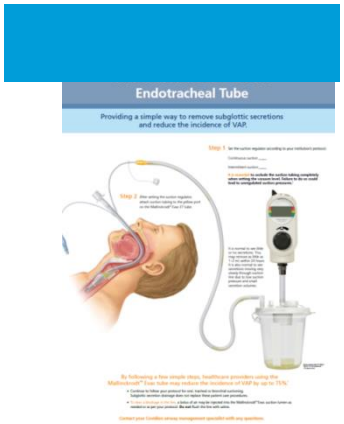

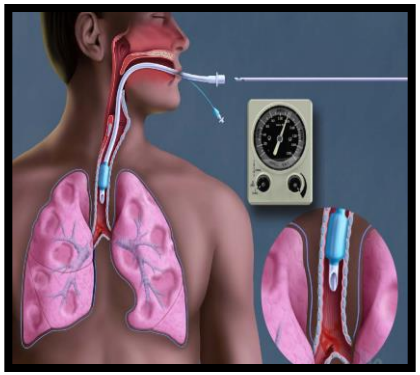

Patient Safety & Lung Protective Strategy: The Hazards of Suctioning (ETT, NG, SSR & CHEST)

Bill Lamb, BS, RRT, CPFT, RCP, FAARC
Wentzville, Missouri, USA

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Disclosure

- Bill Lamb is the National Clinical Manager for Ohio Medical Corporation, Gurnee, Illinois
- The intent of this presentation is to raise the participant's patient safety awareness
- *Any use of images or brand names is not in any way meant to be an endorsement of a specific product, but to merely illustrate a point of emphasis*
- .

Objectives

- List two consensus areas relative to lung damage
- Differentiate between low and high lung volume strategies of ventilation
- Choose the contributing factors that are mechanisms of lung damage in mechanical ventilation
- Explain strategies to avoid hospital-acquired infection
- Understand how to prevent inadvertent over-suctioning and airway trauma
- Explain current patient safety issues around endotracheal suctioning, nasogastric suctioning, sub glottic secretion removal and chest tube suctioning
- Review the new evidence-based AARC and nursing guidelines regarding suctioning procedures
- Discuss actions and precautions the clinician can take to enhance patient safety.

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Health Care Reform

- Patient safety emphasis is a must
- Accountable Care Organization
  - Outcome standards
  - Rewards
  - Penalties
- **WE CAN ALL MAKE A DIFFERENCE**

Lung Protective Strategies

- ARDSnet Ventilation Strategy
  - Small Tidal Volumes (4-6 cc/kg PBW) improves mortality and morbidity
- **Acute Respiratory Distress Syndrome (ARDS) Network study:**
  - **ARDS Net study: higher versus lower tidal volume (VT), which reported a reduction in mortality from 39.8 percent to 31.0 percent with 6 ml/kg ideal body weight rather than 12 ml/kg ideal body weight (number-needed to-treat of 12 patients)**

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Lung Protective Strategies

- Mitigating Ventilator (ETT) Associated Pneumonia:
  - Semi Fowlers positioning
  - Oral care
  - Sub Glottic secretion removal
    - Continuous Aspiration Subglottic Secretions (CASS)
  - Cuff pressure regulation
  - BioFilm in the ETT

"Ventilator" Associated Pneumonia

- **VAP** is now recognized as one of the most common and most frequently fatal types of hospital-acquired infection. Published data show that **VAP** accounts for more deaths than urinary tract infections, infections from central lines or surgical site infections.

Klevens RM, Edwards JR, Richards CL Jr, et al. Estimating health care-associated infections and deaths in U.S. hospitals, 2002. Public Health Rep. 2007;122:160-166.

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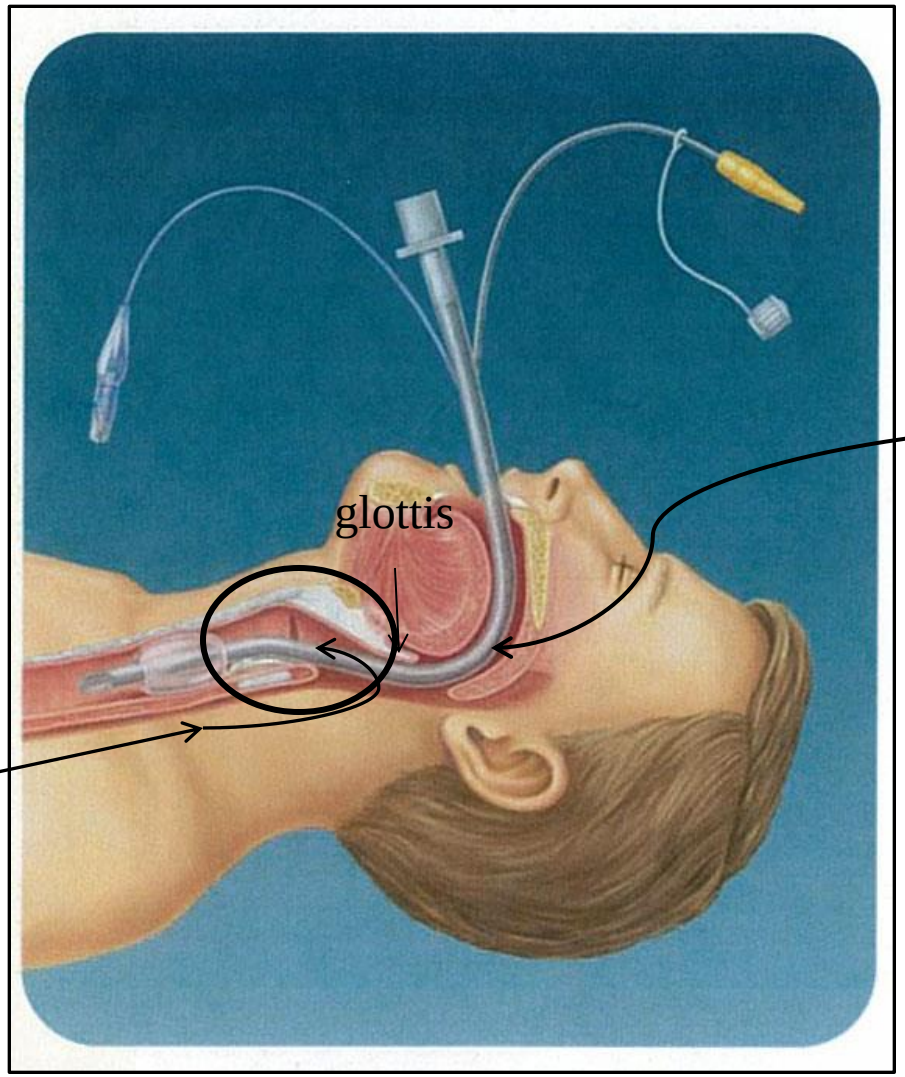
New algorithm for "Ventilator Associated Events"

- Includes definitions for three potentially preventable events that could develop in ventilator patients
  - Ventilator-associated conditions (VAC)
  - Infection-related ventilator-associated conditions (IVAC)
  - Possible or probably VAP

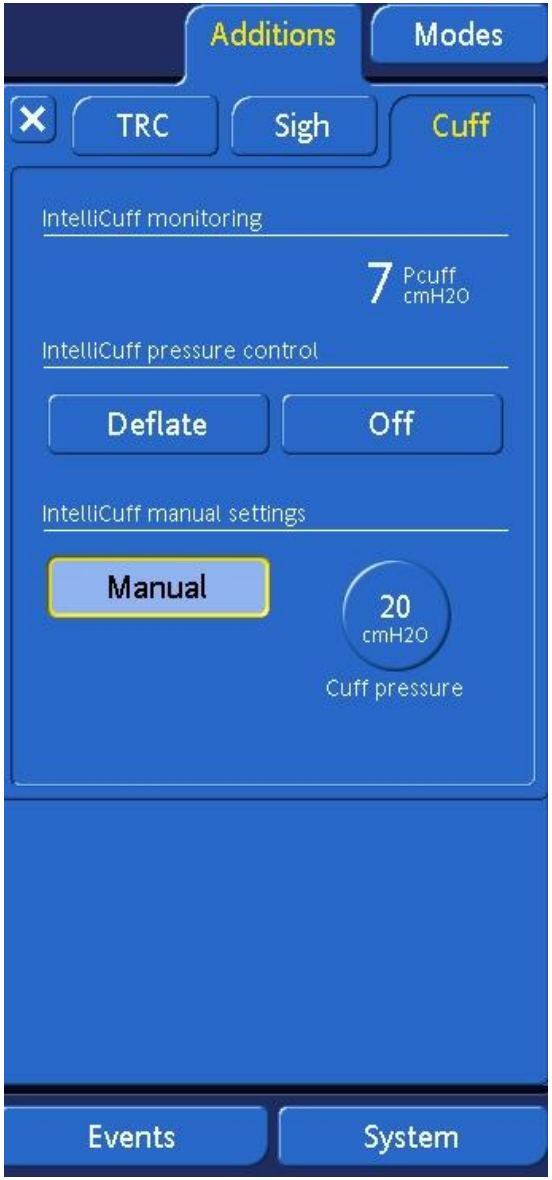
Aspiration of Subglottic Secretions



Bacteria laden oral secretions drain down into trachea

Acidic bacteria laden gastric secretions from stomach

Cuff Pressure Regulation



Hamilton Medical

Stand alone versions available (CuffSentry)

FIGURE 1 – Start time 10:24 AM / Exhaled VT = 355 mL and CP = 27.2 cm H_2O.

FIGURE 2 – Time Stamp 10:50 AM, Elapsed Time 36 Minutes / Exhaled VT = 348 mL and CP = 21.1 cm H_2O.

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FIGURE 3 – Time Stamp 11:23 AM, Elapsed Time 59 Minutes / Exhaled VT = 313 mL and CP = 13.2 cm H_2O.

FIGURE 4 – Time Stamp 11:30 AM / Exhaled VT = 353 mL and CP = 28 cm H_2O.

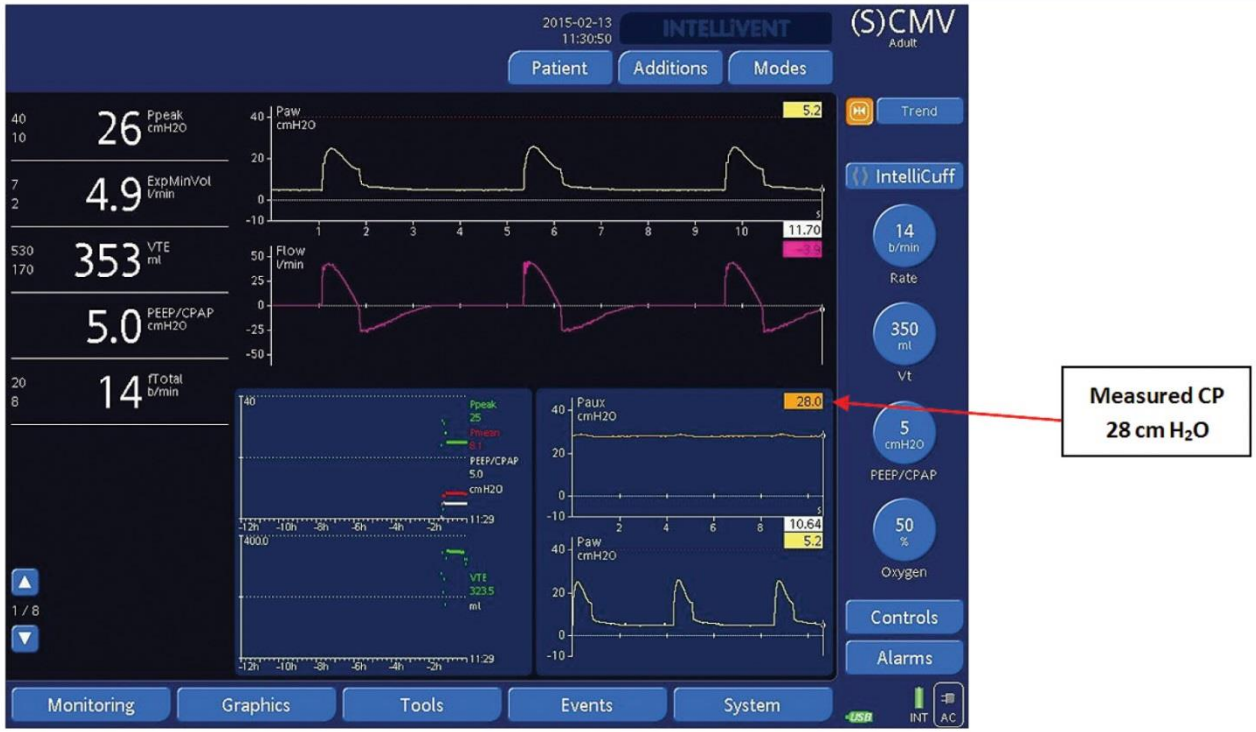

FIGURE 5 – Measurements of CP and exhaled VT are demonstrated after 3 hours of MV.

FIGURE 6 – Elapsed Time 24 Hours, Exhaled VT = 350 mL and CP = 29-30 cm H_2O.

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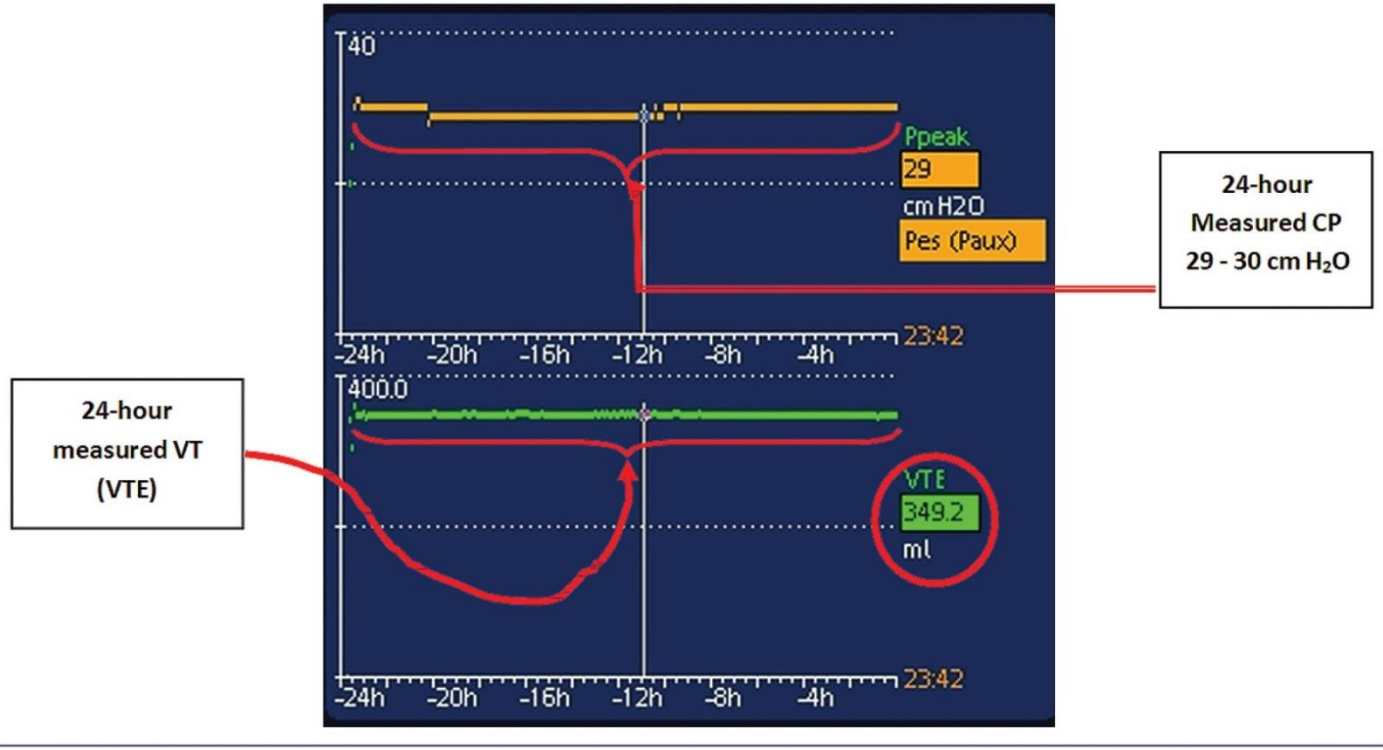
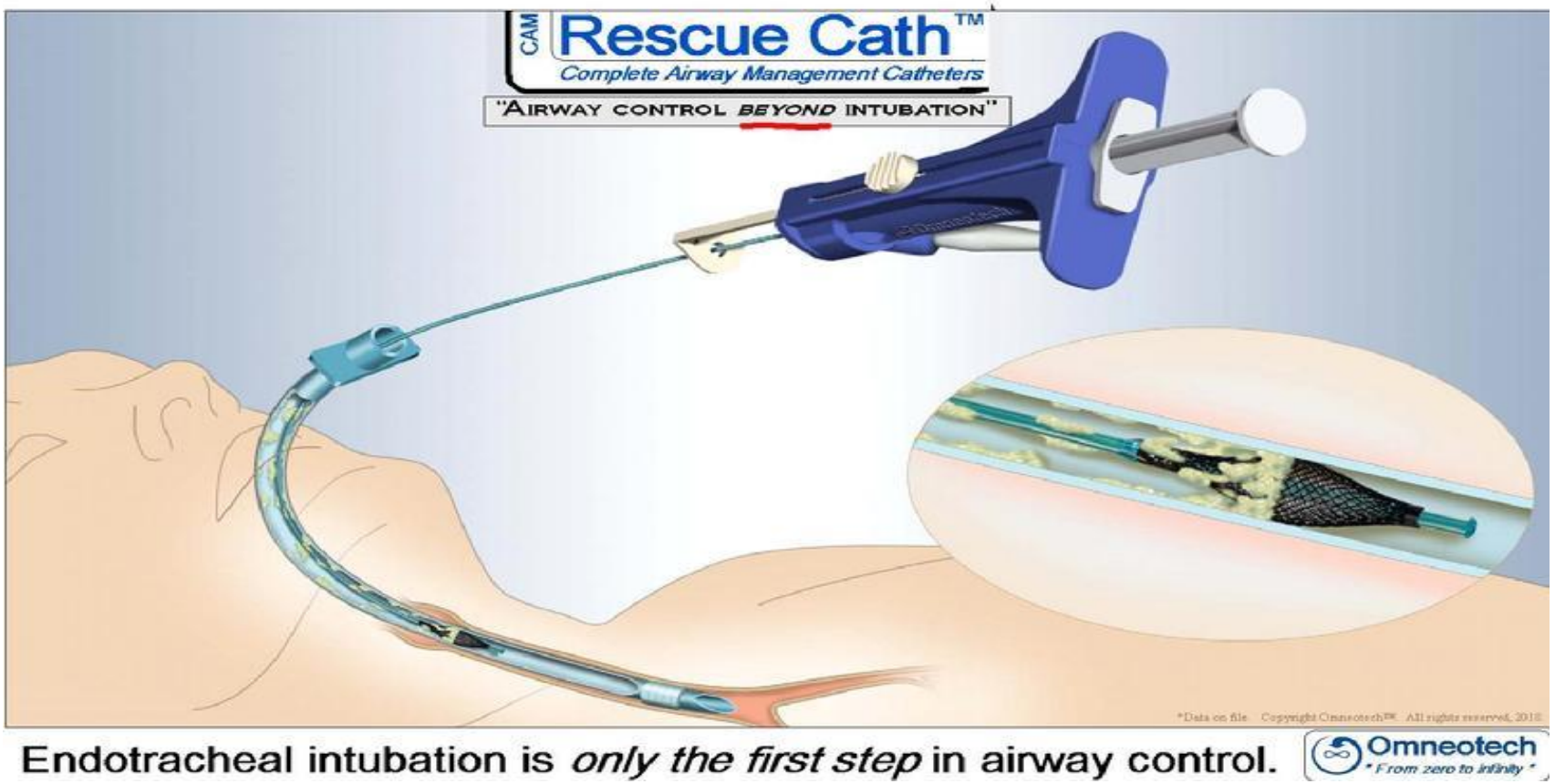
FIGURE 7


40
Ppeak
29
cm H2O
Pes (Paux)
23:42
-24h
-20h
-16h
-12h
-8h
-4h
400.0
VTE
349.2
ml
23:42
-24h
-20h
-16h
-12h
-8h
-4h
24-hour
Measured CP
29 - 30 cm H_2O
24-hour
measured VT
(VTE)

BioFilm in the Endotracheal Tube



Omneotech (other examples: Mucus Shaver, EndoClear)

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Removal of Obstruction in the Tube

Rescue Cath

Patient Protective Strategies

- Safe Suctioning
  - Airway
  - Nasogastric
  - CASS (continuous and intermittent)
  - Chest Drainage

Do your suction canister contents look like this?

Endotracheal Suctioning

What Are The Significant Patient Safety Issues?

AARC Clinical Practice Guidelines address the key patient safety issues.

- Follow recommended guidelines for suction pressure
  - Adults less than -150 mmHg*
  - Neo and peds 80-100 mmHg*
- Deep suctioning may cause significant trachea mucosal damage* - **no longer recommended**
- Do not disconnect from ventilator*
- **Occlude the tubing while setting max suction pressure**

**Per 2010 AARC Guidelines published in Respiratory Care June Issue*

Endotracheal Suction

- Occlude tubing **while setting suction pressure**[1, 2]
- Check suction pressure before every suction event[1]
- Set suction pressure to 150 mmHg or less for adults[1]
- Set suction pressure to 80-100mmHg for neonates[1]

[1] *Excerpt from American Association of Respiratory Care 2010 published Guidelines Endotracheal Suctioning of Mechanically Ventilated Patients with Artificial Airways; Section 2.3*

[2] *Use of Ohio Medical's Push-To-Set vacuum regulators automatically occludes the flow to patient tubing while setting pressures; Manual 8700-0001-000, Section 3, page 2 "Description and Specifications"*

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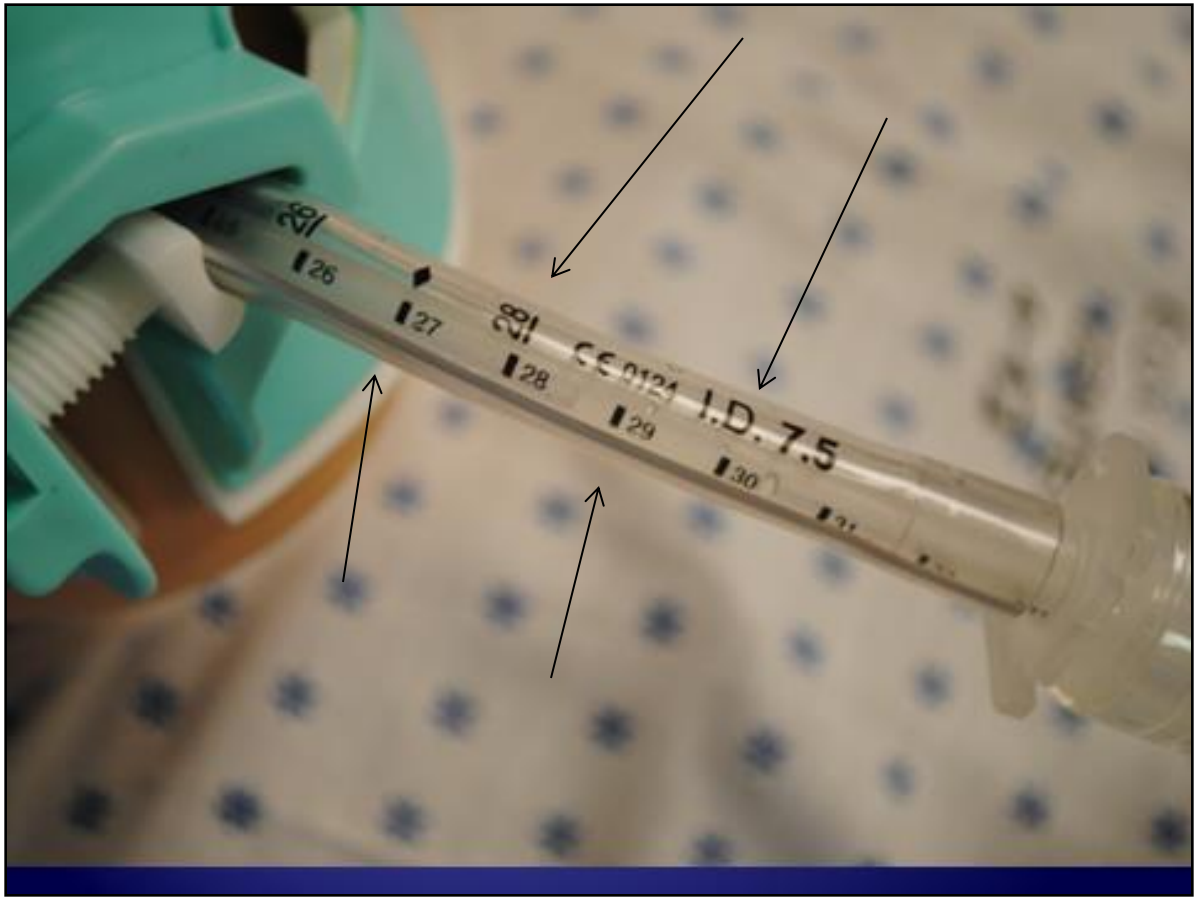
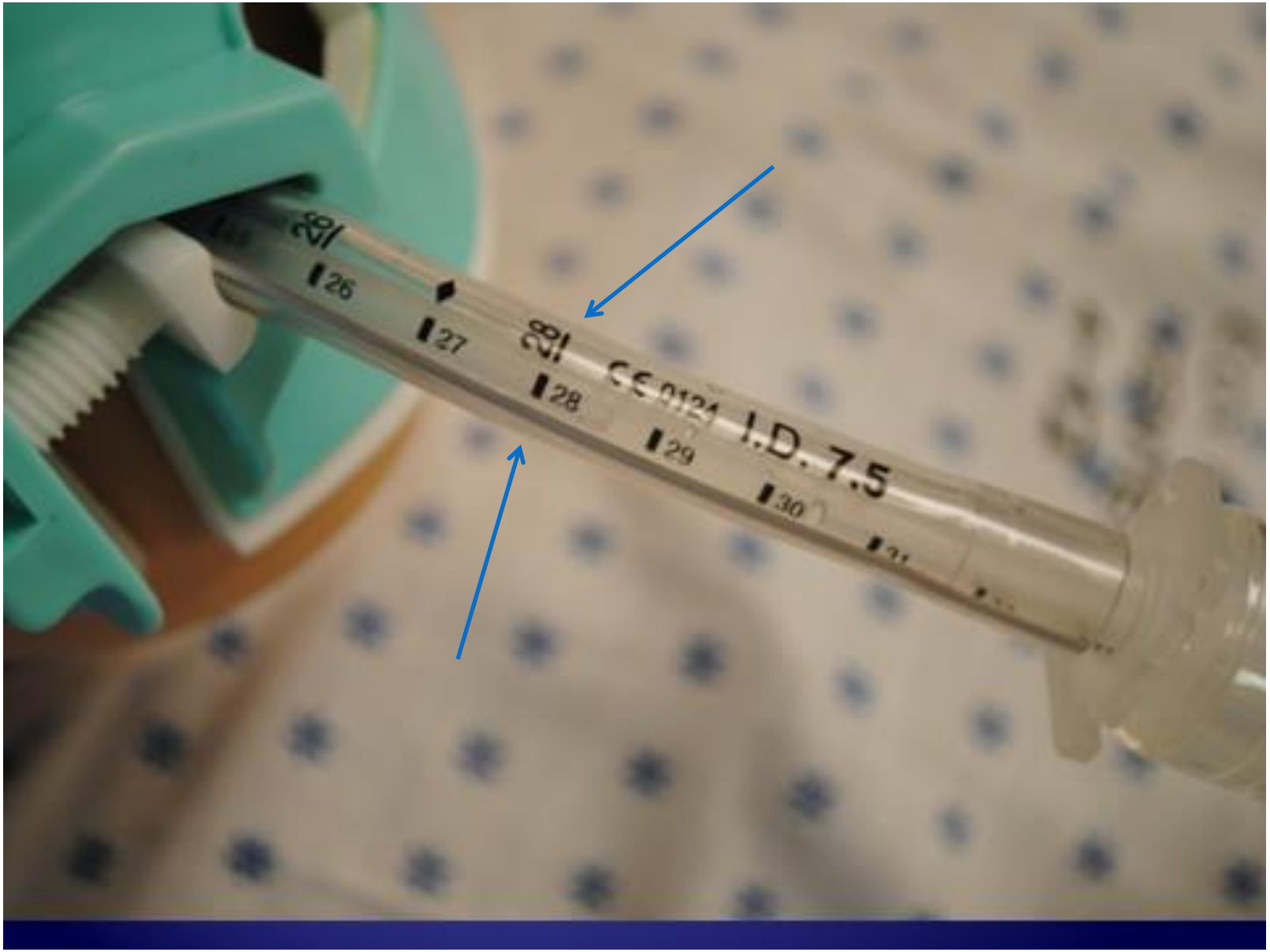
2010 Guidelines

- “Use of shallow suction is suggested instead of deep suction, based on evidence from infant and pediatric studies.”*
- “Shallow suctioning is recommended to prevent trauma to the tracheal mucosa.”*

Per 2010 AARC Guidelines published in Respiratory Care June Issue



Align a marking on the ETT with the same increment on the suction catheter


26
27
28
29
30
I.D. 7.5

Inadvertent Oversuctioning

- Inadvertent oversuctioning is a result of improperly set vacuum regulators
  - Commonly results from lack of understanding of how to properly set the maximum pressure on the regulator
  - can expose patients to vacuum pressures up to 15 times higher than recommended pressures for nasogastric or endotracheal suction procedures.
  - May result in tissue trauma, infection and traumatic atelectasis

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Goal: Preserve FRC and Prevent Traumatic Atelectasis

Improperly set vacuum regulators expose the patient to excessive pressure and may result in inadvertent oversuctioning, tissue damage and Traumatic Atelectasis

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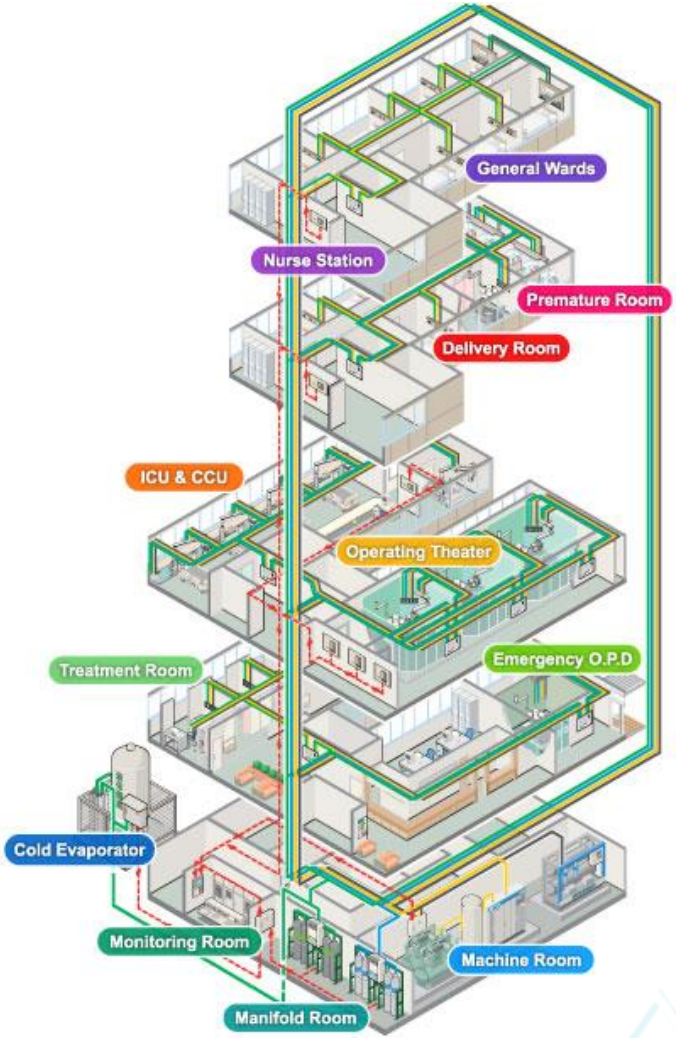
Overview of Hospital Suction System



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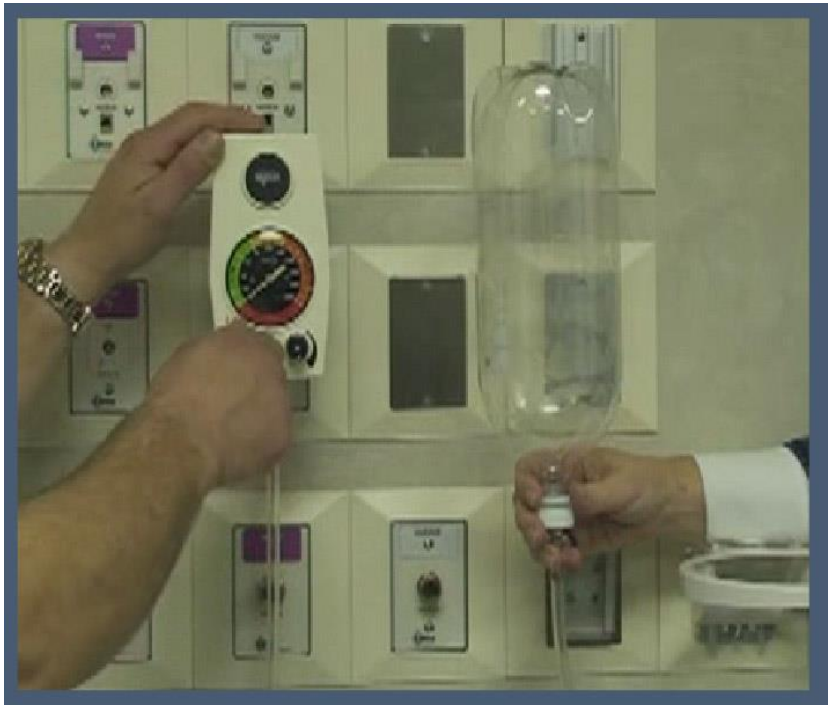
Power of Full Wall Vacuum

Wall vacuum as high as - 635 mmHg (- 25 inHg)

Shows - 17 inHg; norm max - 25 inHg

Real time evacuation of 2 liters (2000 ml) using wall vacuum



Power of Full Wall Vacuum

Shows
- 17 inHg;
norm max
- 25 inHg

Wall vacuum as high as - 635 mmHg (- 25 inHg)

Real time evacuation of
2 liters (2000 ml) using wall vacuum

Fail to “Occlude to Set”

Results in excessive pressure and inadvertent oversuctioning

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Fail to “Occlude to Set”

Results in excessive pressure and inadvertent oversuctioning

Correct Way to Set Suction Occlude-to-Set Procedure

Set a pressure limit on the suction regulator

Correct Way to Set Suction Occlude-to-Set Procedure

Set a pressure limit on the suction regulator

Effects of Applying Excessive Suction Pressure to a Ventilated Porcine Lung Model

Doug Pursley M. Ed RRT -AJIC July 2010

Pre-suction EELV

Post-suction EELV after setting pressure of -120 mmHg with suction tubing occluded

10% Reduction in EELV

Post-suction EELV after setting pressure of -120 mmHg with suction tubing un-occluded

Actual Pressure -220 mmHg
71% Reduction in EELV

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Side Effects of Endotracheal Suction in Pressure and Volume-Controlled Ventilation*

- Endotracheal Suctioning

*Birgitta Almgren, RN; Carl-Johan Wickerts, MD, PhD; Erkki Heinonen, PhD; and Marieann Ho ¨gman, PhD
Chest 2004;125;1077-1080, DOI 10.1378/chest.125.3.1077

Endotracheal Suctioning of the Adult Intubated Patient– What is the Evidence?

- Intubated patients may be unable to adequately cough up secretions. Endotracheal suctioning is therefore important in order to reduce the risk of consolidation and atelectasis that may lead to inadequate ventilation
- **The suction procedure is associated with complications and risks, including bleeding, infection, atelectasis, hypoxemia, cardiovascular instability and elevated intracranial pressure and may also cause lesions in the tracheal mucosa.**

Intensive and Critical Care Nursing
Volume 25, Issue 1, February 2009, Pages 21-30
Carsten M. Pedersen[a], Mette Rosendahl-Nielsen[b], Jeanette Hjermind[c], Ingrid Egerod

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Endotracheal Suctioning of the Adult Intubated Patient– What is the Evidence?

• What is the recommendation on catheter insertion depth?	*It is recommended using minimally invasive endotracheal suctioning, in which the suction catheter is inserted to the length of the ET-tube only*
• What is the recommendation on the duration of the suction procedure?	*It is recommended that the suctioning procedure should last no longer than 15 s*
• What is the recommendation on saline lavage?	*Routine instillation of normal saline prior to endotracheal suctioning is not recommended*
• What is the recommendation on routine versus "prn suctioning"?	*It is recommended that endotracheal suctioning should be performed only when necessary*

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Table 1 Major recommendations for endotracheal suctioning . *C.M. Pedersen et al.*

AJRCCM Published February 2003

Prevention of endotracheal suctioning-related adverse events

- It has been shown that repetitive alveolar collapse and reopening can be injurious for the lung
- Mead and coworkers showed, in a model of heterogeneous lung, that atelectatic regions can be exposed to shear stress generated by the recruitment of collapsed alveoli and the over-distension of the alveolar units adjacent to atelectatic zones
- **The application of a negative pressure could further increase shear forces resulting in lung damage**
- Lung injury resulting from repetitive alveolar opening and closing can affect the release of inflammatory mediators into the lung and the systemic circulation
- **Therefore, preventing the periodic alveolar derecruitment induced by endotracheal suctioning could be more clinically relevant than its reversal in patients with ALI/ARDS**

Prevention of Endotracheal Suctioning-induced Alveolar Derecruitment in Acute Lung Injury
Salvatore M. Maggiore, Francois Lellouche, Jerome Pigeot, Solenne Taille, Nicolas Deye, Xavier Durrmeyer, Jean-Christophe Richard, Jordi Mancebo, Francois Lemaire, Laurent Brochard

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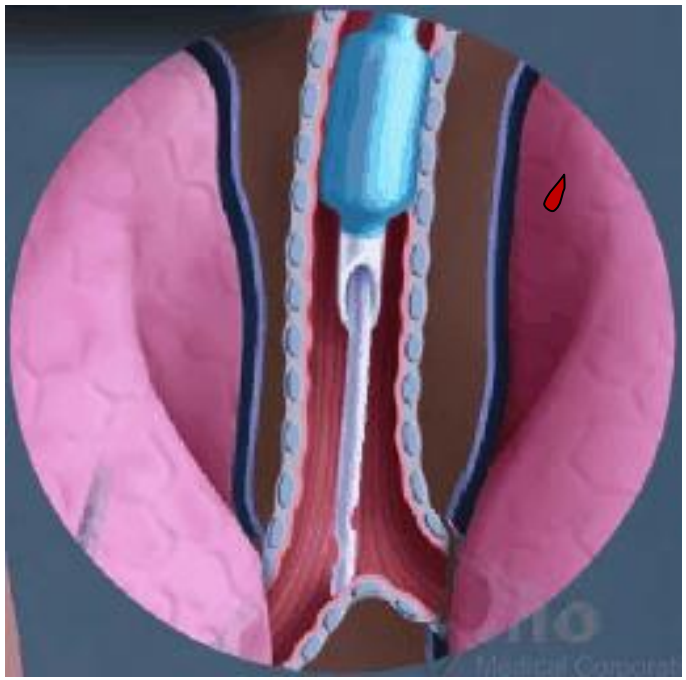
Mucosal Tissue Trauma, Bleeding, Increased Risk of Infection

Application of high suction pressure to delicate airway tissue can result in disruption of epithelium (tissue tear)

Bleeding is also possible since the lung is highly vascular

Tearing of lung tissue (like tearing of any tissue) results in an inflammatory response and possible infection in patients with compromised immune systems



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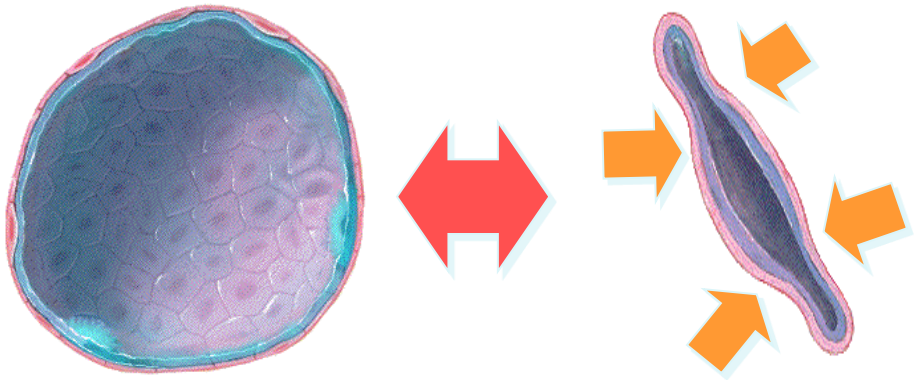
Atelectrauma

- With repeated suctioning, over time the sequence of lung volume reduction and re-expansion may result in lung damage (disruption of alveolar epithelium) from the repetitive opening and closing of alveolar lung units
- This is called atelectrauma or RACE (repetitive alveolar collapse and expansion).
- Repetitive alveolar collapse and reopening of the under-recruited alveoli result in atelectrauma



1.Robertson, B Robertson, B Van Golde, L eds. Pulmonary surfactant. 1984 Elsevier. Amsterdam:
2. Slutsky, A. (1999). Lung injury caused by mechanical ventilation. *Chest*, 116(1 Suppl):9S-15S.

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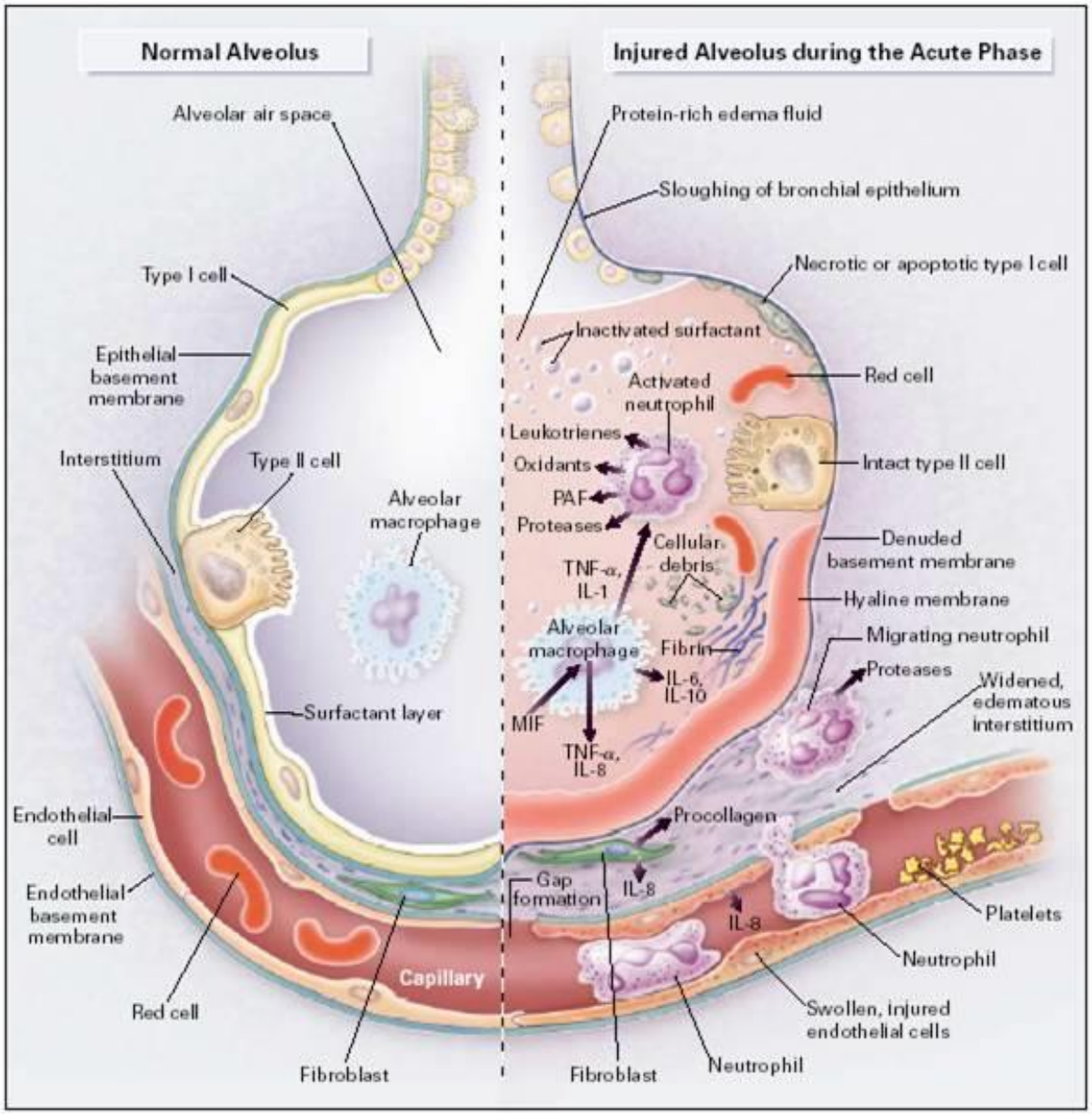
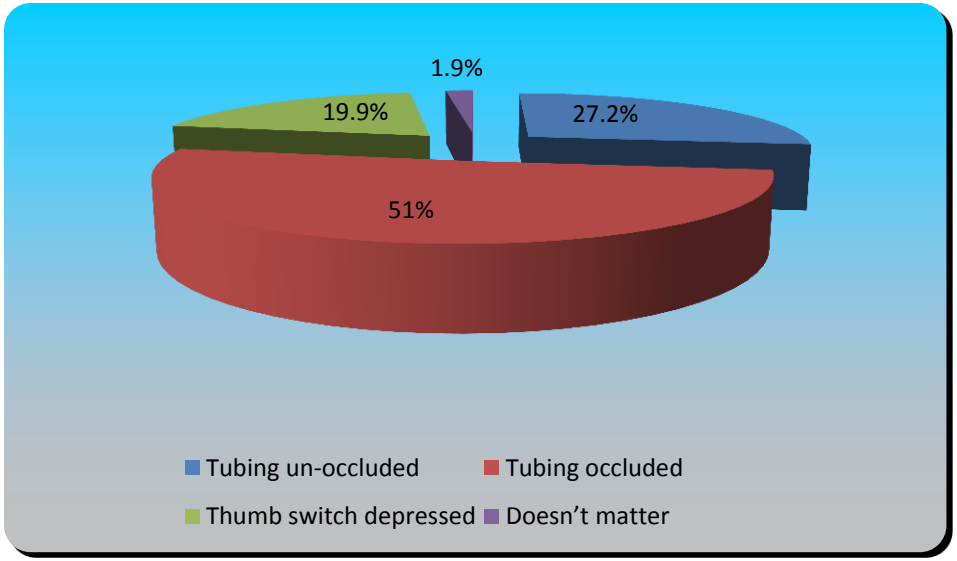

Normal Alveolus
Injured Alveolus during the Acute Phase
Alveolar air space
Type I cell
Epithelial basement membrane
Interstitium
Type II cell
Alveolar macrophage
Surfactant layer
Endothelial cell
Endothelial basement membrane
Red cell
Capillary
Fibroblast
Protein-rich edema fluid
Sloughing of bronchial epithelium
Necrotic or apoptotic type I cell
Inactivated surfactant
Activated neutrophil
Red cell
Leukotrienes
Oxidants
PAF
Proteases
Intact type II cell
Cellular debris
TNF-α, IL-1
Denuded basement membrane
Hyaline membrane
Alveolar macrophage
Fibrin
Migrating neutrophil
Proteases
IL-6, IL-10
MIF
TNF-α, IL-8
Widened, edematous interstitium
Procollagen
Gap formation
IL-8
IL-8
Platelets
Neutrophil
Swollen, injured endothelial cells
Fibroblast
Neutrophil

Suction Pressure Survey Results

How do you properly set suction pressure?	Responses	
Tubing un-occluded	56	27.18%
Tubing occluded	***105***	***50.97%***
Thumb switch depressed	41	19.90%
Doesn't matter	4	1.94%
Totals	**206**	**100%**



Subglottic Secretion Removal (SSR)
aka Continuous Aspiration of Subglottic Secretions (CASS)

- Consensus and evidence:
  - Recommended by Infection Control Community (CDC)
  - When they work, they work well
  - Expensive
  - Reported problems with lumen being occluded (medical literature shows with mucosa)
  - Vacuum regulators set too high contribute to problems with CASS

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Continuous Aspiration of Subglottic Secretions (CASS)

"Dysfunction of the suction lumen occurred in 19 of 40 patients (48%). In 17 of these (43%), it was attributed to blockage of the subglottic suction port by suctioned tracheal mucosa."

Investigating the failure to aspirate subglottic secretions with the Evac endotracheal tube

ANESTHESIA & ANALGESIA, Vol. 105, No. 4, October 2007

"A tracheoesophageal fistula-tracheal injury extended slightly above where the previous endotracheal tube cuff was in contact with the mucosa-The researcher noted this is the location of the C.A.S.S. suction port, indicating this could have caused the fistula to form."

Potential Mucosal Injury Related to Continuous Aspiration of Subglottic Secretion Device

Harvey, R Chandler M.D.; Miller, Preston M.D.†; Lee, Jonathon A. M.D.‡; Bowton, David L. M.D. §; MacGregor, Drew A. M.D.*

Journal of American Anesthesiology October 2007

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CASS Evidence Review

These data suggest three possible ways to decrease the risk of tissue obstructing the suction lumen without decreasing the suction efficiency:

(1) stopping suction when there is no mucus flow

(2) sensing when there is a sudden increase in suction at the proximal port, suggesting occlusion and briefly reversing flow

(3) only using intermittent suction rather than continuous flow to clear mucus secretions

- There also may be an opportunity to change the design of the suction port to retain effective suction while reducing the risk for membrane occlusion

In Vitro Evaluation of Endotracheal Tubes With Intrinsic Suction
Karla I. Mujica-Lopez, MD, Melissa A. Pearce, BS, Kyle A. Narron, Jorge Perez, BS and Bruce K. Rubin, MD, FCCP
Published: CHEST / 138 / 4 / OCTOBER, 2010 (American College of Chest Physicians)

Tube manufacturers' recommendations with occlusion: blow it out.

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Gastric Drainage

Figure 16

Nasogastric Suction

- Occlude tubing **while setting suction** pressure
- Check suction pressure before every suction event
- Set suction to Intermittent
- Set pressure to 30-40mmHg

References: Use of Ohio Medical's Push-To-Set vacuum regulators automatically occludes the flow to patient tubing while setting pressures; Manual 8700-0001-000, Section 3, page 2 "Description and Specifications"

3Smeltzer, Suzanne, Brenda Bare, Janice Hinkle, and Kerry Cheever. Brunner and Suddarth's Textbook of Medical-Surgical Nursing: 12th edition (2009), page 1022

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Common Nasogastric Suction Injury

Photographic evidence of inadvertent application of high suction pressures with a Salem Sump N-G tube

Left: Gastric fundic mucosal fold caught in a side port of a nasogastric suction tube. **
Right: Mucosal fold has been disengaged from the suction tube, revealing the raised erythematous mucosal bleb caused by the suction injury. **

Multiple small circular and oval erythematous mucosal markings, often arranged linearly, induced acutely by nasogastric suction.
With long-standing nasogastric suction, the lesions may also show evidence of associated inflammation, suggesting more significant mucosal trauma.*

**http://www.queens.edu/pdf/upload/nursing/gastrointestinalintubation.ppt#272,16,NG Suction*

***http://www.endoatlas.com/st_ge_07.html*

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Chest Tube Drainage Systems

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Wet Suction Control

- The chamber on the unit is the suction control chamber
- Traditional chest drainage units regulate the amount of suction by the height of a column of water in the suction control chamber
- Note: it is the height of water, **not the setting of the suction source**, that actually limits the amount of suction transmitted to the pleural cavity
- A suction pressure of –20 cm H2O is commonly recommended. Lower levels may be indicated for infants and for patients with friable lung tissue, or if ordered by the physician
- Regulator oressure initially set < 80 mmHg

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Dry Suction Chest Drainage Systems

- Dry suction control systems provide many advantages: higher suction pressure levels can be achieved, set-up is easy, no continuous bubbling provides for quiet operation, and there is no fluid to evaporate which would decrease the amount of suction applied to the patient
- Instead of regulating the level of suction with a column of water, the dry suction units are controlled by a self-compensating regulator. A dial to set the suction control setting is located on the upper left side of each unit
- To set the suction setting, rotate the dial until the red stripe appears in the semi-circular window at the prescribed suction level and clicks into place. Suction can be set at –10, –15, –20, –30 or –40 cm of water
- **Some units are pre-set at –20 cm of water when opened**
- Regulator pressure initially set < 80 mmHg

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Recommended Standard Vacuum Regulator Set-up (NFPA)

To Sterilize or NOT

Canister/liner with integrated hydrophobic filter mounted on the wall

Vacuum regulator

Overflow Safety Trap

18” of 1/4” ID connecting tubing from trap to canister

72” of 1/4” connecting tubing from canister to patient

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Cleaning and Disinfection of Vacuum Regulators

- The Spaulding Classification is the standard for sterilization used by the Centers for Disease Control (CDC) and the World Health Organization (WHO) for hospitals. The actual document may be accessed at: http://www.cdc.gov/hicpac/pdf/guidelines/Disinfection_Nov_2008.pdf
- One should review the actual CDC document when questions arise about what the standards are
- **Note: There is no mention of suction (vacuum) regulators in the entire 158 page CDC 2008 document, *"Guideline for Disinfection and Sterilization in Healthcare Facilities"***

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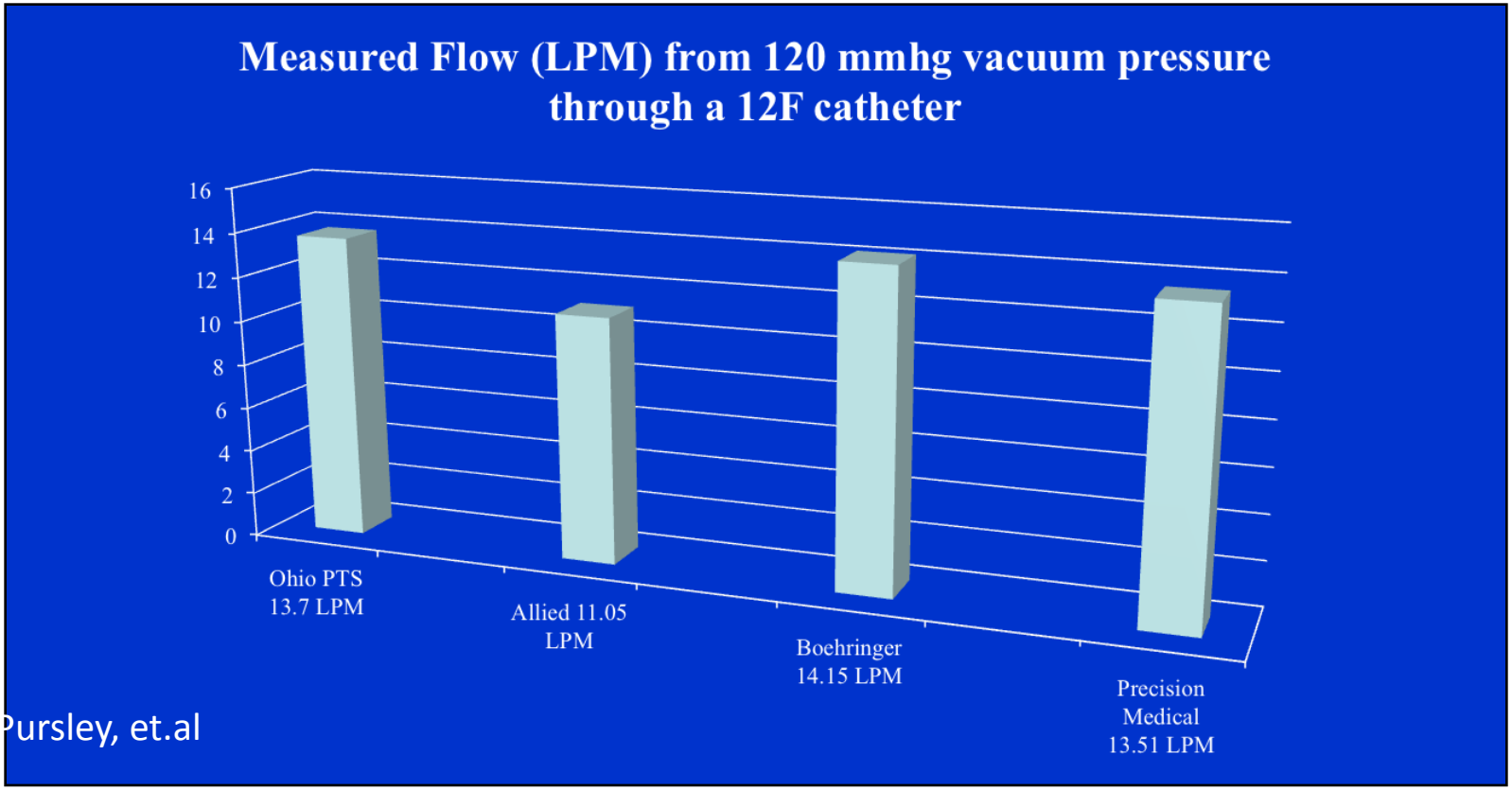
Flow and Pressure

- It is widely understood that maximum flows during suction procedures are limited by the length and diameter of the catheter, tubing and resistance of the system and the viscosity of the fluids being aspirated

Flow and Pressure

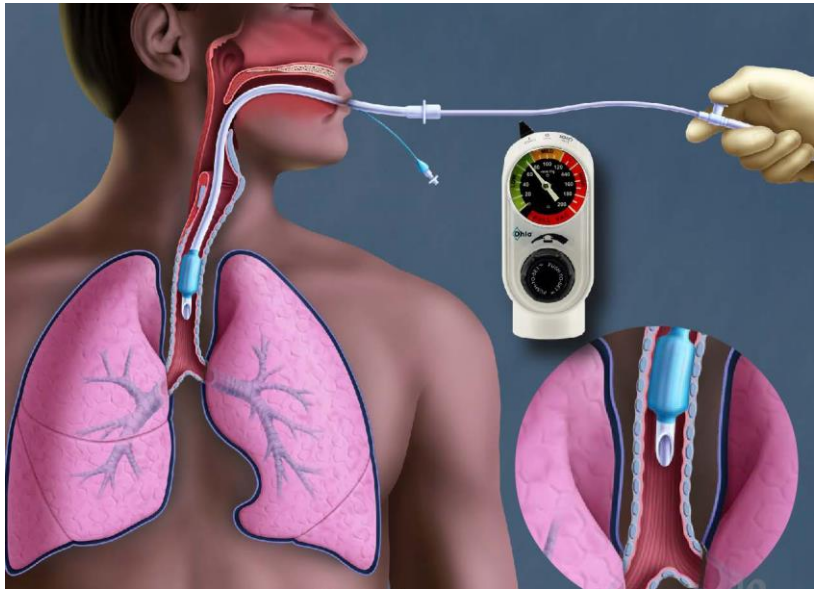


While there is slight variation amongst the vacuum regulators tested, this variation is likely of no clinical significance. ***More flow at the regulator does NOT result in more flow at the patient.***

Minimizing Complications and Adverse Responses

- Careful adherence to procedure is the best way to avoid the complications of suctioning!

OR



Technological advances to reduce the human behavioral elements

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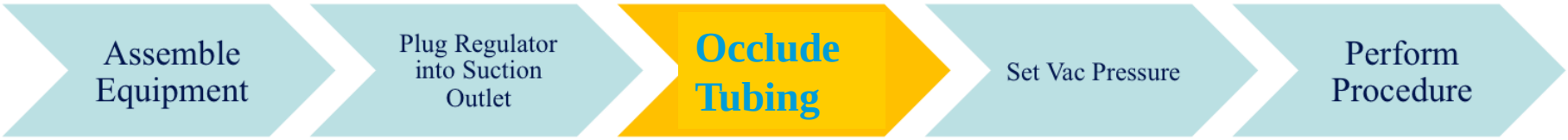
Process Improvement Analysis



- The highlighted step is the **problem step** (human behavioral element)
- Requires education, competency and memory
- If a problem process step can be improved or eliminated, it is a process improvement

Process Improvement Analysis
New Technology

Assemble Equipment → Plug Regulator into Suction Outlet → Push To Set to Set Vac Pressure → Perform Procedure

If a problem process step can be improved or eliminated, it is a process improvement

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Minimizing Complications with ETT Suctioning

- Hypoxemia and cardiac dysrhythmias
  - Pre-oxygenation
- Atelectasis, tissue tears, bleeding, infection and lung injury
  - Use proper technique to set suction pressure
  - Use correct suction pressure
  - Use correct catheter size
  - Keep duration of suctioning to a minimum (10-15 s)
  - Careful adherence to aseptic technique (infection)

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Summary

- Suction is very powerful
- Suction procedures have been overlooked as a potential cause of lung injury until recently
- Clinicians are largely undereducated on suction basics
  - What pressures for various procedures
  - How to set pressure correctly
  - New guideline recommendations
- Critical care clinicians can play an effective patient safety role, integrating their expertise in suctioning and employing lung protective strategies to reduce sepsis and MSOF

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Questions / Thank You

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