

Post Intubation Complications

&

VAP

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Faculty Disclosure

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Introduction

- Pulmonary complications are a major cause of morbidity and mortality especially in the perioperative period
- Reported incidence of postoperative pulmonary complications ranges from 5 to 80 %

Lawrence VA., et al. J Gen Intern Med 1995; 10:671
Fisher BW, et al. Am J Med 2002; 112:219

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Introduction

- In 2004, CMS paid approximately \$102.6 billion in hospital payments.
- Unplanned rehospitalization accounted for approximately \$17.4 billion, nearly 20 percent of this total.
- Almost one quarter (22.4 percent) of Medicare patients that accounted for the estimated \$17.4B in unplanned rehospitalization charges were surgical patients.¹
- Pneumonia was the #2 reason for rehospitalization in this costly group.
- Nearly 1 percent (0.7) of all medicare patients undergoing surgery were readmitted for pneumonia within 30 days.



<http://www.cms.hhs.gov/apps/media/press/release.asp?Counter=3439>
Jenks et al. NEJM. 2009; 360(14):1418-1428.

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Post Intubation Complications Non Infectious

- Laryngeal injury
- Acute upper airway obstruction
- Swallowing impairment
- Tracheal stenosis
- Tracheo esophageal fistula
- Atelectasis
- Hypercapnia and Hypoxemia
- Pleural effusion
- Chemical pneumonitis
- Abdominal compartment syndrome

Arozullah et al. Ann Surg. 2000;232(2):242-253.

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Post Intubation Complications Infectious

- Sinusitis
- Tracheo bronchitis
- Ventilator Associated Pneumonia

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Postoperative Pulmonary Complications Are Surprisingly Common

Summary of studies investigating incidence of postoperative pulmonary complications by surgical site, as per systematic literature review in 2006¹

Surgical site	Reported complication rate	Studies, n
AAA repair	25.5%	16
Esophagectomy	18.9%	11
Abdominal surgery	14.2%	43
Head and neck surgery	10.3%	6
Hip surgery	5.1%	5
Gynecologic/Urologic procedures	1.8%	2

Smetana et al. Ann Intern Med. 2006;144:581-95.

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Postoperative Pulmonary Complications Deserve Equal Attention with Perioperative Cardiac Complications

Complication	Incidence	30-day mortality	1-year mortality
Serious cardiac*	2.0%	22%	36%
Serious pulmonary†	2.6%	17%	44%
p-value:	-	> 0.05	> 0.05

Lawrence et al. Arch Intern Med 2002 14;162(18):2053-7.

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Postoperative Pulmonary Complications Occur More Often Than Cardiac

Complication	Estimated incidence (95% CI)	LOS (SD), p = 0.001
Pulmonary	9.6% (7.2 - 12.0)	22.5 (17) days
Cardiac	5.7% (3.8 - 7.7)	10.4 (4.5) days

Total pulmonary complications occurred nearly twice as often and resulted in hospital lengths of stay over twice as long.

Lawrence *et al.* J Gen Intern Med 1995;10:671-678.

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Pneumonia, Is Very Common in Surgical Patients

- Most common post-surgical complication in non cardiac surgical patients with Mortality: 21%
- Postoperative pneumonia in noncardiac patients increased hospital costs by 55 percent and hospital length of stay by 89 percent.
- Postoperative pneumonia in abdominal surgical patients increased hospital charges by \$31,000 (year 2000 dollars), and length of stay by 11 days.

Khan *et al.* J Gen Intern Med. 2006;21:177-180

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Pneumonia, Is Very Common in Trauma Patients

- Most common complication in trauma patients.
- Respiratory complications, consisting primarily of pneumonia, are the second most expensive type of complication in trauma patients, increasing hospital costs by an estimated \$62,890 per affected patient.

Hemmila *et al.* 2008;144:307-316.

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Pneumonia is also very common in hospitalized Medical patients

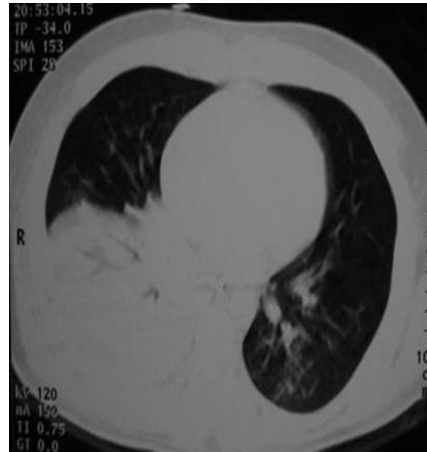
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|---|---|
| ● Incidence of HAP:
18.4 % of
hospitalized patients | ● Incidence of VAP:
15.5 % of
mechanically
ventilated patients |
| ● Mortality: 18.8% | ● Hospital LOS of stay:
38 days |
| ● Hospital charges:
65.000 \$ | ● Mortality: 50% |
| | ● Hospital charges:
75.000 \$ |

Warren DK, *et al.* Crit Care Med 2003; 31:1312-1317
Kollef MH, *et al.* Chest 2005;128(6):3854-62

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HAP / VAP

- The most significant risk factor is mechanical ventilation.
- Intubation increases the risk for HAP by 6 – 21 folds.
- VAP is the most common ICU nosocomial infection



Guideline for prevention of nosocomial pneumonia. Centers for Disease control and Prevention. Respir Care 1994; 39:1191. 13

HAP / VAP Risk factors

- Age > 70
- Chronic lung disease
- Depressed consciousness
- Patient position
- Micro-Aspiration
- Chest surgeries
- NG tubes
- Antacid therapy
- Transport from the ICU
- Reintubation or prolonged intubation
- Previous Antibiotic exposure (3rd generation Cephalosporines)
- Frequent ventilator circuit changes
- Paralytic agents
- Underlying illness

Guideline for prevention of nosocomial pneumonia. Centers for Disease control and Prevention. Respir Care 1994; 39:1191. 14

What can we do ??????



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Acid suppressive agents and Gastric PH

- Studies have noted an increased incidence of HAP/VAP when gastric PH is increased with the use of H2 blockers, PPIs, antacids.
- The society of Healthcare Epidemiology and the IDSA recommends that H2 blockers and PPIs be avoided in patients who are not at high risk of developing stress ulcers.
- Problem, most of patients who are on mechanical ventilation are at risk for stress ulcers and need prophylaxis !

Herzig SJ, et al. JAMA 2009; 301:2120

Coffin SE, et al. Infect Control Hosp Epidemiol 2008; 29 Suppl 1:S31

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Decontamination of the Digestive Tract SDD

- Multiple studies have demonstrated its benefit to improve patient outcomes by preventing VAP.
- **Best available data is application of oral antiseptic (Chlorohexidine) but not oral antibiotics.**
- Problem: cumbersome to nurses, and concerns regarding promoting resistant bacteria.

Bonten MJ. Clin Infect Dis 2011; 52:115

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Patient positioning

- Semi recumbent (35 – 45) has shown to decrease risk of aspiration and VAP compared to the supine position.
- No mortality benefit demonstrated.
- Recommendations: Sit up patients in bed at least 35 degree angle.
- **Problem: no mortality benefits, some contraindications.**

Torres A, et al. Ann Intern Med 1992; 116:540.

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Ventilator circuit changes

- Frequent circuit changes at 2 or 7 days had shown worsening incidence on VAP as compared to no routine changes.
- **Recommendations: no routine change of the ventilator circuit is required, only as needed.**
- **Problem: Heavy secretions sometimes call for very frequent changes.**

Han J, et al. *Respir Care*, 2010;55:467-74.
Tablan OC, et al. *Guideline for prevention of nosocomial pneumonia. Am J Infect Control* 1994; 22(4):247-292

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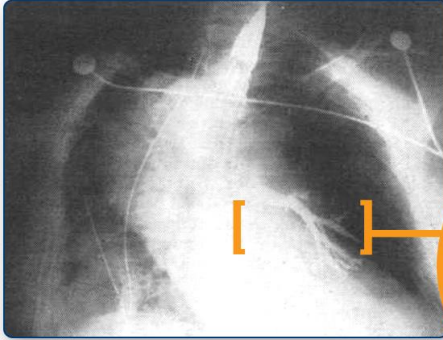
Microaspiration

- **What is microaspiration and why does it occur?**
- Why does microaspiration matter?
- How can microaspiration be addressed?

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Microaspiration:

Microaspiration refers to the migration of foreign, supraglottic material past the airway device (e.g. ETT cuff) into the respiratory tract.



Pictured: inadvertent microaspiration of contrast media after a barium swallow examination in an intubated patient

Reproduced from Macrae *et al. Br Med J.* 1981 (Clin Res Ed);283:1220 with permission from BMJ Publishing Group Ltd.

Cuff Redesign in the 1970s

- Traditional “red rubber” ETTs required high pressures (> 60 cm H₂O) to achieve a seal, and were frequently associated with severe tracheal injury.
- The new ETTs with high-volume, low-pressure (HVLV) cuffs were introduced in the early 1970s to specifically address this issue, achieving clinical seals at safer pressures (< 30 cm H₂O).



Knowlson GTC, Basset HFM. *Br J Anaesth.* 1970;42:834-837.
Seegobin RD, Van Hessel GL. *BMJ.* 1984;288:965-968.

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Cuff Redesign in the 1970s

- By design, HVLP cuff† diameter must be greater than the diameter of the trachea to ensure contact between the two.
- When properly sized cuffs are appropriately inflated, the excess cuff material folds onto itself, which can create channels that allow accumulated secretions to pass into the tracheobronchial tree.

Pictured: a modern high-volume, low-pressure (HVLP) ETT cuff, first introduced in the 1970s

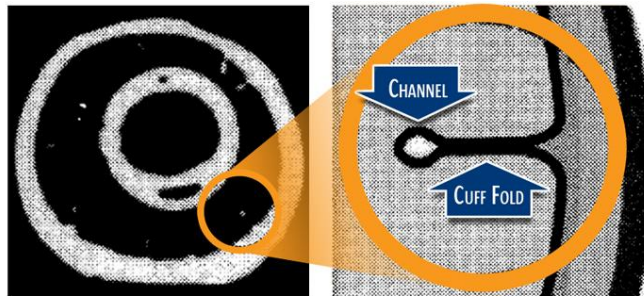


Seegobin et al. Can Anaesth Soc J. 1986;33:27327-9.
Young et al. Anaesthesia. 1999;54:559-563.
Pavlin et al. Anesthesiology. 1975;42:216-219.

Seegobin et al. British Medical Journal. 1984;288:965-968.
Dullenkopf et al. Intensive Care Med. 2003;29:1849-1853. 23

Excess Cuff Material Forming Folds and Channels

CT image of an inflated ETT cuff in a trachea model



LEFT: Full cross section of intubated model trachea

RIGHT: Enlargement of region demonstrating a cuff fold and channel

Dullenkopf et al. Intensive Care Med. 2003;29:1849-1853.

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Microaspiration Has Been Implicated In ICU Pathophysiology for Over 30 Years

- The first appearance was in the literature by Pavlin *et al.* in 1975.
 - Patient with hematemesis was intubated with HVLP cuff inflated to manufacturer recommendation of 20 cm H₂O.
 - Blood continued to be suctioned from ETT until cuff pressure increased to greater than 50 cm H₂O.
 - Cuff subsequently deflated back to 20 cm H₂O and blood resumed.
 - Leakage was reproduced by model in “various dog tracheas” and in glass cylinders.

Pavlin *et al.* *Anesthesiology*. 1975; 42:216-219.

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Microaspiration Is Surprisingly Common in the Operating Room with Conventional HVLP ETTs

- “Extensive folding of cuff material” containing secretions is seen at all cuff pressures (25–100 cmH₂O).

Seegobin *et al.* *Br Med J.* 1984;288:965-968.
- “...high-volume, low-pressure (HVLP) cuffs were introduced. ... these have failed to demonstrate effective prevention of leakage in vitro and in vivo.”

Dullenkopf *et al.* *Intensive Care Med.* 2003;29:1849-1853.
- Microaspiration found in 100 percent of general endotracheal anesthetics.

Seegobin *et al.* *Can Anaesth Soc J.* 1986;33:273-279.

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Microaspiration May Begin as Soon as 5 Minutes After Cuff Inflation



FLUOROSCOPIC IMAGE OF CONTRAST MEDIA ADMINISTERED ABOVE A MALLINCKRODT™ HI-LO™ CUFF AFTER FIVE MINUTES IN A PORCINE MODEL.

Results and image from internal testing.

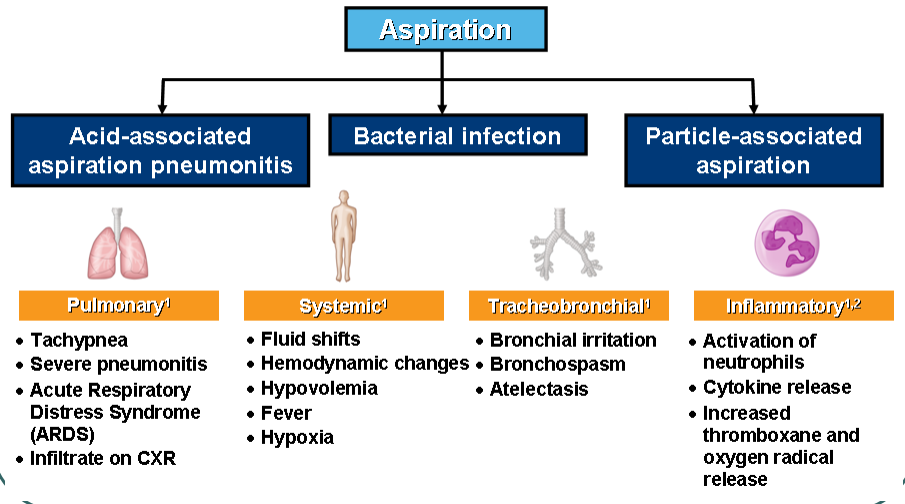
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Microaspiration

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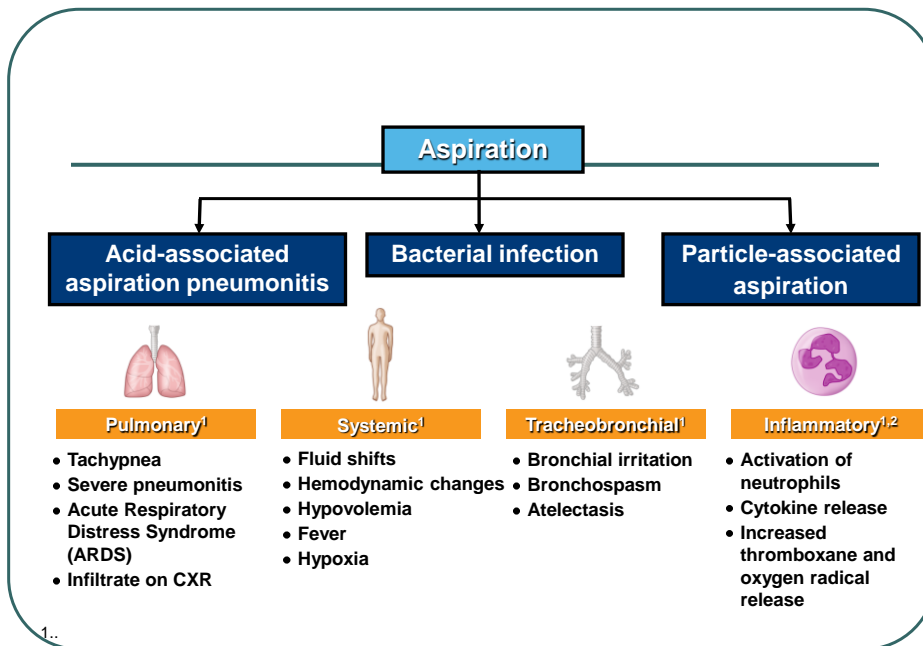
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Aspiration Can Cause Local and Systemic Injury



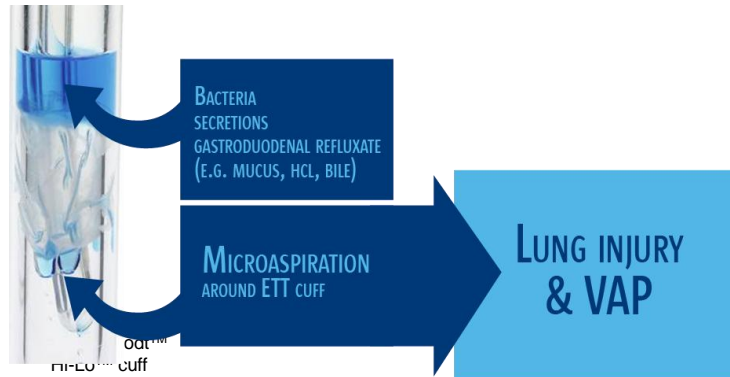
Janda M, et al. Best Pract Res Clin Anaesthesiol. 2006;20:409–427.
Kalinowski CP, et al. Best Pract Res Clin Anaesthesiol. 2004;18:719–737

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The Causal Relationship Between Microaspiration and VAP Has Been Well Established

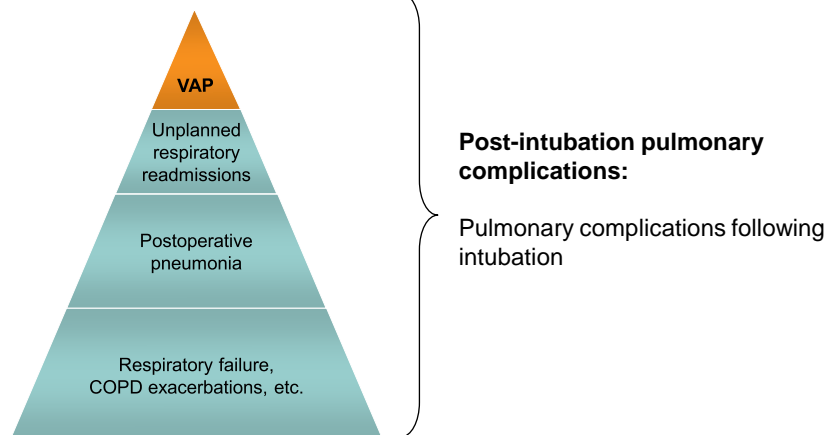


Mahul *et al. Intensive Care Med.* 1992;18:20-25.
Estes *et al. Intensive Care Med.* 1995;21:365-383.
Chastre *et al. Am J Respir Crit Care Med.* 2002;165:867-903.

Sadfar *et al. Respiratory Care.* 2005;50:725-741.
Kollef *et al. Chest.* 1999;116:1339-1346.

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Microaspiration Causing VAP May Be Just the Tip of the Iceberg



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Intraoperative Microaspiration May Lead to Postoperative Pneumonia

- The sputum of 28 percent of postoperative veterans for major elective procedures became colonized with gastric pathogens.
- Incidence of postoperative pneumonia was 40 percent in these patients compared to only 12 percent in those without “evidence of microaspiration.”
- Mortality was 19.2 percent in patients with microaspiration pneumonia vs. 1.7 percent in patients without.

Ephgrave et al. *Surgery*. 1993;114:815-819.

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Studies Examining Secretions Above the Cuff Suggest Surprising Volumes May Accumulate

- Volumes up to 150 ml were removed per day via intermittent aspiration of subglottic secretions.
- Intraoperatively, secretion drainage from the nose and mouth at over 50 ml/hour has been observed in prone patients.

Mahul et al. *Intensive Care Med*. 1992;18:20-25.
Young et al. *Br J Anaesth*. 1997;78:557-562.

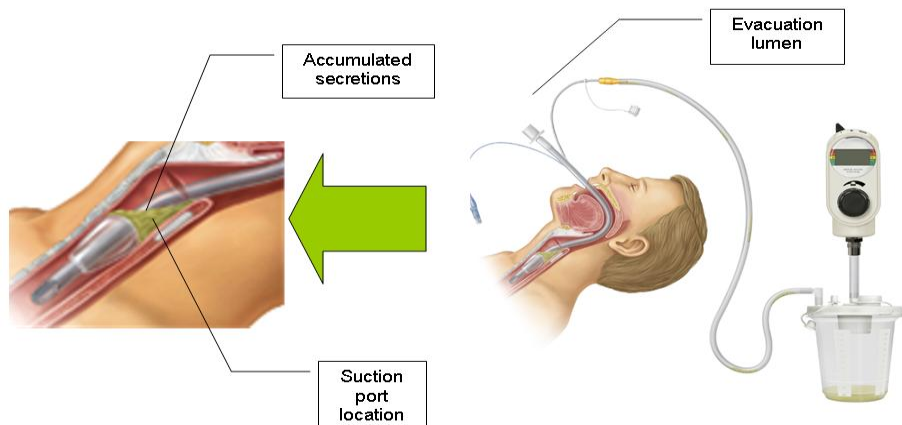
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Microaspiration

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Large Fluid Collections Can Be Prevented by Subglottic Secretion Drainage



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Mallinckrodt™ Evac Technology— Subglottic Secretion Drainage Improves VAP Rates

Study	# of pts	VAP rate, % (Study)	VAP rate, % (Control)
Bouza 2008 ¹ (Pts intubated > 48 h)	714	26.7	47.5
Liu 2006 ²	N/A	6	20
Smulders 2002 ³	150	4	16
Bo 2002 ⁴	68	23	45
Kollef 1999 ⁵	343	5	8.2
Valles 1995 ⁶	190	18.4	32.5
Mahul 1992 ⁷	145	13	29

1. Bouza et al. *Chest*. 2008;134: 938-946.

2. Liu et al. *Zhonghua Jie He He Hu Xi Za Zhi*. 2006; 29(1):19-22.

3. Smulders et al. *Chest*. 2002;121:859-862.

4. Bo et al. *Zhonghua Jie He He Hu Xi Za Zhi*. 2000;23:472-474.

5. Kollef et al. *Chest*. 1999;116:1339-1346.

6. Valles et al. *Annals of Internal Medicine*. 1995;122:179-186.

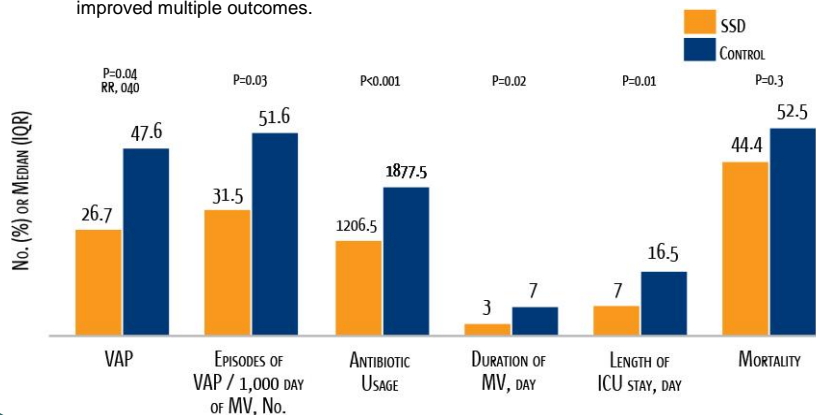
7. Mahul et al. *Intensive Care Medicine*. 1992;18:20-25.

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Subglottic Secretion Drainage Improves Outcomes

Clinical outcome in patients receiving MV for > 48 h

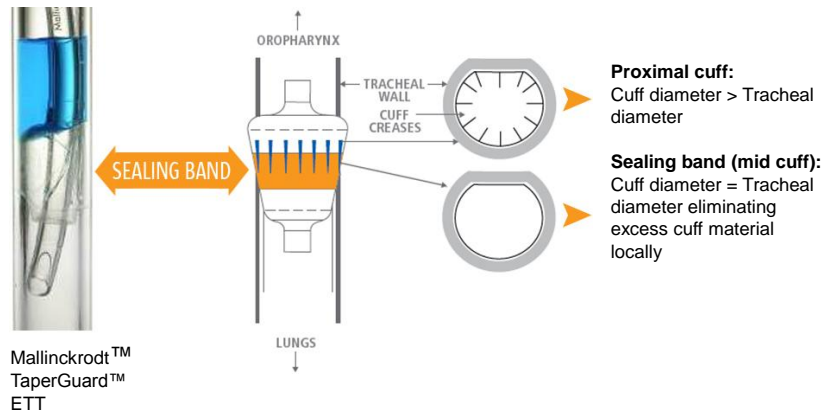
The addition of subglottic secretion drainage improved multiple outcomes.



Bouza et al. *Chest*. 2008; 134: 938-946.

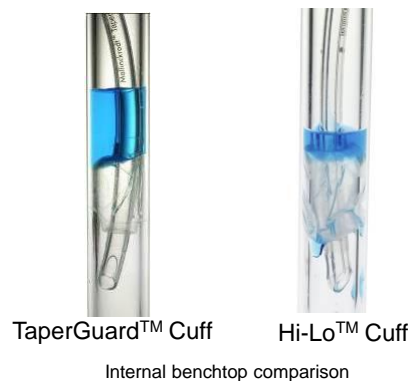
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Altering Cuff Shape Allows for Better Sealing Characteristics



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Better Performing Endotracheal Tube Cuffs May Reduce Risk



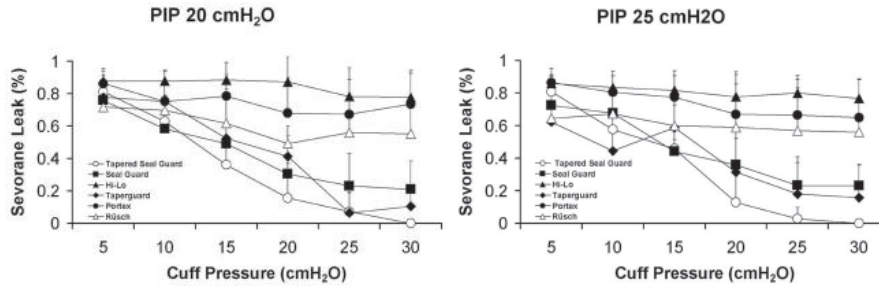
This is the new TaperGuard™ cuff compared to the Hi-Lo™ cuff.

Oikkonen *et al* referred to the Hi-Lo™ cuff as the best sealing of the nine tubes he tested in his study.

The TaperGuard™ cuff has been shown to reduce microaspiration by an average of 90 percent compared to the Hi-Lo™ cuff.

Taper-shaped Cuffs Air Seal Compared to Cylindrical-shaped Cuffs

Intubated lung model, ventilated at 20 and 25 cmH₂O peak inspiratory pressure (PIP), anesthetized with 1% sevoflurane. Leak measured above endotracheal cuff.¹

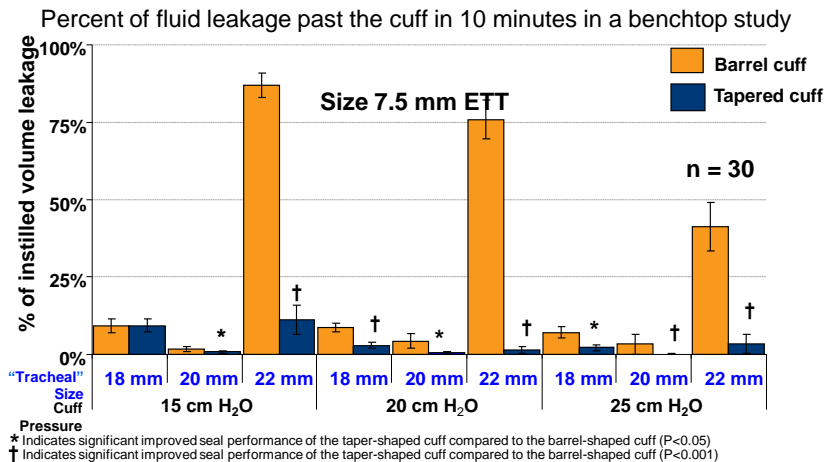


Taper-shaped cuff was found to reduce leak.

Madjdipour et al. European Journal of Anaesthesiology. 2009;26(Suppl 45):19AP7-10.

41

Seal Performance of a Taper-shaped vs. Barrel-shaped Cuff



Campbell S. Internal Testing, 2009.

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Microaspiration Can Cause Lung Injury



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Features of the Mallinckrodt™ TaperGuard™ Endotracheal Tube:

- The current high-volume, low-pressure (HVLP) cuff does not reliably protect the respiratory system from microaspiration.
- Unsterile pharyngeal, gastric and duodenal secretions may accumulate, potentially contaminating the sterile respiratory tree, resulting in pulmonary injury or infection.
- TaperGuard™ Evac : The addition of the evac capability may enhance secretion management compared to basic endotracheal tubes that do not feature built-in suction lines, which may be especially important in certain situations:
 - Copious oral or gastric secretions
 - Trauma
 - Head or neck surgery

Dullenkopf et al. Intensive Care Med. 2003;29:1849-1853.

Lucangelo et al. Critical Care Medicine. 2008; 36;1-5.

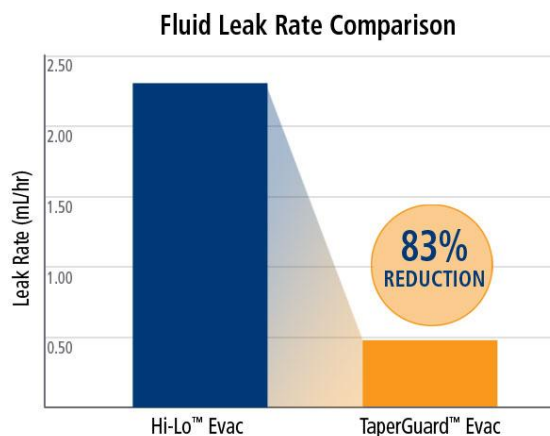
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Secretion Management for the Operating Room

- TaperGuard™ Evac endotracheal tube enables continuous or intermittent secretion management in the operating room in order to:
 - Remove secretions that may collect above the cuff
 - Reduce the risk of secretions moving past the cuff
 - Continuously manage secretions.
 - Prepare the patient for extubation

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TaperGuard™ Evac Tube Has an 80 Percent Improvement in Microaspiration Reduction Under Suction vs. Hi-Lo™ Evac Tube



- Internal testing of Hi-Lo™ and TaperGuard™ cuff tested (90 units each) in benchtop setting.
- Suction rates were equal between the two test arms.
- Use of TaperGuard™ Evac tube resulted in less microaspiration compared to the Hi-Lo™ Evac tube.

Internal testing, 2009.

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Summary

- Microaspiration is the migration of foreign material past the cuff of an endotracheal tube into the tracheobronchial tree.
- Microaspiration past conventional HVLP cuffs is prevalent and well documented.
- Microaspiration may lead to pulmonary and systemic pathology.
- New technological innovations (e.g., taper-shaped cuff) have been designed to address these issues.

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In Conclusion

- Postoperative respiratory complications seriously impact clinical and financial outcomes in healthcare.
- Avoiding these complications will require a multi-faceted approach involving many relevant clinical disciplines.
- Evidence strongly indicates that microaspiration is an important contributor to the incidence and severity of postoperative pulmonary complications.
- Deployment of technology that effectively removes secretions above the cuff in the subglottic space is one key element in reducing downstream complications.
- Incorporation of better sealing cuffs that dramatically reduce the rate of secretion leakage is a second critical aspect to reducing downstream complications.
- Eventually, creation of a “bundle” of protocols and interventions will likely optimize our ability to address this important public health issue.

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Thank you

Questions ?