Headquarters U.S. Air Force

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Mechanical Ventilation Methods in Transport of Critically Injured Patients

Director, ECRC
59MDW/ST
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Disclosures

- The opinions expressed on this document are solely those of the author(s) and do not represent an endorsement by or the views of the United States Air Force, the Department of Defense, or the United States Government
- This study was conducted under a protocol reviewed and approved by the Wilford Hall Ambulatory Surgical Center IRB and in accordance with the approved protocol
- The authors acknowledge Department of Defense Trauma Registry (DoDTR) for providing data for this study

BACKGROUND

Tidal Volumes for Ventilation of Patients with ARDS - ARDSNet ARMA Trial

Male Patients

Height				cc's per Kg						
ft in	in	cm	Pre Wt (Kg)	4	5	6	7	8	9	10
5'6"	66	168	64	255	320	385	445	510	575	640
5'8"	68	173	68	275	340	410	480	545	615	685
5'10"	70	178	73	290	365	440	510	585	655	730
6'	72	183	78	310	390	465	545	620	700	775
6'2"	74	188	82	330	410	495	575	660	740	820
6'4"	76	193	87	345	435	520	610	695	780	870
6'6"	78	198	91	365	455	550	640	730	825	915

Female Patients

Height				cc's per Kg						
ft in	in	cm	Pre Wt (Kg)	4	5	6	7	8	9	10
5'	60	152	46	180	230	275	320	365	410	455
5'2"	62	157	50	200	250	300	350	400	450	500
5'4"	64	163	55	220	275	330	385	440	490	545
5'6"	66	168	59	235	295	355	415	475	535	595
5'8"	68	173	64	255	320	385	445	510	575	640
5'10"	70	178	69	275	345	410	480	550	615	685
6'	72	183	73	290	365	440	510	585	660	730

PEEP Titration Table - ARDSNet ARMA Trial

PEEP	5	5	8	8	10	10	10	12	14	14	14	16	18	18	20	22	24
FiO2	0.3	0.4	0.4	0.5	0.5	0.6	0.7	0.7	0.7	0.8	0.9	0.9	0.9	1	1	1	1

<------Move across table to keep SaO_2 92 – 96 %------->

Patients falling in shaded area are not necessarily too sick for flight but risks and benefits should be considered as described in the CPG.

[1]Increasing PEEP will decrease cardiac output and may cause significant hypotension in hypovolemic patients. Additional volume loading may be necessary to maintain hemodynamics.

[2]This is a fairly accurate indicator of plateau pressure in our patient population. Plateau pressure is the correct parameter to follow but it cannot be easily measured with the Impact 754 ventilator.

[3]Measuring the patient's "wingspan" should be used as an estimate of height. Sternum to fingertip multiplied x 2.

[4]A pH of 7.2 may be an appropriate target if hemodynamics are relatively normal.

CCATT Mechanical Ventilation Clinical Practice Guideline

Primary Author: Lt Col Phillip Mason	phillip.mason@amedd.army.mil	Initial Publication Date: Mar 2012
Peer Reviewers: Lt Col David Norton, Lt Col Mike Petro, Mr. Richard Branson, Lt Col Patrick Allan, Col Warren Dorlac, Maj Julio Lairet, Col Scott Vandehoef, Lt Col Dax Holder		

Volume Control Ventilation

1. Set the I:E ratio at 1:2 to 1:4. Turning the inspiratory time knob on the Impact 754 all the way left will give 1:2 without having to adjust the inspiratory time.
2. Set PEEP and FiO_2 according to ARDSNet ARMA Trial PEEP table to achieve SaO_2 92 - 96%[1]. Note that the Impact 754 and LTV 1000 are limited to PEEP 20.
3. Set tidal volume at 6 cc/Kg and note peak inspiratory pressure (PIP)[2]. If necessary, decrease tidal volume by 1 cc/Kg as needed to keep peak inspiratory pressure ≤ 35 cm H_2O (preferably ≤ 30). Do not go below 4 cc/Kg. Use table below as reference for appropriate tidal volume[3].
4. Adjust respiratory rate to achieve pH ≥ 7.3[4]. The actual PCO_2 is not important, only the pH.

Pressure Control Ventilation

1. Set I time to achieve I:E ratio of 1:2 to 1:4.
2. Set PEEP and FiO_2 according to ARDSNet ARMA Trial PEEP table to achieve SaO_2 92 - 96%[1]. Note that the Impact 754 and LTV 1000 are limited to PEEP 20.
3. Set inspiratory pressure to achieve a tidal volume of 6 cc/kg. If this value is > 30 cm H_2O then decrease until it is ≤ 30 cm H_2O or until tidal volume is 4 cc/kg. Use table below as reference for appropriate tidal volume[3].
4. Adjust respiratory rate to achieve pH ≥ 7.3[4]. The actual PCO_2 is not important, only the pH.

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Study Aims

- Describe ventilator settings of patients transported by CCATT
- Evaluate the influence of ventilator settings on patient outcomes (through 30 days)
- Provide data to improve utilization of existing CPG and identify potential gaps

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Study Design

- Retrospective review
  - CCATT medical records
  - Patients requiring mechanical ventilation
  - Transported 2007-2012
  - Trained data abstractors
    - Consensus review
    - Serial meetings

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Data Collected

- **CCATT Records**
  - Demographics, injury description
  - Pre-flight vitals, labs, and oxygenation status
  - In-flight vitals, labs, interventions, and complications
  - Post-flight vitals and labs
- **Department of Defense Trauma Registry (DoDTR)**
  - ISS
  - Clinical events
  - Outcomes up to 30 days
  - Mortality

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Definitions of Complications

Hyperthermia	Body temperature ≥ 100.5 F or 38 C
Respiratory	SpO2 ≤90% Increase FiO2 >10% or increase oxygen L/min >4% Respiratory rate >22 or <10 bpm pCO2 <35 or >45 or change of 10% from baseline
Hemodynamic	SBP ≤90 or ≥180 or 20% change from baseline MAP ≤65 or ≥120 or 20% change from baseline CVP change from baseline of 5
Heart Rate	<60 bpm or >120 bpm or 20% change from baseline
↓urine output	As determined by CCATT clinical provider
Bleeding	As determined by CCATT provider
Neurologic	As determined by CCATT provider to include: change in mental status, motor, cognitive, or sensory ability; seizure

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Statistical Methods

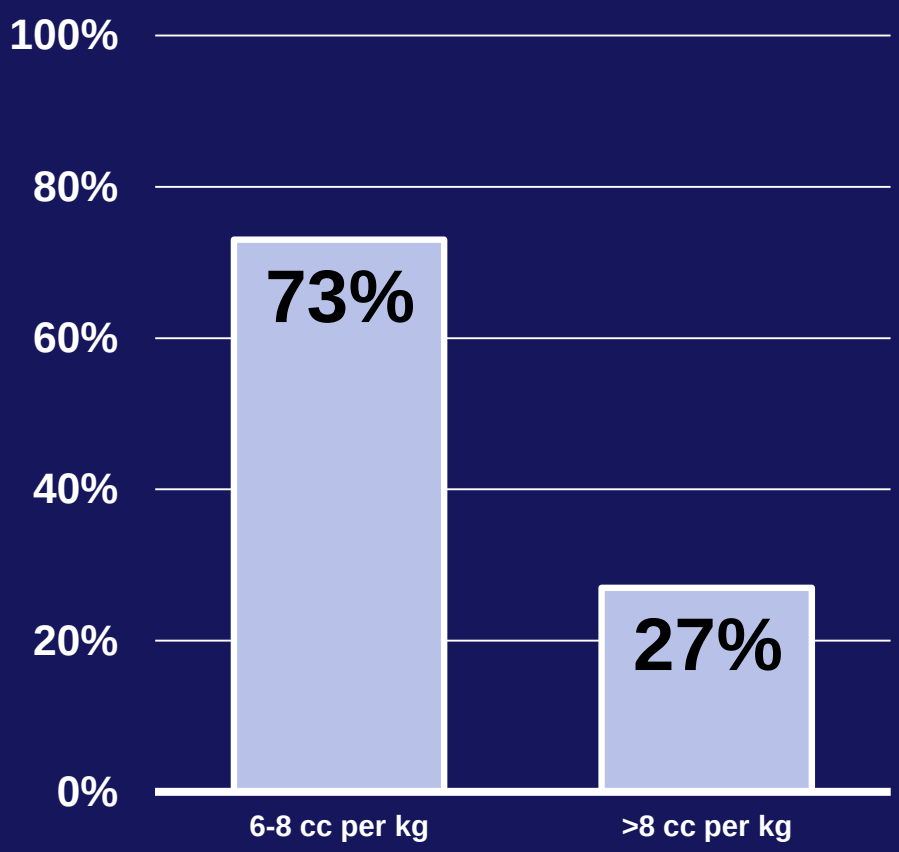
- **Frequencies and proportions**
  - **Chi-square or Fisher's exact for categorical variables (%)**
  - **T-test for continuous variables**
    - **Median [Interquartile Range]**
  - **Significance set at p<0.05**

RESULTS

Study Population

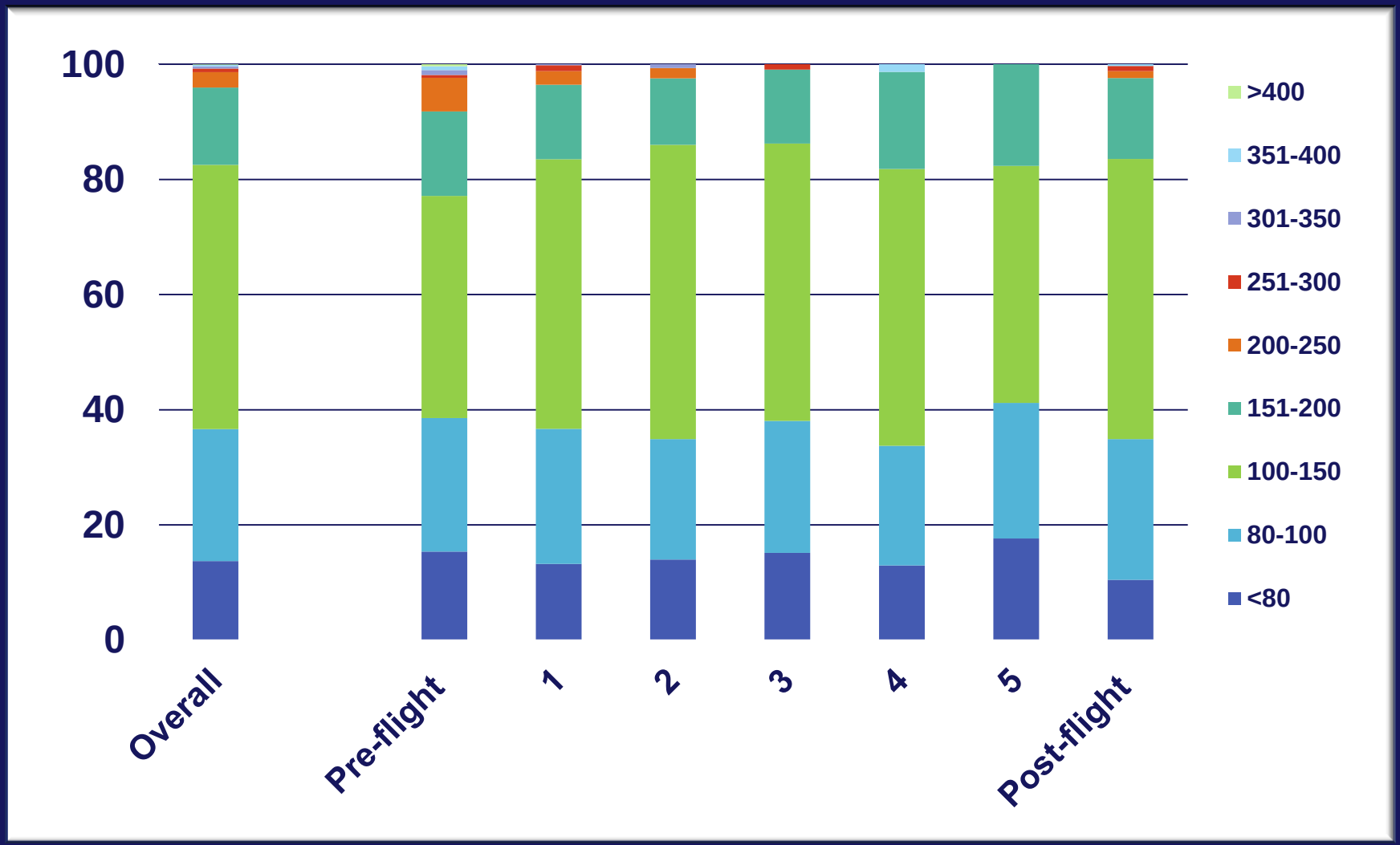
CCATT Records	• 2007-2012 • Role 3 to LRMC
Oxygen Support	• Ventilated 60%
Ventilation Mode	• Pressure Control 2% • Volume Control 98% - 652 patients

Pre-Flight Tidal Volume

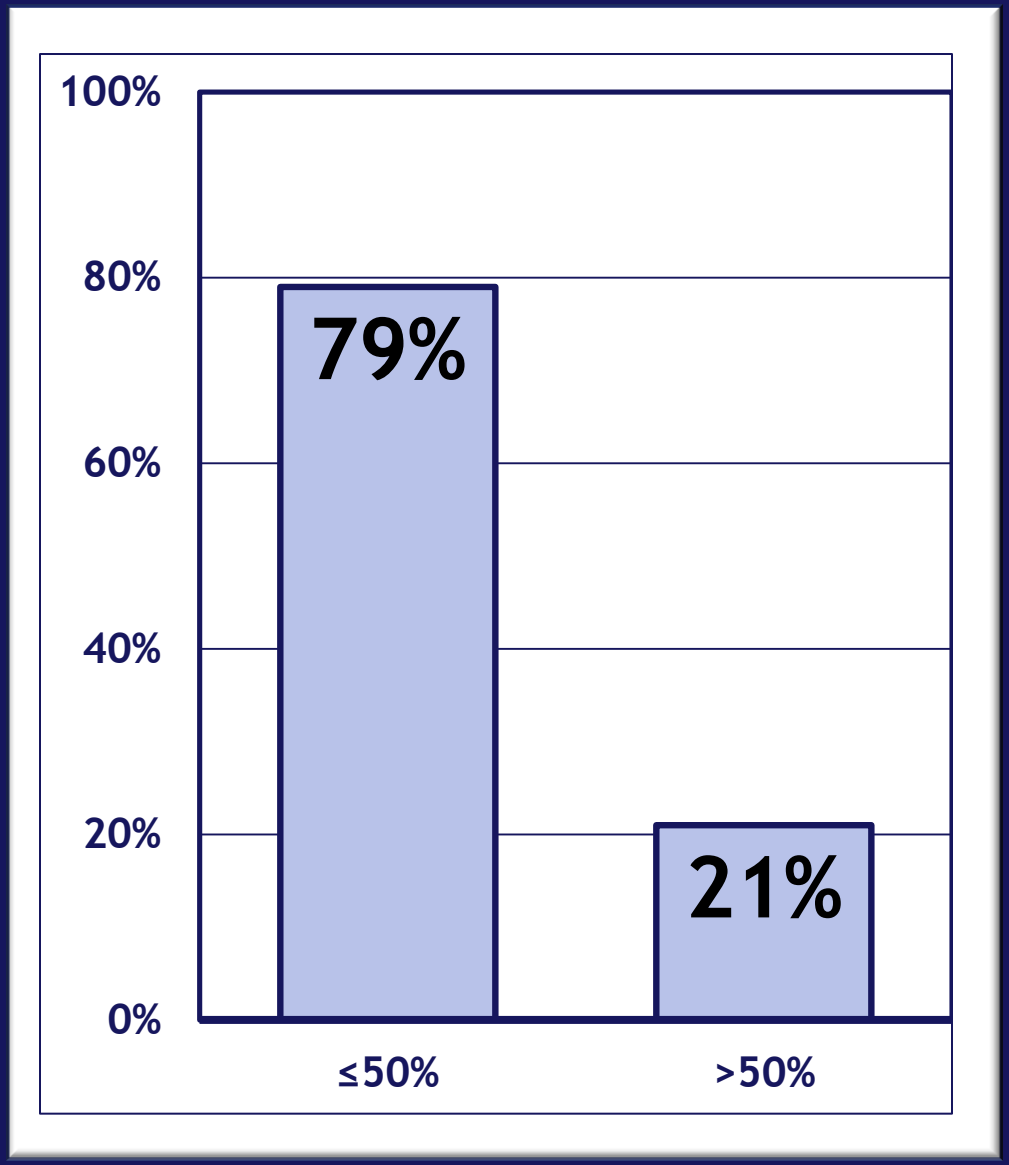


- Greater than 8 cc per kg
  - No differences in demographics
  - Higher ISS
  - No differences in pre-flight, in-flight, or post-flight oxygenation
  - No differences in pre-flight, in-flight or post-flight outcomes

Proportion of Oxygen Saturation Values

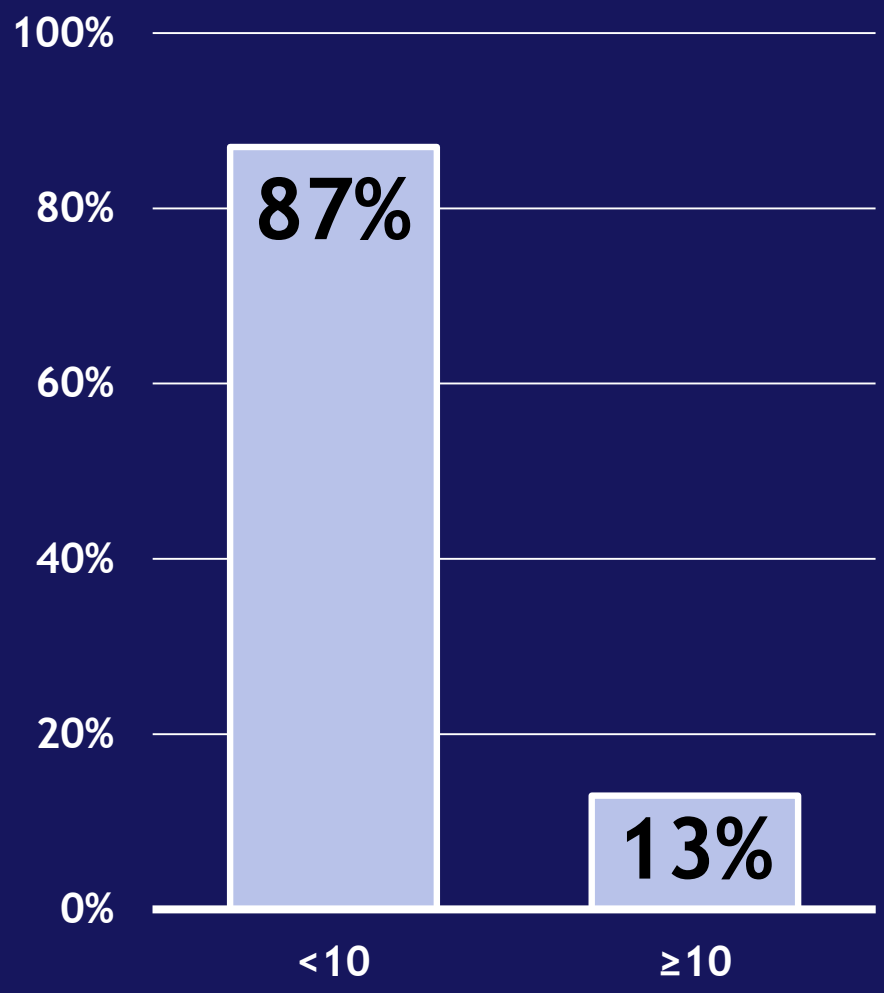


Oxygen Requirement



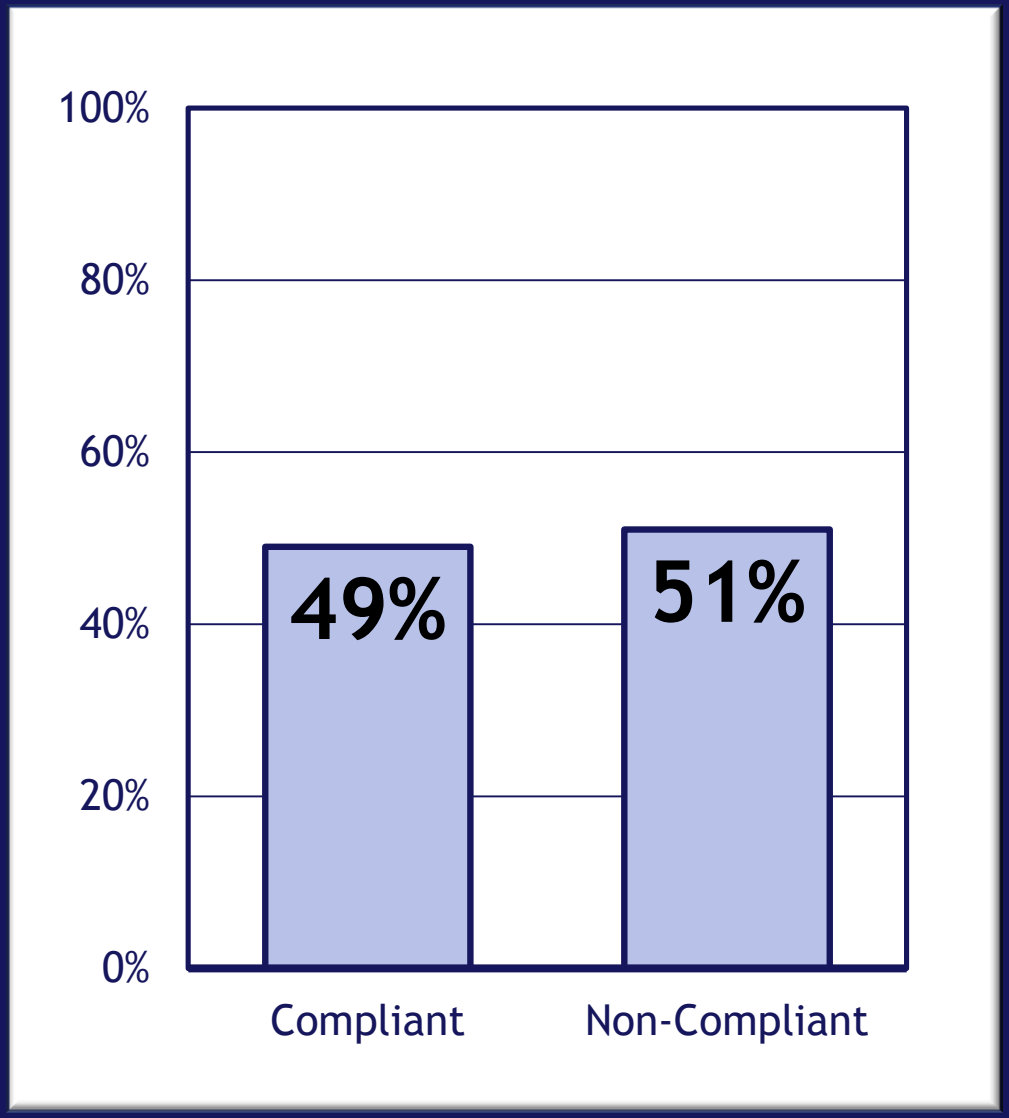
- Greater than 50%
  - No differences in demographics
  - Higher ISS
  - More likely to receive a paralytic and have a chest tube
  - Lower pre-flight PaO_2, but within reference range
  - More likely to have an in-flight respiratory event
    33% vs 63%, $p<0.0001$
  - No differences in post-flight clinical events
  - More ventilator, ICU, hospital days

Peak End Expiratory Pressure



- Greater than or equal to 10
  - No differences in demographics
  - Higher ISS
  - More likely to receive a paralytic and have a chest tube
  - Lower pre-flight PaO_2, but within reference range
  - More likely to have a pre-flight respiratory event
    7% vs 15%, $p<0.02$
  - No differences in in-flight or post-flight clinical events
  - More ventilator days

ARDSNet Table



- Non-Compliant
  - Older (median 24 v. 25)
  - Higher ISS (median 22 v. 27)
  - No other differences in demographics
  - More likely to have chest tube 19% vs 26%, p=0.04
  - Higher rate of in-flight respiratory event 29% vs 50%, p<0.0001

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Outcomes

	Compliant median[IQR] n=322	Non-Compliant median[IQR] n=329	p-value
Post-Flight Respiratory Event	28%	34%	0.07
ARDS/ARF/VAP	2%	9%	**<0.0001**
Post-Flight Coagulopathy	18%	18%	0.90
DVT/PE	9%	11%	0.63
Post-Flight Cardiac Event	16%	16%	0.99
Post-Flight Hemodynamic Event	24%	25%	0.76
Post-Flight Renal/Urinary Event	13%	9%	0.05
Ventilator Days	4 [3-6]	5 [3-8]	**0.004**
ICU Days	6 [4-9]	7 [4-13]	**0.009**
Hospital Days	12 [5-37]	14 [5-38]	0.82
Mortality	3%	5%	**0.03**

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Proportional Hazards

	Ventilator Days	ICU Days	Hospital Days
Risk Ratio	1.21 (1.02-1.45)	1.21 (1.03-1.47)	1.03 (0.86-1.23)
p-Value	0.03	0.02	0.75

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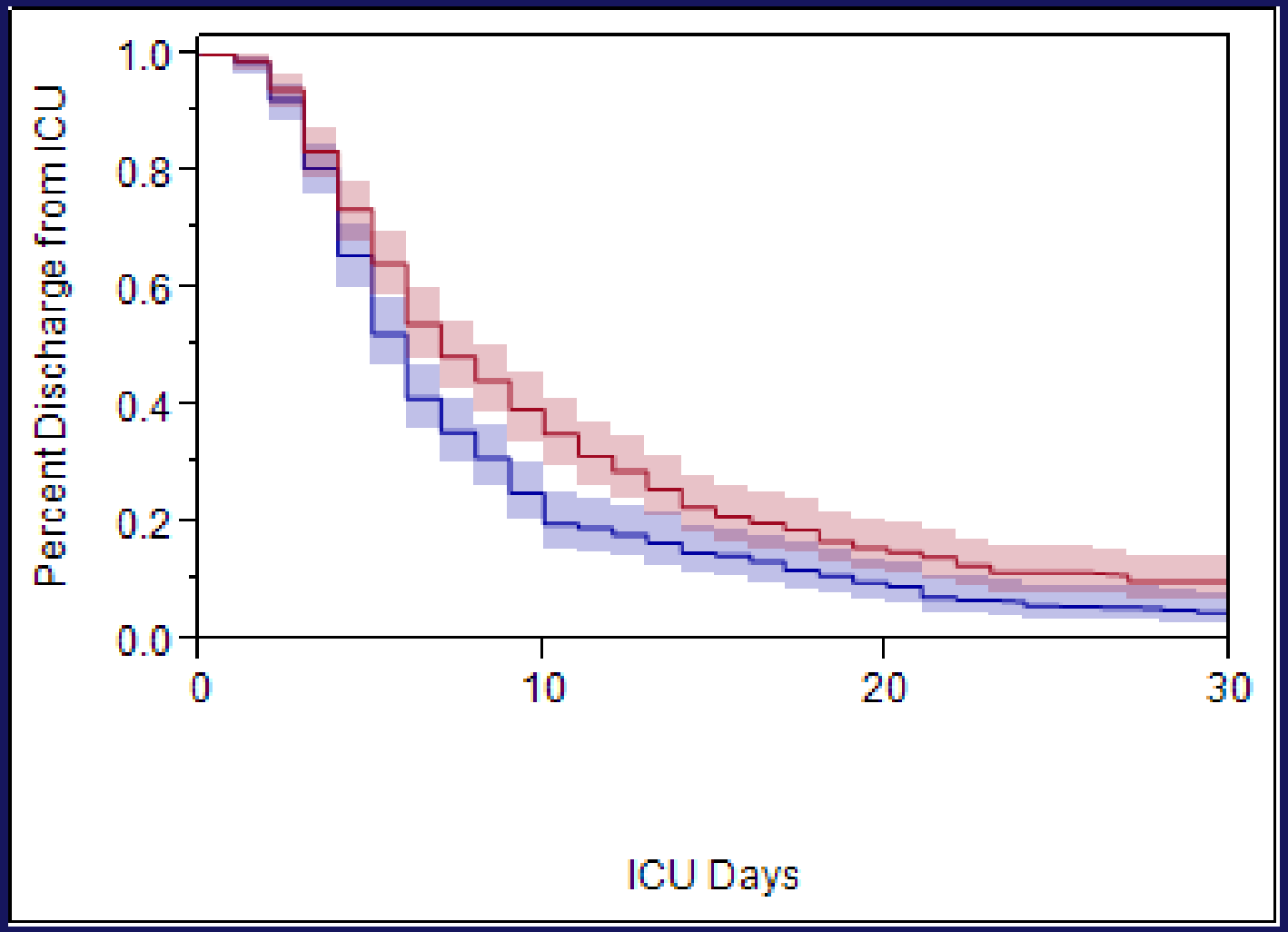
ARDSNet Table Compliance



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Mortality Logistics Regression Analysis

	Odds Ratio	p-Value
ARDSNet Table Non-Compliant	2.17 (1.01-4.95)	0.046

Limitations

- Data collected retrospectively
- Subjectivity despite trained abstractors
- Data missing or unavailable

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Conclusions

- Over half of CCATT patients are mechanically ventilated
- Compliance with ARDSNet guideline is low
- Non-compliance is associated with increased
  - Ventilator days, ICU days, Mortality
- Dissemination of findings = Lives Saved!

Future

- Impact of ERC CPG/training
- Impact of closed loop ventilatory devices
- Impact of ERC hypoxia and hyperoxia on neurologic outcomes

En route Care Research Center

- Thank you
  - Dr. Vikhyat Bebarta
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Questions?


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