Assessment and Management of Patient-Ventilator Dysynchrony

Interactive Clinical Scenarios

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Pulmonary Services Department

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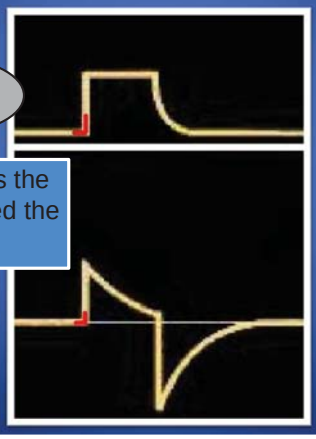
Disclosures

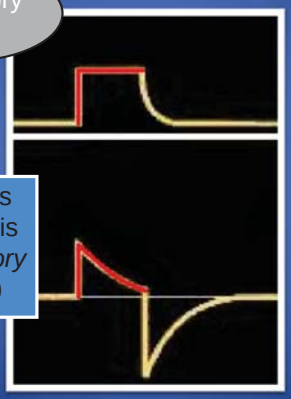
- Clinical consultant and clinical simulation & presentation author for IngMar Medical
- Received funding from Covidien for speaking engagements
- Received funding from Hamilton Medical for speaking engagements
- Received funding from Worrell for clinical consulting

Trigger

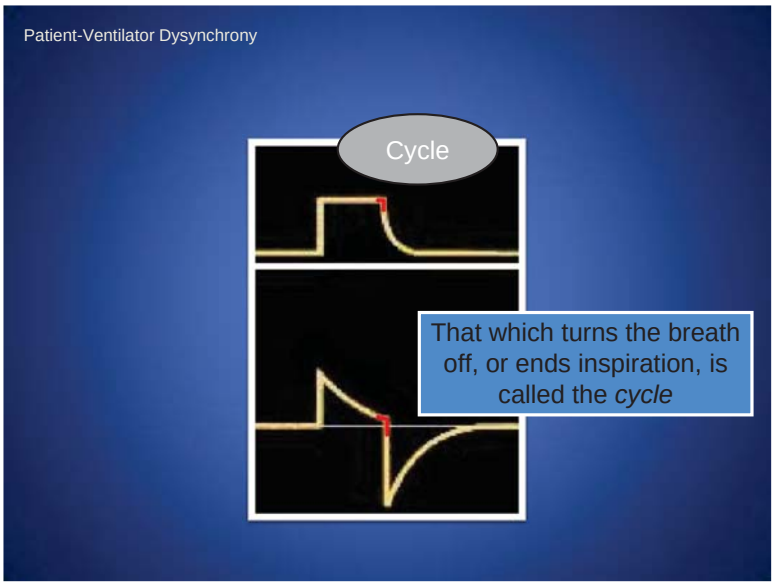


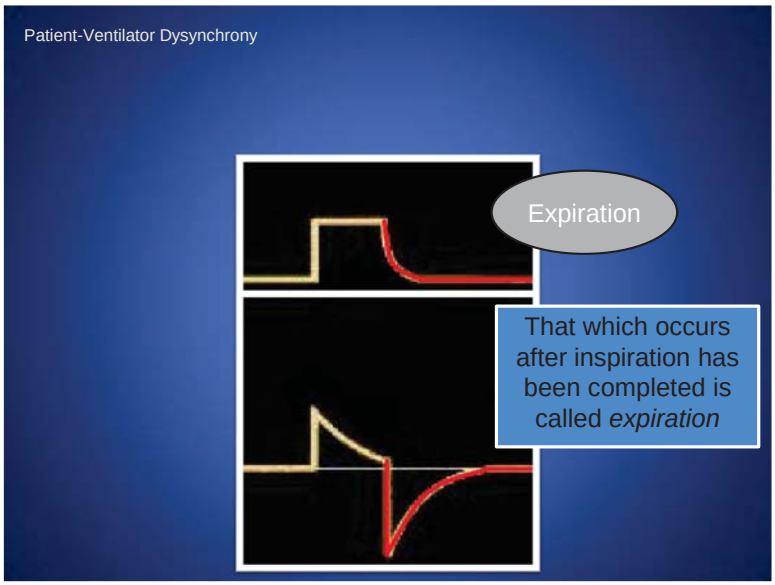
That which turns the breath on is called the *trigger*

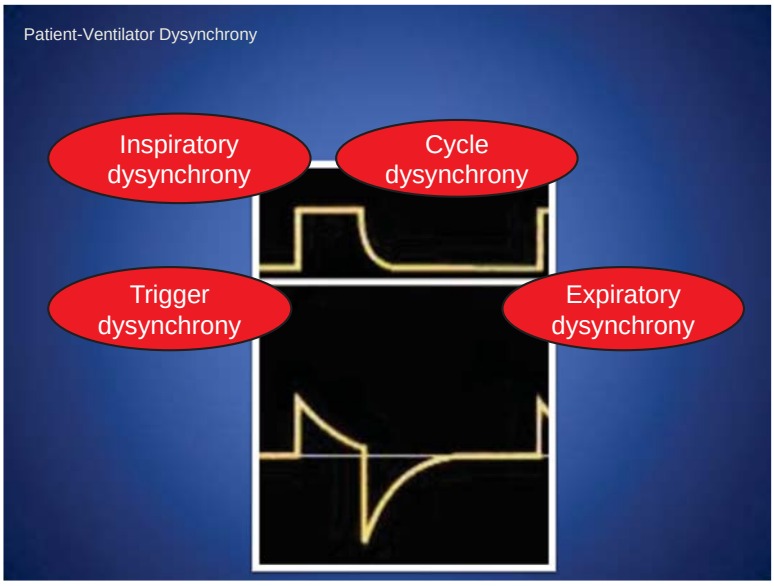
Inspiratory flow

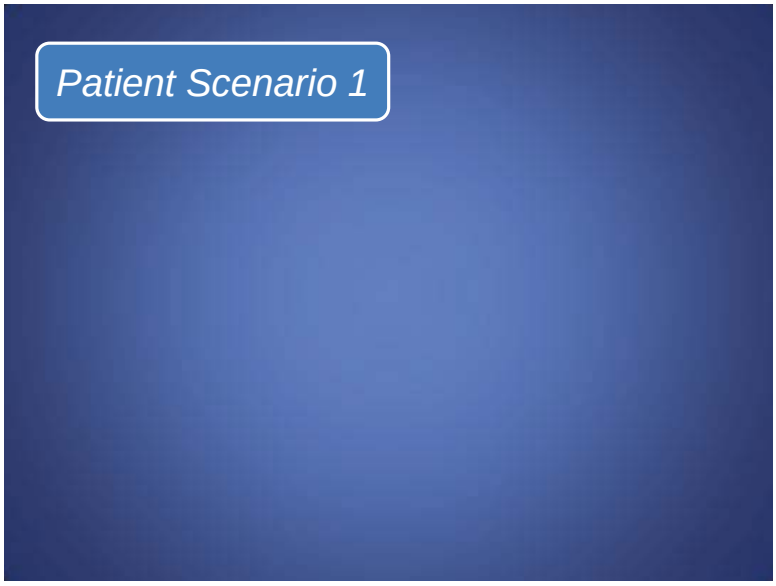


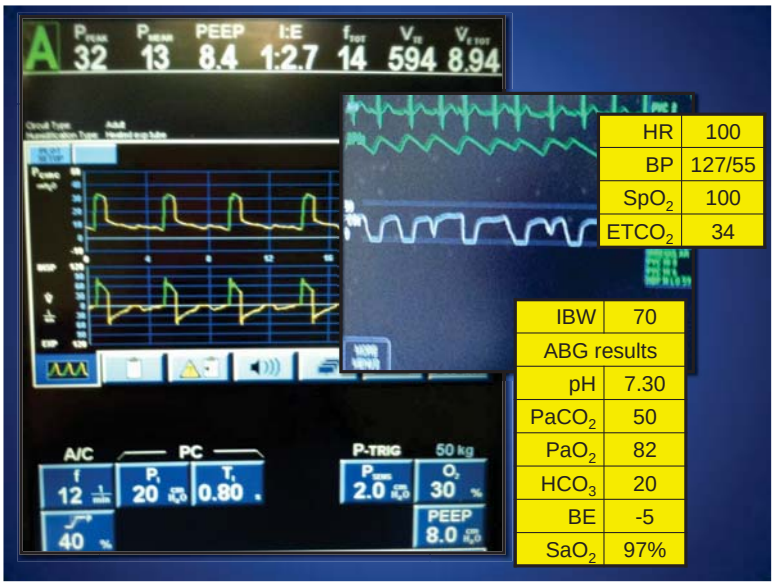
That which occurs during the breath is called the *inspiratory flow* (or the *limit*)


Patient-Ventilator Dysynchrony
Cycle
That which turns the breath off, or ends inspiration, is called the *cycle*


Patient-Ventilator Dysynchrony
Expiration
That which occurs after inspiration has been completed is called *expiration*


Patient-Ventilator Dysynchrony
Inspiratory dysynchrony
Cycle dysynchrony
Trigger dysynchrony
Expiratory dysynchrony


Patient Scenario 1

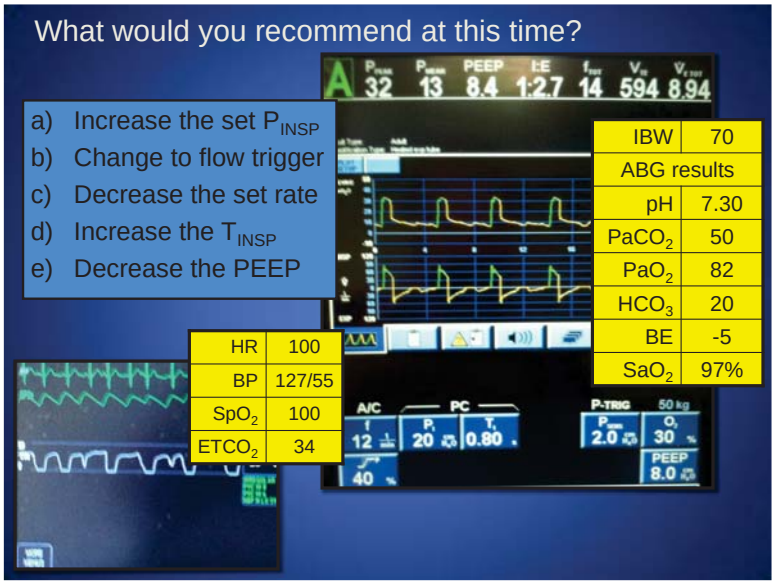


HR	100
BP	127/55
SpO_2	100
$ETCO_2$	34

IBW	70
ABG results	
pH	7.30
$PaCO_2$	50
PaO_2	82
HCO_3	20
BE	-5
SaO_2	97%

What would you recommend at this time?

a) Increase the set P_{INSP}
b) Change to flow trigger
c) Decrease the set rate
d) Increase the T_{INSP}
e) Decrease the PEEP



HR	100
BP	127/55
SpO_2	100
$ETCO_2$	34

IBW	70
ABG results	
pH	7.30
$PaCO_2$	50
PaO_2	82
HCO_3	20
BE	-5
SaO_2	97%

What would you recommend at this time?

a) Increase the P_{INSP}
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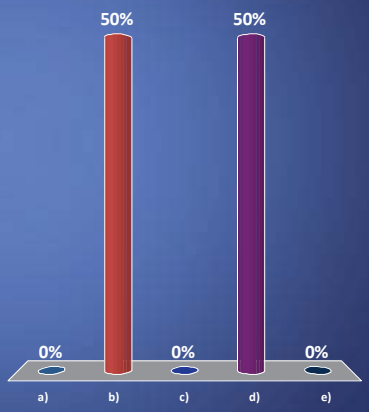
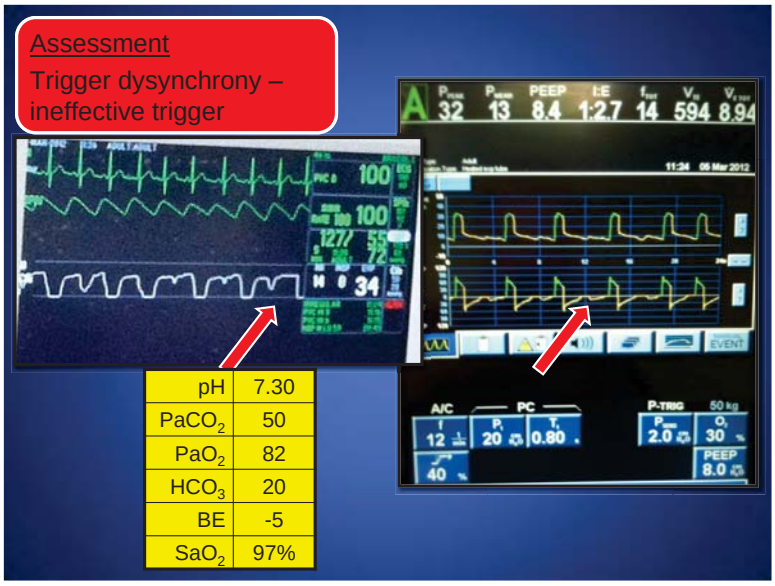


Assessment

Trigger dysynchrony – ineffective trigger



pH	7.30
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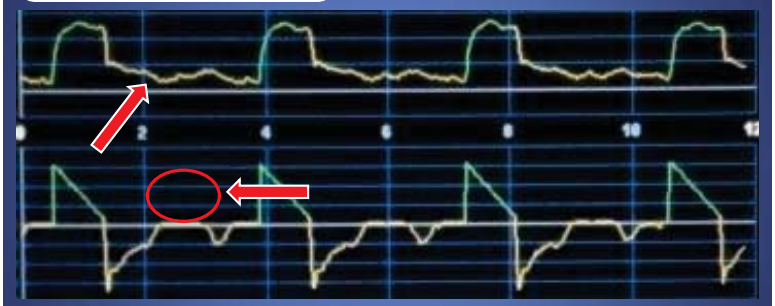
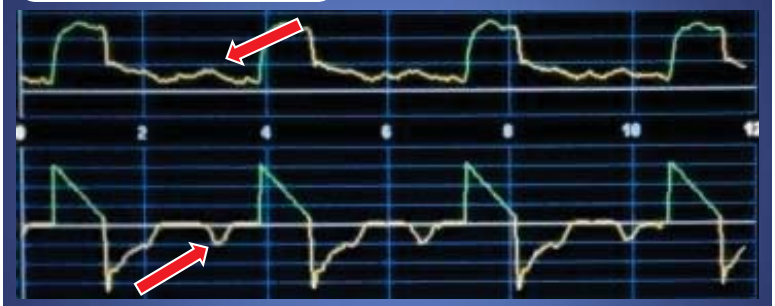
BE	-5
SaO_2	97%

Assessment
Trigger dysynchrony – ineffective trigger



- When the patient begins the inspiratory effort, the pressure decreases slightly
- The ventilator doesn't detect the drop in pressure to initiate an assisted breath, detectable by a lack of inspiratory flow

Assessment
Trigger dysynchrony – ineffective trigger



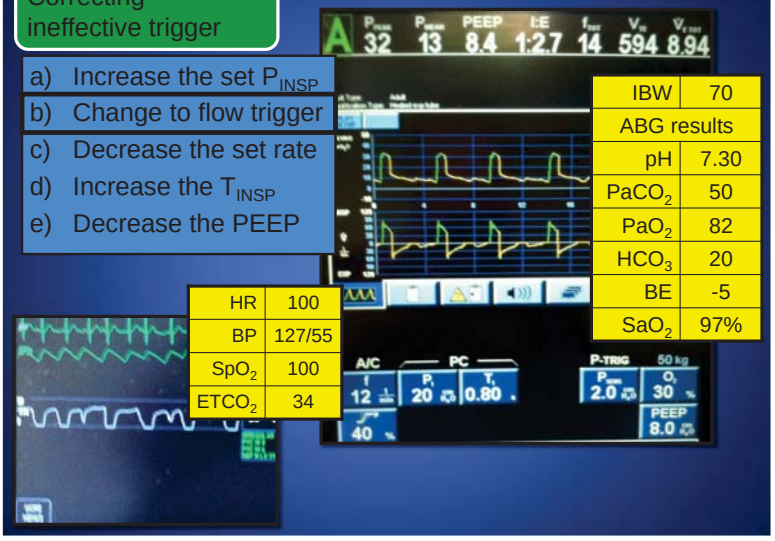
- When the patient finishes the inspiratory effort and effectively exhales out, the pressure begins to increase
- Flow exits the patient's lung and travels towards the expiratory valve, observed on the expiratory arm of the flow-time scalar

Clinical implications of ineffective efforts

- Ineffective efforts result in an increased work of breathing on the patient's behalf
  - This is due to the patient's employment of muscles of inspiration to expand the thoracic cage in an effort to initiate a breath
- Ineffective efforts can also result in a phenomenon of breathlessness and agitation because of the undelivered breath

Correcting ineffective trigger

a) Increase the set P_{INSP}
b) Change to flow trigger
c) Decrease the set rate
d) Increase the T_{INSP}
e) Decrease the PEEP



HR	100
BP	127/55
SpO_2	100
$ETCO_2$	34

IBW	70
ABG results	
pH	7.30
$PaCO_2$	50
PaO_2	82
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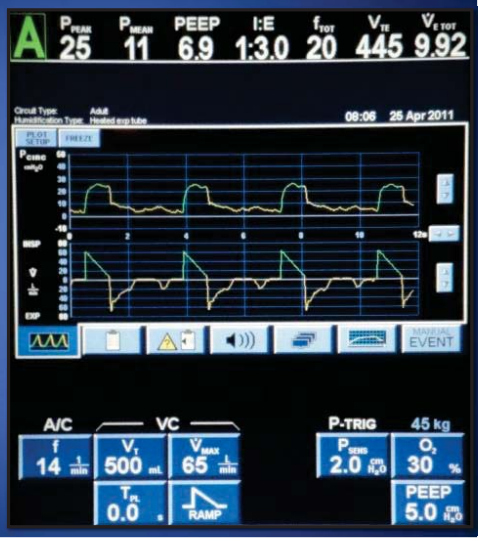
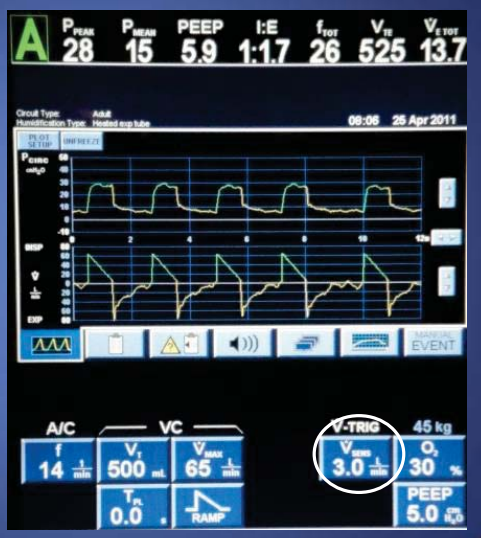
Correcting ineffective trigger

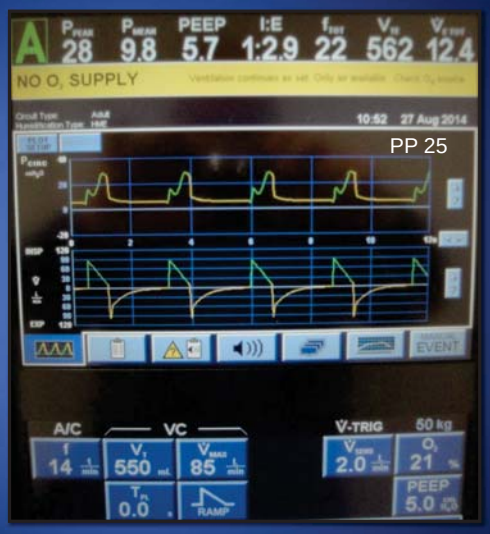


Correcting ineffective trigger



Patient Scenario 2

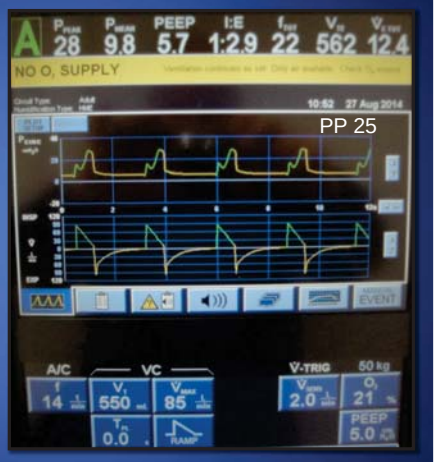
IBW	80
hemodynamics	
HR	115
BP	145/92
ABG results	
pH	7.47
$PaCO_2$	33
PaO_2	72
HCO_3	25
BE	+1
SaO_2	96%
medications	
midazolam fentanyl	



What would you recommend at this time?

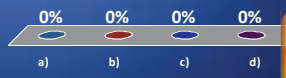
a) Decrease the set volume
b) Increase midazolam
c) Decrease the set rate
d) Increase the inspiratory flow
e) Decrease the FiO_2

ABG results	
pH	7.47
$PaCO_2$	33
PaO_2	72
HCO_3	25
BE	+1
SaO_2	96%



What would you recommend at this time?

a) Decrease the set volume
b) Increase midazolam
c) Decrease the set rate
d) Increase the inspiratory flow
e) Decrease the FiO_2



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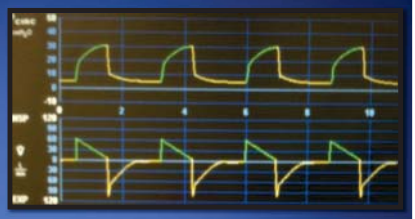
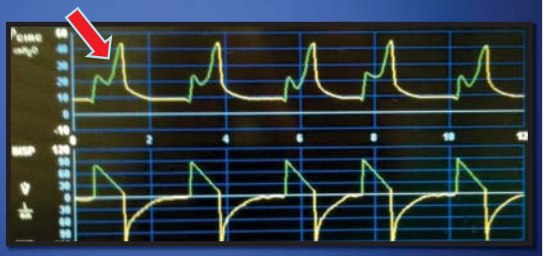
Assessment

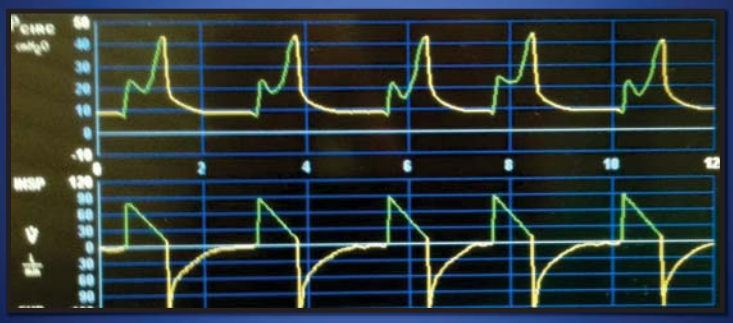
Inspiratory dysynchrony – inadequate flow

ABG results	
pH	7.47
$PaCO_2$	33
PaO_2	72
HCO_3	25
BE	+1
SaO_2	96%



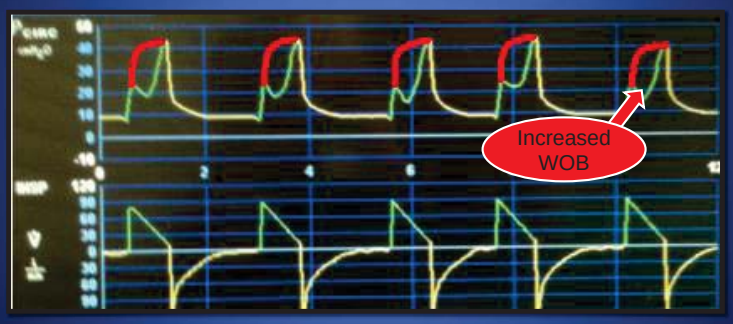


Clinical implications of inadequate flow



Clinical implications of inadequate flow

- The clinical implication of continued inadequate flow is an increased WOB (the area under the reference curve)

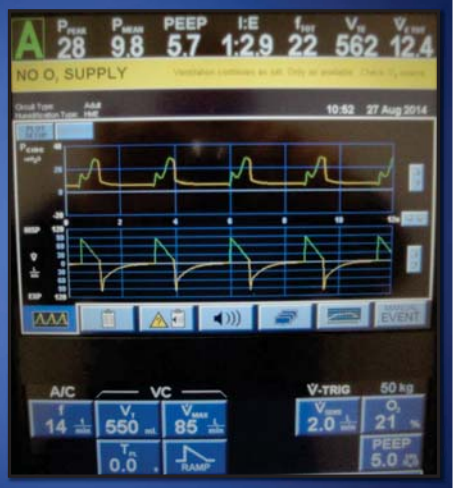


- In addition, there is an phenomenon of breathlessness

Correcting inadequate flow

a) Decrease the set volume
b) Increase midazolam
c) Decrease the set rate
d) Increase the inspiratory flow
e) Decrease the FiO_2

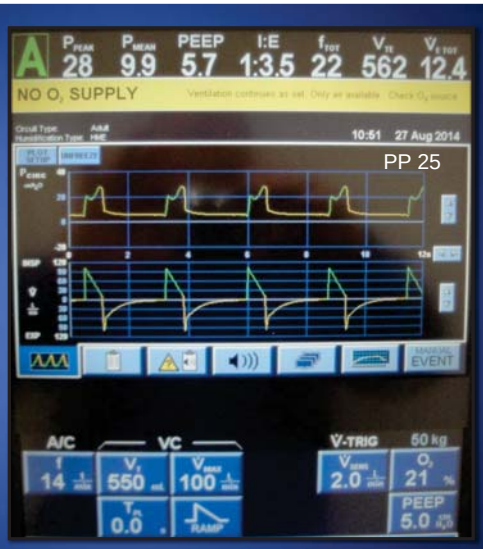
- If inadequate flow is recognized while using CMV Volume, it is corrected by increasing the peak inspiratory flow rate



Patient Scenario 2

Continued one hour later

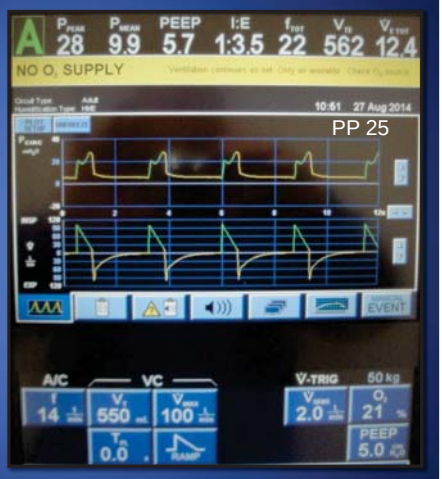
IBW	80
hemodynamics	
HR	124
BP	152/95
ABG results	
pH	7.47
$PaCO_2$	33
PaO_2	72
HCO_3	25
BE	+1
SaO_2	96%
medications	
midazolam fentanyl	



What would you recommend at this time?

a) Increase the set volume
b) Increase midazolam
c) Increase the set rate
d) Increase the inspiratory flow
e) Change to CMV-Pressure

ABG results	
pH	7.47
$PaCO_2$	33
PaO_2	72
HCO_3	25
BE	+1
SaO_2	96%



What would you recommend at this time?

a) Increase the set volume
b) Increase midazolam
c) Increase the set rate
d) Increase the inspiratory flow
e) Change to CMV-Pressure

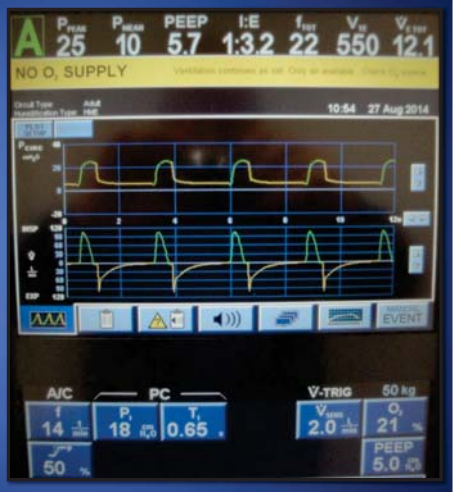
Correcting inadequate flow

a) Increase the set volume
b) Increase midazolam
c) Increase the set rate
d) Increase the inspiratory flow
e) Change to CMV-Pressure

- If inadequate flow is recognized while using CMV Volume, it is corrected by increasing the peak inspiratory flow rate

Correcting inadequate flow

- If inadequate flow is recognized while using CMV Volume, it is corrected by increasing the peak inspiratory flow rate
- To correct continued inadequate flow, the change to a pressure-limited mode of ventilation may be helpful
  - Inspiratory flow is variable in pressure-limited modes



Patient Scenario 3

Mode	CMV Volume
FiO_2	0.30
PEEP	5
set RR	10
total RR	32
set flow	75
set V_T	500 (6.7ml/kg)
V_E	21.8
PIP	45
PP	unable to obtain

pH	7.52
$PaCO_2$	29
PaO_2	82
HCO_3	25.2
BE	+1.8

hemodynamics	
HR	125
BP	98/60

pharmacology
- fentanyl
- midazolam
- norepinephrine
- vasopressin
- milrinone

subjective / objective
- accessory muscle use
- agitated

---

a) Decrease the trigger sensitivity
b) Increase the inspiratory flow
c) Increase the set volume
d) Decrease the respiratory rate
e) Decrease the set volume

What would you recommend at this time?

Mode	CMV Volume
FiO_2	0.30
PEEP	5
set RR	10
total RR	32
set flow	75
set V_T	500 (6.7ml/kg)
V_E	21.8
PIP	45
PP	N/A

pH	7.52
$PaCO_2$	29
PaO_2	102
HCO_3	25.2
BE	+1.8

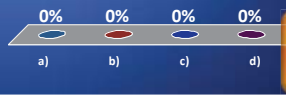
hemodynamics	
HR	125
BP	98/60

pharmacology
- fentanyl
- midazolam
- norepinephrine
- vasopressin
- milrinone

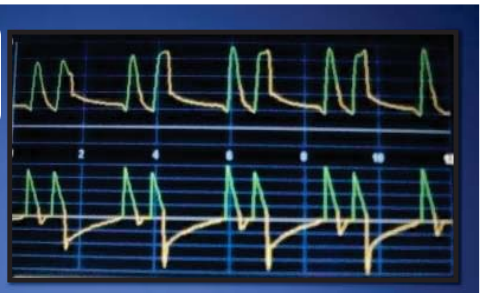
subjective / objective
- accessory muscle use
- agitated

What would you recommend at this time?

a) Decrease the trigger sensitivity
b) Increase the inspiratory flow
c) Increase the set volume
d) Decrease the respiratory rate
e) Decrease the set volume



Assessment
Cycle dysynchrony – premature cycling



- Premature cycling or “double-triggering”
  - Caused by a dysynchrony between the patient’s neural inspiratory time and the ventilator’s inspiratory time
    1. The ventilator has cycled the inspiratory phase (delivered the set volume)
    2. However, the patient continues to inspire and expand their thoracic cage
    3. The pressure / flow in the circuit is thereby decreased and an additional breath is triggered without exhaling the previous

Assessment
Cycle dysynchrony – premature cycling

- In addition to the graphical presentation used to identify premature cycling, the exhaled V_T will read 0 ml for the breaths that were not exhaled followed by a “doubled volume”

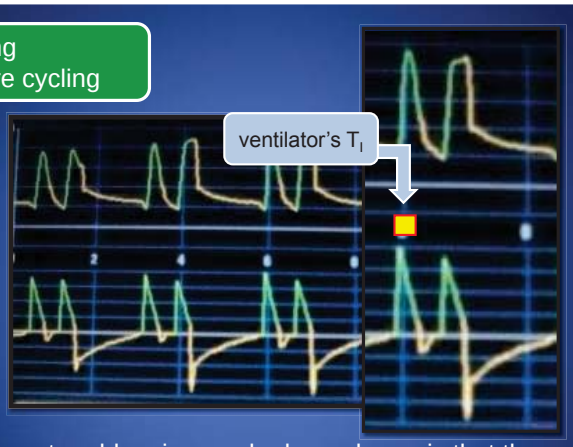
Assessment
Cycle dysynchrony – premature cycling

- In addition to the graphical presentation used to identify premature cycling, the exhaled V_T will read 0 ml for the breaths that were not exhaled followed by a “doubled volume”

Clinical implications of premature cycling

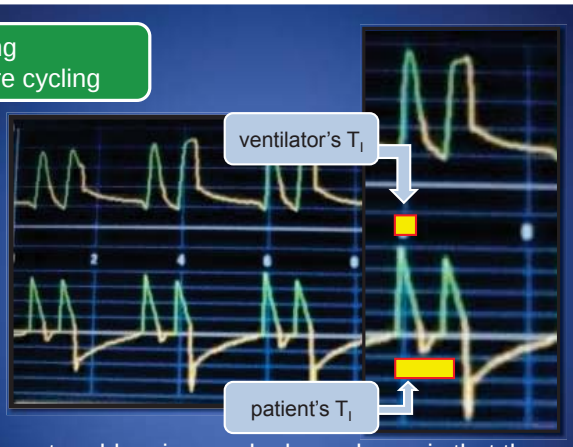
- The clinical implications of severe cycle dysynchrony can be profound if the intention is to volume limit a patient who has ARDS

Correcting premature cycling



- The inherent problem in a cycle dysynchrony is that the ventilator's inspiratory time is shorter than the patient's inspiratory time

Correcting premature cycling



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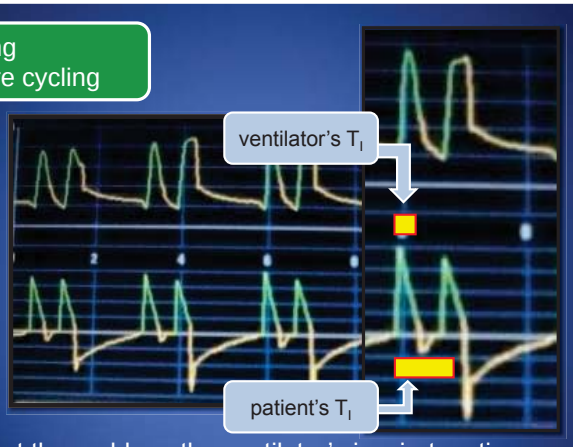
Correcting premature cycling



- To correct the problem, the ventilator's inspiratory time needs to be lengthened to match the patient's neural inspiratory time
- In CMV Volume, the flow can be decreased OR
- In CMV Volume, the volume can be increased

a) Decrease the trigger sensitivity
b) Increase the inspiratory flow
c) Increase the set volume
d) Decrease the respiratory rate
e) Decrease the set volume

Mode	VC
FiO_2	0.30
PEEP	5
set RR	10
total RR	32
set flow	75
set V_T	500 (6.7ml/kg)
V_E	21.8
PIP	45
PP	N/A

pH	7.52
$PaCO_2$	29
PaO_2	102
HCO_3	25.2
BE	+1.8

hemodynamics	
HR	125
BP	98/60

pharmacology
- fentanyl
- midazolam
- norepinephrine
- vasopressin
- milrinone

subjective / objective
- accessory muscle use
- agitated

Patient Scenario 3

Ten minutes later

Mode	volume-cycled
FiO_2	0.50
PEEP	5
set RR	10
total RR	24
set flow	75
set V_T	600 (8ml/kg)
V_E	14.8
PIP	32
PP	19

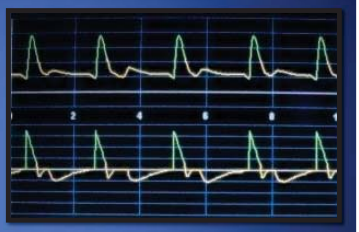
hemodynamics	
HR	102
BP	102/71

pharmacology
• fentanyl • midazolam • norepinephrine • vasopressin • milrinone

subjective / objective
• accessory muscle use • agitated

a) Increase the set volume
b) Change to spontaneous mode & wean to extubate
c) Decrease the inspiratory flow
d) Maintain settings
e) Increase midazolam

What would you recommend at this time?



Mode	VC
FiO_2	0.50
PEEP	5
set RR	10
total RR	24
set flow	75
set V_T	600 (8ml/kg)
V_E	14.8
PIP	32
PP	19

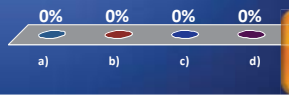
hemodynamics	
HR	102
BP	102/71

pharmacology
• fentanyl • midazolam • norepinephrine • vasopressin • milrinone

subjective / objective
• accessory muscle use • agitated

What would you recommend at this time?

a) Increase the set volume
b) Change to spontaneous mode & wean to extubate
c) Decrease the inspiratory flow
d) Maintain settings
e) Increase midazolam

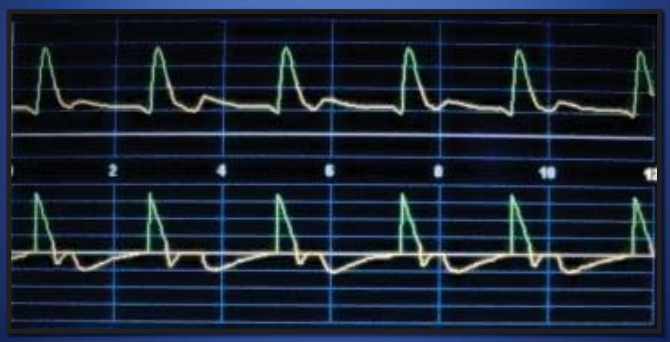


Assessment
Cycle dysynchrony – premature cycling

severe cycle dysynchrony

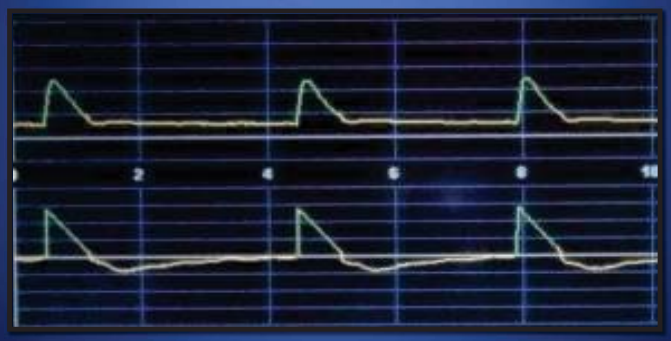
Assessment
Cycle dysynchrony – premature cycling

moderate cycle dysynchrony



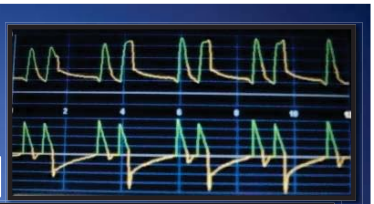
Assessment
Cycle dysynchrony – premature cycling

mild cycle dysynchrony



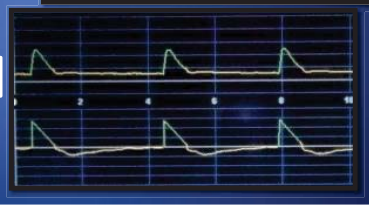
Assessment
Cycle dysynchrony – premature cycling

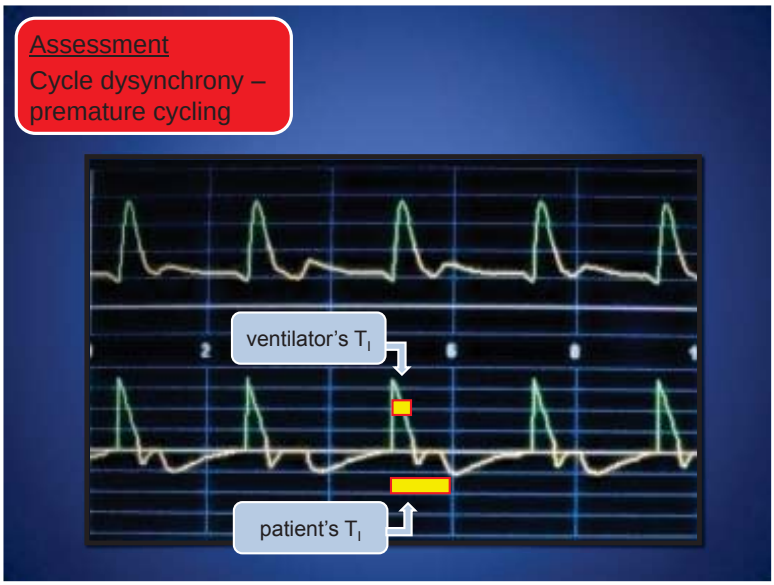
severe cycle dysynchrony

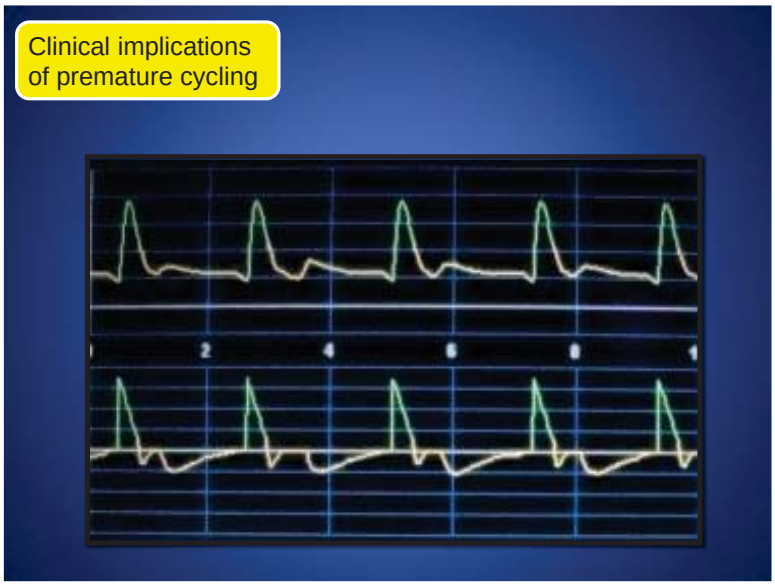


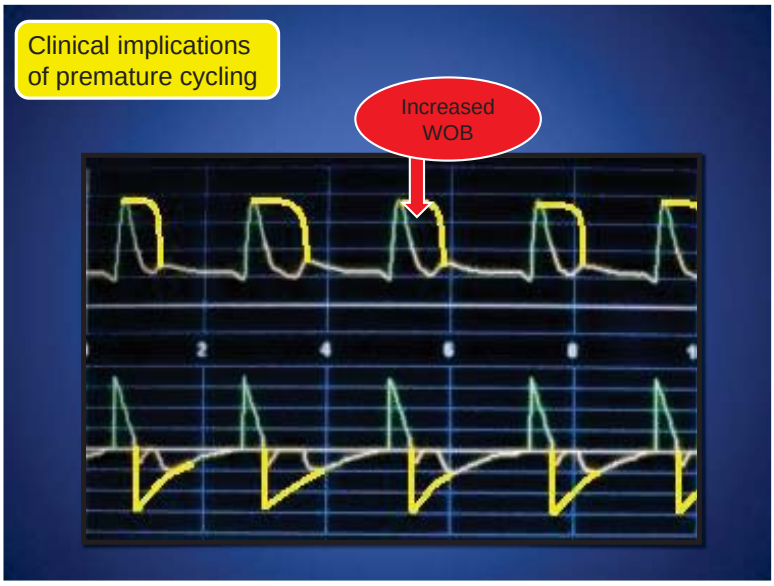
moderate cycle dysynchrony

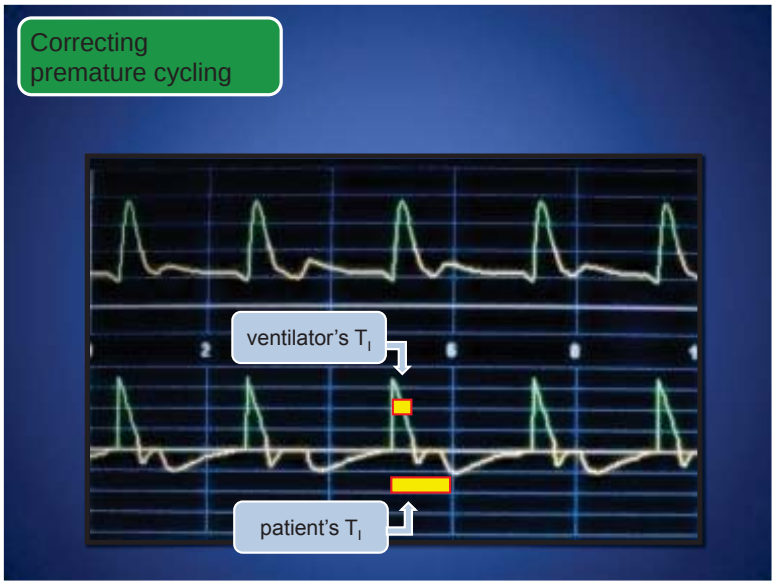
mild cycle dysynchrony



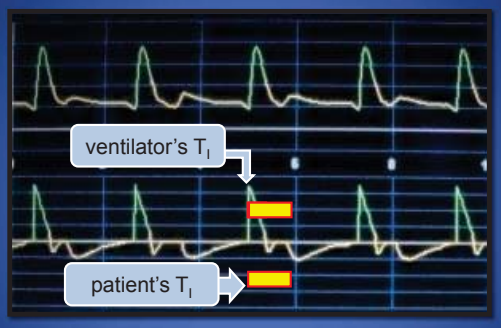

Assessment
Cycle dysynchrony – premature cycling
ventilator's T_I
patient's T_I


Clinical implications of premature cycling


Clinical implications of premature cycling
Increased WOB

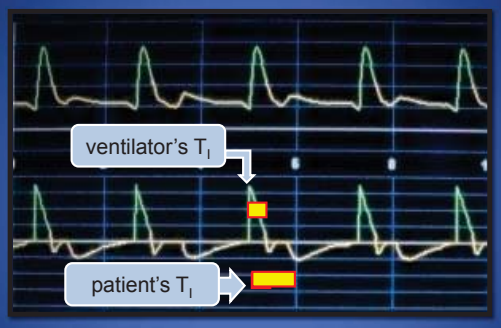

Correcting premature cycling
ventilator's T_I
patient's T_I

Correcting premature cycling



- To correct the problem, the ventilator's inspiratory time needs to be lengthened to match the patient's neural inspiratory time
- In CMV Volume, the flow can be decreased OR
- In CMV Volume, the volume can be increased

Correcting premature cycling

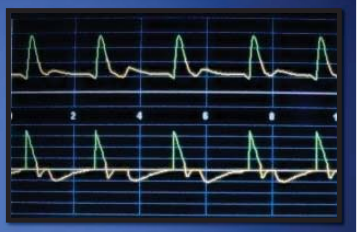


OR

- To correct the problem, the patient's neural inspiratory time needs to be shortened to match the ventilator's inspiratory time with sedation

a) Increase the set volume
b) Change to spontaneous mode & wean to extubate
c) Decrease the inspiratory flow
d) Maintain settings
e) Increase midazolam

What would you recommend at this time?



Mode	VC
FiO_2	0.50
PEEP	5
set RR	10
total RR	24
set flow	75
set V_T	600 (8ml/kg)
V_E	14.8
PIP	32
PP	19

hemodynamics	
HR	102
BP	102/71

pharmacology
• fentanyl • midazolam • norepinephrine • vasopressin • milrinone

subjective / objective
• accessory muscle use • agitated

Patient Scenario 4

What would you recommend at this time?

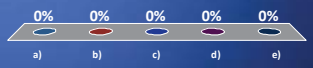
pH	7.29
$PaCO_2$	53
PaO_2	72
HCO_3	25
BE	+1
SaO_2	95%

IBW	60
HR	110
BP	87/61

a) Decrease the volume
b) Increase the inspiratory flow
c) Decrease the PEEP
d) Decrease the respiratory rate
e) Change to a flow trigger

What would you recommend at this time?

a) Decrease the volume
b) Increase the inspiratory flow
c) Decrease the PEEP
d) Decrease the respiratory rate
e) Change to a flow trigger



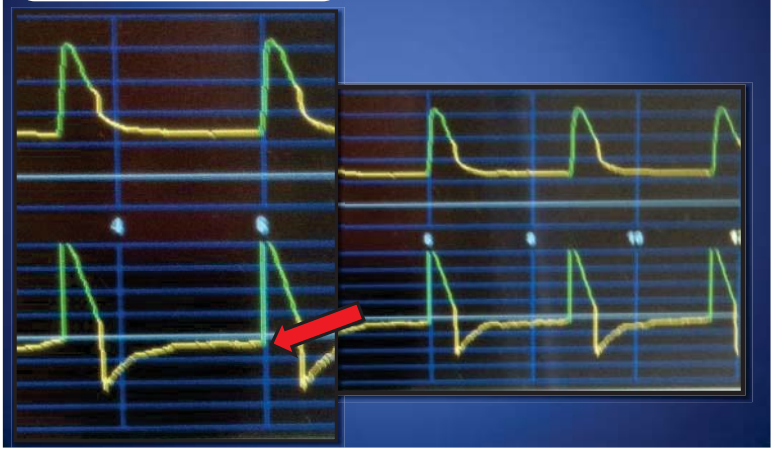
20
Countdown

Assessment
Expiratory dysynchrony – air trapping → auto-PEEP

- Expiratory hold to measure auto-PEEP
- Air-trapping or auto-PEEP can be difficult to measure quantitatively in the clinical setting

Assessment
Expiratory dysynchrony – air trapping → auto-PEEP

- If expiratory flow does not return to baseline, air-trapping is present



Assessment

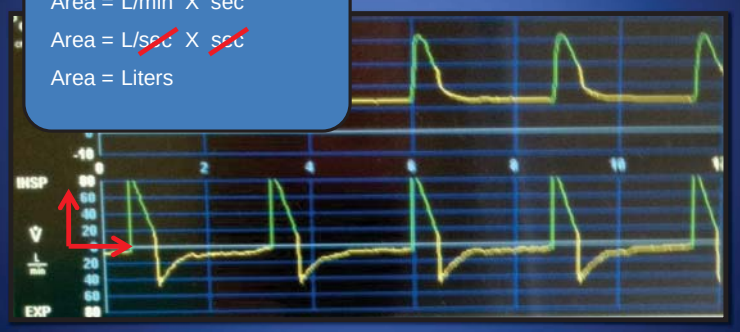
Expiratory dysynchrony – air trapping → auto-PEEP

- If the area under the expiratory flow curve is less than that of the inspiratory flow, then a degree of air trapping is present

Area = L/min X sec

Area = L/~~sec~~ X ~~sec~~

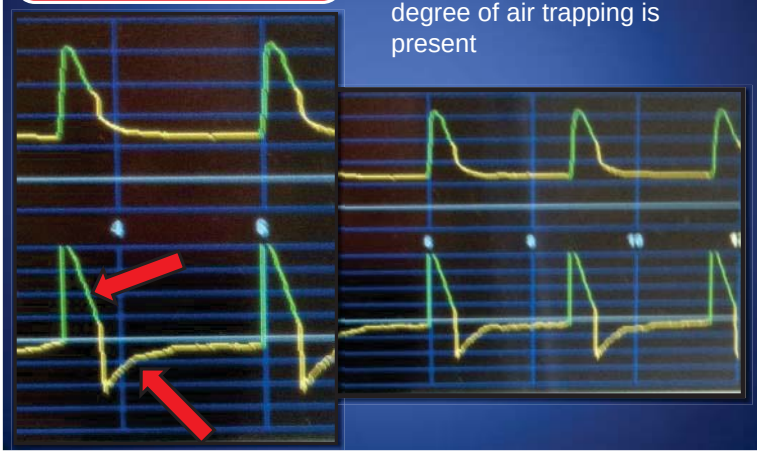
Area = Liters



Assessment

Expiratory dysynchrony – air trapping → auto-PEEP

- If the area under the expiratory flow curve is less than that of the inspiratory flow, then a degree of air trapping is present



Clinical implications of air-trapping/auto-PEEP

– Air-trapping → auto-PEEP can cause:

1) Increased work of breathing due to difficulty in triggering (ineffective triggering)
2) Decreased cardiac output and blood pressure

Correcting air-trapping/auto-PEEP

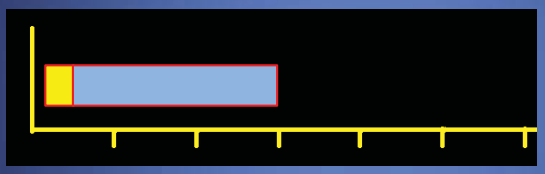
– To correct auto-PEEP the expiratory time must be lengthened
  – Expiratory time can be increased indirectly by decreasing the T_I in the appropriate manner dependent on the mode of ventilation
  – Expiratory time can be increased directly by decreasing the respiratory rate
    – If the patient is assisting above the set respiratory rate then pharmacological means may be necessary
  – If excessive expiratory time is required due to obstructed expiratory flow, then bronchodilator therapy should also be instituted

Correcting
air-trapping/auto-PEEP

Correcting
air-trapping/auto-PEEP

T_I
0.5 sec

T_E
2.5 sec



RR
20

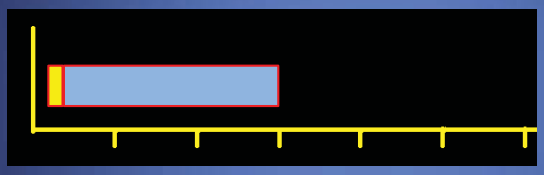
V_T
500

flow
60

Correcting
air-trapping/auto-PEEP

T_I
0.25 sec

T_E
2.75 sec



RR
20

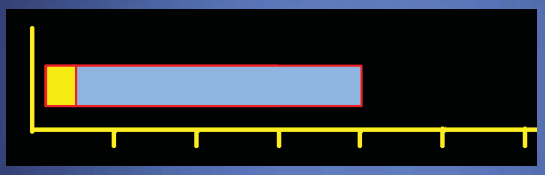
V_T
250

flow
90

Correcting
air-trapping/auto-PEEP

T_I
0.5 sec

T_E
3.5 sec



RR
15

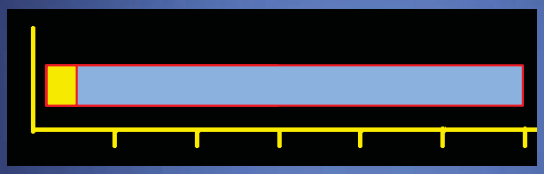
V_T
500

flow
60

Correcting air-trapping/auto-PEEP

T_I 0.5 sec

T_E 5.5 sec



RR 10

V_T 500

flow 60

What would you recommend at this time?

pH	7.29
$PaCO_2$	53
PaO_2	72
HCO_3	25
BE	+1
SaO_2	95%

IBW	60
HR	110
BP	87/61

a) Decrease the volume
b) Increase the inspiratory flow
c) Decrease the PEEP
d) Decrease the respiratory rate
e) Change to a flow trigger

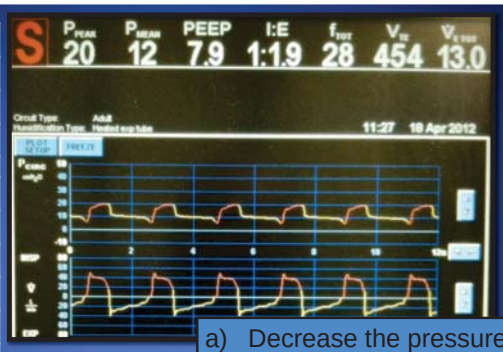
Patient Scenario 5

Mode	PS
FiO_2	0.30
PEEP	5
P_{INSP} (PS)	10
pH	7.43
$PaCO_2$	32
PaO_2	86
HCO_3	18.1
BE	-6.2
IBW	60 kg

hemodynamics	
HR	135
BP	142/91

pharmacology
• fentanyl
• midazolam (PRN)

Mode	PS
FiO_2	0.30
PEEP	5
P_{INSP} (PS)	10
pH	7.43
$PaCO_2$	32
PaO_2	86
HCO_3	18.1
BE	-6.2
IBW	60 kg



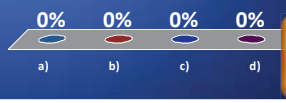
hemodynamics	
HR	135
BP	142/91

pharmacology
• fentanyl • midazolam (PRN)

a) Decrease the pressure support
b) Add bronchodilator to management plan
c) Increase the pressure support
d) Maintain current settings

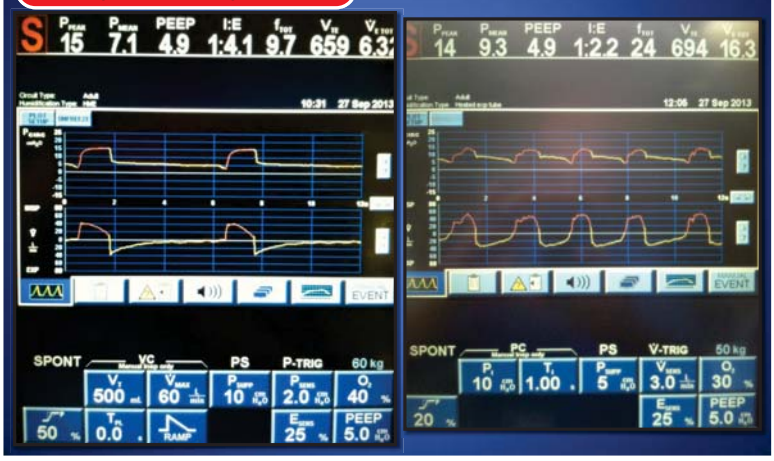
What would you recommend at this time?

A. Decrease the pressure support
B. Add bronchodilator to management plan
C. Increase the pressure support
D. Maintain current settings

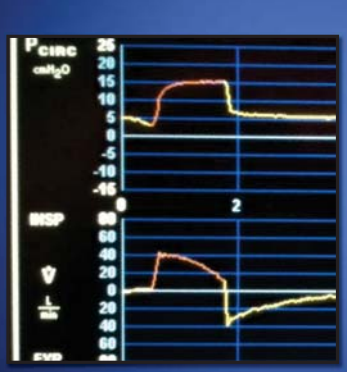


20

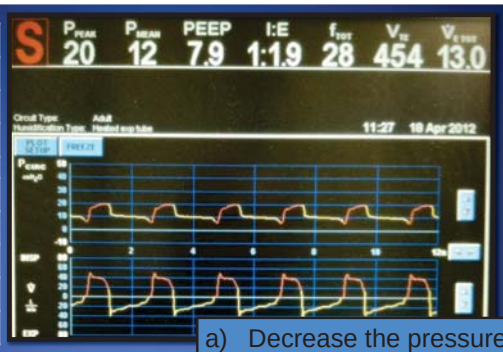
Assessment
Inspiratory dysynchrony – inadequate flow / pressure



Assessment
Inspiratory dysynchrony – inadequate flow / pressure



Mode	PS
FiO_2	0.30
PEEP	5
P_{INSP} (PS)	10
pH	7.43
$PaCO_2$	32
PaO_2	86
HCO_3	18.1
BE	-6.2



hemodynamics	
HR	135
BP	142/91

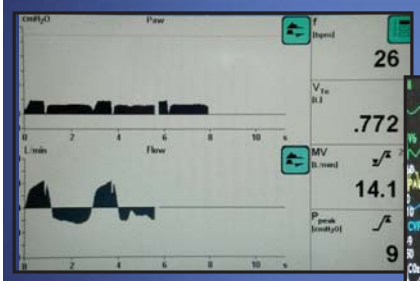
pharmacology
• fentanyl • midazolam (PRN)

a) Decrease the pressure support
b) Add bronchodilator to management plan
c) Increase the pressure support
d) Maintain current settings

Patient Scenario 6

Mode	CMV - Volume-targeted pressure		
FiO_2	0.50	V_T	500
PEEP	5	set RR	12
		T_I	0.80

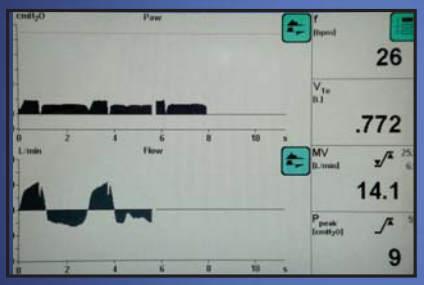
pH	7.33
$PaCO_2$	49
PaO_2	72
HCO_3	25
BE	+1
SaO_2	95%



What would you recommend at this time?

Mode	CMV - Volume-targeted pressure		
FiO_2	0.50	V_T	500
PEEP	5	set RR	12
		T_I	0.80

pH	7.33
$PaCO_2$	49
PaO_2	72
HCO_3	25
BE	+1
SaO_2	95%

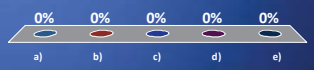


What would you recommend at this time?

a) Decrease the target volume
b) Increase the inspiratory time
c) Change to CMV - pressure
d) Decrease the inspiratory time
e) Maintain settings

What would you recommend at this time?

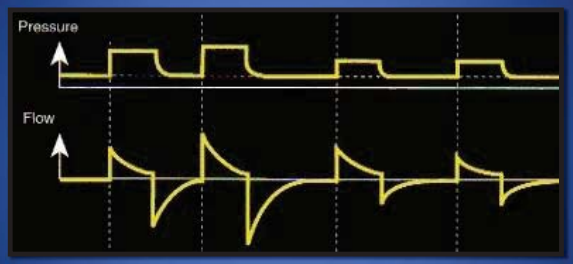
a) Decrease the target volume
b) Increase the inspiratory time
c) Change to CMV - pressure
d) Decrease the inspiratory time
e) Maintain settings



20
Countdown

Assessment
Inspiratory dysynchrony – inadequate flow / pressure

Assessment
Inspiratory dysynchrony – inadequate flow / pressure



- In the CMV volume-targeted, pressure mode, the ventilator measures the exhaled volume and then adjusts the inspiratory pressure on the subsequent breath, either up or down, to achieve a targeted tidal volume

Assessment
Inspiratory dysynchrony – inadequate flow / pressure

However, when patients begin to become distressed their inspiratory effort will initially increase

Assessment

Inspiratory dysynchrony – inadequate flow / pressure

However, when patients begin to become distressed their inspiratory effort will initially increase

↓

The ventilator will allow the flow and volume to be inspired by the patient because it is variable

Assessment

Inspiratory dysynchrony – inadequate flow / pressure

However, when patients begin to become distressed their inspiratory effort will initially increase

↓

The ventilator will allow the flow and volume to be inspired by the patient because it is variable

↓

This typically results in a larger-than-target exhaled volume

Assessment

Inspiratory dysynchrony – inadequate flow / pressure

However, when patients begin to become distressed their inspiratory effort will initially increase

↓

The ventilator will allow the flow and volume to be inspired by the patient because it is variable

↓

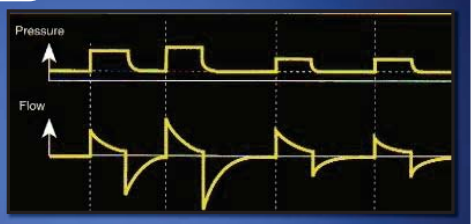
This typically results in a larger-than-target exhaled volume

↓

In this mode, the ventilator will decrease the inspiratory pressure on the next breath to maintain the target volume

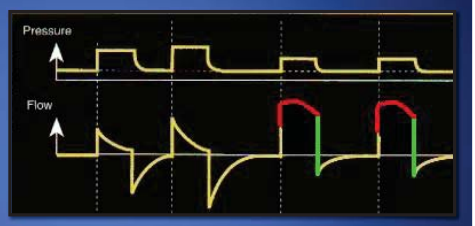
Assessment

Inspiratory dysynchrony – inadequate flow / pressure



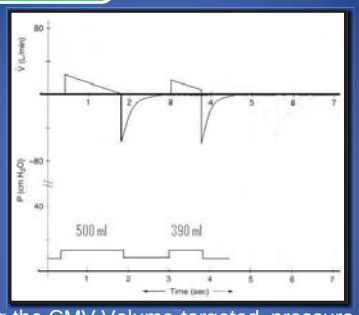
- The unintended consequence is that a decreased inspiratory pressure results in a decreased required flow from the ventilator

Clinical implications of inadequate flow / pressure



- This decrease in required flow increases the patient's work of breathing as they try to obtain their demand flow
- A vicious cycle is started as the ventilator decreases its level of support when the patient actually requires more support

Correcting inadequate flow / pressure

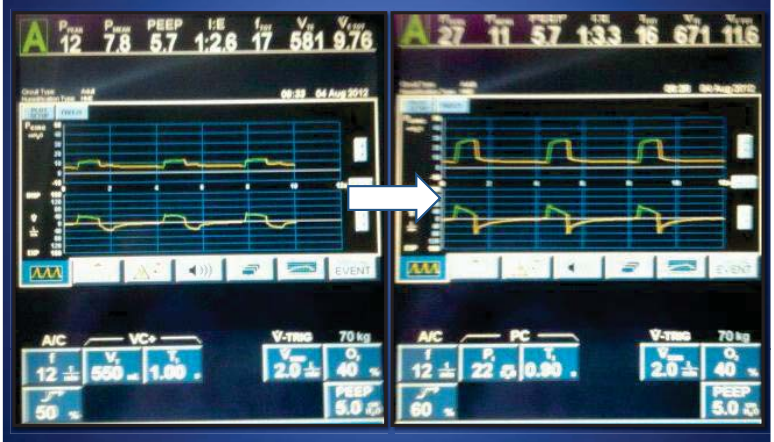


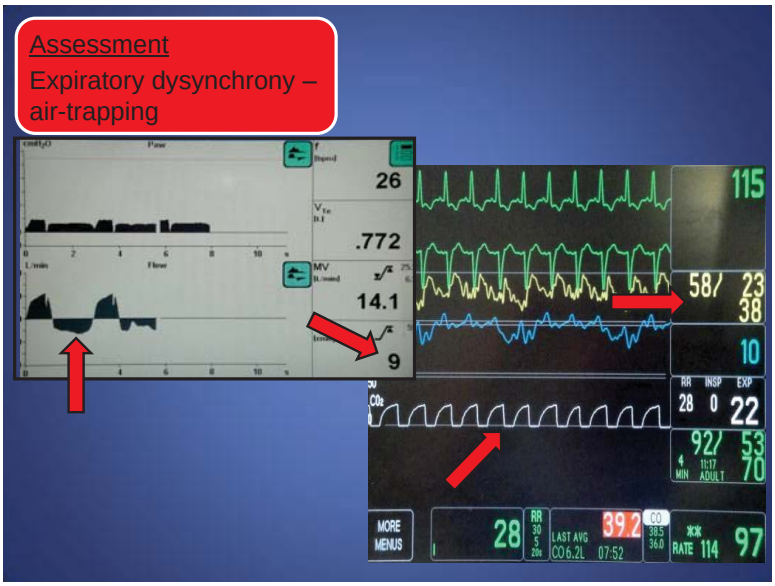
1. While maintaining the CMV Volume-targeted, pressure mode, you can decrease the T_I
   - Decreasing T_I will decrease the V_T on the first breath of the sequence
   - As a result of the decreased V_T the ventilator will increase the pressure, and therefore the required flow, to maintain the target volume

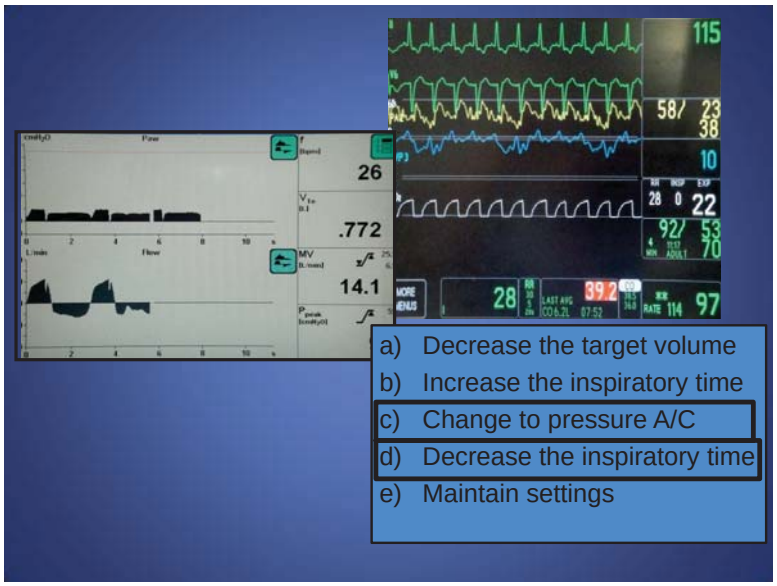
Correcting inadequate flow / pressure

2. While maintaining the CMV Volume-targeted, pressure mode, you can also increase the V_T
   - Increasing the target volume will require more pressure, and therefore more demand flow
3. Change the mode to CMV Pressure
   - You will be required to set an inspiratory pressure that does not vary
   - This set pressure will also ensure a required flow delivery
4. Change the mode to CMV Volume
   - Changing to this mode would require you to set a flow rate
   - A set flow rate would alleviate the work of breathing, provided it is adequate

Correcting inadequate flow / pressure

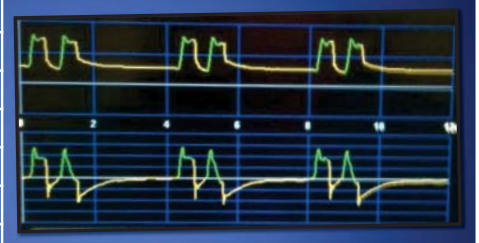






Patient Scenario 7

Mode	CMV pressure
FiO_2	0.50
PEEP	5
set RR	14
total RR	32
T_I	0.45
P_{INSP}	22
exh V_T	450-750
V_E	11.2



hemodynamics	
HR	85
BP	124/83

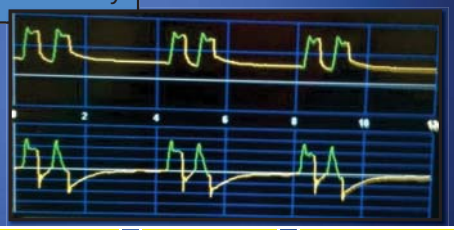
pharmacology
• propofol

subjective / objective
• No accessory muscle use

What would you recommend at this time?

a) Decrease the inspiratory time
b) Increase propofol
c) Increase the inspiratory pressure
d) Increase the inspiratory time
e) Decrease the trigger sensitivity

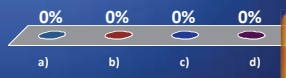
Mode	CMV-P
FiO_2	0.50
PEEP	5
set RR	14
total RR	32
T_I	0.45
P_{INSP}	22
exh V_T	450-750
V_E	11.2



hemodynamics		pharmacology	subjective / objective
HR	85	• propofol	• No accessory muscle use
BP	124/83		

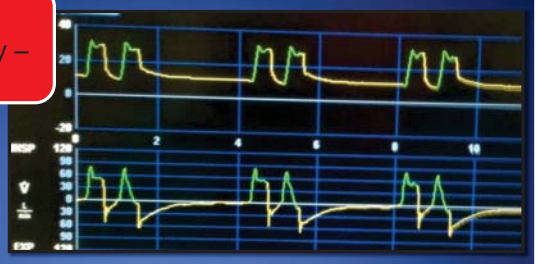
What would you recommend at this time?

a) Decrease the inspiratory time
b) Increase propofol
c) Increase the inspiratory pressure
d) Increase the inspiratory time
e) Decrease the trigger sensitivity



20

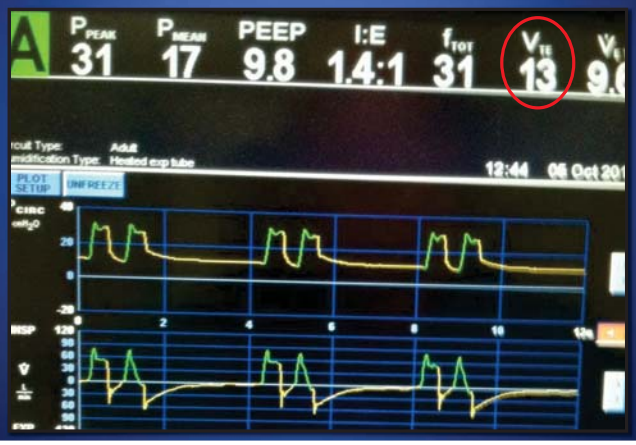
Assessment
Cycle dysynchrony – premature cycling

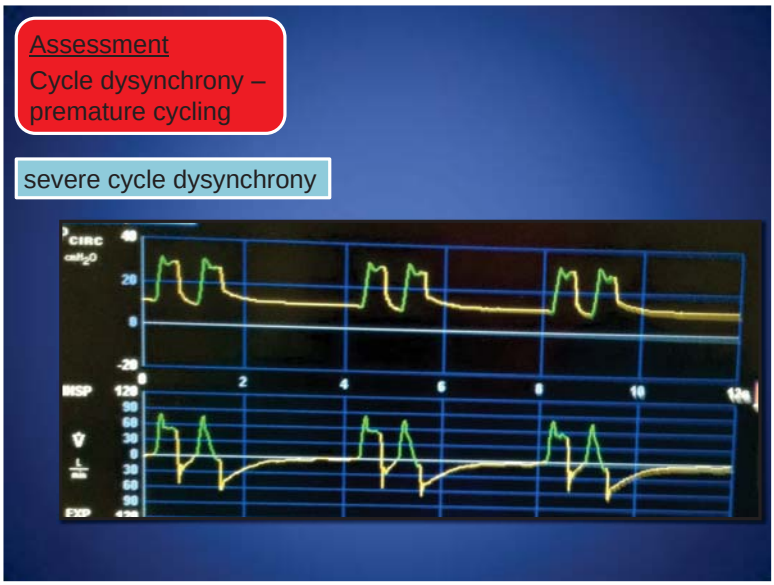


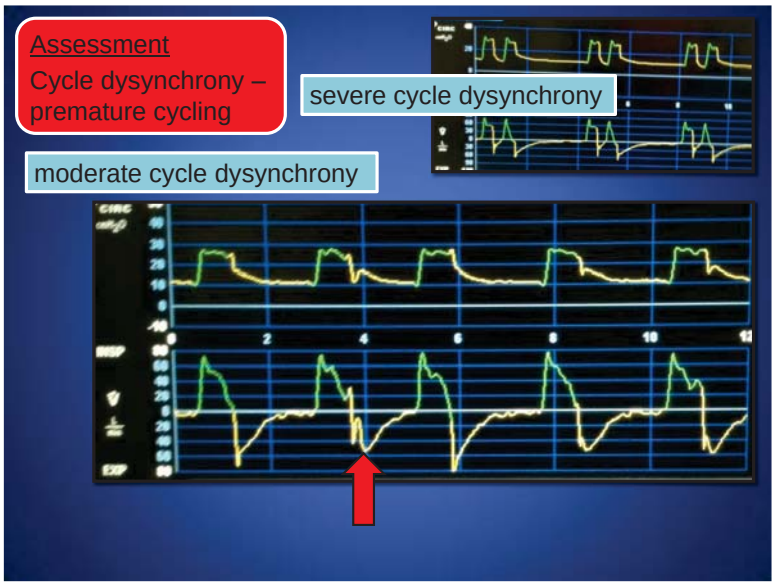
- Premature cycling or "double-triggering"
  - Caused by a dysynchrony between the patient's neural inspiratory time and the ventilator's inspiratory time
    1. The ventilator has cycled the inspiratory phase (set inspiratory time)
    2. However, the patient continues to inspire and expand their thoracic cage
    3. The pressure / flow in the circuit is thereby decreased and an additional breath is triggered without exhaling the previous

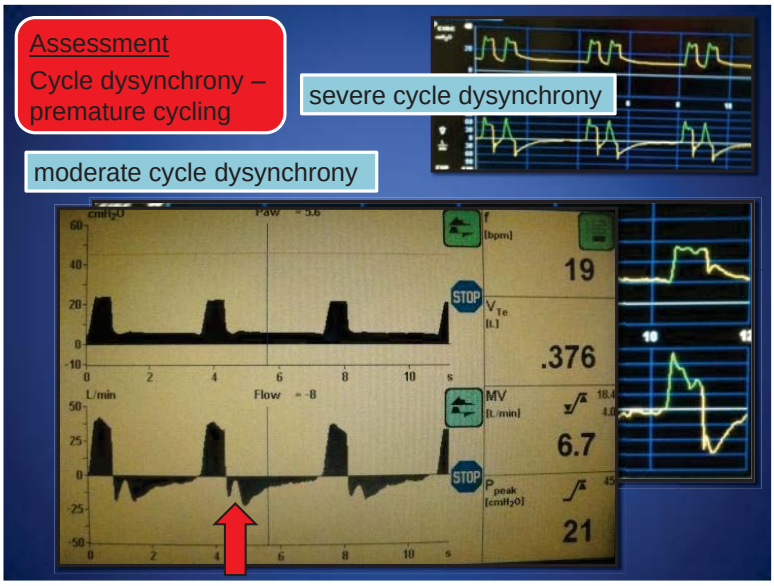
Assessment
Cycle dysynchrony – premature cycling

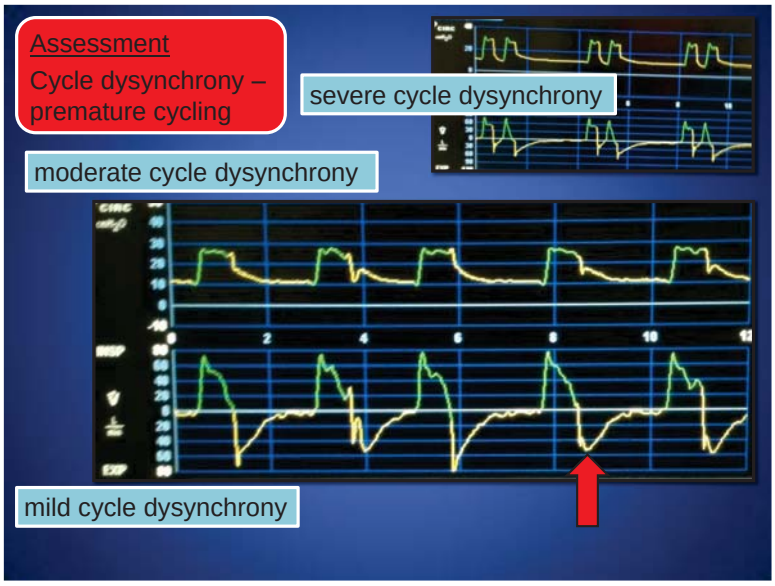
- In addition to the graphical presentation used to identify premature cycling, the exhaled V_T will read very low for the breaths that were not exhaled followed by a "very large volume"



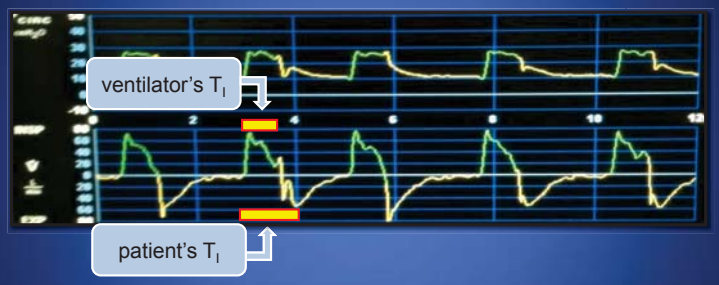

Assessment
Cycle dysynchrony – premature cycling
severe cycle dysynchrony


Assessment
Cycle dysynchrony – premature cycling
severe cycle dysynchrony
moderate cycle dysynchrony


Assessment
Cycle dysynchrony – premature cycling
severe cycle dysynchrony
moderate cycle dysynchrony
19
.376
6.7
21


Assessment
Cycle dysynchrony – premature cycling
severe cycle dysynchrony
moderate cycle dysynchrony
mild cycle dysynchrony

Correcting premature cycling

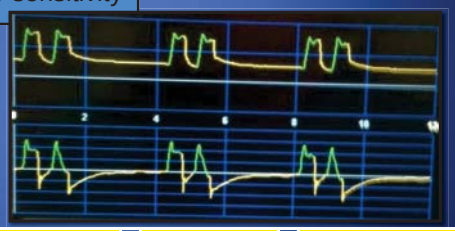


- To correct the problem, the ventilator's inspiratory time needs to be lengthened to match the patient's neural inspiratory time
- In CMV pressure the inspiratory time can be directly increased

Correcting premature cycling

a) Decrease the inspiratory time
b) Increase propofol
c) Increase the inspiratory pressure
d) Increase the inspiratory time
e) Decrease the trigger sensitivity

Mode	CMV-P
FiO_2	0.50
PEEP	5
set RR	14
total RR	32
T_I	0.45
P_{INSP}	22
exh V_T	450-750
V_E	11.2



hemodynamics	
HR	85
BP	124/83

pharmacology
• propofol

subjective / objective
• No accessory muscle use

Patient Scenario 8

- 53 year old female (IBW 58 kg)

- Admitted for perforated bowel
- Emergent exploratory laparotomy for bowel repair on hospital day #1
- Returned to operating room on hospital day #7 for exploratory laparotomy due to accumulation of intra-abdominal abscess

- Post-operatively, the patient was assessed

pH	7.28
$PaCO_2$	58
PaO_2	67
HCO_3	16.4
BE	-8.3
SvO_2	53%
Lactate	7.4
WBC	21.2

hemodynamics	
HR	132
BP	91/60
BT	39.2°C

pharmacology
• fentanyl • propofol • norepinephrine • vasopressin

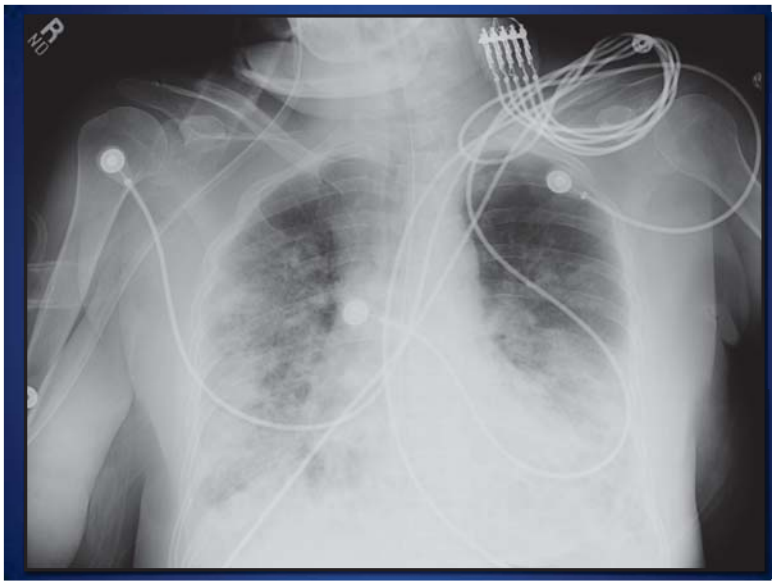
subjective / objective
• accessory muscle use • agitated

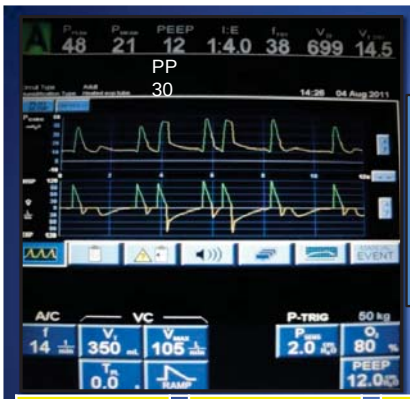
pH	7.28
$PaCO_2$	58
PaO_2	67
HCO_3	16.4
BE	-8.3
SvO_2	53%
Lactate	7.4
WBC	21.2

hemodynamics	
HR	132
BP	91/60
BT	39.2°C

pharmacology
• fentanyl • propofol • norepinephrine • vasopressin

subjective / objective
• accessory muscle use • agitated





What would you recommend at this time?

a) Increase the set volume
b) Decrease the inspiratory flow
c) Increase the set respiratory rate
d) Change to CMV pressure mode
e) Administer vecuronium

hemodynamics	
HR	132
BP	91/60
BT	39.2°C

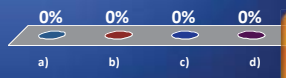
pharmacology
• fentanyl • propofol • norepinephrine • vasopressin

subjective / objective
• accessory muscle use • agitated

pH	7.28
$PaCO_2$	58
PaO_2	67
HCO_3	16.4
BE	-8.3
SvO_2	53%
Lactate	7.4
WBC	21.2

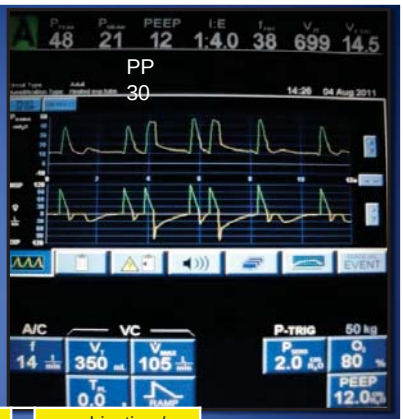
What would you recommend at this time?

a) Increase the set volume
b) Decrease the inspiratory flow
c) Increase the set respiratory rate
d) Change to CMV pressure mode
e) Administer vecuronium



20

Assessment
Cycle dysynchrony – premature cycling



pH	7.28
$PaCO_2$	58
PaO_2	67
HCO_3	16.4
BE	-8.3
SvO_2	53%
Lactate	7.4
WBC	21.2

hemodynamics	
HR	132
BP	91/60
BT	39.2°C

pharmacology
• fentanyl • propofol • norepinephrine • vasopressin

subjective / objective
• accessory muscle use • agitated

Assessment
•Septic shock / hypotension
•ARDS

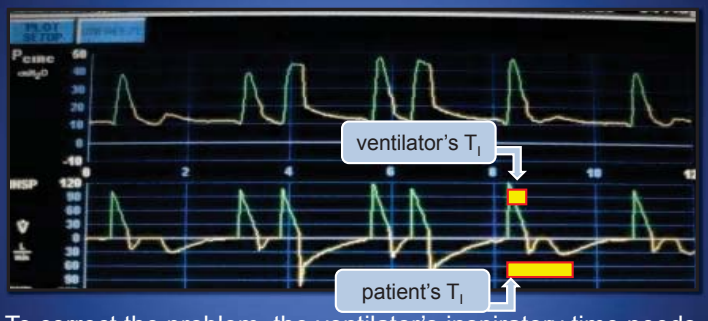
pH	7.28
$PaCO_2$	58
PaO_2	67
HCO_3	16.4
BE	-8.3
SvO_2	53%
Lactate	7.4
WBC	21.2

hemodynamics	
HR	132
BP	91/60
BT	39.2°C

pharmacology
• fentanyl • propofol • norepinephrine • vasopressin

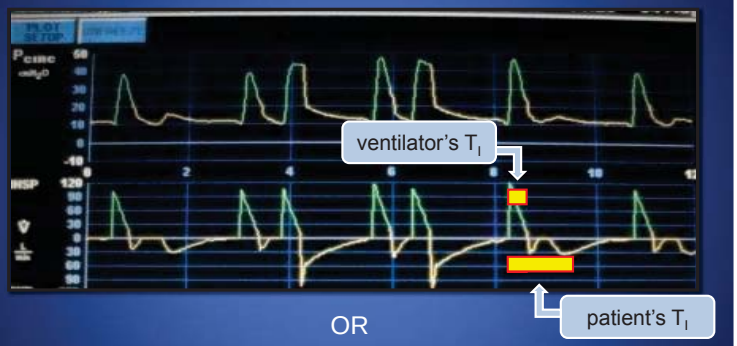
subjective / objective
• accessory muscle use • agitated

Correcting premature cycling



- To correct the problem, the ventilator's inspiratory time needs to be lengthened to match the patient's neural inspiratory time
- In volume A/C, the flow can be decreased OR
- In volume A/C, the volume can be increased

Correcting premature cycling



OR

- To correct the problem, the patient's neural inspiratory time needs to be shortened to match the ventilator's inspiratory time with sedation

a) Increase the set volume
b) Decrease the inspiratory flow
c) Increase the set respiratory rate
d) Change to CMV pressure
e) Administer vecuronium

hemodynamics	
HR	132
BP	91/60
BT	39.2°C

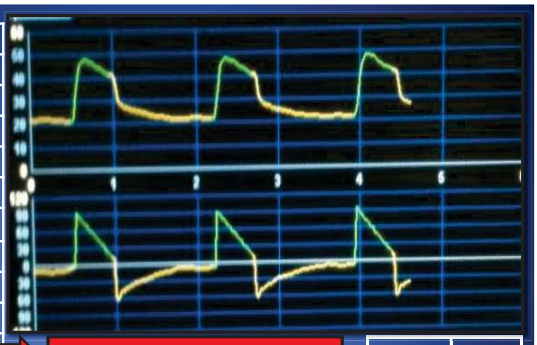
pharmacology
• fentanyl
• propofol
• norepinephrine
• vasopressin

subjective / objective
• accessory muscle use
• agitated

pH	7.28
$PaCO_2$	58
PaO_2	67
HCO_3	16.4
BE	-8.3
SvO_2	53%
Lactate	7.4
WBC	21.2

- The patient was volume resuscitated over the next several hours according to sepsis resuscitation guidelines and antibiotics were started
- Six hours later the patient was reassessed

Mode	CMV - V
FiO_2	1.0
PEEP	20
set RR	35
total RR	35
set flow	90
set V_T	350 (6ml/kg)
V_E	21.8
PIP	48
PP	34
MAP	30



RM at 40cmH_2O 4-5 times/hr

hemodynamics	
HR	118
BP	94/63
BT	39.2°C

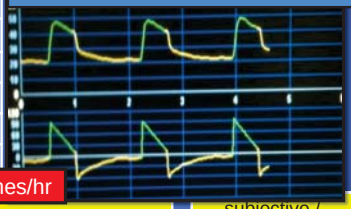
pharmacology
- fentanyl
- propofol
- vecuronium (PRN)
- norepinephrine
- vasopressin

subjective / objective
- accessory muscle use
- agitated

pH	7.17
$PaCO_2$	72
PaO_2	67
HCO_3	19.8
BE	-5.3
SvO_2	62%
Lactate	4.1

Mode	CMV - V
FiO_2	1.0
PEEP	20
set RR	35
total RR	35
set flow	90
set V_T	350 (6ml/kg)
V_E	21.8
PIP	48
PP	34
MAP	30

a) Increase the set volume
b) Put the patient into the prone position
c) Increase the set respiratory rate
d) Change to CMV pressure mode
e) Change to airway pressure release
f) Change to high frequency oscillatory ventilation



RM at 40cmH_2O 4-5 times/hr

hemodynamics	
HR	118
BP	94/63
BT	39.2°C

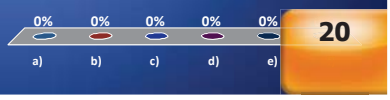
pharmacology
- fentanyl
- propofol
- vecuronium (PRN)
- norepinephrine
- vasopressin

subjective / objective
- accessory muscle use
- agitated

pH	7.17
$PaCO_2$	72
PaO_2	67
HCO_3	19.8
BE	-5.3
SvO_2	62%
Lactate	4.1

What would you recommend at this time?

a) Increase the set volume
b) Put the patient into the prone position
c) Increase the set respiratory rate
d) Change to CMV pressure mode
e) Change to airway pressure release
f) Change to high frequency oscillatory ventilation



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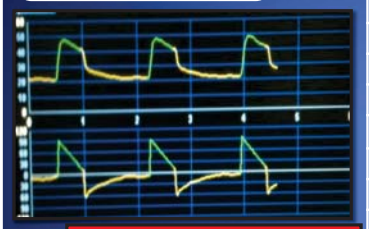
Assessment
Failure of ARDSnet



Mode	CMV V
FiO_2	1.0
PEEP	20
set RR	35
total RR	35
set flow	90
set V_T	350 (6ml/kg)
V_E	21.8
PIP	48
PP	34
MAP	30

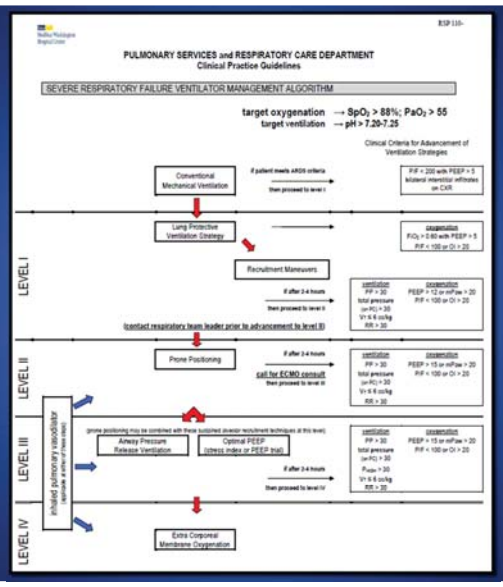
RM at 40cmH_2O 4-5 times/hr

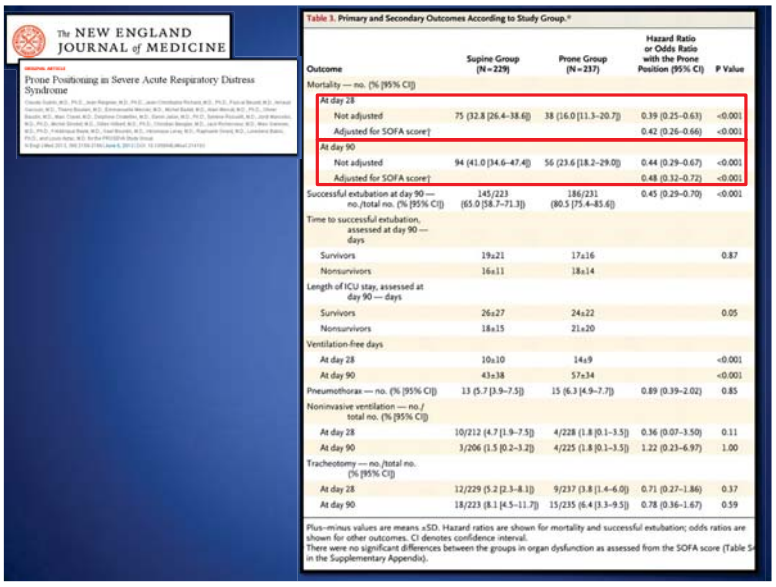
hemodynamics	
HR	118
BP	94/63
BT	39.2°C

pharmacology
- fentanyl
- propofol
- vecuronium (PRN)
- norepinephrine
- vasopressin

subjective / objective
- accessory muscle use
- agitated

pH	7.17
$PaCO_2$	72
PaO_2	67
HCO_3	19.8
BE	-5.3
SvO_2	62%
Lactate	4.1





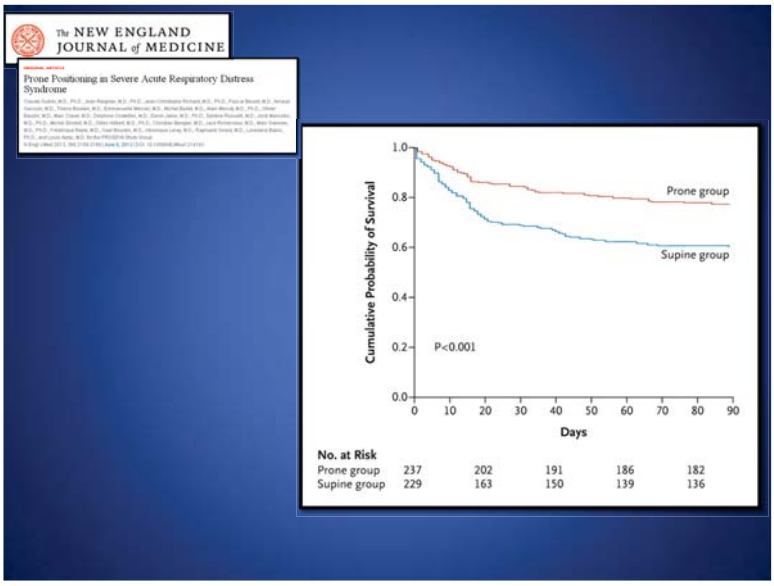
The NEW ENGLAND JOURNAL of MEDICINE

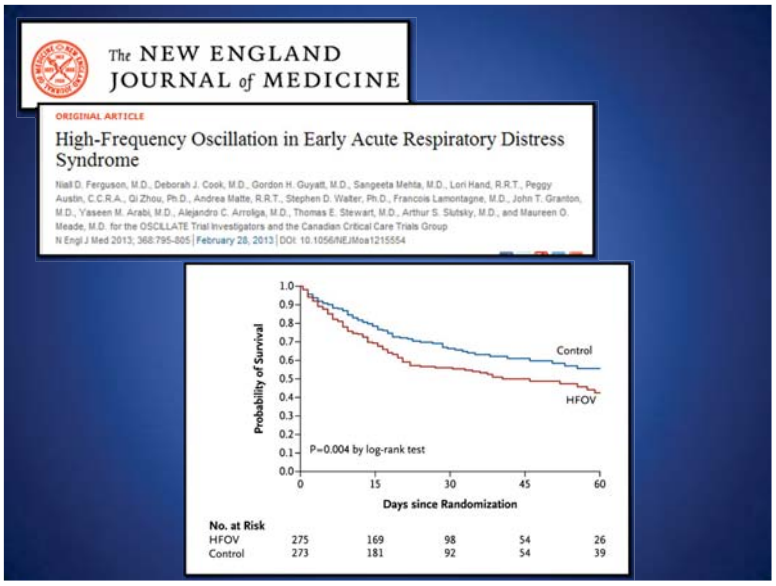
Prone Positioning in Severe Acute Respiratory Distress Syndrome

Table 3. Primary and Secondary Outcomes According to Study Group.*

Outcome	Supine Group (N = 229)	Prone Group (N = 237)	Hazard Ratio or Odds Ratio with the Prone Position (95% CI)	P Value
Mortality — no. (% [95% CI])				
At day 28				
Not adjusted	75 (32.8 [26.4–38.6])	38 (16.0 [11.3–20.7])	0.39 (0.25–0.63)	<0.001
Adjusted for SOFA score†			0.42 (0.26–0.66)	<0.001
At day 90				
Not adjusted	94 (41.0 [34.6–47.4])	56 (23.6 [18.2–29.0])	0.44 (0.29–0.67)	<0.001
Adjusted for SOFA score†			0.48 (0.32–0.72)	<0.001
Successful extubation at day 90 — no./total no. (% [95% CI])	145/223 (65.0 [58.7–71.3])	186/231 (80.5 [75.4–85.6])	0.45 (0.29–0.70)	<0.001
Time to successful extubation, assessed at day 90 — days				
Survivors	19±21	17±16		0.87
Nonsurvivors	16±11	18±14		
Length of ICU stay, assessed at day 90 — days				
Survivors	26±27	24±22		0.05
Nonsurvivors	18±15	21±20		
Ventilation-free days				
At day 28	10±10	14±9		<0.001
At day 90	43±38	57±34		<0.001
Pneumothorax — no. (% [95% CI])	13 (5.7 [3.9–7.5])	15 (6.3 [4.9–7.7])	0.89 (0.39–2.02)	0.85
Noninvasive ventilation — no./total no. (% [95% CI])				
At day 28	10/212 (4.7 [1.9–7.5])	4/228 (1.8 [0.1–3.5])	0.36 (0.07–3.50)	0.11
At day 90	3/206 (1.5 [0.2–3.2])	4/225 (1.8 [0.1–3.5])	1.22 (0.23–6.97)	1.00
Tracheotomy — no./total no. (% [95% CI])				
At day 28	12/229 (5.2 [2.3–8.1])	9/237 (3.8 [1.4–6.0])	0.71 (0.27–1.86)	0.37
At day 90	18/223 (8.1 [4.5–11.7])	15/235 (6.4 [3.3–9.5])	0.78 (0.36–1.67)	0.59

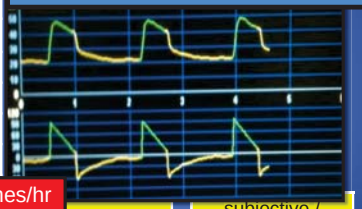
Plus–minus values are means ±SD. Hazard ratios are shown for mortality and successful extubation; odds ratios are shown for other outcomes. CI denotes confidence interval.
There were no significant differences between the groups in organ dysfunction as assessed from the SOFA score (Table S4 in the Supplementary Appendix).





Mode	VC
FiO_2	1.0
PEEP	20
set RR	35
total RR	35
set flow	90
set V_T	350 (6ml/kg)
V_E	21.8
PIP	48
PP	34
MAP	30

a) Increase the set volume
b) Put the patient into the prone position
c) Increase the set respiratory rate
d) Change to CMV pressure mode
e) Change to airway pressure release
f) Change to high frequency oscillatory ventilation



RM at 40cmH_2O 4-5 times/hr

hemodynamics	
HR	118
BP	94/63
BT	39.2°C

pharmacology
- fentanyl
- propofol
- vecuronium (PRN)
- norepinephrine
- vasopressin

subjective / objective
- accessory muscle use
- agitated

pH	7.17
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PaO_2	67
HCO_3	19.8
BE	-5.3
SvO_2	62%
Lactate	4.1

Summary

Continuous Mandatory Ventilation

CMV Volume

CMV Pressure

CMV Volume-Targeted Pressure

Trigger dysynchrony

Inspiratory dysynchrony

Cycle dysynchrony

Expiratory dysynchrony

Continuous Spontaneous Ventilation

csv CPAP

csv Pressure Support

csv Volume-Targeted Pressure

Trigger dysynchrony

Inspiratory dysynchrony

Cycle dysynchrony

Expiratory dysynchrony