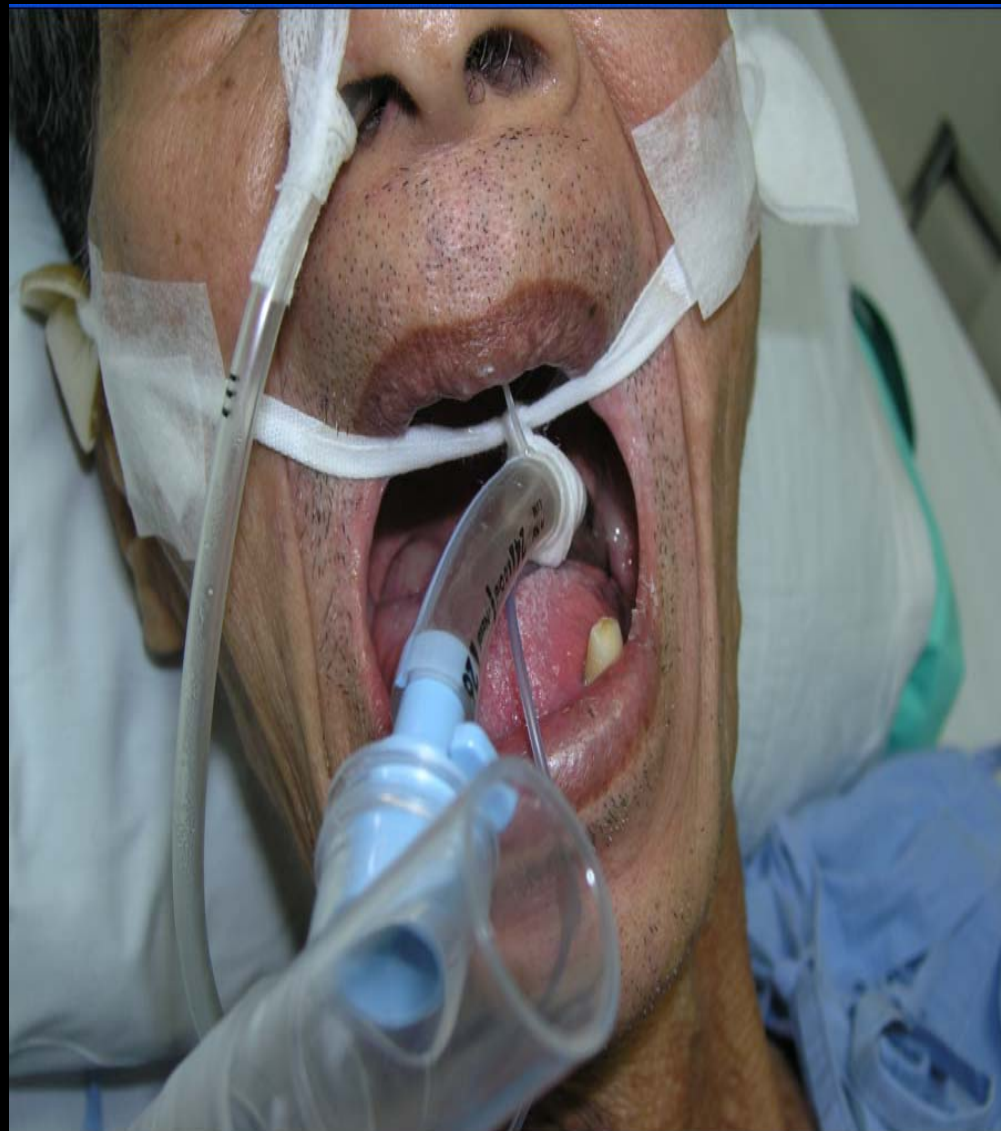
=



- ✓ Use orotracheal tubes to prevent nosocomial sinusitis → pneumonia



# Oral Care



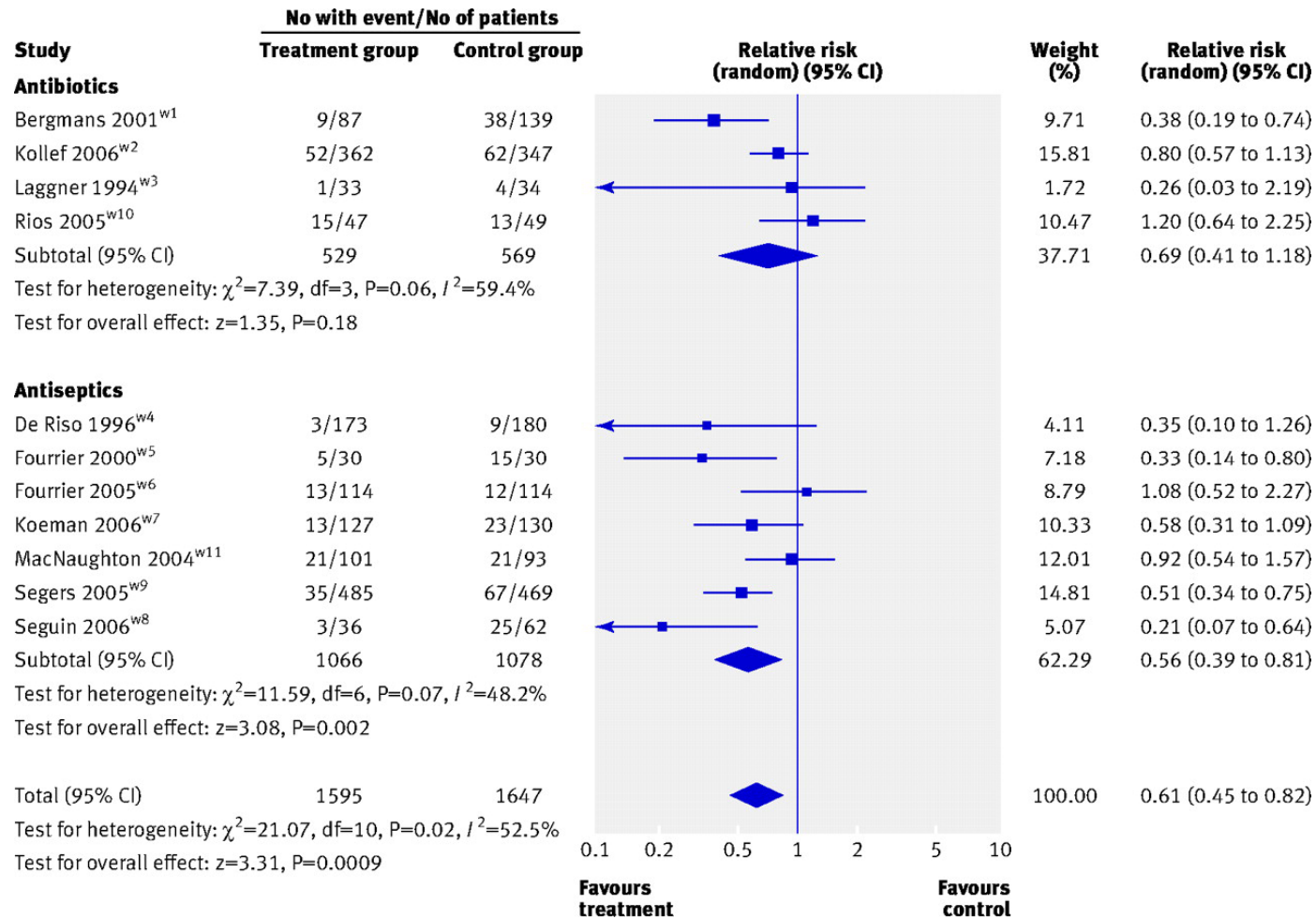
# Oral Care

THE ORAL CAVITY  
A Proven Source of VAP



- Linking oral and dental colonization with respiratory infection
- Modulation of colonization
  - Oral antiseptics
  - Comprehensive oral care

**Fig 2 Forest plot showing effect of oral decontamination prophylaxis compared with no prophylaxis on risk of ventilator associated pneumonia**



Chan, E. Y. et al. *BMJ* 2007;334:889

# Oral Care

THE ORAL CAVITY  
A Proven Source of VAP



- Linking oral and dental colonization with respiratory infection
- Modulation of colonization
  - Oral antiseptics : 2% Chlorhexidine?
  - Comprehensive oral care
  - Pharyngeal Suction **before** suctioning ETT, **before** repositioning ETT, **before** deflating cuff, **before** repositioning patient to prevent aspiration of pooled secretions



# Medications Altering Gastric pH

## Tracheal and oropharyngeal colonization with G(-) bacilli

Variable	Antacid (n=76)	Ranitidine (n=73)	Sucralfate (n=75)
Tracheal colonization, n (%)	24 (32)	36 (49)	22 (29)
High-count, n (%)	17 (22)	27 (37)	11 (15)
Oropharyngeal colonization, n (%)	41 (54)	44 (60)	34 (45)
High-count, n (%)	32 (42)	39 (53)	27 (36)

*Ann Intern Med* 1994;120:653-62

# Stress Ulcer Prophylaxis

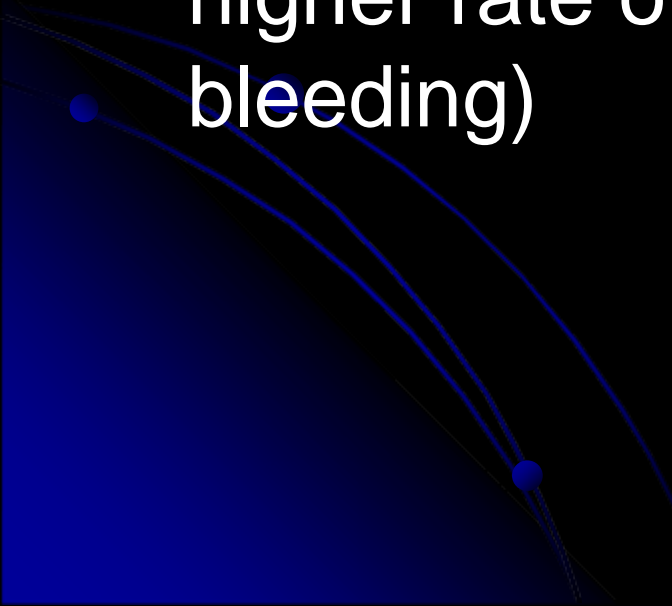
*Who gets stress ulcer prophylaxis in your ICU?*

- ① Mechanical ventilation > 48 h
- ② Coagulopathy

*Cook et al. Risk factors for gastrointestinal bleeding in critically ill patients. N Engl J Med 1994;330:377-81.*

# Modifiable Risk factors

## *Stress bleeding prophylaxis*

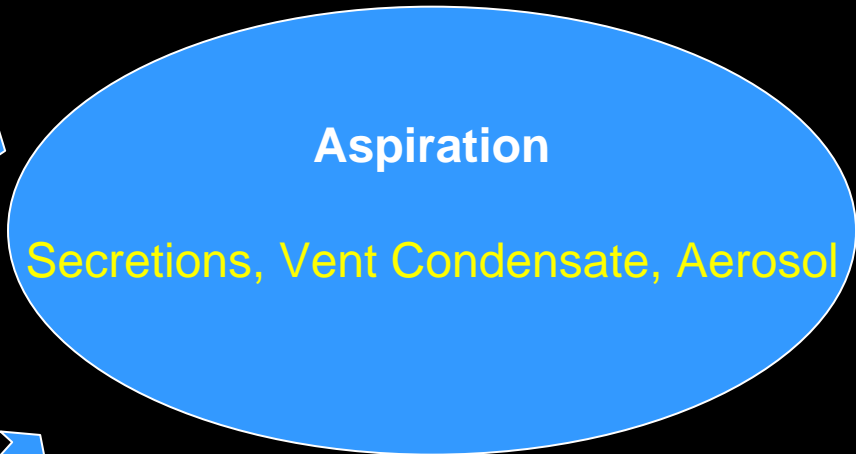
- ✓ If needed, stress bleeding prophylaxis with either H2 antagonists or sucralfate (Reduced VAP with sucralfate but slightly higher rate of clinically significant gastric bleeding)
- 

Inadequate Staffing  
Nursing, Respiratory Therapy

Low Endotracheal  
Intracuff Pressure

Supine Position

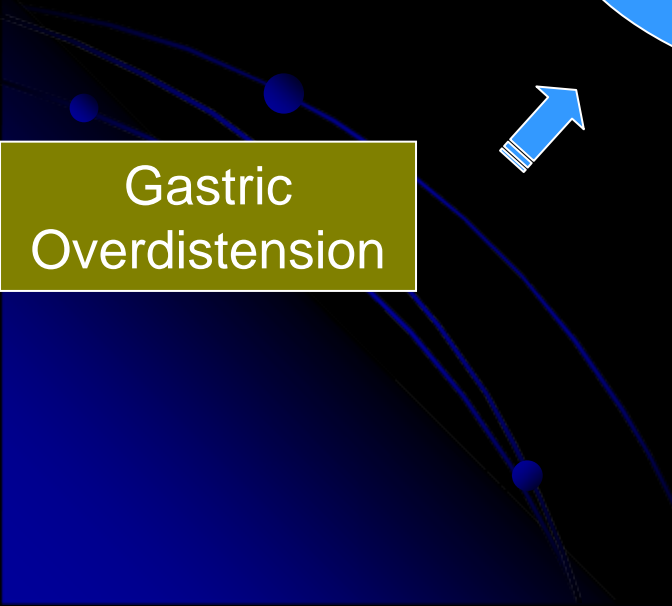
ET Tube



Gastric  
Overdistension

Accidental Extubation

Contaminated Water,  
Medication Solutions,  
Equipment







**HOB Elevation 30-45 Degrees**

# Adult intubated patients (N=86) on mechanical ventilation assigned to semi-recumbent (45°) or supine position

	Semi-recumbent	Supine
Suspected VAP (CI for difference 10-42%: p=0.003)	8%	34%
Confirmed VAP (CI for difference 4-32%: p=0.018)	5%	23%

# HOB Elevation 30-45 Degrees

- ✓ All intubated patients
- ✓ All patients on enteral feeds

Reduces Reflux & Aspiration





## Endotracheal intracuff pressure (Pcuff)

- Pcuff > 30 cmH<sub>2</sub>O : tracheal mucosal ischemia & injury
- Pcuff < 20 cmH<sub>2</sub>O associated with VAP
- Pcuff between 20-30 cmH<sub>2</sub>O should be desirable level for intubated patients

*Rello et al.  
Am J Respir Crit Care Med 1996:111-5*



# Endotracheal intracuff pressure



- Monitor  $P_{cuff}$   $q \leq 12$  h
- Keep  $P_{cuff}$  25 - 30 cmH<sub>2</sub>O

3/4/51

 **โรงพยาบาลธนบุรี**  
THINKERS HOSPITAL

☎ 0-2412-0020

SUPINE       UPRIGHT

KV 58      MAS 4.5

DATE 3/12/51      TIME 10:19u

TECH KPV

# Gastric Overdistension

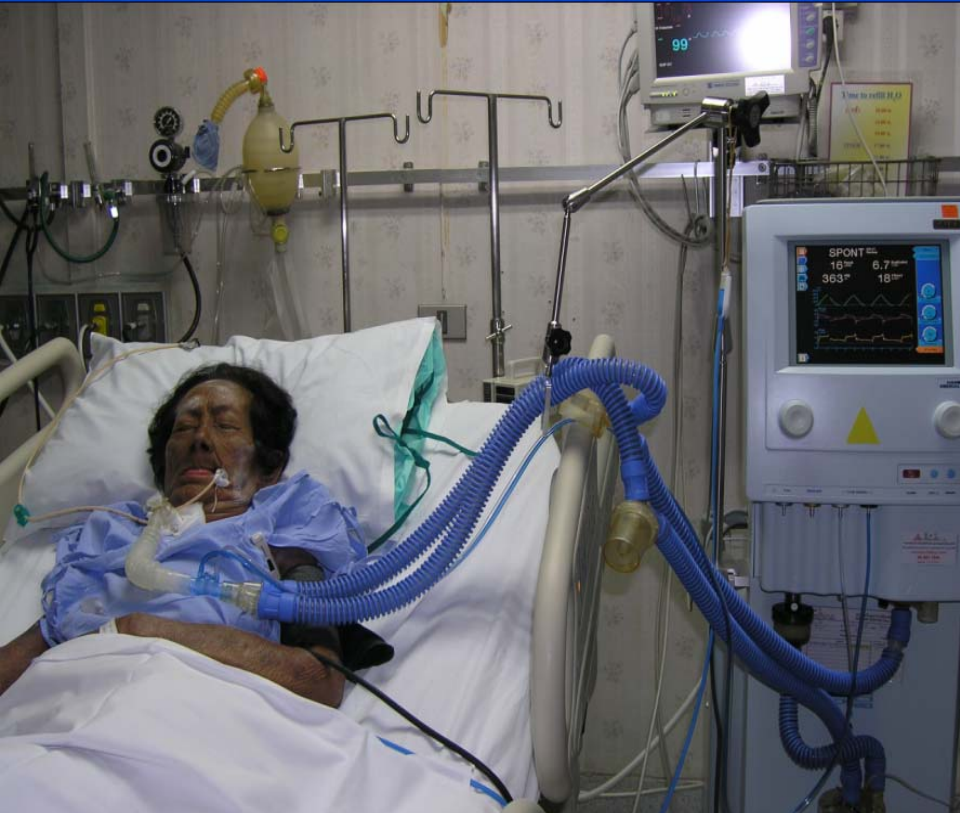
## Before feeding

- Check position of feeding tube
- Monitor gastric residual volumes

(Delay feeding if residual volume  $> 150 - 200$  mL)

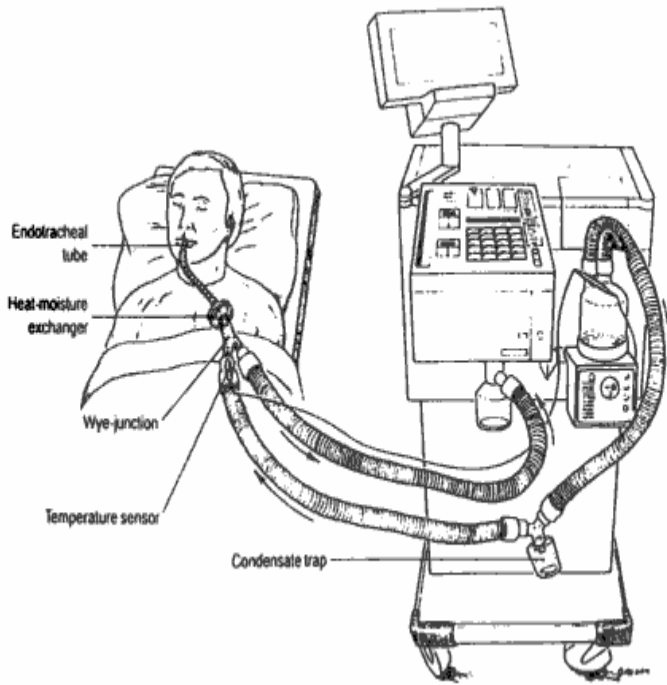
**Remove feeding tube as soon as possible**







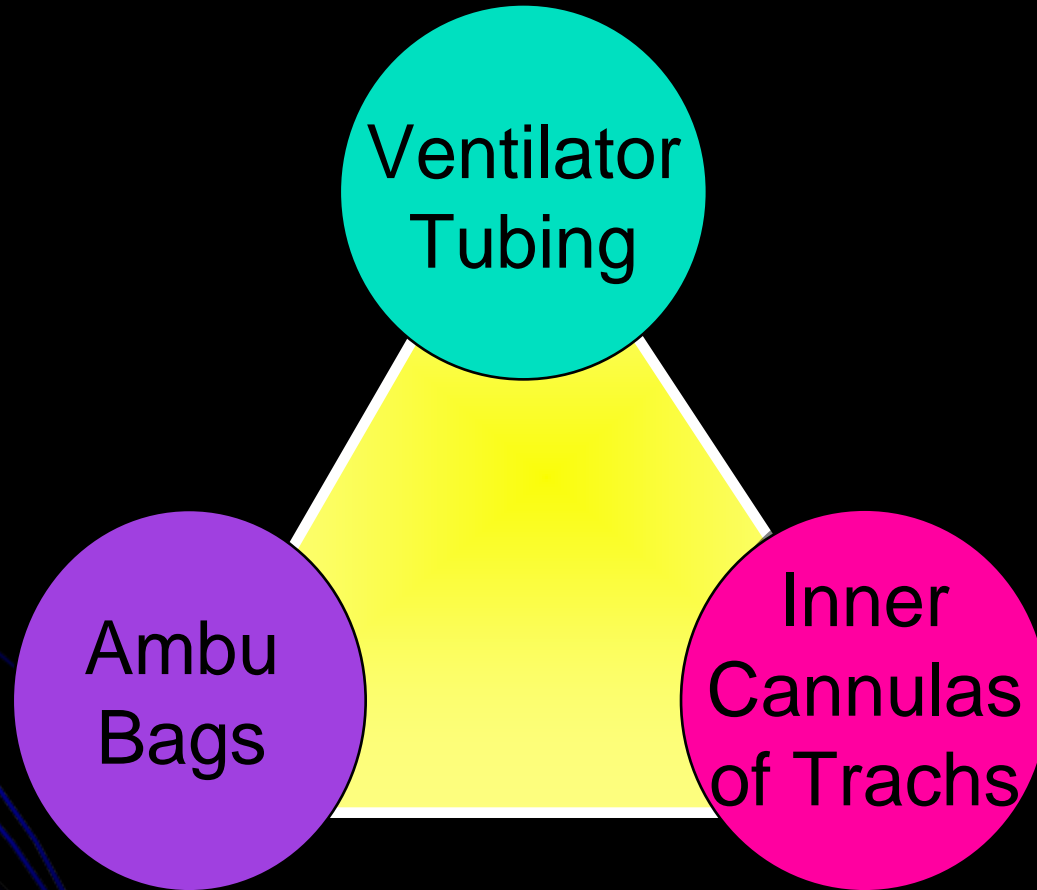
# Ventilator Circuit Condensate



Ventilator circuit condensate = Reservoir of nosocomial pathogens

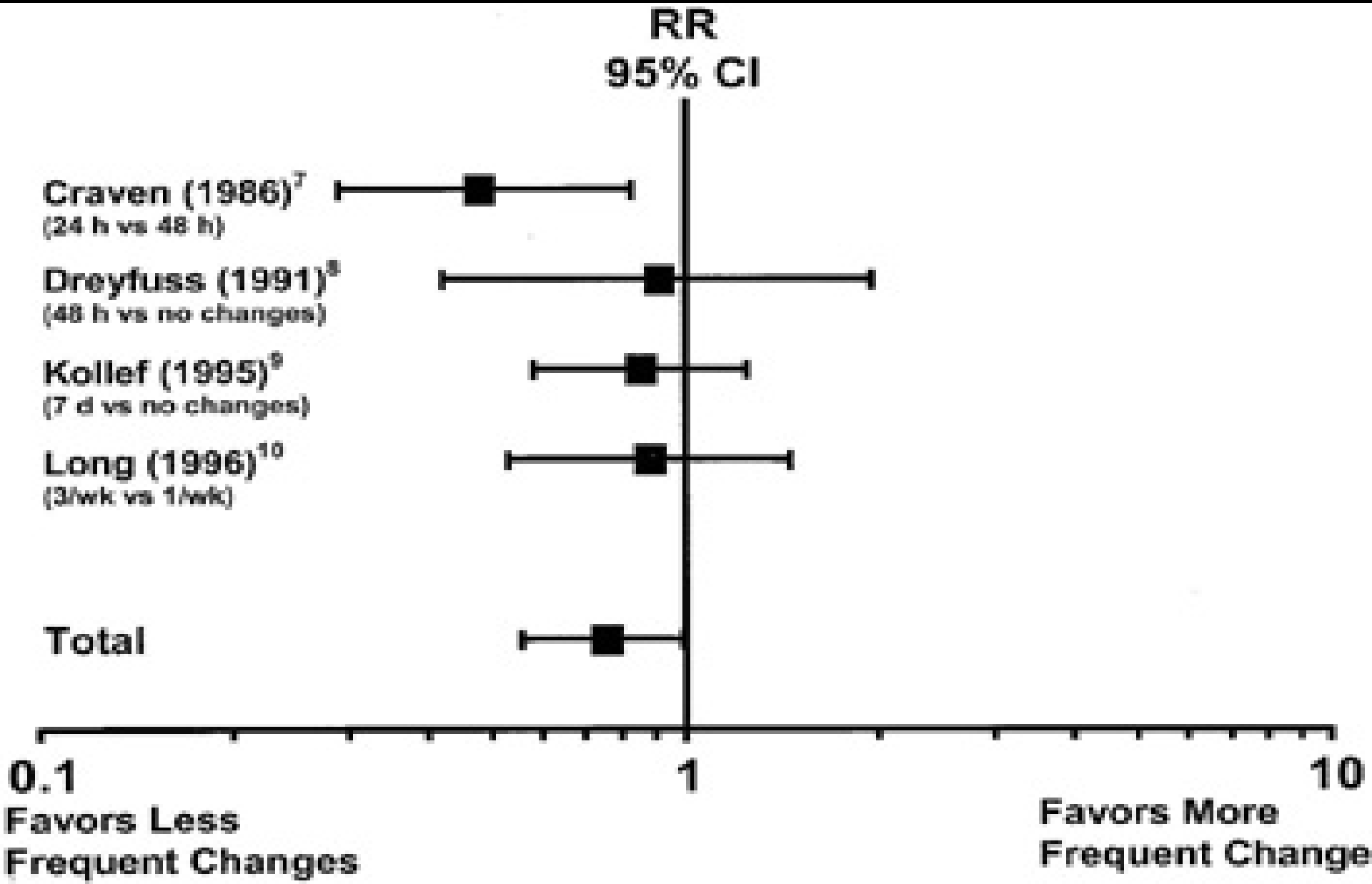
- Prevent flushing of condensate into patient & in-line medication
- Regular vigilance
- Drain condensate before repositioning patient
- Avoid cross contamination

# Frequency of Equipment Changes



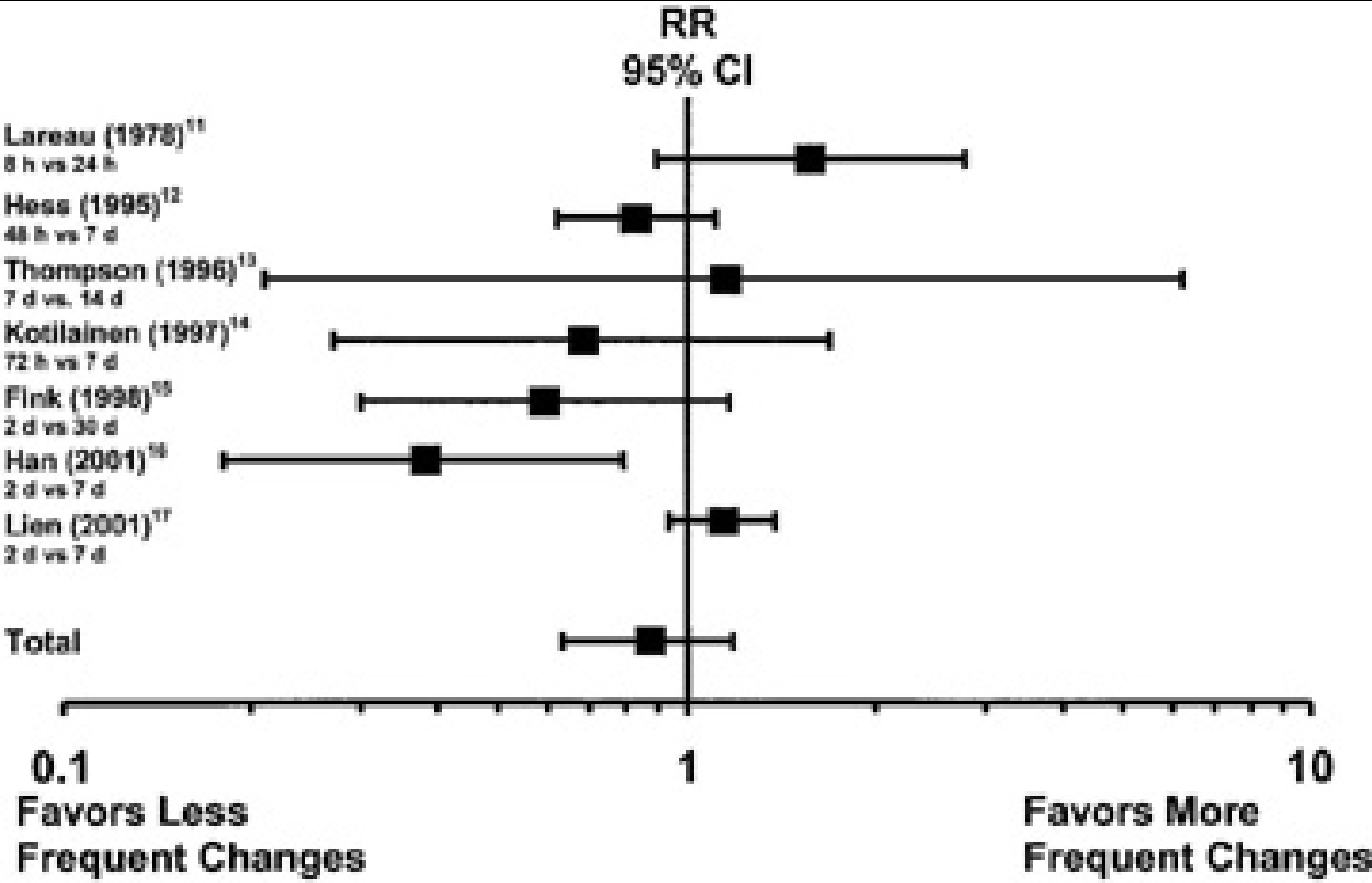
# Ventilator Circuit Change Frequency & VAP

Randomized, controlled trials



# Ventilator circuit change frequency & VAP

## Observational Studies



# Frequency of Equipment Changes

$q \geq 7$  days

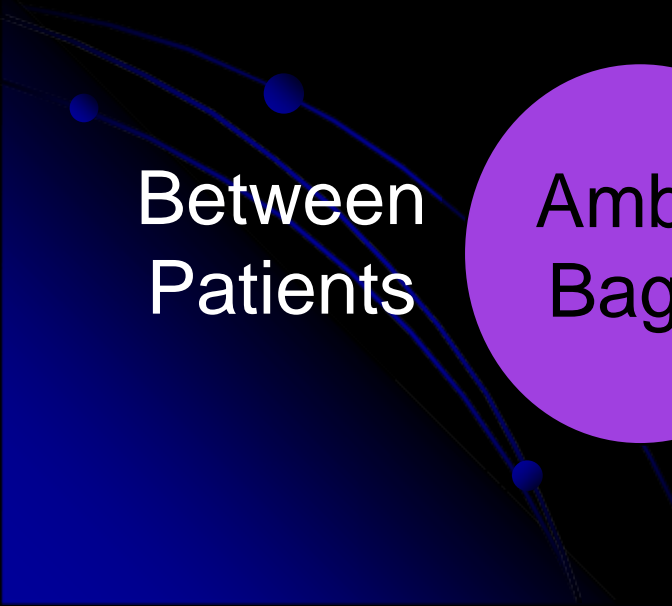
Ventilator  
Tubing

Between  
Patients

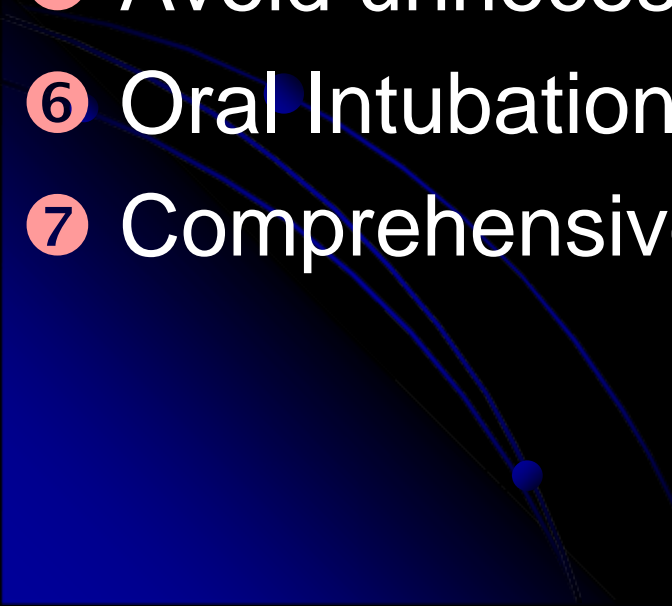
Ambu  
Bags

Inner  
Cannulas  
of Trachs

Not Enough  
Data



# Prevention of Bacterial Colonization

- ① Appropriate hand disinfection
  - ② Adequate staffing
  - ③ Avoid unnecessary antibiotic administration
  - ⑤ Avoid unnecessary stress ulcer prophylaxis
  - ⑥ Oral Intubation
  - ⑦ Comprehensive oral care
- 

# Prevention of Aspiration

- ① Avoid tracheal intubation / accidental extubation
- ② Shorten duration of mechanical ventilation
- ③ Semirecumbent positioning
- ④ Maintain endotracheal intracuff pressure  
25 – 30 cmH<sub>2</sub>O
- ⑤ Avoid gastric overdistension
- ⑥ Avoid ventilator circuit changes / manipulate
- ⑦ Drain ventilator circuit condensate



Wishing you  
a day of  
enjoyment and  
relaxation!