

Prevention Strategies in the Intensive Care Unit

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ICU Care

- The modern ICU provides life-saving treatment
- Cost of ICU care is >1% of the U.S. gross national product
- The ICU symbolizes healthcare's dilemma: miracles occur, but only at great expense
- Preventable adverse events commonly occur in the ICU

Overview of the Talk

- Infectious Complications
 - Homo sapiens-related
 - Device-related
- Non-infectious Complications
 - Upper GI Bleeding
 - Venous thromboembolism
- Conclusions

Infectious Complications

Homo sapiens-related



Hand Hygiene

Contact Isolation

Homo Sapiens-Related Infectious Complications: Hand Hygiene

- Raise your hand if you believe hand washing is unimportant
- Raise your hand if you believe that most physicians adhere to hand washing recommendations
- Methods for improving hand hygiene
 - Re-engineering the sinks
 - Providing disinfecting hand rub dispensers
 - Empowering the patient

Infectious Complications

Homo sapiens-related



Hand Hygiene

Contact Isolation

Homo Sapien-Related Infectious Complications: Contact Isolation

- Multi-drug resistant bacterial infections have become increasingly common
- Vancomycin-resistant Enterococcus (VRE) is frequently isolated in ICU patients (~ 25%)
- Authorities recommend that patients with VRE and other resistant infections be placed under “Contact Precautions”

CDC Position Paper. Infect Control Hosp Epidemiol 1995;16:105-113

Homo Sapien-Related Infectious Complications: Contact Precautions

- Require physicians to gown and glove prior to patient examination
- Patients with certain infections are “cohorted”
 - Separate rooms
 - Dedicated stethoscopes
- Infection status is reported to other facilities
- Physicians find it “a pain”

Contact Precautions: Is There Data to Support this Practice?

- Epidemic setting: Yes
- Endemic setting: Perhaps
- Contact precautions without active culture surveillance:
 - Studies do not consistently support this practice
- Contact precautions with active culture surveillance:
 - Studies appear to support this practice

(Srinivasan et al. Muto et al. Mayhall ICHE August 2002)

 - Expensive and time-consuming

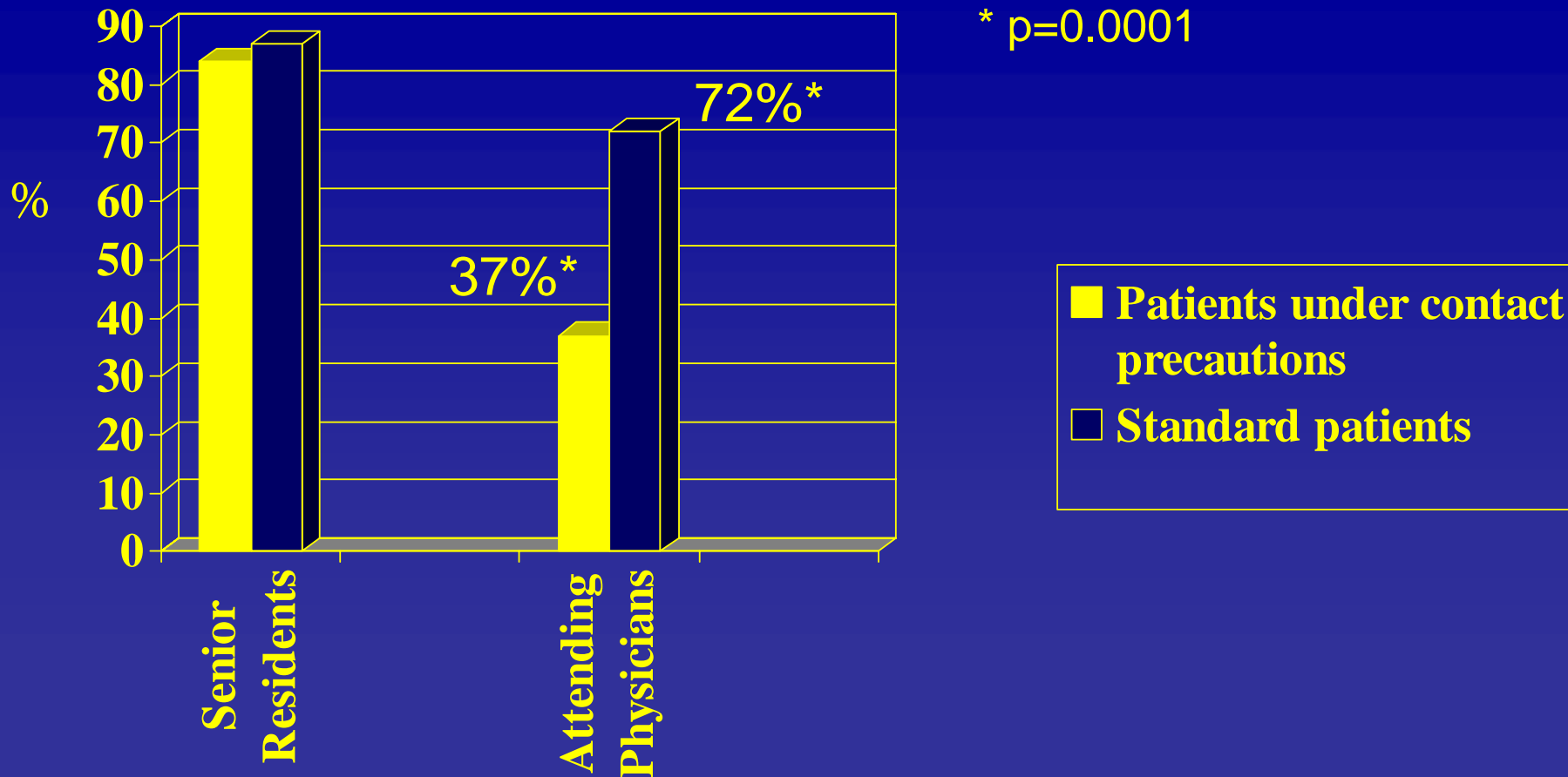
Contact Precautions: Another Drawback

Contact precautions may actually
impede a physician's ability to
examine patients

Examining Patients Under Contact Precautions

- Research question: Are hospitalized patients under contact precautions examined *less* frequently by physicians during morning rounds?
- Design: Prospective cohort study
- Subjects: Senior residents & attending physicians at 2 academic medical centers
- We directly observed morning rounds and recorded whether patients were examined

Examining Patients Under Contact Precautions: Results



(Saint S, et al. Am J Infect Cont 2003)

Contact Precautions: Conclusions

Epidemic setting:

Yes

Endemic setting:

Without active surveillance



Unclear benefit

With active surveillance



Appears beneficial

Overview

- Infectious Complications
 - Homo sapiens-related
 - Device-related
 - Urinary catheter
 - Ventilator
 - Central venous catheter
- Non-infectious Complications
 - Upper GI Bleeding
 - DVT
- Conclusions

Catheter-related UTI Prevention

- Background
- Prevention

Urinary Catheter-related Infection: Background

- Urinary tract infection (UTI) causes over 40% of hospital-acquired infections
- Most infections due to urinary catheters
- 25% of inpatients are catheterized; even higher percent of ICU patients have catheters

Prevention of Catheter-related Infection

- #1) Make sure the catheter is indicated
- #2) Use a closed drainage system (and keep it closed)
- #3) Remove the catheter as soon as possible
- #4) Consider other methods for prevention

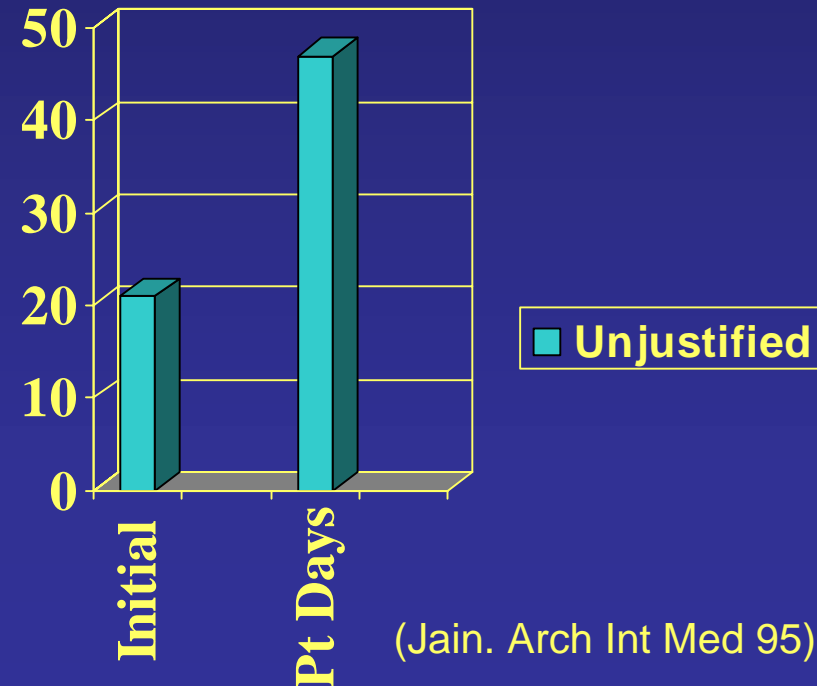
UTI Prevention Rule #1: Make Sure the Patient Really Needs the Catheter

Appropriate indications

- Bladder outlet obstruction
- Incontinence and sacral wound
- Urine output monitored
- Patient's request (end-of-life)
- During or just after surgery

(Wong and Hooton - CDC 1983)

Percent unjustified



Why are Catheters Used Inappropriately?

- Perhaps physicians “forget” that their patient has a urinary catheter
- We sought to determine the extent to which physicians are aware which of their inpatients have urinary catheters
- Surveyed 56 medical teams at 4 sites; 256 providers completed the survey (response rate = 89%)
(Saint S, Wiese J, Amory J, et al. Am J Med 2000)

Urethral Catheters: Lost in Place?

Training Level	Proportion Unaware	95% CI
Medical Student	18%	8-32%
Intern	22%	13-34%
Resident	28%	20-38%
Attending	38%	26-45%

(Saint S, Wiese J, Amory J, et al. Am J Med 2000)

Prevention of Catheter-related Infection

#1) Make sure the catheter is indicated

#2) Use a closed drainage system

#3) Remove the catheter as soon as possible

#4) Consider other methods for prevention

Systems Approach to Reducing Urethral Catheterization

- Seattle VA: *Computerized* catheter removal reminder after 72° of catheter use; cross-over study on 2 wards
(Cornia et al Am J Med 2003)
- U of Michigan: *Written* reminder placed on the chart by a research nurse after 48° of catheter use; pre-post study on 2 hospital wards with 2 prospective control wards
- Computerized reminder appears more effective than a written reminder

Prevention of Catheter-related Infection

#1) Make sure the catheter is indicated

#2) Use a closed drainage system

#3) Remove the catheter as soon as possible

#4) Consider other methods for prevention

Methods for Preventing Urinary Catheter-related Infection

- Bladder irrigation: NOT
- Antibacterial agents in collection bag: NOT
- Rigorous meatal cleaning: NOT
- Silver-coated catheter
- Consider other urinary collection strategies

Prevention of Catheter-related UTI using Silver Catheters: The Silver Bullet?

- Efficacy of silver catheters shown in meta-analysis of randomized trials (Saint, Veenstra, et al. Am J Med 1998)
- Additional cost of \$5.30 per silver catheter tray
- Is the reduction in catheter-related infection worth the extra cost?

Results: Silver catheters prevent morbidity and save money in patients high-risk for infection

	Costs	Symptomatic UTI	Bacteremia
Silver Catheter	\$16.78	1.6%	0.25%
Standard Catheter	\$20.87	3%	0.45%
Difference	-\$4.09	-1.4%	-0.2%

(Saint, Veenstra,, Sullivan, Chenoweth, Fendrick. Arch Intern Med 2000)

Silver Catheters: Policy Implications

Silver catheters should be considered in *appropriate* patients requiring catheterization for 2 to 10 days and who are at high-risk for infection (e.g., the critically ill)

Methods for Preventing Urinary Catheter-related Infection

- Bladder irrigation: NOT
- Antibacterial agents in collection bag: NOT
- Rigorous meatal cleaning: NOT
- Silver-coated catheter: Promising
- Other urinary collection strategies
 - Intermittent catheterization
 - Suprapubic catheter
 - Condom catheter

Catheter-related UTI Prevention: Recommendations

- Use urethral catheters only when necessary
- Use only a closed drainage system and keep it closed
- Consider silver catheters in high-risk patients who require catheterization for 2 to 10 days
- Consider using a urinary catheter “stop order” to limit inappropriate catheterization

Ventilator Associated Pneumonia (VAP)



- Epidemiology
- Definitions and Microbiology
- Pathophysiology
- Prevention

VAP: Epidemiology

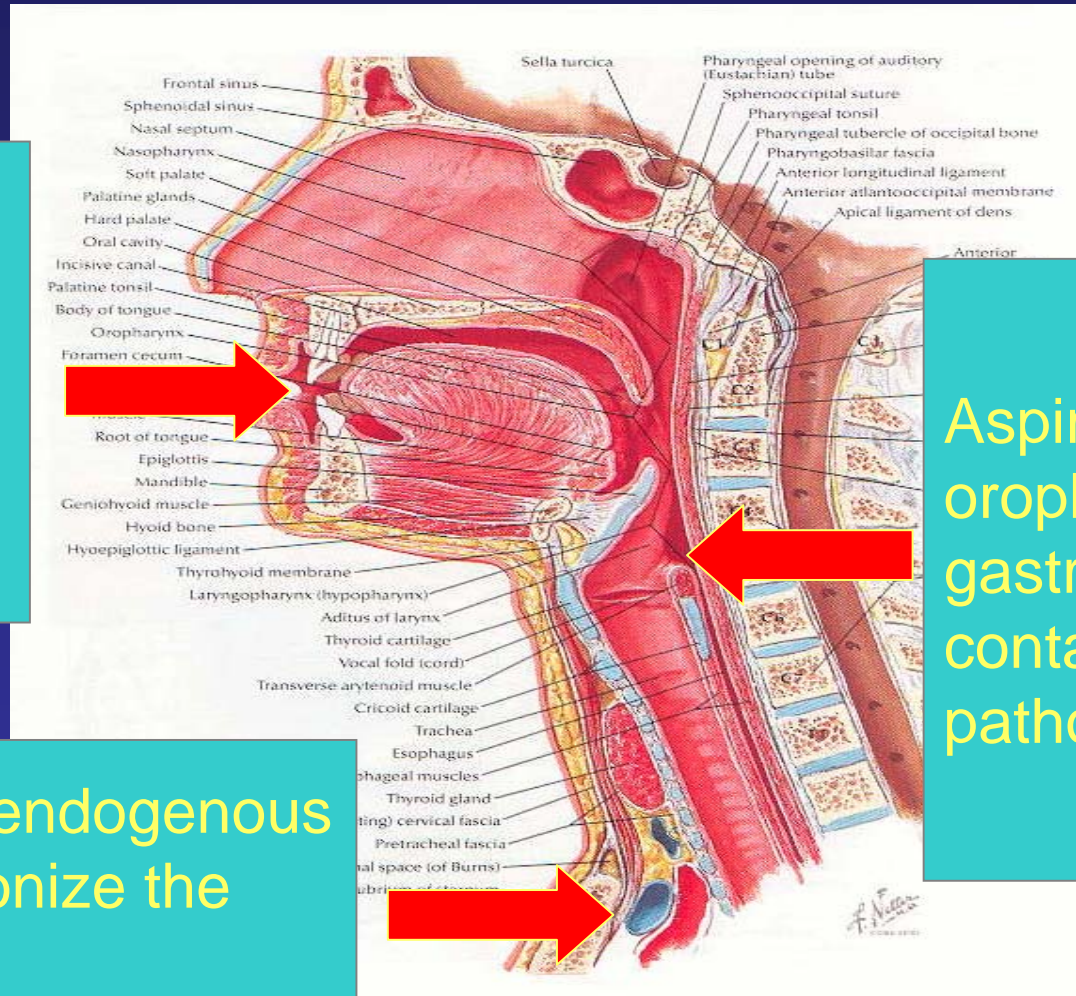
- 10 to 25% of mechanically ventilated patients develop VAP
- VAP rate ~ 1 to 3% per day of mechanical ventilation

VAP: Definitions & Microbiology

- Early-onset VAP: Occurring < 4 days after tracheal intubation
 - *S. pneumoniae*, *H. influenzae*, anaerobes
- Late-onset VAP: Occurring > 4 days after tracheal intubation
 - *P. aeruginosa*, *Acinetobacter spp*,
Enterobacter spp, *S. aureus*, enteric organisms

VAP: Pathophysiology

Exogenous/
endogenous
bacteria
colonize the
patient's
oropharynx



Aspiration of
oropharyngeal or
gastric secretions
containing
pathogenic bacteria

Exogenous/endogenous
bacteria colonize the
stomach

Prevention of VAP: Possible Methods

- Selective Digestive Tract Decontamination (SDD)
- Subglottic Secretion Drainage
- Semi-Recumbent Positioning
- Sucralfate for Stress Ulcer Prophylaxis
- Change methods of enteral feeding
- Kinetic/rotational beds
- Ventilator tubing circuit management
- Oral chlorhexidine gluconate wash
- Silver-coated endotracheal tubes

(Collard, Saint, Matthay, Ann Intern Med 2003)

Selective digestive tract decontamination (SDD)

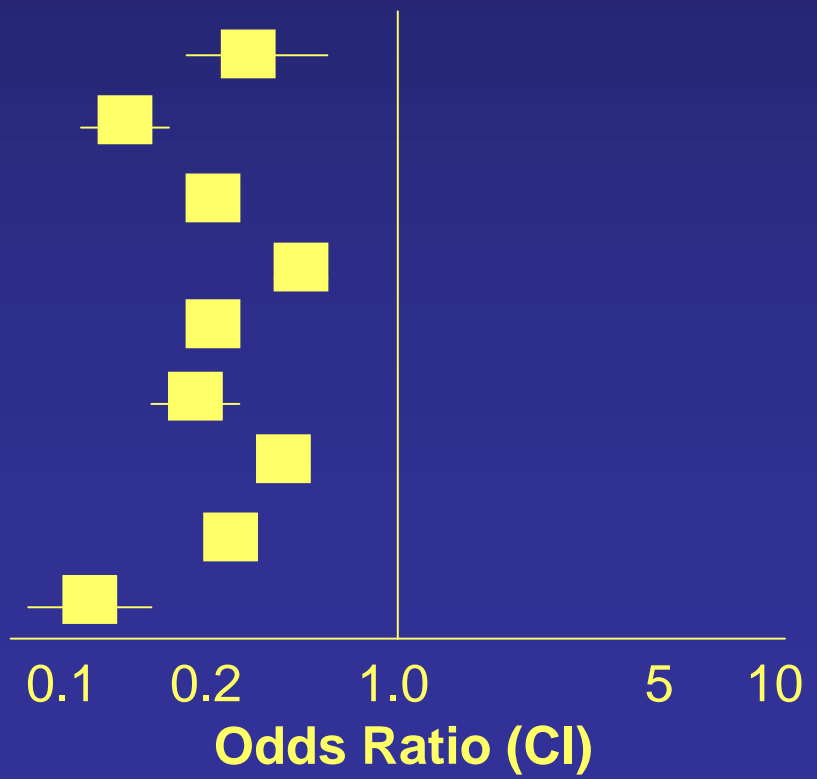
- Non-absorbable antibiotics (e.g., Polymyxin) applied to the upper GI tract
- Many also use short-term systemic antibiotics (e.g., ceftriaxone)
- 7 meta-analyses of over 40 randomized trials have evaluated VAP incidence and mortality

SDD: Effective in Preventing VAP

Favors SDD

Favors Control

- Nathens, 1999 (medical)
- Nathens, 1999 (surgical)
- D'Amico, 1998 (+ IV abx)
- D'Amico, 1998 (- IV abx)
- Hurley, 1995
- Kollef, 1994
- Heyland, 1994
- SDD Collaborative Gp., 1993
- Vandenbroucke-Grauls, 1991

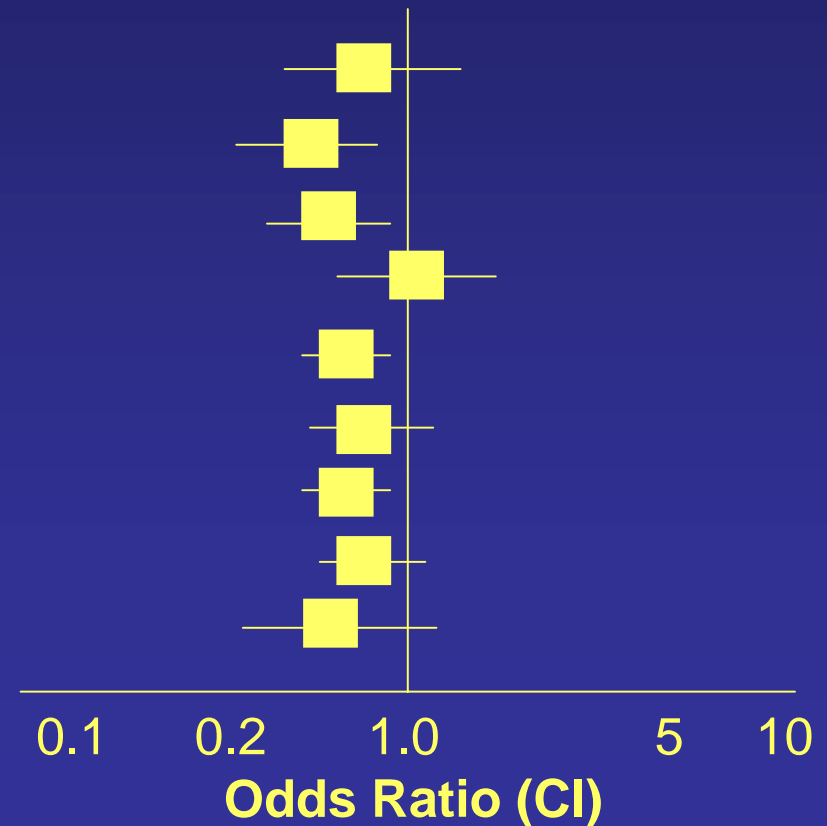


SDD: Maybe Effective in Preventing Death

Favors SDD

Favors Control

Nathens, 1999 (medical)
Nathens, 1999 (surgical)
D'Amico, 1998 (+ IV abx)
D'Amico, 1998 (- IV abx)
Hurley, 1995
Kollef, 1994
Heyland, 1994
SDD Collaborative Gp., 1993
Vandenbroucke-Grauls, 1991



Selective Digestive Tract Decontamination : Issues

- Promotion of antibiotic-resistant organisms
- Inverse relationship between methodological quality of the SDD study and SDD effectiveness
(van Nieuwenhoven et al. *JAMA*. 2001;286:335-340)
- SDD currently not recommended for routine use

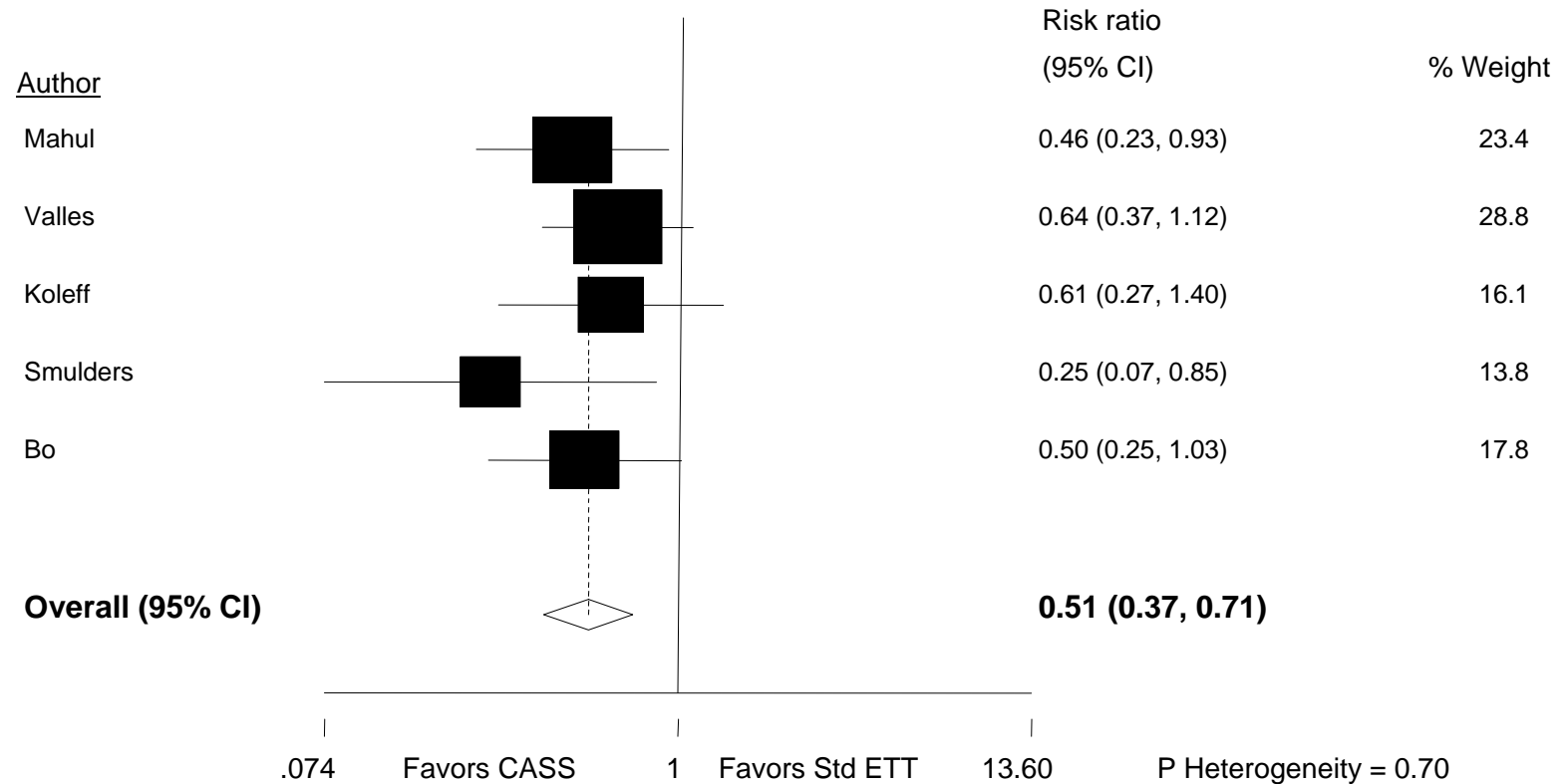
Prevention of VAP: Possible Methods

✓ Selective Digestive Tract Decontamination (SDD)

➤ Subglottic Secretion Drainage

- Semi-Recumbent Positioning
- Subglottic Secretion Drainage
- Change methods of enteral feeding
- Kinetic/rotational beds
- Ventilator tubing circuit management
- Oral chlorhexidine gluconate wash
- Silver-coated endotracheal tubes

Meta-analysis of Subglottic Secretion Drainage for Preventing VAP



Subglottic Secretion Drainage: Conclusions

- Subglottic secretion drainage probably works in patients requiring >3 days of mechanical ventilation
- Additional randomized trials are needed
- Recommendation: Consider this intervention in patients requiring > 3 days of mechanical ventilation

Prevention of VAP: Possible Methods

- ✓ Selective Digestive Tract Decontamination (SDD)
- ✓ Subglottic Secretion Drainage
- **Semi-Recumbent Positioning**
 - Sucralfate for Stress Ulcer Prophylaxis
 - Change methods of enteral feeding
 - Kinetic/rotational beds
 - Ventilator tubing circuit management
 - Oral chlorhexidine gluconate wash
 - Silver-coated endotracheal tubes

Semi-Recumbent Positioning

- Description: Elevation of the head of bed to 45° for the duration of mechanical ventilation
- Theory: reduces aspiration of oral & gastric secretions
- 3 studies (2 cross-over and 1 randomized) – all showed benefit

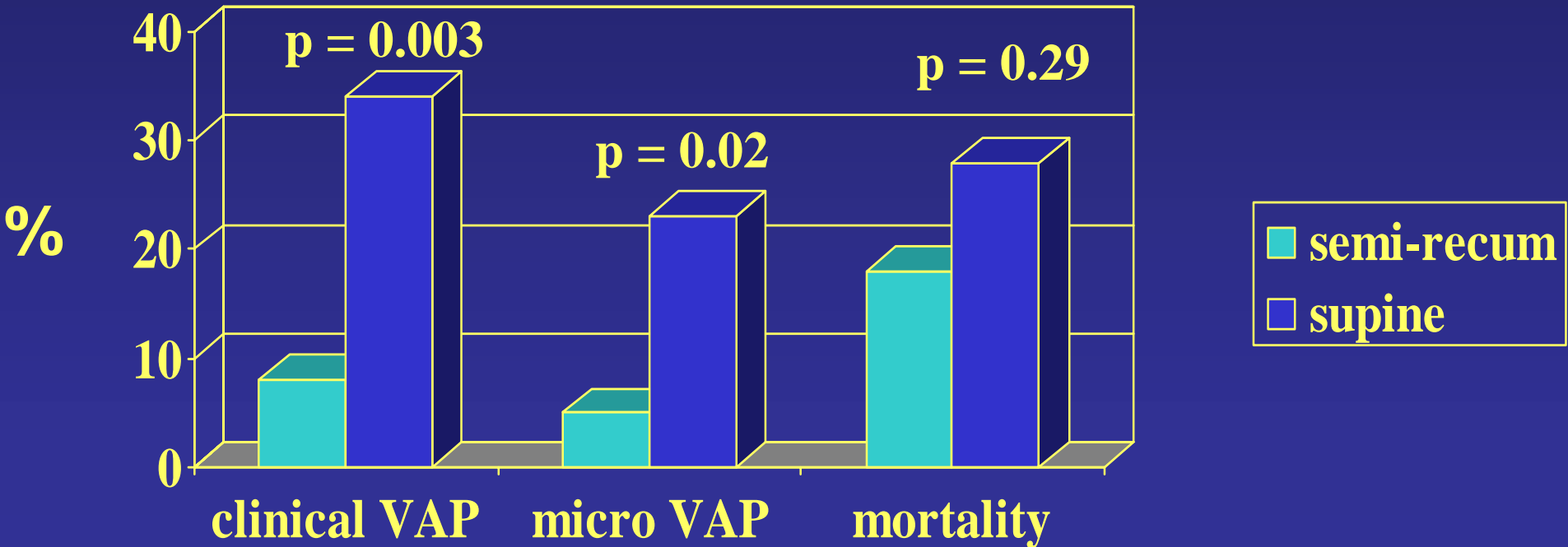
Drakulovic. Lancet 1999;354:1851-1858

Orozco-Levi. Am J Resp Crit Care Med 1995;152:1387-1390

Torres. Ann Intern Med 1992;116:540-543

Semi-Recumbent Positioning: Effectiveness

- 86 ventilated patients randomized to semi-recumbent or supine positioning



Drakulovic. Lancet 1999;354:1851-1858

Semi-Recumbent Positioning: Conclusions

- Appears to work!
- No reported adverse effects (those with recent abdominal or neurological surgery and shock excluded)
- Recommendation: Position mechanically ventilated patients in a semi-recumbent position (45°) unless contraindicated

Preventing VAP: Recommendations

- Avoid/limit length of endotracheal intubation
- Position patients in semi-recumbent position (45° elevation) unless contraindicated
- Consider subglottic secretion drainage in patients requiring > 3 days of mechanical ventilation
- Selective digestive tract decontamination: not yet

Central Venous Catheter-related Infection Prevention



- Background
- Risk Factors
- Prevention

Catheter-related Bloodstream Infection (CR-BSI): Background

- Vascular catheters are the leading cause of nosocomial bacteremia; most due to central venous catheters
- 150,000 cases of CR-BSI annually in U.S.
- 10% to 30% attributable mortality rate
- Annual cost between \$300 million and \$2 billion

Vascular Catheter-related Infections: Modifiable Risk Factors

- Prolonged catheterization ?
- Location of catheter ?

Duration and Location of Catheter affects Risk of Infection

Type of Catheter

Incidence of Local Infection

Peripheral venous
Peripheral arterial
Central venous

1.3% per day
1.9% per day
3.3% per day

(Hampton & Sherertz. Surg Clin N Am. 1988)

Vascular Catheter-related Infections: Modifiable Risk Factors

- Prolonged catheterization? *Avoid*
- Location of catheter? *Important*

Vascular Catheter-related Infection: Prevention

- Use of maximum sterile barriers - ?
- Routine line changes - ?
- Antimicrobial central venous catheters - ?
- Chlorhexidine for vascular site skin disinfection - ?

Use of Maximum Sterile Barriers during Insertion

- Maximum sterile barriers (mask and sterile drape, gown, and gloves) during central line insertion reduces CR-BSI
(Raad et al. ICHE 1994)
- Compliance is poor
- Before-and-after evaluation of an educational intervention aimed at students and interns:
 - 32% increase in use of maximum barriers ($P < 0.001$)
 - 28% decrease in catheter-related infection ($P < 0.01$)
(Sherertz et al Ann Intern Med 2000)

Vascular Catheter-related Infection: Prevention

- Use of maximum sterile barriers - YES
- Routine line changes - ?
- Antimicrobial central venous catheters - ?
- Chlorhexidine for vascular site skin disinfection - ?

Vascular Catheter-related Infection: Prevention

- Maximum sterile barriers - YES
- Routine line changes - ?
- Antimicrobial central venous catheters - ?
- Chlorhexidine for vascular site skin disinfection - ?

Routine Line Changes: Just Say No

Evidence from meta-analysis of 12 trials:

“Exchanging catheters over guidewires or at new sites did not reduce infection compared with as-needed replacement.”

(Cook D et al Crit Care Med 1997)

Evidence from several individual trials:

New sites: decreased infection rate offset by increased mechanical complication rate

Guidewire changes: no decrease in infection rate

(Snyder: Ann Surg '88; Eyer Crit Care Med '90; Cobb: NEJM '92)

Vascular Catheter-related Infection: Prevention

- Maximum sterile barriers -YES
- Routine line changes - NO
- Antimicrobial central venous catheters - ?
- Chlorhexidine for vascular site skin disinfection - ?

Prevention of Catheter-related Infection: Antiseptic Central Venous Catheters

- Different types of coated catheters
- Chlorhexidine/silver sulfadiazine catheters: best studied
- Efficacy of antiseptic catheters shown in meta-analysis of randomized trials (Veenstra, Saint, Saha, et al. JAMA 1999)
- Is the benefit worth the extra \$25 per catheter?

Results:

Antiseptic catheters save lives and money

	Costs	CR-BSI	Death
Antiseptic Catheter	\$336	3.0%	0.45%
Standard Catheter	\$532	5.2%	0.78%
Difference	-\$196	-2.2%	-0.33%

(Veenstra, Saint, Sullivan. JAMA 1999)

Antiseptic Catheters: Policy Implications

Antiseptic catheters recommended in critically ill patients requiring central venous access for 2 to 10 days

“Back of the Envelope” Economic Analysis

Annual Cost Savings for the University of Michigan

Base Case	\$ 110,000
Best Case Scenario	\$ 423,000
Worst Case Scenario	\$ 41,250

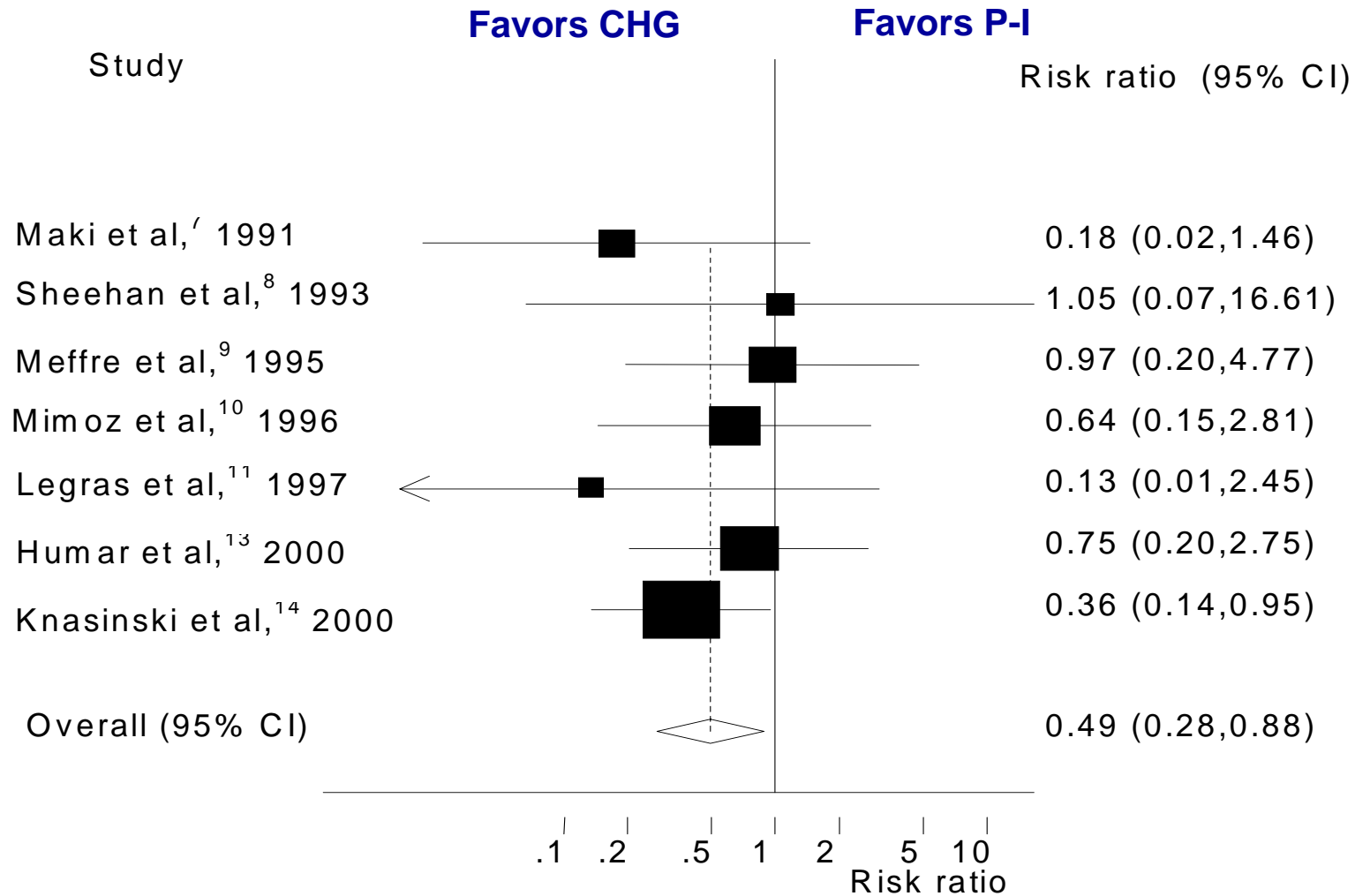
Vascular Catheter-related Infection: Prevention

- Maximum sterile barriers - Yes
- Routine line changes - No
- **Antimicrobial central venous catheters - Yes**
- Chlorhexidine for vascular site skin disinfection - ?

Which Disinfectant Should be Used for Catheter Site Care?

- Povidone-iodine (PI) is currently the most widely used agent for site disinfection
- Chlorhexidine gluconate (CHG) has been compared to PI with mixed results
- We performed a formal meta-analysis of published and unpublished studies to clarify relative efficacy

Chlorhexidine for Site Disinfection: CR-BSI

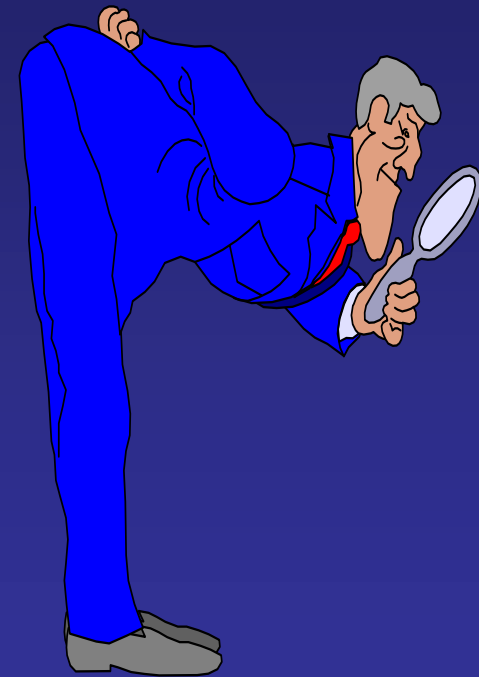


Which Disinfectant Should be Used for Catheter Site Care? Caveats

- Chlorhexidine gluconate costs 2-fold more than povidone-iodine
 - \$0.41 vs \$0.92 for same amount
 - An economic evaluation indicates that this strategy is cost-saving
- Effect of CHG *in addition to* antimicrobial catheters unclear
- UM now using this new disinfectant and we plan to evaluate the results

After Close Inspection: Recommendations to Prevent Vascular Catheter-related Infection

- Peripheral lines better than central
- Aseptic insertion important
- No evidence favoring routine line changes
- Minimize duration
- Antimicrobial catheters – yes
- Chlorhexidine for site disinfection – very promising

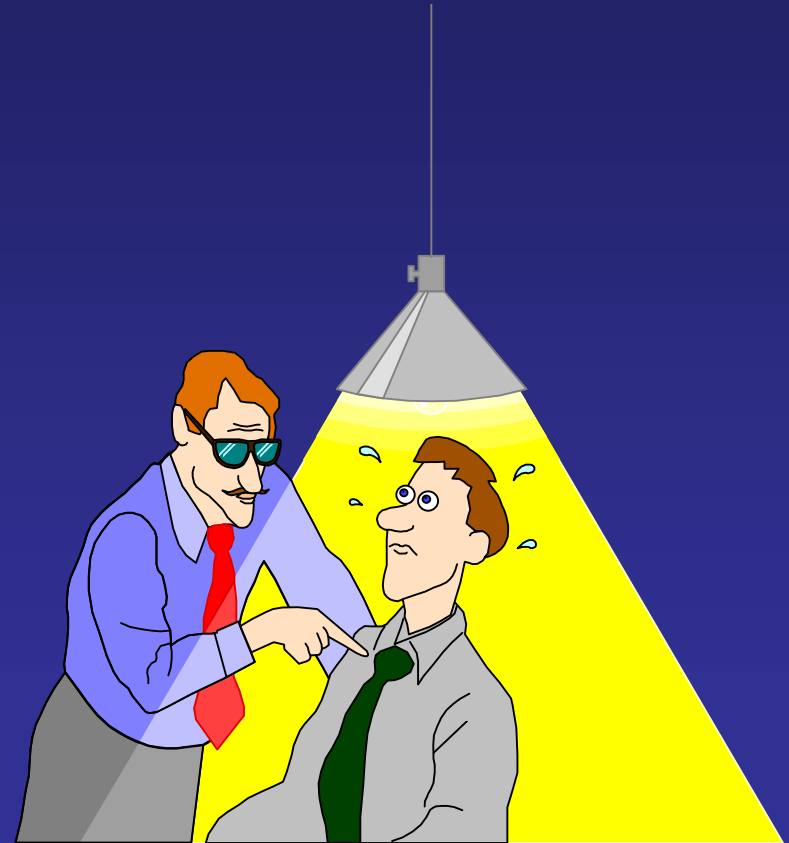


Overview

- Infectious Complications
 - Homo sapiens-related
 - Device-related
- Non-infectious Complications
 - Upper GI Bleeding
 - DVT
- Conclusions

Stress-Related Upper GI Bleeding

- Who bleeds?
- Prevention of bleeding



Stress-related UGIB: Who Bleeds?

- Cohort study of 2252 pts admitted to an ICU
- 674 (30%) received prophylaxis
- 100 (4.4%) had overt bleeding
- 33 (1.5%) had clinically-important UGIB

Risk Factors for UGIB:

Resp failure: OR= 16

Coagulopathy: OR= 4

Hypotension: OR= 4

(Cook D. et al. NEJM. 1994)

UGIB Prevention: With What?

- H2-blockers, sucralfate, antacids, PPIs: most commonly used agents
- Efficacy and side effects are both important
- >60 studies comparing these agents

Upper GI Bleeding: Summary of Evidence

- H2-blockers have a higher GI bleeding risk compared with sucralfate
- Sucralfate appears to have a lower VAP risk compared with H2-blockers (especially in preventing *late-onset* VAP)
- Neither has shown to significantly decrease mortality
- Not enough data on PPIs to conclude much

Prod'hom. Ann Intern Med 1994;120:653-660

Cook. NEJM 1998;338:791-797

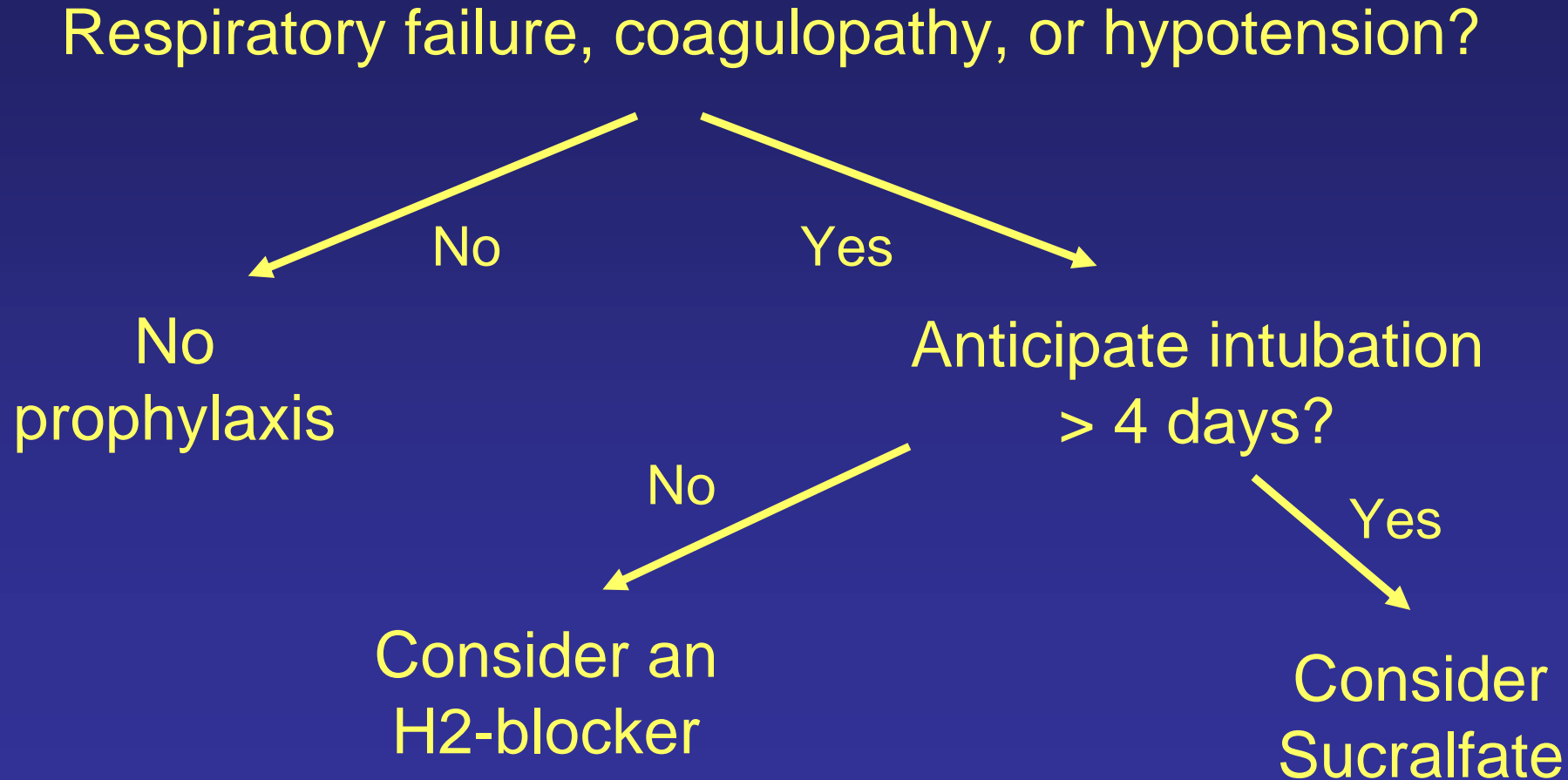
Messori A. BMJ 2000;21:1-7

Stress-Related UGIB Prevention: Conclusions

(Dressler D, Williams MV, Rask K. AHRQ's Making Healthcare Safer. 2001)

- “The evidence available does not conclusively demonstrate that the benefits of GI prophylaxis outweigh its risks for every patient in the ICU.”
- “Published evidence does not yet support this practice for many patients currently receiving this therapy.”
- Thus, targeting patients who are likely to benefit is important

Stress-Related UGIB Prevention: One Approach



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Venous Thromboembolism: Background

- Over 5 million DVT's per year in the U.S.
- PE may be the most common preventable cause of hospital death

Clinical Risk Factors for VTE in Critically Ill Patients

Factors present before ICU admission:

- Recent surgery
- Trauma, burns
- Malignancy and its treatment
- Sepsis
- Immobilization/bed rest, stroke, spinal cord injury
- Increasing age
- Heart/respiratory failure
- Previous DVT or PE
- Pregnancy
- Estrogens

Additional factors acquired in the ICU:

- Central venous lines
- Sepsis
- Pharmacologic sedation, paralysis
- Mechanical ventilation

(Geerts & Selby. Chest Dec 2003)

Thromboprophylaxis Utilization in Critically Ill Patients

Source	Type of ICU	Prophylaxis Use
Keane (1994)	Medical	33%
Peters (1997)	Medical/surgical	45%
Cook (2000)	Medical/surgical	63%
Lentine (2002)	Medical	74%
Mysliwiec (2002)	Medical	84%

Thromboprophylaxis Trials in Critically Ill Patients

Source	Intervention	DVT (%)	
		Control	Experimental
Cade (1982)	Heparin, 5,000 U SC bid	29	13
Kapoor (1999)	Heparin, 5,000 U SC bid	31	11
Fraisse (2000)	LMWH	28	15

Prophylaxis Recommendations* in ICU Patients

Bleeding Risk	Thrombosis Risk	Prophylaxis Recommendations
Low	Moderate	LDUH
Low	High	LMWH
High	Moderate	Mechanical – LDUH when bleeding risk decreases
High	High	Mechanical – LMWH when bleeding risk decreases

*(Geerts & Selby. Chest Dec 2003)

DVT Prophylaxis: Conclusions

- Critically ill patients appear to be at high risk for DVT and warrant DVT prophylaxis
- Unfractionated low-dose heparin or LMWH are both acceptable (based on RCTs)
- Benefits > Risks
- Intermittent pneumatic compression is probably also effective in those at high risk for bleeding

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Prevention Strategies in the ICU: Conclusions

- Reducing the risk of ICU complications can decrease LOS and costs, and enhance patient safety
- The last section of the Assessment & Plan should be titled “ICU prophylaxis” - consider both infectious and non-infectious complications
- Hospitalists can and should take the lead in reducing hospital-acquired complications