Pearls & Pitfalls in Infectious Diseases

Prevention of HAIs

What physicians should know? part I

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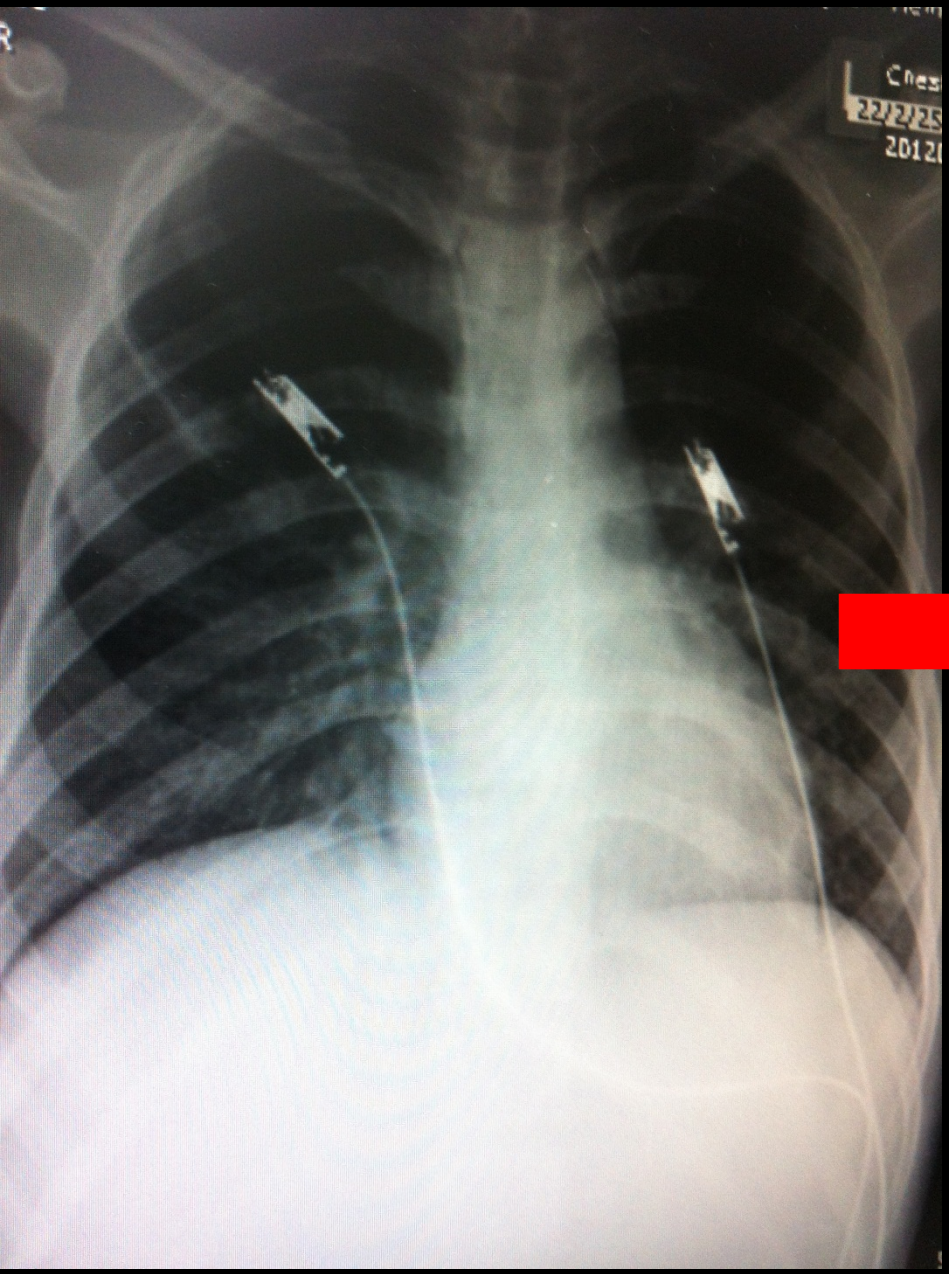
Faculty of Medicine, Chulalongkorn University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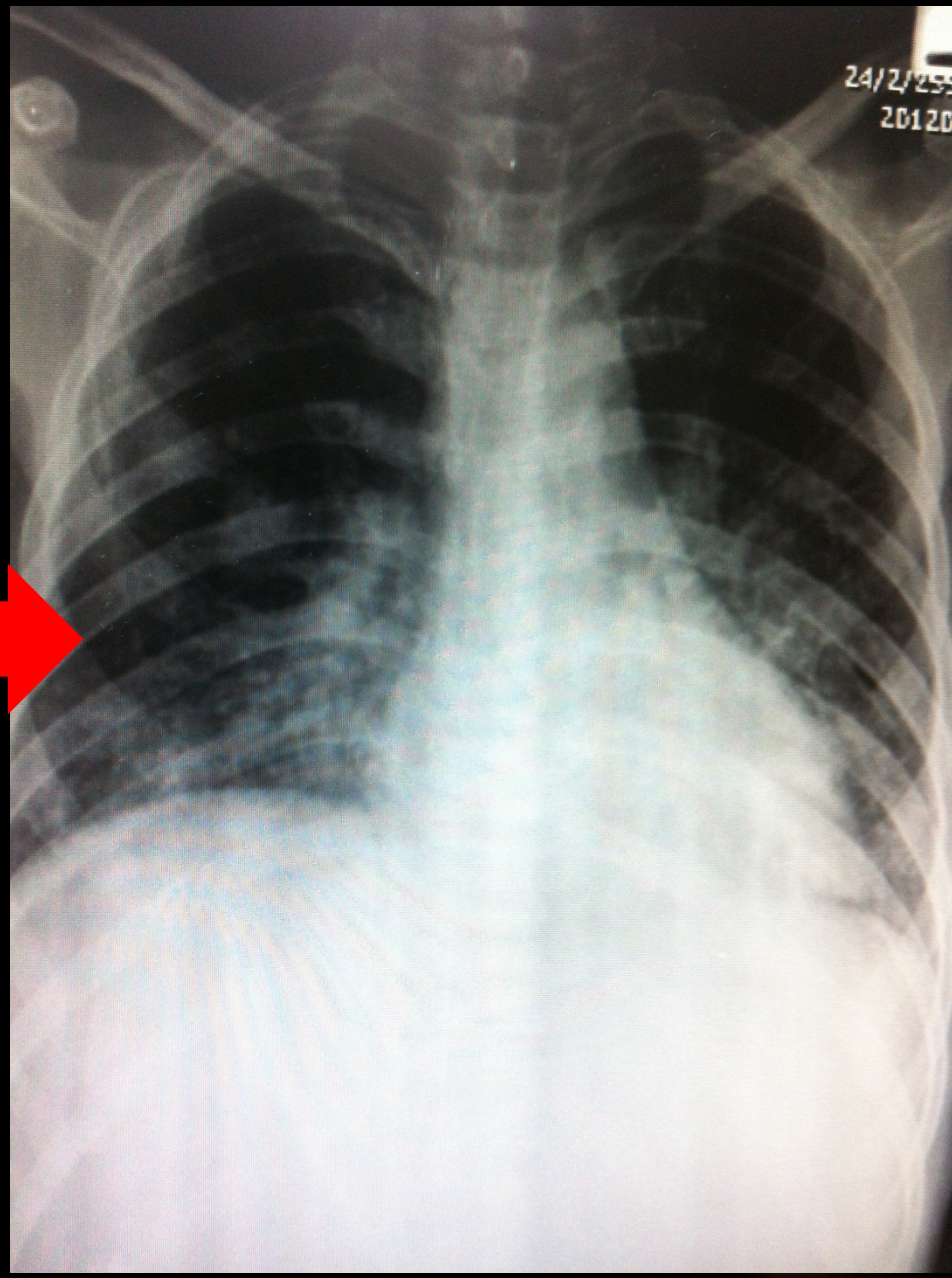
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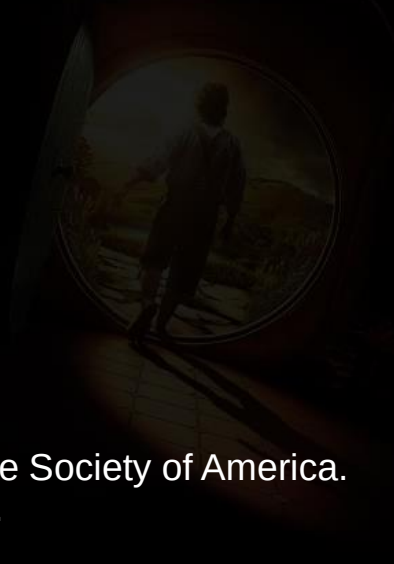
Overview

- Hospital-acquired pneumonia (HAP)
- Ventilator-associated pneumonia (VAP)
- Pathogenesis
- Prevention strategies

HAP vs VAP

- Hospital-acquired pneumonia (HAP)
  - pneumonia that occurs 48 hours or more after admission

- Ventilator-associated pneumonia (VAP)
  - pneumonia that arises more than 48–72 hours after endotracheal intubation



American Thoracic Society & Infectious Disease Society of America. Am J Respir Crit Care Med 2005;171:388–416.

Pathogenesis HAP

- Balance between host defenses VS microbial propensity for colonization → invasion

- Microbial pathogens → lower respiratory tract → colonization → overwhelm host's mechanical defenses

- Sources of infection
  - Healthcare devices
  - Environment (air, water, equipment, and fomites)
  - Transfer of microorganisms between staff and patients

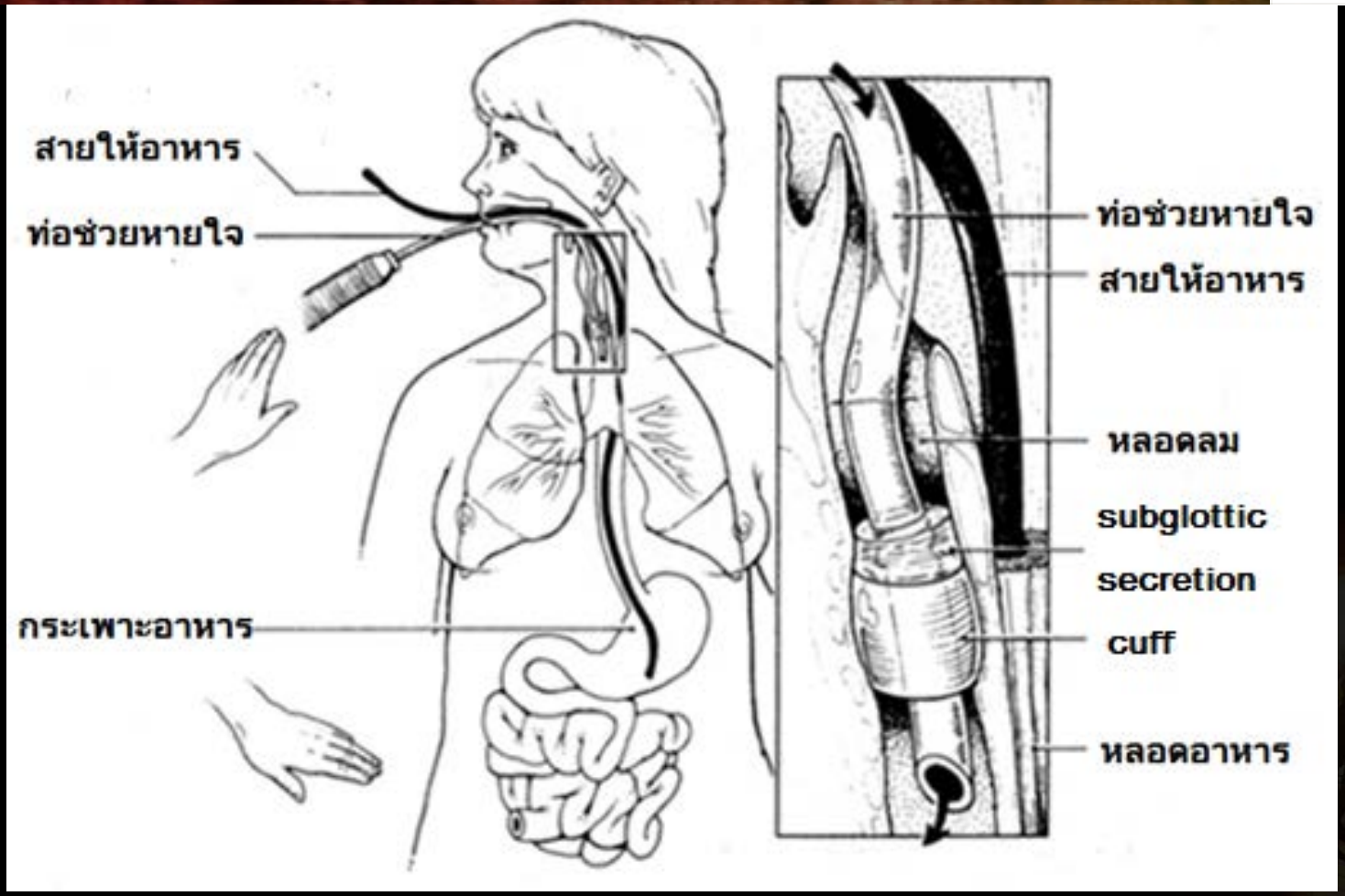
American Thoracic Society & Infectious Disease Society of America. Am J Respir Crit Care Med 2005;171:388–416.

Pathogenesis VAP

- Aspiration of oropharyngeal pathogens
- Leakage of bacteria around the endotracheal tube cuff
- Colonization of ET tube with bacteria encased in biofilm → suction / bronchoscopy → alveoli
- Inhalation of pathogens from contaminated aerosols
- Direct inoculation
- Hematogenous spread

American Thoracic Society & Infectious Disease Society of America. Am J Respir Crit Care Med 2005;171:388–416.

Pathogenesis VAP



Adapted from Craven DE, Steger KA. Infect Control Hosp Epidemiol. 1997 Nov;18(11):783-95.

Prevention strategies

VAP bundle

VAP rate up to 65%

↓

VAP Bundle:

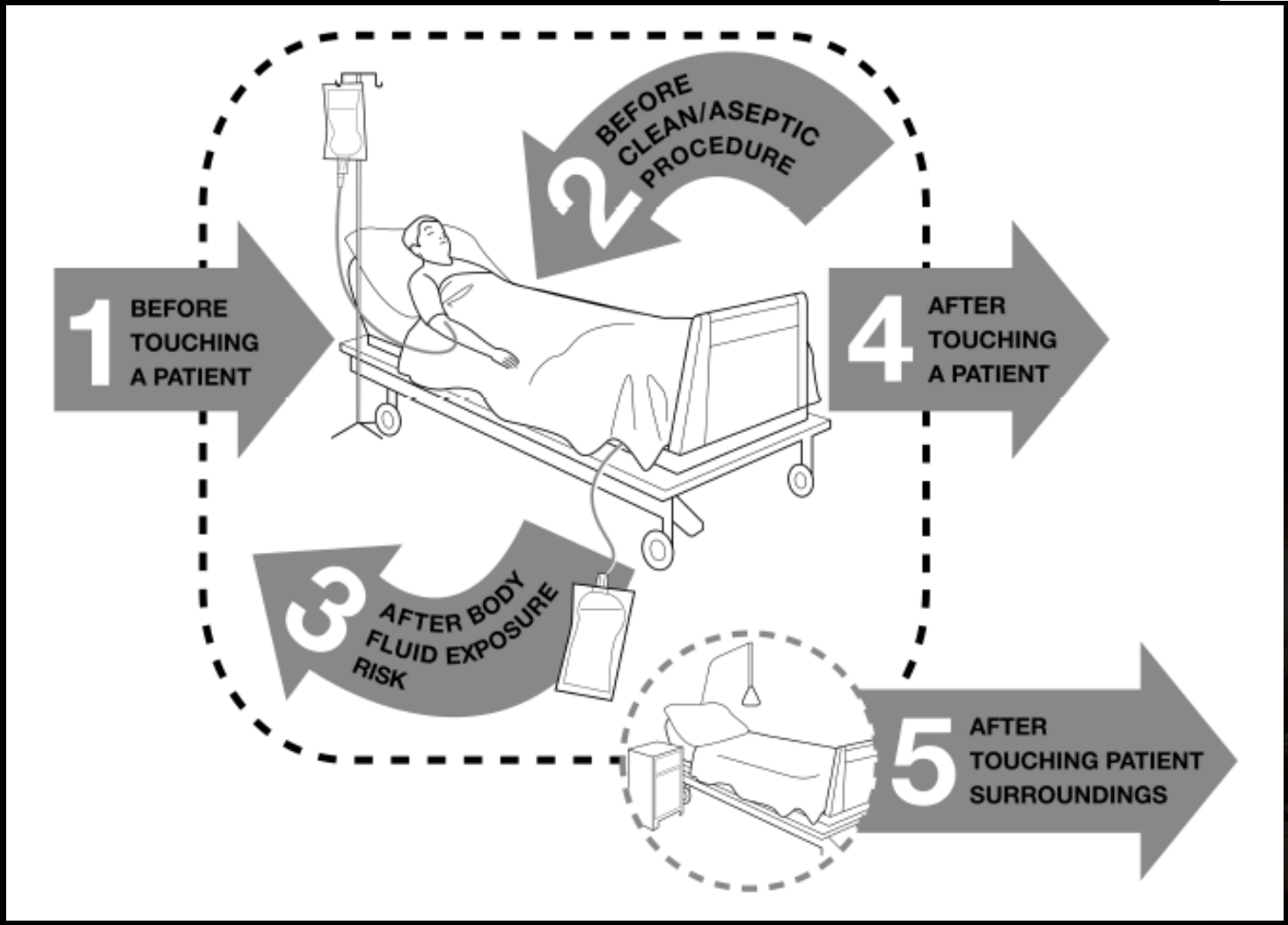
- Head of bed elevation 30-45°
- DVT prophylaxis
- Stress ulcer prophylaxis
- Daily interruption of sedation
- Daily oral care with chlorhexidine

↓

VAP rate reduced by 44.5%

Resar R, et al. Jt Comm J Qual Patient Saf 2005; 31:243–248.

Hand hygiene



Pittet D, Allegranzi B, Boyce J, et al. Infect Control Hosp Epidemiol 2009;30:611-622.

Non-invasive positive pressure ventilator (NIPPV)

NONINVASIVE VENTILATION FOR ACUTE EXACERBATIONS OF CHRONIC OBSTRUCTIVE PULMONARY DISEASE

LAURENT BROCHARD, M.D., JORDI MANCEBO, M.D., MARC WYSOCKI, M.D., FRÉDÉRIC LOFASO, M.D., GIORGIO CONTI, M.D., ALAIN RAUSS, M.D., GÉRALD SIMONNEAU, M.D., SALVADOR BENITO, M.D., ALESSANDRO GASPARETTO, M.D., FRANÇOIS LEMAIRE, M.D., DANIEL ISABEY, PH.D., AND ALAIN HARF, M.D.

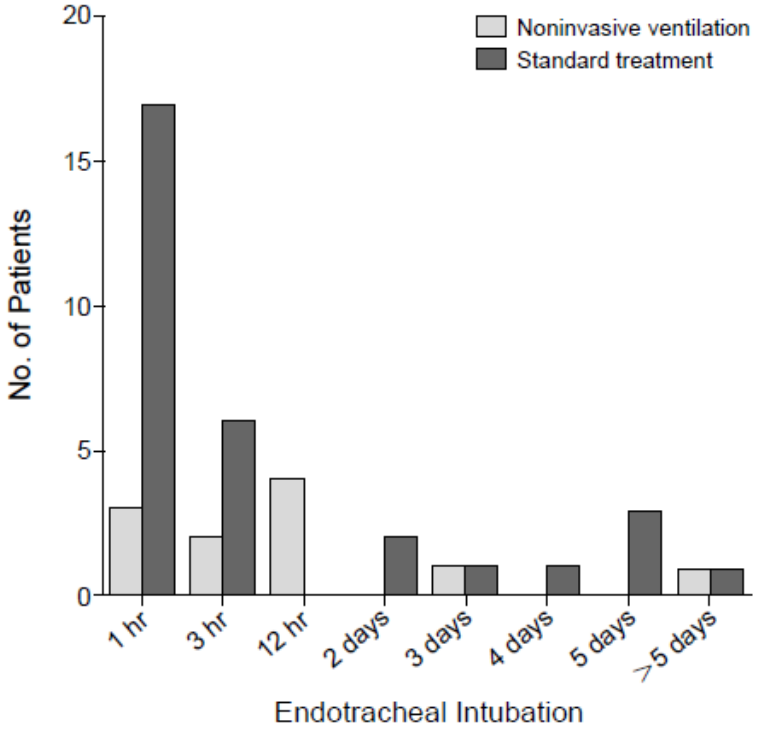


Figure 2. The Time at Which Endotracheal Intubation Was Performed in the Two Treatment Groups.

A total of 17 patients required intubation after the first hour in the standard-treatment group, as compared with only 3 patients in the noninvasive-ventilation group.

Table 4. Complications and Lethal Events in the Two Treatment Groups.*

Complication	Standard Treatment (N = 42)		Noninvasive Ventilation (N = 43)	
	No. of Complications	No. Leading to Death	No. of Complications	No. Leading to Death
Pneumonia	7	2	2	0
Sepsis	3	2†	2	1
Gastrointestinal tract disorders	2	1	1	0
Myocardial infarction	2	1	1	1‡
Multiple pneumothoraxes	1	1	0	0
Difficult or complicated endotracheal intubation	4§	1	0	0
Pulmonary embolism	1	1	0	0
Cerebral hemorrhage	0	0	1	1
Cardiac or respiratory problems during weaning	1	1¶	1	1
Cardiac arrest after weaning	2	2†	0	0
Facial-skin necrosis	0	0	1	0
Total	232	121	9	4

*Each of five patients had two complications.
†One patient was not intubated.
‡The patient was not intubated.
§One patient removed the tube.
¶One patient had a do-not-resuscitate order.

Brochard L, et al. N Engl J Med. 1995 Sep 28;333(13):817-22.

NIPPV

Study	Patient Population	Design	Patients (*n*)		Pneumonia Rate (%)	
			NPPV	Control	NPPV	Control
Brochard et al[10]	COPD exacerbation	Randomized controlled trial	43	42	5	17
Guerin et al[11]	Medical intensive care unit	Prospective cohort	30	199	0	8
Antonelli et al[12]	Acute hypoxemic respiratory failure	Randomized controlled trial	32	32	3	25
Nava et al[13]	Intubated COPD patients randomized to extubation and NPPV or remained intubated	Randomized controlled trial	25	25	0	28
Nourdine et al[14]	All mechanically ventilated patients during study period	Prospective cohort	129	607	0	13
Antonelli et al[15]	Acute respiratory failure in patients with solid-organ transplantation	Randomized controlled trial	20	20	10	20
Hilbert et al[16]	Acute respiratory failure in immunocompromised patients	Randomized controlled trial	26	26	8	23
Girou et al[17]	Medical intensive care unit	Matched case control	50	50	8	22
Carlucci et al[1]	All mechanically ventilated patients during study period	Prospective cohort	65	380	2	19
Keenan et al[18]	Post-extubation respiratory failure	Randomized controlled trial	39	42	41	40
Ferrer[19]	Persistent weaning failure	Randomized controlled trial	21	22	24	59
Ferrer[20]	Acute hypoxemic respiratory failure	Randomized controlled trial	51	54	10	24

NPPV = noninvasive positive-pressure ventilation
COPD = chronic obstructive pulmonary disease

Hess DR. Respir Care. 2005 Jul;50(7):924-9.

NIPPV

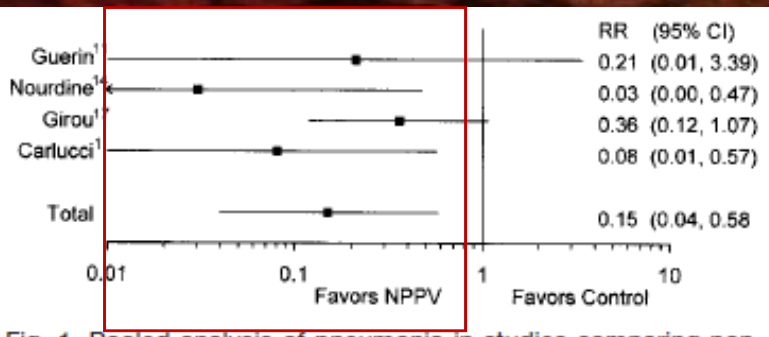


Fig. 1. Pooled analysis of pneumonia in studies comparing noninvasive positive-pressure ventilation (NPPV) with invasive mechanical ventilation. p = 0.13 for heterogeneity. p = 0.006 for overall effect. RR = relative risk. CI = confidence interval.

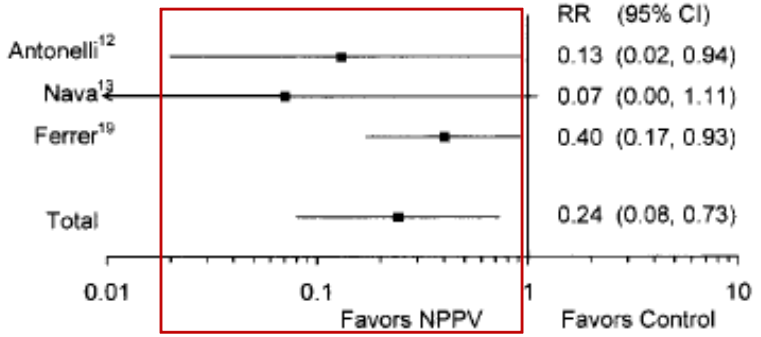


Fig. 2. Pooled analysis of pneumonia in studies where patients were assigned to noninvasive positive-pressure ventilation (NPPV) or invasive mechanical ventilation. p = 0.25 for heterogeneity. p = 0.01 for overall effect. RR = relative risk. CI = confidence interval.

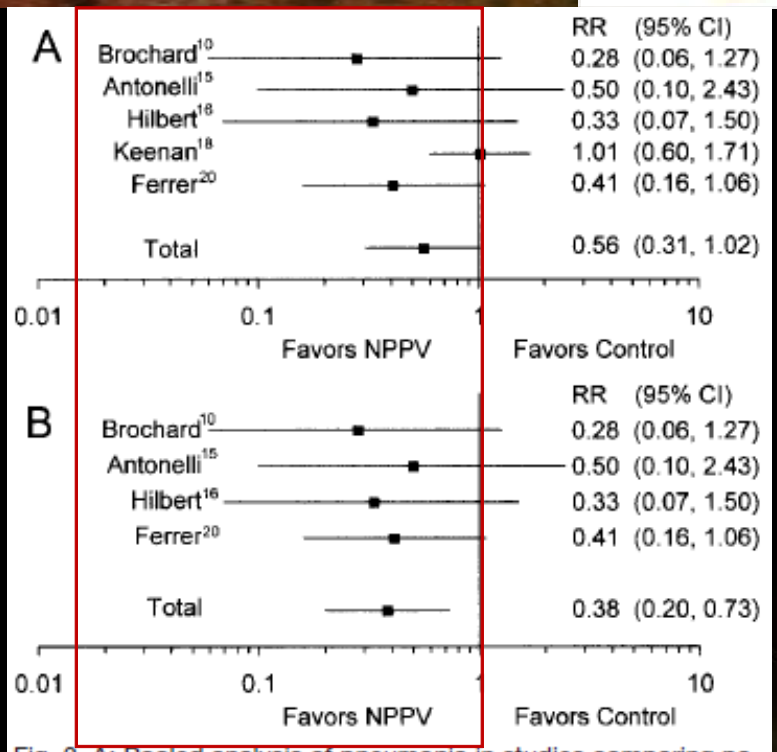


Fig. 3. A: Pooled analysis of pneumonia in studies comparing patients assigned to noninvasive positive-pressure ventilation (NPPV) or assigned to standard therapy. p = 0.19 for heterogeneity. p = 0.06 for overall effect. B: Pooled analysis of pneumonia in studies comparing patients assigned to NPPV or assigned to standard therapy after removal of the study showing no benefit for noninvasive positive-pressure ventilation (NPPV) (failed extubation). p = 0.96 for heterogeneity. p = 0.003 for overall effect. RR = relative risk. CI = confidence interval.

Hess DR. Respir Care. 2005 Jul;50(7):924-9.

Body Position

AMERICAN JOURNAL OF
Respiratory and Critical Care Medicine®

Semirecumbent position protects from pulmonary aspiration but not completely from gastroesophageal reflux in mechanically ventilated patients.

M Orozco-Levi, A Torres, M Ferrer, C Piera, M el-Ebiary, J P de la Bellacasa and R Rodriguez-Roisin

- 2 body positions → supine & semirecumbency
- Samples of gastric contents, pharyngeal and bronchial secretions
- NG tube isotopic instillation of Tc99m → Radioactivity counting (RAc values)
- RAc values in bronchial secretions were higher at 5 h in
  - Supine position VS baseline ($p < 0.05$)
  - Supine position VS semirecumbency ($p < 0.01$)

Orozco-Levi M, Torres A, Ferrer M, et al. Am J Respir Crit Care Med 1995;152(4):1387-90.

Supine body position as a risk factor for nosocomial pneumonia in mechanically ventilated patients: a randomised trial

Mitra B Drakulovic, Antoni Torres, Torsten T Bauer, Jose M Nicolas, Santiago Nogué, Miquel Ferrer

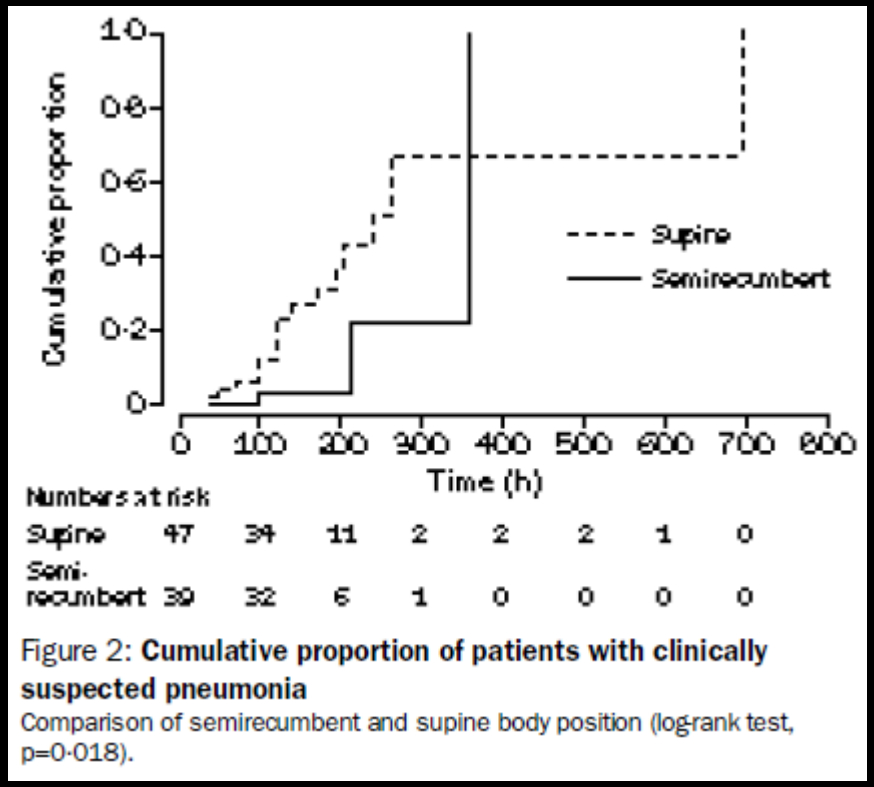


Figure 2: **Cumulative proportion of patients with clinically suspected pneumonia**
Comparison of semirecumbent and supine body position (log-rank test, p=0·018).

- 86 intubated and mechanically ventilated patients
- semirecumbent (n=39) or supine (n=47)
- Supine body position (odds ratio 6·8 [1·7–26·7], p=0·006) → independent risk factors for nosocomial pneumonia

Drakulovic MB, Torres A, Bauer TT, et al. *Lancet* 1999;354:1851-8.

Feasibility and effects of the semirecumbent position to prevent ventilator-associated pneumonia: A randomized study*

Christianne A. van Nieuwenhoven, MD; Christine Vandenbroucke-Grauls, PhD; Frank H. van Tiel, PhD; Hans C. A. Joore, MD; Rob J. M. Strack van Schijndel, MD; Ingeborg van der Tweel, PhD; Graham Ramsay, PhD; Marc J. M. Bonten, PhD

Context: Reducing aspiration of gastric contents by placing mechanically ventilated patients in a semirecumbent position has been associated with lower incidences of ventilator-associated pneumonia (VAP). The feasibility and efficacy of this intervention in a larger patient population, however, are unknown.

Objective: Assessment of the feasibility of the semirecumbent position for intensive care unit patients and its influence on development of VAP.

Design: In a prospective multicentered trial, critically ill patients undergoing mechanical ventilation were randomly assigned to the semirecumbent position, with a target backrest elevation of 45°, or standard care (i.e., supine position) with a backrest elevation of 10°.

Main Outcome Measures: Backrest elevation was measured continuously during the first week of ventilation with a monitor-linked device. A deviation of position was defined as a change of the randomized position >5°. Diagnosis of VAP was made by quantitative cultures of samples obtained by bronchoscopic techniques.

Results: One hundred nine patients were assigned to the supine group and 112 to the semirecumbent group. Baseline characteristics were comparable for both groups. Average elevations were 9.8° and 16.1° at day 1 and day 7, respectively, for the supine group and 28.1° and 22.6° at day 1 and day 7, respectively, for the semirecumbent group ($p < .001$). The target semirecumbent position of 45° was not achieved for 85% of the study time, and these patients more frequently changed position than supine-positioned patients. VAP was diagnosed in eight patients (6.5%) in the supine group and in 13 (10.7%) in the semirecumbent group (NS), after a mean of 6 (range, 3–9) and 7 (range, 3–12) days, respectively. There were no differences in numbers of patients undergoing enteral feeding, receiving stress ulcer prophylaxis, or developing pressure sores or in mortality rates or duration of ventilation and intensive care unit stay between the groups.

Conclusions: The targeted backrest elevation of 45° for semirecumbent positioning was not reached in the conditions of the present randomized study. The achieved difference in treatment position (28° vs. 10°) did not prevent the development of VAP.
(Crit Care Med 2006; 34:396–402)

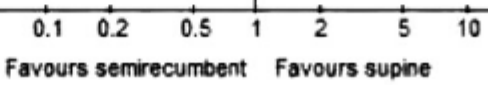
Van Nieuwenhoven CA, Vanderbroucke-Grauls C, van Tiel FH, et al. Crit Care Med 2006;34:396-402.

Body position

VAP incidence

Study	Semirecumbent n/N	Supine n/N	OR (fixed) 95% CI	Weight %	OR (fixed) 95% CI
Drakulovic	3/39	16/47		36.83	0.16 [0.04, 0.61]
Van Nieuwenhoven	16/112	20/109		47.77	0.74 [0.36, 1.52]
Keeley	5/17	7/13		15.40	0.36 [0.08, 1.62]
Total (95% CI)	168	169		100.00	0.47 [0.27, 0.82]

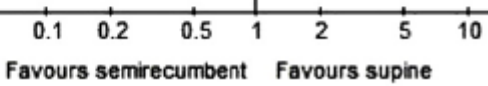
Total events: 24 (Semirecumbent), 43 (Supine)
Test for heterogeneity: $Chi^2 = 4.19$, df = 2 ($P = .12$), $I^2 = 52.2\%$
Test for overall effect: $Z = 2.64$ ($P = .008$)



Mortality

Study	Semirecumbent position n/N	Supine position n/N	OR (fixed) 95% CI	Weight %	OR (fixed) 95% CI
Drakulovic	7/39	13/47		25.30	0.57 [0.20, 1.62]
Van Nieuwenhoven	39/112	38/109		65.64	1.00 [0.57, 1.74]
Keeley	4/17	4/13		9.06	0.69 [0.14, 3.52]
Total (95% CI)	168	169		100.00	0.86 [0.54, 1.37]

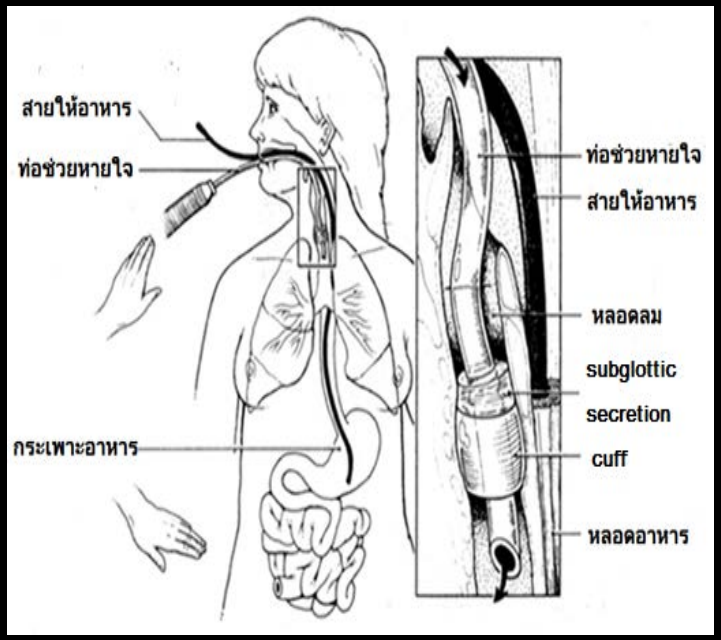
Total events: 50 (Semirecumbent positi), 55 (Supine position)
Test for heterogeneity: $Chi^2 = 0.94$, df = 2 ($P = .63$), $I^2 = 0\%$
Test for overall effect: $Z = 0.62$ ($P = .53$)

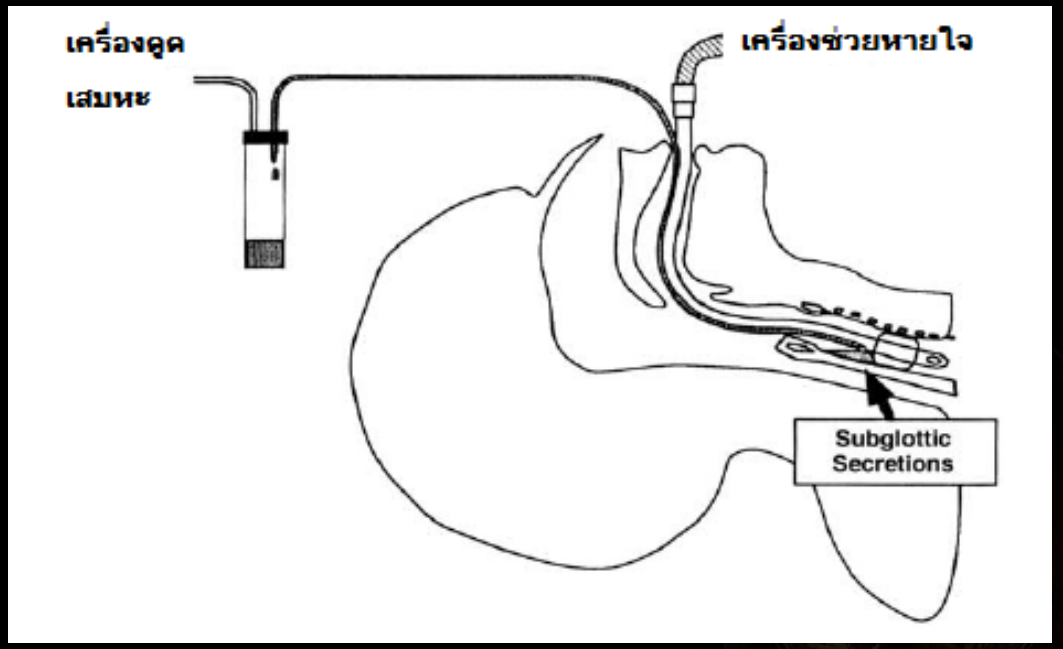


Pittet D, Allegranzi B, Boyce J, et al. Infect Control Hosp Epidemiol 2009;30:611-622.

Subglottic suction

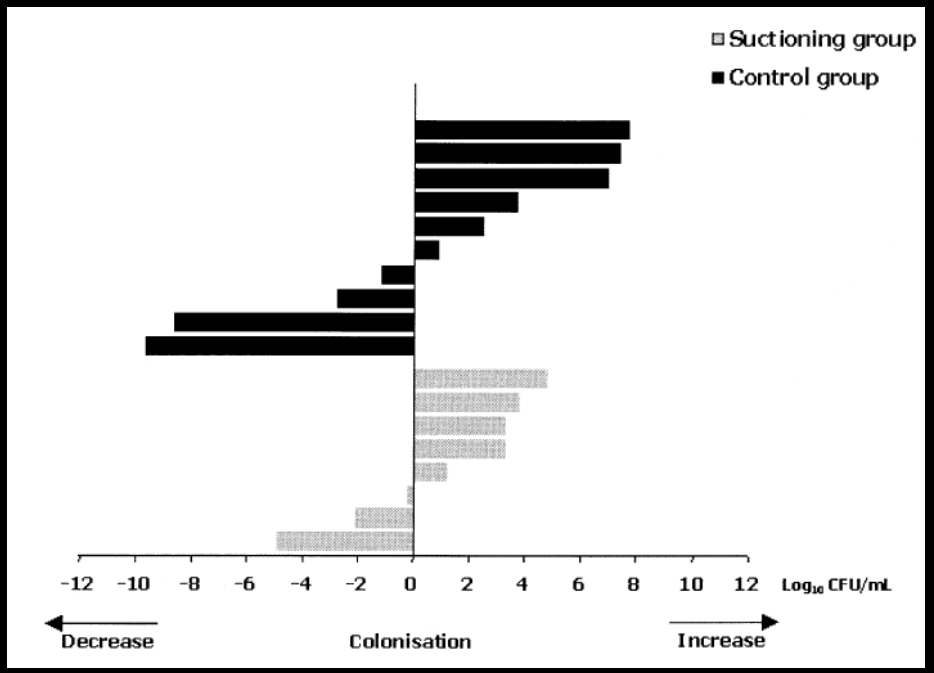
Subglottic suction



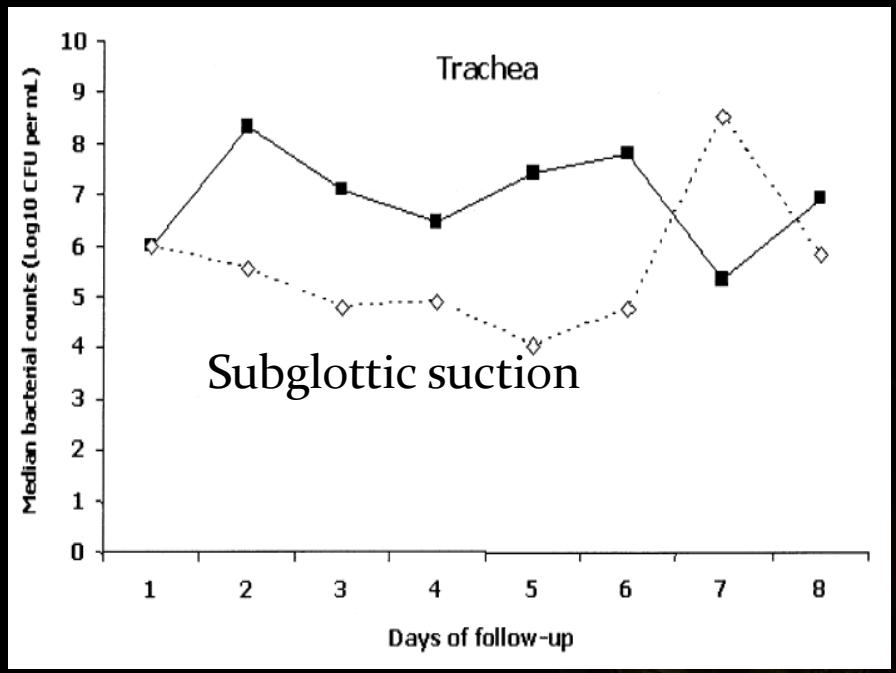


Adapted from: Dezfulian C, Shojania K, Collard HR, et al. Am J Med 2005;118:11-8.

Subglottic suction



Tracheal bacterial counts



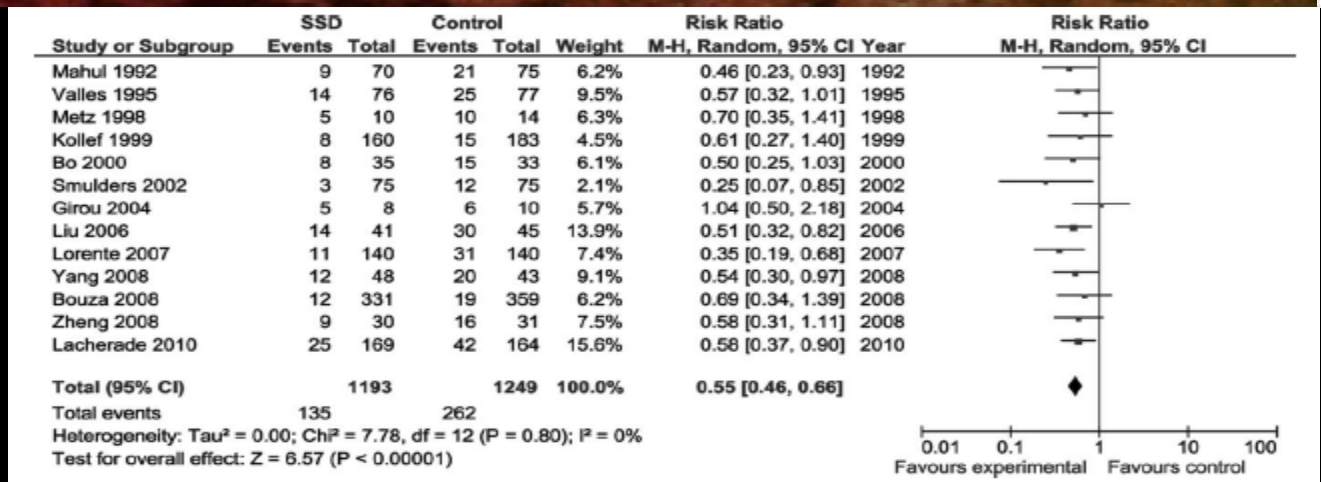
Time course of tracheal colonisation

Girou E, Buu-Hoi A, Stephan F, et al. Intensive Care Med 2004;30:225-33.

Author, Year	Population (n)	Inclusion Criteria	Clinical Suspicion of VAP[a]	VAP[b]	Cointerventions[c]	Score[d]	Rate of VAP a. Cases/1000 Ventilator-Days b. Cases/Patients		
							SSD	Control	*p*
Mahul, 1992	145	Expected duration of MV >3 days	Chest radiograph	BAL	None specified	6	a. 8/1000 b. 9/70	a. 17.5/1000 b. 21/75	a. <.05 b. NR
Valles, 1995	153	Expected duration of MV >3 days	Chest radiograph plus temp >38.5°C, WBC >12 or <4, purulent secretions	BAL or PSB	None specified	9	a. 19.9/1000 b. 14/76	a. 39.6/1000 b. 25/77	a. NR b. NR
Metz, 1998	24	Expected duration of MV >3 days	Chest radiograph, temp > 38.5°C, WBC >12 or <3, purulent secretions	ETA or BAL	None specified	7	a. NA/1000 b. 5/10	a. NA/1000 b. 10/14	a. NA b. NS
Kollef, 1999	343	Need for MV after cardiac Surgery	Chest radiograph plus pulmonary abscess or histology or positive blood or pleural cultures or 2 of 3 of the following: fever, leukocytosis, purulent sputum	ETA or no micro	None specified	11	a. 34.5/1000 b. 8/160	a. 43.2/1000 b. 15/183	a. NR b. 0.24
Bo, 2000	68	Expected duration of MV >72 hrs	Chest radiograph + temp ≥38.3°C or WBC >12 or <4 or purulent sputum	BAL or PSB	None specified	8	a. NA/1000 b. 8/35	a. NA/1000 b. 15/33	a. NA b. <.05
Smulders, 2002	150	Expected duration of MV >72 hrs	Chest radiograph ± evidence for cavitation, histology, positive blood culture, a positive pleural fluid culture, or any of the 2 following symptoms/ signs: fever (rectal >38°C), WBC <3 or >10, purulent tracheal aspirate (>25 WBC per field)	ETA	None specified	9	a. 9.2/1000 b. 3/75	a. 22.5 b. 12/75	a. NR b. .01
Girou, 2004	18	Expected duration of MV >5 days	Chest radiograph, temp ≥38.3°C or WBC >12, or purulent sputum	PSB or BAL	Elevation of head of bed in SSD group	9	a. NA/1000 b. 5/8	a. NA/1000 b. 6/10	a. NA b. NS
Liu, 2006	86	Age older than 60 yrs, expected MV >48 hrs	Chest radiograph and 3 of 4: temp >38.0°C or <35.5°C, WBC >10 or <3, >10 WBC high-power field in ETA, or a positive ETA culture	PSB or BAL or positive blood or pleural fluid culture	Elevation of head of bed, gastrointestinal agents in SSD group	9	a. NA/1000 b. 14/41	a. NA/1000 b. 30/45	a. NA b. <.01
Lorente, 2007	280	Expected MV >24 hrs	Chest radiograph, purulent secretions, temp >38°C or <35.5°C, WBC >10 or <4	Quantitative ETA	Polyurethane cuff in addition to SSD	13	a. 7.5/1000 b. 11/140	a. 19.9/1000 b. 31/140	a. .001 b. .003
Bouza, 2008	714	Major heart surgery	Chest radiograph and 2 of: temp >38.5°C or <36°C, WBC > 12, purulent secretions, reduction in PF >15% or CPIS >6	Quantitative ETA or PSB	None specified	12	a. 17.9/1000 b. 12/359	a. 27.6 b. 19/331	a. .2 b. .18
Yang, 2008	91	MV >48 hrs	Chest radiograph and 2 of: temp >38.3°C, WBC >12, WBC <4.0, purulent secretions	No micro or ETA or positive blood culture	None specified	9	a. NA/1000 b. 12/48	a. NA/1000 b. 20/43	a. NA b. .03

Muscedere J, et al. Crit Care Med. 2011 Aug;39(8):1985-91.

Subglottic suction



Study or Subgroup	SSD Events	SSD Total	Control Events	Control Total	Weight	Risk Ratio M-H, Random, 95% CI	Year
Mahul 1992	9	70	21	75	6.2%	0.46 [0.23, 0.93]	1992
Valles 1995	14	76	25	77	9.5%	0.57 [0.32, 1.01]	1995
Metz 1998	5	10	10	14	6.3%	0.70 [0.35, 1.41]	1998
Kollef 1999	8	160	15	183	4.5%	0.61 [0.27, 1.40]	1999
Bo 2000	8	35	15	33	6.1%	0.50 [0.25, 1.03]	2000
Smulders 2002	3	75	12	75	2.1%	0.25 [0.07, 0.85]	2002
Girou 2004	5	8	6	10	5.7%	1.04 [0.50, 2.18]	2004
Liu 2006	14	41	30	45	13.9%	0.51 [0.32, 0.82]	2006
Lorente 2007	11	140	31	140	7.4%	0.35 [0.19, 0.68]	2007
Yang 2008	12	48	20	43	9.1%	0.54 [0.30, 0.97]	2008
Bouza 2008	12	331	19	359	6.2%	0.69 [0.34, 1.39]	2008
Zheng 2008	9	30	16	31	7.5%	0.58 [0.31, 1.11]	2008
Lacherade 2010	25	169	42	164	15.6%	0.58 [0.37, 0.90]	2010
Total (95% CI)		**1193**		**1249**	**100.0%**	**0.55 [0.46, 0.66]**	
Total events	135		262				

Heterogeneity: Tau² = 0.00; Chi² = 7.78, df = 12 (P = 0.80); I² = 0%
Test for overall effect: Z = 6.57 (P < 0.00001)

Figure 1. Rate of ventilator-associated pneumonia between groups with subglottic secretion and without subglottic secretion. *M-H*, Mantel-Henszel; *SSD*, subglottic secretion drainage; *CI*, confidence interval.

Study or Subgroup	SSD Events	SSD Total	Control Events	Control Total	Weight	Risk Ratio M-H, Random, 95% CI
Bouza 2008	12	331	19	359	18.4%	0.69 [0.34, 1.39]
Kollef 1999	8	160	15	183	13.3%	0.61 [0.27, 1.40]
Lacherade 2010	25	169	42	164	46.3%	0.58 [0.37, 0.90]
Lorente 2007	11	140	31	140	22.0%	0.35 [0.19, 0.68]
Total (95% CI)		**800**		**846**	**100.0%**	**0.54 [0.40, 0.73]**
Total events	56		107			

Heterogeneity: Tau² = 0.00; Chi² = 2.23, df = 3 (P = 0.53); I² = 0%
Test for overall effect: Z = 3.99 (P < 0.0001)

Figure 2. Rate of ventilator-associated pneumonia between groups with subglottic secretion and without subglottic secretion in studies of high methodologic quality. *M-H*, Mantel-Henszel; *SSD*, subglottic secretion drainage; *CI*, confidence interval.

Muscedere J, et al. Crit Care Med. 2011 Aug;39(8):1985-91.

Oral Care with antiseptics

Oral decontamination for prevention of pneumonia in mechanically ventilated adults: systematic review and meta-analysis

Ee Yuee Chan, nurse educator,[1] Annie Ruest, infectious diseases consultant,[2] Mai
professor,[3] Deborah J Cook, professor[3]

BMJ

Bergmans 2001[w1]	Mixed	Orabase with gentamicin, colistin, and vancomycin, 4 times daily until extubation, death, limited to 21 days	Control A, placebo in intensive care unit with patients receiving topical antimicrobial prophylaxis; control B, placebo in intensive care unit with no topical antimicrobial prophylaxis	Ventilator associated pneumonia: clinical, radiological, and bacteriological investigations, including quantitative culture of bronchoalveolar lavage fluid or protected specimen brush. Mortality in hospital	Until extubation or death	Local and industry
De Riso 1996[w4]	Cardiothoracic (open heart surgery)	Chlorhexidine 0.12% 15 ml preoperatively and twice daily postoperatively until discharge from intensive care or death	Placebo	Ventilator associated pneumonia: Centers for Disease Control and Prevention criteria.‡ Mortality in hospital	Until discharge from intensive care unit or death	Local
Fourrier 2000[w5]*	Medical or surgical	Chlorhexidine 0.2% gel three times daily during stay in intensive care unit until 28 days, discharge from intensive care, or death	Standard treatment	Ventilator associated pneumonia: clinical, radiological, and bacteriological investigations and quantitative culture of tracheal aspirate or bronchoalveolar lavage fluid, or both. Mortality in intensive care unit	Until discharge from intensive care unit or death	Local
Fourrier 2005[w6]*†	60% medical, 40% surgical	Chlorhexidine 0.2% gel three times daily during stay in intensive care unit until 28 days	Placebo	Ventilator associated pneumonia: clinical, radiological, and bacteriological investigations and quantitative culture of tracheal aspirate or bronchoalveolar lavage fluid, or both. Mortality in intensive care unit by day 28	Until 28 days in intensivecare, discharge from intensive care unit, or death	Local, and industry provided study drug
Koeman 2006[w7]*	Mixed	Treatment A, chlorhexidine 2% in white petroleum vehicle four times daily until diagnosis of ventilator associated pneumonia, death, or extubation; treatment B, chlorhexidine 2% and colistin four times daily	Placebo	Ventilator associated pneumonia: clinical, radiological, and bacteriological investigations and semiquantitative culture of tracheal aspirates. Independent adjudication committee determined if patients had ventilator associated pneumonia. Mortality in intensive care unit	Until extubation, discharge from intensive care unit, or death	Local
Kollef 2006[w2]†	83% non-trauma, 27% trauma	Iseganan 3 ml (9 mg) six times daily until 14 days. Treatment discontinued if patient developed ventilator associated pneumonia or was extubated	Placebo	Ventilator associated pneumonia: clinical, radiological, and bacteriological investigations, including quantitative culture of bronchoalveolar lavage fluid or non-directed bronchoalveolar lavage fluid. Mortality in intensive care unit by day 14	Until 21 days or death	Industry

Chan EY, Ruest A, Meade MO, et al. *BMJ* 2007 doi: 10.1136/bmj.39136.528160.BE.

Oral decontamination for prevention of pneumonia in mechanically ventilated adults: systematic review and meta-analysis

Ee Yuee Chan, nurse educator,[1] Annie Ruest, infectious diseases consultant,[2] Mai professor,[3] Deborah J Cook, professor[3]

BMJ

Laggner 1994[w3]	General intensive care	Gentamicin gel four times daily until extubation. All received oral amphotericin B and oral disinfection with phenylhydragyrum boricum and hexetidine	Placebo	Ventilator associated pneumonia: clinical and radiological investigations and positive culture of tracheal secretions. Mortality in intensive care unit	Until extubation	Not reported
MacNaughton 2004[w11]*	Medical or surgical	Chlorhexidine 0.2% oral rinse twice daily until extubation or death	Placebo	Ventilator associated pneumonia: leucocytosis and pyrexia >38°C; deterioration in arterial blood gases; chest signs; new consolidation on chest radiography; and significant semiquantitative culture of non-directed bronchoalveolar lavage fluid. Definite pneumonia 4/4 if met all four criteria. Mortality in intensive care unit	Not available	Local
Rios 2005[w10]*	Medical or surgical (including trauma)	Polymyxin B and gentamicin gel three times daily until 24 hours after extubation	Placebo	Ventilator associated pneumonia: clinical, radiological, and bacteriological, including positive quantitative culture of tracheal secretions. Mortality in intensive care unit	Until 28 days after ventilator associated pneumonia diagnosis or discharge from intensive care unit, or hospital discharge	Local
Segers 2005[w9]*	Cardiothoracic	Chlorhexidine 0.12%, nasal ointment, and 10 ml oropharynx rinse four times daily on allocation and admission to hospital until extubation or removal of nasogastric tube	Placebo	Ventilator associated pneumonia: Centers for Disease Control and Prevention criteria (no microbiological confirmation required). Mortality in hospital	Until 48 hours after discharge	Local
Seguin 2006[w8]*	Surgical (severe closed head trauma)	Povidone iodine 10% 20 ml reconstituted to 60 ml with sterile water to nasopharynx and oropharynx six times daily until extubation	Control A, saline rinse 60 ml; control B, standard treatment	Ventilator associated pneumonia: clinical, radiological, and bacteriological investigations including positive quantitative culture of bronchoalveolar lavage fluid or non-directed bronchoalveolar lavage fluid. Mortality in intensive care unit	Until discharge from intensive care unit	Not funded

*Published and unpublished data.
†Trial stopped early.
‡Unclear if clinically defined ventilator associated pneumonia or microbiology confirmed ventilator associated pneumonia.

Chan EY, Ruest A, Meade MO, et al. *BMJ* 2007 doi: 10.1136/bmj.39136.528160.BE.

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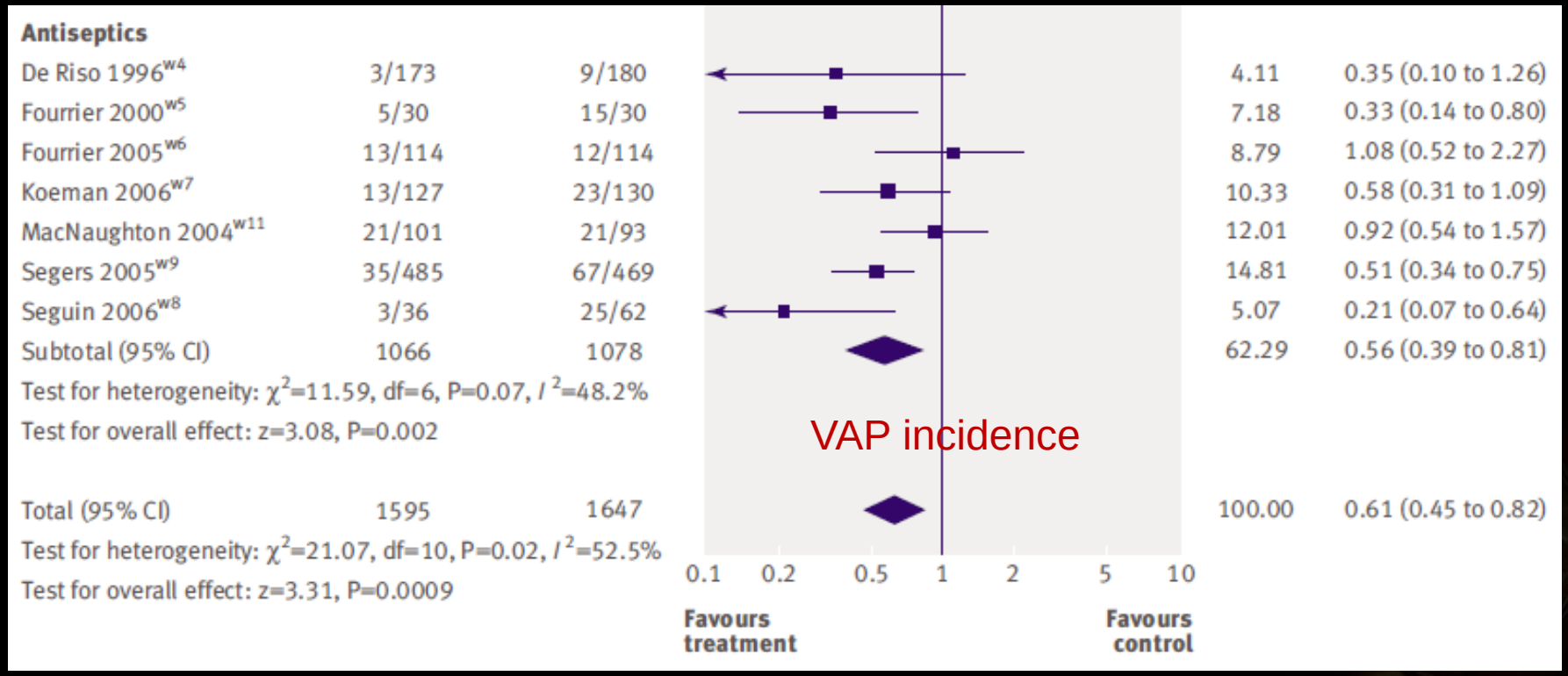
BMJ



Chan EY, Ruest A, Meade MO, et al. *BMJ* 2007 doi: 10.1136/bmj.39136.528160.BE.

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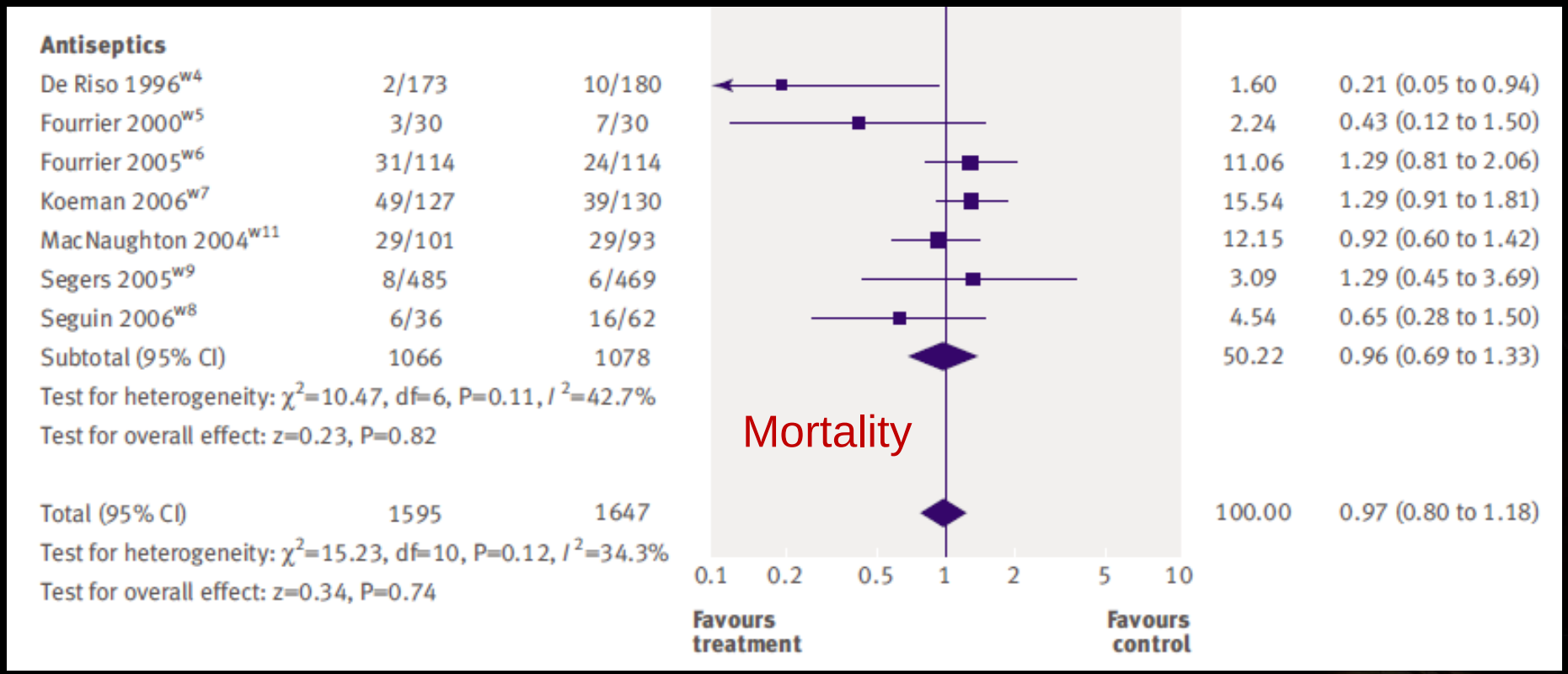


Chan EY, Ruest A, Meade MO, et al. *BMJ* 2007 doi: 10.1136/bmj.39136.528160.BE.

Antibiotics prophylaxis

SOD vs SDD

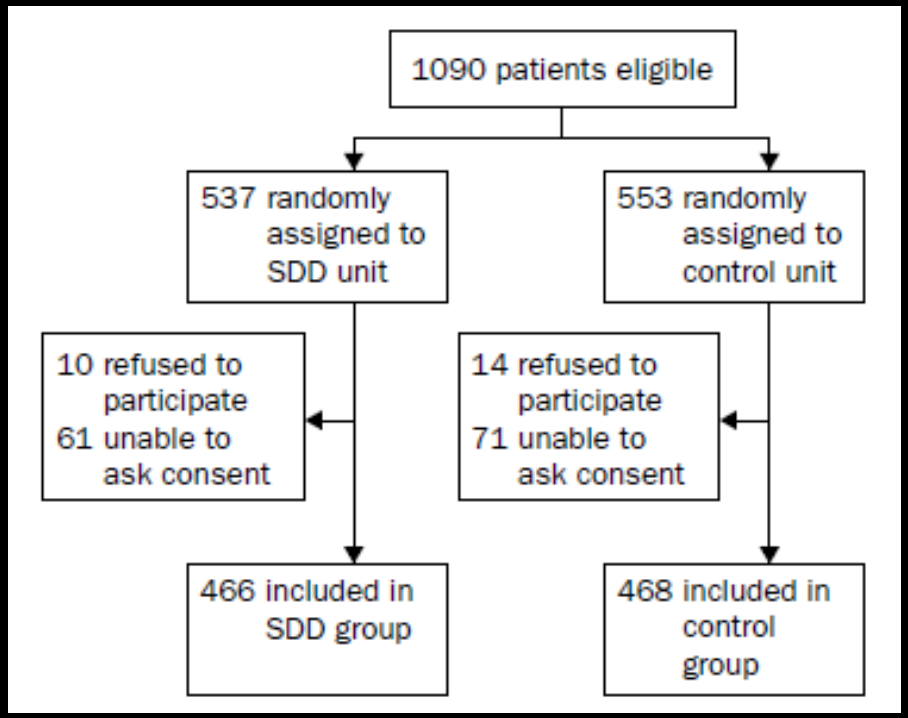
- Selective oropharyngeal decontamination (SOD)
  - Application of topical antibiotics in the oropharynx only
- Selective digestive tract decontamination (SDD)
  - Administered both topically and systemically without antianaerobic activity

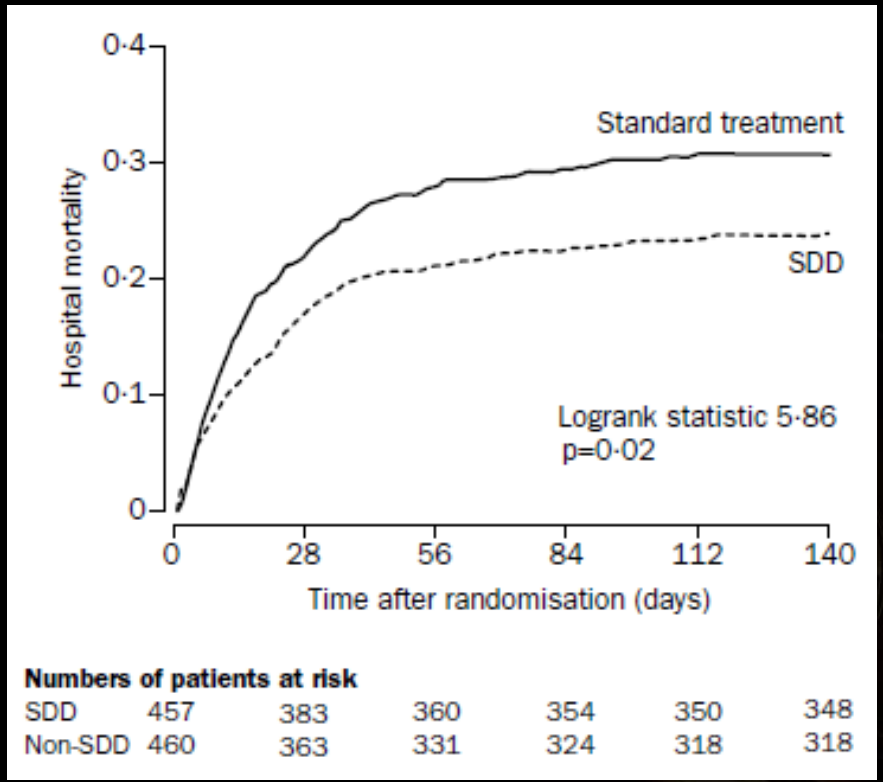
de Smet AM, et al. N Engl J Med. 2009 Jan 1;360(1):20-31.

Articles

Effects of selective decontamination of digestive tract on mortality and acquisition of resistant bacteria in intensive care: a randomised controlled trial

Evert de Jonge, Marcus J Schultz, Lodewijk Spanjaard, Patrick M M Bossuyt, Margaretha B Vroom, Jacob Dankert, Jozef Kesecioglu





de Jonge E, et al. Lancet 2003; 362: 1011–16.

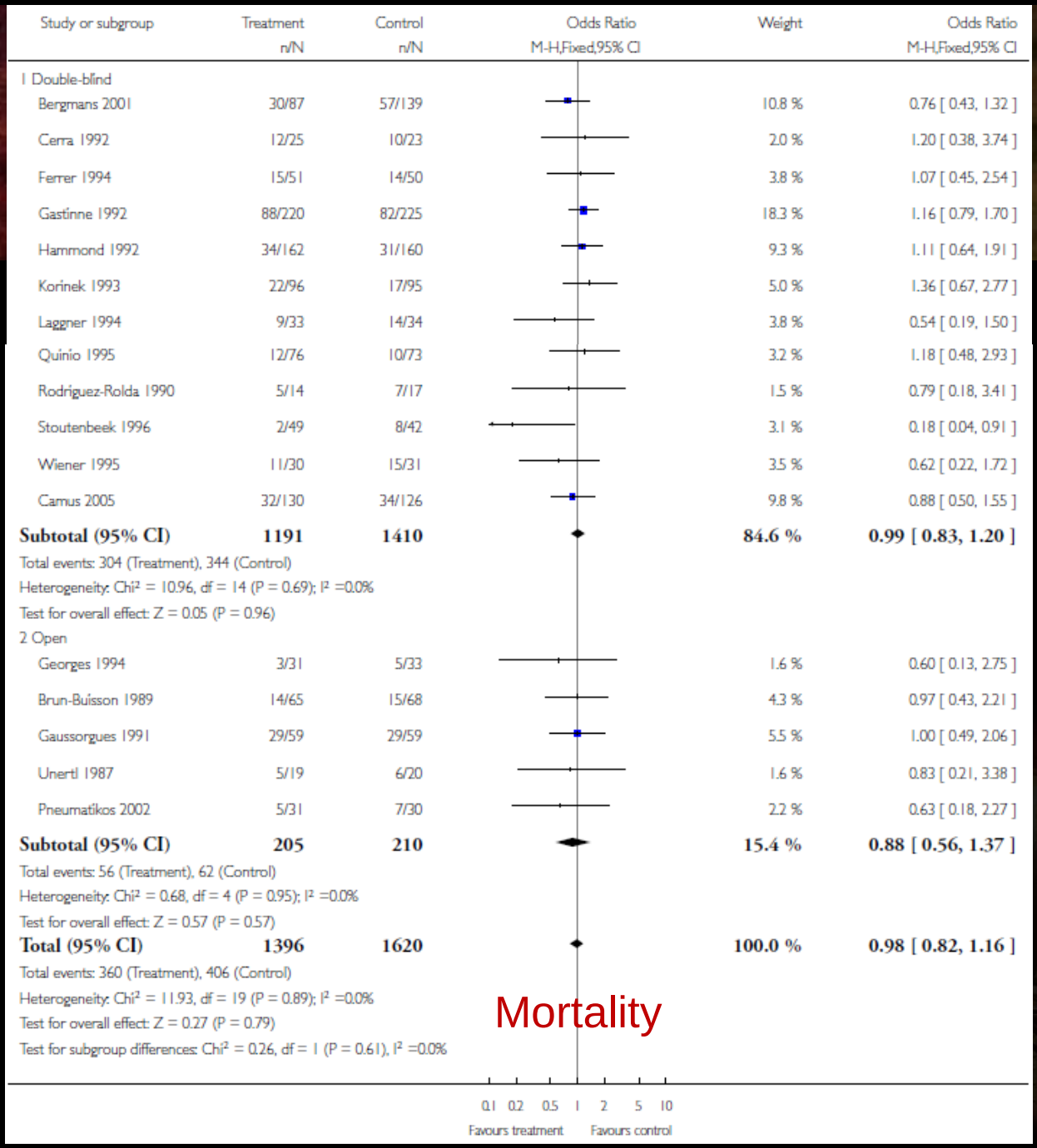
Cochrane Library

Cochrane Database of Systematic Reviews

Antibiotic prophylaxis to reduce respiratory tract infections and mortality in adults receiving intensive care (Review)

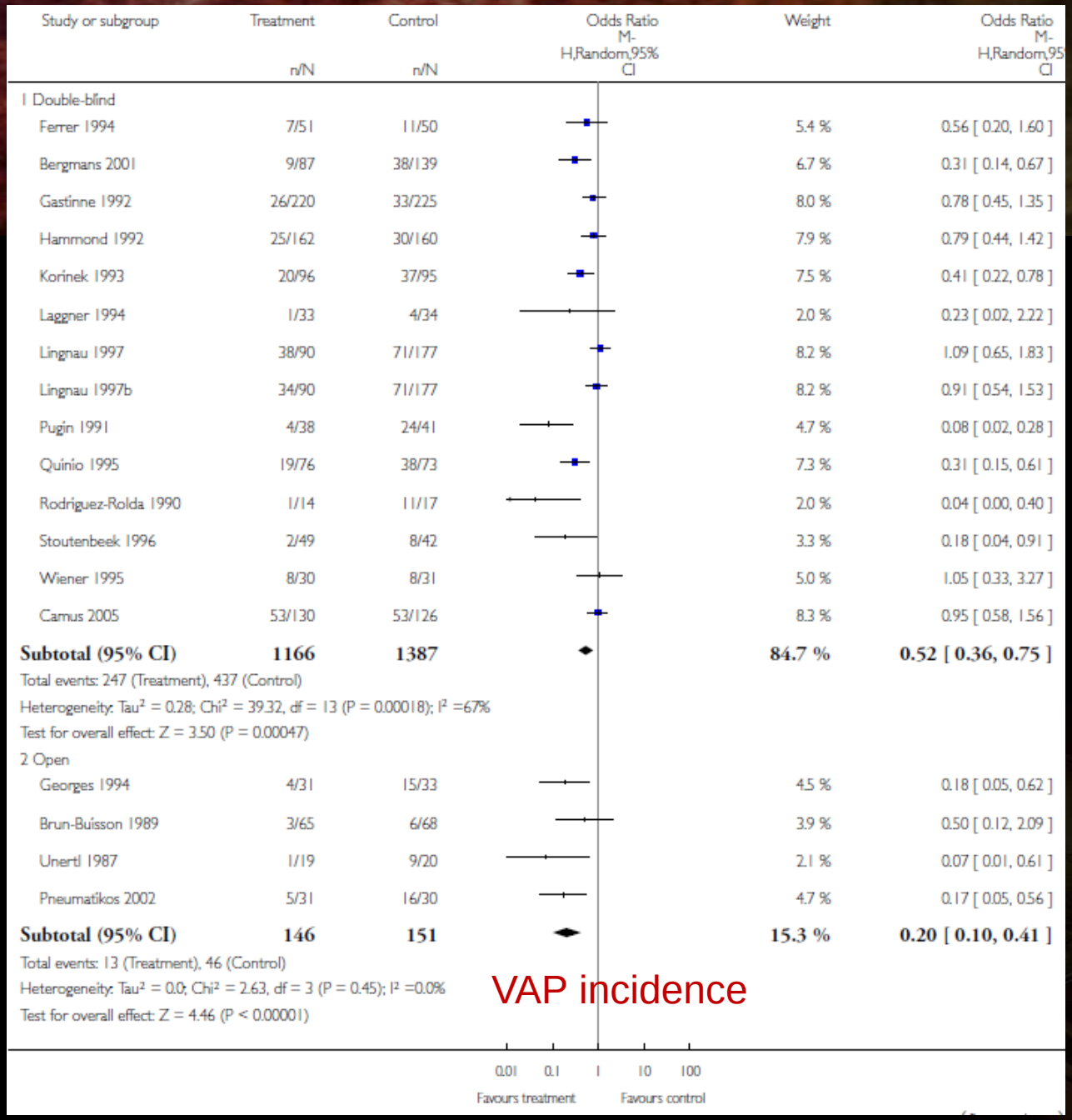
D'Amico R, Pifferi S, Torri V, Brazzi L, Parmelli E, Liberati A

SOD



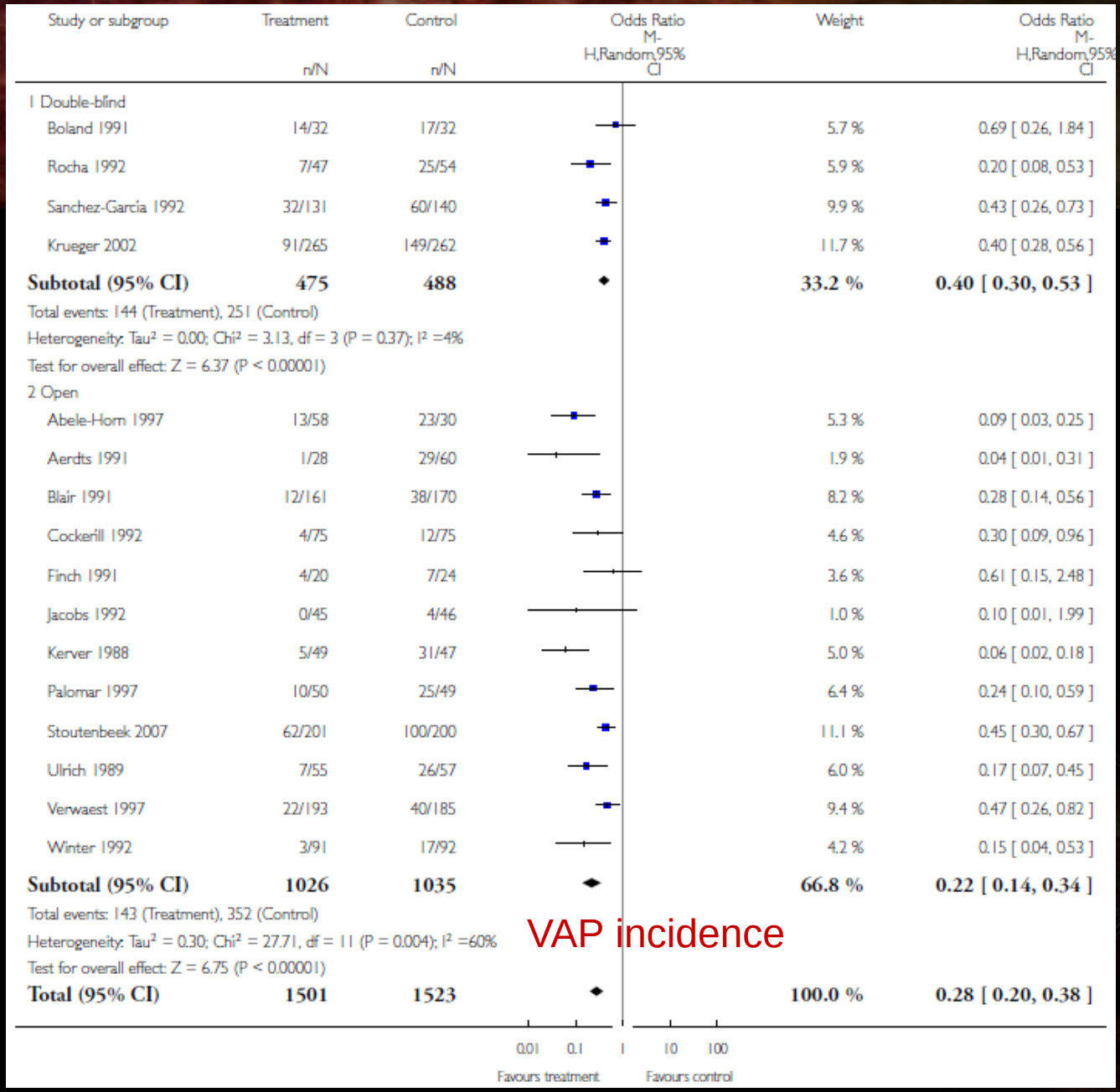
Liberati A, et al. Cochrane Database Syst Rev. 2009 Oct 7;(4):CD000022.

SOD



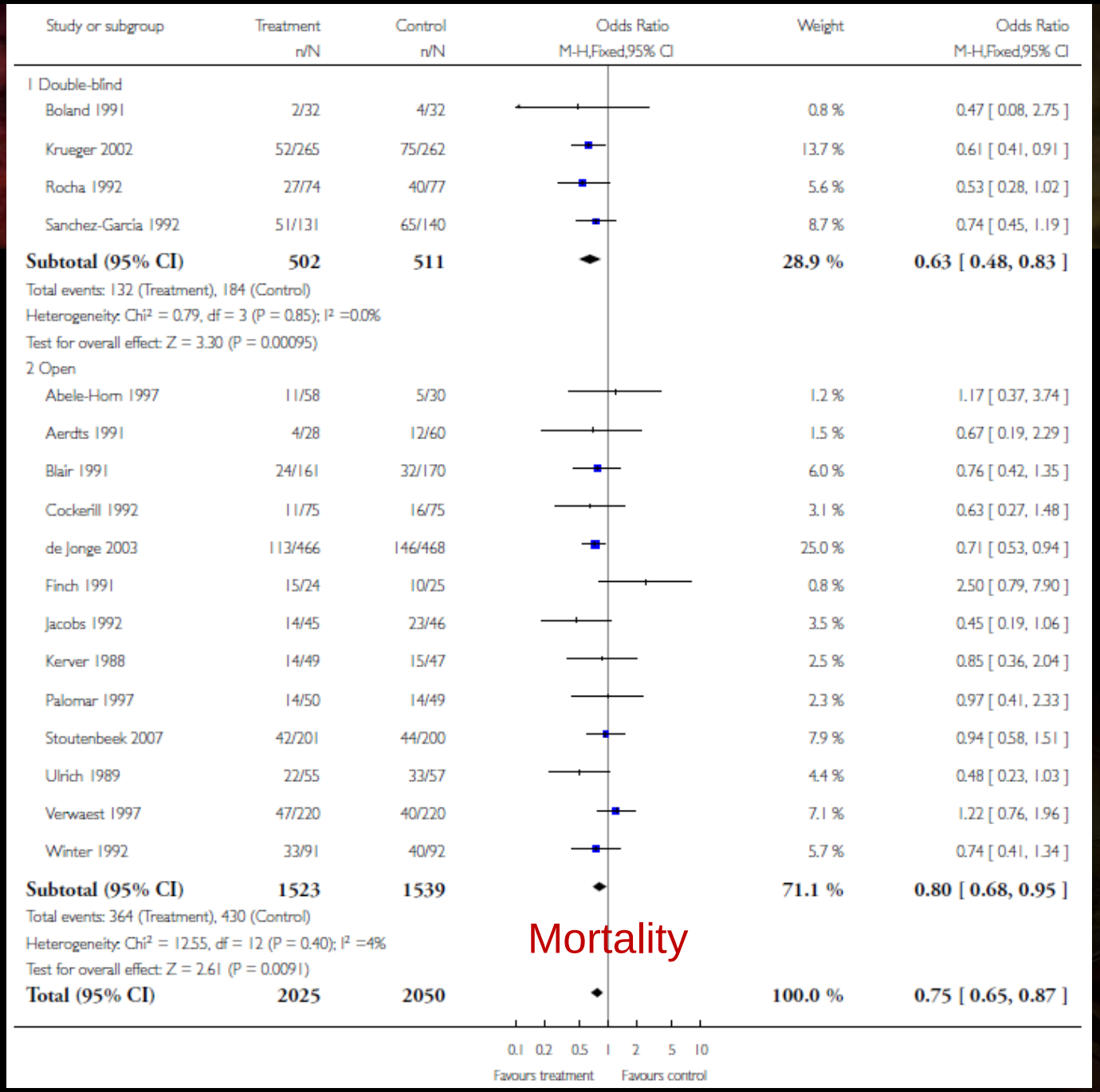
Liberati A, et al. Cochrane Database Syst Rev. 2009 Oct 7;(4):CD000022.

SDD



Liberati A, et al. Cochrane Database Syst Rev. 2009 Oct 7;(4):CD000022.

SDD



Liberati A, et al. Cochrane Database Syst Rev. 2009 Oct 7;(4):CD000022.

SOD vs SDD

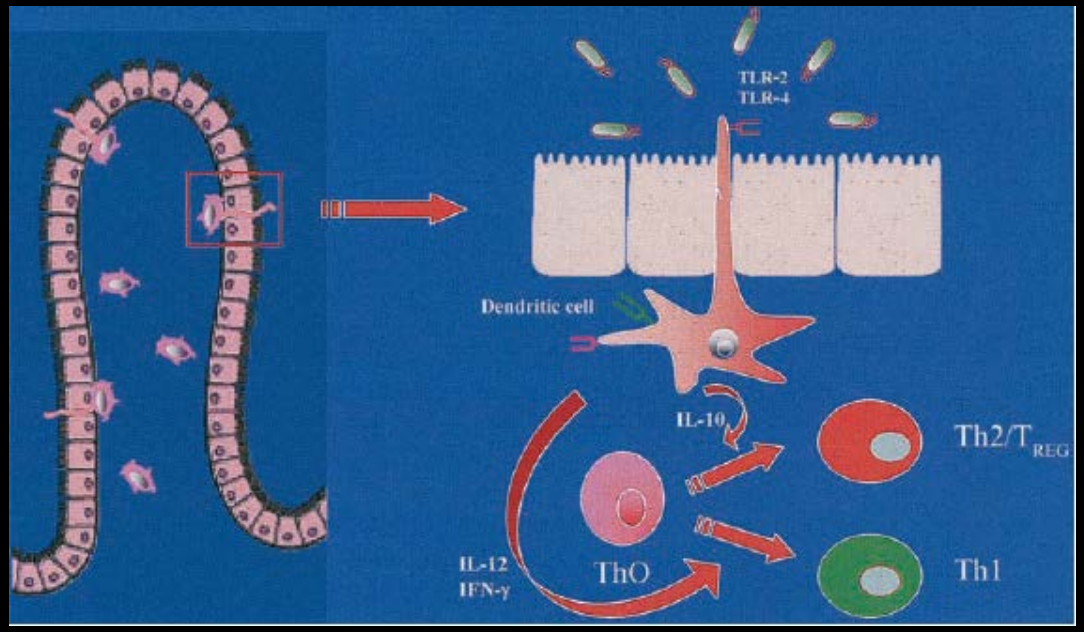
- This strategy has not yet been adopted in general practice
- This might increase the risk of antibiotic-resistant infections including *C. difficile* infections.
- Long-term studies for antimicrobial resistance are lacking.
- No data in hospitals with high baseline rates of antibiotic resistance.

de Smet AM, et al. N Engl J Med. 2009 Jan 1;360(1):20-31.
Klompas M, et al. Infect Control Hosp Epidemiol. 2014 Aug;35(8):915-36.

Probiotics

Probiotics

- Generalized mucosal immune response
- Balanced T-helper cell response
- Self-limited inflammatory response
- Polymeric IgA secretion



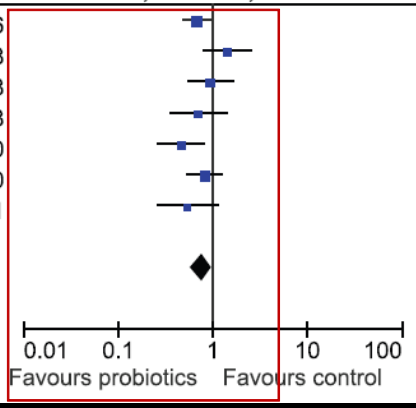
Walker WA. Clin Infect Dis. 2008 Feb 1;46 Suppl 2:S87-91.

Probiotics vs VAP

Study or Subgroup	Probiotics Events	Total	Control Events	Total	Weight	Risk Ratio M-H, Random, 95% CI	Year
Kotzampassi 2006	19	35	24	30	23.0%	0.68 [0.48, 0.97]	2006
Besselink 2008	24	152	16	144	12.6%	1.42 [0.79, 2.56]	2008
Forestier 2008	19	102	21	106	13.7%	0.94 [0.54, 1.64]	2008
Knight 2009	12	130	17	129	9.9%	0.70 [0.35, 1.41]	2008
Morrow 2010	13	73	28	73	13.2%	0.46 [0.26, 0.82]	2010
Barraud 2010	26	87	29	80	18.6%	0.82 [0.53, 1.27]	2010
Tan 2011	7	26	13	26	9.0%	0.54 [0.26, 1.13]	2011
Total (95% CI)		**605**		**588**	**100.0%**	**0.75 [0.59, 0.97]**	
Total events	120		148				

Heterogeneity: $Tau^2 = 0.04$; $Chi^2 = 9.23$, df = 6 (P = 0.16); $I^2 = 35\%$

Test for overall effect: Z = 2.20 (P = 0.03)

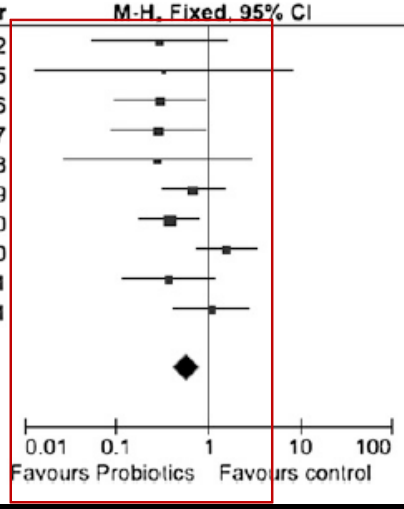


Petrof EO, et al. Crit Care Med. 2012 Dec;40(12):3290-302.

Study or Subgroup	Probiotics Events	Total	Control Events	Total	Weight	Odds Ratio M-H, Fixed, 95% CI	Year
Rayes	2	30	6	30	5.4%	0.29 [0.05, 1.55]	2002
Rayes_	0	33	1	33	1.4%	0.32 [0.01, 8.23]	2005
Kotzampassi	19	35	24	30	11.3%	0.30 [0.10, 0.91]	2006
Spindler-Vesel	4	26	34	87	12.7%	0.28 [0.09, 0.89]	2007
Klarin	1	23	3	21	2.9%	0.27 [0.03, 2.85]	2008
Knight	12	130	17	129	14.8%	0.67 [0.31, 1.47]	2009
Morrow	17	68	33	70	23.3%	0.37 [0.18, 0.77]	2010
Barraud	23	87	15	80	11.0%	1.56 [0.75, 3.25]	2010
Tan	7	26	13	26	9.1%	0.37 [0.12, 1.17]	2011
Oudhuis	10	130	9	124	8.1%	1.06 [0.42, 2.72]	2011
Total (95% CI)		**588**		**630**	**100.0%**	**0.58 [0.42, 0.79]**	
Total events	95		155				

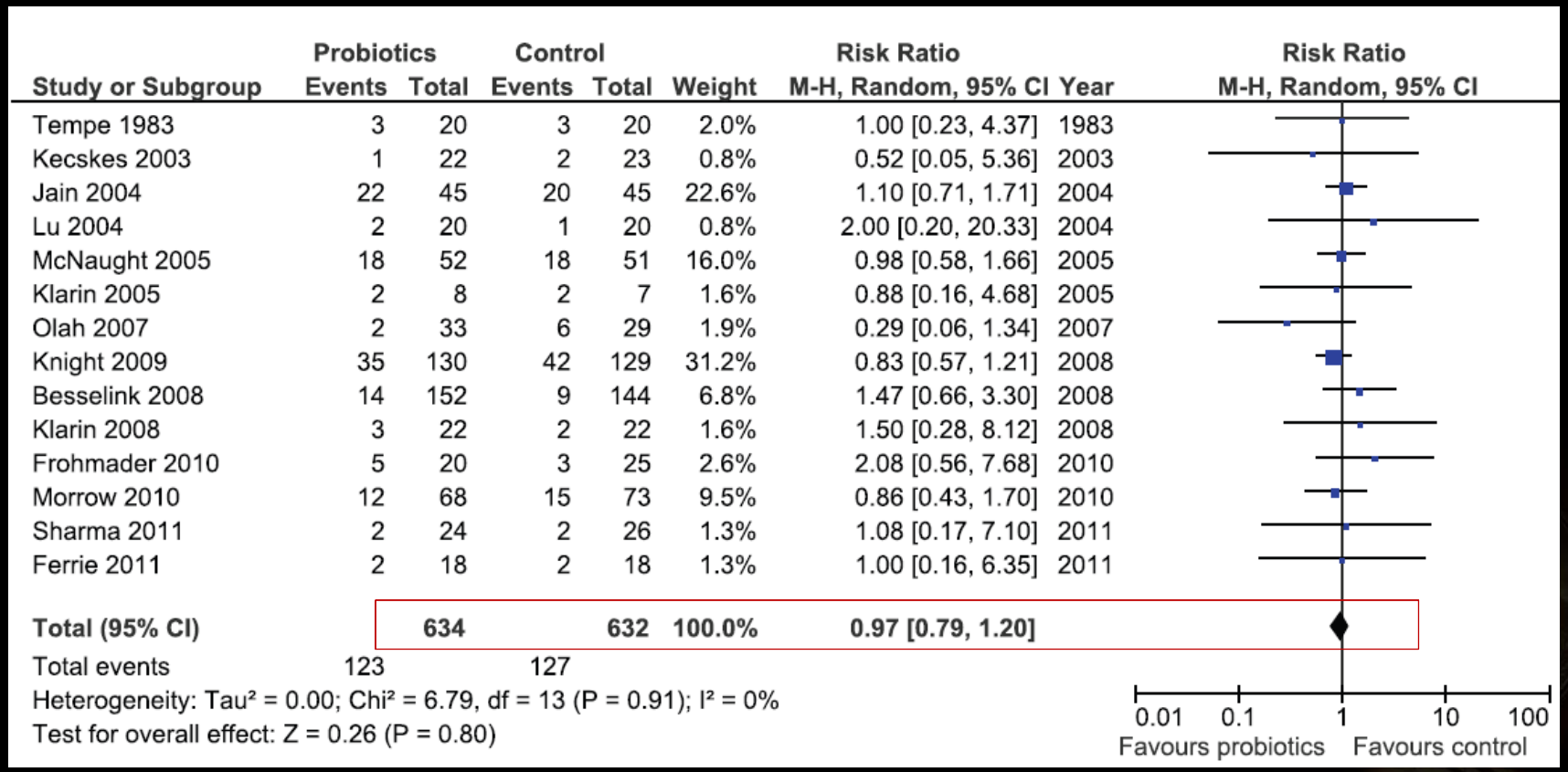
Heterogeneity: $Chi^2 = 14.75$, df = 9 (P = 0.10); $I^2 = 39\%$

Test for overall effect: Z = 3.46 (P = 0.0005)



Barraud D, et al. Chest. 2013 Mar;143(3):646-55.

Probiotics vs Mortality



Study or Subgroup	Probiotics Events	Total	Control Events	Total	Weight	Risk Ratio M-H, Random, 95% CI	Year
Tempe 1983	3	20	3	20	2.0%	1.00 [0.23, 4.37]	1983
Kecskes 2003	1	22	2	23	0.8%	0.52 [0.05, 5.36]	2003
Jain 2004	22	45	20	45	22.6%	1.10 [0.71, 1.71]	2004
Lu 2004	2	20	1	20	0.8%	2.00 [0.20, 20.33]	2004
McNaught 2005	18	52	18	51	16.0%	0.98 [0.58, 1.66]	2005
Klarin 2005	2	8	2	7	1.6%	0.88 [0.16, 4.68]	2005
Olah 2007	2	33	6	29	1.9%	0.29 [0.06, 1.34]	2007
Knight 2009	35	130	42	129	31.2%	0.83 [0.57, 1.21]	2008
Besselink 2008	14	152	9	144	6.8%	1.47 [0.66, 3.30]	2008
Klarin 2008	3	22	2	22	1.6%	1.50 [0.28, 8.12]	2008
Frohmader 2010	5	20	3	25	2.6%	2.08 [0.56, 7.68]	2010
Morrow 2010	12	68	15	73	9.5%	0.86 [0.43, 1.70]	2010
Sharma 2011	2	24	2	26	1.3%	1.08 [0.17, 7.10]	2011
Ferrie 2011	2	18	2	18	1.3%	1.00 [0.16, 6.35]	2011
Total (95% CI)		**634**		**632**	**100.0%**	**0.97 [0.79, 1.20]**	
Total events	123		127				

Heterogeneity: Tau² = 0.00; Chi² = 6.79, df = 13 (P = 0.91); I² = 0%

Test for overall effect: Z = 0.26 (P = 0.80)

Petrof EO, et al. Crit Care Med. 2012 Dec;40(12):3290-302.

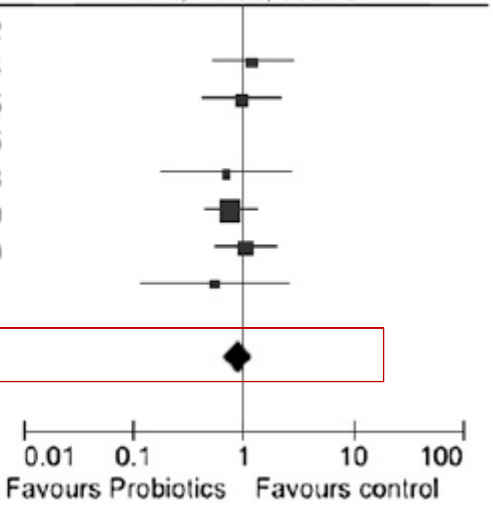
Barraud D, et al. Chest. 2013 Mar;143(3):646-55.

Probiotics vs Mortality

Study or Subgroup	Probiotics Events	Total	Control Events	Total	Weight	Odds Ratio M-H, Fixed, 95% CI	Year
Rayes	0	30	0	30		Not estimable	2002
Jain	22	45	20	45	12.9%	1.20 [0.52, 2.74]	2004
McNaught	18	52	18	51	14.9%	0.97 [0.43, 2.18]	2005
Rayes_	0	33	0	33		Not estimable	2005
Klarin	5	23	6	21	6.2%	0.69 [0.18, 2.73]	2008
Knight	35	130	42	129	38.8%	0.76 [0.45, 1.30]	2009
Barraud	27	87	24	80	21.7%	1.05 [0.54, 2.03]	2010
Tan	3	26	5	26	5.6%	0.55 [0.12, 2.58]	2011
Total (95% CI)		**426**		**415**	**100.0%**	**0.90 [0.65, 1.23]**	
Total events	110		115				

Heterogeneity: Chi² = 1.59, df = 5 (P = 0.90); I² = 0%

Test for overall effect: Z = 0.67 (P = 0.50)



Barraud D, et al. Chest. 2013 Mar;143(3):646-55.

Other stategies

- May lower VAP rates but insufficient data to determine impact
  - Ultrathin polyurethane endotracheal tube cuffs
  - Automated control of endotracheal tube cuff pressure
  - Saline instillation before tracheal suctioning
  - Mechanical tooth brushing

Klompas M, et al. Infect Control Hosp Epidemiol. 2014 Aug;35(8):915-36.

Prevention Postop Pneumonia

Table 4. **Strength of the Evidence for Specific Interventions To Reduce the Risk for Postoperative Pulmonary Complications**

Risk Reduction Strategy	Strength of Evidence*	Type of Complication Studied
Postoperative lung expansion modalities	A	Atelectasis, pneumonia, bronchitis, severe hypoxemia
Selective postoperative nasogastric decompression	B	Atelectasis, pneumonia, aspiration
Short-acting neuromuscular blockade	B	Atelectasis, pneumonia
Laparoscopic (vs. open) operation	C	Spirometry, atelectasis, pneumonia, overall respiratory complications
Smoking cessation	I	Postoperative ventilator support
Intraoperative neuraxial blockade	I	Pneumonia, postoperative hypoxia, respiratory failure
Postoperative epidural analgesia	I	Atelectasis, pneumonia, respiratory failure
Immunonutrition	I	Overall infectious complications, pneumonia, respiratory failure
Routine total parenteral or enteral nutrition†	D	Atelectasis, pneumonia, empyema, respiratory failure
Right-heart catheterization	D	Pneumonia

* Definitions for categories of strength of evidence, modified from the U.S. Preventive Services Task Force categories (11). A = good evidence that the strategy reduces postoperative pulmonary complications and benefit outweighs harm; B = at least fair evidence that the strategy reduces postoperative pulmonary complications and benefit outweighs harm; C = at least fair evidence that the strategy may reduce postoperative pulmonary complications, but the balance between benefit and harm is too close to justify a general recommendation; D = at least fair evidence that the strategy does not reduce postoperative pulmonary complications or harm outweighs benefit; I = evidence of effectiveness of the strategy to reduce postoperative pulmonary complications is conflicting, of poor quality, lacking, or insufficient or the balance between benefit and harm cannot be determined.

† Evidence remains uncertain (strength of evidence I) on total parenteral or enteral nutrition for severely malnourished patients or when a protracted time of inadequate nutritional intake is anticipated.

Lawrence VA, et al. Ann Intern Med. 2006 Apr 18;144(8):596-608.

Conclusion

มาตรการการป้องกัน	ลดอัตราปอดติดเชื้อในโรงพยาบาล	ลดอัตราเสียชีวิต	คุณภาพหลักฐาน	หมายเหตุ
การดูแลผู้ป่วยโดยทั่วไป				
- การใช้เครื่องช่วยหายใจชนิด noninvasive positive pressure ventilator	✓	✗	สูง	
- การยกหัวเตียงสูง 30° – 45°	✓	✗	ต่ำ	
- การดูดเสมหะ subglottic suction	✓	✗	ปานกลาง	โดยเฉพาะในผู้ป่วยที่ใช้เครื่องช่วยหายใจนาน 48 – 72 ชั่วโมง
- การทำความสะอาดช่องปากด้วย antiseptics	✓	✗	ปานกลาง	
- การทำความสะอาดช่องปากด้วยยาปฏิชีวนะ selective oropharyngeal decontamination	✓	✗	สูง	ไม่มีข้อมูลเรื่องความเสี่ยงการเกิดเชื้อดื้อยาในระยะยาว ยังไม่แนะนำให้ใช้โดยทั่วไป
- การใช้ยาปฏิชีวนะเฉพาะที่ร่วมกับยาทางหลอดเลือดในการกำจัดเชื้อแบคทีเรียในทางเดินอาหาร (selective digestive tract decontamination: SDD)	✓	✓	สูง	
- การใช้ probiotics	✓	✗	ปานกลาง	ระวังการใช้ในผู้ป่วยที่มีภาวะภูมิคุ้มกันบกพร่อง

Jelic S, et al. Crit Care. 2008;12(2):209.
Klompas M, et al. Infect Control Hosp Epidemiol. 2014 Aug;35(8):915-36.

Thank you