5th World Conference on Pediatric Critical Care
Geneva, Switzerland

The Bundles of Mechanical Ventilation

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What are “bundles”?

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The problem:

No clear definition

Heterogeneity in information

Low quality information

Not much data about pediatrics

What are “bundles”?

The Bundle Concept

A "bundle" is a group of interventions related to a disease process that, when executed together, result in better outcomes than when implemented individually.

LOURDES

Resar R et al. Using a bundle approach to improve ventilator care processes and reduce ventilator associated pneumonia. *Jt Comm J Qual Patient Saf*. 2005;31:243-248.

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What are “bundles”?

The Bundle Concept

A group of evidence based treatments related to a disease process, instituted together over a specific time frame and termed 'a care bundle', is anticipated to result in better outcomes than when they are executed individually.

CRITICAL CARE

Gao F et al. The impact of compliance with 6-hour and 24-hour sepsis bundles on hospital mortality in patients with severe sepsis: a prospective observational study. Crit Care 2005;9(6):R764-70

What are "bundles"?

The problem with pediatric bundles

Much of current clinical practice in the pediatric ICU is based on anecdotal experience combined with extrapolation from adult data.

What are "bundles"?

The MV Bundle Contents

Prevent Ventilator Induced Lung Injury (VILI)	Lung protective ventilation strategies	Low TV/ low plateau pressure PEEP Daily "vacation" from sedation
Prevent Ventilator Associated Pneumonia (VAP)		Head over the bed Gastric ulcer prophylaxis Deep venous thrombosis prophylaxis Daily "vacation" from sedation
Weaning		Spontaneous breathing test

MV Bundle Contents

Prevent Ventilator Induced Lung Injury (VILI)

Prevent Ventilator Associated Pneumonia (VAP)

Liberation from mechanical ventilation

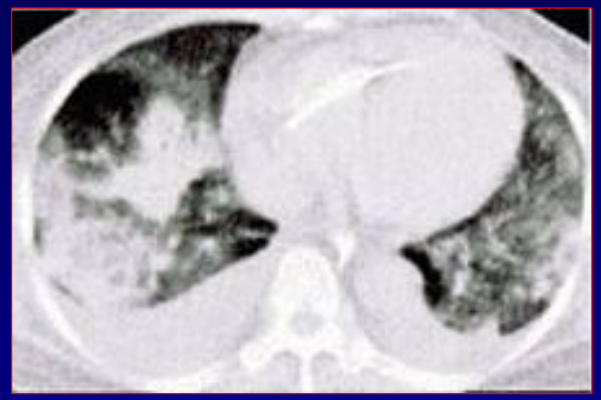
Prevention of VILI

The Fundamentals of Lung Protective Ventilation

Low tidal volume ventilation

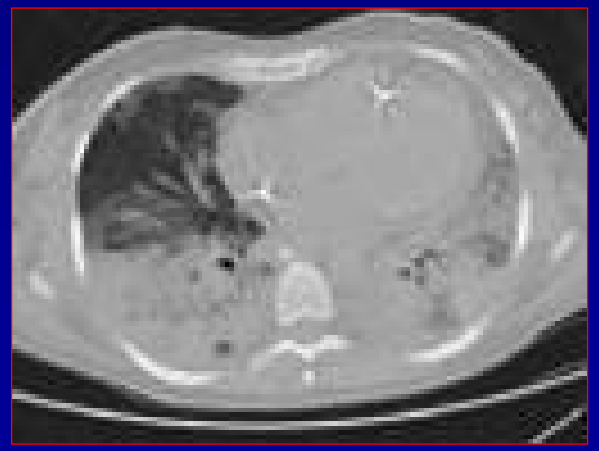
Prevention of volutrauma

+ Injured lung is not homogeneous
+ A normal TV would go primarily to healthier regions
+ Regional overinflation



Prevention of atelectrauma

+ Affects recruitable alveoli
+ Recruitment-derecruitment
+ Disruption of the surfactant monolayer
+ Requirement of higher pressures



Prevention of VILI

The Fundamentals of Lung Protective Ventilation

	Tidal volume		Mortality %		p-value
	Low TV	Control	Low TV	Control	
Amato et al N Engl J Med 1998 347- 54	6.1± 0.2	11.9± 0.5	38	71	< 0.001
Stewart et al N Engl J Med 1998 355 – 61	7.2 ± 0.8	10.6± 0.2	50	47	0.38
Brochard et al AJRCCM 1998 1831 – 38	7.2 ± 0.2	10.4± 0.2	47	38	0.60
ARDS Network N Engl J Med 2000 1301-8	6.3 ± 0.1	11.7± 0.1	31	40	0.007
Villar et al Crit Care Med 2006 1311-8	7.1 ± 0.1	10 ± 0.2	32	53	0.04

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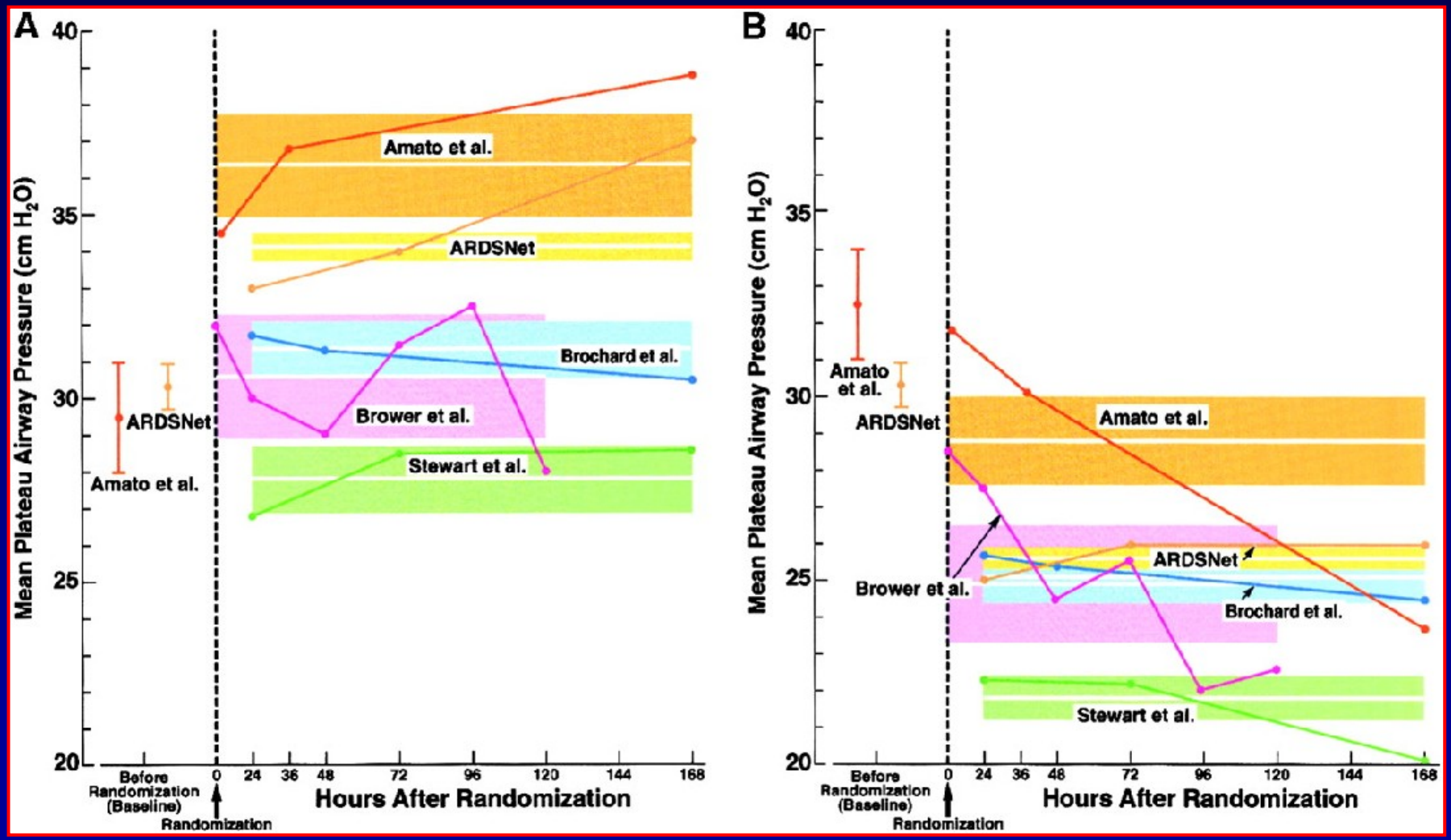
Prevention of VILI: pressure or volume



AMERICAN JOURNAL OF
Respiratory and
Critical Care Medicine

Eichacker PQ. Am J Respir Crit Care Med. 2002;166:1510-4

Prevention of VILI

Pressure or volume?

- Maximum transalveolar pressure (and/or tidal pressure excursion) is the primary generator of damaging tissue strains—not tidal volume *per se*.
- Transalveolar pressure is a function of tidal volume in relation to specific compliance.
- Although subject to chest wall compliance, the transalveolar pressure is strongly correlated to end-inspiratory plateau pressure

Critical Care Medicine
OFFICIAL JOURNAL OF THE SOCIETY OF CRITICAL CARE MEDICINE

Marini JJ. Crit Care Med 2006;34:1540-2

Prevention of VILI

Pressure or volume?

	Age Range		
	0-2 yr	0-5 yr	0-18 yr
Crs, st	2.60 ± 0.6	2.02 ± 0.4	1.76 ± 0.2
Crs, dyn	3.06 ± 0.5	2.31 ± 0.3	2.06 ± 0.4

51 patients from 3 wk to 15 yr studied while under anesthesia –using nitrous oxide and alcuronium– for urological surgery or repair of inguinal hernias.

Lanteri CJ. J Appl Physiol 1993;74:369-378

Prevention of VILI

Application of PEEP

	Day 1		Day 4	Day 6	
Patients with PEEP n	Overall 549	ARDS 15	Overall 255	Overall 153	ARDS 12
(%)	83%	(95%)	(75%)	(80%)	(91%)
Applied PEEP	4 (2,5)	8 (5,10)	4 (3,5)	4 (3,5)	5 (4,9)

EUROPEAN SOCIETY OF INTENSIVE CARE MEDICINE

Farias JA and IGMVC; Intensive Care Med 2004 30:918–925

Prevention of VILI

Application of PEEP

How much PEEP is correct?

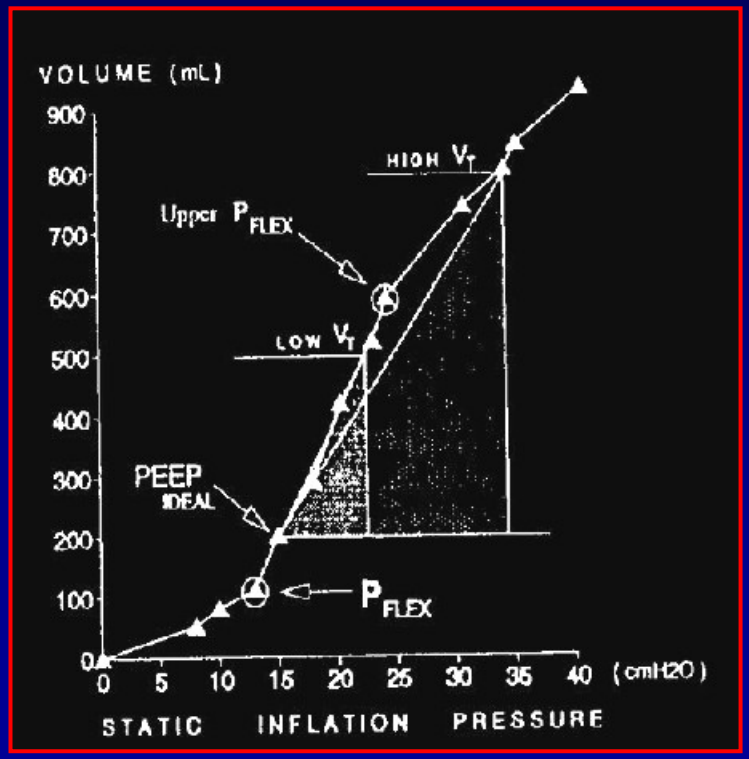
Prevention of VILI

How much PEEP?

Amato & Villar **vs.** **ARDS Network**

Prevention of VILI

How much PEEP?



VS.

Allowable combinations of FiO_2 and PEEP (cm of water)‡
0.3 and 5
0.4 and 5
0.4 and 8
0.5 and 8
0.5 and 10
0.6 and 10
0.7 and 10
0.7 and 12
0.7 and 14
0.8 and 14
0.9 and 14
0.9 and 16
0.9 and 18
1.0 and 18
1.0 and 20
1.0 and 22
1.0 and 24

Prevention of VILI

Daily discontinuation of sedatives

Protocol

- Daily interruption of the infusion of sedatives and analgesics until the patients were awake and could follow instructions or until they became uncomfortable or agitated and were deemed to require the resumption of sedation.
- Each day, the team assessed each patient's mental status with respect to wakefulness.
- The primary end points of the study were the duration of mechanical ventilation, the length of stay in the intensive care unit, and the length of stay in the hospital

The NEW ENGLAND JOURNAL of MEDICINE

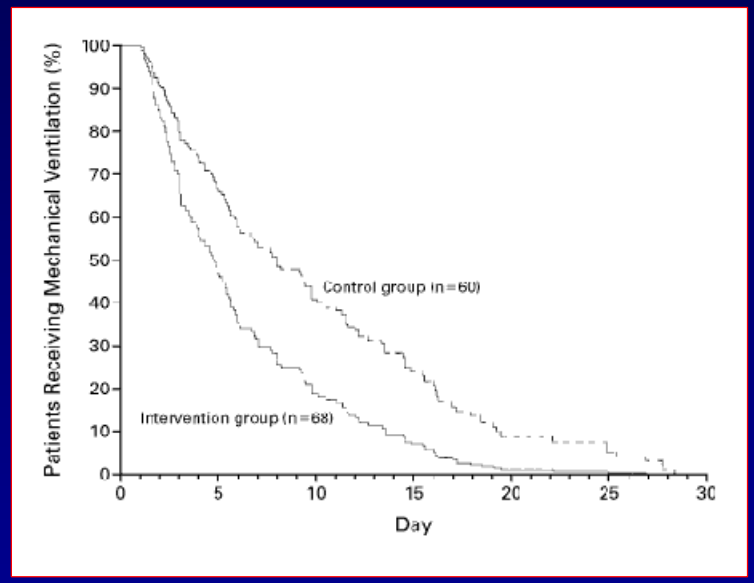
Kress JP et al. Daily interruption of sedative infusions in critically ill patients undergoing mechanical ventilation NEJM 2000;342:1471-7

Prevention of VILI

Daily discontinuation of sedatives

Results

- The median duration of MV was 4.9 days in the intervention group, as compared with 7.3 days in the control group (p=0.004)
- The median length of stay in the intensive care unit was 6.4 days as compared with 9.9 days, respectively (p=0.02).



- There were no differences in the rates of complications (e.g., removal of the endotracheal tube by the patient) between both groups m(p=0.88).

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MV Bundle Contents

Prevent Ventilator Induced Lung Injury (VILI)

Prevent Ventilator Associated Pneumonia (VAP)

Weaning

Ventilator bundle

Ventilator Associated Pneumonia

The key components of the Ventilator Bundle are:

- Elevation of the Head of the Bed
- Daily "Sedation Vacations" and Assessment of Readiness to Extubate
- Peptic Ulcer Disease Prophylaxis
- Deep Venous Thrombosis Prophylaxis

Resar R et al. Using a bundle approach to improve ventilator care processes and reduce ventilator associated pneumonia. *Jt Comm J Qual Patient Saf*. 2005;31:243-248.

Ventilator bundle

	Semirecumbent group	Supine group	p value
Rate of clinically suspected NP	3/39 [8%]	16/47 [34%]	0.003
Rate of microbiologically confirmed NP	2/39 [5%]	11/47 [23%]	0.018
Supine body position and enteral nutrition were independent risk factors for nosocomial pneumonia and the frequency was highest for patients receiving enteral nutrition in the supine body position (14/28, 50%). *Drakulovic MB. Lancet 1999;354:1851-8*			

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+ Peptic Ulcer Disease Prophylaxis

+ Deep Venous Thrombosis Prophylaxis

The Joint Commission Journal on Quality and Patient Safety

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Ventilator bundle

	Intervention group	Control group	p value
Duration of MV	4.9 (2.5-8.6)	7.3 (3.4-16.1)	0.004
Length of stay (days)			
ICU	6.4 [3.9-12.0]	9.9 [4.7-17.9]	0.02
Hospital	13.3 [7.3-20.0]	16.9 [8.5-26.6]	0.19
Kress JP et al. N Eng J Med 2000;342:1471-7			

	S
Rate of clinically suspected NP	
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Drakulovic MB. Lancet 1

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Borrero E, Bank S, Margolis I, et al: Comparison of antacid and sucralfate in the prevention of gastrointestinal bleeding in patients who are critically ill. *Am J Med* 1985;79:62–64

Bresalier RS, Grendell JH, Cello JP, et al: Sucralfate versus titrated antacid for the prevention of acute stress-related gastrointestinal hemorrhage in critically ill patients. *Am J Med* 1987; 83:110–116

Cook D, Guyatt G, Marshall J, et al: A comparison of sucralfate and ranitidine for the prevention of upper gastrointestinal bleeding in patients requiring mechanical ventilation. Canadian Critical Care Trials Group. *N Engl J Med* 1998; 338:791–797

The Joint Commission *Journal on Quality and Patient Safety*

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Table 17—*Thromboprophylaxis Trials in Critical Care Patients

Study/Year	Method of Diagnosis	Intervention		DVT†	
		Control	Experimental	Control	Experimental
Cade[685]/1982	FUT for 4–10 d	Placebo	Heparin, 5,000 U SC bid	NR/NR (29)	NR/NR (13)
Kapoor et al[756]/1999	DUS on admission and every 3 d	Placebo	Heparin, 5,000 U SC bid	122/390 (31)	44/401 (11)
Fraisse et al[754]/2000	Venography before day 21	Placebo	Nadroparin, approximately 65 U/kg SC once daily	24/85 (28)	13/84 (15)
Goldhaber et al[757]/2000	DUS on days 3, 7, 10, and 14	Heparin, 5,000 U SC bid	Enoxaparin, 30 mg SC bid	NR/NR (13)	NR/NR (16)

*Randomized clinical trials in which routine screening with an objective diagnostic test for DVT was used in critical care unit patients.
†Values given as No. of patients with DVT/total No. of patients (%).

Trials Group. *N Engl J Med* 1998; 338:791–797

Resar R et al. Using a bundle approach to improve ventilator care processes and reduce ventilator associated pneumonia. *Jt Comm J Qual Patient Saf*. 2005;31:243-248.

Other bundles

Ventilator Associated Pneumonia

1. Elevation of the head of the bed (HOB) to 30° to 45° unless medically contraindicated,
2. Continuous removal of subglottic secretions,
3. Change of ventilator circuit no more often than every 48 hours, and
4. Washing of hands before and after contact with each patient.

AMERICAN JOURNAL OF CRITICAL CARE

Arlene F et al. Am J Crit Care. 2007;16(1):20-7

Other bundles

Reference	Year	Design	Significant outcomes	Suggested practice
HOB elevation				
Drakulovic et al[3]	1999	Randomized controlled trial	HOB elevation and VAP	HOB elevation at 30°-45°
Kollef[4]	1993	Inception cohort design	Mortality rate and VAP	
Kollef et al[5]	1997	Comparison studies, surveillance of patients, and data collection	Transport of patients and VAP rate	
Grap et al[6]	2005	Longitudinal, descriptive design	Height of back rest and VAP, comfort and skin integrity of patient	HOB elevation
Metheny et al[7]	2006	Prospective, descriptive design	HOB and outcomes; risk factors for VAP	HOB elevation >30°
Hanneman and Gusick[8]	2005	Cross-sectional design, observational data	HOB and outcomes, supine and 30°, semiprone with head down 15°-20°	HOB elevation
Torres et al[9]	1992	Comparison	Comparison of semirecumbent and supine positions	HOB elevation at least 45° prophylactic measure for gastric aspiration
Babcock et al[10] Salahuddin et al[11] Zack et al[12]	2004 2004 2002	Before and after education	Staff education decreased VAP incidence	Staff education on VAP
Warren et al[13]	2003	Association and multiple regression	VAP and length of stay in intensive care unit, hospital stay, mortality rate, hospital cost	
Cook et al[14]	2002	Semistructured interviews and focus groups	Barriers leading to underuse of HOB elevation	

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AMERICAN JOURNAL OF CRITICAL CARE

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Torres et al[9]	1992	Comparison	Comparison of semirecumbent and supine positions	HOB elevation at least 45° prophylactic measure for gastric aspiration
				VAP
Oral care				
Bergman et al[21] Pugin et al[22]	2001 1991	Randomized controlled trial	Tracheobronchial colonization and VAP incidence	
Bergman et al[21]	2001	Randomized controlled trial	Antibiotics and colonization	Prophylactic antibiotics
DeRiso et al[23]	1996	Randomized controlled trial	Chlorhexidine reduced respiratory infection	Oral care
Mentec et al[24]	2001	Randomized controlled trial	Gastric residual volume and vomiting increased incidence of VAP	Check gastric residual volume
Cutler and Davis[25]	2005	Observation before and after education	Implementation of oral care protocol improved oral care	Oral care protocol and provision of appropriate tools

AMERICAN JOURNAL OF CRITICAL CARE

Arlene F et al. Am J Crit Care. 2007;16(1):20-7

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DeRiso et al[23]	1996	Randomized controlled trial		
Mentec et al[24]	2001	Randomized controlled trial		
Cutler and Davis[25]	2005	Observational and a		
Hand washing				
Girou et al[15]	2002	Randomized controlled trial	Bacterial count for alcohol-based solution and hand washing	Use of alcohol-based solution for hand washing
Lucet et al[16]	2002			
Trick et al[17]	2003			
Zaragosa et al[18]	1999			
Trick et al[17]	2003	Randomized controlled trial	Wearing rings and hand contamination	Refraining from wearing rings during work
Doebbeling et al[19]	1992	Crossover trial	Use of chlorhexidine, soap, and alcohol and VAP incidence	Use of chlorhexidine, soap, and alcohol
Pittet et al[20]	1999	Observation study	Hand washing and bacterial count	Hand washing before and after contact with patient

AMERICAN JOURNAL OF CRITICAL CARE

Arlene F et al. Am J Crit Care. 2007;16(1):20-7

In Pediatrics …

Ventilator Associated Pneumonia

IMPLEMENTATION OF A PEDIATRIC SPECIFIC VAP BUNDLE RESULTS IN NEAR ELIMINATION OF VENTILATOR-ASSOCIATED PNEUMONIA (VAP) IN A TERTIARY PEDIATRIC ICU

Richard J. Brilli MD* Dan Wells RRT Julie Shaw RN Cincinnati Childrens Hospital, Cincinnati, OH

- Change ventilator circuits only when soiled
- Drain circuit condensate every 2-4 hours
- Store oral suction devices in non-sealed plastic bags at bedside
- Mouth care every 4 hours
- Elevate head of bed
- Drain ventilator circuit before moving patient

CHEST

Chest 2006; 130: 138S-139S

In Pediatrics …

Ventilator Associated Pneumonia

	Pre-bundle	Post-bundle	p
Mean VAP rate	6.6/1000 vent days	0.5/1000 vent days	<0.05
VAP incidence	39/1076 (3.6%)	1/409 (2.4%)	

RESULTS: Mean baseline VAP rate was 6.6 infections per 1000 ventilator days. Post bundle implementation, mean VAP rate was 0.5/1000 vent days ($p < 0.05$) and days between VAP infections was 228. Pre-bundle there were 39 infections in 1076 ventilated patients (3.6%) compared to 1 infection in 409 patients (2.4%) post-bundle. Measured adherence with implementation of each bundle element was 100%. PICU mortality rates, LOS, and average duration of mechanical ventilation were not different pre and post VAP bundle.

CHEST

Chest 2006; 130: 138S-139S

MV Bundle Contents

Prevent Ventilator Induced Lung Injury (VILI)

Prevent Ventilator Associated Pneumonia (VAP)

Liberation from mechanical ventilation

Liberation from mechanical ventilation

When to initiate?

Adequate oxygenation (*eg*, $Po_2 \geq 60$ mm Hg on $Fio_2 \leq 0.4$; PEEP ≤ 5–10 cm H_2O; $Po_2/Fio_2 \geq$ 150–300);

Stable cardiovascular system (*eg*, HR ≤ 140; stable BP; no (or minimal) pressors)

Afebrile (temperature < 38°C)

No significant respiratory acidosis

Adequate hemoglobin (*eg*, Hgb ≥ 8–10 g/dL)

Adequate mentation (*eg*, arousable, GCS ≥ 13, no continuous sedative infusions)

Stable metabolic status (*eg*, acceptable electrolytes)

Resolution of disease acute phase; physician believes discontinuation possible; adequate cough

CHEST

MacIntyre NR. Chest 2001;120:375S-396S

Liberation from mechanical ventilation

Can the patient sustain spontaneous breathing?

	n	SE	EF	TF
Farias JA; et al. Int Care Med 1998:1070-5	84	89 %	16 %	10 %
Farias JA; et al. Int Care Med 2002:752-7	418	77 %	14 %	23 %
Randolph; A et al. JAMA 2002: 2561-8	313	42 %	11%	58 %
Noizet O; et al. Crit Care Med 2005, 798-7	54 (57)	80 %	20 %	3 %
Chavez A; et al. PCCM 2006. 324-328	70	91 %	7.8 %	9 %

Liberation from mechanical ventilation

Spontaneous breathing trial in children

- Multicenter, prospective, RCT including 257 infants and children who received MV at least for 48h and were considered able to undergo a SBT by their primary physician
- Patients were randomly assigned to perform a SBT in one of two ways: PSV of 10 cmH_2O or T-piece.

EUROPEAN SOCIETY OF INTENSIVE CARE MEDICINE

Farias JA et al. Intensive Care Med 2001; 27:1649-54

Liberation from mechanical ventilation

Spontaneous breathing trial in children

	Reconnected	Extubated	Reintubated within 48h
Pressure support (n=125)	26 (21%)	99 (79%)	15 (15%)
T-piece (n=132)	30 (23%)	102 (77%)	13 (13%)

	Pressure support (n=125)	T-piece (n=132)	p
Patients that remain extubated 48 h after SBT	67.2	67.4	0.97
Reintubation rate	15.1	12.7	0.62
Trial failure rate	20.8	22.7	0.81

EUROPEAN SOCIETY OF INTENSIVE CARE MEDICINE

Farias JA et al. Intensive Care Med 2001; 27:1649-54

Liberation from mechanical ventilation

Spontaneous breathing trial in children

As in adults, successful extubation can be achieved in most children after the first breathing trial, performed either with pressure support of 10 cmH_2O or a T-piece.

EUROPEAN SOCIETY OF INTENSIVE CARE MEDICINE

Farias JA et al. Intensive Care Med 2001; 27:1649-54

Finally .....

Proposed The Bundles of Mechanical Ventilation For Children

Prevent Ventilator Induced Lung Injury (VILI)

Lung protective ventilation strategies

- Low TV//low plateau pressure
- PEEP *define potential for recruitment*
- Daily "vacation" from sedation

Yet to be proven in pediatrics

Prevent Ventilator Associated Pneumonia (VAP)

- Head over the bed ✓
- Gastric ulcer prophylaxis ✓
- ylaxis
  - Change ventilator circuits only when soiled
  - Drain circuit condensate every 2-4 hours
  - Store oral suction devices in non-sealed plastic bags at bedside
  - Mouth care every 4 hours
  - Elevate head of bed
  - Drain ventilator circuit before moving patient

Weaning

- Spontaneous breathing test ✓


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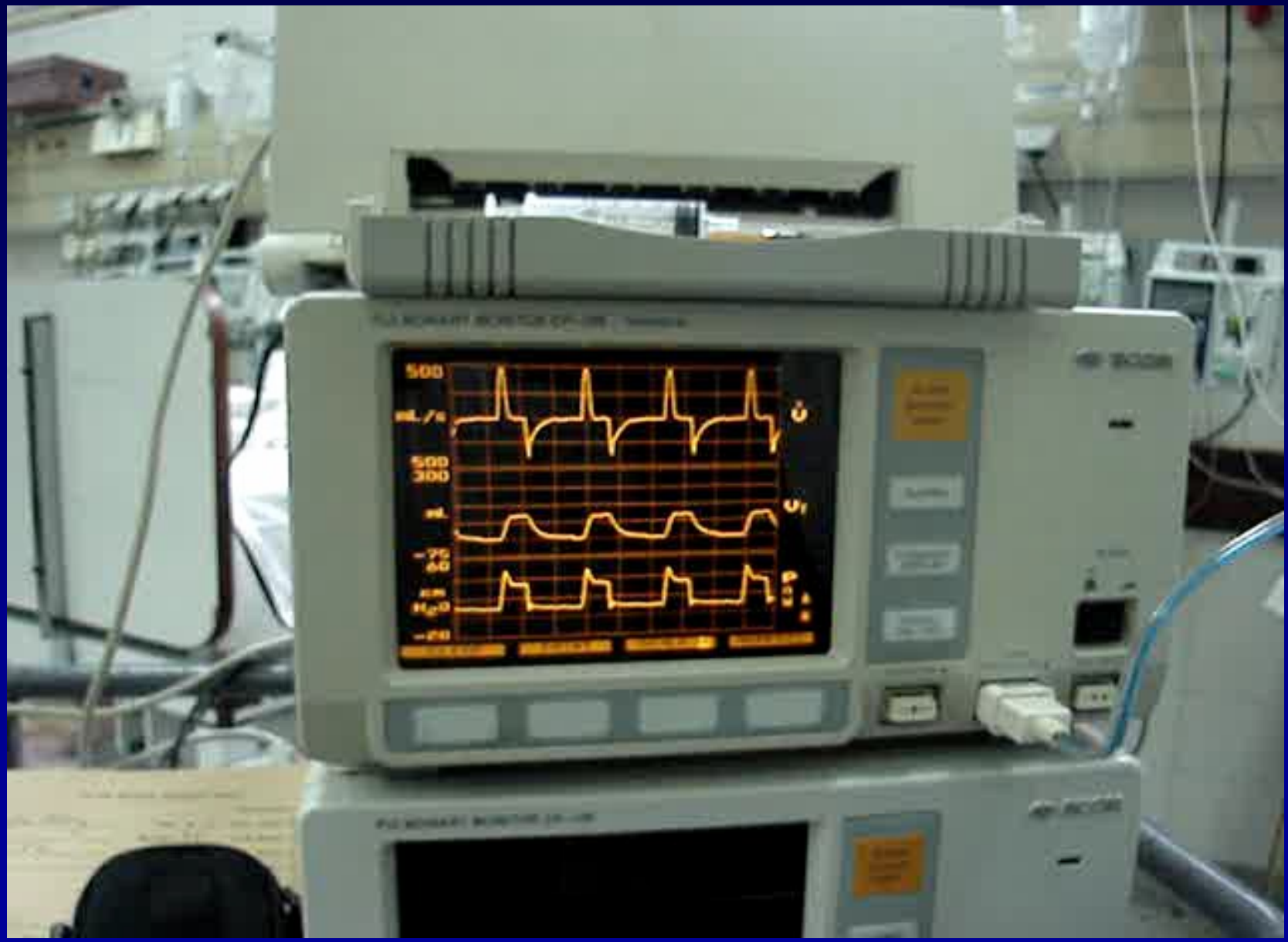
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300


Thank you