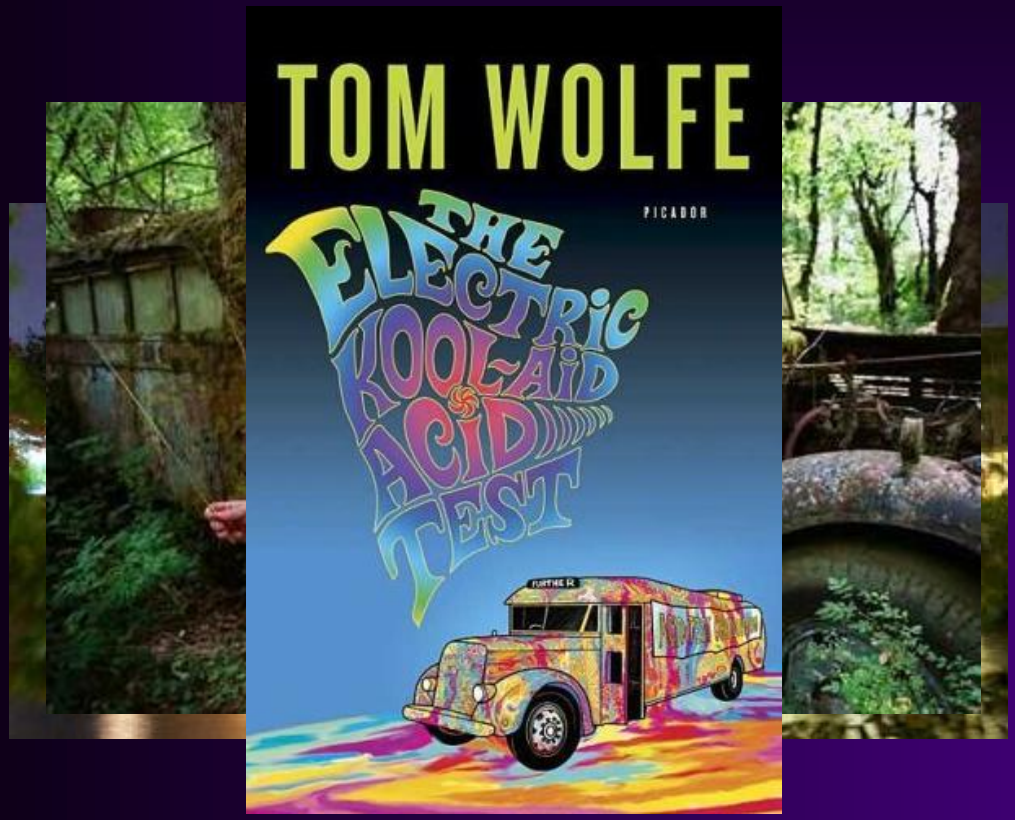
Recent Advances in Ventilator Liberation: Protocolized Care in Closed- Loop Systems



Oregon Society for Respiratory Care

Eugene, Oregon

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Presented by:
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Dräger medical

So what is the big deal about “ventilator liberation?”

ICU Average Daily Cost:	$3,184 per day
Mean Incremental Ventilator Cost:	$1,522 per day
Total Cost:	$4,706 per day

What if we could reduce ICU length of stay by 5 days?

$15,920 saved per patient!

What if we could reduce duration of mechanical ventilation by 3 days?

$14,566 saved per patient!

Dasta, McLaughlin, et al. Daily cost of an ICU day: The contribution of mechanical ventilation. Critical Care Medicine 2005 Vol 3, No. 6

Liberation from MV: EBM of technique

Gradual Reduction in
Rate/ Pressure Support → SBT

vs.

Assist- Control → SBT on T-piece

Results:

Multiple studies show superiority of technique that is most commonly used at the study site.

Surprise, surprise!

Liberation from mechanically assisted ventilation:

> 40% of the duration of mechanical ventilation in the ICU is used for weaning.

The use of ventilator liberation protocols can reduce duration of assisted ventilation and costs in the ICU.

This “protocolized care” can be automated within the ventilator.

Known in the literature as “Computer- driven weaning” aka CDW.

Challenges to Implementation of Ventilator- Liberation Protocols

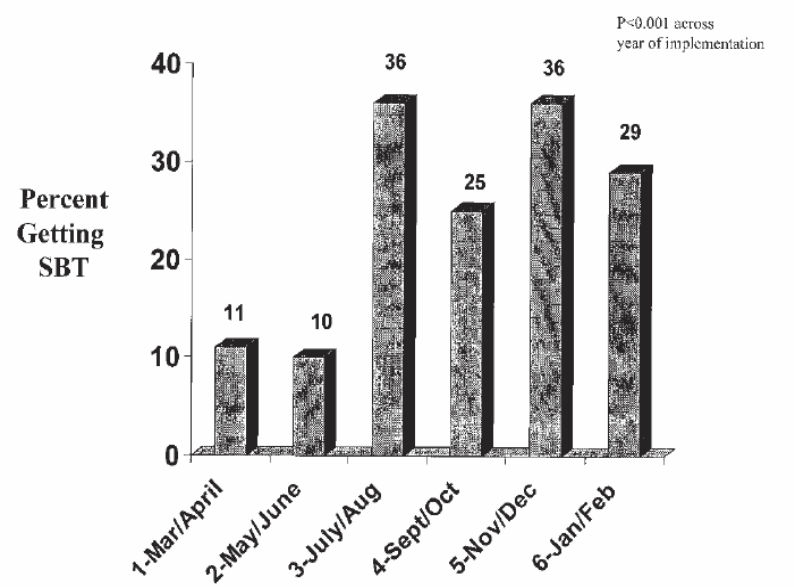


Figure 2. Histogram showing the percent of patients who received a spontaneous breathing trial after having passed the daily screen. Periods 1 to 6 on the *x*-axis represent the six 2-mo intervals of implementation, which demonstrated a statistically significant improvement in spontaneous breathing trial compliance rates across the year ($p < 0.001$).

"During a 12-mo period, we reintroduced a previously validated protocol …

Important barriers to protocol compliance… included:

Physician unfamiliarity with the protocol,

RCP inconsistency in seeking an order for an SBT from the physician…

and lack of stationary unit assignments by RCPs…"

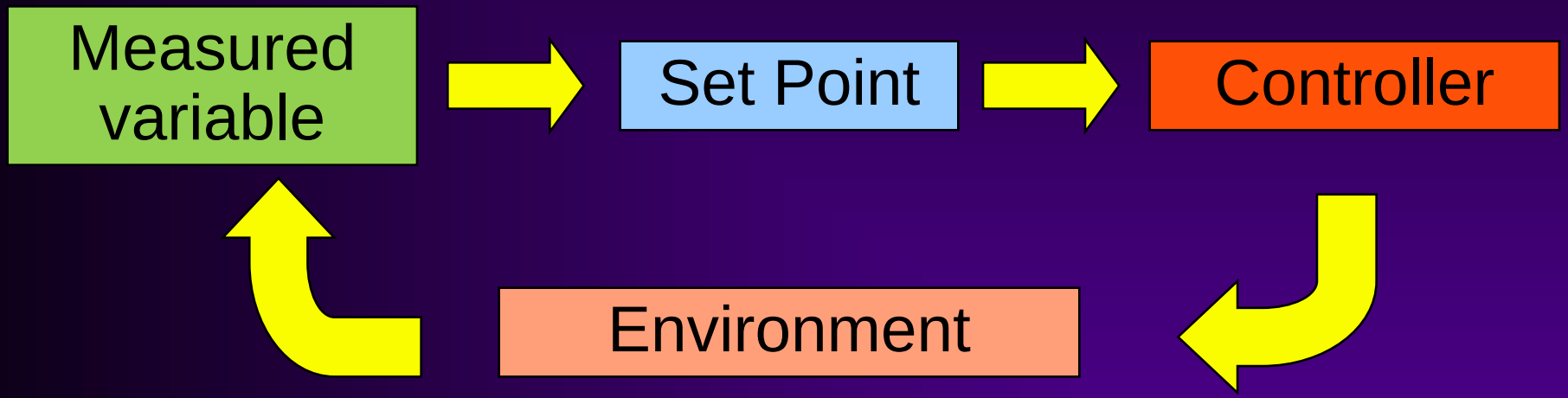
Ely, et al. Large Scale Implementation of a Respiratory Therapist– driven Protocol for Ventilator Weaning. Am J Respir Crit Care Med Vol 159. pp 439–446, 1999

Open- loop Control principle

eg: simple pressure ventilator

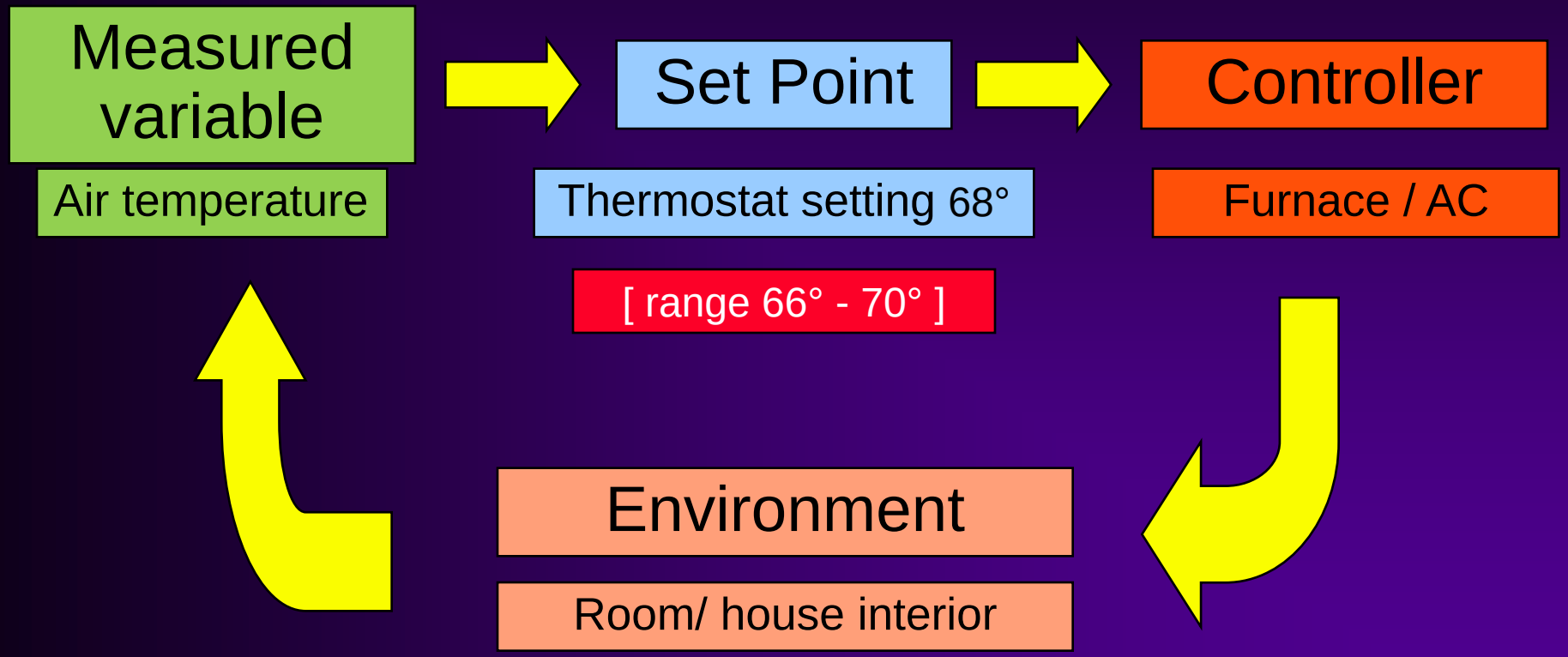
Adapted from: Chatburn. Computer Control of Mechanical Ventilation. Resp Care (2004) 49;5.507-517

Closed- loop Control principle (aka Feedback Control)



Adapted from: Chatburn. Computer Control of Mechanical Ventilation. Resp Care (2004) 49;5.507-517

Closed- loop Control principle
eg: Home Thermostat



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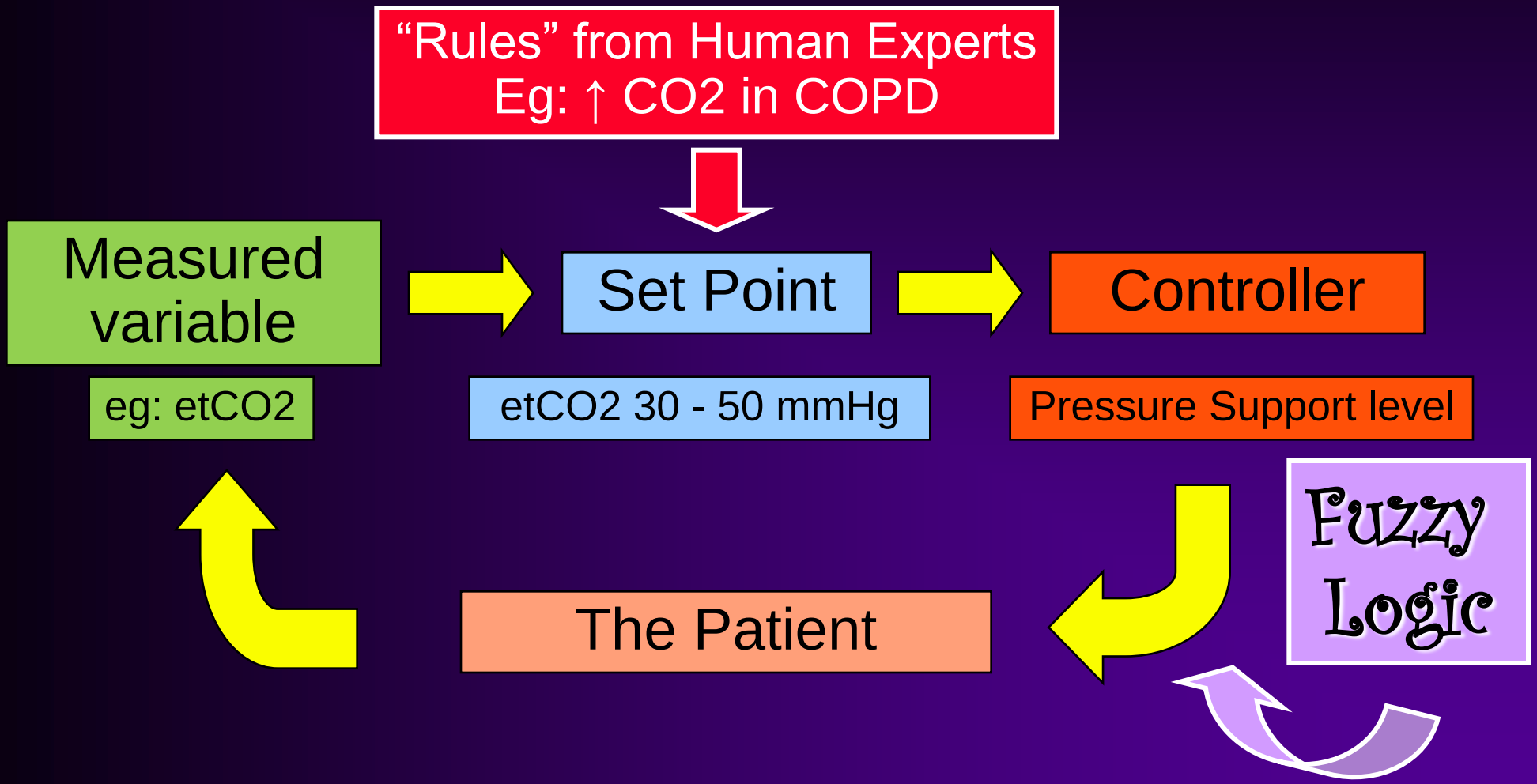
Knowledge- based Closed- loop Control



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Components of Knowledge- based Closed- loop Control

1. Measured Variable — eg: tidal volume
2. Set Point — eg: V_T 5 mL/ kg
3. Human "expert rules" — Lower VT acceptable
4. "Fuzzy Logic" — Integrates multiple set points & rate of change (?AI)
5. Controller — the ventilator's gas delivery
6. Environment — The patient's lung

Computerized- driven weaning: Development Pioneers

Michel Dojat, PhD

Laurent Brochard, MD

Service de Réanimation Médicale, Hôpital Henri Mondor
Paris, France

ASSISTANCE PUBLIQUE HÔPITAUX DE PARIS

Computer- driven weaning: Development History

- 1992: termed *NeoGanesh* by Michel Dojat, PhD
- 1999: started clinical testing with ventilator driven by PC
- 2001-02: “Phase One” clinical trials
- October 2004: Multicenter study results presented at ESICM, Berlin
- July 2005: USA FDA marketing approval as SmartCare™
- September, 2006: Multicenter trial published *Amer J Resp Crit Care Med*

The “Zone of Respiratory Comfort”

The 3 monitored parameters:

- spontaneous breath rate, f_{spn}
- spontaneous tidal volume, V_T
- $etCO_2$

The limits of these values define a “Zone of Respiratory Comfort.”

Goals:

1) Regulate Pressure Support to stabilize the patient within their Zone.

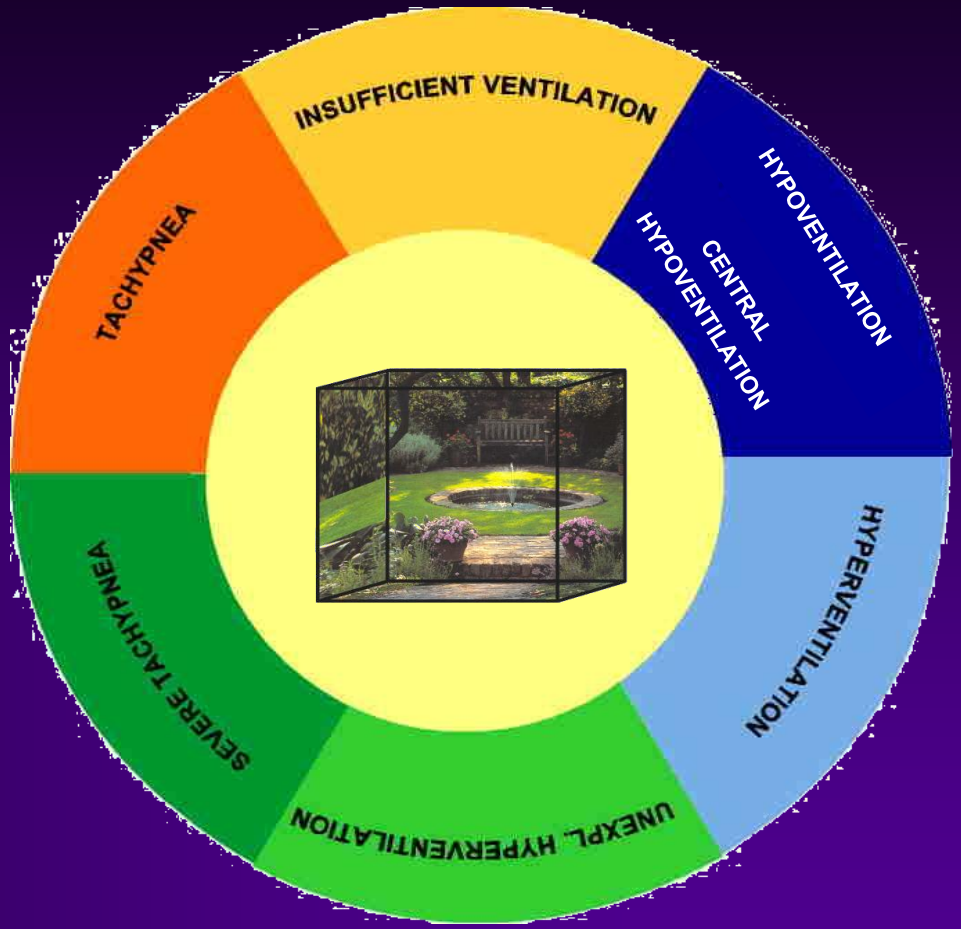
2) Reduce PS stepwise to no support, keeping the patient within their Zone

3) Conduct a Spontaneous Breathing Trial with no support; if patient remains within Zone, recommend separation from ventilator.

CDW Classification of Patient Ventilation

Every patient's Zone of comfort will be dependent on:

- body size
- type of airway
- diagnosis, e.g. COPD?
- time of day: awake or asleep?
- other daily activities and care

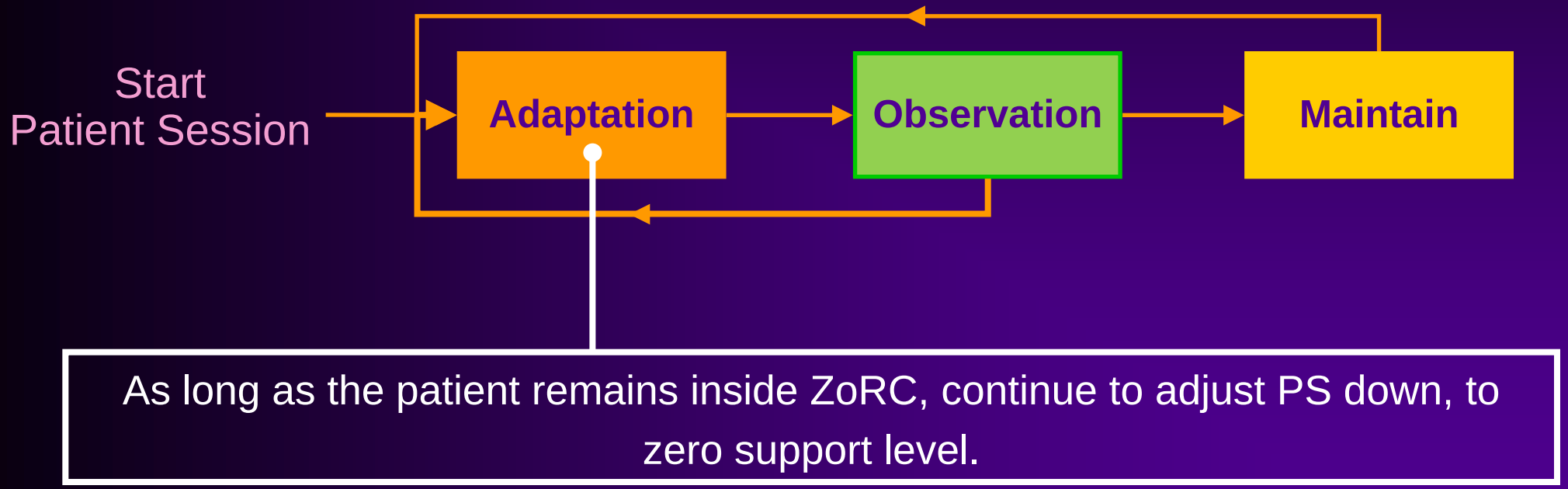


CDW Classification of Patient Ventilation

- ✓ Data acquisition from ventilator every 10 sec
- ✓ Decision making every 2 minutes (5 min if PS level adjusted)
- ✓ Time between weaning steps depends on current PS level
- ✓ Step change of PS depends on classification and current PS level
- ✓ Timed Night Rest programmable
- ✓ Tolerance of temporary instabilities by actual patient history
- ✓ Special treatment after suction

CDW phases of weaning

Adaptation: Guiding the patient inside a “zone of respiratory comfort” to a minimum level of pressure support. PEEP must be ≤ 20 cmH2O.



CDW Classification of Patient Ventilation

The 3 Monitored parameters:

- f_{spont}
- V_T
- $etCO_2$

The 8 classifications:

- Normal ventilation
- Insufficient Ventilation
- Hypoventilation
- Central Hypoventilation
- Tachypnea
- Severe Tachypnea
- Unexplained Hyperventilation
- Hyperventilation

CDW Classification of Patient Ventilation

Normal Ventilation: everything inside the respiratory zone of comfort

Acceptable frequency,

$etCO_2$

and V_T

Action: Decrease PS by 2 or 4 cmH2O
depending on the current level of PS.

CDW Classification of Patient Ventilation

Insufficient Ventilation: outside the respiratory zone of comfort

Acceptable frequency

but $etCO_2$ is too high

or V_T is too low

Action: Increase PS by 2 or 4 cmH2O
depending on the current level of PS.

CDW Classification of Patient Ventilation

Hypoventilation: outside the respiratory zone of comfort

Acceptable V_T

but low frequency

and high $etCO_2$

Action: Increase PS by 4 cmH2O.

CDW Classification of Patient Ventilation

Central Hypoventilation: outside the respiratory zone of comfort

Low V_T

and low Frequency

and high $etCO_2$

Action: No change in PS.

Alarm !!! – “Central Hypoventilation”

CDW Classification of Patient Ventilation

Tachypnea: outside the respiratory zone of comfort

Acceptable etCO2 *and* VT

but high frequency

Action: Increase PS by 2 or 4 cmH2O depending on the current level of PS.

Alarm !!! – “Persistent Tachypnea” with 3 successive classifications of “Tachypnea.”

CDW Classification of Patient Ventilation

Severe Tachypnea: outside the respiratory zone of comfort

Acceptable $etCO_2$ *and* V_T

but very high frequency

Action: Increase PS by 4 cmH2O.

Alarm !!! – “Persistent Tachypnea” with 3 successive classifications of “Severe Tachypnea.”

CDW Classification of Patient Ventilation

Hyperventilation: outside the respiratory zone of comfort

Acceptable $etCO_2$ and V_T

but frequency is low

The patient is receiving too much support

THIS IS DIFFERENT THAN “HYPOCARBIA”

Action: Decrease PS by 4 cmH2O.

CDW Classification of Patient Ventilation

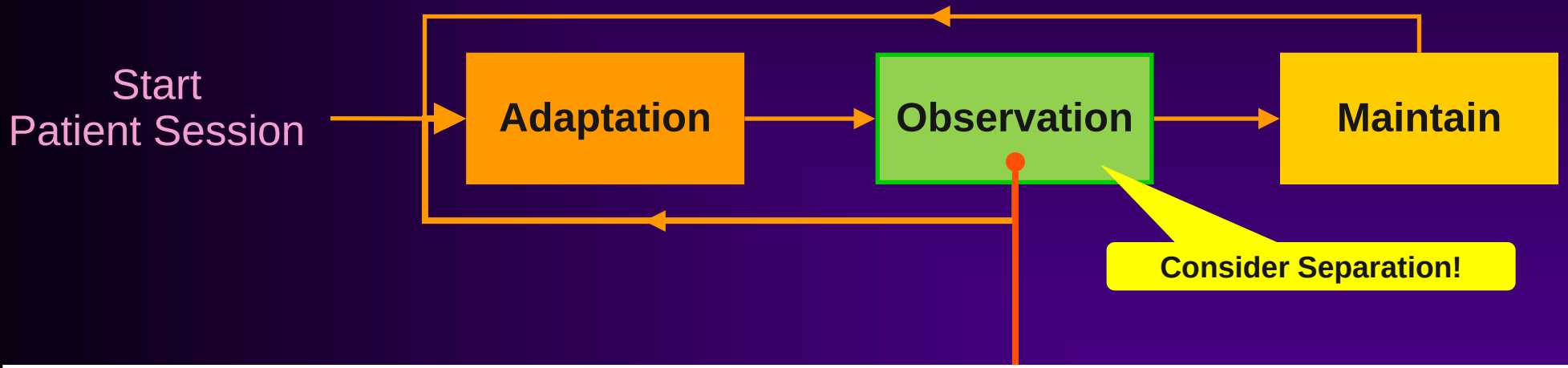
Unexplained Hyperventilation:
outside the respiratory zone of comfort

Acceptable V_T
but high frequency
and low $etCO_2$

Action: No change in PS.
Alarm !!! – “Unexplained Hyperventilation”

CDW phases of weaning

Observation: Supervised spontaneous breathing trial at minimum level of pressure support. PEEP must be ≤ 5cmH2O.

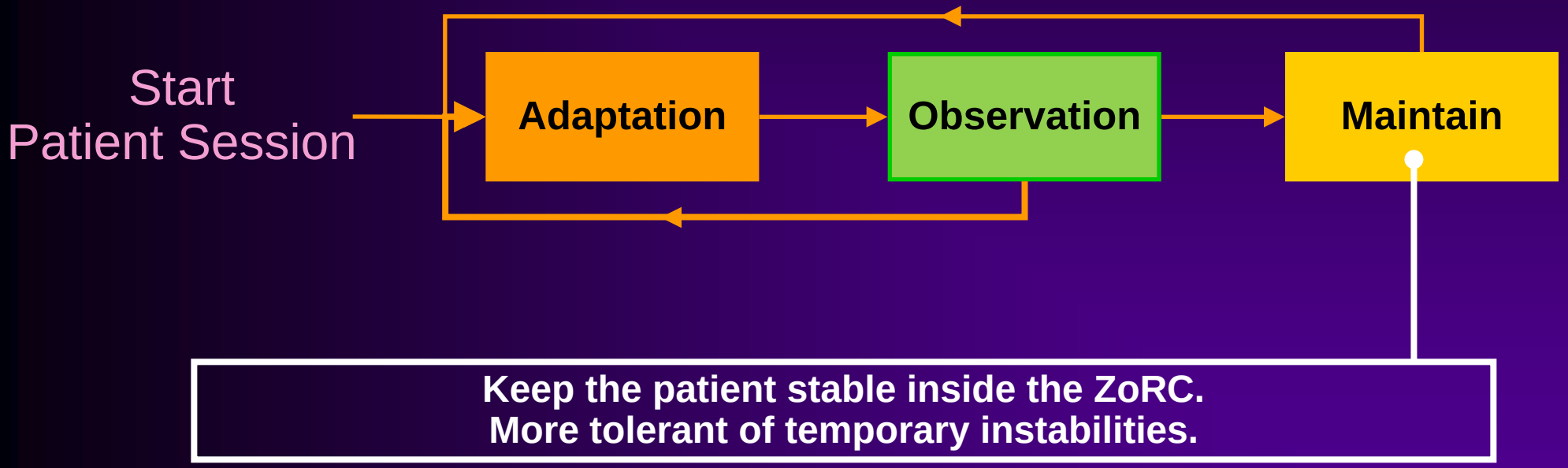


SBT with no support for minimum 1or 2 hours.

IF successful, SC recommends separation.

CDW phases of weaning

Maintain: Keep the patient under automatic control after he/she has been declared “ready for separation from mechanical ventilation.”



Computer- driven Weaning (CDW) : Clinical Evidence

Lellouche F, Mancebo J, Jolliet P, *et al.* A multicenter randomized trial of computer- driven protocolized weaning from mechanical ventilation. *Amer J Respir Crit Care* 2006; 174: 894- 900.

144 patients, MV > 24 hrs (~ 20% COPD) in 5 European centers, randomized to either:

- the written manual weaning protocol already in use (control group)
- the computer- driven weaning (CDW) protocol of Dojat / Brouchard

Endpoints included:

- time from inclusion to first/ successful extubation
- total duration of mechanical ventilation
- length of ICU stay
- length of hospital stay

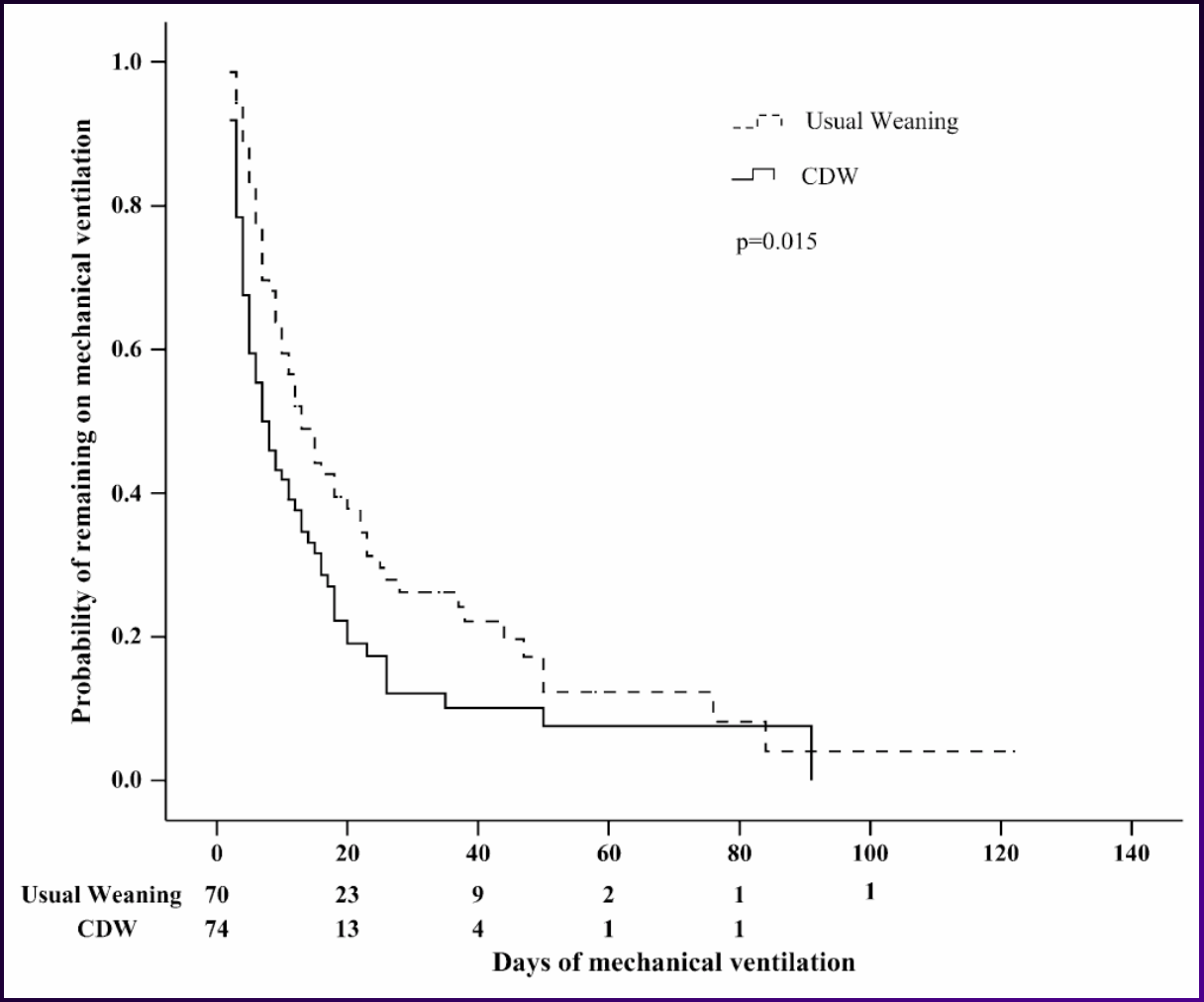
Computer- driven Weaning (CDW) : Clinical Evidence

TABLE 2. COMPARISON OF THE OUTCOMES IN THE TWO GROUPS

OUTCOME median no. of days (interquartile range)	CDW group (N = 74)	Usual weaning group (N = 70)	P Value
Time to first extubation†	2.00 (1.75-6.25)	4.00 (2.00-8.25)	0.02
Duration of mechanical ventilation until first extubation†	6.50 (3.00-12.25)	9.00 (5.75-16.00)	0.03
Time to successful extubation *	3.00 (2.00-8.00)	5.00 (2.00-12.00)	0.01
Total duration of mechanical ventilation *	7.50 (4.00-16.00)	12.00 (7.00-26.00)	0.003
Intensive care length of stay	12.00 (6.00-22.00)	15.50 (9.00-33.00)	0.02
Hospital length of stay	30.00 (17.00-54.75)	35.00 (21.00-60.25)	0.22

Lellouche F, Mancebo J, Jolliet P, *et al.* A multicenter randomized trial of computer- driven protocolized weaning from mechanical ventilation. *Amer J Respir Crit Care* 2006; 174: 894- 900.

Computer- driven Weaning (CDW) : Clinical Evidence



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Computer- driven Weaning (CDW) : Clinical Evidence

Kataoka G, Murai N, Kodera K, *et al*. Clinical experience with Smart Care after off- pump coronary artery bypass for early extubation. J Artif Organs (2007) 10:218-222.s

45 patients at one Japanese center, non- randomly “divided” to either:

- weaning by AC > SIMV or CPAP, no protocol (control group), *n* = 10
- the computer- driven weaning option, *n* = 35

Endpoint:

- intubation time

Result:

Table 5. Postoperative complications and blood gas analysis

	SC group ($n = 10$)	Control group ($n = 35$)	*P* values
Intubation time (min)	172.6 ± 51.0	342.0 ± 239.0	0.032

Computer- driven Weaning (CDW) : Clinical Evidence

Rose L, Presneill J, Johnston L, Cade J. A randomised, controlled trial of conventional versus automated weaning from mechanical ventilation using SmartCareTM/PS. Intensive Care Med (2008) 34:1788–1795.

102 patients, in one Australian ICU > 24 hrs MV, no COPD, randomized to either:

- decreasing PS weaning without a protocol (control group) with care by a nurse: patient ratio of 1:1
- the computer- driven weaning option

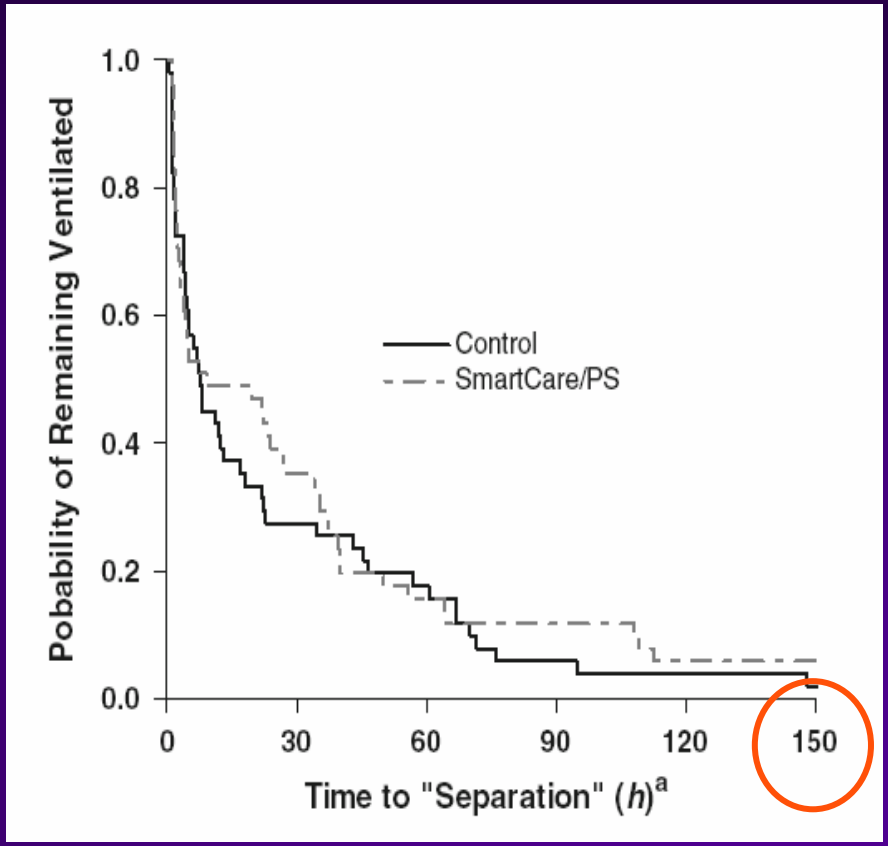
Endpoints included:

- time to “separation from MV
- total duration of mechanical ventilation
- length of ICU stay

Computer- driven Weaning (CDW) : Clinical Evidence

Rose L, Presneill J, Johnston L, Cade J. A randomised, controlled trial of conventional versus automated weaning from mechanical ventilation using SmartCareTM/PS. Intensive Care Med (2008) 34:1788–1795.

"Conclusions: Substantial reductions in weaning duration previously demonstrated were not confirmed when the SmartCare/PS system was compared to weaning managed by experienced critical care specialty nurses, using a **1:1 nurse-to-patient ratio.** The effect of SmartCare/PS may be influenced by the local clinical organisational context."



Computer- driven Weaning (CDW) : Clinical Evidence

2006: Randomized multi- center trial (*n* = 145)
CDW vs. 5 different paper- based protocols

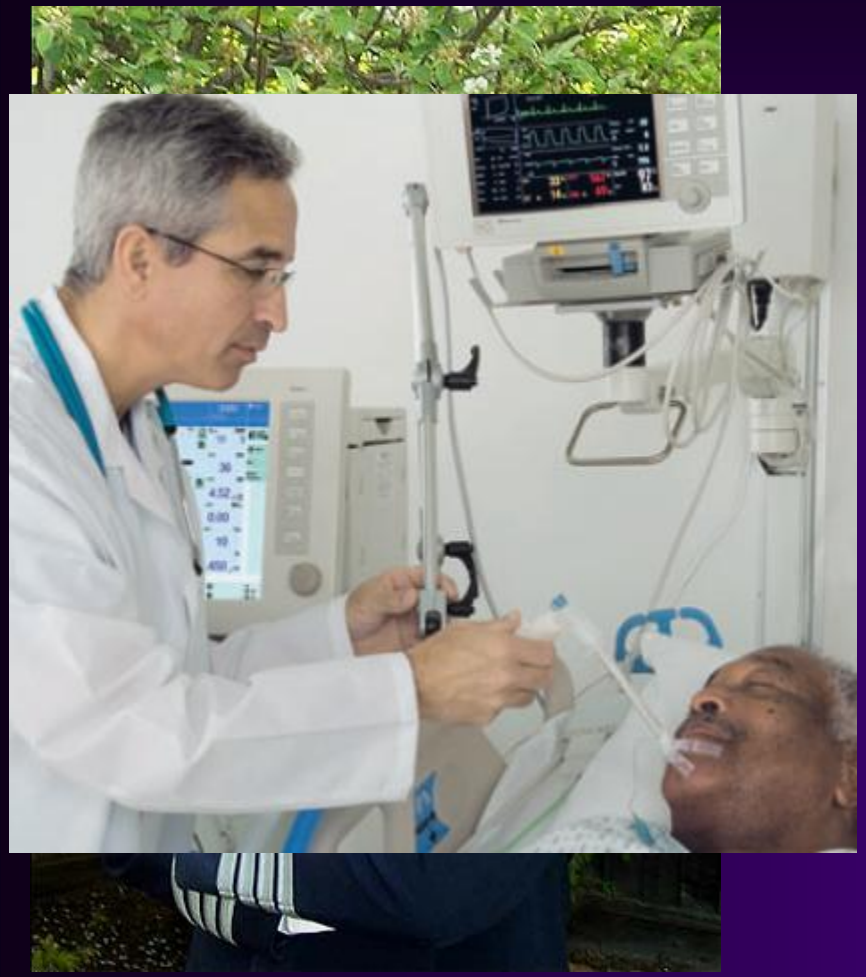
- CDW had less MV, ETT time, shorter ICU & hosp LOS
- no RTs in Europe

2007: Observational study in post- op CAB pts (*n* = 45)

- CDW had less ETT time, shorter ICU & hosp LOS
- Low power study

2008: Randomized single- center trial, (*n* = 102)

- No difference between CDW & 1:1 nurse weaning
- Study of short duration MV pts (≤ 150 hours)



But like airplanes, mechanical ventilators still need good "pilots!"

...and that's us, folks!

“Take Home” RCP messages:

Search out the EBM, bring technology to the bedside that can improve outcomes.

Understand the technology, and teach the physicians, nurses, etc.

Participate in clinical research and development- enrich the future of Respiratory Care.

In other words, realize that you are part of a **Profession**, so behave **Professionally**!