Ventilation : getting started

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RP von Rahden : Declarations

- Lectured for, with honoraria:
  - Scientific Group
  - Adcock-Ingram Critical Care
- Prize conference sponsorships:
  - Teleflex Medical
- Conference sponsorships:
  - Fresenius-Kabi
  - Adcock-Ingram Critical Care
  - Aspen

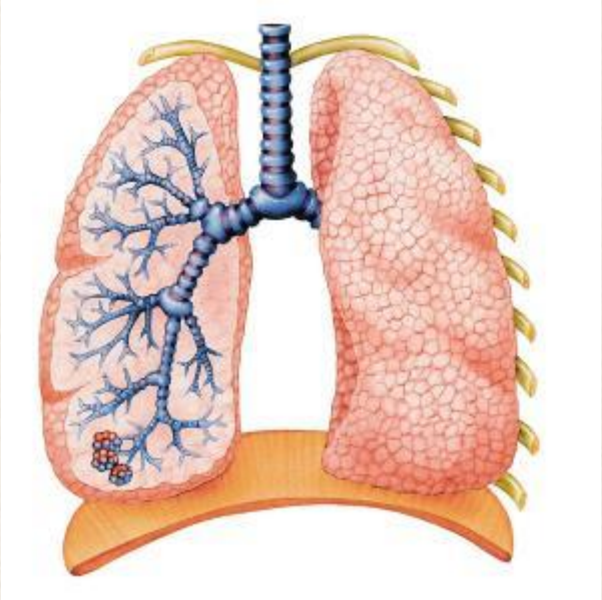
IPPV

Intermittent Positive Pressure Ventilation

Blowing air into the lungs.

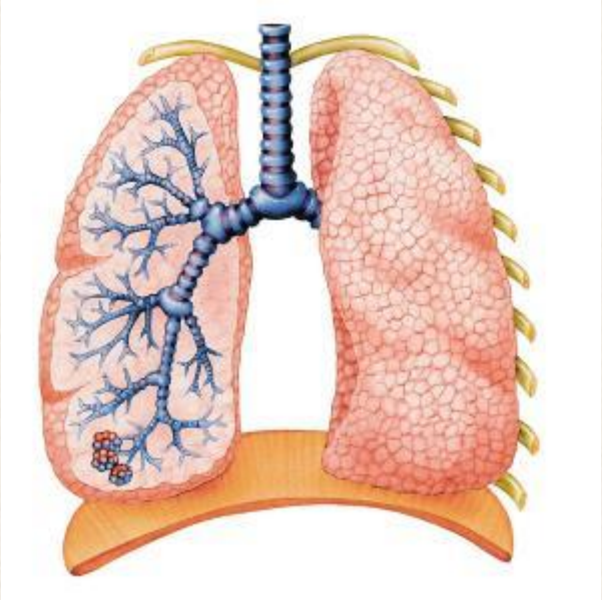
Why ventilate?

- Pulmonary functions
  - Oxygen
    - air → blood >> cells
  - Carbon dioxide
    - air ← blood << cells



Why ventilate?

- Pulmonary functions
  - Oxygen
    - a… blood >> cells
  - Carb… dioxide
    - … ← blood << cells
- "Respiratory Failure"
  - actual
  - imminent



Respiratory Failure

- **FAILURE OF OXYGENATION**
  - **Low SaO_2 = *<u>THE</u>* problem!**
  - **Low O_2 in blood → low O_2 in cells → cells die**

- Failure of CO_2 elimination
  - ↑$PaCO_2$: low attributable damage
    - unless ↑ICP, ↑PAP, massive acidosis
  - ↑$PaCO_2$ → ↑SNS tone, ↓inflammation

Respiratory Failure : Classification

- "Type 1"
  - low PaO_2
  - normal $PaCO_2$
- "Type 2"
  - low PaO_2
  - high $PaCO_2$

Can you remember this?

Does this help you fix the problem?

Before we ventilate…

- We MUST recognize:
  - why is there respiratory failure?
  - what do we want IPPV to fix?

- Affects:
  - immediate goals
  - methods of ventilation
  - endpoint

Respiratory failure mechanisms

with thanks to Dr RE Hodgson!

RESPIRATORY FAILURE

"Non-lung causes"

↓ Respiratory movement

Failure of
- **brain**
- spinal cord
- nerves
- muscle

↑ Respiratory movement

eg metabolic acidosis → hyperventilation
- *consumes energy*
- *fatigues muscles*

"Lung causes"

Bronchiolar disease

eg asthma

Alveolar disease

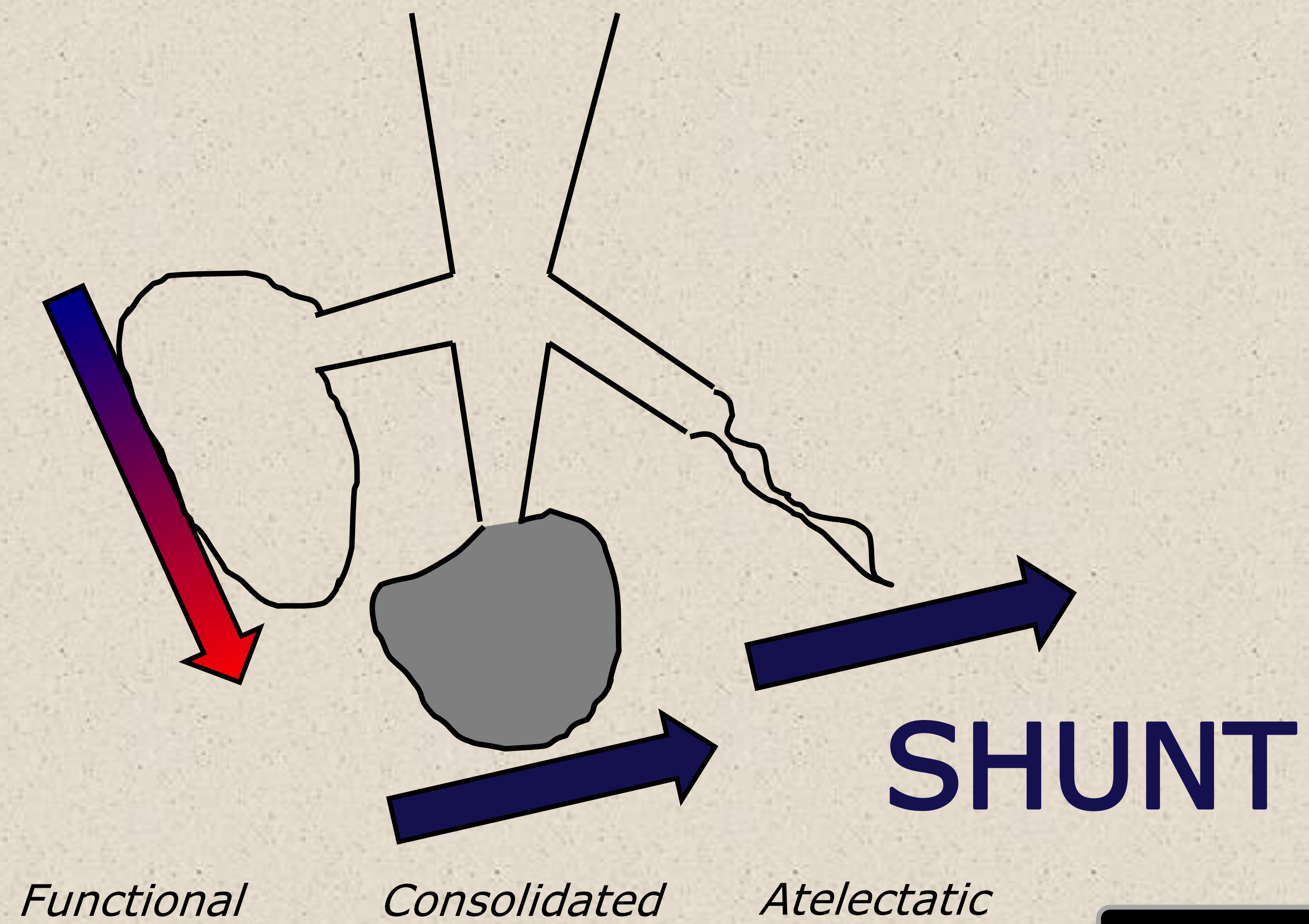
- consolidation
- atelectasis

↓

- dead space
- **SHUNT**

Alveolar disease

- *3 alveolar populations*
- → Effects on capillary blood
- "1 red cell, 1 alveolus"



Shunt

- Commonest cause of hypoxaemia from alveolar lung disease.

Shunt

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- Management:
  - recruit atelectatic alveoli
    - IPPV may help
  - prevent atelectasis worsening
    - IPPV helps … PEEP
  - clear consolidation
    - time, drugs … IPPV not helpful
  - don’t damage functional alveoli
    - BEWARE: IPPV may injure them!

IPPV goals …

- 1° goal= **adequate** oxygenation of blood
  - **Overwhelming importance**
  - $SaO_2 \geq 90\%$ (adult)

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  - Only relevant if ↑ICP, ↑PAP
    - aim $PaCO_2$ 5kPa
  - ??? control if profound metabolic acidosis ???

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- 3° goal = ↓ Work of Breathing

… IPPV goals

- Do the above…

  WHILE MINIMIZING DAMAGE!

- Lungs made for negative pressure
  - <u>POSITIVE PRESSURE CAUSES LUNG DAMAGE.</u>
  - IPPV <u>rarely</u> helps lung
    - ? recruitment = exception ?

Minimize damage from…

- Volutrauma
  - = breaths too big = “excessive Tidal Volume”
  - Target $V_T \leq$ 6ml / kg IDEAL mass for height

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  - = pressures too high
  - Keep $P_{plateau}$ *[Volume mode]* | P_{max} *[Pressure mode]* ≤ 30 cmH_2O

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  - Splint alveoli open with enough PEEP : ≥10cmH_2O (rpvr)

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  - Splint alveoli open with enough PEEP : ≥10cmH_2O (rpvr)
- Oxytrauma
  - = chemical damage from high FiO_2
  - Get FiO_2 below 60% as soon as possible
    - only need to achieve SaO_2 of 90%!

Starting strategies

- 2 fundamental strategies
  - "Lung protective" DEFAULT
  - "Neuroprotective" If ↑ ICP

also severe Pulmonary Hypertension

?? severe Metabolic Acidosis ??

"Lung protective ventilation"

- = Default strategy
  - for almost all types of Respiratory Failure

- Goal : SaO_2 = 90%

- With
  - $V_T \leq$ 6ml / kg IDEAL mass for height
  - Pplateau | Pmax $\leq$ 30 cmH_2O
  - PEEP $\geq$ 10 cmH_2O
    - recruitment if diffuse atelectasis likely
  - FiO_2 < 60% ASAP (though start at 100%)

“Neuroprotective ventilation”

Try do all the above ($SaO2 \geq 90\%$),

but also **keep $PaCO_2 = 5.0 \pm 0.2$ kPa**

Controlling $PaCO_2$

- $PaCO_2$ inverse to Minute Volume
  - Minute Volume = V_T x Respiratory Rate
- ↑ $PaCO_2$? : fix by ↑ Minute Volume!
  - ↑ Respiratory Rate :
    - (practical maximum 24 / min in adult)
  - $PaCO_2$ still ↑ ? : ↑ V_T, ↑P above the limits
  - **Brain takes precedence over lungs.**
- **Only "neuroprotect" if <u>really</u> indicated!**
  - ↑V_T, ↑P to ↓$PaCO_2$ damage lungs

Non-invasive ventilation?

- Endotracheal intubation = default

- Non-invasive ventilation – very useful!
  - avoids perils of intubation
  - not for unskilled use on sick patients
  - IF SEVERE RESPIRATORY FAILURE : INTUBATE

  - NIV useful alone for
    - COPD exacerbations
    - Cardiac failure

"It's all so complicated!"

“Modes” of ventilation

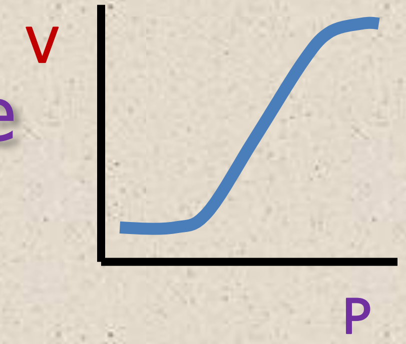
- **Dozens** of ways ventilators could work!
- Manufacturer terminology inconsistent

- Defined by
  - Gasflow targeted to achieve
    - a certain tidal volume — “Volume modes”
    - a certain pressure — “Pressure modes”
  - Degree of patient interaction allowed
    - Controlled
    - Assisted
    - Supported
    - Mixed (SIMV-like)

Volume modes *vs* pressure modes

- Primary machine target =
  - achieve set VOLUME over a set time |
  - blow air to set PRESSURE for set time

- V_T = compliance * driving Pressure
  - set one parameter – check the other



- Either can achieve the same effect!
  - if targets achieved
- No overall outcome differences

Volume modes

- Pros:
  - always get a guaranteed volume
    - NB in OR
  - may recruit collapsed lung better (but high P's!)

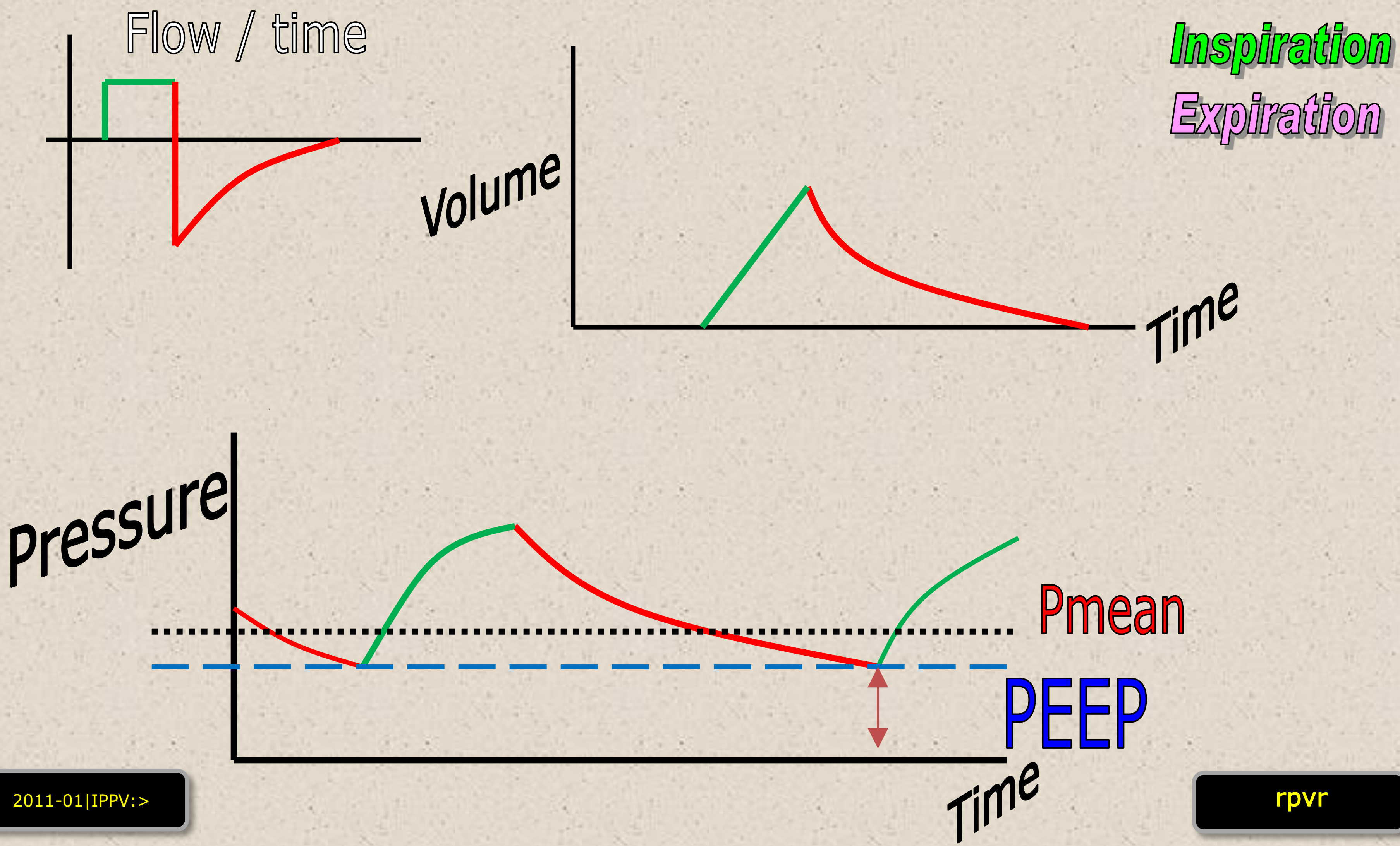
- Cons
  - patient dyssynchrony
    - squarewave gasflow on older machines
  - high pressures can occur
  - set pause | plateau time

Pressure modes

- Pros
  - pressure limited
  - gasflow more physiological – patient synchrony
  - copes with leaks
    - paediatric uncuffed ett

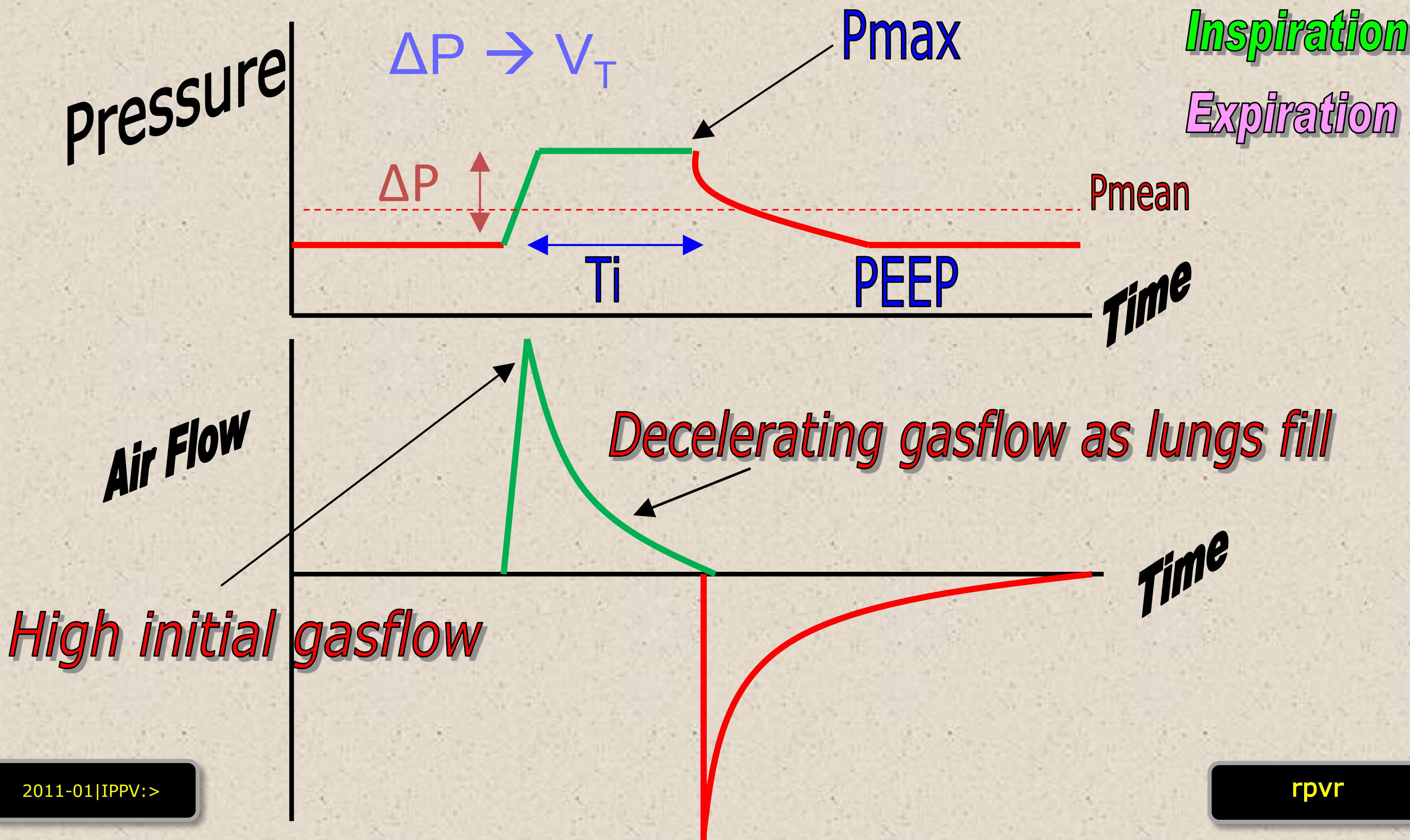
- Cons
  - Ti setting vital, variable VT if not monitored
  - does not recruit already-collapsed lung as well

Volume mode


Flow / time
Volume
Time
Inspiration
Expiration
Pressure
Pmean
PEEP
Time


Volume Control
Automode
Admit patient
Nebulizer
Status
10-24 13:59
30 cmH2O
Ppeak (cmH2O)
23
40
Pmean (cmH2O)
10
PEEP (cmH2O)
6
70 l/min
RR (b/min)
16
30
5
O2 (%)
40
45
35
I:E
1:2.0
-70
400 ml
MVe (l/min)
C
4.9
40.0
2.0
VTi (ml)
301
VTe (ml)
306
Additional settings
O2 conc.
40
%
21
100
PEEP
6
cmH2O
0
50
Resp. Rate
16
b/min
4
150
Tidal Volume
300
ml
100
4000
Additional values

Pressure Control



Pressure Control
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16
30
5
O2 (%)
40
45
35
I:E
1:2.5
-70
400 ml
MVe (l/min)
C
4.8
40.0
2.0
VTi (ml)
298
VTe (ml)
303
Additional settings
O2 conc.
40
%
21
100
PEEP
6
cmH2O
0
50
Resp. Rate
16
b/min
4
150
PC above PEEP
14
cmH2O
0
120
Additional values

Modes: patient interaction

Mode	Starting inspiration / Trigger	Ending inspiration/ Cycle to expiration/ Control Ti | inspiration duration	Patient input
Controlled	Ventilator	Ventilator	0
Assisted	Patient	Ventilator	+
Supported	Patient	Patient	++

- Controlled or Assisted modes can be Volume or Pressure targeted.
- Supported modes : Pressure targeted
- Controlled and Assisted modes often combined into “Assist-Control”

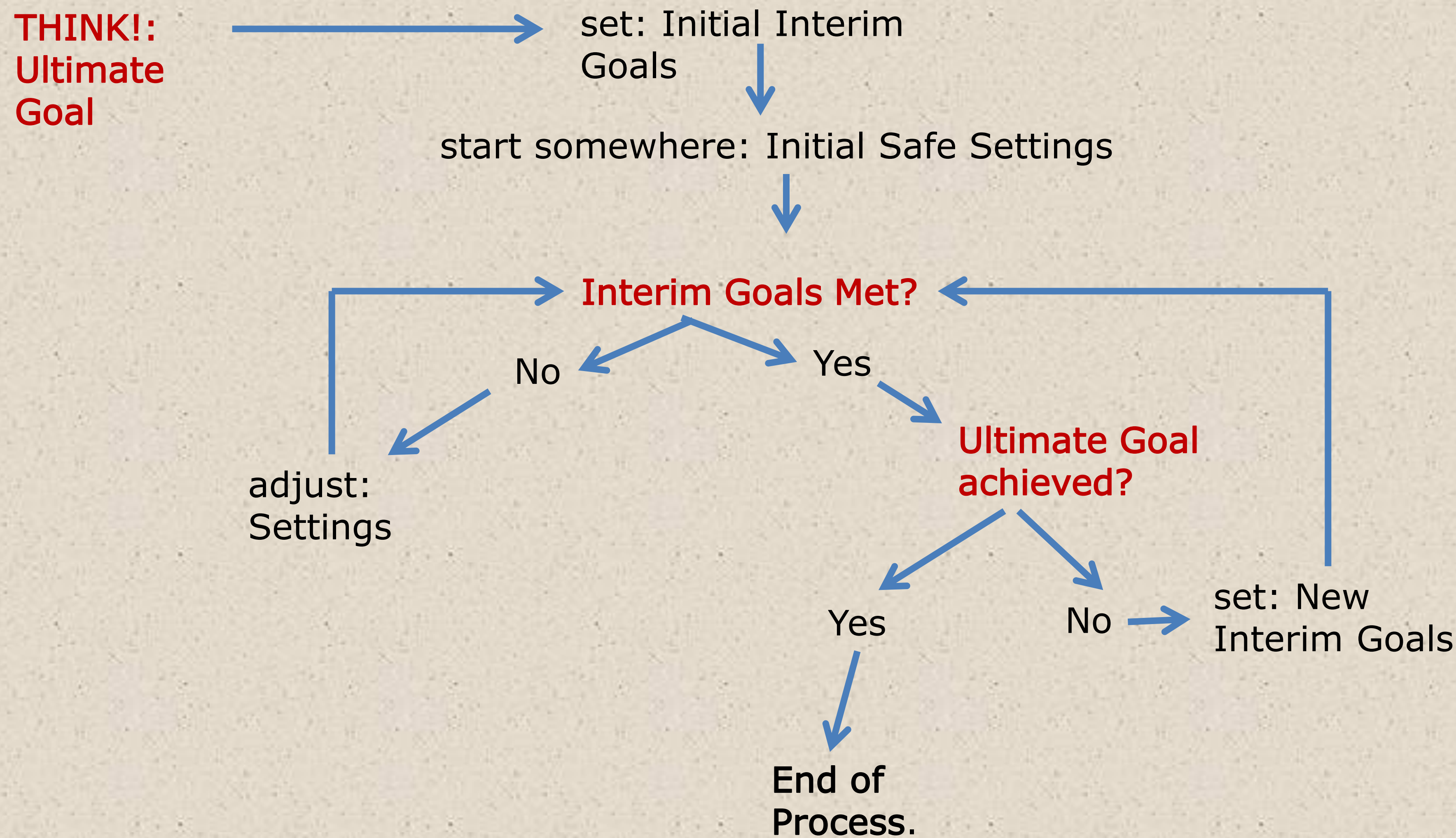
- SIMV effectively a mix of all 3…

All this data

☹

What do I *do*?!!

Critical care cycle



Initial goal

- "Capture"
  - Anaesthetize
  - Intubate
  - Deep sedation
  - Control ventilation (Assist-CONTROL mode)

- ± Recruit (if: skills✓ pathology✓)

- Oxygenate!
  - FiO2 90%
  - Lung-protective limits

Universal initial ventilator settings : Bear 1000 : Adult & Paediatric ≥ 10kg

Preset:

Mode:	Pressure Control		(=*Pressure-Targeted Assist-Control)*
PEEP:	10	cmH_2O	
Rate:	15-20	breaths/min	
FiO_2:	100	%	
Assist Sensitivity	1	cmH_2O	
Inspiratory Time	1.0 – 1.5	s	
Inspiratory Pressure	**5**	**cmH_2O**	(*above PEEP)*
Slope	-3		

Connect patient.

Adjust **Inspiratory Pressure** over first few breaths, to maximum 20cmH_2O

Goal: Measured Tidal Volume = 6ml/kg ideal mass for height *(F≈400ml, M≈500ml)*

For first hour: review every 10minutes

If SpO_2 ≥ 95% reduce FiO_2 by 10% until FiO_2 = 40% | Increase FiO_2 by 10% if SpO_2 <90%

Adjust Inspiratory Pressure to keep Measured Tidal Volume = 6ml/kg

If regular patient triggers, can reduce Rate to 10 breaths / minute.

Consider ABG after 1hour. Review SpO_2, Tidal Volume and patient effort 1-hourly thereafter.

Universal initial ventilator settings : Servo-i : Adult & Paediatric ≥ 10kg
(configured for Ti setting)

Preset:

Mode:	Pressure Control		(=*Pressure-Targeted Assist-Control)*
PEEP:	10	cmH_2O	
Resp Rate:	15-20	breaths/min	
O_2Conc:	100	%	
TriggFlow	1	L/min	
Ti	1.0 – 1.5	s	
TinspRise	0.15	s	
PC above PEEP	**5**	**cmH_2O**	

Connect patient.
Adjust **PC above PEEP** over first few breaths, to maximum 20cmH_2O
Goal: Measured Tidal Volume = 6ml/kg ideal mass for height *(F≈400ml, M≈500ml)*

For first hour: review every 10minutes
If SpO_2 ≥ 95% reduce O_2Conc by 10% until FiO_2 = 40% | Increase O_2Conc by 10% if SpO_2 <90%
Adjust PC above PEEP to keep Measured Tidal Volume = 6ml/kg
If regular patient triggers, can reduce RespRate to 10 breaths / minute.
Consider ABG after 1hour. Review SpO_2, Tidal Volume and patient effort 1-hourly thereafter.

Universal initial ventilator settings : Dräger Savina & Evita 2 : Adult & Paediatric ≥ 10kg

Preset:

Mode:	IPPV AutoFlow		(=*Volume-Targeted Assist-Control)*
PEEP:	10	mbar	
Rate:	15-20	breaths/min	
FiO_2:	100	%	
Flow Sensitivity	1	L/min	
Tinsp	1.0 – 1.5	s	
Ramp	0.2	s	
Tidal Volume	6ml/kg ideal mass for height		*(Female ≈400ml Male ≈500ml)*

Connect patient.
Observe measured Pmax. If Pmax exceeds 30mbar, increase Tinsp to maximum 2s. If still exceeding 30mbar, reduce set Tidal Volume by 50ml.
If measured Tidal Volume significantly below set Tidal Volume, check for leaks.

For first hour: review every 10minutes
If SpO_2 ≥ 95% reduce FiO_2 by 10% until FiO_2 = 40% | Increase FiO_2 by 10% if SpO_2 <90%
Review Pmax and Tidal Volume, target Tinsp 1.0 to 1.5s
If regular patient triggers, can reduce Rate to 10 breaths / minute.
Consider ABG after 1hour. Review SpO_2, Tidal Volume, Pmax and patient effort 1-hourly thereafter.

Once captured

- First hour

- Take away excess
  - FiO_2 … if SpO_2 ≥ 95%... only need 90%
  - Pressure … if V_T high

- First hour dynamic
  - many changes likely
  - reassess q10min

Once stabilized

- Encourage spontaneous respiration
  - in 90% of patients
  - diaphragm moving → basal recruitment

  - Reduce sedation
  - Reduce set rate

  - ASSIST-Control … patient-triggered breaths

Over time

- Continuous reduction : remove un-needed

- Wean toward a SUPPORT mode

- As lungs improve…
  - reduce inspiratory pressures
  - give patient full control

  - wean PEEP last

- T-piece trial usually unnecessary

Pre-extubation checklist.

All parameters should be met prior to attempting extubation.

[ ] Original cause(s) Respiratory Failure fixed
[ ] Oxygenation Index <5 (unless chronic lung disease confirmed)
[ ] No mandatory breaths required
[ ] RSBI (on PS 6cmH2O) < 80
[ ] Minimal / thin, clearable secretions
[ ] Adequate cough
[ ] Can protect airway: GCS > 9 | No local anatomical complications

Occasional exception

- Extreme lung pathology | Deranged CNS
- Obsolete ventilator

→

- Keep deeply sedated.
- Keep on Assist-Control mode.
- Meet lung-protective targets

- Once daily: sedation hold
  - T-piece trial (15 mins)
  - Pass → extubate | Fail → resedate for 24h

Summary

- Target = oxygenate
  - Adequate SaO_2 to sustain life
- Protect lungs
- Hit target – exact method less important

- Get control
- Continual reassessment, adjustment
- Reduce intervention as patient improves

- Patient focus

Thanks to HRH!

Questions?