Handling of ventilator
basic and novel modes

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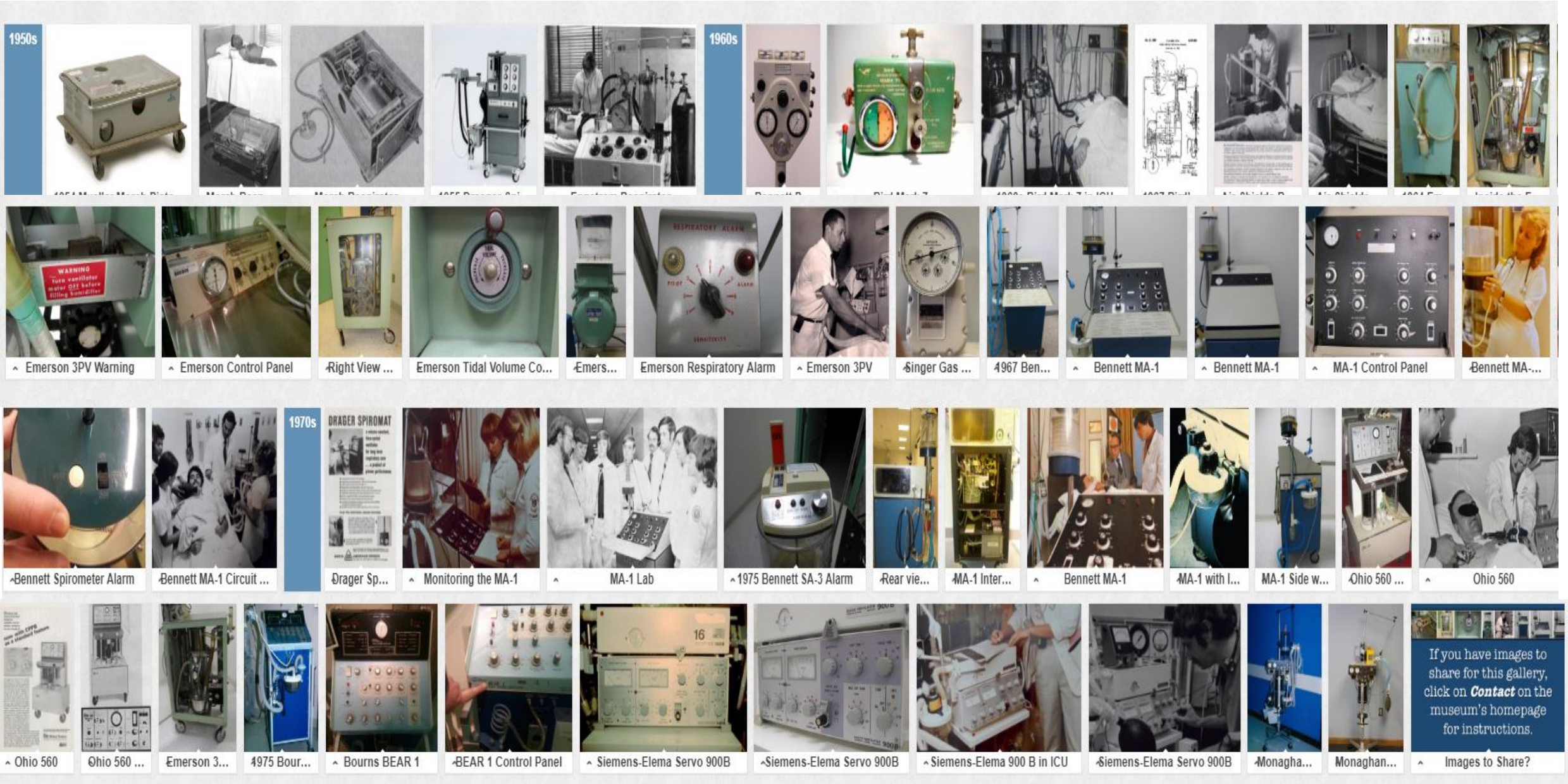
Disclosure

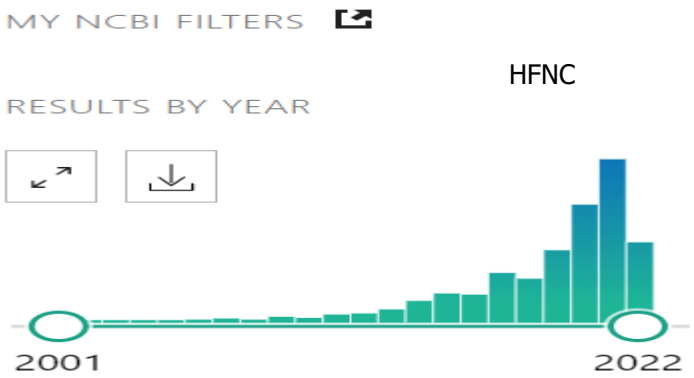
I do not have any potential conflicts of interest to disclose.

Early ICU Ventilation



http://museum.aarc.org/gallery/early-icu-ventilators/

機械通氣發展



1928

Negative ventilation

1955

1960

1980

Iron lung

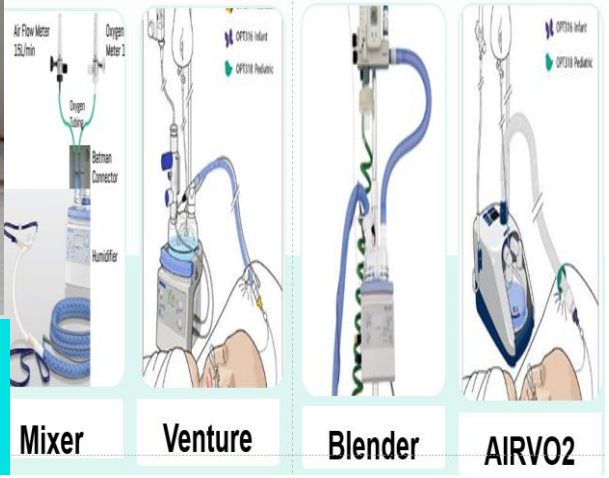
Chest Cuirass (shell)

Bird

VC-MV

CPAP、BiPAP

HFOT



1928年設計
1937年開始臨床使用
1950年代小兒麻痺流行

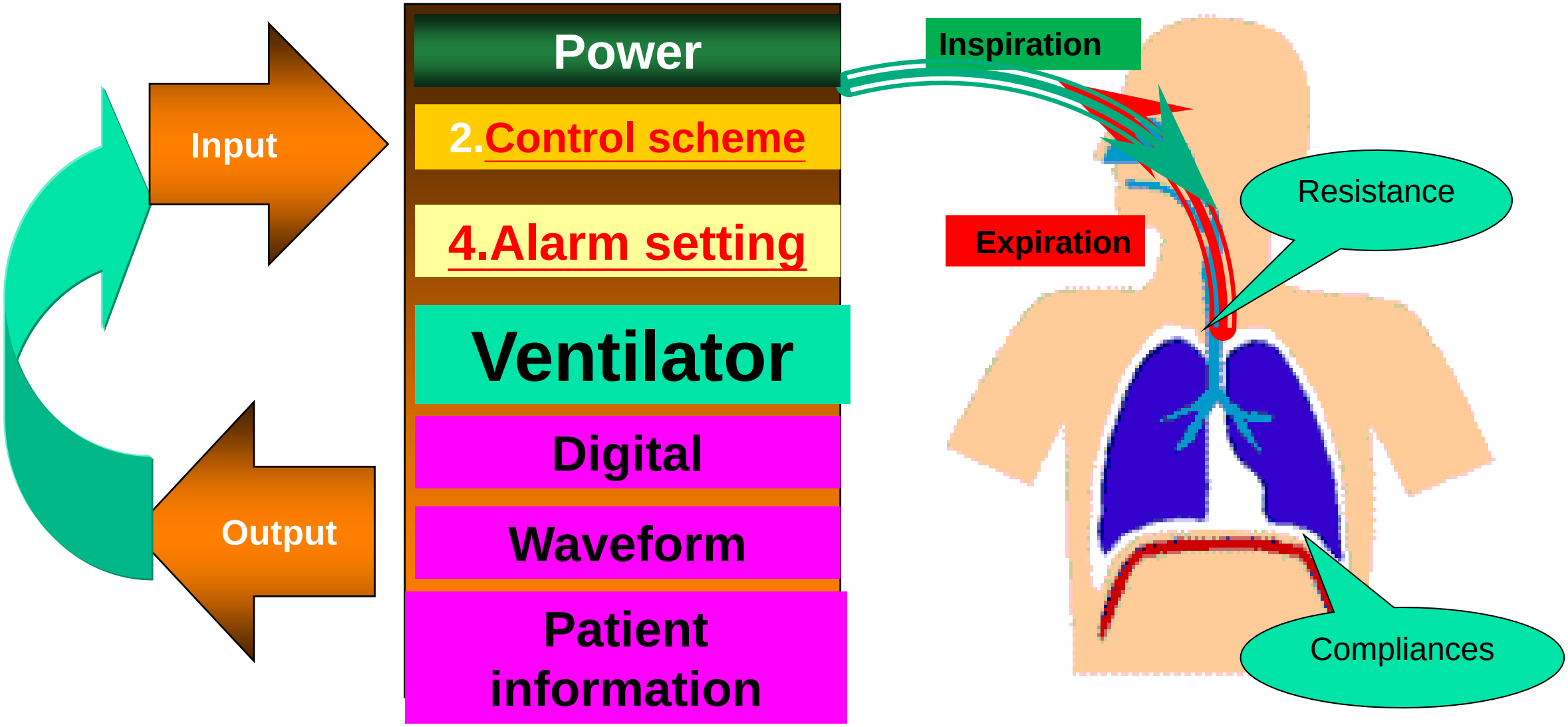
1950年代小兒麻痺流行

1960年第一台容積控制呼吸器

1980年鼻面罩CPAP治療OSA
1989年nasal mask + PS治療急性呼吸衰竭

http://museum.aarc.org/gallery/early-icu-ventilators/

A Patient-Ventilator System



控制設計的內容
Control Scheme

- 控制參數（ Control Variables ）
- 呼吸週期參數 (Phase Variables)
- 條件參數 (Conditional Variables)
- 通氣模式 (Mode of Ventilation)
- 控制次選項(Control subsystems)

臨床上要選哪一個通氣模式?

ASV

PPS

PS

PAV

autoFlow

PRVC

AMV

APRV

PLV

Auto mode

ASB

IPPV

Combined

ILV

Specialty

CSV

VS

MMV

SIMV

VAPS

CPAP

VCV

BIPAP

CMV

BIPAP

PCV

Invasive and Noninvasive Ventilatory Support

- Invasive positive pressure ventilation (IPPV)
  - Positive pressure ventilation delivered through a invasive interface
  - Invasive interface: endotracheal tube, tracheostomy tube
- Noninvasive positive pressure ventilation (NPPV、NIPPV、NPV)
  - Positive pressure ventilation delivered through a noninvasive interface.
  - Noninvasive interface: nasal mask, facemask or nasal plugs

Full and Partial Ventilatory Support

- Full Ventilatory Support (FVS)
  ventilator provides all the energy necessary to maintain effective alveolar ventilation ($PaCO_2$ < 45 mmHg, RR>8 BPM)
- Partial Ventilatory Support (PVS)
  ventilator provides in the work of breathing (WOB) to help maintain effective alveolar ventilation,

https://thoracickey.com/selecting-the-ventilator-and-the-mode/#s0045

Ventilatory Modes

- **Conventional modes**
  - **CMV**
    - **Continuous (Control) Mandatory Ventilation**
  - **IMV**
    - **Intermittent Mandatory Ventilation**
  - **CSV**
    - **Continuous Spontaneous Ventilation**
- **Additional modes**

Volume Control
Pressure Control
Dual Control

Ventilatory Modes

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- **Additional modes**

Volume Control
Pressure Control
Dual Control

Ventilatory Modes

TABLE 42-1

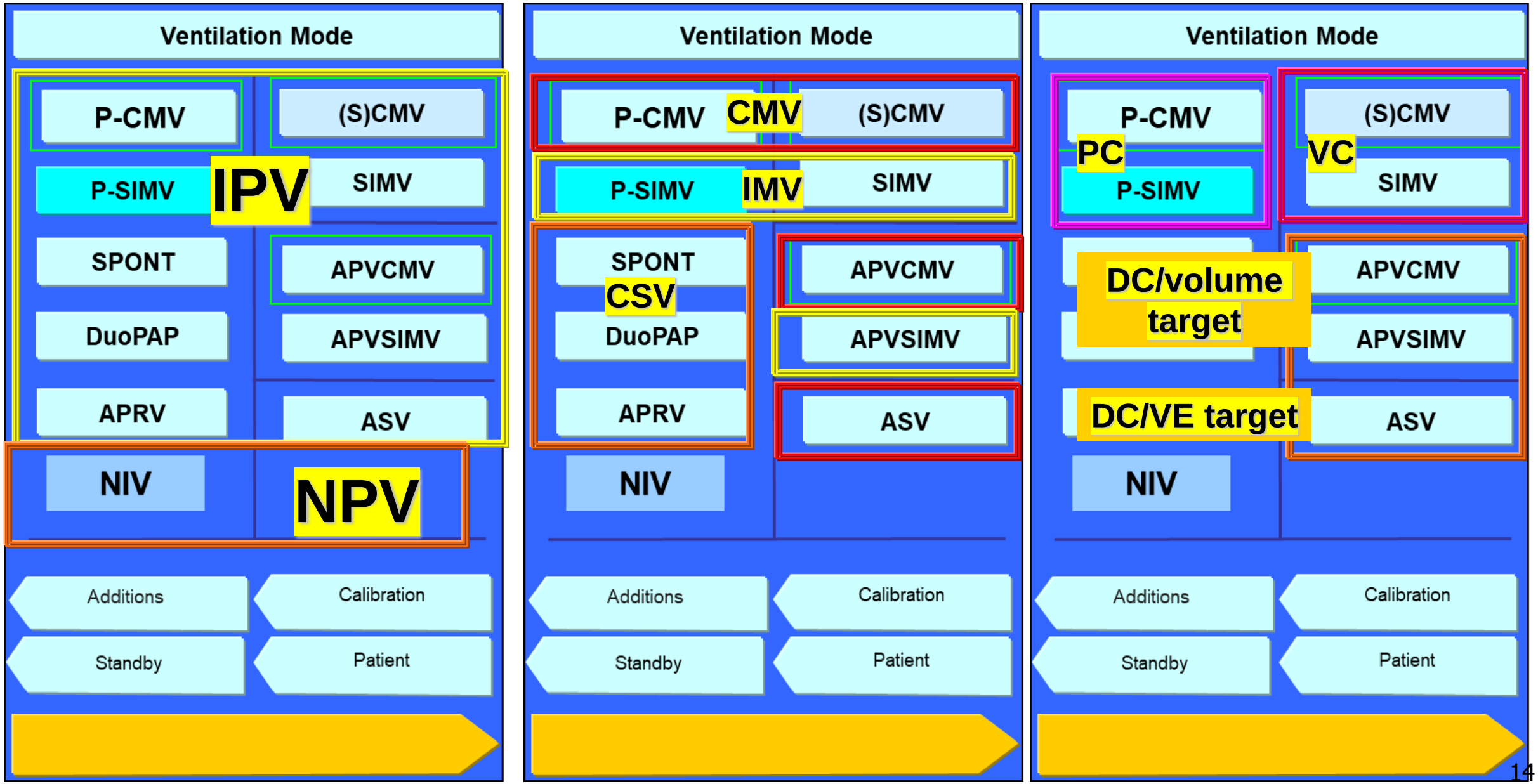
All Modes of Ventilation Can Be Characterized by One of These Nine Breathing Patterns

Breath Control Variable	Breath Sequence	Abbreviation
Volume (control)	Continuous mandatory ventilation	VC-CMV
	Intermittent mandatory ventilation	VC-IMV
	Continuous spontaneous ventilation	VC-CSV
Pressure (control)	Continuous mandatory ventilation	PC-CMV
	Intermittent mandatory ventilation	PC-IMV
	Continuous spontaneous ventilation	PC-CSV
Dual (control)	Continuous mandatory ventilation	DC-CMV
	Intermittent mandatory ventilation	DC-IMV
	Continuous spontaneous ventilation	DC-CSV

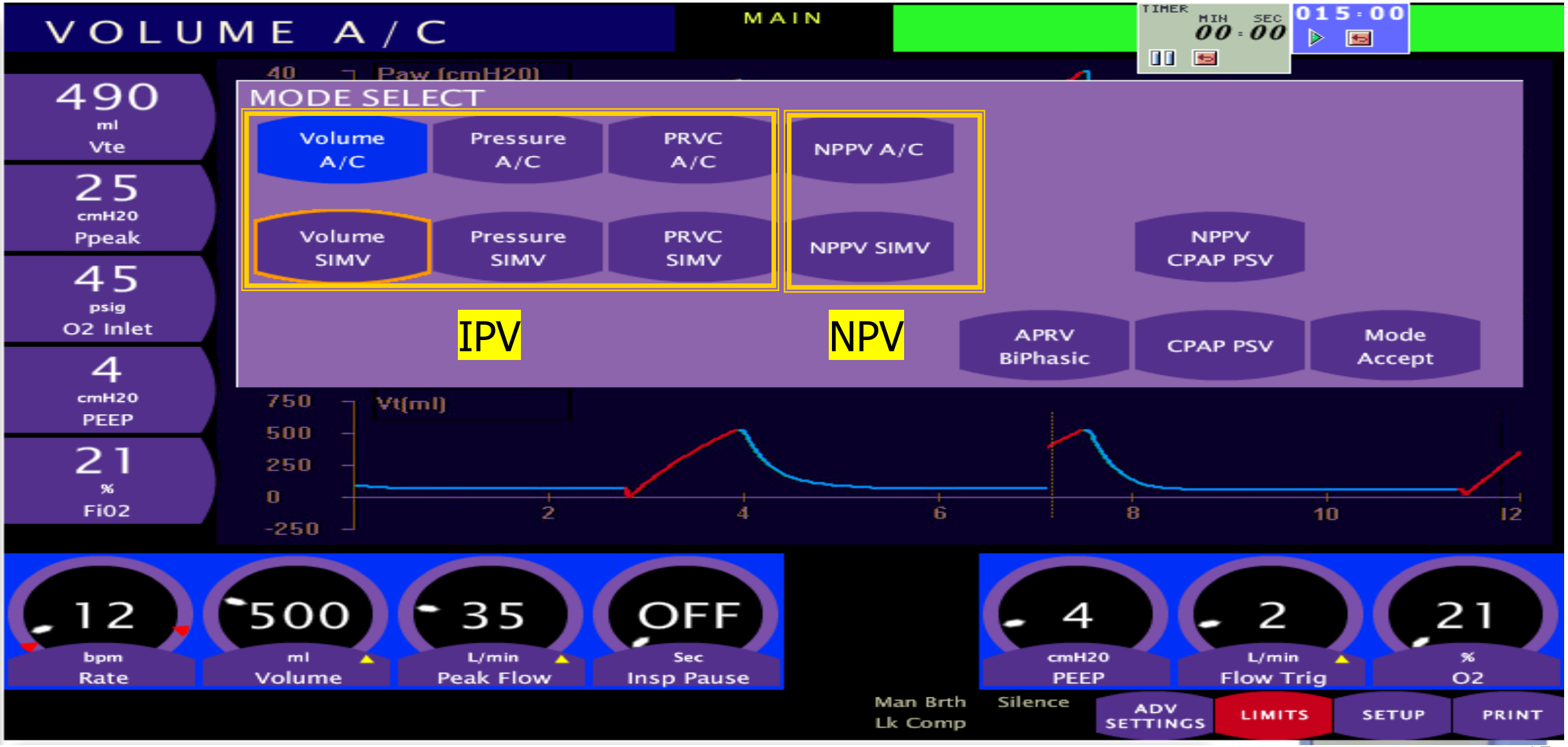
Ventilatory Modes

- Conventional modes
- Additional modes
  - VAPS, VAPV, Paug
  - PRVC, APV, autoflow, Vsyn,
  - MMV , ASV
  - PPS, PAV
- WOB compensation
  - ATC (automatic tube compensation)-Drager E-4, Avea
  - TC (tube compensation) PB840
- Auto mode

Hamilton Galileo mode



Viasys Vela mode selection



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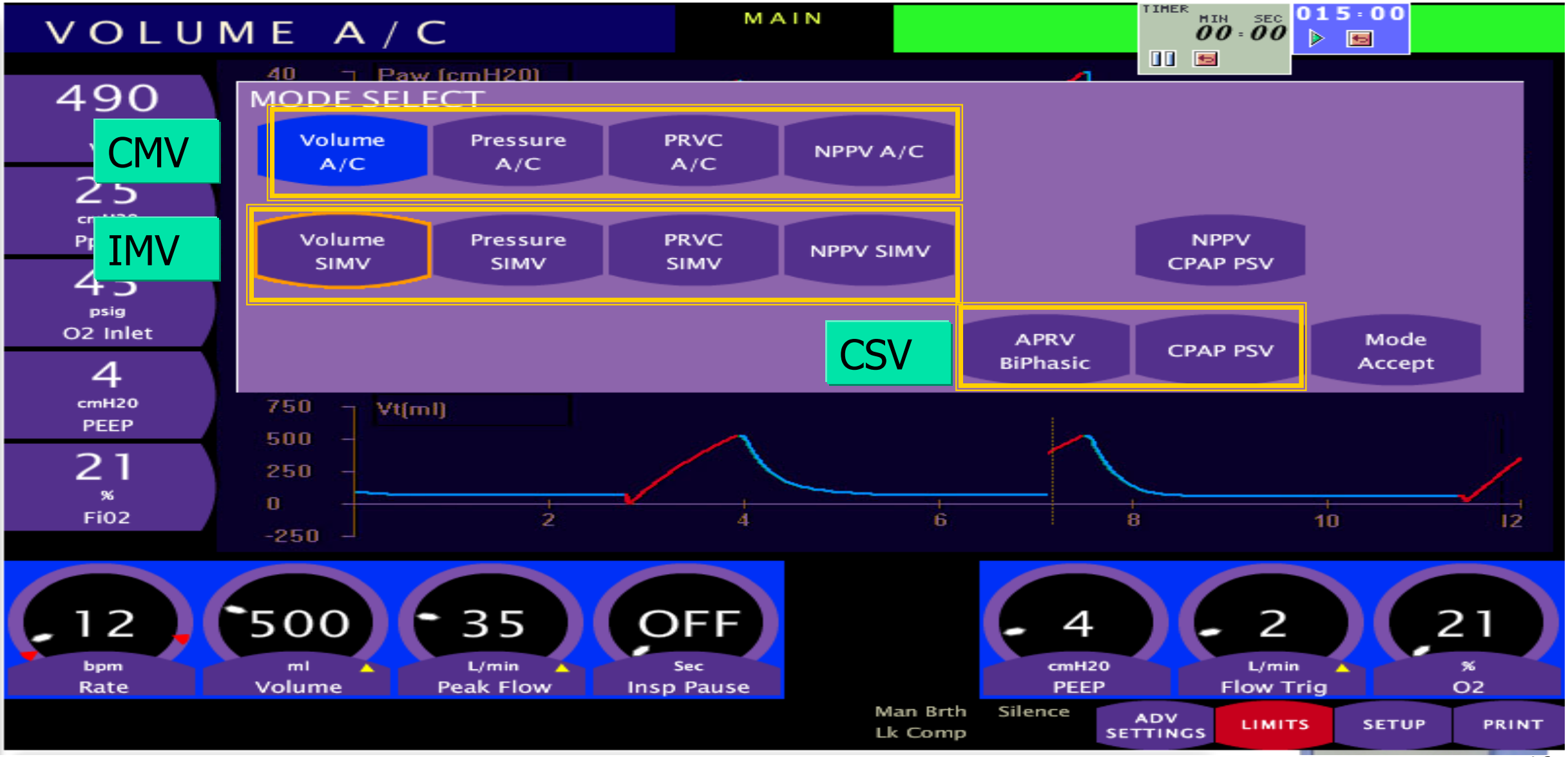

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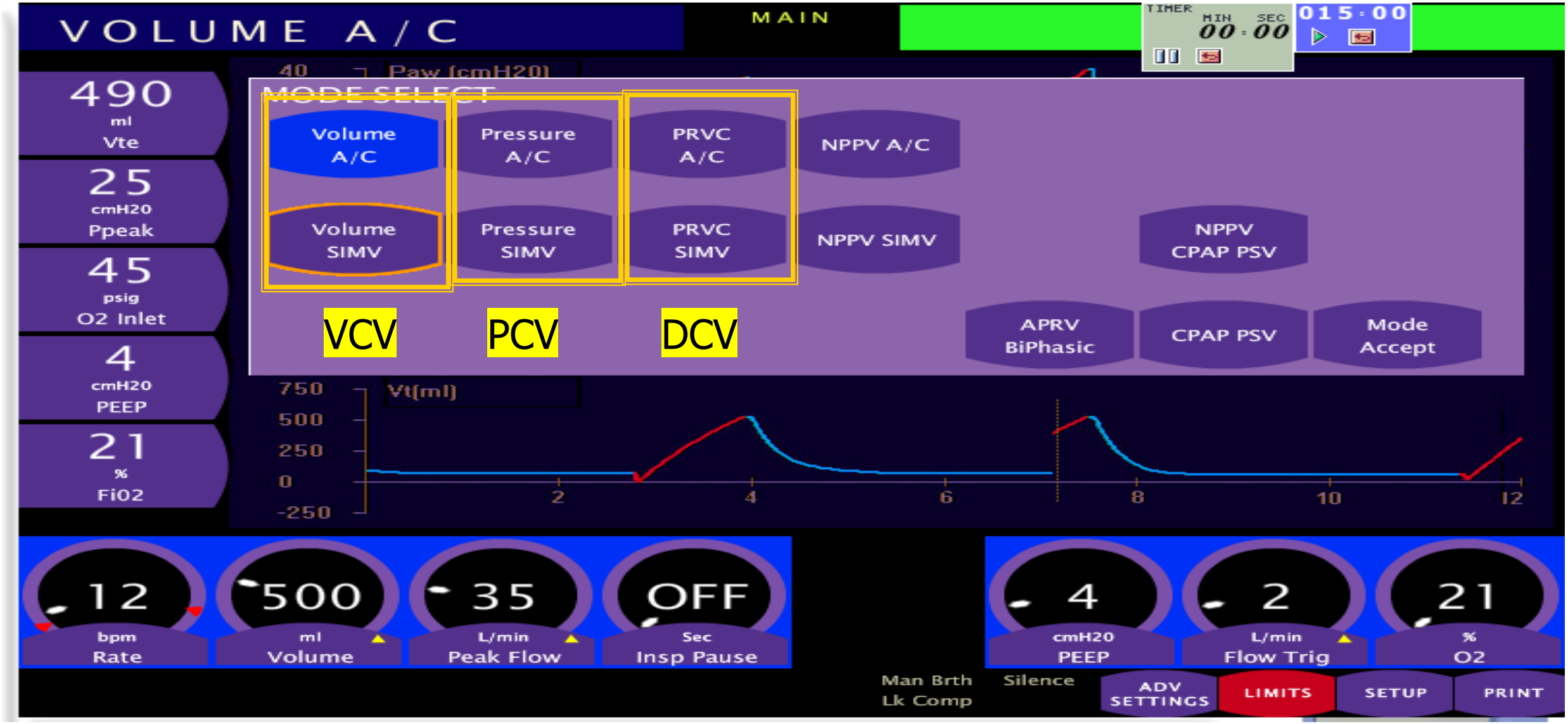
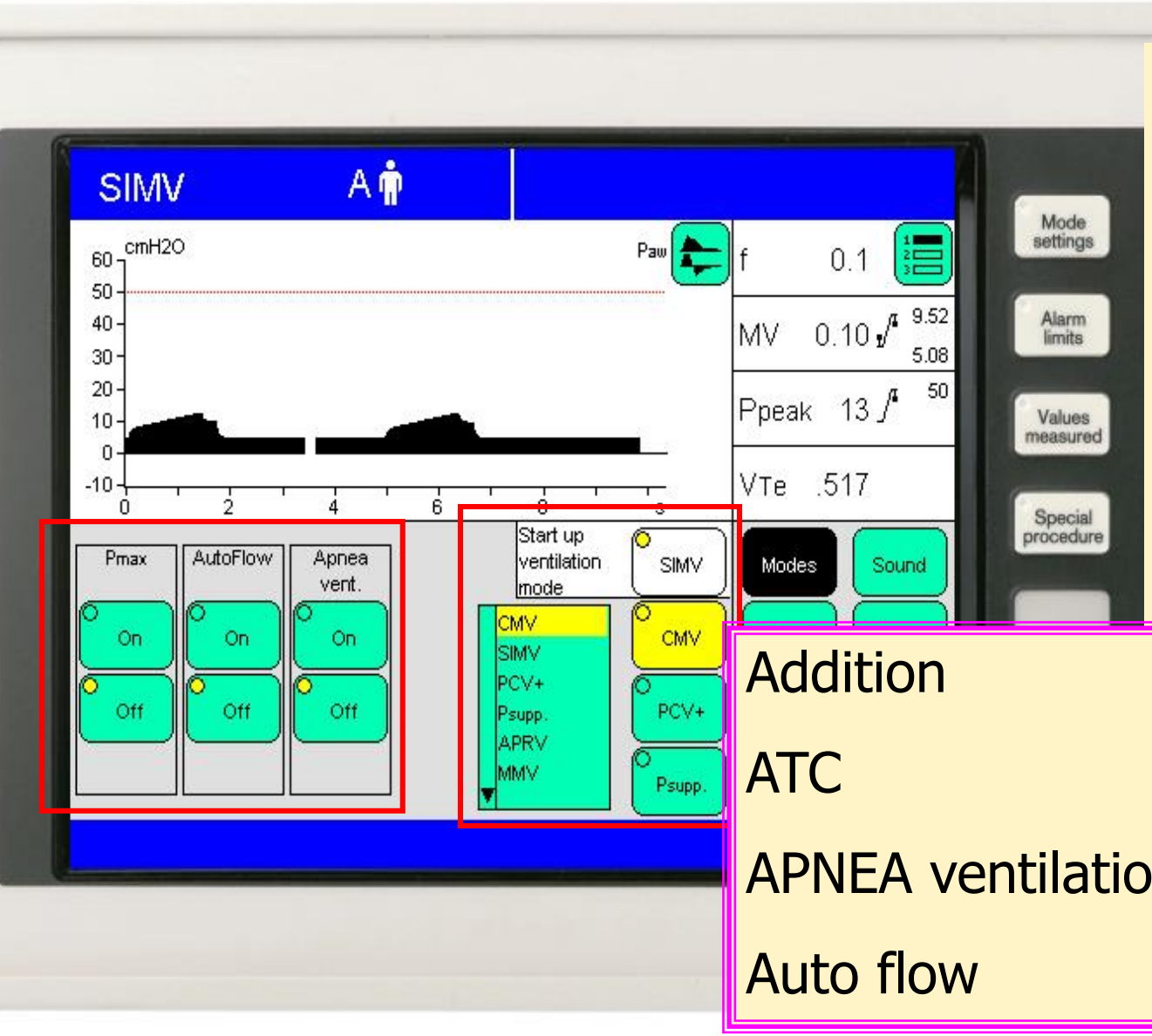


Drager series Evita-4



Addition

ATC

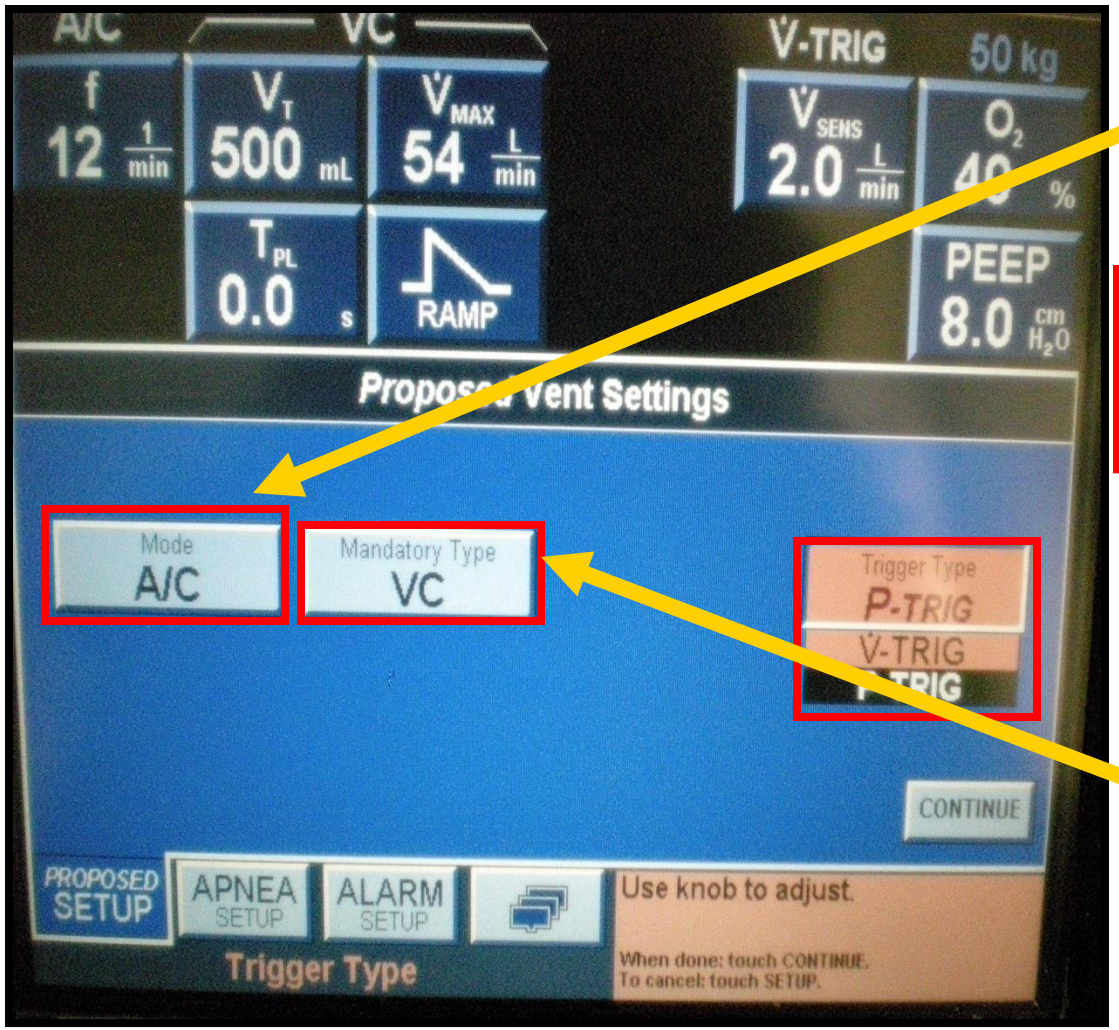
APNEA ventilation

Auto flow

- US English (English)
  - CMV （ IPPV ）
  - SIMV
  - PCV+ (BIPAP).
  - PCV+ Assist (BIPAP Assist)
  - MMV
  - APRV
  - Psupp（ASB）
  - PPS

計算病人肺阻力與順應性回饋，自動調整呼吸器

PB 840 mode selection



Mode:
A/C、 SIMV
SPONT、BiLevel (option)

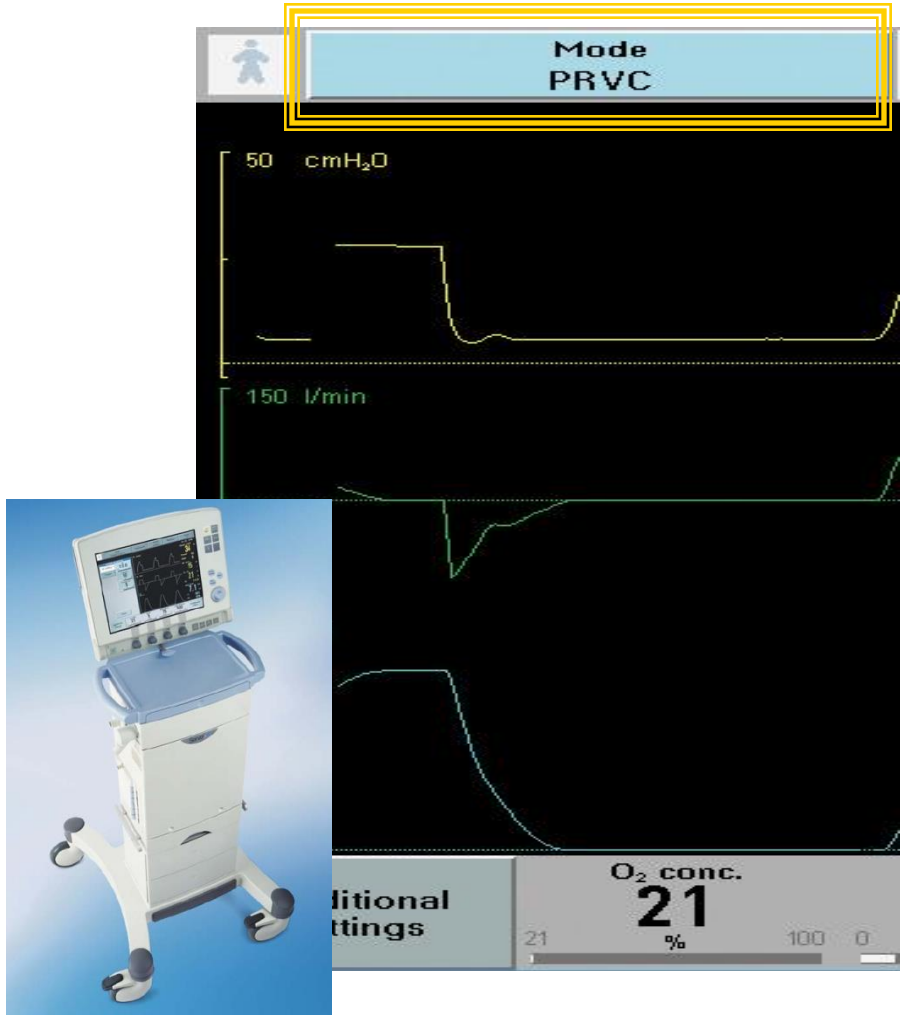
Spontaneous breath type:
(PS) Pressure Support
CPAP

(TC) Tube Compensation (option)

計算病人人工氣道阻力，自動代償呼吸功

Mandato
VCV、PCV

SERVO-i Mode selection

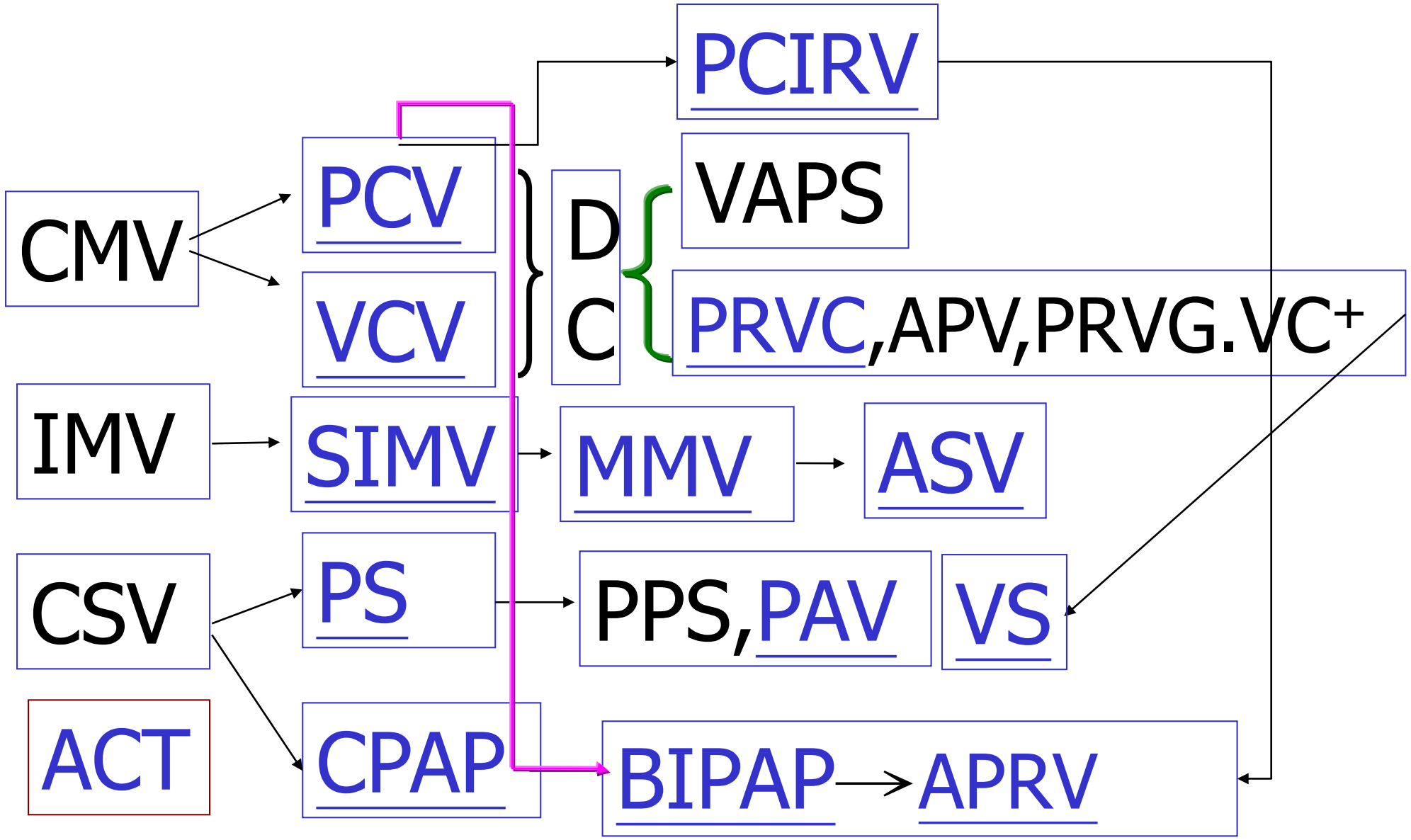


- **Volume Control**
- **Pressure Control**

Conventional ventilation modes		Adaptive ventilation modes
Pressure modes		**Simple adaptive modes**
• Pressure A/C mode	1	• Adaptive A/C mode
• Pressure SIMV mode	1	• Adaptive SIMV mode
• Pressure support mode	1	• Volume support (VS) mode
Volume modes		**Advanced adaptive modes**
• Volume A/C mode	1	• Adaptive support ventilation mode
• Volume SIMV mode	1	

- **AutoMode**
- **Bi-Vent**
- **NIV**

Ventilatory Modes



Ventilatory Modes

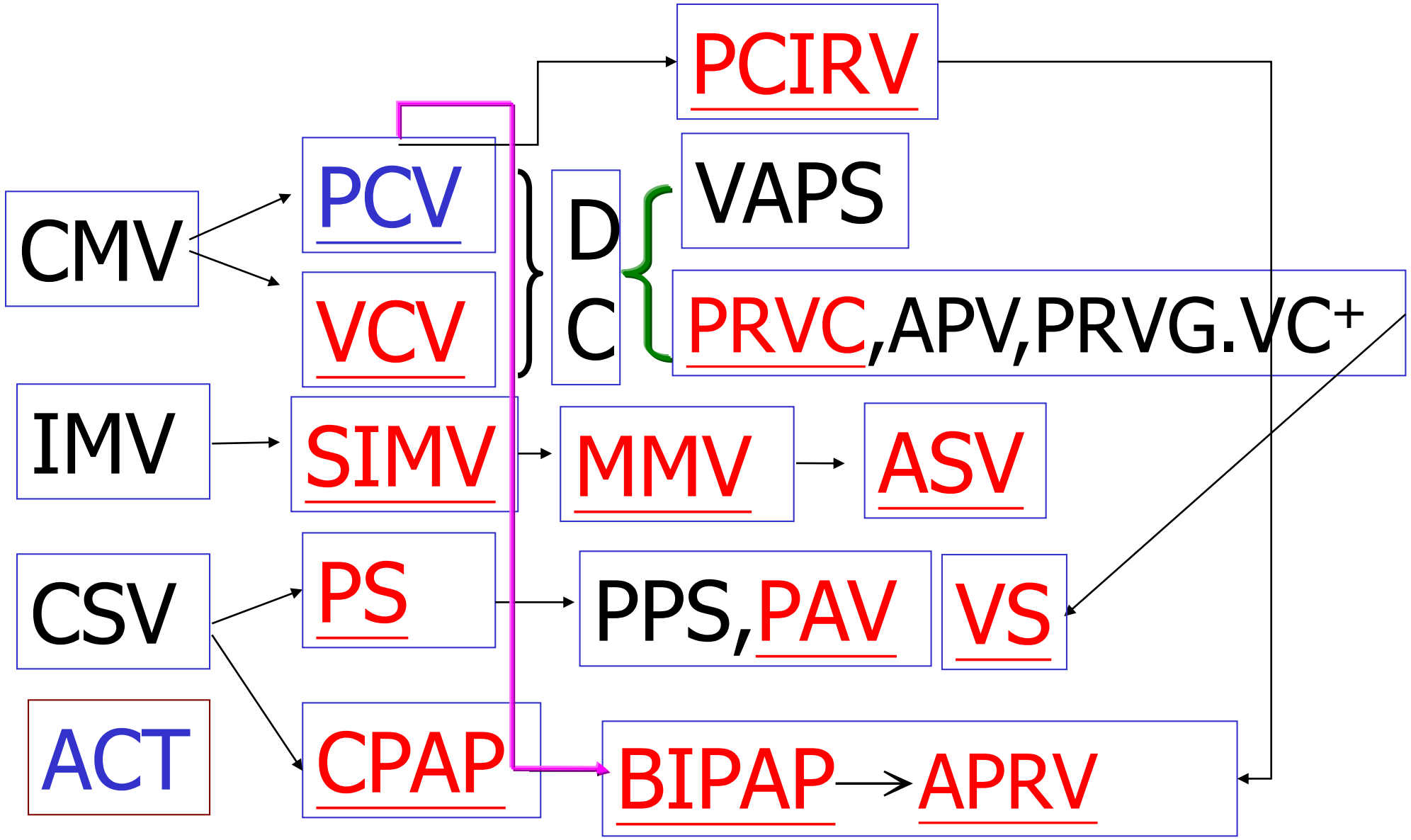


TABLE 13-2 Comparison of Common Ventilator Modes

Ventilator	Assist/ Control CMV-Vol	PCV	SIMV-VC	SIMV-PC	PRVC	SIMV PRVC	PSV/CPAP	APRV	Additional Mode(s) or Feature(s)
CareFusion AVEA	Volume A/C	Pressure A/C	Volume SIMV	Pressure SIMV	PRVC	PRVC SIMV	CPAP-PSV	APRV Biphasic	TCPL-A/C and TCPL-SIMV
Dräger Evita Infinity V500	CMV-Vol	CMV-Pres	SIMV (vol.) and PSV	SIMV (Press.)+ PSV	AutoFlow™	AutoFlow™ with SIMV (volume)	CPAP with or without PSV	APRV	MMV, SmartCare PPS
Dräger EvitaXL	CMV	PCV+	SIMV (vol.) and PSV	SIMV (Press.)+ PSV	AutoFlow™	AutoFlow™ with SIMV (volume)	PSV-CPAP	APRV	MMV & MMV + PS
GE CareStation	CMV-Vol	CMV-Pres	SIMV (vol.) and PSV	SIMV (Press)+ and PSV	CMV-PRVG	SIMV—PRVG	PSV—CPAP	BiLevel	BiLevel-PRVG
Hamilton C3	N/A	PCV+	NA	SIMV+ With PSV	CMV-APV	SIMV-APV	Spont/PSV	DuoPAP	ASV
Hamilton G5	CMV-VC	CMV-PC	SIMV-VC With PSV	SIMV-VC With PSV	CMV-APV	SIMV-APV	Spont/PSV	DuoPAP	ASV
Maquet Servo^{i} and Servo^{s}	VC	PC	SIMV (Vol. Contr.)	SIMV (Press. Contr.)	PRVC	SIMV (PRVC)	PSV/CPAP	BiVent	VS, NAVA available on Servo^{i}
Covidien PB 840	Assist/ control (volume)	Assist/ control (Press.)	SIMV (volume)	SIMV (pressure)	VC+	SIMV VC+	SPONT (PSV-CPAP)	Bilevel	PAV+ /VS

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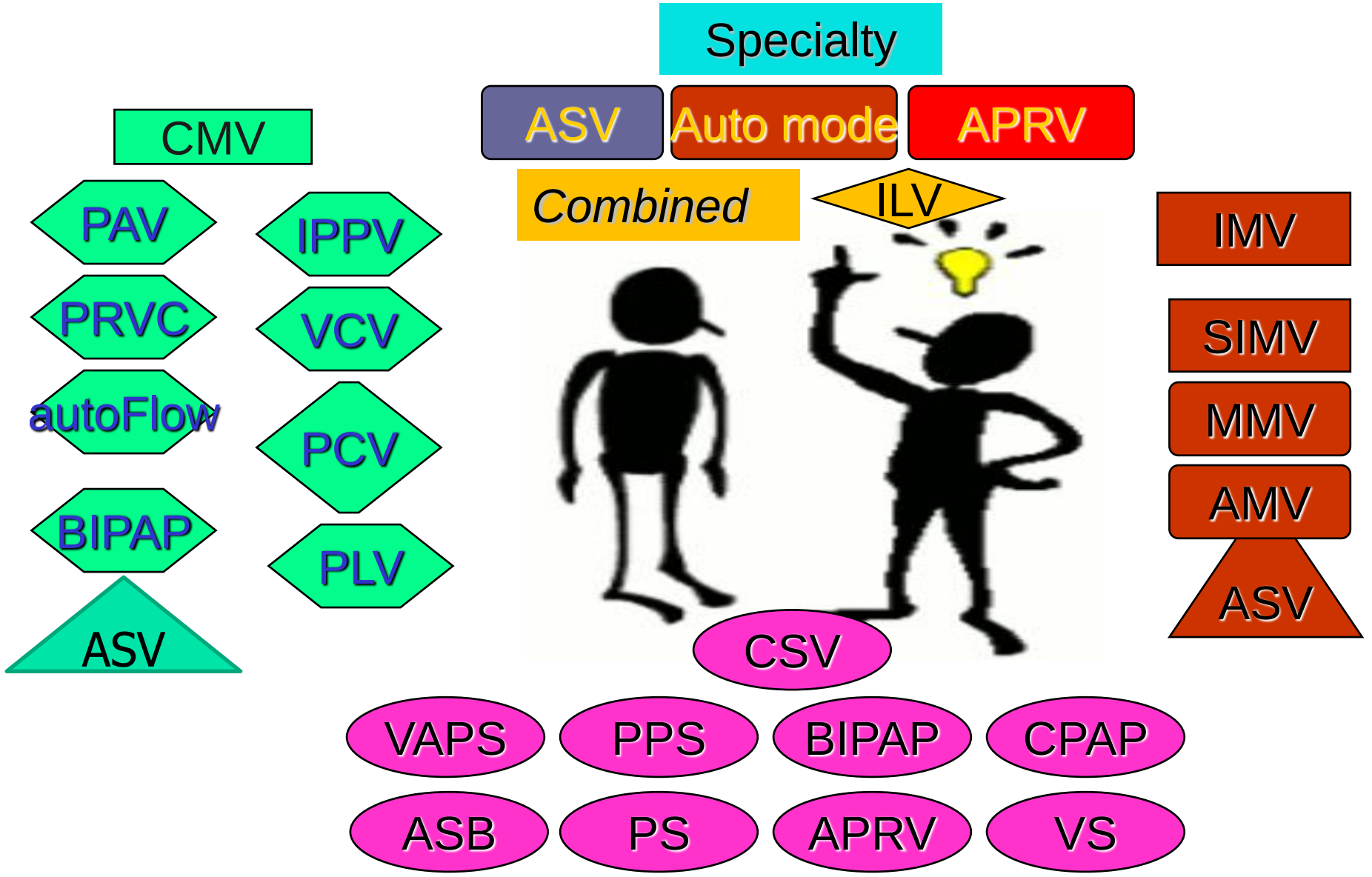
What mode of ventilation to use?



Take home messages

- 容控：主控VE
- 壓控：主要考慮呼吸道壓力P_{aw}
- CMV（A / C）：提供全支持。
- IMV:高設定可能就是全支持；低設定則是部分支持
- PSV：自主呼吸，呼吸機提供部分支持（大多數患者控制在所有支持模式）。
- CPAP：自發模式僅提高基線壓力，從而提高FRC。

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Hamilton C3	N/A	PCV+	NA	SIMV+ With PSV	CMV-APV	SIMV-APV	Spont/PSV	DuoPAP	ASV
Hamilton G5	CMV-VC	CMV-PC	SIMV-VC With PSV	SIMV-VC With PSV	CMV-APV	SIMV-APV	Spont/PSV	DuoPAP	ASV
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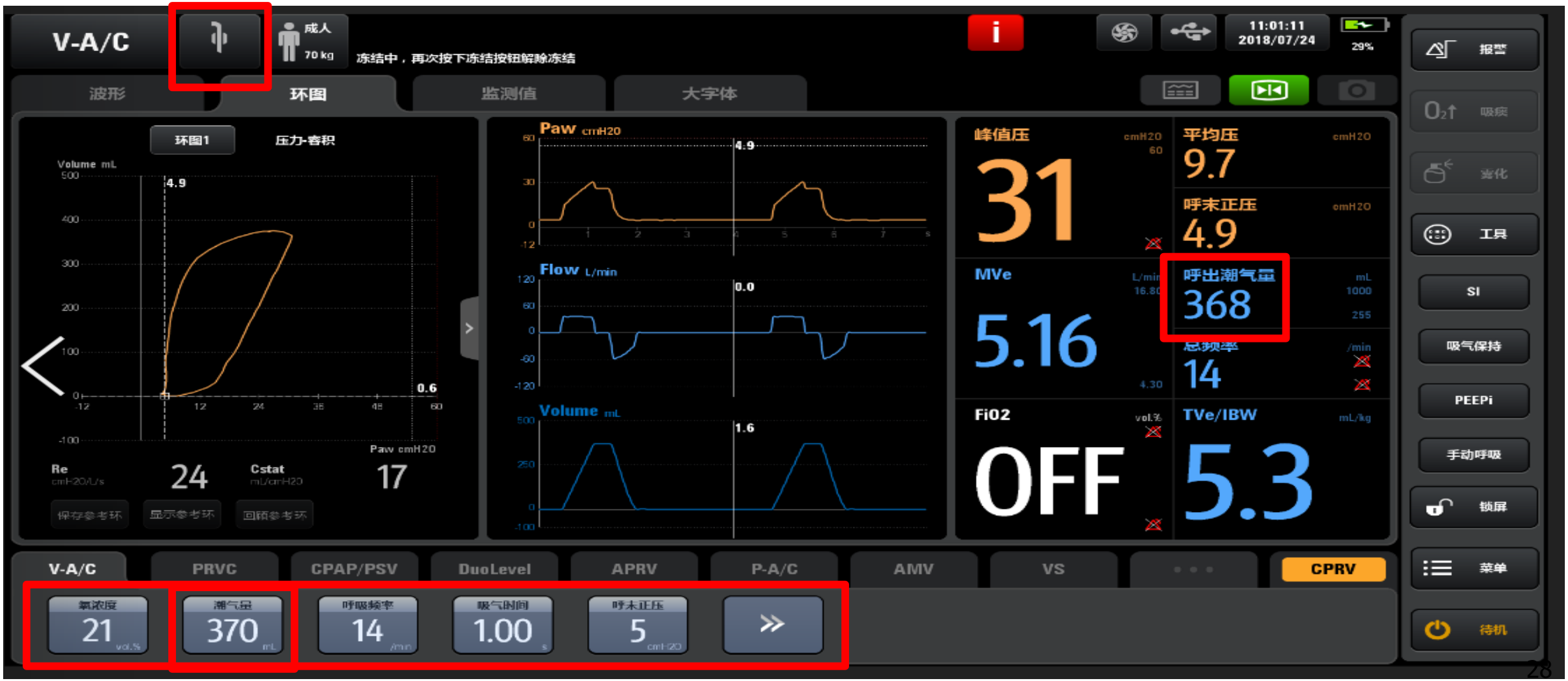
THANK YOU

I’ll take your questions!!

VC-CMV (A/C)

Time triggered, Flow limited, Volume cycled Ventilation



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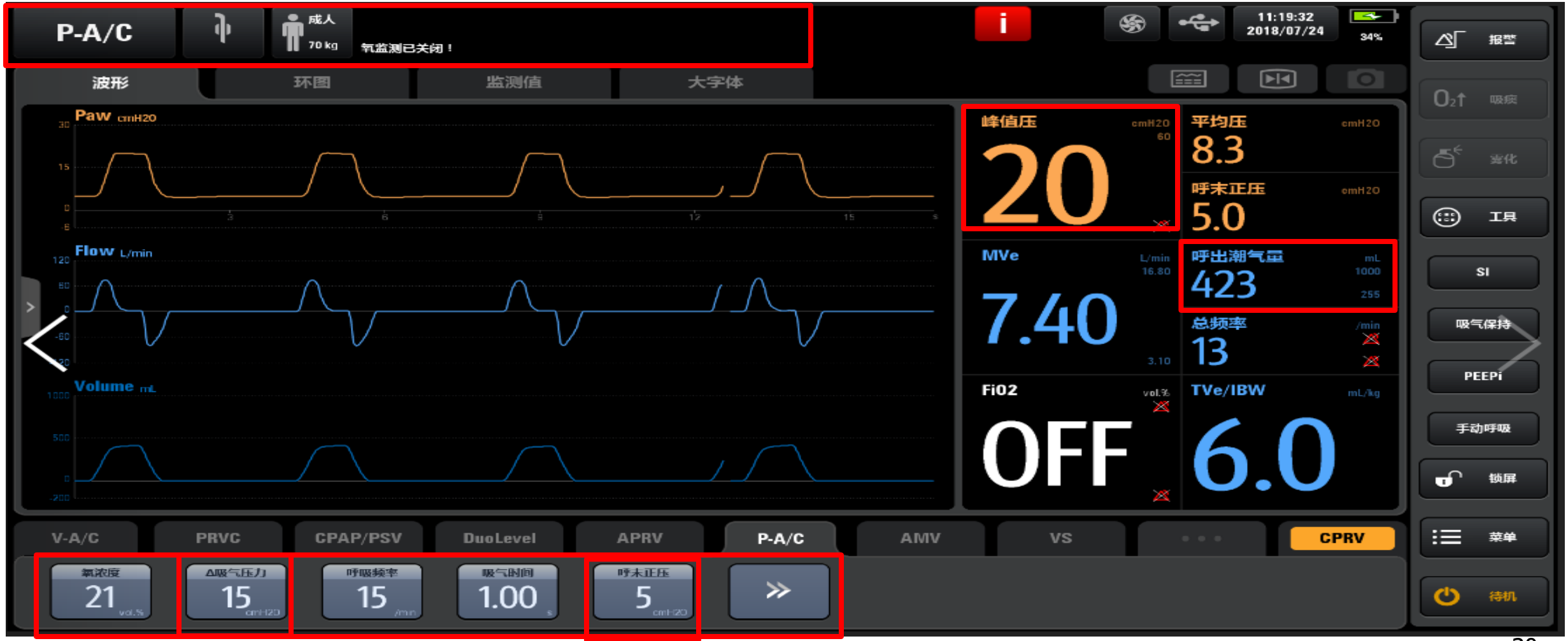
PC-CMV (A/C)

Time Triggered, Pressure Limited, Time Cycled Ventilation



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GE CareStation	CMV-Vol	CMV-Pres	SIMV (vol.) and PSV	SIMV (Press)+ and PSV	CMV-PRVG	SIMV—PRVG	PSV—CPAP	BiLevel	BiLevel-PRVG
Hamilton C3	N/A	PCV+	NA	SIMV+ With PSV	CMV-APV	SIMV-APV	Spont/PSV	DuoPAP	ASV
Hamilton G5	CMV-VC	CMV-PC	SIMV-VC With PSV	SIMV-VC With PSV	CMV-APV	SIMV-APV	Spont/PSV	DuoPAP	ASV
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Covidien PB 840	Assist/ control (volume)	Assist/ control (Press.)	SIMV (volume)	SIMV (pressure)	VC+	SIMV VC+	SPONT (PSV-CPAP)	Bilevel	PAV+ /VS

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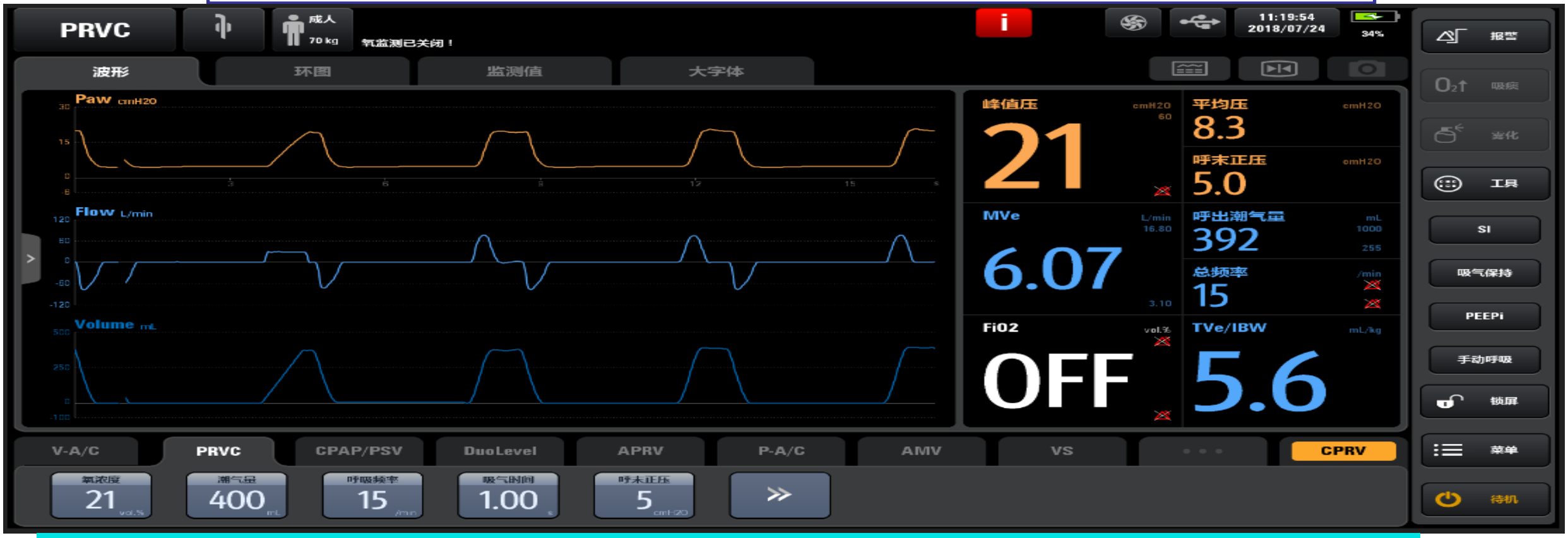
DC-CMV (A/C)

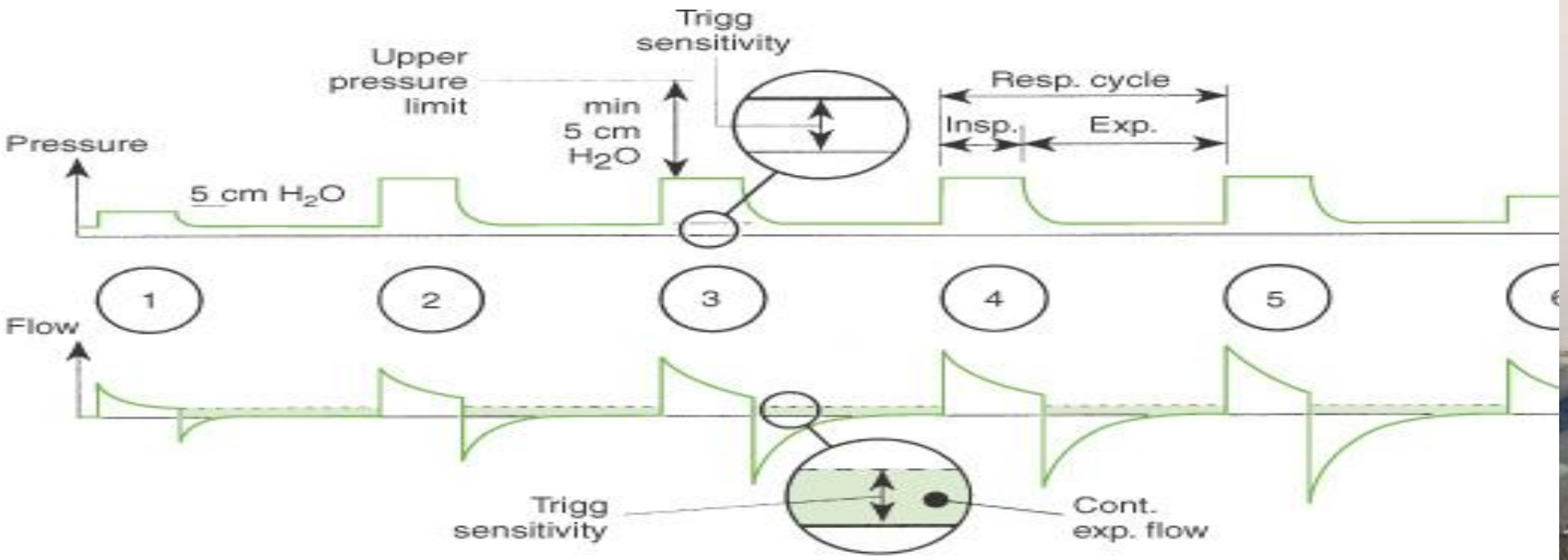
Time Triggered, Pressure Regulated, Volume Traget, Time Cycled Ventilation



- **AVEA、Vela 、 mindray**
  - 第一口氣是以target VT 給予，即volume control，第二口氣是以PIP的壓力值給氣
  - 有最大volume limit之設定
  - 給氣的壓力上限為pressure alarm的數值

Pressure Regulated Volume Controlled (PRVC)

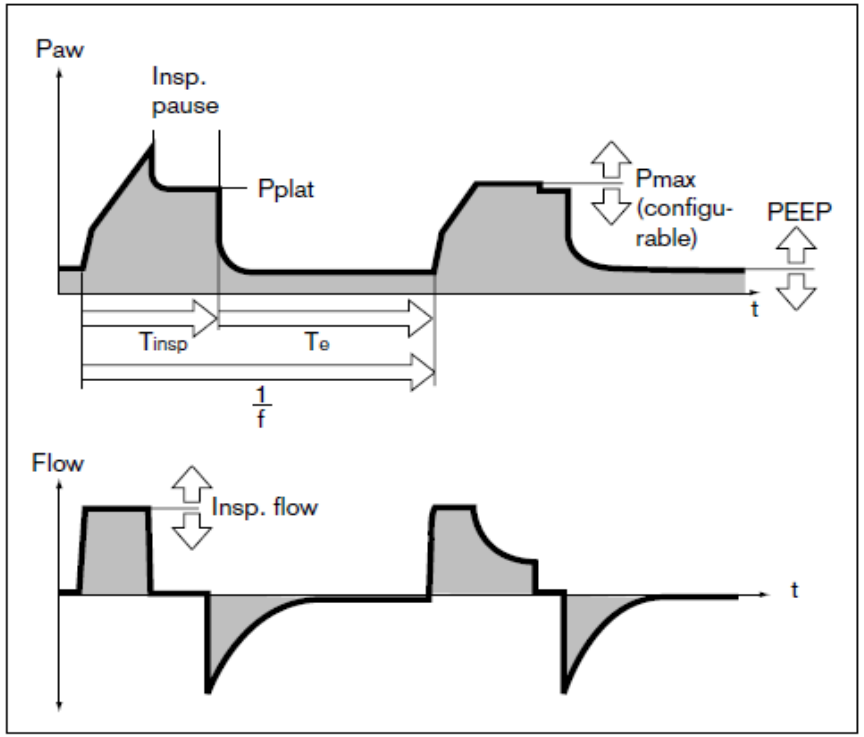
Servo-300

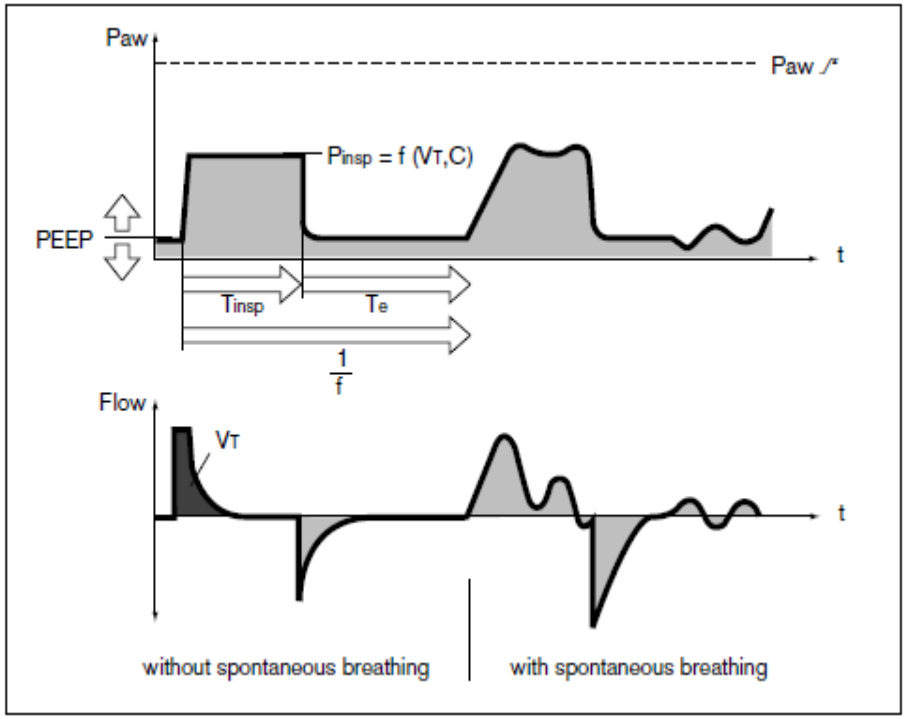


- **Servo-300**
  - 前三次呼吸為測試（每次增加5cmH2O），於第四口氣執行PRVC
  - 有最小給予volume的保證設定
  - 給氣的壓力上限為pressure alarm- 5cmH2O

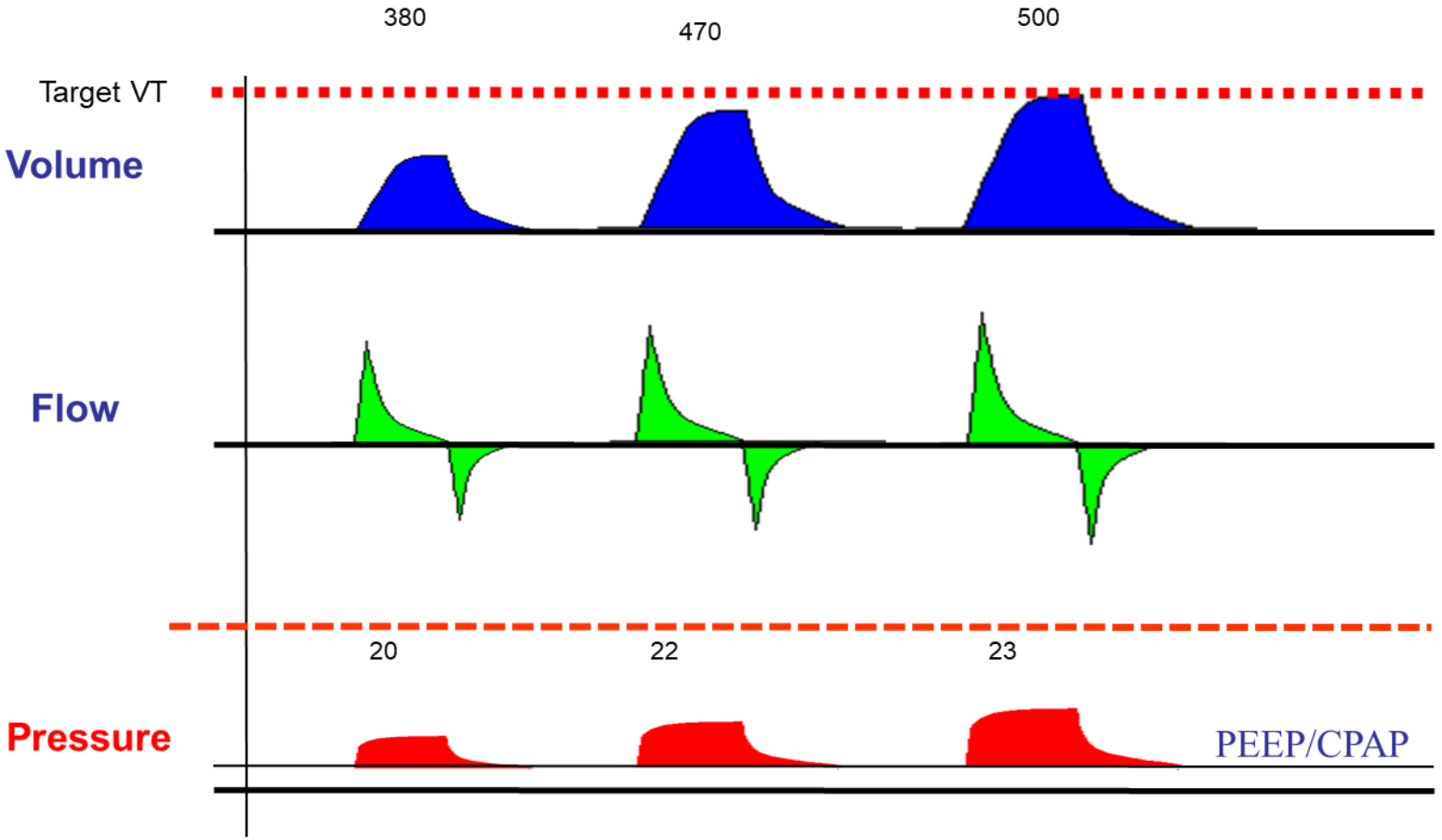
AutoFlow in Drager series

- 在恆定容量通氣模式IPPV(VCMV)，V-SIMV和MMV中調節強制通氣吸氣期間的吸氣流量
- 容積為目標，因應病人肺順應姓與呼吸道阻力變化自動調整吸氣流速，並允許病人自主呼吸。





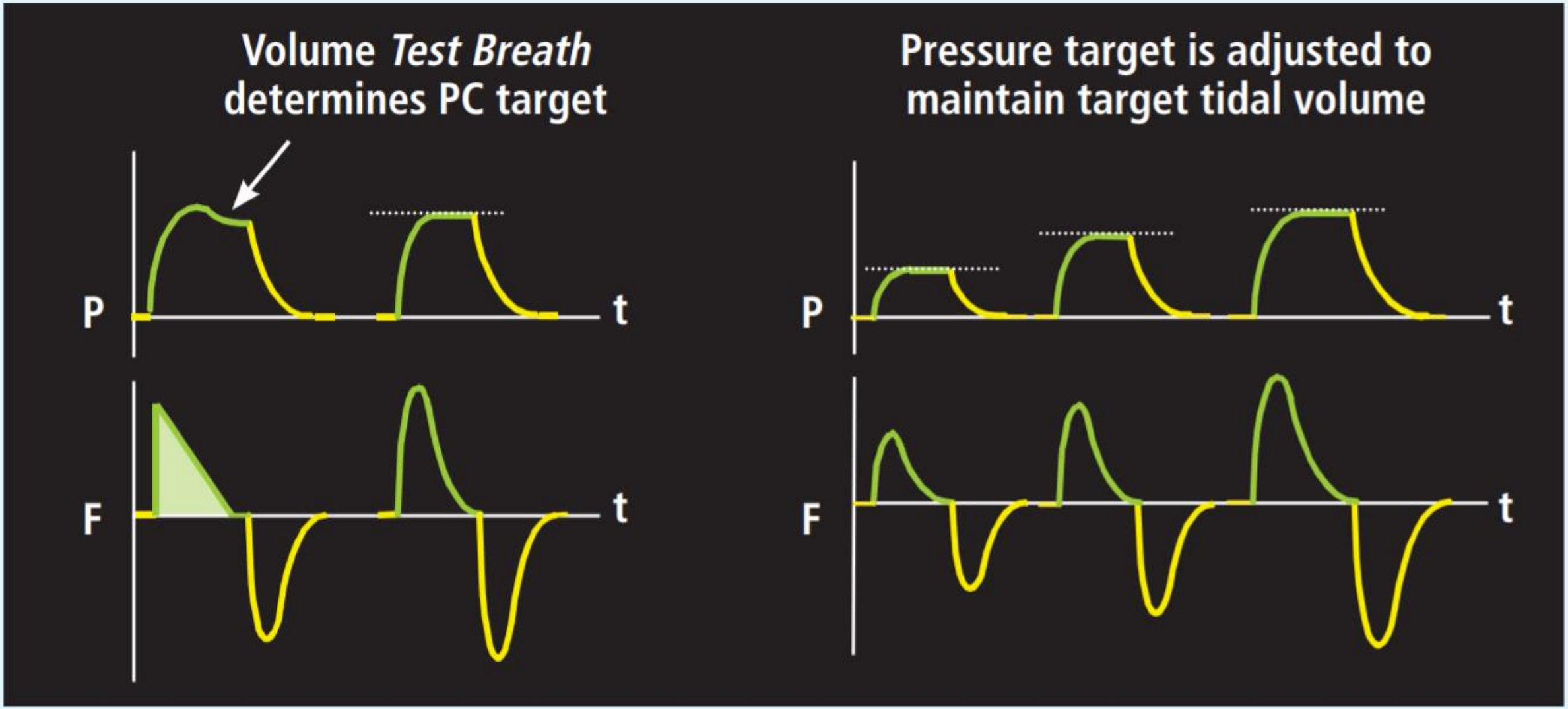
APV in Hamilton series
APV(Adaptive Pressure Ventilation)



Pressure Alarm setting-10cmH2O =Pressure limitation Alarm

(Hamilton Galileo)

VC+ in PB840



Note: The software program for VV+ includes the VC+ and VS options (part #4-078126-00).

PRVG (GE carestation)
pressure controlled volume guaranteed

Screenshot: Aisys & Avance

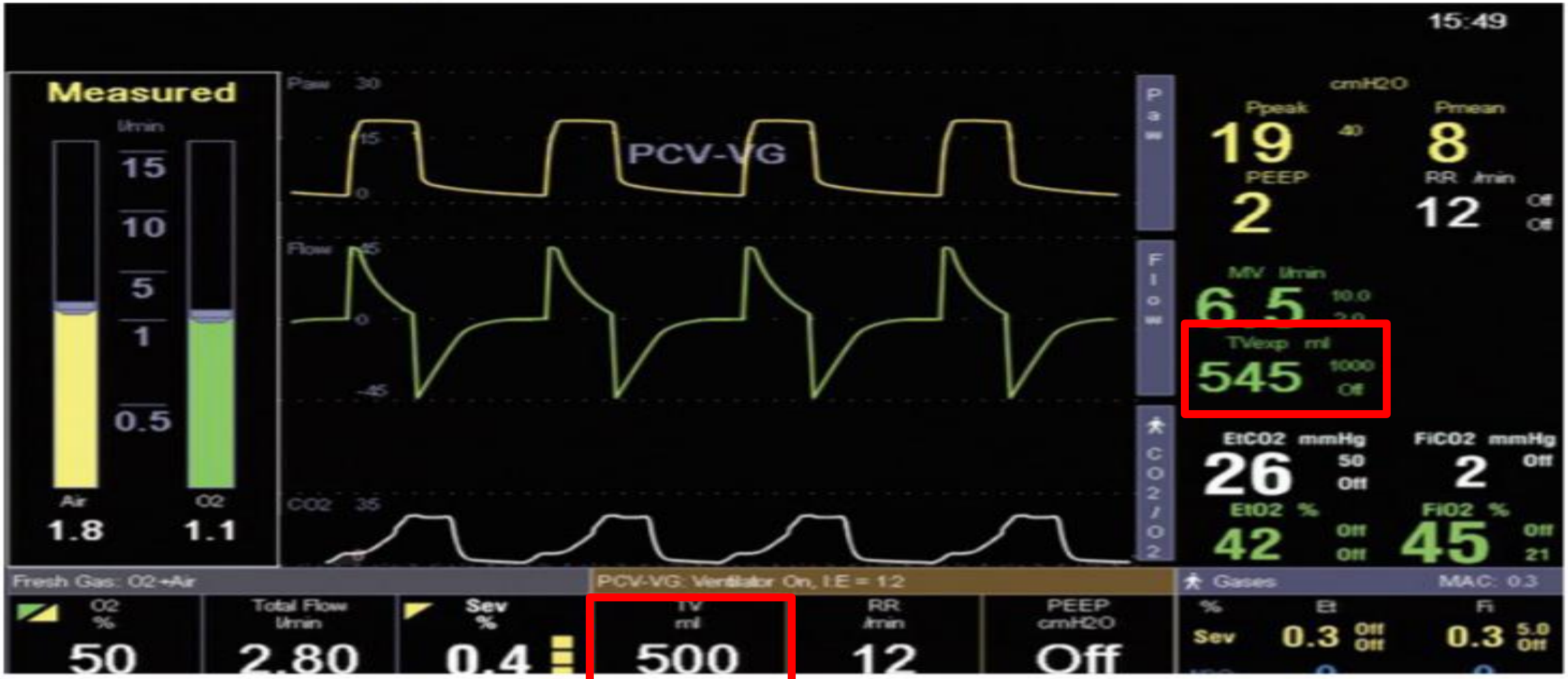


TABLE 13-2 Comparison of Common Ventilator Modes

PRVC 相關

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GE CareStation	CMV-Vol	CMV-Pres	SIMV (vol.) and PSV	SIMV (Press)+ and PSV	CMV-PRVG	SIMV—PRVG	PSV—CPAP	BiLevel	BiLevel-PRVG
Hamilton C3	N/A	PCV+	NA	SIMV+ With PSV	CMV-APV	SIMV-APV	Spont/PSV	DuoPAP	ASV
Hamilton G5	CMV-VC	CMV-PC	SIMV-VC With PSV	SIMV-VC With PSV	CMV-APV	SIMV-APV	Spont/PSV	DuoPAP	ASV
Maquet Servo^{i} and Servo^{s}	VC	PC	SIMV (Vol. Contr.)	SIMV (Press. Contr.)	PRVC	SIMV (PRVC)	PSV/CPAP	BiVent	VS, NAVA available on Servo^{i}
Covidien PB 840	Assist/ control (volume)	Assist/ control (Press.)	SIMV (volume)	SIMV (pressure)	VC+	SIMV VC+	SPONT (PSV-CPAP)	Bilevel	PAV+ /VS

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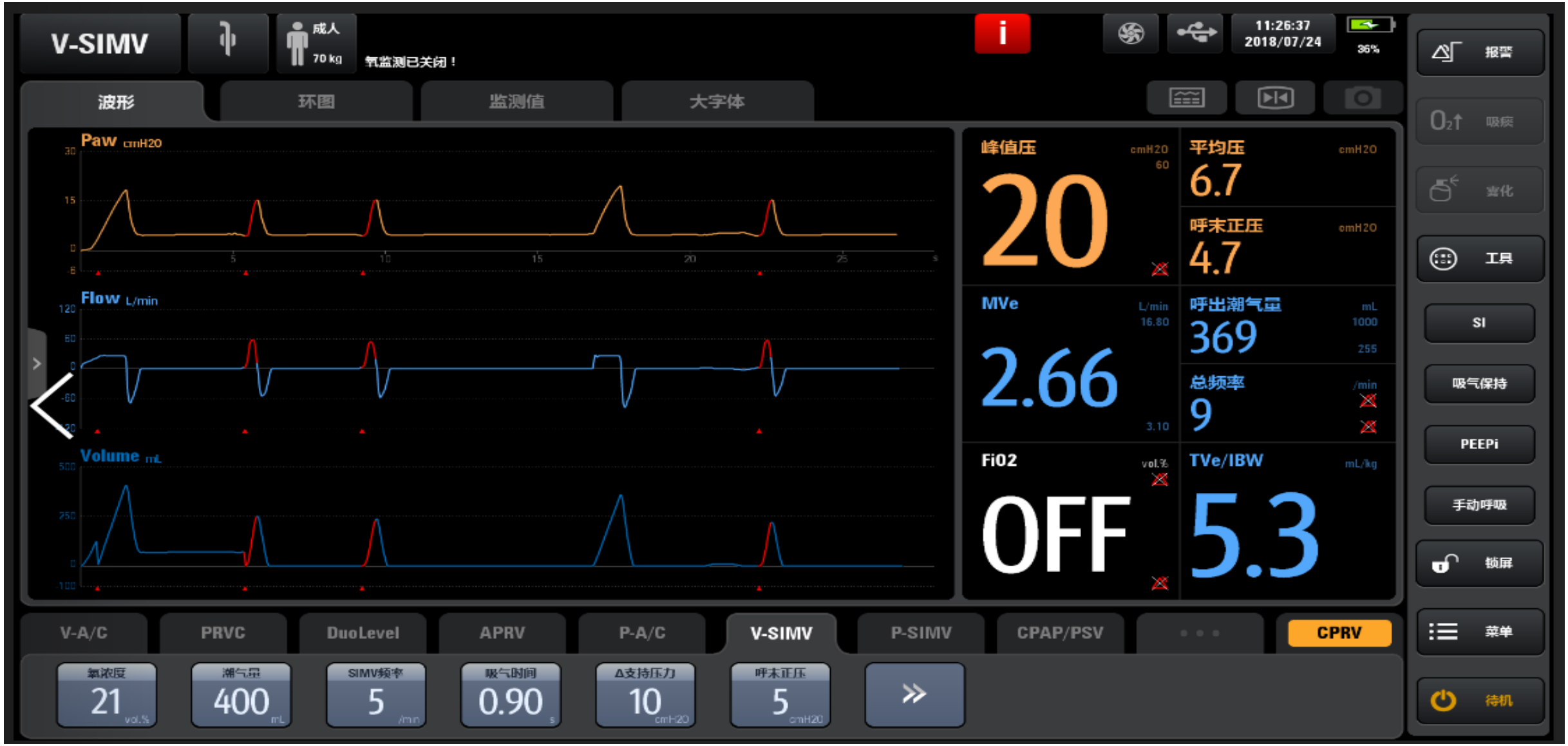
VC-SIMV


V-SIMV
成人
70 kg
氧监测已关闭！
11:26:37
2018/07/24
36%
报警
吸痰
变化
工具
SI
吸气保持
PEEPi
手动呼吸
锁屏
菜单
待机
波形
环图
监测值
大字体
Paw cmH2O
Flow L/min
Volume mL
峰值压
cmH2O
60
20
平均压
cmH2O
6.7
呼末正压
cmH2O
4.7
MVe
L/min
16.80
2.66
3.10
呼出潮气量
mL
1000
369
255
总频率
/min
9
FiO2
vol.%
OFF
TVe/IBW
mL/kg
5.3
V-A/C
PRVC
DuoLevel
APRV
P-A/C
V-SIMV
P-SIMV
CPAP/PSV
CPRV
氧浓度
21
vol.%
潮气量
400
mL
SIMV频率
5
/min
吸气时间
0.90
s
Δ支持压力
10
cmH2O
呼末正压
5
cmH2O

PC-SIMV

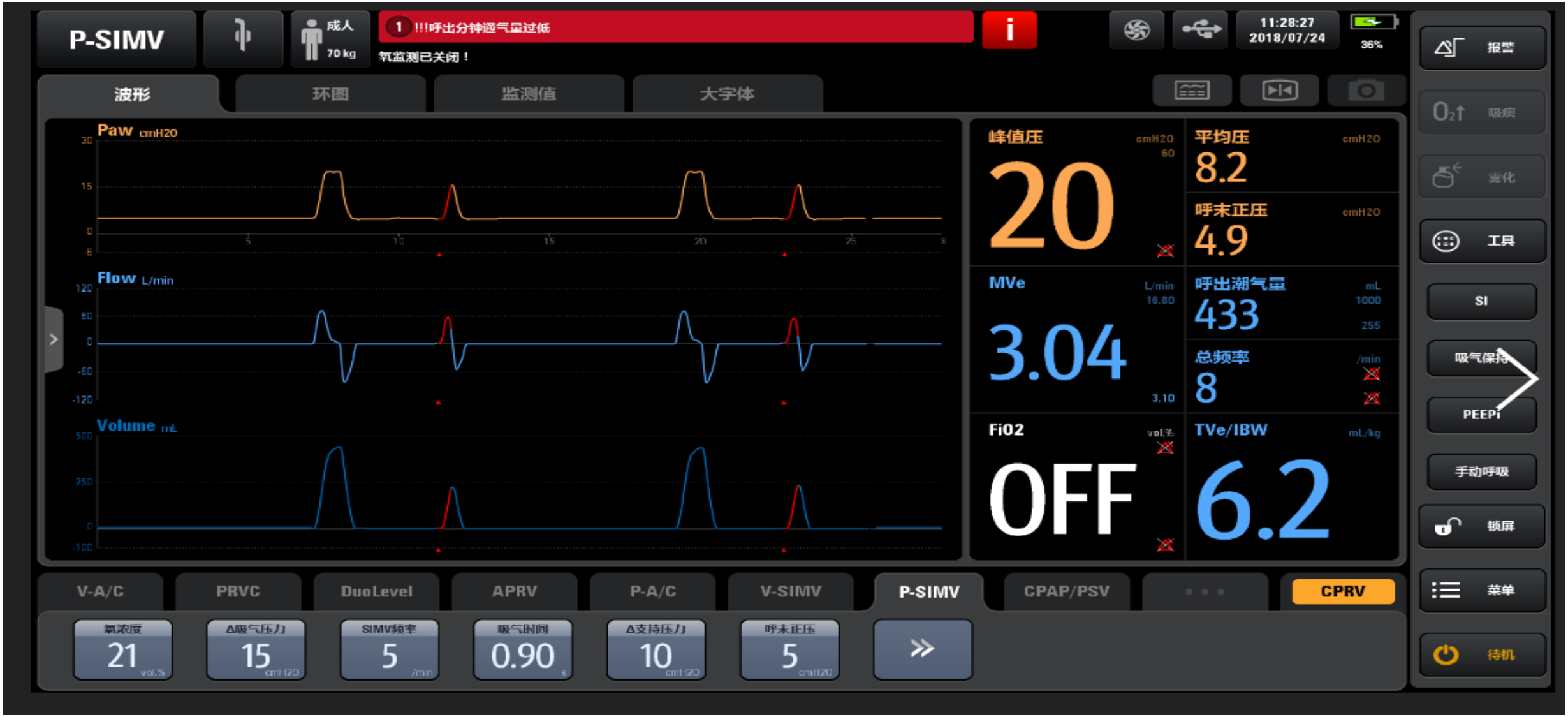

P-SIMV
成人
70 kg
1 !!!呼出分钟通气量过低
氧监测已关闭！
11:28:27
2018/07/24
36%
报警
吸痰
雾化
工具
SI
吸气保持
PEEPi
手动呼吸
锁屏
菜单
待机
波形
环图
监测值
大字体
Paw cmH2O
Flow L/min
Volume mL
峰值压
cmH2O
60
20
平均压
cmH2O
8.2
呼末正压
cmH2O
4.9
MVe
L/min
16.80
3.04
3.10
呼出潮气量
mL
1000
433
255
总频率
/min
8
FiO2
vol.%
OFF
TVe/IBW
mL/kg
6.2
V-A/C
PRVC
DuoLevel
APRV
P-A/C
V-SIMV
P-SIMV
CPAP/PSV
CPRV
氧浓度
21
vol.%
ΔPEEP
15
cmH2O
SIMV频率
5
/min
吸气时间
0.90
s
ΔPS
10
cmH2O
PEEP
5
cmH2O

TABLE 13-2 Comparison of Common Ventilator Modes

Ventilator	Assist/ Control CMV-Vol	PCV	SIMV-VC	SIMV-PC	PRVC	SIMV PRVC	PSV/CPAP	APRV	Add Mode(s) or Feature(s)
CareFusion AVEA	Volume A/C	Pressure A/C	Volume SIMV	Pressure SIMV	PRVC	PRVC SIMV	CPAP-PSV	APRV Biphasic	TCPL-A/C and TCPL-SIMV
Dräger Evita Infinity V500	CMV-Vol	CMV-Pres	SIMV (vol.) and PSV	SIMV (Press.)+ PSV	AutoFlow™	AutoFlow™ with SIMV (volume)	CPAP with or without PSV	APRV	MMV, SmartCare PPS
Dräger EvitaXL	CMV	PCV+	SIMV (vol.) and PSV	SIMV (Press.)+ PSV	AutoFlow™	AutoFlow™ with SIMV (volume)	PSV-CPAP	APRV	MMV & MMV + PS
GE CareStation	CMV-Vol	CMV-Pres	SIMV (vol.) and PSV	SIMV (Press)+ and PSV	CMV-PRVG	SIMV—PRVG	PSV—CPAP	BiLevel	BiLevel-PRVG
Hamilton C3	N/A	PCV+	NA	SIMV+ With PSV	CMV-APV	SIMV-APV	Spont/PSV	DuoPAP	ASV
Hamilton G5	CMV-VC	CMV-PC	SIMV-VC With PSV	SIMV-VC With PSV	CMV-APV	SIMV-APV	Spont/PSV	DuoPAP	ASV
Maquet Servo^{i} and Servo^{s}	VC	PC	SIMV (Vol. Contr.)	SIMV (Press. Contr.)	PRVC	SIMV (PRVC)	PSV/CPAP	BiVent	VS, NAVA available on Servo^{i}
Covidien PB 840	Assist/ control (volume)	Assist/ control (Press.)	SIMV (volume)	SIMV (pressure)	VC+	SIMV VC+	SPONT (PSV-CPAP)	Bilevel	PAV+ /VS

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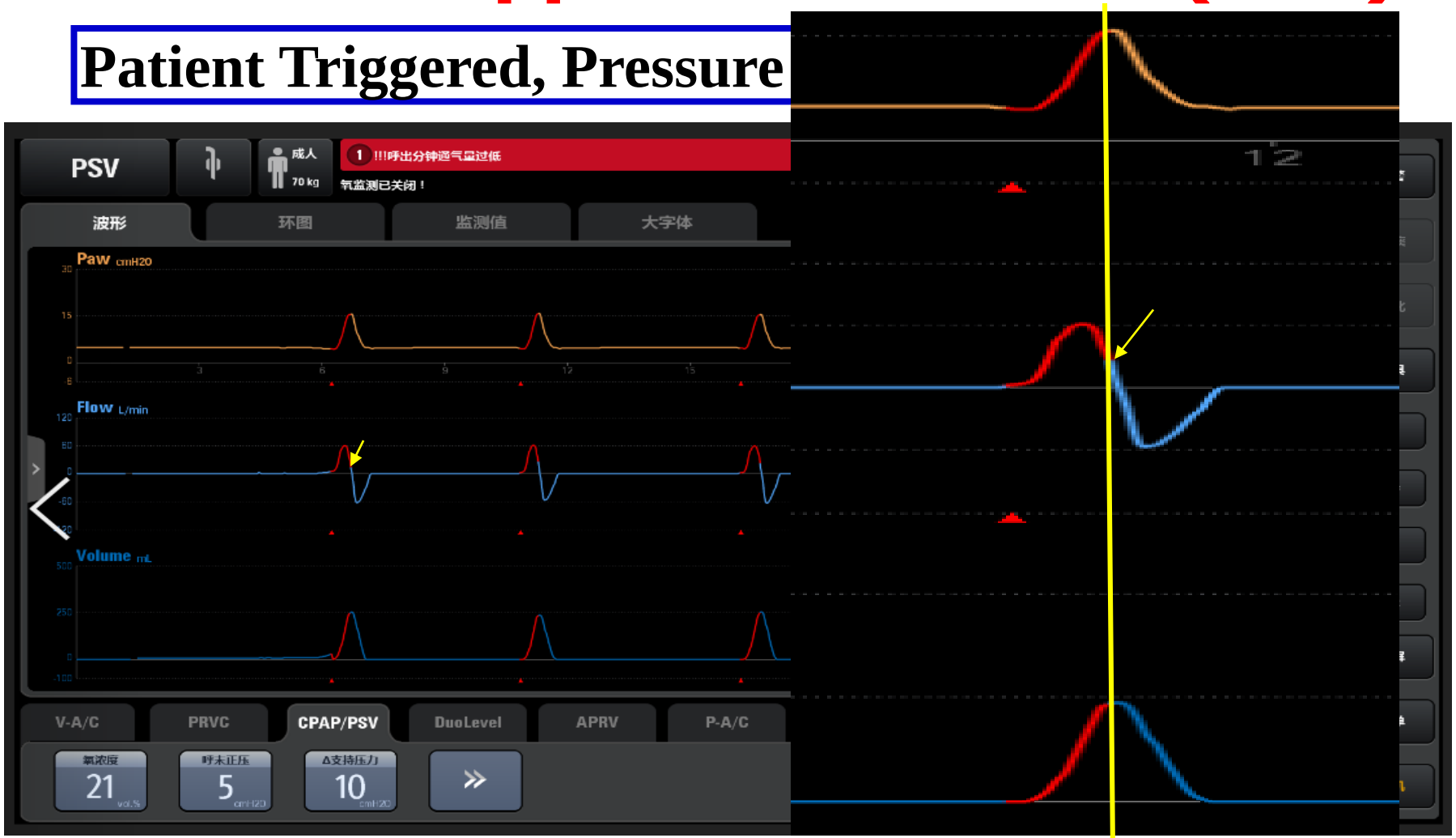
Pressure Support Ventilation (PSV)

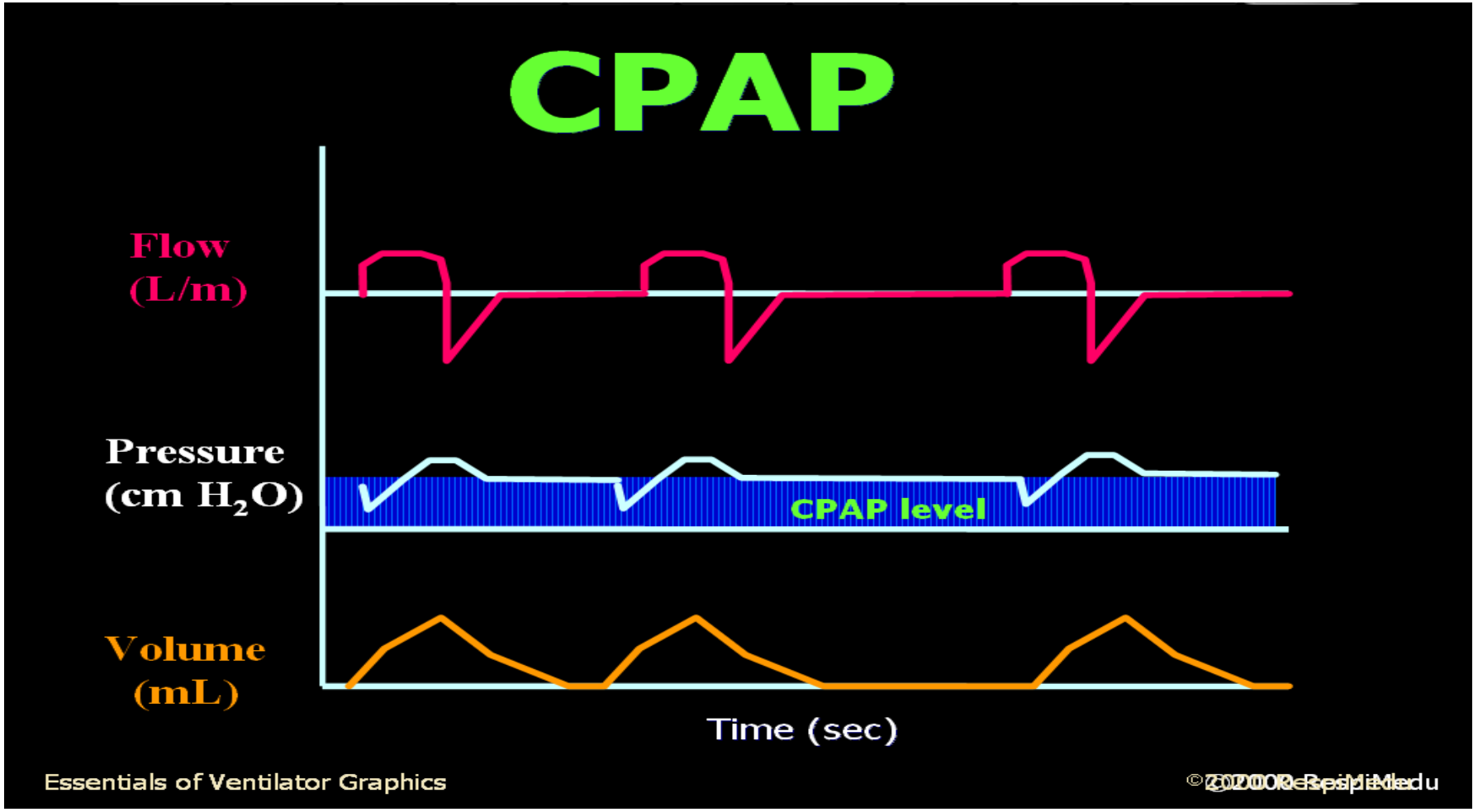
Patient Triggered, Pressure



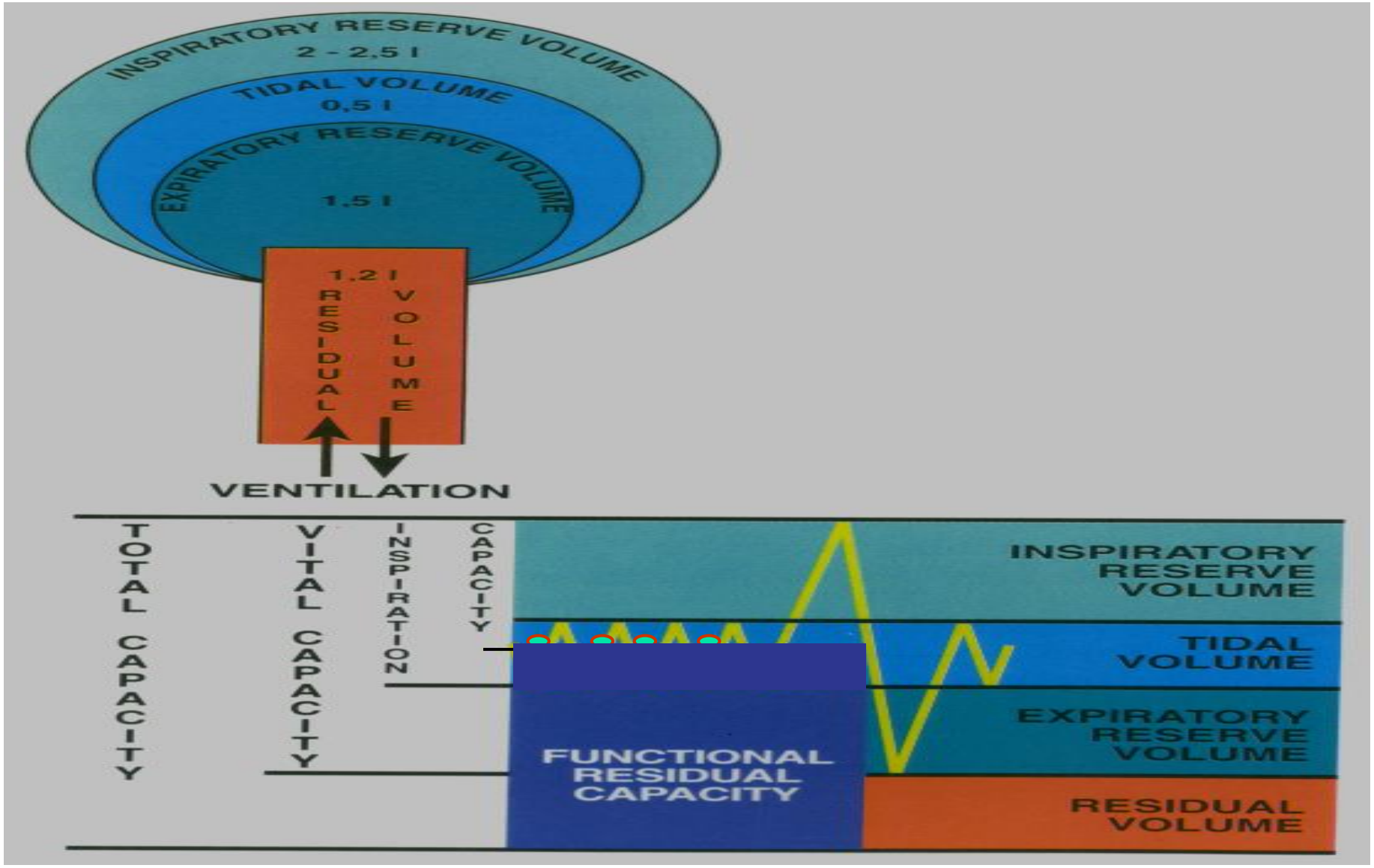
PSV 的吸氣中止 (cycle off) 機轉有三種:
(1)吸氣流速降到尖峰流速 25-30% 時、(2)吸氣時間超過 5 秒鐘時、(3)吸氣壓力高於設定之最高壓力限制時

CPAP

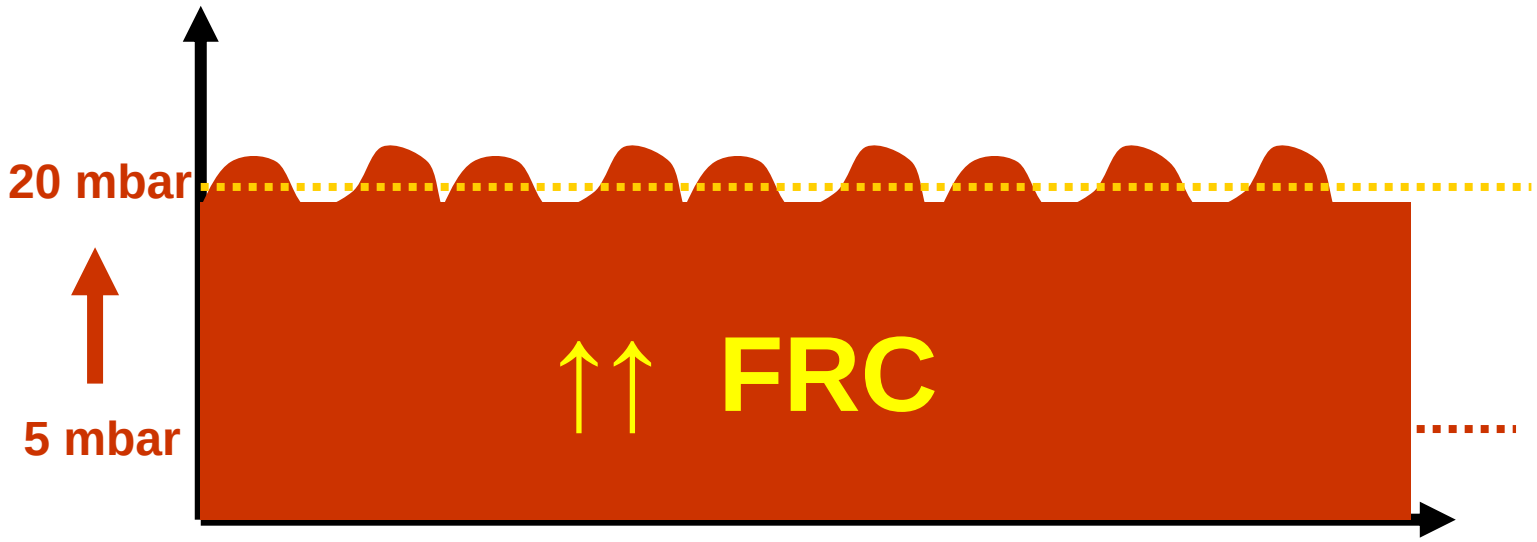
CPAP=spontaneous breathing + PEEP



PEEP: increase FRC



CPAP



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Dräger Evita Infinity V500	CMV-Vol	CMV-Pres	SIMV (vol.) and PSV	SIMV (Press.)+ PSV	AutoFlow™	AutoFlow™ with SIMV (volume)	CPAP with or without PSV	APRV	MMV, SmartCare PPS
Dräger EvitaXL	CMV	PCV+	SIMV (vol.) and PSV	SIMV (Press.)+ PSV	AutoFlow™	AutoFlow™ with SIMV (volume)	PSV-CPAP	APRV	MMV & MMV + PS
GE CareStation	CMV-Vol	CMV-Pres	SIMV (vol.) and PSV	SIMV (Press)+ and PSV	CMV-PRVG	SIMV—PRVG	PSV—CPAP	BiLevel	BiLevel-PRVG
Hamilton C3	N/A	PCV+	NA	SIMV+ With PSV	CMV-APV	SIMV-APV	Spont/PSV	DuoPAP	ASV
Hamilton G5	CMV-VC	CMV-PC	SIMV-VC With PSV	SIMV-VC With PSV	CMV-APV	SIMV-APV	Spont/PSV	DuoPAP	ASV
Maquet Servo^{i} and Servo^{s}	VC	PC	SIMV (Vol. Contr.)	SIMV (Press. Contr.)	PRVC	SIMV (PRVC)	PSV/CPAP	BiVent	VS, NAVA available on Servo^{i}
Covidien PB 840	Assist/ control (volume)	Assist/ control (Press.)	SIMV (volume)	SIMV (pressure)	VC+	SIMV VC+	SPONT (PSV-CPAP)	Bilevel	PAV+ /VS

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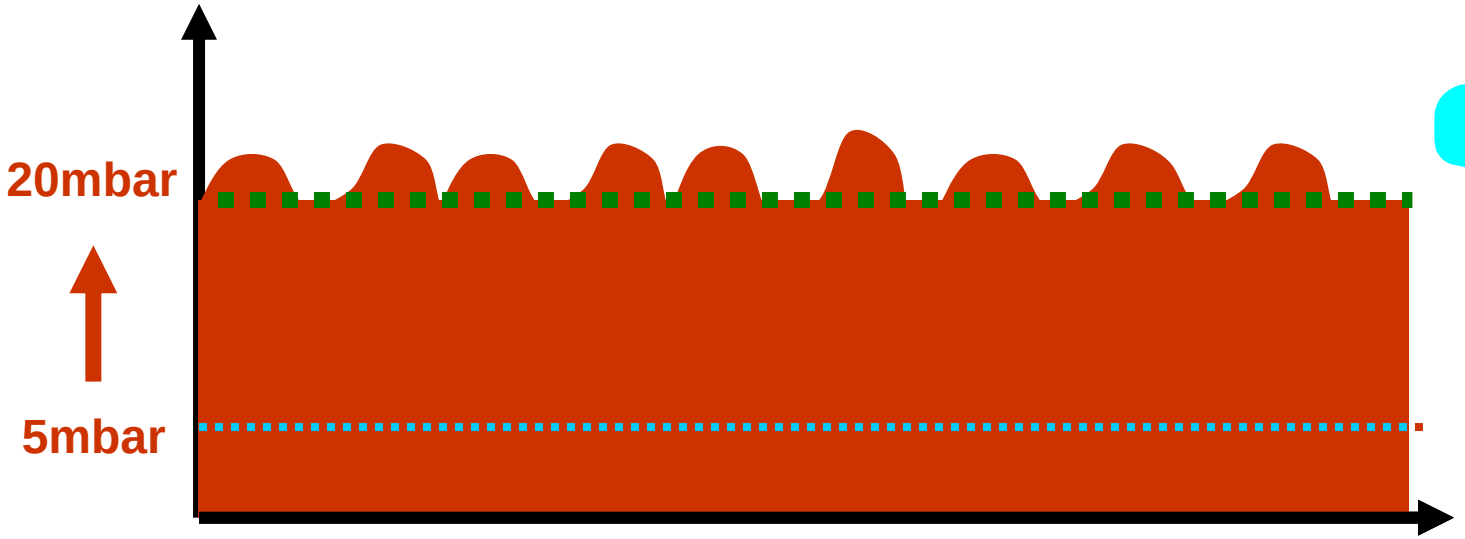
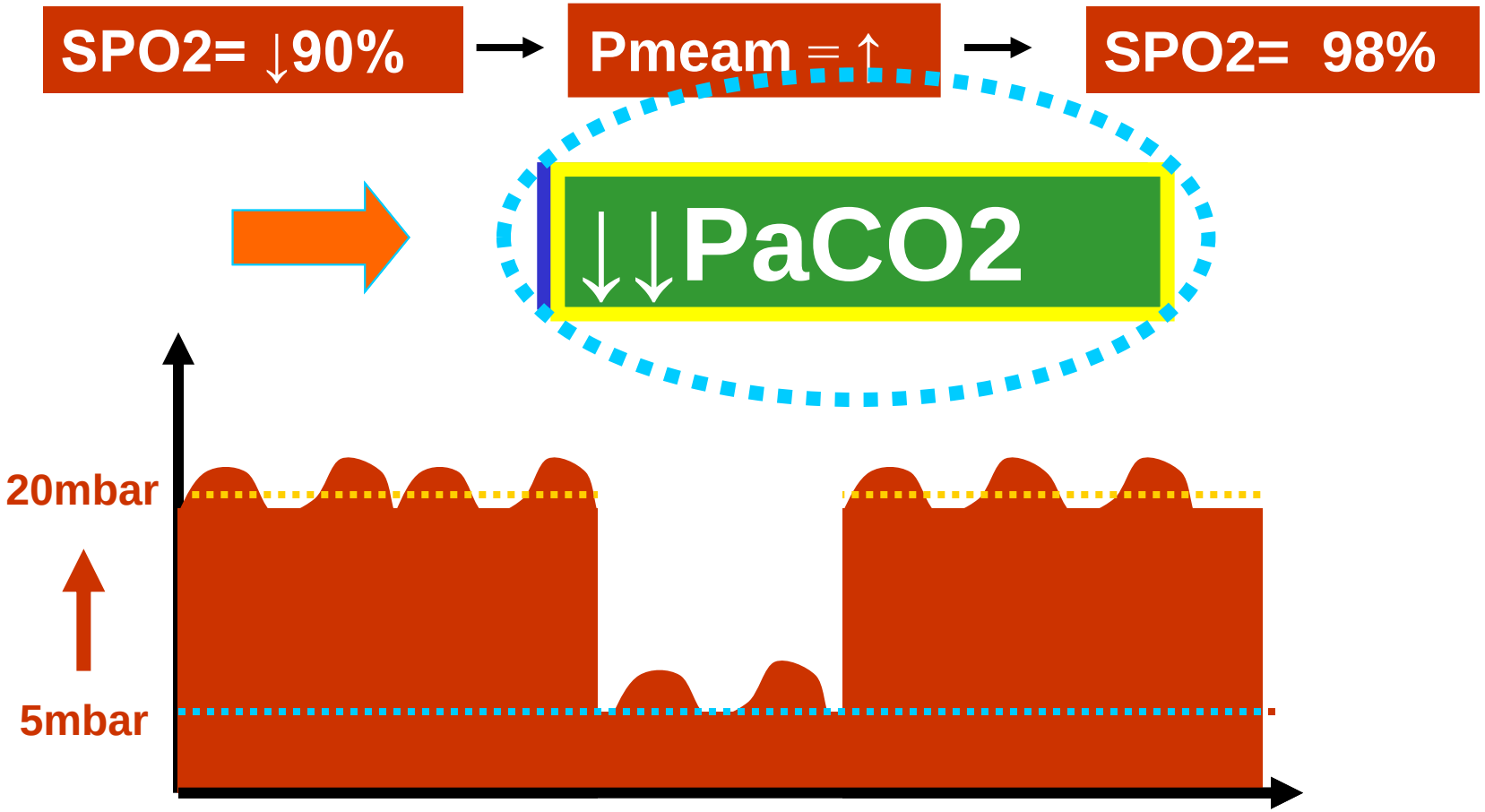
High PEEP

SPO2= ↓90% → Pmeam = ↑ → SPO2= 98%

PaCO=↑↑

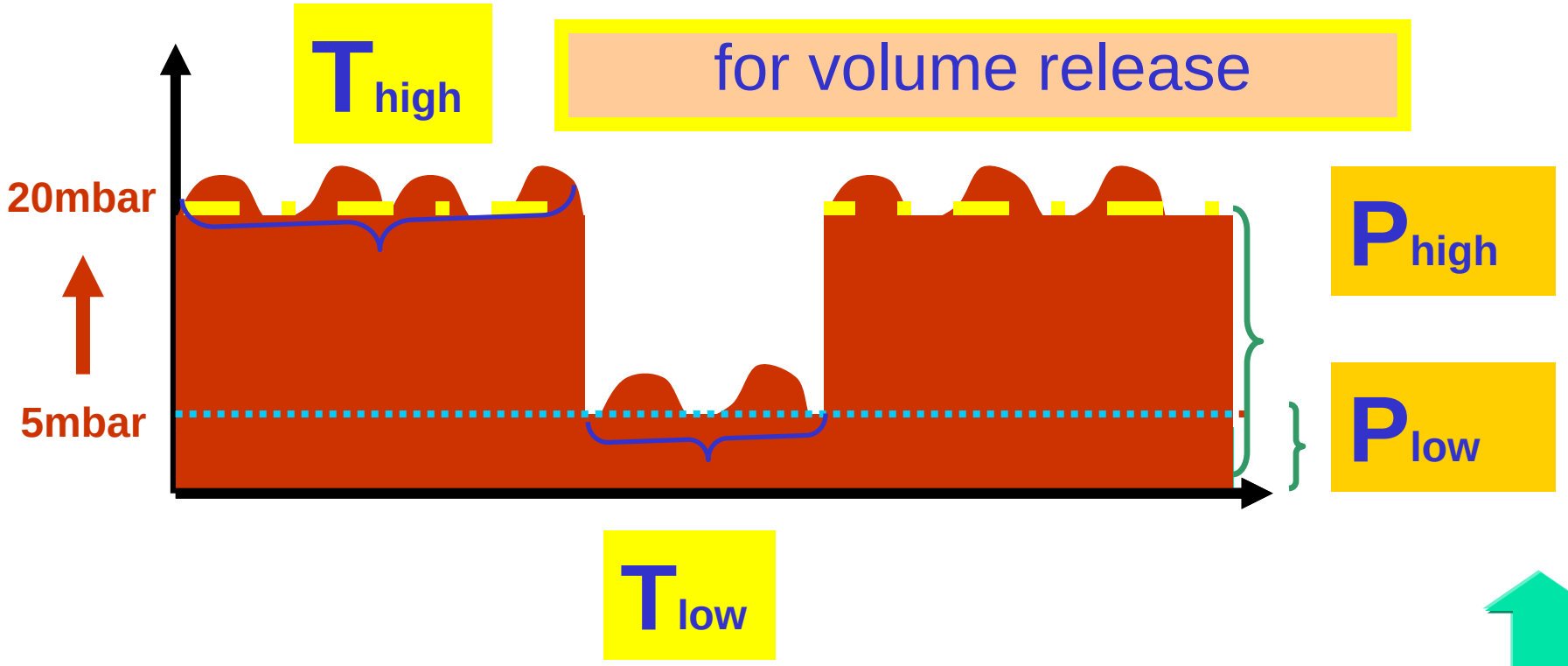



SPO2= ↓90%
Pmeam = ↑
SPO2= 98%
↓↓PaCO2
20mbar
5mbar

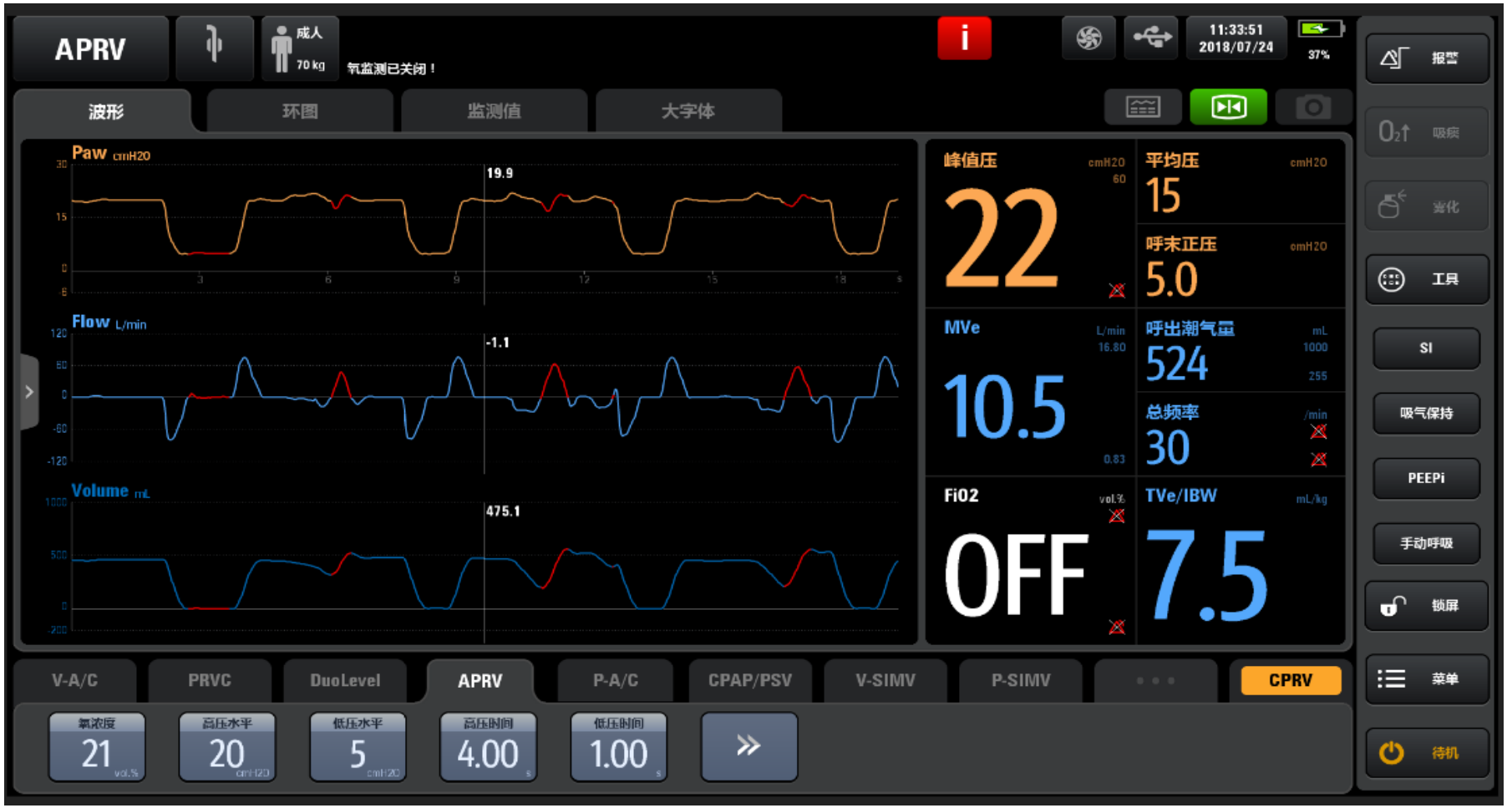
2 CPAP → APRV

APRV ONLY 4 ADJUSTABLE VARIABLES :

- 2 reference Pressure : Phigh & Plow
- 2 matching Time : Thigh & Tlow

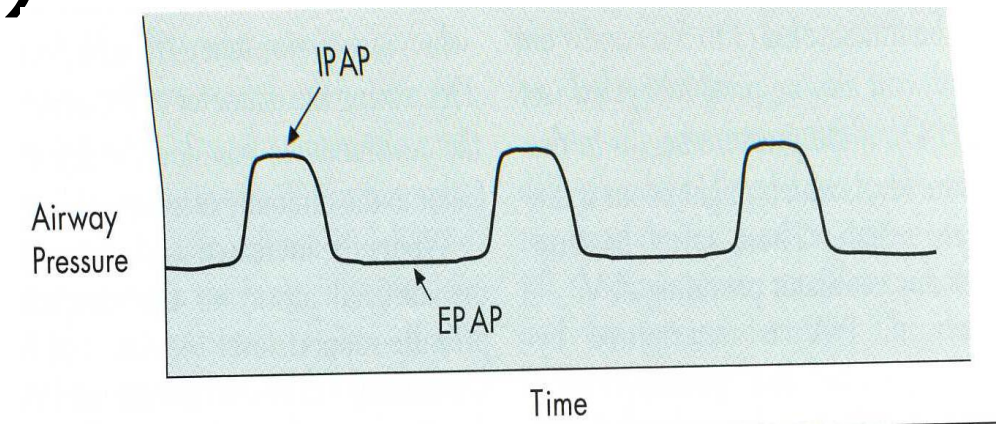


APRV
Airway Pressure Release Ventilation



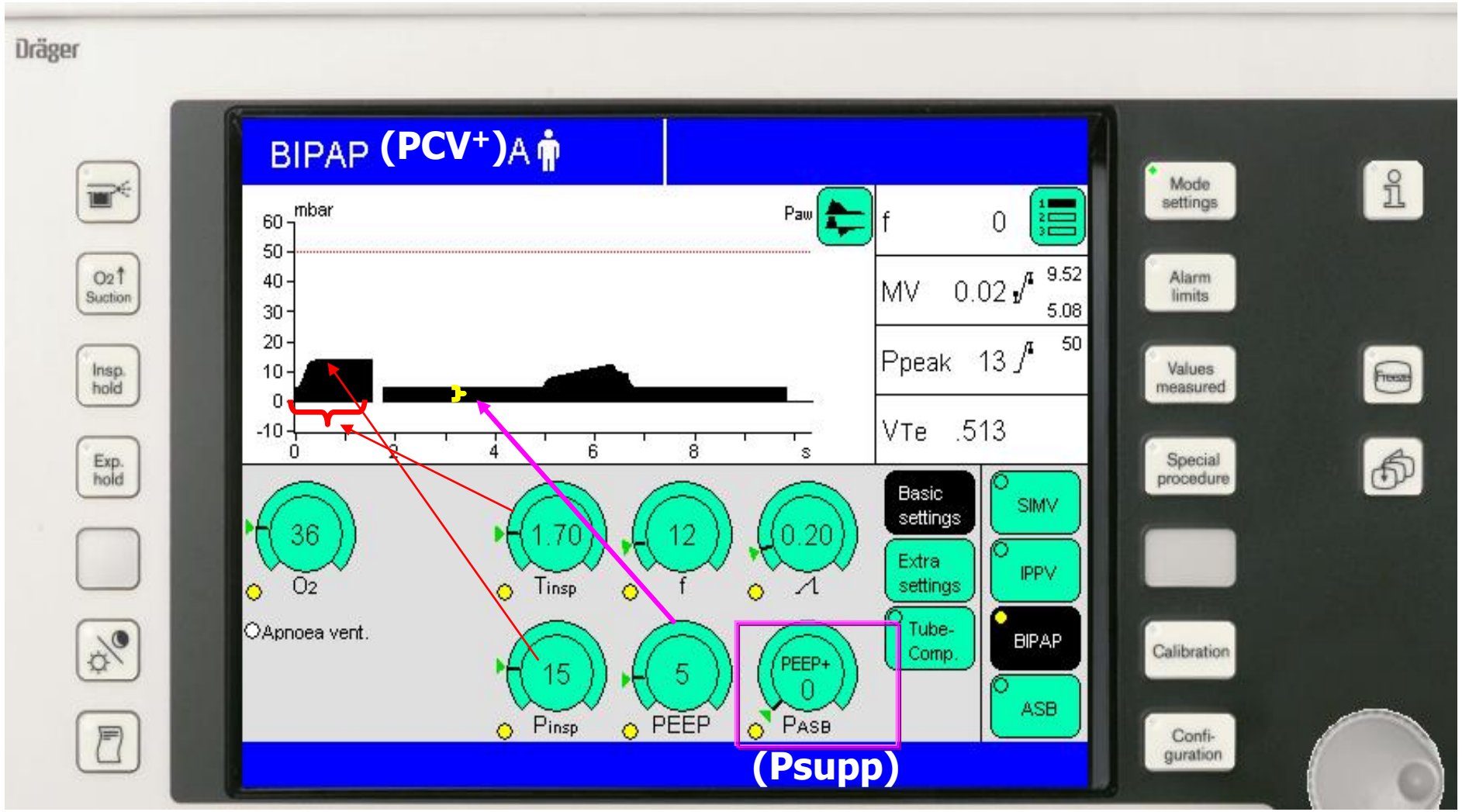
氣道雙期壓力

- Bi-phase Positive Airway Pressure
  - BIPAP(=PCV+）(Drager)
  - DuoPAP (Hamilton Galileo)
  - Bi-Phasic (Vela, Avea)
  - Bi-vent (servo i)

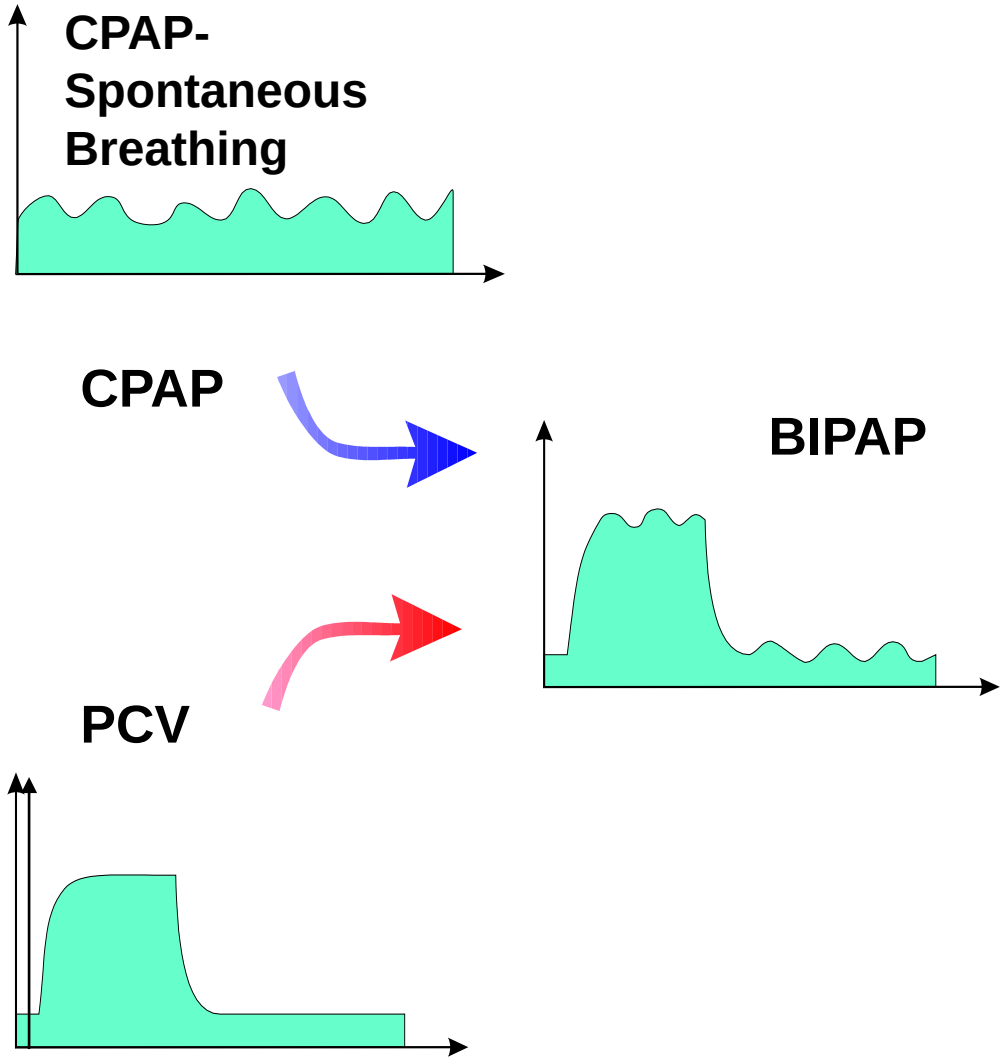


BIPAP (PCV+) setting

Drager

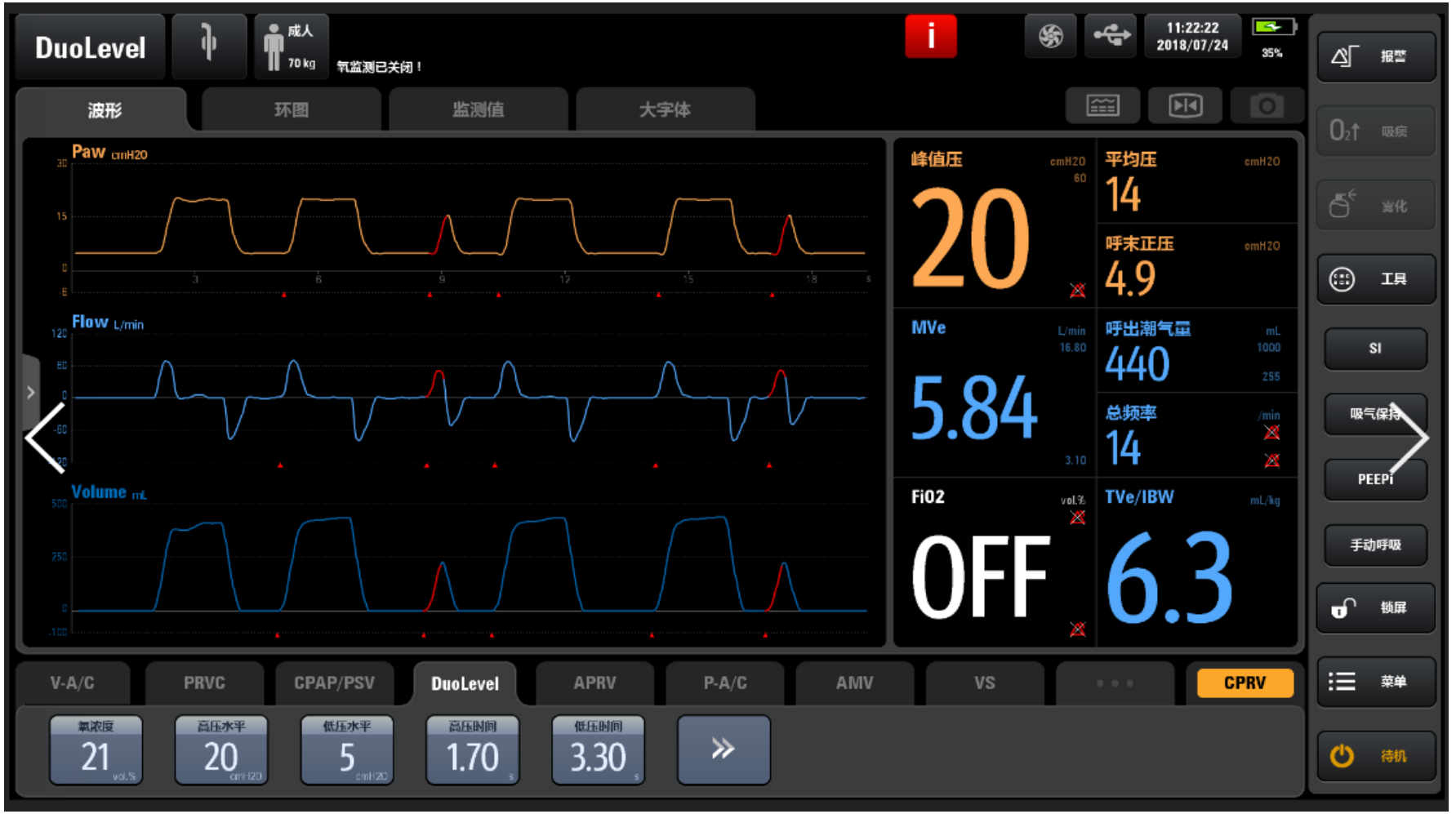


BIPAP®



- 降低機械換氣的侵略.
- 降低Sedation的用藥.
- 從Intubation to Weaning無須更換其他呼吸MODE.
- 使病患較舒適.

DuoLevel/ BiLevel/ BiPhasic/ DuePAP/ BiVent



APRV/Biphasic

TABLE 13-2 Comparison of Common Ventilator Modes

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Dräger Evita Infinity V500	CMV-Vol	CMV-Pres	SIMV (vol.) and PSV	SIMV (Press.)+ PSV	AutoFlow™	AutoFlow™ with SIMV (volume)	CPAP with or without PSV	APRV	MMV, SmartCare PPS
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GE CareStation	CMV-Vol	CMV-Pres	SIMV (vol.) and PSV	SIMV (Press)+ and PSV	CMV-PRVG	SIMV—PRVG	PSV—CPAP	BiLevel	BiLevel-PRVG
Hamilton C3	N/A	PCV+	NA	SIMV+ With PSV	CMV-APV	SIMV-APV	Spont/PSV	DuoPAP	ASV
Hamilton G5	CMV-VC	CMV-PC	SIMV-VC With PSV	SIMV-VC With PSV	CMV-APV	SIMV-APV	Spont/PSV	DuoPAP	ASV
Maquet Servo^{i} and Servo^{s}	VC	PC	SIMV (Vol. Contr.)	SIMV (Press. Contr.)	PRVC	SIMV (PRVC)	PSV/CPAP	BiVent	VS, NAVA available on Servo^{i}
Covidien PB 840	Assist/ control (volume)	Assist/ control (Press.)	SIMV (volume)	SIMV (pressure)	VC+	SIMV VC+	SPONT (PSV-CPAP)	Bilevel	PAV+ /VS

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Volume Support (VS)

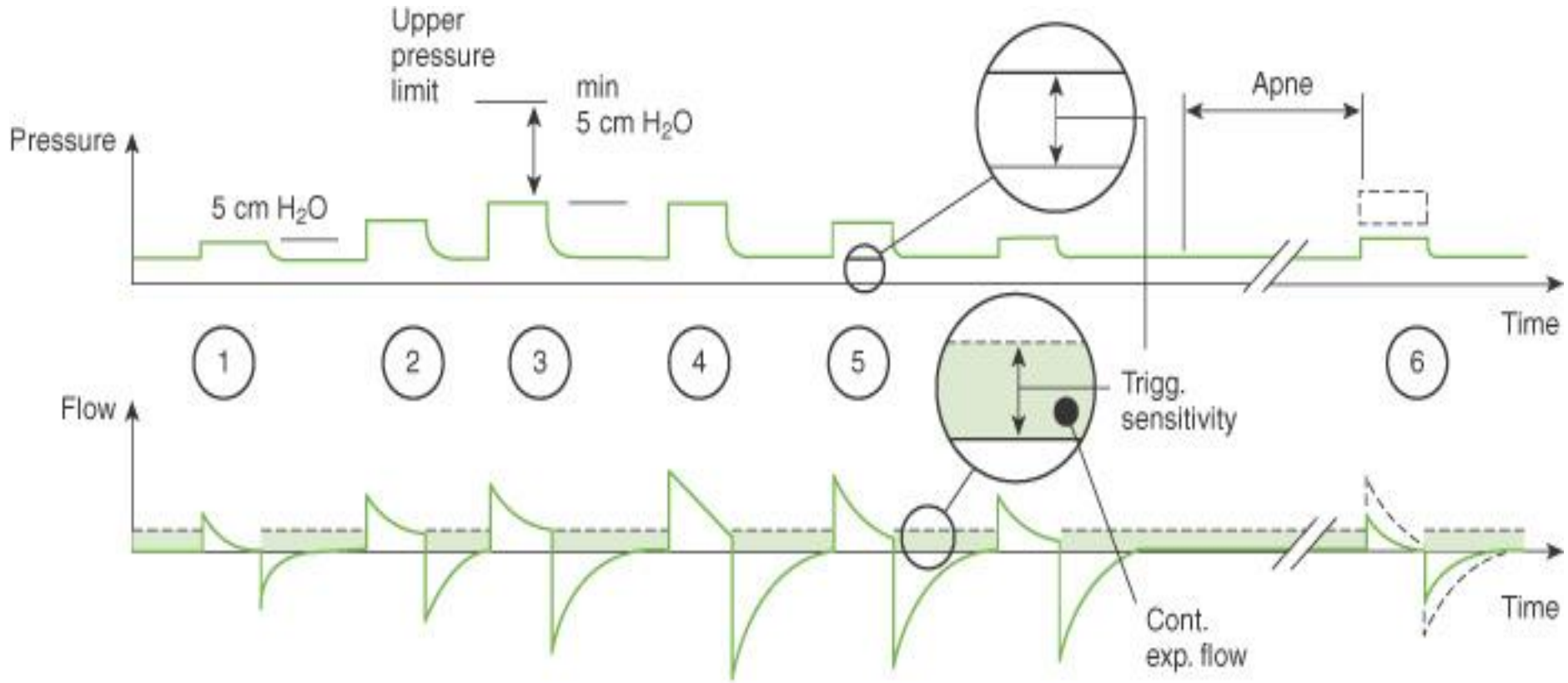

Fig. 6-11 (*1*), VS test breath (5 cm H_2O); (*2*), pressure is increased slowly until target volume is achieved; (*3*), maximum available pressure is 5 cm H_2O below upper pressure limit; (*4*), V_T higher than set V_T delivered results in lower pressure; (*5*), patient can trigger breath; (*6*) if apnea alarm is detected, ventilator switches to PRVC. (The 5 cm H_2O test breath and breath delivery pattern are features of the original design; these have been modified in newer models of the Servo 300 and Servo^i.)

(Courtesy Maquet, Bridgewater, N.J.)

Volume Support (VS)

VS

TABLE 13-2 Comparison of Common Ventilator Modes

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GE CareStation	CMV-Vol	CMV-Pres	SIMV (vol.) and PSV	SIMV (Press)+ and PSV	CMV-PRVG	SIMV—PRVG	PSV—CPAP	BiLevel	BiLevel-PRVG
Hamilton C3	N/A	PCV+	NA	SIMV+ With PSV	CMV-APV	SIMV-APV	Spont/PSV	DuoPAP	ASV
Hamilton G5	CMV-VC	CMV-PC	SIMV-VC With PSV	SIMV-VC With PSV	CMV-APV	SIMV-APV	Spont/PSV	DuoPAP	ASV
Maquet Servo^{i} and Servo^{s}	VC	PC	SIMV (Vol. Contr.)	SIMV (Press. Contr.)	PRVC	SIMV (PRVC)	PSV/CPAP	BiVent	VS, NAVA available on Servo^{i}
Covidien PB 840	Assist/ control (volume)	Assist/ control (Press.)	SIMV (volume)	SIMV (pressure)	VC+	SIMV VC+	SPONT (PSV-CPAP)	Bilevel	PAV+ /VS

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MMV (Bear 1000、Drager series) Minimum minute volume

- SIMV演進AMV演進MMV
- 設定平均每分鐘吐氣容積，病人呼吸必須超過設定最小閾值(1L or 10%)，否則就會產生支持次數(backup rate)

MMV mandatory minute ventilation
minimum minute ventilation
augmented minute ventilation

- 在 SIMV/CPAP(PSV)，若有設定 MMV level 時，只要病患的分鐘通氣量低於 MMV level 的設定值下，MMV 即會啟動取代病患之呼吸，以維持最低的分鐘通氣量，當機器監測病患之分鐘通氣量大於 MMV level 設定值 10% 或 1 升/分以上時，MMV 停止功能恢復 SIMV 模式。

Tidal Volume	900 ml
Rate	5 BPM
MMV LEVEL	9 Liters/min
"Backup Rate"	10 BPM

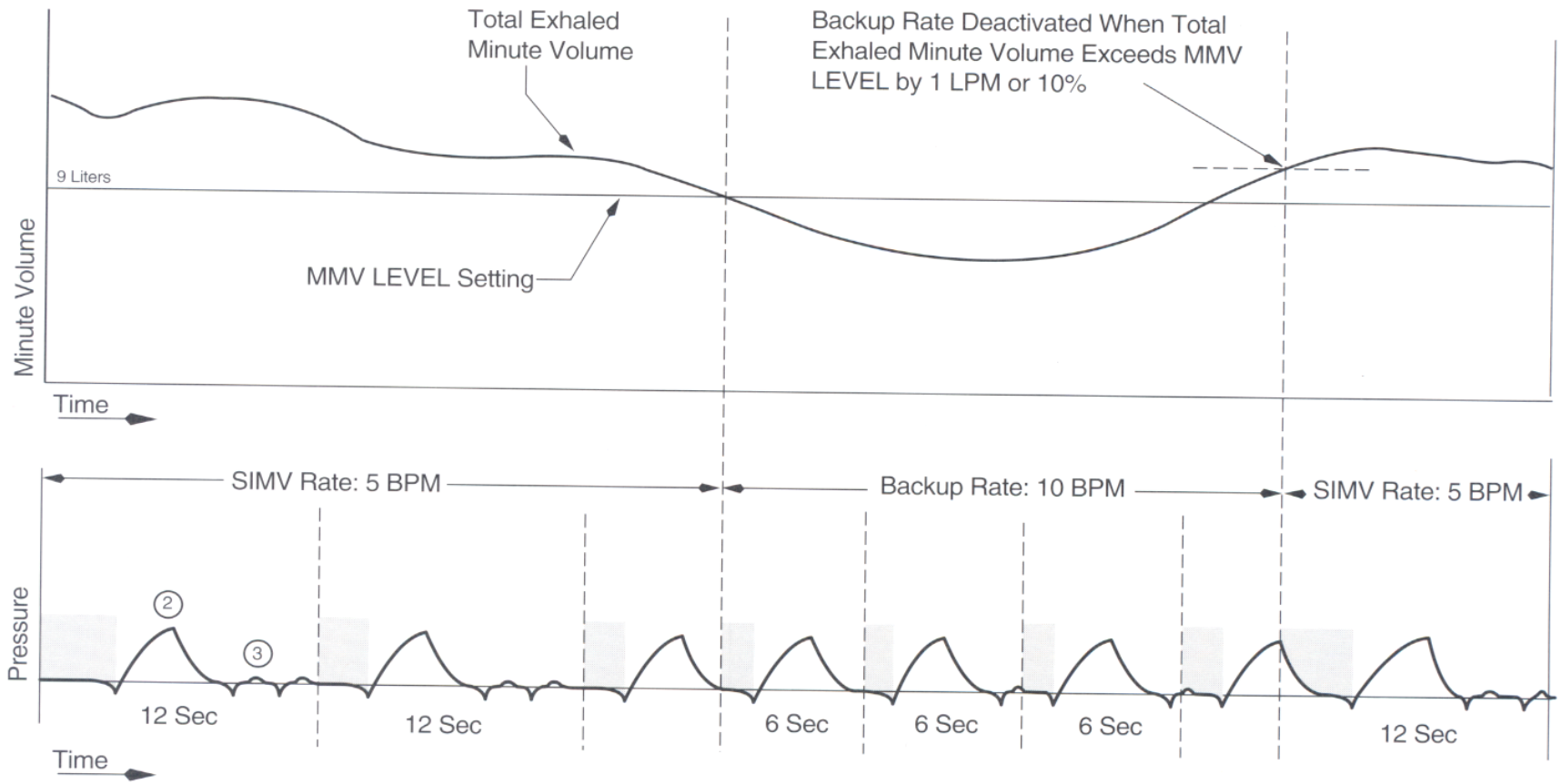
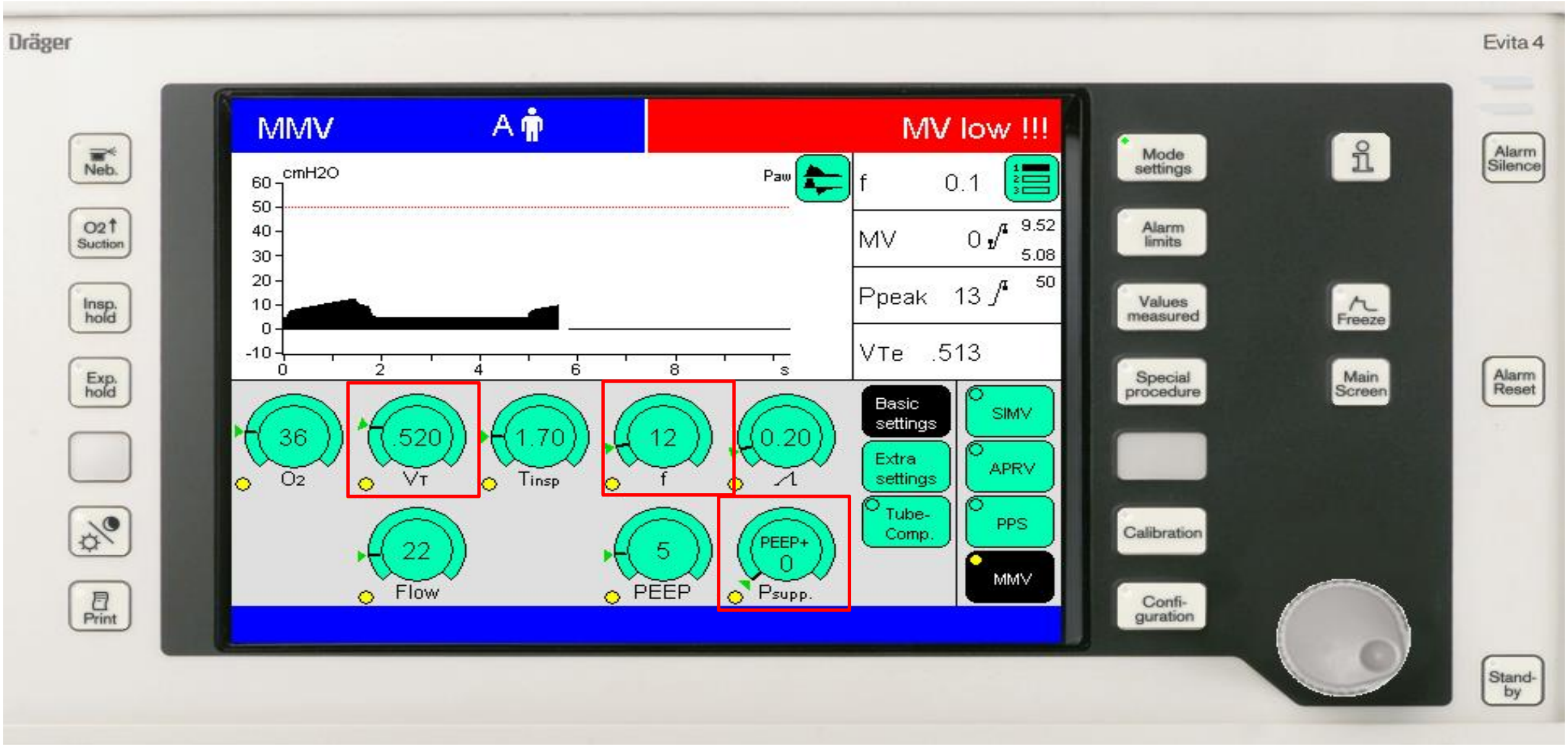


Figure 4-7 • MMV Operation During SIMV

MMV


Dräger
Evita 4
MMV
A
MV low !!!
cmH2O
60
50
40
30
20
10
0
-10
0
2
4
6
8
s
Paw
f 0.1
MV 0 9.52 5.08
Ppeak 13 50
VTe .513
36
O2
.520
VT
1.70
Tinsp
12
f
0.20
22
Flow
5
PEEP
PEEP+ 0
Psupp.
Basic settings
Extra settings
Tube-Comp.
SIMV
APRV
PPS
MMV
Mode settings
Alarm limits
Values measured
Special procedure
Calibration
Confi-guration
Freeze
Main Screen
Alarm Silence
Alarm Reset
Stand-by
Neb.
O2↑ Suction
Insp. hold
Exp. hold
Print

MMV

TABLE 13-2 Comparison of Common Ventilator Modes

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CareFusion AVEA	Volume A/C	Pressure A/C	Volume SIMV	Pressure SIMV	PRVC	PRVC SIMV	CPAP-PSV	APRV Biphasic	TCPL-A/C and TCPL-SIMV
Dräger Evita Infinity V500	CMV-Vol	CMV-Pres	SIMV (vol.) and PSV	SIMV (Press.)+ PSV	AutoFlow™	AutoFlow™ with SIMV (volume)	CPAP with or without PSV	APRV	MMV, SmartCare PPS
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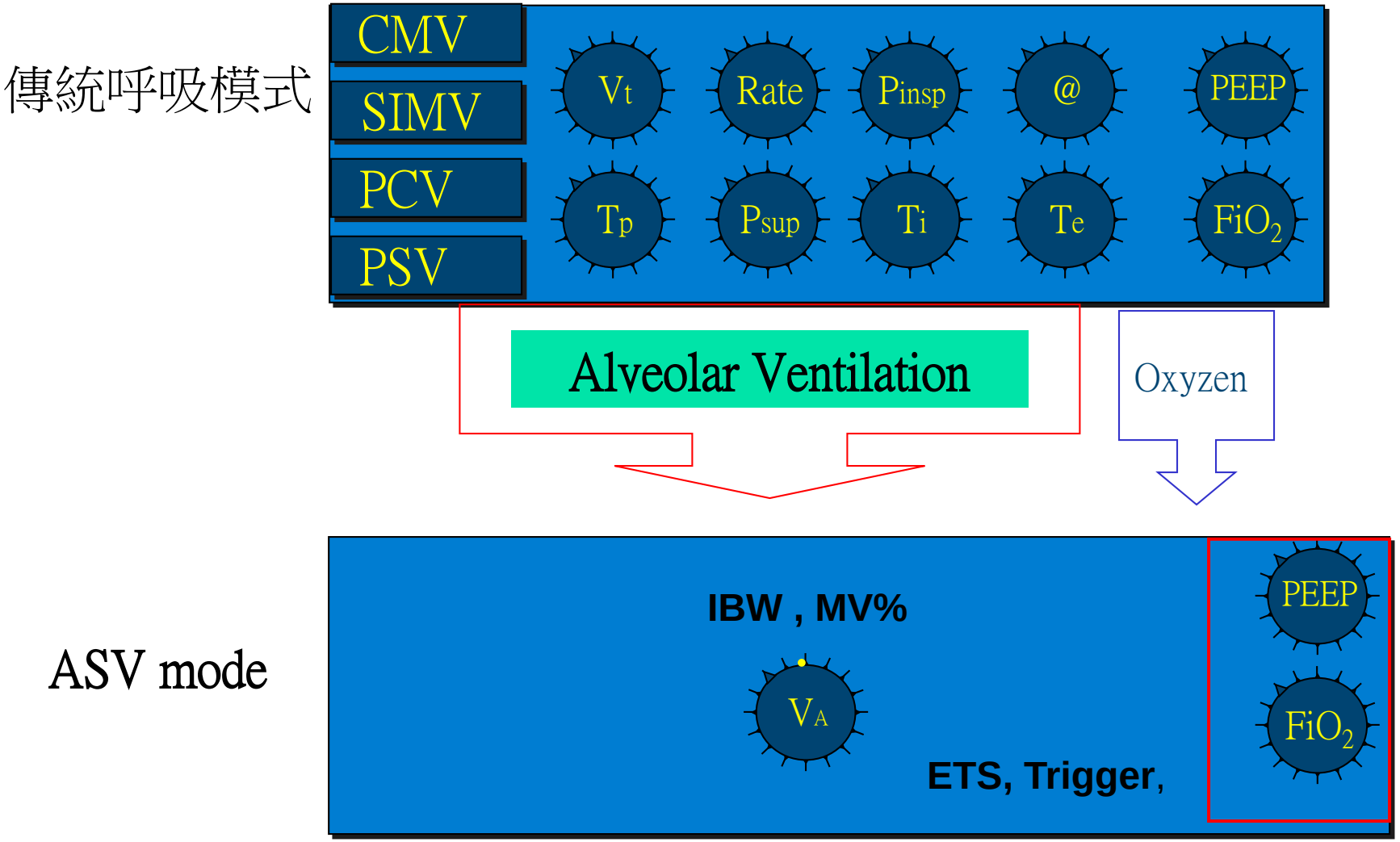
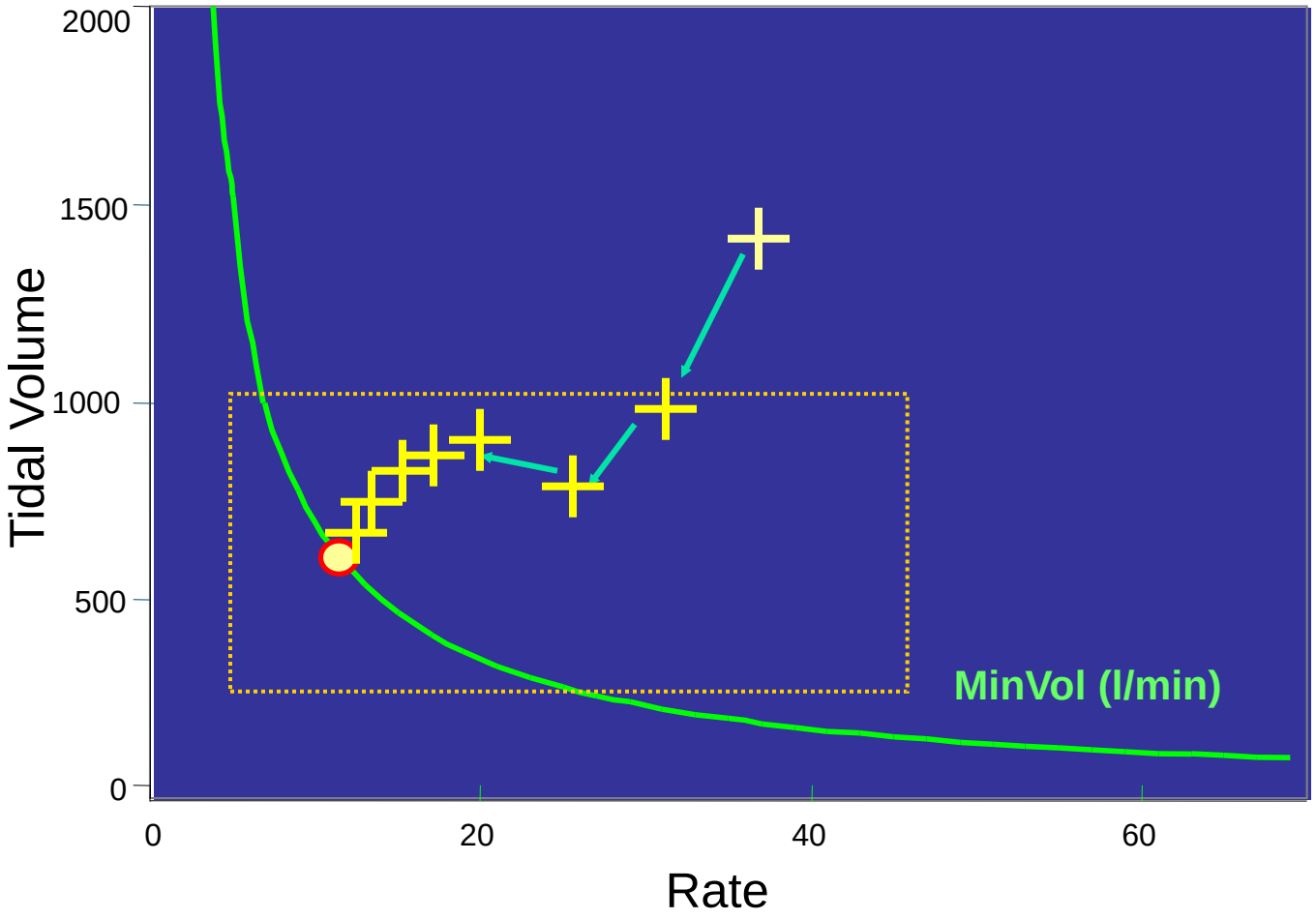
Hamilton C3/ G5
Adaptive Support Ventilation

ASV (adaptive support ventilation) Hamilton Galileo

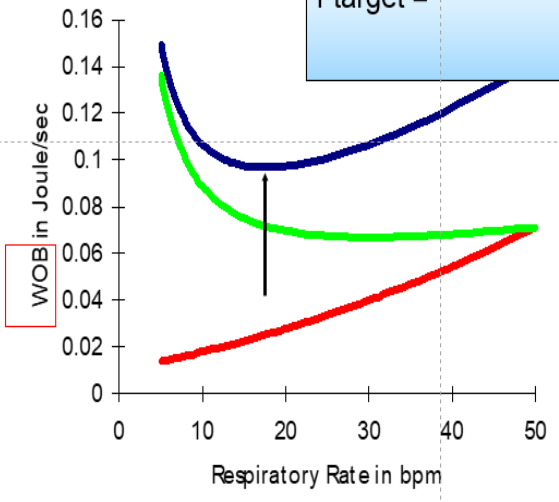
ASV 和 傳統呼吸模式比較



4. Approach the target



$$f\text{-target} = \frac{\sqrt{1 + 4\pi^2 * RCe * (MV - V'D)/VD} - 1}{2\pi^2 * RCe}$$



Rce=呼氣時間常數
MV=分通氣容積
VD=無效容積

Adaptive Minute Ventilation

$$f = \frac{\sqrt{1 + 2a \cdot RC_{exp} \cdot \frac{MV - f \cdot V_d}{V_d}} - 1}{a \cdot RC_{exp}}$$

ASV

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Hamilton C3	N/A	PCV+	NA	SIMV+ With PSV	CMV-APV	SIMV-APV	Spont/PSV	DuoPAP	ASV
Hamilton G5	CMV-VC	CMV-PC	SIMV-VC With PSV	SIMV-VC With PSV	CMV-APV	SIMV-APV	Spont/PSV	DuoPAP	ASV
Maquet Servo^{i} and Servo^{s}	VC	PC	SIMV (Vol. Contr.)	SIMV (Press. Contr.)	PRVC	SIMV (PRVC)	PSV/CPAP	BiVent	VS, NAVA available on Servo^{i}
Covidien PB 840	Assist/ control (volume)	Assist/ control (Press.)	SIMV (volume)	SIMV (pressure)	VC+	SIMV VC+	SPONT (PSV-CPAP)	Bilevel	PAV+ /VS

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Proportional Assist™ Ventilation Plus (PAV™+)*

- Puritan Bennett *840* ventilator
- *PAV+* amplifies the patient's own spontaneous effort to breathe by increasing airway pressure during inspiration.
- 降低無效呼吸作功的機會

PAV+ (PB840)降低無效呼吸作功機會

- 與呼吸系統力學 (respiratory system mechanics) 有關之 resistance 與 elastance 會隨患者狀態不斷變動，因此需常規監測方能在 over-assist 或 under-assist 出現時修正之。非侵入性的監測工具「PAV+」(PAV with load-adjustable gain factors) 便因應而生，PAV+ 會依據瞬間的 flow 與 volume 而自動、且即時調整呼吸器的壓力輸出。
- 比例輔助通氣（PAV），在沒有預選目標的情況下產生與壓力成比例的壓力，比例輔助通氣加（PAV +）測量順應性和阻力，計算呼吸功，並調節對預設輔助水平的支持

J Intensive Care Med. 2018 Jan 1:885066618769021.

比例輔助通氣方程式

正常的呼吸負荷

Muscle pressure=(normal elastance × volume) + (normal resistance × flow)

有肺部病灶的呼吸負荷

Muscle pressure={(normal elastance + abnormal elastance) × volume} +{(normal resistance + abnormal resistance) × flow

呼吸器應該負擔的部分

- 使用MV的目的是協助病人克服因肺部的病理變化所產生的異常復載(abnormal load), PAV的目標是協助肌肉的負載回到正常(病人負擔正常肺部力學的部分；呼吸器負擔不正常肺部力學的部分)

PAV+

TABLE 13-2 Comparison of Common Ventilator Modes

Ventilator	Assist/ Control CMV-Vol	PCV	SIMV-VC	SIMV-PC	PRVC	SIMV PRVC	PSV/CPAP	APRV	Additional Mode(s) or Feature(s)
CareFusion AVEA	Volume A/C	Pressure A/C	Volume SIMV	Pressure SIMV	PRVC	PRVC SIMV	CPAP-PSV	APRV Biphasic	TCPL-A/C and TCPL-SIMV
Dräger Evita Infinity V500	CMV-Vol	CMV-Pres	SIMV (vol.) and PSV	SIMV (Press.)+ PSV	AutoFlow™	AutoFlow™ with SIMV (volume)	CPAP with or without PSV	APRV	MMV, SmartCare PPS
Dräger EvitaXL	CMV	PCV+	SIMV (vol.) and PSV	SIMV (Press.)+ PSV	AutoFlow™	AutoFlow™ with SIMV (volume)	PSV-CPAP	APRV	MMV & MMV + PS
GE CareStation	CMV-Vol	CMV-Pres	SIMV (vol.) and PSV	SIMV (Press)+ and PSV	CMV-PRVG	SIMV—PRVG	PSV—CPAP	BiLevel	BiLevel-PRVG
Hamilton C3	N/A	PCV+	NA	SIMV+ With PSV	CMV-APV	SIMV-APV	Spont/PSV	DuoPAP	ASV
Hamilton G5	CMV-VC	CMV-PC	SIMV-VC With PSV	SIMV-VC With PSV	CMV-APV	SIMV-APV	Spont/PSV	DuoPAP	ASV
Maquet Servo^{i} and Servo^{s}	VC	PC	SIMV (Vol. Contr.)	SIMV (Press. Contr.)	PRVC	SIMV (PRVC)	PSV/CPAP	BiVent	VS, NAVA available on Servo^{i}
Covidien PB 840	Assist/ control (volume)	Assist/ control (Press.)	SIMV (volume)	SIMV (pressure)	VC+	SIMV VC+	SPONT (PSV-CPAP)	Bilevel	PAV+ /VS

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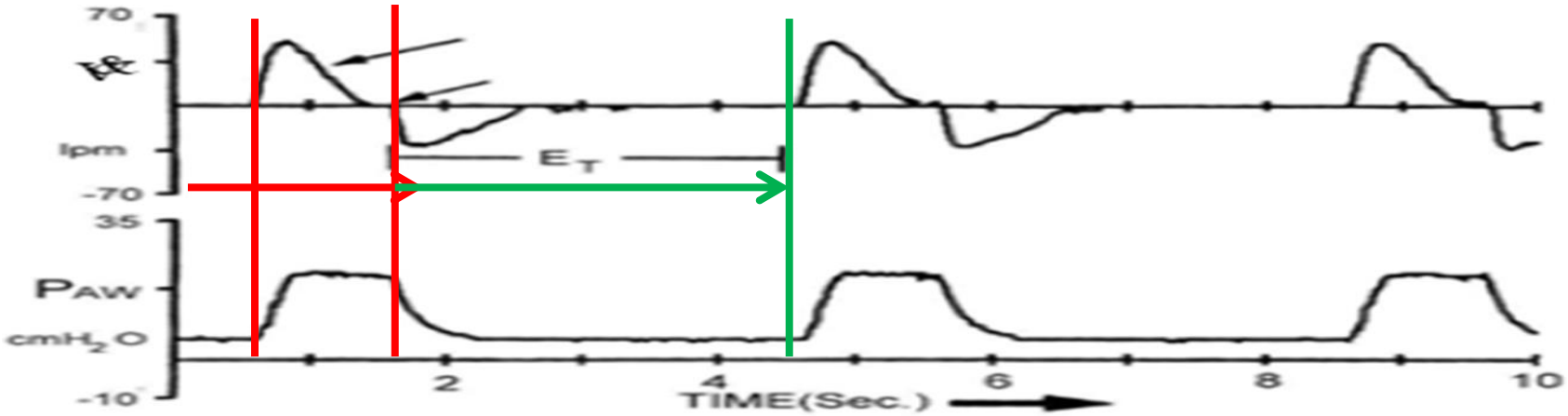
What is PCIRV

- PCIRV (Pressure Controlled Inverse Ratio Ventilation)**壓力控制顛倒吸氣吐氣比率的換氣(1:2 to 2:1)**
- 將吸氣時間調高，超過呼氣時間
- 主要目的是為了增加氧氣交換的時間，提高氧合作用。
- 如此違反生理原則病人會非常不舒服，因此使用此模式必須鎮靜病人，目前不建議使用

PCV vs PCIRV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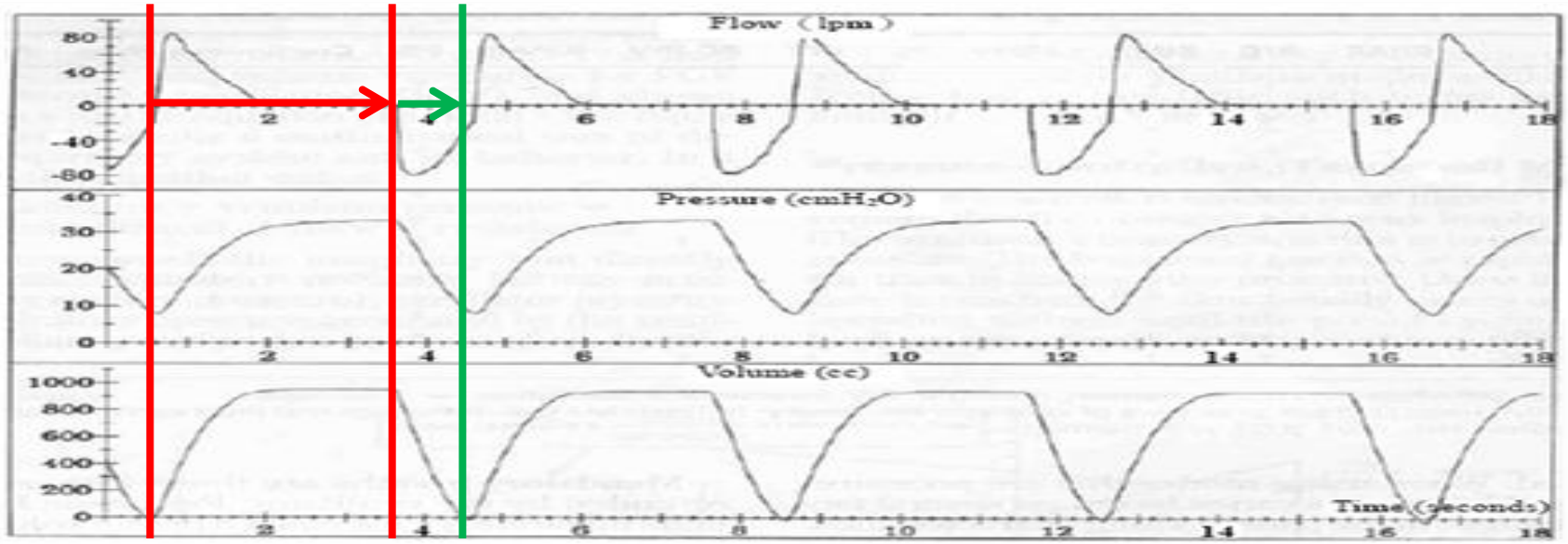
lpm
-70
35
PAW
cmH2O
-10
ET
2
4
6
8
10
TIME(Sec.)


Flow (lpm)
Pressure (cmH2O)
Volume (cc)
Time (seconds)