PRONING: IS FLIPPING SUCH A GOOD THING?
PRO/CON

Toan Huynh, MD, FACS, FCCM (*The Con*)
vs
William S. Miles MD, FACS, FCCM, FAPWCA (*The Pro*)

MY OPPONENT
TOAN HUYNH

- Toan = "tone", "twin" "tin" "twan (John? Joan?)
- Huynh = "hune" "hun" "wayne"
- So it must be Twan (John) Wayne---
- How is he an expert on proning?

GASTON

- I assumed Gaston Co. NC
- I was wrong when researched
- He always says he is "GASTONESE"

GASTONESE

GAS-TUN (GASTUNESE)

I FOUND SEVERAL PICTURES OF MY OPPONENT

GASTUNESE

Ninja Proning

Dancing with the Stars

Proning Expert

BEING FROM GASTUN

- They have many children…….

THESE ARE JUST 9 OF HIS 12 KIDS FROM GASTUN

PRONING EXPERT

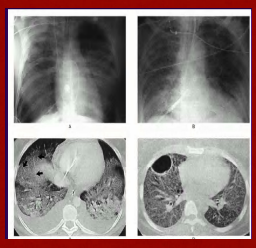
- He has spent a lot of time proning, being a "Ninja" and all
- So I guess I do have a worthy opponent!

SO…..PRONING

CONCEPT

- Dense consolidation of dependent lung units is common in ARDS patients who are kept supine
- These lung units are richly perfused owing to gravitational forces
- The ***net result*** is shunt with refractory hypoxemia
- By turning the patients in the prone position, theoretically the less consolidated areas will receive more ventilation & perfusion

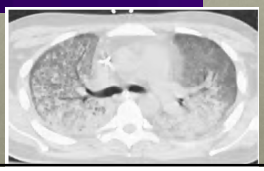
ARDS/ALI



- Diffuse bilateral infiltrates
- Severe hypoxemia (P/F < 300)
- Decreased lung compliance
- Decreased FRC ("baby lung")

STRATEGIES TO COMBAT

- "open-lung ventilation"
- Low tidal volume/low plateau pressure
- Permissive hypercapnea
- High levels of PEEP
- Demonstrated to improve survival



ADJUNCTS

- Alternate modes of ventilation – HFOV, APRV, Bi-Level
- Neuromuscular Paralysis
- Nitric Oxide
- ECMO
- Liquid ventilation
- Prone Positioning

MECHANISM

- In prone position, the weight of heart is on sternum (rather than on the lung as in supine position)
- This may cause the pleural pressure to be less positive in the dependent areas & hence decrease atelectasis of the alveoli
- Thus there appears to be a **more homogenous distribution of regional ventilation in prone position**
- Regional perfusion is relatively unaffected by changing from supine to prone position
- The net effect is reduction in V/Q mismatching & improved oxygenation

BENEFITS OF PRONE POSITIONING

- Improves V/Q mismatch
- Increased ventilation in dependent areas
- Decreases physiologic shunt
- Improved ventilation in areas where perfusion remains the same
- Decreases compression/Increase FRC
- Prevent ventilator associated lung injury
- Enhances mobilization of secretions

PHYSIOLOGY
VENTILATION REDISTRIBUTION

Normal Lung —alveolar distension pressures follow a gravitational gradient

Transpulmonary pressure is greater in nondependent areas

- Areas of lung collapse are common in patients with acute respiratory distress syndrome (ARDS).
- An elevated alveolar distending pressure is desirable to recruit closed alveoli.
- The alveolar distending pressure is estimated by the transpulmonary pressure (Ptp), which is defined as the difference between airway (Paw) and pleural pressure (Ppl): Ptp = Paw - Ppl

TRANSPULMONIC PRESSURE IN ARDS

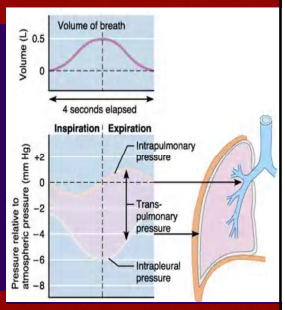
Ptp = Paw – Ppl

In ARDS Ptp is decreased in dependent areas

Leads to overdistension of alveoli in non-dependent areas

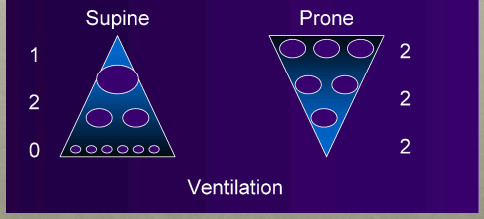
Goal is to ↑ Ptp in dependent areas

- PEEP
- Prone positioning

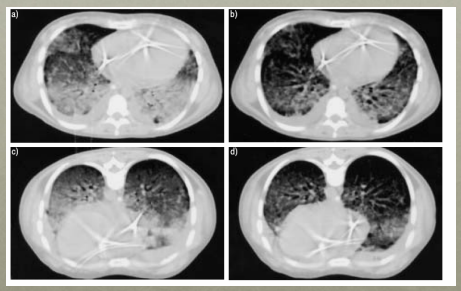


VENTILATION REDISTRIBUTION

- In PP there is a more homogeneous distribution of Ptp and alveolar distension



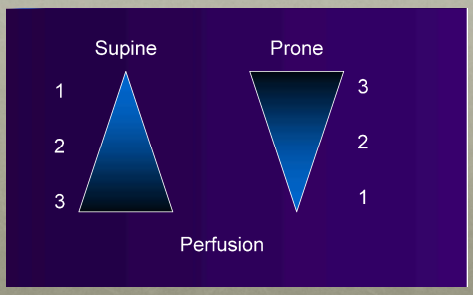
EFFECT OF PRONE POSITION ON VENTILATION REDISTRIBUTION



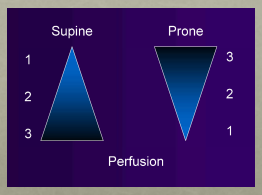
PHYSIOLOGY
PERFUSION REDISTRIBUTION

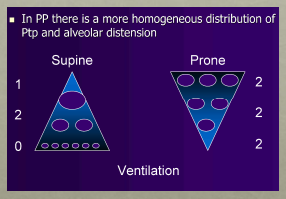
- In normal lungs in supine position there is a perfusion gradient going from non dependent to dependent areas
- In prone position there does not seem to be any change in distribution of perfusion i.e. dorsal; areas remain maximally perfused

PERFUSION REDISTRIBUTION

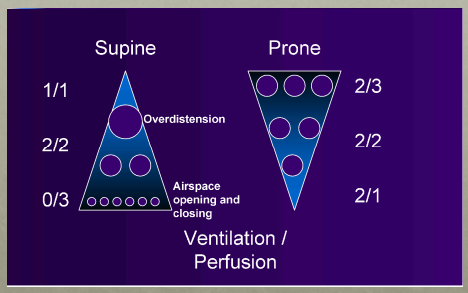


JUST COMPARE





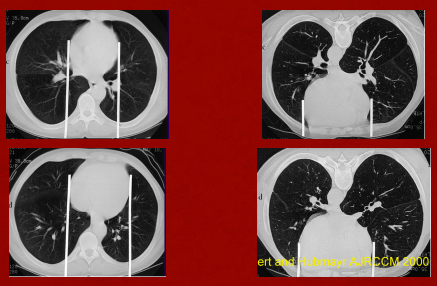
V/Q RELATION IN PRONE POSITION



LUNG COMPRESSION BY HEART

- % of total lung volume under heart when supine: 7% (subcarinal) to 42% (lower section)
- % of total lung volume under heart when prone: 1% to 4% for same sections
- This effect is more prominent on left lung

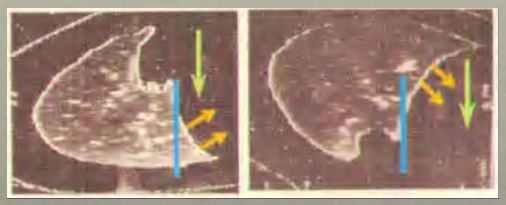
CARDIAC COMPRESSION



LUNG COMPRESSION BY ABDOMINAL CONTENTS

- **Supine position** —intra-abdominal pressure causes cephalad displacement of diaphragm
  - Decreases FRC
  - Enhanced by sedation and paralysis
- **Prone position** —less affect of intra-abdominal pressure on diaphragms
  - Improves FRC
  - Works best when abdomen is unsupported

LUNG COMPRESSION BY ABDOMINAL CONTENTS



supine prone

MOBILIZATION OF SECRETIONS

- **It is observed in multiple studies that there is increased bronchial secretions & need for suctioning with pts prone**
- Although one study tried to correlate amount of secretions with change in P/F but did not show any correlation

– Gillart, et al. *Ann Fr Anesth Reanim.* 2000 Mar;19(3):156-63

BENEFITS PRONE POSITIONING IN ARDS

- More than 60% of pts demonstrate improvement in oxygenation
- The degree of improvement varies in different studies
- Patients who benefit from prone positioning are likely to show some improvement in the first 30 minutes after switching from supine to prone

BENEFITS PRONE POSITIONING IN ARDS

- The improvement in oxygenation is most likely in the early, exudative phase of ARDS
- This improvement may be sustained in 50% of patients even when they are switched back from prone to supine position

Pelosi et al. Eur Respir J, 2002; 20: 1017-1028.

Table 2. – Synopsis of current trials of prone positioning

First author [ref.]	Type	Year	Patient n	Prevalent disease	Support	Improved patients %	Pa,O_2 supine kPa	Pa,O_2 prone kPa	Survival %
PIEHL [4]	R	1976	5	M	FA	100	9.6±1.7	14.1±1.2	60
DOUGLAS [5]	P	1977	6	M	FA	100	8.4±1.3	18.4±8.9	50
GATTINONI [18]	P	1991	10	M	FA	30	9.3±0.9	15.4±4.3	60
PELOSI [22]	P	1998	17	PR	FA	76	13.3±3.5	16.6±3.6	59
BLANCH [23]	P	1997	23	M	NS	67	9.3±3.6#	12.0±7.0	52
SERVILLO [24]	P	1997	12	S	FA	83	16.4±2.9	20.3±2.3	42
GUERIN [25]	P	1999	12	U	FA	67	18.1±2.3	27.1±3.2	58
LANGER [26]	P	1988	13	M	U	62	9.2±1.1	14.8±2.7	54
CHATTE [27]	P	1997	32	PR	U	31	13.3±4.8	23.9±4.9	44
GATTINONI [28]	P	1997	54	M	FA	76	16.4±5.3#	25.9±9.3	54
GERMANN [39]	P	1998	47	PR	U	74	15.3¶	21.9	91
PAPAZIAN [40]	P	1998	14	PR	U	64	17.0±5.9#	25.7±11.0	85
MARTINEZ [41]	P	1999	14	PR	FA	41	14.6±7.3#	21.4±11.8	43
DUPONT [42]	P	2000	27	M	U	74	12.2±3.5#	22.5±10.1	37
JOLLIET [43]	P	1997	12	PR	U	58	8.2±0.9	9.6±1.9	33
ALBERT [50]	R	1993	9	M	FA	78	8.4±2.0	30.7±16.1	
WALZ [51]	R	1992	16	U	U	100			
SHECHNOHE [52]	R	1991	7	U	U	100			
THULIG [53]	C	1991	1	U	U	100	8.9	11.8	
FALLER [54]	L	1988	3	U	U	100	13.7±3.3	26.2±3.9	
MANARA [55]	L	1987	4	U	U	75	39.9±7.0+	19.0±2.0	25
PAPPERT [56]	P	1994	12	S	NS	56	9.8±1.5	16.4±3.9	58
VOLLMAN [57]	P	1996	15	PR	U	60	11.6±1.9	13.6±4.4	
BRUSSEL [58]	P	1993	10	U	U	74	9.7±3.9	13.4±5.2	90
VOGGENREITER [59]	P	1999	22	U	U	90	19.8±1.1#	39.5±4.0	82
WENZ [60]	P	2000	10	M	U	80	20.0±4.9	29.3±2.3	90
FRIEDRICH [61]	P	1996	20	M	U	60	12.9±0.5	20.2±2.0	90
MURE [62]	P	1997	13	S	FA	92	69.7±18.1+	34.3±18.8	69
FLAATTEN[63]	P	1998	14	S	FA	90	11.7±0.8	18±1.4	57

GUERIN, ET AL. EFFECTS OF SYSTEMATIC PRONE POSITIONING IN HYPOXEMIC ACUTE RESPIRATORY FAILURE. JAMA , 2004; 292(19): 2379- 2387. JAMA

Prospective, RCT, unblind,791 pts from 21 ICU's in France

Inclusion criteria

- Age > 18
- Hemodynamically stable
- P/F < 300
- Expected length of MV > 48 hrs
- **Exclusion criteria**
- Prone positioning prior to enrollment
- High risk of death in 48hrs
- Chronic respiratory failure
- Contraindication to lying prone

GUERIN, ET AL. EFFECTS OF SYSTEMATIC PRONE POSITIONING IN HYPOXEMIC ACUTE RESPIRATORY FAILURE. JAMA , 2004; 292(19): 2379 2387. JAMA, 2379-

- **Study Protocol**
- Vent mode, sedation, paralytics as per protocol
- Complete prone position for at least 8hr/d
- Pts in control group could cross over for severe hypoxemia
- Prone position was stopped if complications or once improvement was shown
- Weaning was per protocol
- Significant crossovers

GUERIN, ET AL. EFFECTS OF SYSTEMATIC PRONE POSITIONING IN HYPOXEMIC ACUTE RESPIRATORY FAILURE. JAMA , 2004; 292(19): 2379 2387. JAMA, 2379-

Complications

- Decrease in P/F by 20%
- Extubation
- ETT obstruction
- Hemoptysis
- O2 sat <85% for > 5min
- Cardiac arrest
- Bradycardia > 1min
- SBP < 60 for 5 min
- Pressure sores
- Elevated ICP
- Pneumothorax
- VAP

Improvement

- **Major Criteria (at least 1)**

1. Improvement in P/F >30% from randomization
2. FiO2<60%

- **Minor Criteria (at least 1)**

1.PEEP <8cm H2O
2.No sepsis
3.Cause of ARF under control
4.Stable or improving CXR 5. <3 organ dysfunction<dysfunction

GUERIN, ET AL. EFFECTS OF SYSTEMATIC PRONE POSITIONING IN HYPOXEMIC ACUTE RESPIRATORY FAILURE. JAMA , 2004; 292(19): 2379 2387. JAMA, 2379-

Primary End Point

- mortality at 28 days

Secondary End Points

- Mortality at 90 days
- Incidence of VAP
- Duration of mechanical ventilation
- oxygenation

Table 3. Outcome Measures

Outcome Measures	Supine (n = 378)	Prone (n = 413)	Relative Risk (95% Confidence Interval)	P Value†
Mortality, No./Total (%) of patients				
28 Day	119/378 (31.5)	134/413 (32.4)	0.97 (0.79-1.19)	.77
90 Day	159/377 (42.2)	179/413 (43.3)	0.98 (0.84-1.13)	.74
Mechanical ventilation assessed at 90 days				
Mechanical ventilation, mean (SD), d*	14.1 (8.6)	13.7 (7.8)		
Patients successfully extubated, No./total (%)	248/378 (65.8)	266/413 (64.4)		
Inclusion to successful extubation, mean (SD), d	16.0 (13.6)	14.9 (11.2)		
Intubation to successful extubation, mean (SD), d	17.6 (13.7)	16.9 (11.4)		
First episode of VAP				
Episodes of VAP/patient days of intubation (rate per 100-patient days of intubation)	91/4247 (2.14)	85/5120 (1.66)		.045
Patients with VAP, No. (%)	91 (24.1)	85 (20.6)		
Inclusion to VAP, median IQR, d	10 (6-16)	10.5 (6-17)		
Pao_2/Fio_2, mean (SD)				<.001
Day				
1	182 (78) [n = 365]	188 (78) [n = 305]		
2	193 (76) [n = 338]	210 (82) [n = 317]		
3	199 (78) [n = 325]	213 (85) [n = 310]		
4	206 (84) [n = 311]	227 (87) [n = 286]		
5	205 (79) [n = 278]	224 (88) [n = 286]		
6	204 (78) [n = 265]	223 (91) [n = 274]		
7	206 (78) [n = 238]	228 (91) [n = 254]		

COMPLICATIONS

Table 5. Incidence of Complications During the 28 Days After Randomization

	Supine Position			Prone Position		
	Patient-Days	No. of Occurrences	Incidence per 100 Days (95% CI)	Patient-Days	No. of Occurrences	Incidence per 100 Days (95% CI)
Unplanned extubation	5188	47	0.91 (0.65-1.16)	5756	44	0.76 (0.54-0.98)
Selective intubation*	5188	0	0	5756	6	0.10 (0.02-0.19)
ETT obstruction†	5188	12	0.23 (0.10-0.36)	5756	34	0.59 (0.39-0.79)
Hemoptysis	5188	34	0.66 (0.44-0.88)	5756	45	0.78 (0.55-1.01)
Spo_2 <85%	5188	207	3.99 (3.45-4.53)	5755	236	4.10 (3.58-4.62)
Cardiac arrest	5188	88	1.70 (1.34-2.05)	5754	87	1.51 (1.19-1.83)
Heart rate <30/min	5188	72	1.39 (1.07-1.71)	5755	81	1.41 (1.10-1.71)
SAP <60 mm Hg	5188	148	2.85 (2.39-3.31)	5754	135	2.35 (1.96-2.74)
Pressure sores‡	5188	157	3.03 (2.55-3.50)	5756	208	3.61 (3.12-4.10)
Atelectasis	5188	28	0.54 (0.34-0.74)	5756	28	0.49 (0.31-0.67)
Intracranial hypertension	5188	3	0.06 (0.00-0.12)	5756	9	0.16 (0.05-0.26)
Pneumothorax	5188	28	0.54 (0.34-0.74)	5756	22	0.38 (0.22-0.54)

Abbreviations: CI, confidence interval; ETT, endotracheal tube; SAP, systolic arterial pressure; 95% Spo_2, transcutaneous oxygen saturation of arterial blood.
*P = .01.
†P = .002.
‡P < .005 between supine and prone position groups.

GUERIN, ET AL. EFFECTS OF SYSTEMATIC PRONE POSITIONING IN HYPOXEMIC ACUTE RESPIRATORY FAILURE. JAMA , 2004; 292(19): 2379- 2387. JAMA

Conclusions

- Prone positioning did not reduce mortality and was associated with some harmful effects
- It did improve oxygenation and reduce the incidence of VAP
- Same results as in Gattinoni et al. NEJM 2001

Weaknesses

- – Cross Cross-over from supine to prone group
- – Mechanical ventilation not per protocol
- – 25% of prone patients were proned for <8 hrs/d
- – No difference in pCO2

GATTINONI, ET AL. CRIT CARE MED 2003; 31 (12): 2727-2733.

- Retrospective analysis of patients in pronation arm of controlled RCT on arm prone positioning in ALI/ARDS (225 pts)
- If PaCO2 decreased by >1mmHg there was improved 28-day survival

– 35% vs 52%-survival

MANCEBO J, FERNANDEZ R, BLANCH L, ET AL: A MULTICENTER TRIAL OF PROLONGED PRONE VENTILATION IN SEVERE ACUTE RESPIRATORY DISTRESS SYNDROME. *AM J RESPIR CRIT CARE MED* 173. (11): 1233-1239.2006

- A prospective randomized study (n = 136), with guidelines established for ventilator settings and weaning, examined the efficacy of the prolonged prone position (continuous prone position for 20 hours daily) in severe **ARDS** patients with 48 hours of tracheal intubation.
- Multivariate analysis documented that randomization to the supine position was an independent risk factor for mortality (OR 2.53, *P* = .03).
- CONCLUSION: ***prone ventilation is feasible and safe, and may reduce mortality in patients with severe ARDS when it is initiated early and applied for most of the day.***

ABROUG F., OUANES-BESBES L., DACHRAOUI F., ET AL: AN UPDATED STUDY-LEVEL META-ANALYSIS OF RANDOMISED CONTROLLED TRIALS ON **PRONING** IN **ARDS** AND ACUTE LUNG INJURY. *CRIT CARE* 15. (1): R6. 2011

- In patients with ALI or **ARDS**, more recent randomized controlled trials (RCTs) showed a consistent trend of mortality reduction with prone ventilation.
- An updated meta-analysis included 2 subgroups of studies: those that included all ALI or hypoxemic patients, and those that restricted inclusion to only **ARDS** patients.
- ***In the overall meta-analysis that included 7 RCTs with 1675 adult patients (862 in prone position), prone position was not associated with a mortality reduction (OR 0.91, 95% CI 0.75–1.2, P = .39).***

ABROUG F., OUANES-BESBES L., DACHRAOUI F., ET AL: AN UPDATED STUDY-LEVEL META-ANALYSIS OF RANDOMISED CONTROLLED TRIALS ON **PRONING** IN **ARDS** AND ACUTE LUNG INJURY. *CRIT CARE* 15. (1): R6.2011

- However, in ***the 4 most recent RCTs*** that enrolled only patients with **ARDS**, and that also applied the longest prone position durations and used lung-protective ventilation, ***prone position was associated with significantly reduced mortality*** (OR 0.71, 95% CI 0.5–0.99, *P* = .048; number needed to treat = 11).
- Prone position was ***not associated with any increase in major airway complications*** in this meta-analysis.

CESANA B.M., ANTONELLI P., CHIUMELLO D., ET AL: POSITIVE END-EXPIRATORY PRESSURE, PRONE POSITIONING, AND ACTIVATED PROTEIN C: A CRITICAL REVIEW OF META-ANALYSES. *MINERVA ANESTESIOL* 76. (11): 929-936.2010

- A recent review of all published meta-analyses on the efficacy of prone position in ALI and **ARDS** concluded that ***prone ventilation was associated with reduced mortality in patients with severe hypoxemic respiratory failure***

SO, WHO SHOULD WE PRONE WHEN AND HOW?

PREDICTORS OF RESPONSE

- Secondary ARDS vs primary ARDS
- Patchy or lobar infiltrates
- Patients with increased intra-abdominal pressure
- Patients with good chest wall compliance
- Patients in whom there is an initial drop in pCO2

SUGGESTED TECHNIQUE

- Sedation/paralysis is needed
- Increase FiO2 to 1.0 app 15-20 min before repositioning
- Ensure that patient is hemodynamically stable
- Explain procedure to the patient if applicable

HOW YOU DO IT?

Vollman Proner

KCI Rotoprone Bed

USE FOUR PERSONS (AT LEAST)

- One to stabilize endotracheal tube & ventilator tubings
- One to stabilize vascular access, A line
- Two people to turn the patient from supine to lateral & finally to prone position
- Do not apply pressure to the abdomen, the chest & pelvis should be supported during the turn.

- Support the head, chest and pelvis with the pillows. This should relieve the abdomen of most of the pressure
- Check following:
- PIPs
- VT
- SaO2

- Suction the patient
- Lower down the FiO2 to pre positioning level in 15-20 min
- Switch from prone to supine & supine to prone every 8 – 12 hours
- Patients who demonstrate a significant deterioration with prone positioning can be reverted back earlier

SIGHS AND RECRUITMENT MANEUVERS

- Because Prone position increases homogeneity of lung inflation, may enhance potential for recruitment

Pelosi et al. AJRCC 2003; 167: 521Pelosi 521-527.

– Increased PaO2 with sighs in prone position

Oczenski et al.CritCare Med2005;33(1):54-61.

– Increased P/F with RM after 6hrs Prone in both responders and non-responders

PRACTICAL CONSIDERATIONS

Contraindications

- Spine instability
- Hemodynamic instability
- Arrhythmias
- Thoracic and abdominal surgeries
- Increased intracranial pressure

Complications

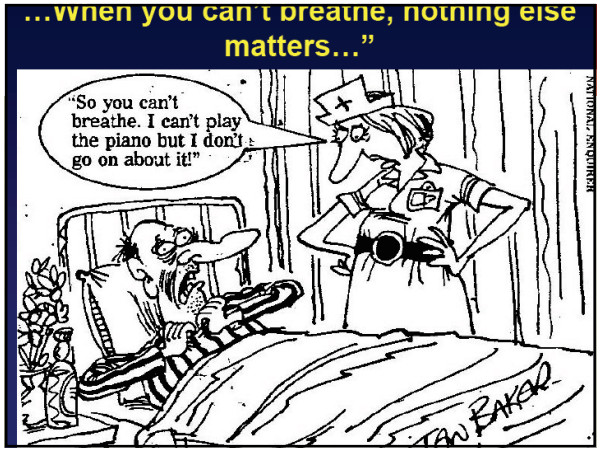
- Hemodynamic instability
- Extubation
- Selective intubation
- ETT obstruction
- Dislodging CVCs
- Facial edema
- Pressure sores
- Fall in SpO2

SUMMARY

- Theoretical benefits of prone position include improved V/Q mismatch, improved FRC, decreased VLI, and improved secretion clearance

(All would meet goals of "open open-lung" ventilation)

- Prone position has been shown to improve oxygenation in ALI/ARDS, and other diseases
- Several studies have begun to show benefit on ventilator free days and trending mortality with Prone positioning=If started early!



QUESTIONS LATER…..

- Now your 2011 NCSRC Physician of the Year

Dr. Toan Wayne

- Routine prone positioning of all patients with ALI or ARDS is not recommended because there is substantial inconvenience associated with its use and there is insufficient data demonstrating improvement of patient-important outcomes.
- Consider prone positioning if goals of lung-protective ventilation are not being met, or if there is persistent respiratory acidosis or tissue hypoxia despite standard ventilation in the supine position.

- Prone positioning appears to improve the oxygenation of most patients with ALI or ARDS; however, a mortality benefit has not been established.
- Post-hoc analyses of multiple studies suggest that the greatest benefit of prone positioning occurs in the sickest patients if used early after the diagnosis of ALI or ARDS.