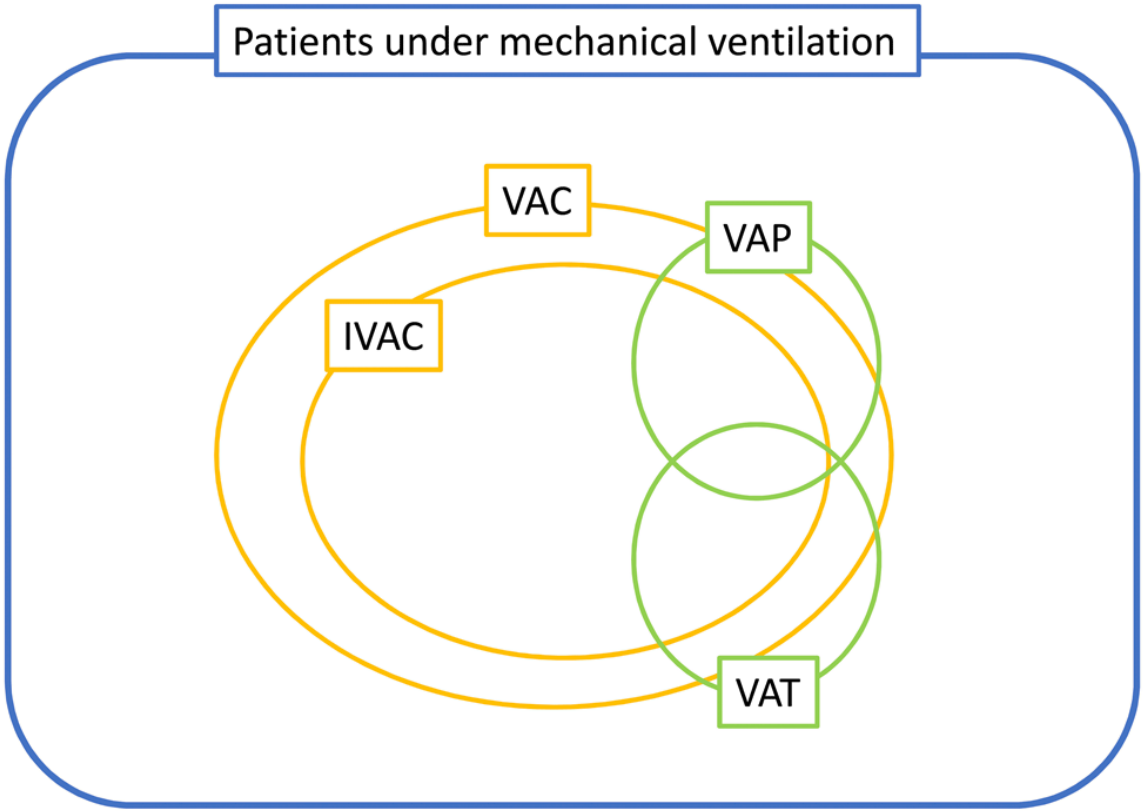
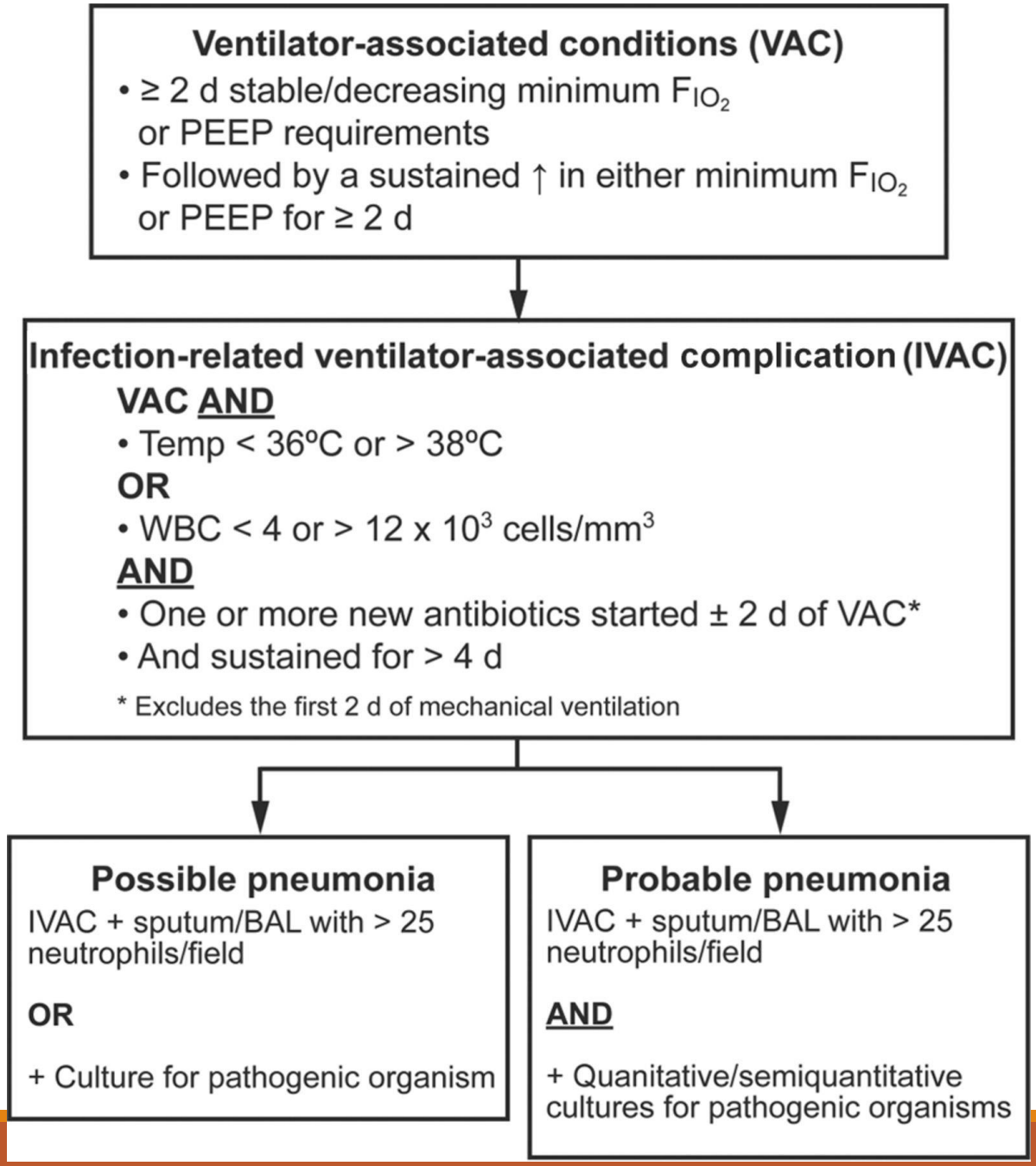
PREVENT VENTILATOR ASSOCIATED PNEUMONIA

NICU – CHILDREN'S HOSPITAL 2

What is VAP?




Ventilator-associated conditions (VAC)
• ≥ 2 d stable/decreasing minimum F_{IO_2} or PEEP requirements
• Followed by a sustained ↑ in either minimum F_{IO_2} or PEEP for ≥ 2 d
Infection-related ventilator-associated complication (IVAC)
VAC AND
• Temp < 36ºC or > 38ºC
OR
• WBC < 4 or > 12 x 10^3 cells/mm^3
AND
• One or more new antibiotics started ± 2 d of VAC*
• And sustained for > 4 d
* Excludes the first 2 d of mechanical ventilation
Possible pneumonia
IVAC + sputum/BAL with > 25 neutrophils/field
OR
+ Culture for pathogenic organism
Probable pneumonia
IVAC + sputum/BAL with > 25 neutrophils/field
AND
+ Quanitative/semiquantitative cultures for pathogenic organisms

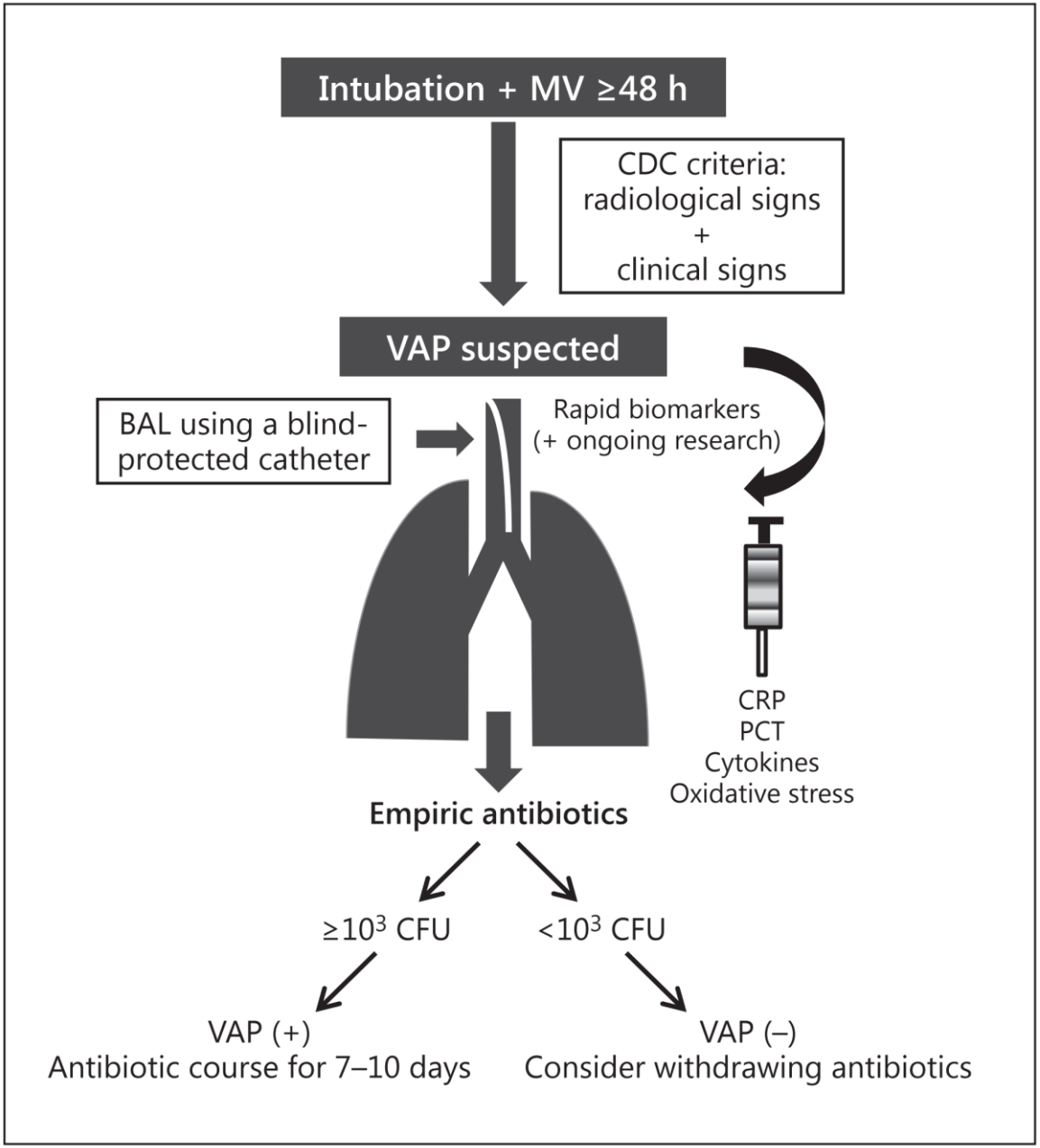


Fig. 1. Diagnostic algorithm for neonatal VAP in newborns. CRP = C-reactive protein; CFU = colony-forming units.

Table 1. CDC Alternate Criteria for Diagnosis of VAP Among Infants Age ≤1 Year

Radiographic criteria[a]
- New or progressive infiltrate and persistent infiltrate
- Consolidation
- Cavitation
- Pneumatoceles

Clinical criteria
- Worsening gas exchange (eg, oxygen desaturations, increased oxygen requirements, increased ventilator demand)

And three of the following
- Temperature instability
- Leukopenia (<4,000 WBC/mm^3) or leukocytosis (>15,000 WBC/mm^3) and left shift (>10% band forms)
- New onset of purulent sputum or change in character of sputum, or increased respiratory secretions or increased suctioning requirements
- Apnea, tachypnea, nasal flaring with retraction of chest wall or nasal flaring with grunting
- Wheezing, rales, or rhonchi
- Cough
- Bradycardia (<100 beats per minute) or tachycardia (>170 beats per minute)

CDC=Centers for Disease Control and Prevention; VAP=ventilator-assisted pneumonia; WBC=white blood cell count.

[a]In the absence of underlying conditions, one definitive chest radiograph is acceptable. Among infants who have underlying conditions, two or more serial definitive radiographs are required. For neonates, underlying pulmonary or cardiac disease may include respiratory distress syndrome, bronchopulmonary dysplasia, pulmonary edema, chronic obstructive pulmonary disease, and/or congenital heart disease.

Table 2. CDC Microbiologic Criteria for Diagnosis of Common Bacterial or Fungal VAP

In addition to radiographic and clinical criteria, at least one of the following is present:

- Positive growth in blood culture not related to another source of infection
- Positive growth in culture of pleural fluid
- Positive quantitative culture from minimally contaminated lower respiratory tract specimen (eg, BAL, protected specimen brushing)
- ≥5% BAL-obtained cells contain intracellular bacteria on direct microscopic examination (eg, Gram-stain)
- Histopathologic examination shows at least one of the following indications of pneumonia:
  - Abscess formation or foci of consolidation with intense PMN accumulation in bronchioles and alveoli
  - Positive quantitative culture of lung parenchyma
  - Evidence of lung parenchyma invasion by fungal hyphae or pseudohyphae

BAL=bronchoalveolar lavage; CDC=Centers for Disease Control and Prevention; PMN=polymorphonuclear leukocyte; VAP=ventilator-assisted pneumonia.

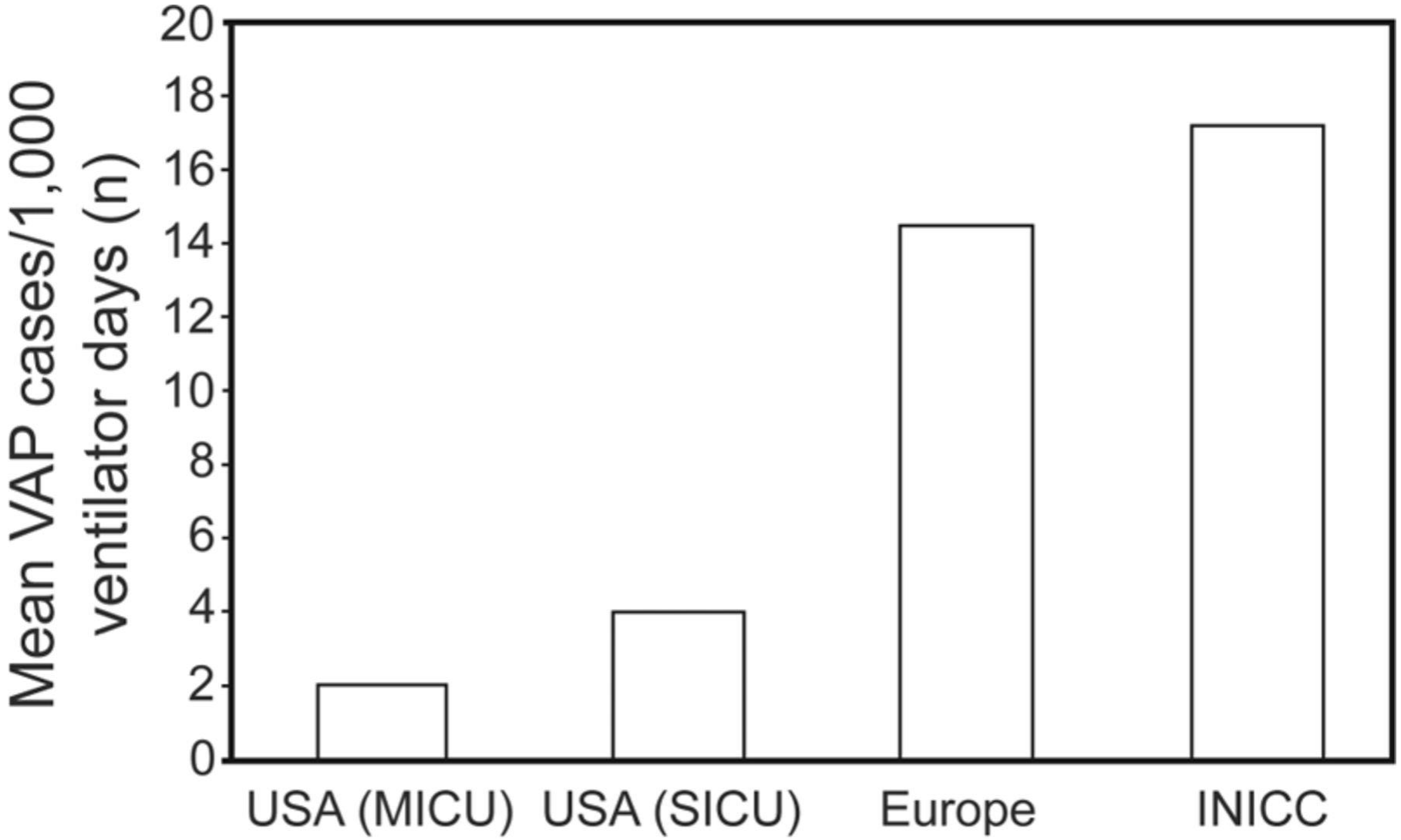

Mean VAP cases/1,000 ventilator days (n)
20
18
16
14
12
10
8
6
4
2
0
USA (MICU)
USA (SICU)
Europe
INICC

Table 2. Description of the most relevant features of studies published in relation to VAP in the neonatal period

	Afjeh et al. [12]	Apisarnthanarak et al. [13]	Cernada et al. [10]	Deng et al. [18]	Geffers et al. [14]	Tripathi et al. [11]	Yuan et al. [15]
Study design	Prospective cohort	Prospective cohort	Prospective cohort	Retrospective case-control	Prospective surveillance	Prospective cohort	Retrospective cohort
Population	Newborn; MV >48 h	BW <2,000 g; MV >48 h	Newborn; MV >48 h	Newborn; MV >48 h	BW <1,500 g; MV >48 h	Newborn; MV >48 h	Newborn; MV >48 h
Diagnostic criteria	Radiographic Clinical	Radiographic Need for antibiotics	Radiographic Clinical Microbiologic (BAL)	CDC criteria for infants aged <1 year [7]	Radiographic Clinical Analytical	CDC criteria for infants aged <1 year [7]	Radiographic Clinical Purulent secretions
Incidence[1]	11.6 episodes	<28 weeks: 6.5 episodes >28 weeks: 4 episodes	10.9 episodes	Prevalence: 33.5%	2.7 episodes	37.2 episodes	Prevalence: 20.1%
Sampling method	ET aspirate	ET aspirate	Blind-protected BAL	ET aspirate	Not provided	ET aspirate	ET aspirate
Most common pathogen (mono-polymicrobial)	*E. coli* *K. pneumoniae*	*Pseudomonas* spp. *Enterobacter* spp. Polymicrobial 58%	*P. aeruginosa* *S. aureus* Polymicrobial 16.7%	*Klebsiella* spp. *A. baumanii* Polymicrobial 24.8%	CONS *S. aureus*	*K. pneumonia* *E. coli* Polymicrobial 6%	*K. pneumoniae* *P. aeruginosa*
Outcome	Not provided	Increased mortality Increased LOF	Increased LOF	Not provided	Not provided	Increased mortality Increased LOF	Increased LOF

[1] Expressed as episodes per 1,000 ventilator days. BW = Birth weight; ET = endotracheal; LOF = length of stay; CONS = coagulase-negative staphylococci.

Table 1
Organisms recovered from tracheal aspirates of 26 neonates with VAP[a]

Organism	Neonates with VAP (%)
Gram-Negative Rods	
P aeruginosa	38
Enterobacter spp	38
Klebsiella spp	23
E coli	15
Acinetobacter spp	8
Citrobacter spp	8
Stenotrophomonas maltophilia	4
Gram-Positive Cocci	
S aureus	23
Enterococcus	15
Group B *Streptococcus*	4

Apisarnthanarak A, Holzmann-Pazgal G, Hamvas A, et al. Ventilator-associated pneumonia in extremely preterm neonates in a neonatal intensive care unit: characteristics, risk factors, and outcomes. Pediatrics 2003;112:1286–9

Endogenous sources of micro-organism

(1) Impaired natural protection/clearance system allows increased colonization of nasopharynx

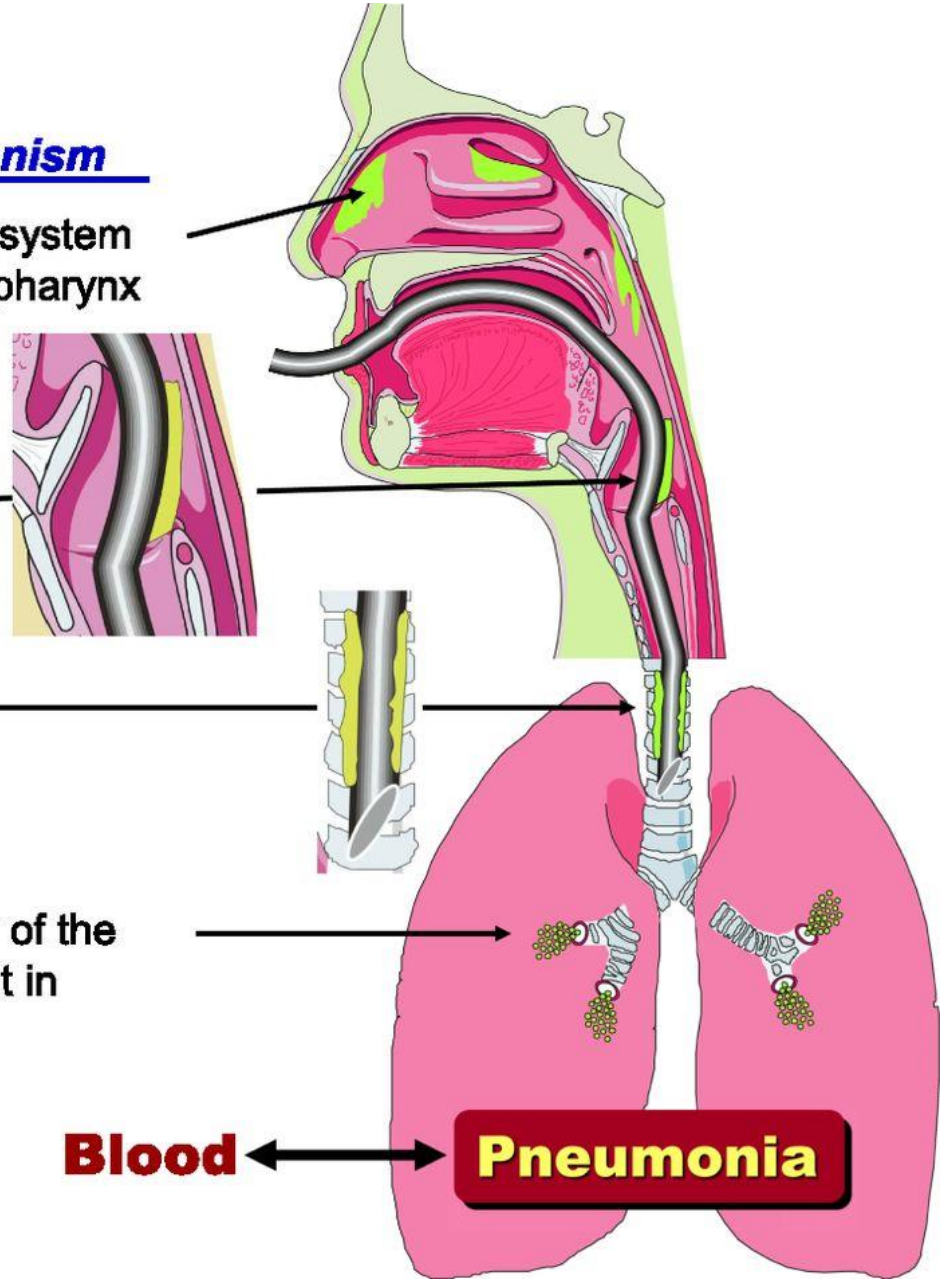
(2) Colonized oropharynx and gastric fluid pool along tube in neonates

(3) Colonized tracheal secretions

Mechanism for pneumonia

(1) Aspiration of colonized fluids from any of the above sources into the lungs can result in pneumonia

(2) A hematogenous source seeding the lungs may rarely cause pneumonia

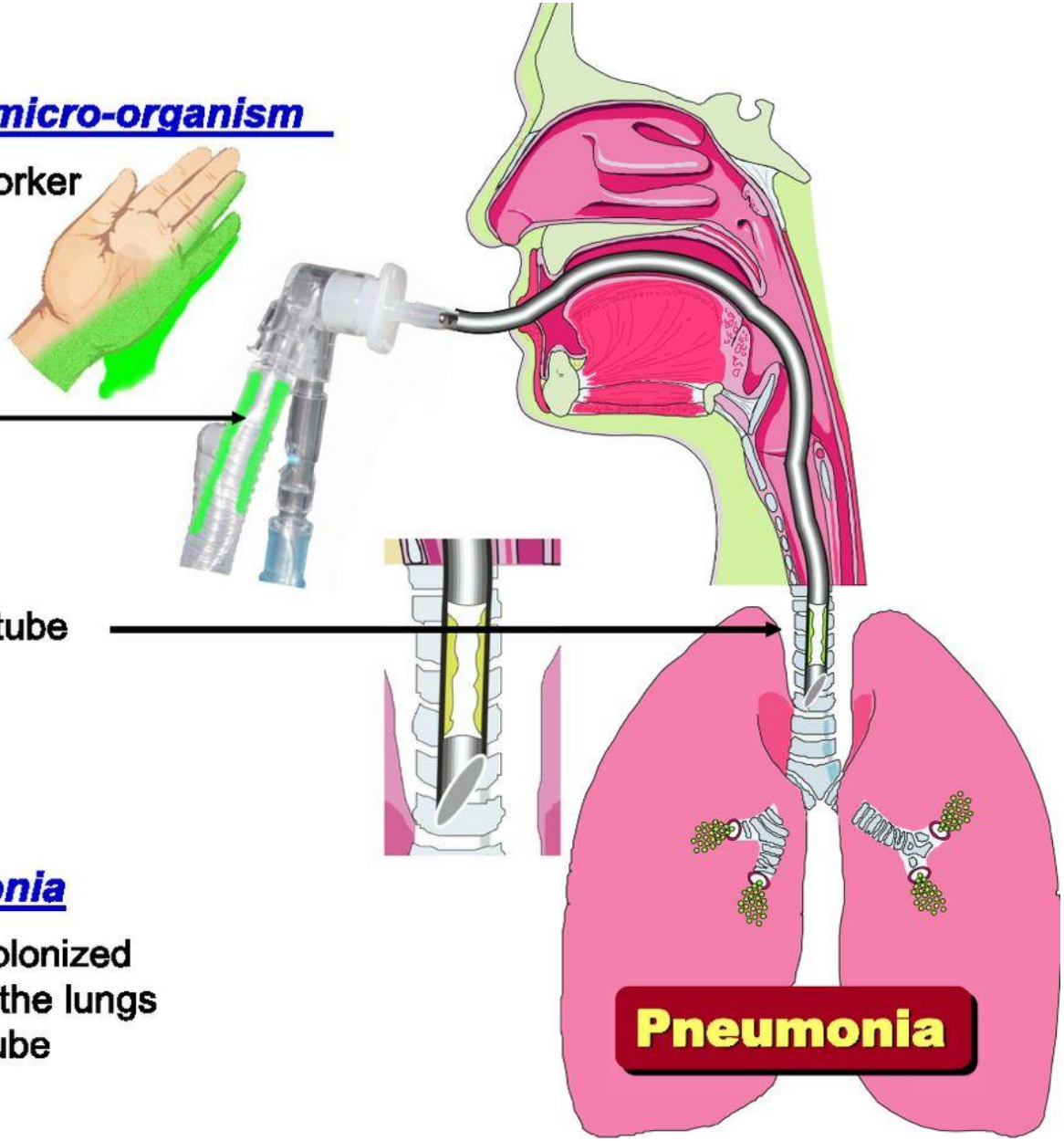


Exogenous sources of micro-organism

(1) Hands of health-care worker

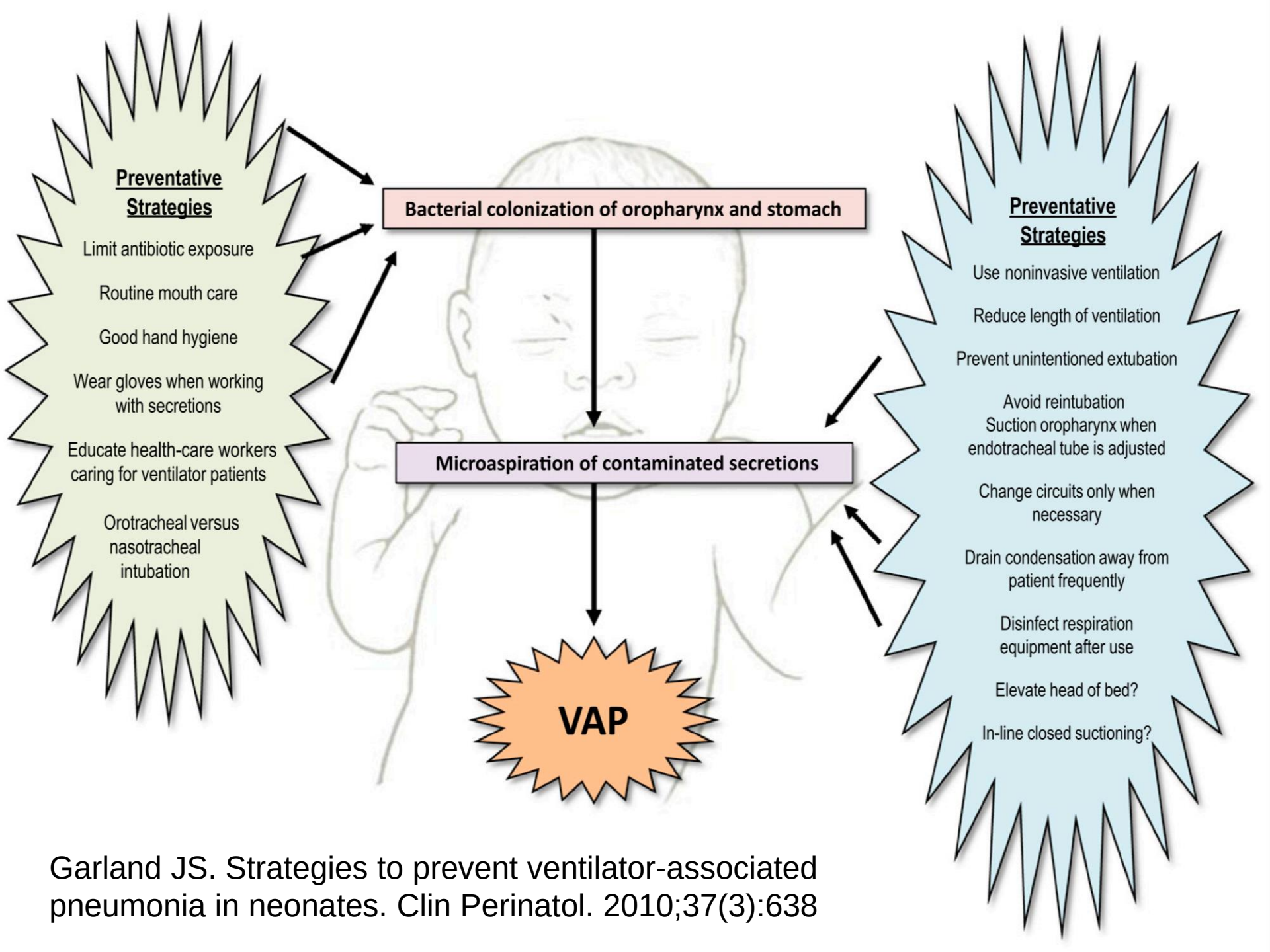
(2) Ventilator circuit

(3) Biofilm of endotracheal tube



Mechanism for pneumonia

Pneumonia occurs when colonized secretions are inhaled into the lungs through the endotracheal tube



Garland JS. Strategies to prevent ventilator-associated pneumonia in neonates. Clin Perinatol. 2010;37(3):638

Table 2
Interventions often included in bundles to prevent VAP

Adult Interventions to Prevent VAP Not Applicable to Neonates	Adult or Pediatric Interventions to Prevent VAP Applicable to Neonates	Adult Interventions to Reduce VAP Unknown Risk: Benefit in Neonates
Cuffed endotracheal tubes (II[a])	Caregiver education (IA)	Elevation of head of the bed (II)
Subglottic suctioning of secretions (II)	Hand hygiene (IA)	Oral care with antiseptic solution (II)
Silver-coated endotracheal tubes	Wearing gloves when in contact with secretions (IB)	Orotracheal vs nasotracheal intubation (IB)
Deep venous thrombosis prophylaxis	Minimize days of ventilation (IB)	In-line (closed) suctioning
	Prevent gastric distension	Sedation vacation to assess extubation readiness
	Avoid unplanned extubation	Orogastric tube vs nasogastric tube
	Change ventilator circuit only when visibly soiled or malfunctioning (IA)	
	Disinfect respiratory equipment before storage (IA)	
	Remove condensate from ventilator circuit frequently (IB)	
	Avoid reintubation (II)	

THE VENTILATOR CIRCUIT APPEARS TO HAVE ONLY A SMALL EFFECT ON THE DEVELOPMENT OF VAP

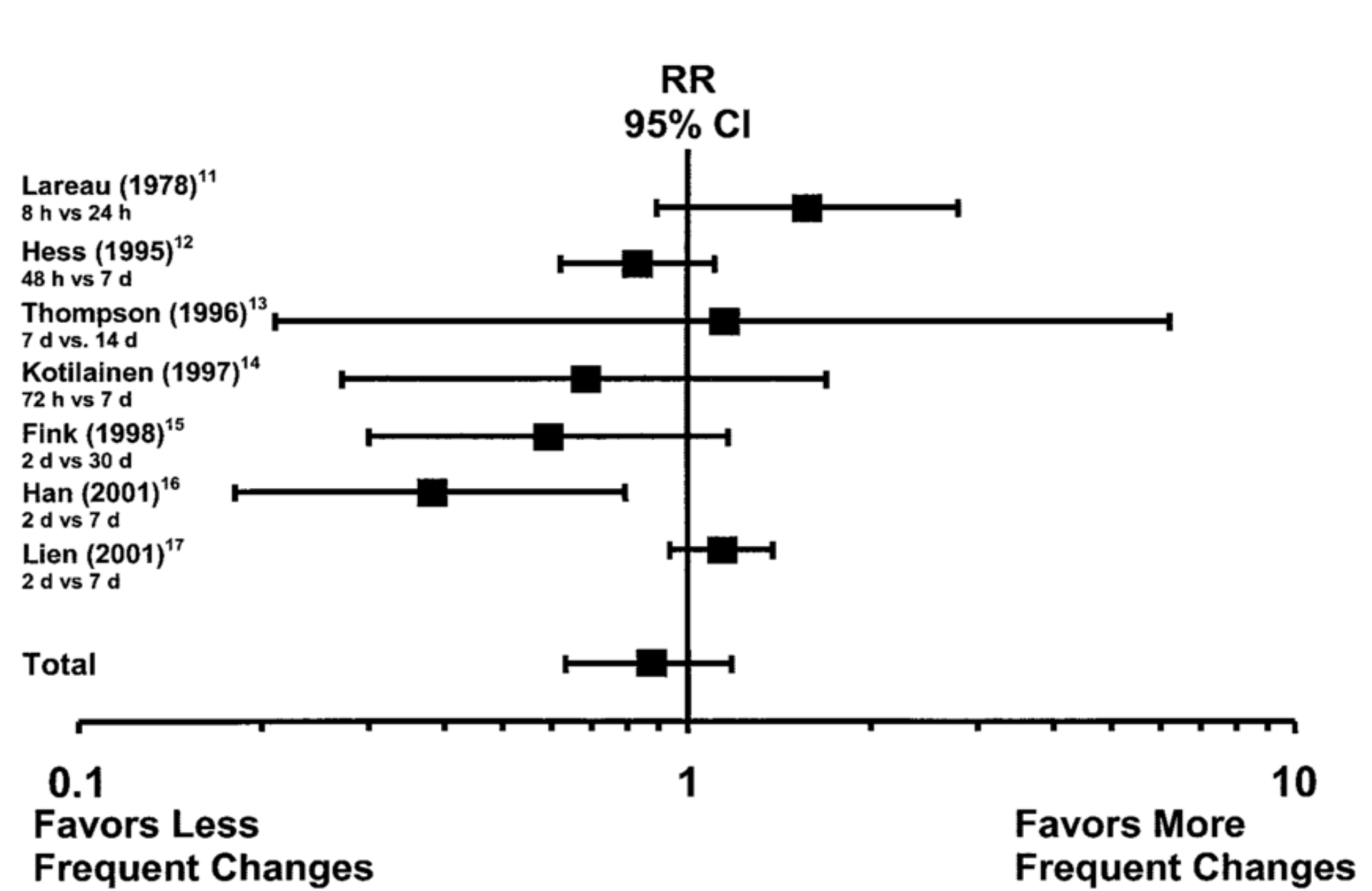
This contradicts the widely held belief that the ventilator circuit is an important contributor to the development of VAP

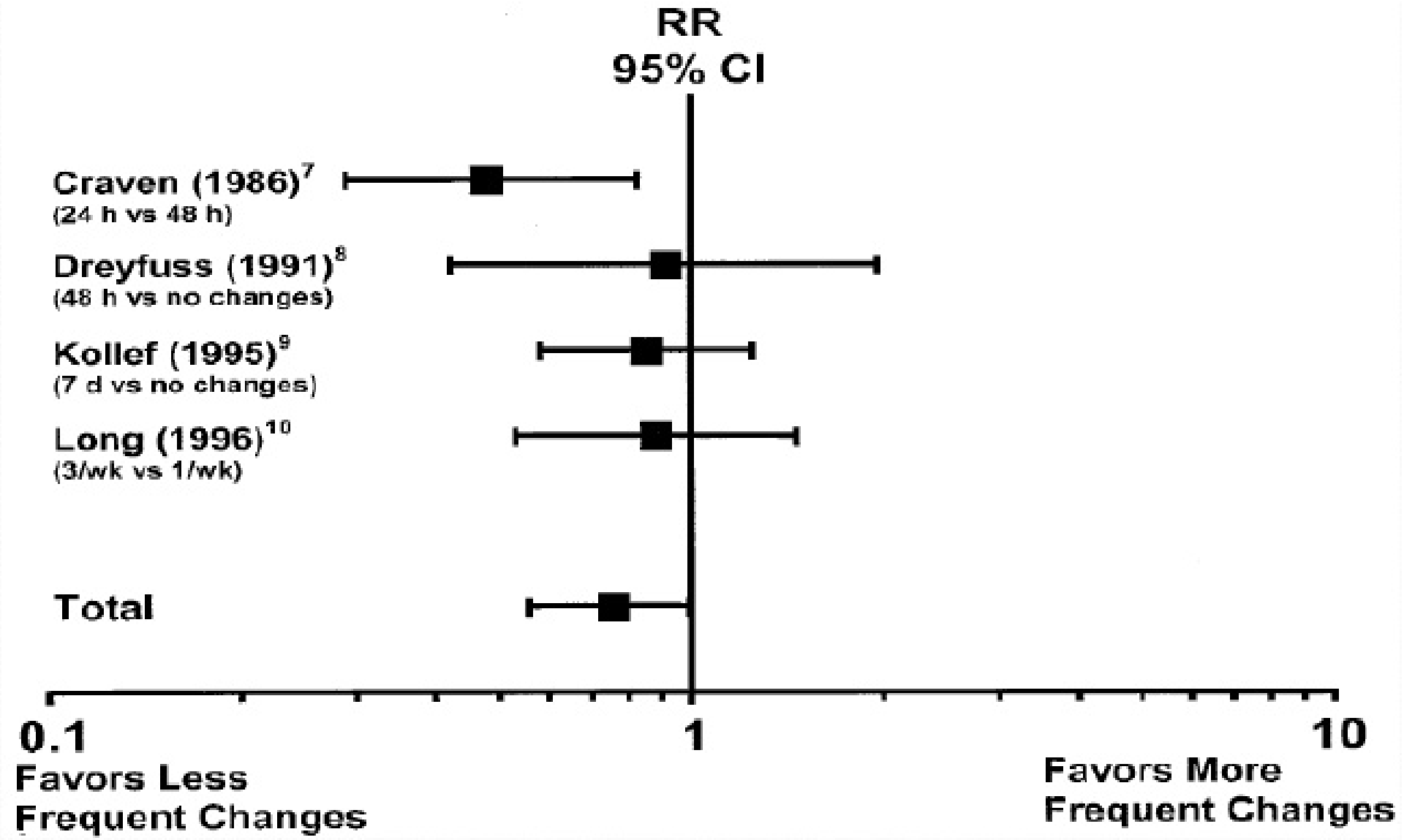
Franciscan
MEDICAL SPECIALISTS

THE SOURCE OF CONTAMINATION

- The patient contaminates the circuit, rather than the circuit contaminates the patient

- The microorganisms that colonize the ventilator circuit originate from the patient


RR
95% CI
Lareau (1978)[11]
8 h vs 24 h
Hess (1995)[12]
48 h vs 7 d
Thompson (1996)[13]
7 d vs. 14 d
Kotilainen (1997)[14]
72 h vs 7 d
Fink (1998)[15]
2 d vs 30 d
Han (2001)[16]
2 d vs 7 d
Lien (2001)[17]
2 d vs 7 d
Total
0.1
1
10
Favors Less
Frequent Changes
Favors More
Frequent Changes


RR
95% CI
Craven (1986)[7]
(24 h vs 48 h)
Dreyfuss (1991)[8]
(48 h vs no changes)
Kollef (1995)[9]
(7 d vs no changes)
Long (1996)[10]
(3/wk vs 1/wk)
Total
0.1
1
10
Favors Less
Frequent Changes
Favors More
Frequent Changes

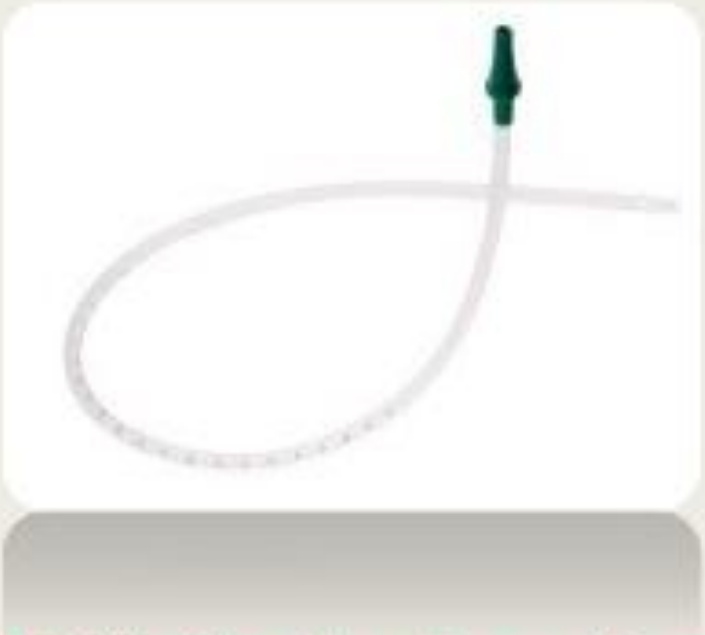
Change ventilator circuit **only** when **visibly soiled** or **malfunctioning** (IA)

Do we have to suction routinely ?

- It is recommended that endotracheal suctioning should be performed only when secretions are present, and not routinely.
  - *Inspection*
  - *Ascultation*
  - *Ventilator graphics*

Based of AARC 2010 gduieline

Endotracheal suctioning techniques



Which better do you think?

Open

- Disconnected from the ventilator during procedure:
  - ↑ *Desaturation*
  - ↑ *Atelectasis*
  - ↑ *VAP*
  - ↑ *Drop in the HR*

Closed

- Connected to the ventilatoy during the procedure:
  - ↓*Desaturation*
  - ↓ *Atelectasis*
  - ↓*VAP incidance*
  - ↓*drop in the HR*

Closed versus Open Endotracheal Suctioning in Extremely Low-Birth-Weight Neonates: A Randomized, Crossover Trial 2012

Closed versus partially ventilated endotracheal suction in extremely preterm neonates: physiologic consequences 2005

Cochrane Library

Cochrane Database of Systematic Reviews

Tracheal suctioning without disconnection in intubated ventilated neonates (Review)

Taylor JE, Hawley G, Flenady V, Woodgate PG

Main results

Four trials (252 infants) / suctioning with or without disconnection was compared.

Suctioning without disconnection resulted in:

- ↓ **episodes of hypoxia**
  (typical RR 0.48, CI 95% 0.31 to 0.74; 3 studies; 241 participants)
- ↓ **percentage change in heart rate**
  (weighted mean difference (WMD) 6.77, 95% CI 4.01 to 9.52; 4 studies; 239 participants)
- ↓ **number of infants experiencing a decrease in heart rate by > 10%**
  (typical RR 0.61, CI 0.40 to 0.93; 3 studies; 52 participants)
- ↓ **number of infants having bradycardic episodes**
  (typical RR 0.38, CI 95% 0.15 to 0.92; 3 studies; 241 participants)

Authors' conclusions

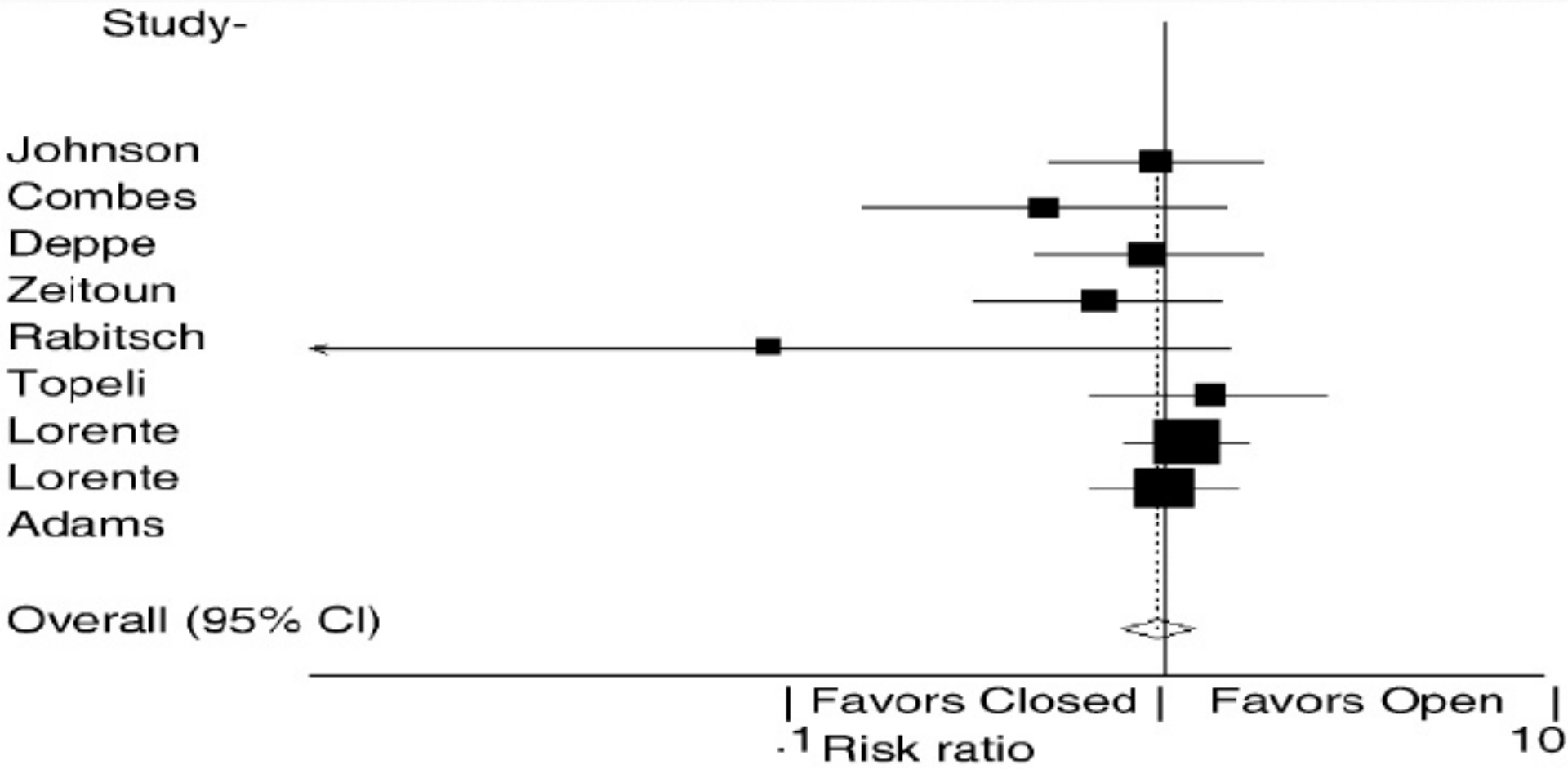
There is some evidence to suggest suctioning without disconnection from the ventilator improves the short term outcomes; however the evidence is not strong enough to recommend this practice as the only method of endotracheal suctioning.

Future research utilizing larger trials needs to address the implications of the different techniques on ventilator associated pneumonia, pulmonary morbidities and neurodevelopment. Infants less than 28 weeks also need to be included in the trials.

Impact of the suctioning system (open vs. closed) on the incidence of ventilation-associated pneumonia: meta-analysis of randomized controlled trials

Intensive Care Med (2006) 32:1329–1335
DOI 10.1007/s00134-006-0241-3

ORIGINAL



Journal of Intensive Care Medicine
26(5) 326-329

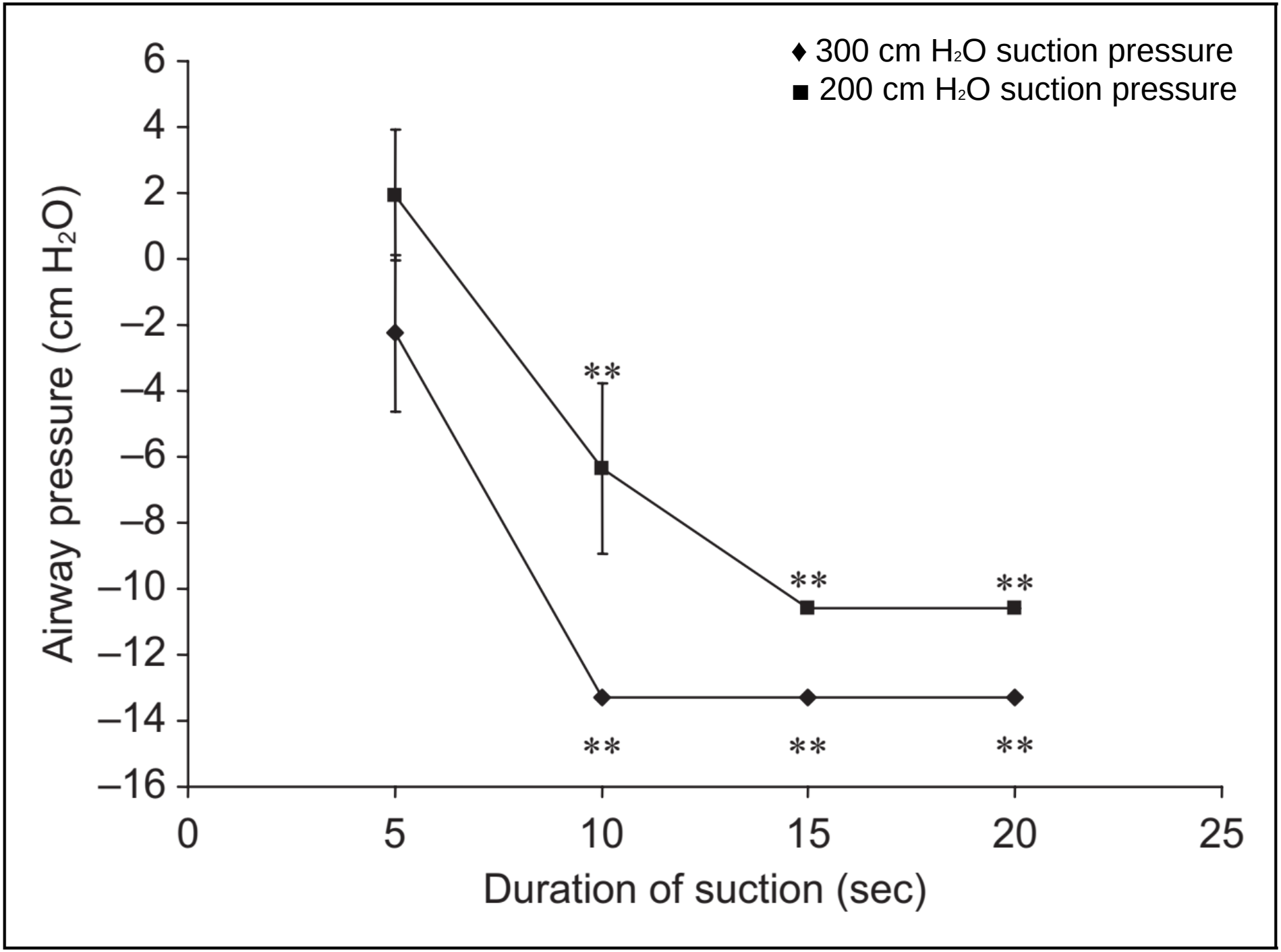
DOI: 10.1177/0885066610392516
http://jicm.sagepub.com

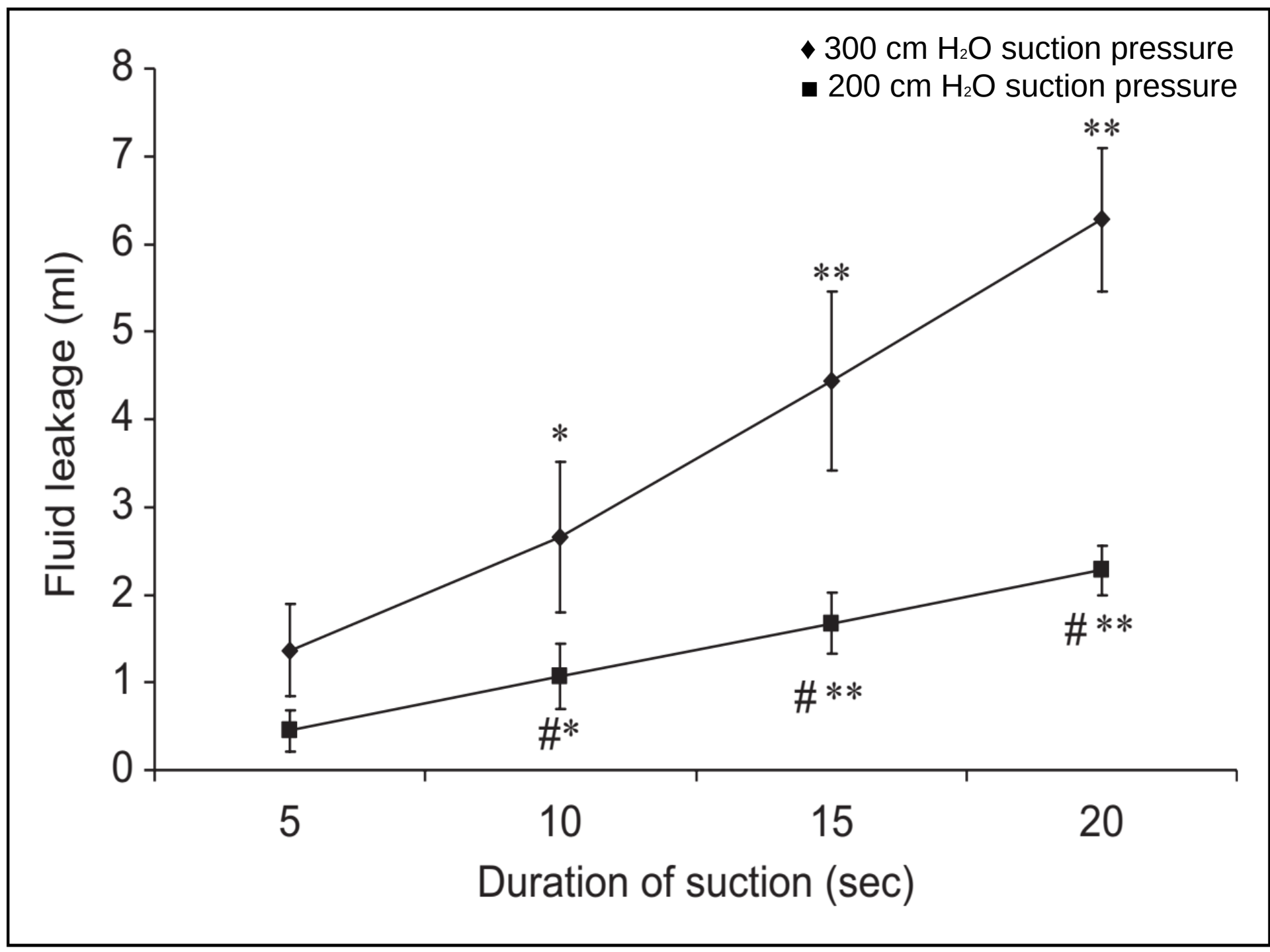
Massive Aspiration Past the Tracheal Tube Cuff Caused by Closed Tracheal Suction System

Mital H. Dave, MD[1], Angela Frotzler, PhD[1], Caveh Madjdpour, MD[1], Nelly Koepfer, MSc[1], and Markus Weiss[1]

Abstract

Background: Aspiration past the tracheal tube cuff has been recognized to be a risk factor for the development of ventilator-associated pneumonia (VAP). This study investigated the effect of closed tracheal suctioning on aspiration of fluid past the tracheal tube cuff in an in vitro benchtop model. **Methods:** High-volume low pressure tube cuffs of 7.5 mm internal diameter (ID) were placed in a 22 mm ID artificial trachea connected to a test lung. Positive pressure ventilation (PPV) with 15 cm H_2O peak inspiratory pressure and 5 cm H_2O positive end-expiratory pressure (PEEP) was used. A closed tracheal suction system (CTSS) catheter (size 14Fr) was attached to the tracheal tube and suction was performed for 5, 10, 15, or 20 seconds under 200 or 300 cm H_2O suction pressures. Amount of fluid (mL) aspirated along the tube cuff and the airway pressure changes were recorded for each suction procedure. Fluid aspiration during different suction conditions was compared using Kruskal-Wallis and Mann-Whitney test (Bonferroni correction [$\alpha = .01$]). **Results:** During 10, 15, and 20 seconds suction, airway pressure consistently dropped down to -8 to -13 cm H_2O ($P < .001$) from the preset level. Fluid aspiration was never observed under PPV + PEEP but occurred always during suctioning. Aspiration along the tube cuff was higher with -300 cm H_2O than with -200 cm H_2O suction pressure ($P < .001$) and was much more during 15 and 20 seconds suction time as compared to 5seconds ($P < .001$). Conclusion: Massive aspiration of fluid occurs along the tracheal tube cuff during suction with the closed tracheal suction system.


♦ 300 cm H₂O suction pressure
■ 200 cm H₂O suction pressure
Airway pressure (cm H₂O)
6
4
2
0
–2
–4
–6
–8
–10
–12
–14
–16
0
5
10
15
20
25
Duration of suction (sec)
**
**
**
**
**
**


♦ 300 cm H2O suction pressure
■ 200 cm H2O suction pressure
Fluid leakage (ml)
0
1
2
3
4
5
6
7
8
5
10
15
20
Duration of suction (sec)
*
**
**
#*
#**
#**

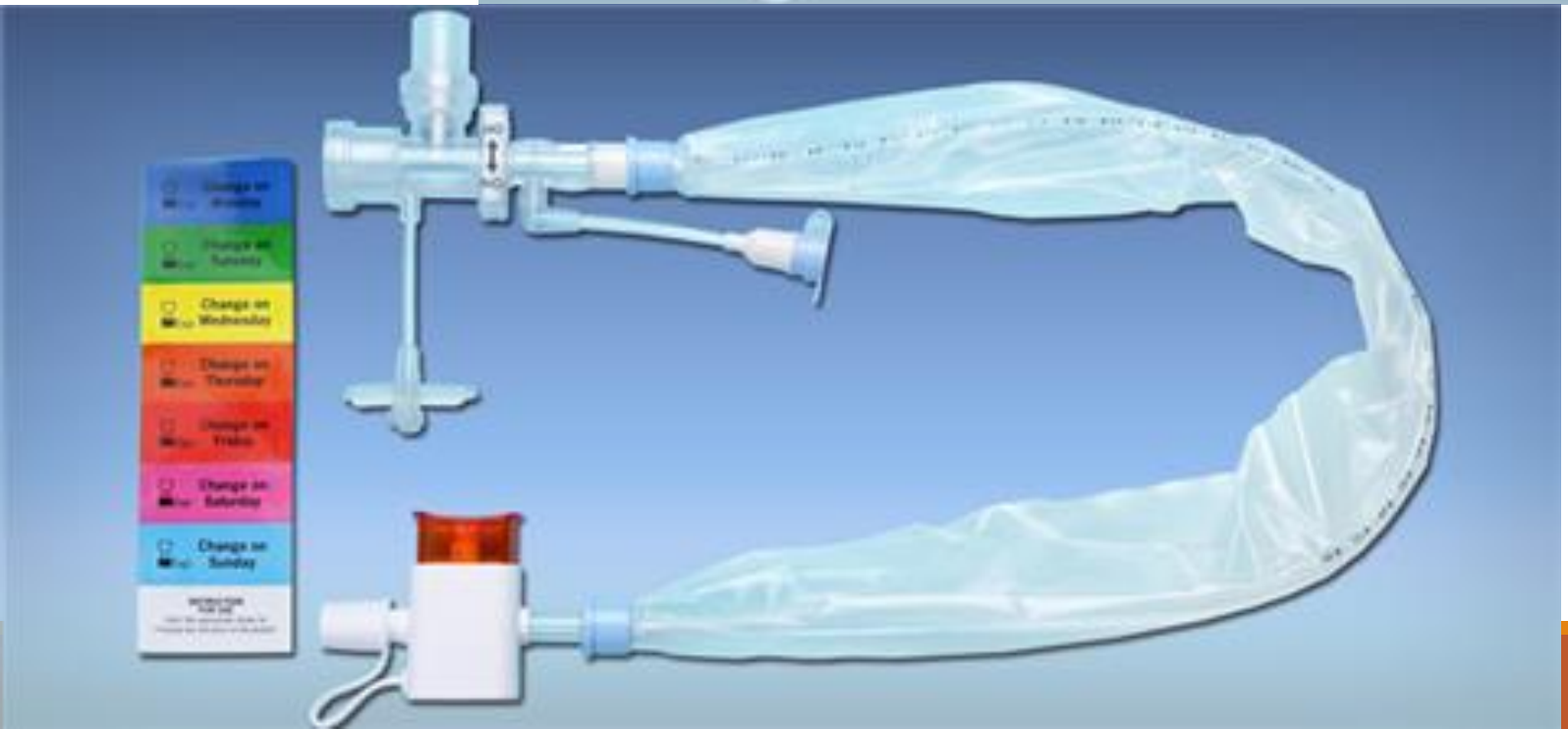
Suction pressure

- For neonates (-60 to -80)
- Children (-80 to –100)

LESS THAN 15 SEC

Age	Weight (kg)	ETT (mm ID)	Mucus Consistency, Catheter Size (FG)		
			Liquid	Medium	Thick
Newborn	<1	2.0	5	5	5
Newborn	1	2.5	5	5	6
Newborn	2	3.0	5	6	6
Newborn	3.5	3.5	5	6	7
3 months	6	3.5	5	6	7
1 year	10	4.0	6	7	7
2 years	12	4.5	6	7	8
3 years	14	4.5	6	7	8
4 years	16	5.0	7	8	8
6 years	20	5.5	7	8	8
8 years	24	6.0	8	10	10
10 years	30	6.5	8	10	12
12 years	>30	7.0	8	10	12

ETT, endotracheal tube; mm ID, mm internal diameter; FG, French gauge.


Change on Monday
Change on Tuesday
Change on Wednesday
Change on Thursday
Change on Friday
Change on Saturday
Change on Sunday

Goals

- Decrease / Prevent Ventilator Associated Pneumonia (VAP)
- Decrease LOS in the ICU