AIRWAY CARE, VAP, VAE, ETC

CAUSATION & PREVENTION: EVIDENCE AND LORE

Marvin C Weiss, MD, PHD
SCPMG, retired

10%-20% of ventilated patients develop nosocomial pneumonia despite widespread prevention efforts.

Attributable mortality from ventilator-assisted pneumonia (VAP) is about 13%.

VAP, VAC, and iVAC continue to be relatively common in critically ill patients who are mechanically ventilated and are associated with adverse outcomes. There is some overlap between them, but the agreement between VAC, iVAC, and VAP is low. Given the association between VAC and iVAC and adverse outcomes, they may be useful quality indicators.

VACs and iVACs are associated with significant morbidity and mortality. Although the agreement between VAC, iVAC, and VAP is poor, a higher adoption of measures to prevent VAP was associated with lower VAP and VAC rates.

Muscedere, CHEST 2013; 144(5):1453–1460

PREVENTION

Ref:

Society for Healthcare Epidemiology of America/Infectious Diseases Society of America (SHEA/IDSA) 2014 recommendations for prevention of VAP

Canadian Critical Care Society and Canadian Critical Care Trials Group 2008 recommendations for prevention of VAP

- **Consider implementing practices with little risk of harm that decrease duration of mechanical ventilation, length of stay, mortality, and/or costs.**

- Avoid intubation and reintubation if possible (Strong recommendation).

- Use noninvasive ventilation whenever possible (Strong recommendation).

- **If intubation is unavoidable:**
  - Institute protocols to improve the use of sedation and reduce the length of mechanical ventilation (Strong recommendation), such as:
    - daily interruption of sedation
    - daily spontaneous breathing trials
    - maintenance and improvement of physical conditioning of intubated patients
  - **Minimize the pooling of secretions above the endotracheal tube cuff.**
    - **Provide endotracheal tubes with subglottic secretion drainage ports for patients likely to require greater than 48 or 72 hours of intubation (Strong recommendation).**
  - Elevate the head of the bed to 30-45 degrees (Strong recommendation). (Cochrane, 2016: "A semi-recumbent position (>=30°) may reduce clinically suspected VAP compared to a 0° to 10° supine position. However, the evidence is seriously limited with a high risk of bias. No adequate evidence is available to draw any definitive conclusion on other outcomes and the comparison of alternative semi-recumbent positions. Adverse events, particularly venous thromboembolism, were under-reported."
  - Maintain ventilator circuits and change them only if visibly soiled or malfunctioning.

SUBGLOTTIC SECRETION DRAINAGE

Caroff, Crit Care Med 2016; 44:830-840

Meta-analysis: lower VAP, no change MV, LOS, VAE, mortality

Damas, Crit Care Med 2015; 43:22-30

RCT: lower VAP, lower antibiotic use, no change ICU LOS, mortality, no change in VAC

Hubbard, J Trauma Acute Care Surg 2016; 80: 218-222

Retrospective review: lower VAP, vent days, ICU LOS in trauma patients

Mao, Critical Care 2016; 20:353

Meta-analysis: lower VAP and vent days, delayed VAP, no change ICU LOS or mortality (hosp or ICU)

Frost, Australian Critical Care 2013; 26: 80-188

Meta-analysis: lower VAP, delayed VAP, may reduce vent days, no change mortality (hosp or ICU)

Muscedere, Crit Care Med 2011; 391985-1991

Meta-analysis: lower VAP, possible reduction vent days, ICU LOS

Prevention of Ventilator-Associated Pneumonia and Ventilator-Associated Conditions: A Randomized Controlled Trial With Subglottic Secretion Suctioning

Damas, Crit Care Med 2015; 43:22–30

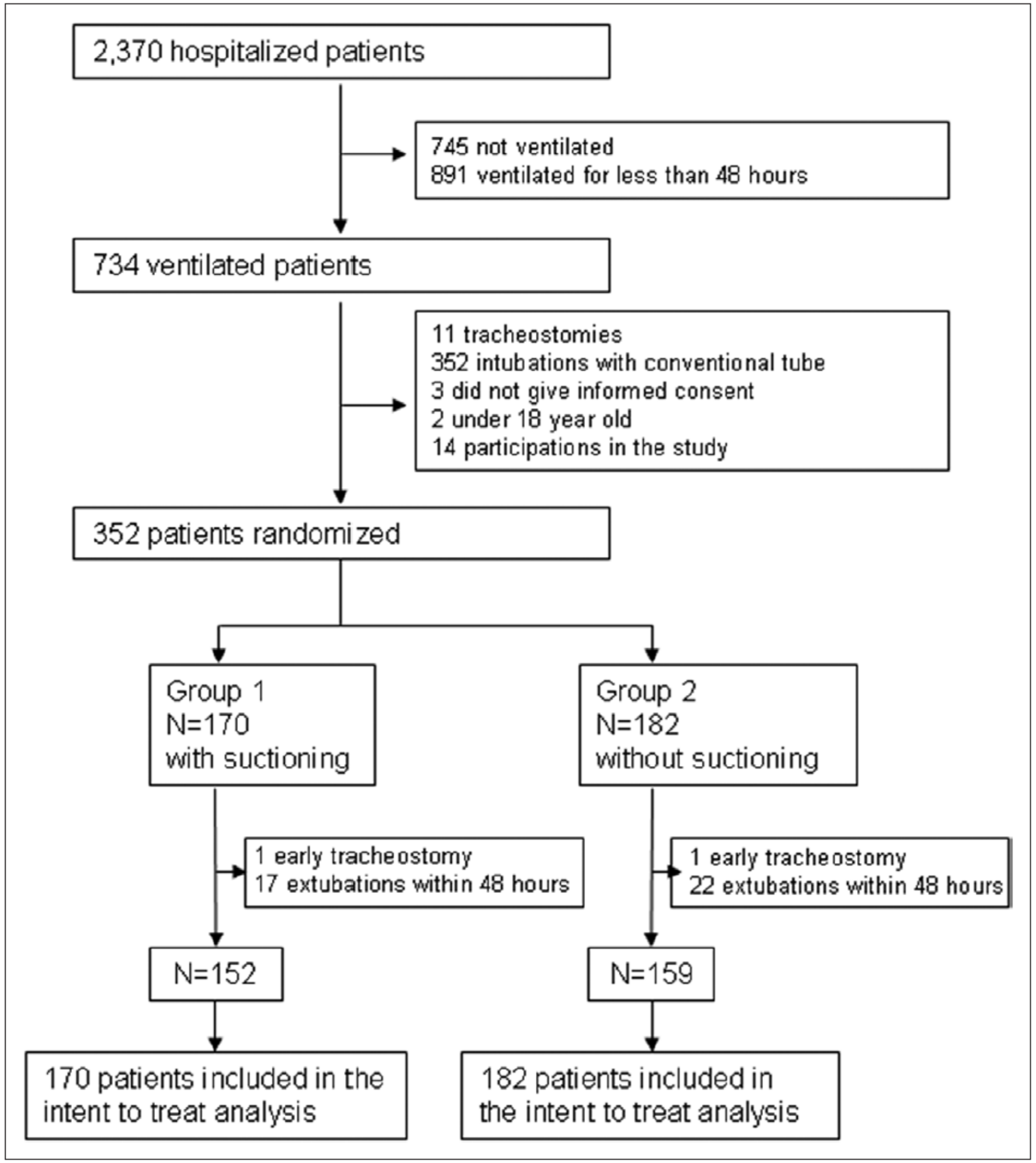


Figure 1. Flow chart of patients admitted to the ICUs between January 2012 and March 2013.

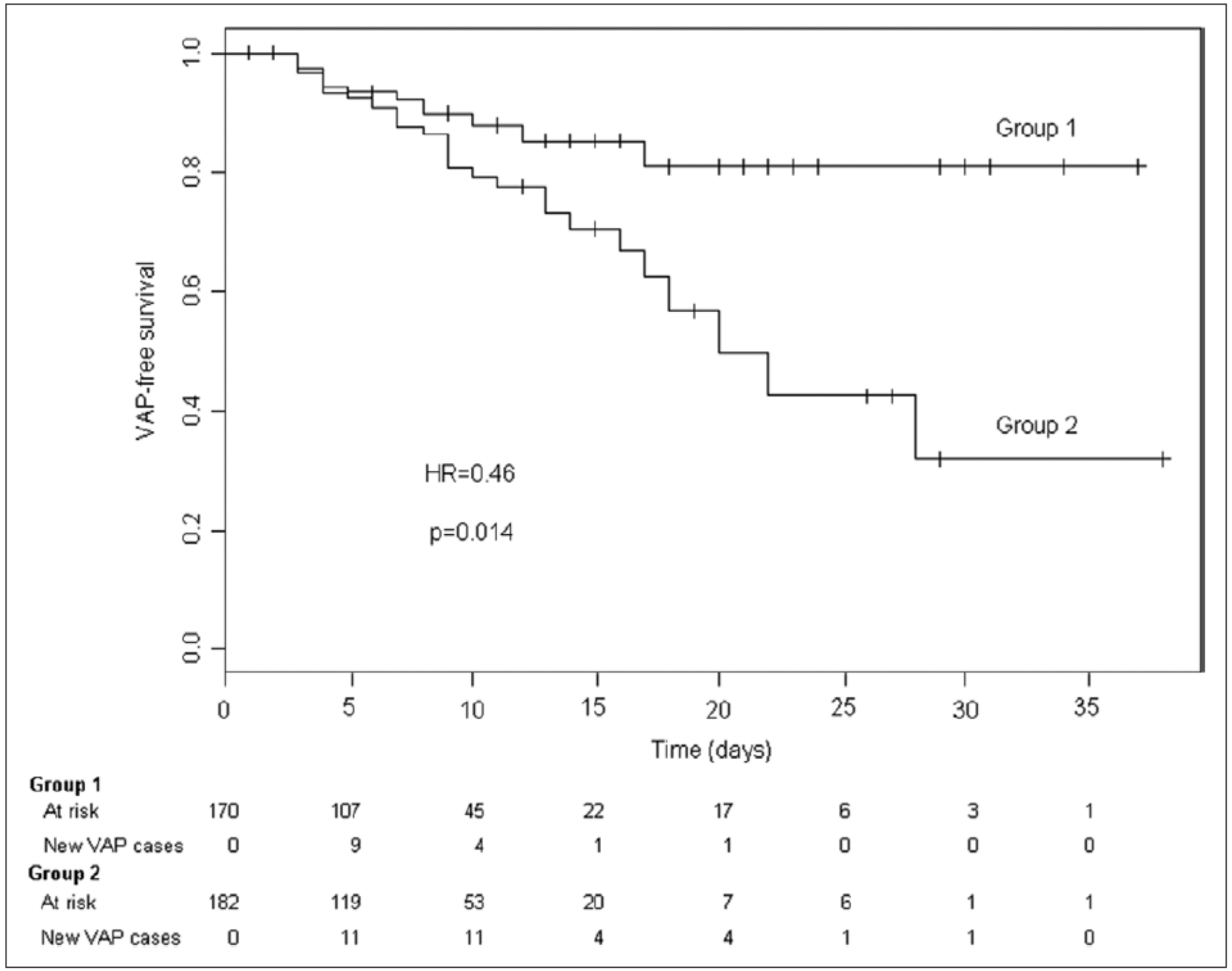


Figure 2. Cumulative rates of patients remaining free of ventilator-associated pneumonia (VAP) in group 1 with subglottic suctioning and control group (group 2) using the Kaplan-Meier method. HR = hazard ratio.

TABLE 3. Primary and Secondary Outcomes

Outcomes	Group 1 Experimental ($n = 170$)	Group 2 Control ($n = 182$)	p
Patients developing any kind of infection after intubation with TIET, n (%)	54 (34.9)	63 (39.0)	0.57
Respiratory infection at any time, n (%)	35 (22.4)	52 (32.7)	0.08
Early pneumonia (< 48 hr), n (%)	8 (5.3)	8 (5.0)	1.00
Ventilator-associated pneumonia during TIET, n (%)	15 (8.8)	32 (17.6)	0.016
Pneumonia after TIET withdrawal, n (%)	14 (7.2)	14 (7.5)	1.00
Patients with ventilator-associated condition, n (%)	37 (22.0)	41 (22.9)	0.84
Patients with infection-related ventilator-associated complication, n (%)	14 (8.2)	21 (11.5)	0.37
Duration of antibiotic treatment (d), median (IQR)	7 (3–14)	8 (5–13)	0.45
Antibiotic days during ICU stay (%)	61.6	68.5	< 0.0001
Antibiotic days during TIET ventilation (%)	68.3	75.7	0.001
ICU length of stay, median (IQR)	11 (7–21)	12 (7–19)	0.71
ICU mortality, n (%)	63 (37.1)	74 (40.9)	0.46
Hospital length of stay (d), median (IQR)	47 (21–148)	49 (19–96)	0.51
Hospital mortality, n (%)	78 (45.9)	93 (51.1)	0.33
Standardized mortality ratio	0.85	0.99	0.23

TIET = teleflex ISIS endotracheal tube, IQR = interquartile range.

Damas, Crit Care Med 2015; 43:22–30

Subglottic Secretion Drainage and Objective Outcomes: A Systematic Review and Meta-Analysis

Caroff, Crit Care Med 2016; 44:830-840

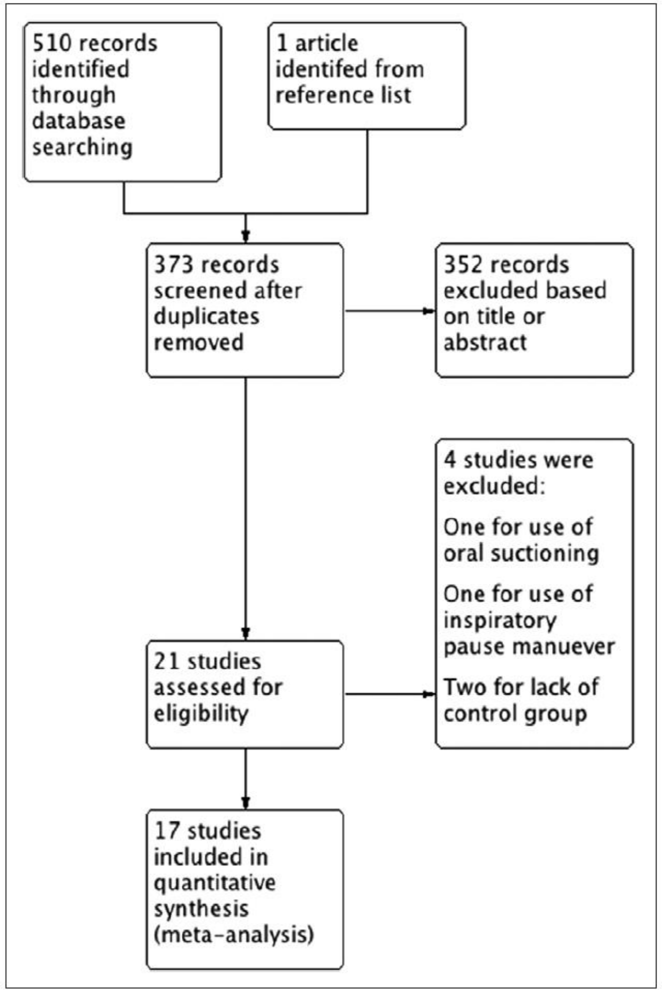


Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses study flowchart.

	SSD		Control			Risk Ratio	
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Random, 95% CI	Year
Mahul 1992	9	70	21	75	3.8%	0.46 [0.23, 0.93]	1992
Valles 1995	14	95	25	95	5.5%	0.56 [0.31, 1.01]	1995
Kollef 1999	8	160	15	183	2.8%	0.61 [0.27, 1.40]	1999
Bo 2000	8	35	15	33	3.7%	0.50 [0.25, 1.03]	2000
Smulders 2002	3	75	12	75	1.3%	0.25 [0.07, 0.85]	2002
Girou 2004	5	8	6	10	3.5%	1.04 [0.50, 2.18]	2004
Liu S 2006	3	48	10	50	1.3%	0.31 [0.09, 1.07]	2006
Liu Q 2006	14	41	30	45	8.5%	0.51 [0.32, 0.82]	2006
Lorente 2007	11	140	31	140	4.6%	0.35 [0.19, 0.68]	2007
Zheng 2008	9	30	16	31	4.6%	0.58 [0.31, 1.11]	2008
Yang 2008	12	48	20	43	5.6%	0.54 [0.30, 0.97]	2008
Bouza 2008	13	345	19	369	4.0%	0.73 [0.37, 1.46]	2008
Lacherade 2010	25	169	42	164	9.6%	0.58 [0.37, 0.90]	2010
Tao 2014	52	102	34	47	28.3%	0.70 [0.54, 0.91]	2014
Damas 2014	15	170	32	182	5.7%	0.50 [0.28, 0.89]	2014
Koker 2014	5	23	10	28	2.3%	0.61 [0.24, 1.53]	2014
Gopal 2015	13	120	25	120	5.0%	0.52 [0.28, 0.97]	2015
Total (95% CI)		**1679**		**1690**	**100.0%**	**0.58 [0.51, 0.67]**	
Total events	219		363				

Heterogeneity: $\mathrm{Tau}^2 = 0.00$; $\mathrm{Chi}^2 = 12.12$, df = 16 ($P = 0.74$); $I^2 = 0\%$
Test for overall effect: $Z = 7.71$ ($P < 0.00001$)

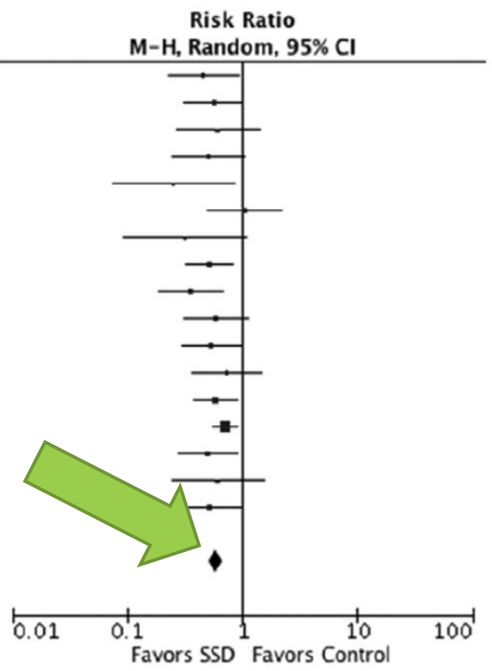


Figure 2. Ventilator-associated pneumonia in patients with subglottic secretion drainage (SSD) versus controls. M–H = Mantel-Haenszel.

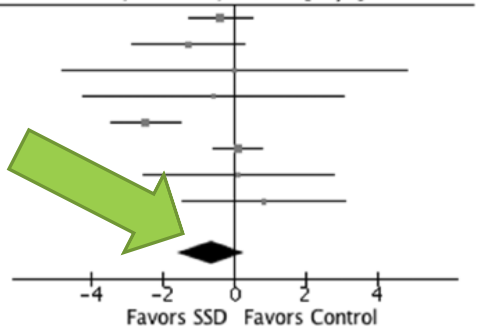
Caroff, Crit Care Med 2016; 44:830-840

A

Study or Subgroup	SSD Mean [days]	SSD SD [days]	SSD Total	Control Mean [days]	Control SD [days]	Control Total	Weight	Mean Difference IV, Random, 95% CI [days]	Year
Kollef 1999	1.5	3.3	160	1.9	5.1	183	19.5%	-0.40 [-1.30, 0.50]	1999
Smulders 2002	5.8	4.4	75	7.1	5.4	75	14.2%	-1.30 [-2.88, 0.28]	2002
Liu S 2006	15	14	48	15	10	50	3.2%	0.00 [-4.83, 4.83]	2006
Lorente 2007	10.5	15.91	140	11.1	15.19	140	5.2%	-0.60 [-4.24, 3.04]	2007
Zheng 2008	7.9	2.6	30	10.4	0.9	31	18.8%	-2.50 [-3.48, -1.52]	2008
Bouza 2008	2	5.3	345	1.9	3.8	369	21.1%	0.10 [-0.58, 0.78]	2008
Lacherade 2010	10.9	10.6	169	10.8	14	164	8.1%	0.10 [-2.57, 2.77]	2010
Damas 2014	11.71	11.87	170	10.87	9.79	182	9.8%	0.84 [-1.44, 3.12]	2014
Total (95% CI)			**1137**			**1194**	**100.0%**	**-0.65 [-1.59, 0.28]**	

Heterogeneity: $Tau^2 = 0.96$; $Chi^2 = 21.22$, df = 7 ($P = 0.003$); $I^2 = 67\%$
Test for overall effect: $Z = 1.37$ ($P = 0.17$)

Mean Difference
IV, Random, 95% CI [days]

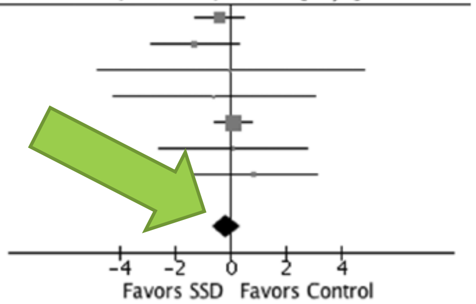


B

Study or Subgroup	SSD Mean [days]	SSD SD [days]	SSD Total	Control Mean [days]	Control SD [days]	Control Total	Weight	Mean Difference IV, Random, 95% CI [days]	Year
Kollef 1999	1.5	3.3	160	1.9	5.1	183	29.1%	-0.40 [-1.30, 0.50]	1999
Smulders 2002	5.8	4.4	75	7.1	5.4	75	9.5%	-1.30 [-2.88, 0.28]	2002
Liu S 2006	15	14	48	15	10	50	1.0%	0.00 [-4.83, 4.83]	2006
Lorente 2007	10.5	15.91	140	11.1	15.19	140	1.8%	-0.60 [-4.24, 3.04]	2007
Bouza 2008	2	5.3	345	1.9	3.8	369	50.8%	0.10 [-0.58, 0.78]	2008
Lacherade 2010	10.9	10.6	169	10.8	14	164	3.3%	0.10 [-2.57, 2.77]	2010
Damas 2014	11.71	11.87	170	10.87	9.79	182	4.5%	0.84 [-1.44, 3.12]	2014
Total (95% CI)			**1107**			**1163**	**100.0%**	**-0.16 [-0.64, 0.33]**	

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 3.68$, df = 6 ($P = 0.72$); $I^2 = 0\%$
Test for overall effect: $Z = 0.64$ ($P = 0.52$)

Mean Difference
IV, Random, 95% CI [days]



Abbreviations:
SSD, subglottic secretion drainage; *M-H*, Mantel-Haenszel; *CI*, confidence interval; *IV*, inverse variance; *SD*, standard deviation

Figure 3. Duration of mechanical ventilation in patients with subglottic secretion drainage (SSD) versus controls. **A**, All studies with available mean and SD for duration of mechanical ventilation. One study (Zheng et al [36]) is an outlier relative to all other studies and leads to high heterogeneity on meta-analysis ($I^2 = 67\%$). **B**, Findings on meta-analysis after excluding Zheng et al (36) ($I^2 = 0\%$). M–H = Mantel-Haenszel, IV = inverse variance.

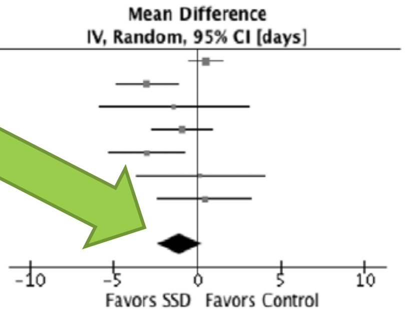
Caroff, Crit Care Med 2016; 44:830-840

ICU Length-of-Stay

A

Study or Subgroup	SSD Mean [days]	SSD SD [days]	SSD Total	Control Mean [days]	Control SD [days]	Control Total	Weight	Mean Difference IV, Random, 95% CI [days]	Year
Kollef 1999	3.7	4.6	160	3.2	4.5	183	22.5%	0.50 [-0.47, 1.47]	1999
Smulders 2002	9.3	7.4	75	12.3	3.6	75	17.3%	-3.00 [-4.86, -1.14]	2002
Lorente 2007	14.1	17.91	140	15.5	19.93	140	6.9%	-1.40 [-5.84, 3.04]	2007
Bouza 2008	5.6	10.7	345	6.5	14.2	369	17.4%	-0.90 [-2.74, 0.94]	2008
Zheng 2008	9.3	2.9	30	12.3	5.7	31	15.0%	-3.00 [-5.26, -0.74]	2008
Lacherade 2010	15.9	14.4	169	15.7	20.4	164	8.6%	0.20 [-3.60, 4.00]	2010
Damas 2014	16.2	13.52	170	15.76	13.15	182	12.3%	0.44 [-2.35, 3.23]	2014
Total (95% CI)			**1089**			**1144**	**100.0%**	**-1.04 [-2.40, 0.33]**	

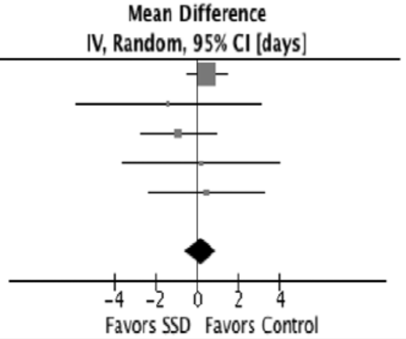
Heterogeneity: $Tau^2 = 1.92$; $Chi^2 = 16.62$, df = 6 ($P = 0.01$); $I^2 = 64\%$
Test for overall effect: $Z = 1.49$ ($P = 0.14$)



B

Study or Subgroup	SSD Mean [days]	SSD SD [days]	SSD Total	Control Mean [days]	Control SD [days]	Control Total	Weight	Mean Difference IV, Random, 95% CI [days]	Year
Kollef 1999	3.7	4.6	160	3.2	4.5	183	66.3%	0.50 [-0.47, 1.47]	1999
Lorente 2007	14.1	17.91	140	15.5	19.93	140	3.1%	-1.40 [-5.84, 3.04]	2007
Bouza 2008	5.6	10.7	345	6.5	14.2	369	18.3%	-0.90 [-2.74, 0.94]	2008
Lacherade 2010	15.9	14.4	169	15.7	20.4	164	4.3%	0.20 [-3.60, 4.00]	2010
Damas 2014	16.2	13.52	170	15.76	13.15	182	8.0%	0.44 [-2.35, 3.23]	2014
Total (95% CI)			**984**			**1038**	**100.0%**	**0.17 [-0.62, 0.95]**	

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 2.27$, df = 4 ($P = 0.69$); $I^2 = 0\%$
Test for overall effect: $Z = 0.41$ ($P = 0.68$)



Hospital Length-of-Stay

Study or Subgroup	SSD Mean [days]	SSD SD [days]	SSD Total	Control Mean [days]	Control SD [days]	Control Total	Weight	Mean Difference IV, Random, 95% CI [days]	Year
Kollef 1999	11	11.2	160	12.4	14.2	183	48.5%	-1.40 [-4.09, 1.29]	1999
Smulders 2002	26.8	23.3	75	28.3	28.2	75	5.1%	-1.50 [-9.78, 6.78]	2002
Liu S 2006	30	31	48	32	19	50	3.4%	-2.00 [-12.23, 8.23]	2006
Bouza 2008	14	25.4	345	13.7	17.4	369	34.0%	0.30 [-2.91, 3.51]	2008
Damas 2014	34.92	32.56	170	33.27	26.36	182	9.1%	1.65 [-4.56, 7.86]	2014
Total (95% CI)			**798**			**859**	**100.0%**	**-0.57 [-2.44, 1.30]**	

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 1.26$, df = 4 ($P = 0.87$); $I^2 = 0\%$
Test for overall effect: $Z = 0.60$ ($P = 0.55$)

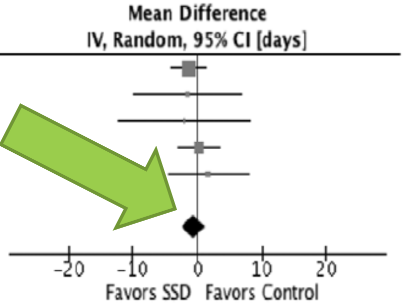


Figure 4. Length of stay in patients with subglottic secretion drainage (SSD) versus controls. **A**, All studies with available mean and SD for intensive care length of stay. Two studies (Smulders et al [12] and Zheng et al [36]) have very small SDs in the control and treatment arms, respectively, that lead to high heterogeneity on meta-analysis ($I^2 = 64\%$). **B**, Findings on meta-analysis after excluding these two studies ($I^2 = 0\%$). IV = inverse variance.

Caroff, Crit Care Med 2016; 44:830-840

Study or Subgroup	SSD Events	SSD Total	Control Events	Control Total	Weight	Risk Ratio M-H, Random, 95% CI	Year
Mahul 1992	17	70	16	75	3.0%	1.14 [0.62, 2.07]	1992
Valles 1995	39	95	35	95	8.3%	1.11 [0.78, 1.59]	1995
Kollef 1999	6	160	8	183	1.0%	0.86 [0.30, 2.42]	1999
Smulders 2002	12	75	10	75	1.8%	1.20 [0.55, 2.61]	2002
Liu Q 2006	18	41	13	45	3.2%	1.52 [0.86, 2.70]	2006
Liu S 2006	5	48	11	50	1.1%	0.47 [0.18, 1.26]	2006
Lorente 2007	26	140	32	140	5.0%	0.81 [0.51, 1.29]	2007
Yang 2008	32	48	29	43	12.8%	0.99 [0.74, 1.32]	2008
Zheng 2008	8	30	12	31	1.9%	0.69 [0.33, 1.44]	2008
Bouza 2008	34	345	35	369	5.3%	1.04 [0.66, 1.63]	2008
Lacherade 2010	80	169	84	164	22.3%	0.92 [0.74, 1.15]	2010
Tao 2014	48	102	29	47	11.4%	0.76 [0.56, 1.03]	2014
Damas 2014	78	170	93	182	22.7%	0.90 [0.72, 1.11]	2014
Gopal 2015	2	120	1	120	0.2%	2.00 [0.18, 21.76]	2015
Total (95% CI)		**1613**		**1619**	**100.0%**	**0.93 [0.84, 1.03]**	
Total events	405		408				

Heterogeneity: Tau² = 0.00; Chi² = 9.99, df = 13 (P = 0.69); I² = 0%
Test for overall effect: Z = 1.31 (P = 0.19)

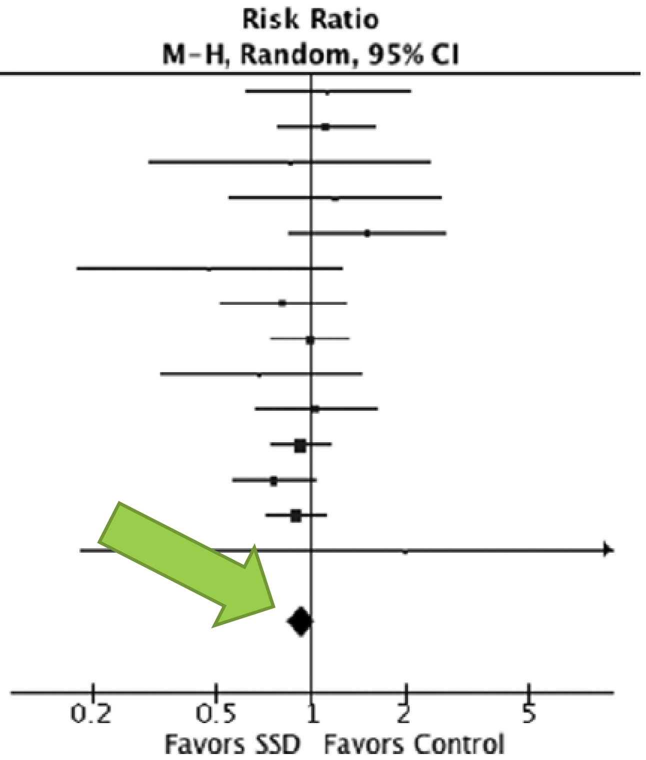


Figure 5. Mortality rates in patients with subglottic secretion drainage (SSD) versus controls. All studies that provided mortality data regardless of mortality time point were included. Analyses restricted to studies that reported ICU mortality and hospital mortality, respectively, are reported in the text. M–H = Mantel-Haenszel.

Caroff, Crit Care Med 2016; 44:830-840

Challenges with SSD

- Specialized tube required
- Continuous vs intermittent suction
- Wall vs manual vs automated suction
- Location of drainage port
- Numbers of ports
- Tracheal wall damage
- Mucosal desiccation
- Endoluminal size restriction
- Possible drainage port occlusion
- Cross contamination wall regulator

Potential Benefits (Automated Intermittent SSD) SIMEX™

- Intermittent aspiration reduces the risk of injury due to drying of mucous membranes or adverse pressure trauma
- Customizable to each patient's needs
- Increased patient comfort during aspiration process
- Minimized maceration of surrounding tissue due to reduction of secretion leakage
- Decreased need for frequent tracheal dressing changes due to reduction of secretion leakage
- Self-contained collection canisters help prevent cross-contamination and minimize incidence of infection

	Traditional Approaches			Automated Approach
	Continuous	*Intermittent*	*Manual*	*Intermittent*
Method	Wall Suction or General Suction	Wall Suction or General Suction	Syringe	Specialized Suction Device
Pressure	-20 mmHg (may be too low to aspirate viscous secretion and increased above recommended guidelines)	-150 mmHg (high frequency aspiration – virtually continuous at a much higher pressure)	-580 to -720 mmHg (nearly 4-5 times higher than recommended)	Tailored by patient, -50 to -150 mmHg
Accuracy of Pressure Delivered	Not reliable	Not reliable	Always Higher than recommended Guidelines	Accurate/reliable
Frequency	Continuously, 24/7	Aspirating virtually continuously with short pauses (16 seconds), 24/7	Hourly (often less regularly)	Tailored by patient, Aspiration for 10 - 20 seconds and pause for 5 - 20 minutes, 24/7
Daily Aspirations	Non-Stop Aspiration	1,440 - 3,600 aspirations daily	24 aspirations daily	24 -144 aspirations daily
Noise Level	Highly Noisy	Highly Noisy	None	Quiet
Staff Time (per bed per day)	10 minutes	10 minutes	120 minutes	10 minutes
Volume of Secretions	10 - 30 ml	10 - 30 ml	30 ml	100 - 500 ml
FDA Cleared	No	No	No	Yes
Specifically Designed for SSD	No	No	No	Yes
Potential for Cross Contamination	Yes	Yes	Yes	Minimized

Cozean J, Benefits of automated intermittent subglottic secretion drainage. Respiratory Therapy 2015;10:4:27-28

Determination of the amount of Negative Pressure that is generated by Syringe using various size Syringes (Bench Test)

Various size syringes 2, 5, 10 and 20 ml syringes were utilized to measure the amount of Negative Pressure that each syringe generates. A calibrated pressure sensor was used to measure the amount of negative pressure in mmHg. For each syringe the test was repeated 3 times and the results are tabulated in the following table. The photo below demonstrates how the syringe is connected via a tube to the pressure measuring device.

This bench test[1], clearly demonstrates that the larger the syringe, the higher the negative pressure it generates. The most common size syringe used in hospitals for removal of secretion from respiratory airway is 10 ml syringe. As it is shown in the table below, all size syringes generate negative pressure in excess of the -770 mbar or -578mmHg which is quite high and four (4) times the AARC recommended MAXIMUM pressure range of -200 mbar or -150 mmHg. The results of this bench test are in line with other published test and data demonstrating the fact that syringes do generate higher suction pressure.[2-3]

Test to measure peak vacuum pressure of syringes with different volumes

Volume of Syringe	Vacuum / Pressure [mmHg]			
	1	2	3	Average
2 ml	-578	-578	-578	-578
5 ml	-671	-671	-671	-671
10 ml	-706	-706	-706	-706
20 ml	-722	-722	-722	-722

A Single-center, Randomized Controlled Study Comparing the Efficacy of the Simex Automated Intermittent Subglottic Aspiration System in the Prevention of Ventilator-associated Pneumonia and Ventilator-associated Events in Long-term, Tracheostomized, Mechanically-ventilated Patients

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Alphonso Quinones, DHA, MA, RT, RRT-NPS, RPFT, RPSGT, CCT, AE-C, FACHE | Associate Professor of Allied Healthcare Science, Molloy College, Rockville Centre, NY

EASTCHESTER
REHABILITATION AND HEALTH CARE CENTER

Introduction

Ventilator-acquired pneumonia (VAP) continues to be a significant cause of morbidity and mortality, increased hospital stays, increased antibiotic use, and increased costs. VAP is the most common and preventable nosocomial infection among mechanically ventilated patients (Davis, K., 2006). Research suggests that subglottic suctioning decreases incidence of VAP; preventing aspiration of contaminated secretions into the sterile lower airways. High mortality rates among VAP patients are primarily due to patients' comorbidities and the virulence of the colonizing bacterium. The SIMEX Automated Intermittent Subglottic Aspiration System has been utilized in Europe, in over 1000 patients, with excellent clinical outcomes.

This Randomized Control Trial (RCT), the first of its type in the world, measured the effects of the SIMEX Automated Intermittent Subglottic Aspiration System in a long-term, 40-bed ventilator unit. Working in conjunction with a 5-step VAP protocol, the SIMEX Subglottic Aspiration System yielded significant positive clinical outcomes.

Importance of VAP Prevention

- VAP rates are important in long term ventilator units due to 45% increase in mortality rates (Ibrahim, EH., et al, 2001).
- VAP is responsible for increased morbidity rates, decreased revenue, increased duration on mechanical ventilation, and treatment costs that may exceed $40,000 (Guterl, G., 2013).

RCT Methodology

- 25 patients randomized to treatment – (designated Group A, device group) See Figure 1.
- 15 patients – (designated Group B, non-device control group).
- RCT was 4 months in duration.
- Amount of aspirate recorded daily.
- Portex Blueline subglottic tracheostomy tube – with dorsal lumen – was used for subglottic access.
- Most effective settings used in the trial was suction pressure -150 mmHg /12-second suction duration/10-minute suction intervals.

Clinical Problems Associated with Tracheostomy Tubes

- Due to tracheostomy tube placement, normal airway defense mechanisms are compromised.
- If bacteria are introduced into the normally sterile lower airway – colonization and infection begin.
- Tracheostomy tubes disrupt the mucocilliary escalator and impair the cough reflex.
- Tracheostomy tubes can cause injury to the tracheal tissue.

Redefining Tracheal Cuff Pressures

- The tracheostomy cuff is used to seal airway to provide positive pressure mechanical ventilation.
- The cuff can provide a platform for secretions to pool and eventually leak around the cuff.
- Most Respiratory Therapists set cuff pressures to "minimally occluded volume" – between 20-25 cmH_2O.
- Our research found that "minimally occluded volume" pressures are too low to prevent leakage of contaminated secretions.
- We found that cuff pressures of 30 cmH_2O (+/- 5 cmH_2O) are ideal for leak prevention. Results are similar to (Chendrasekhar, A. et al, 2013).
- Average cuff pressures in RCT were 28-33 cmH_2O without adverse tracheal wall damage or patient discomfort.

Respiratory Care Protocol

- Once admitted, Respiratory Therapist changes tracheostomy tube to subglottic version.
- Patient is connected to SIMEX Automated Intermittent Subglottic Aspiration System.
- Active humidification is discontinued and switched to Heat and Moisture Exchanger (HME).
- Medication nebulizers are discontinued and switch to MDIs.

- VAP Protocol allows differentiation between nosocomial and community acquired.
- If patient is admitted to the ventilator unit and spikes a temperature within 48 hours, patient is worked up for a possible VAP – considered a community-acquired VAP.
- 5-step VAP program initiated: (1) head of bed 30-45 degrees; (2) DVT prophylaxis; (3) proton pump inhibitor; (4) chlorhexidine 0.12% oral rinse; and (5) daily weaning from mechanical ventilation.

Benchmarks Prior to Introduction of SIMEX Automated System and New VAP Protocol

- Prior to use of SIMEX subglottic devices VAP rate averaged 16.25% – with VAP protocol in place.
- Transfers to hospital with VAP averaged 50%.
- Mortality rates for transferred patients averaged 50%.
- Respiratory therapists manually aspirated subglottic ports 4x/shift – very labor intensive.
- Average manual suction volume with 20cc syringe – 30-40 ml/day.
- Suction pressures with 20cc syringe were dangerously high (-700 mmHg) – potentially causing tracheal tissue damage.
- Difficult to apply consistent and safe suction pressures.
- No way to ensure maximal aspiration of subglottic volume.

Randomized Controlled Trial Results

- Initial subglottic secretion volumes ranged between 60-120ml/day. See Figure 3.
- After "redefining" "minimal occluded volume" – collected subglottic volumes ranged between 130-420 ml/day. This indicated leakage of subglottic secretions at lower tracheostomy cuff pressures. See Figure 3.
- Tracheostomy subglottic suction port design and position play an important role in efficiency and effectiveness of subglottic suctioning.
- Maceration of tissue surrounding the stoma decreased significantly resulting in less soiled clothing and need for frequent tracheostomy tie changes. See Figure 2.
- Conclusion of RCT – 25 patients on SIMEX device Group A resulted in VAP rate of 8% versus VAP rate of 33% in 15 patient control Group B.
- Post RCT Statistics – 40 patients on SIMEX device – past 8 months (March – October, 2016) – 2 confirmed VAP – 1 treated in-house – 1 required transfer to hospital and returned within 7 days.
- No mortality with VAP.
- Respiratory therapists report SIMEX device simple to program, maintain, and monitor.

Conclusion

The SIMEX Automated Intermittent Subglottic Aspiration System, working in conjunction with the 5-step VAP protocol, significantly decreased the incidence of VAP in our ventilator unit. These results are important considering the 50% VAP mortality rate. We have saved significant facility resources and keep patients in beds – increasing revenue. We have also decreased the 30-day transfer rates back to feeder hospitals, improving our relationships while improving patient care. Lastly, we have decreased time on mechanical ventilation and improved quality of life.

Poster Presented at 2016 CHEST Annual Meeting, Los Angeles, California

FIGURE 1
SIMEX Automated Intermittent Subglottic Aspiration System – setup on a patient in facility with subglottic secretions collected in the aspiration container.

FIGURE 2
Subglottic Tracheostomy tube connected to the SIMEX Aspiration System.

FIGURE 3

Optimal Suction Settings on the SIMEX Automated Intermittent Subglottic Aspiration Device	
-150 mmHg – 12 second duration – 10 minute intervals	
Cuff Pressures	Subglottic Secretion Volume
18 – 25 cmH_2O	60 – 120 ml/day
25 – 30 cmH_2O	130 – 250 ml/day
30 – 35 cmH_2O	250 – 420 ml/day

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The Role of Subglottic Secretion Drainage in VAP Prevention: ICU Experience with an Automated Intermittent Subglottic Secretion Drainage System

Wolf, Respiratory Therapy 2016; 11:28-33

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Table 1. Automated Subglottic Aspiration System Patients

Pt	M/F	Age	Condition	Pathogen(s)	Secretion/Daily	Other Observations
01	M	63	Coronary artery bypass OP. Cerebeller infarction	Morganella morgagnii	100 ml mucopurulent (fecal smell)	Delirium Dysphagia
02	M	85	Valve replacement. CHF. Diabetes	E.coli. Morganella morgagnii. Stenotrophomonas	150-250 mucopurulent	Delirium Dysphagia
03	M	67	55 day post esophagectomy for cancer. COPD		400 ml watery	Gastric regurgitation
04	M	74	Coronary artery bypass OP with aortic valve replacement. Acute persistent renal failure. Severe critical illness polyneuropathy. Slow recovery due to axonal type		150 ml mucopurulent. 1400 ml total collected within a few days	Dysphagia Depression
05	M	83	29 days post emergency coronary artery bypass OP. Severe critical illness polyneuropathy		250-350 ml mucopurulent	
06	F	79	48 hours post intubation for AECOPD	Stenotrophomonas maltohilia	50 ml mucopurulent. 600 ml total collected within a few days	Dysphagia Anxiety disorder
07	F	63	Intubated for pneumonia. MS for 20 years		400-600 ml watery	Dysphagia
08	M	75	AECOPD	Enterobacter. Serratia	50-100 ml Mucoid, hemorrhagic secretions	Delirium Dysphagia
09	M	75	AECOPD. ICU weakness. CIP. CIM.	E.coli. Pseudomonas. Klebsiella. Multi resistant against 3-4 major antibiotic classes.	500-1000 ml watery	Severe dysphagia
10	M	71	92 days post ARDS, following spondylodiscitis with sepsis and fibrotic lung	Enterococcus resistant to 4 major antibiotic classes		De-cannulated but later died not wanting further treatment
11	M	66	37 days post pneumonia. Sepsis. Multiple organ failure. Severe weakness		50-100 ml mucopurulent	Delirium Dysphagia
12	F	82	Valve replacement for endocarditis. ICU acquired weakness	Multi-resistant Klebsiella and E. coli	50 ml Mucoid, hemorrhagic secretions	Delirium
13	F	73	32 days post op for aortic dissection	Stenotrophomonas in sputum. Non-invasive ventilation		
14	F	69	AECOPD. Extreme weakness	Very resistant MRSA and Enterococcus	50-150 ml mucopurulent	Dysphagia
15	F	48	123 days post pulmonary embolism. Slightly obese	Klebsiella in sputum on non-invasive ventilation		
16	M	67	26 days intubated for pneumonia and AECOPD	Klebsiella oxytoca	500 ml watery	Dysphagia Delirium

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Example of watery secretions collected (400-800ml daily)

Example of watery secretions collected (500-1000ml daily)

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"Automated intermittent subglottic suctioning…offers a lower rate of VAP than manual and other methods, less endotracheal (bronchial) suctioning, less atelectasis, easier use of a speaking valve, <u>shortened ICU stays</u>, and <u>lowers staff burden</u>."

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