Stress Index Can Be Accurately and Reliably Assessed by Visually Inspecting Ventilator Waveforms

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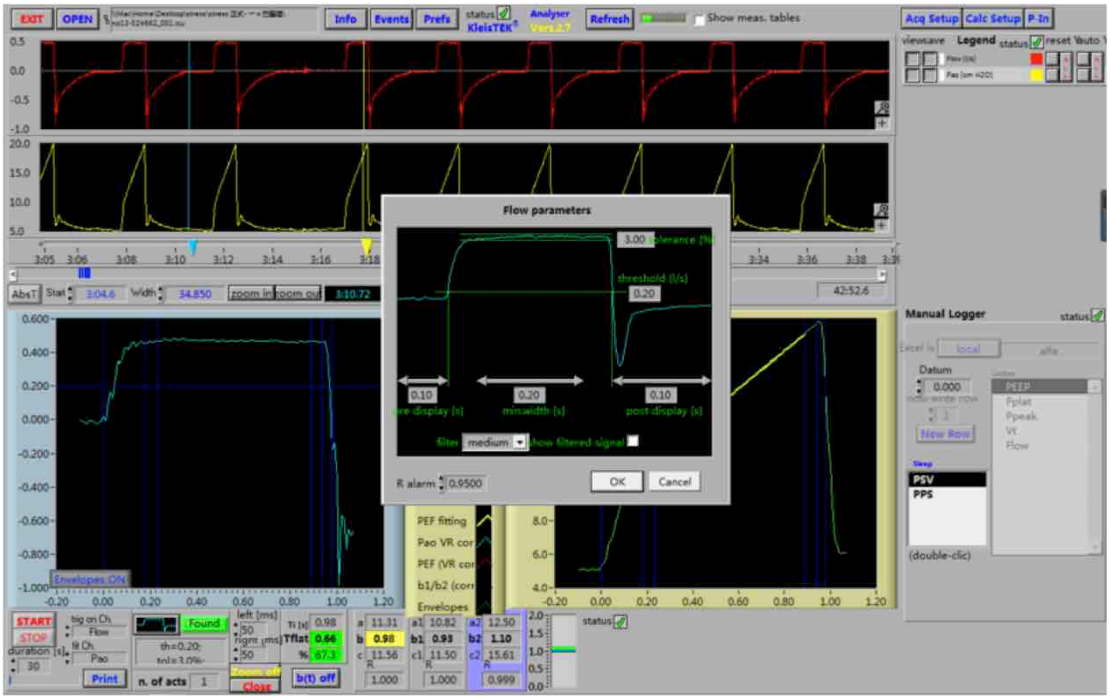
Data Supplement

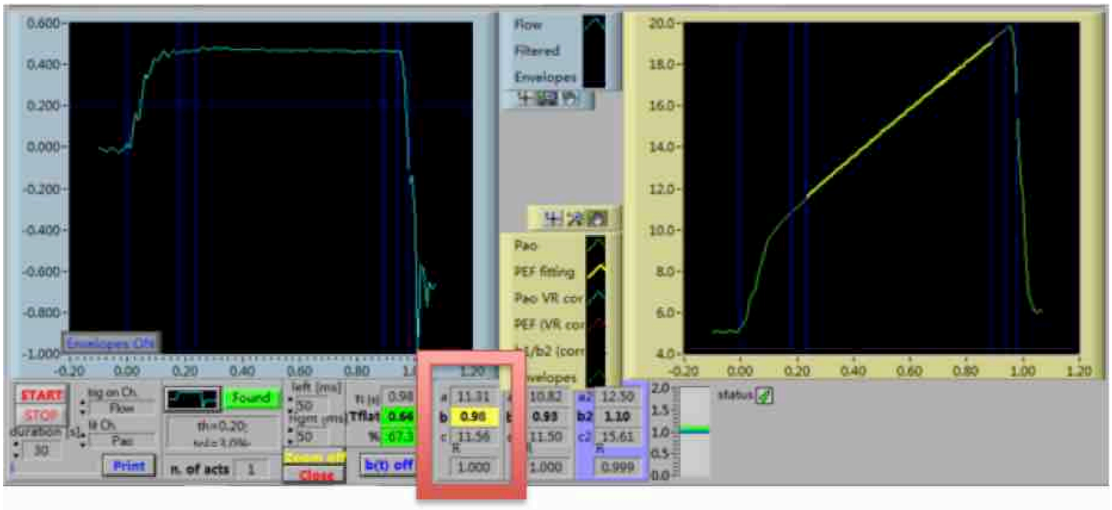
Contents

Figure E1 Identification of the constant flow segment



ICU-Lab 2.5 Software Package (KleisTEK, Bari, Italy) was used in off-line dynamic airway pressure-time (Paw-t) curve profile analysis. The software identified the beginning and the end of recorded breath by a threshold value in the flow tracing (0.2 L/sec). The constant flow segment was identified as the fluctuation was within ± 3% of the steady value. To eliminate the influence of on-flow and off-flow transients, the segment was further narrowed for 50 ms after the beginning and before the end of the constant flow portion. If a constant segment could not be found or the length of selected segment was less than one-third of the entire inspiratory phase, data were discarded but documented.

Figure E2 Paw-t curve fitting



After confirming the qualified constant flow segment, Paw-t curve within the corresponding segment was automatically fitted by the equation:

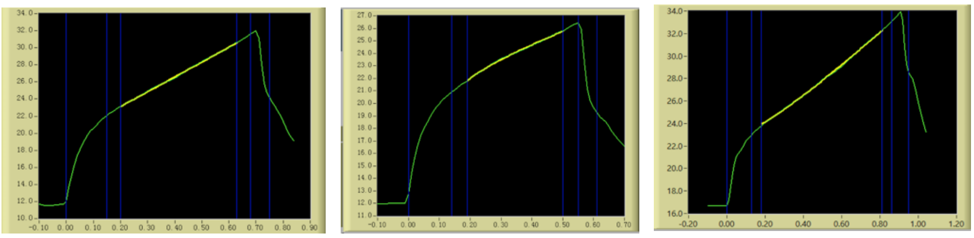
Paw = $a \times \text{time}^{b} + c$

The R values were calculated automatically and if lower than 0.95, the data were discarded but documented. In the equation, a represents the slope of Paw-t curve as time equal to 1 s; c is the airway pressure as time of 0 s; and b is a dimensionless parameter named as SI, which reflects the shape of the Paw-t curve and is related to respiratory system elastance (Ers). Assuming that the airway resistive and viscoelastic properties remain invariant, the change of slope along the Paw-t curve is mostly contributed to the change of Ers during tidal inspiration.

Reference:

Ranieri VM, Zhang H, Mascia L, Aubin M, Lin CY, Mullen JB, et al. Pressure-time curve predicts minimally injurious ventilatory strategy in an isolated rat lung model. Anesthesiology 2000;93(5):1320-1328.

Figure E3 Paw-t curve shape classification according to the SI value



SI = 1.00 SI = 0.81 SI = 1.20

Paw-t curve shape can be classified into three categories:

1) an SI between 0.9 and 1.1 corresponding to a linear shape of qualified Paw-t curve segment that describes an unchanged Ers with time;

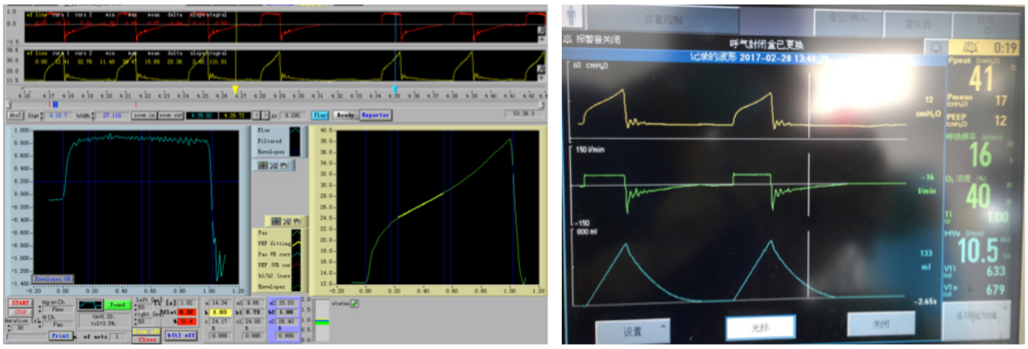
2) an SI < 0.9 corresponding to an upward concavity shape that represents a decreasing Ers with time

3) an SI > 1.1 corresponding to a downward concavity shape that represents an increasing Ers with time.

Reference:

Terragni P, Bussone G, Mascia L. Dynamic airway pressure-time curve profile (Stress Index): a systematic review. Minerva Anestesiol 2016;82(1):58-68.

Figure E4 Example of unqualified Paw-t curve



a b

Panel a is the example of unqualified Paw-t curve analyzed by the software. The unstable flow at the end inspiratory caused that the length of constant flow segment (0.32s) was less than one-third of the inspiratory phase (1.02s). Simultaneously, the Paw during the unstable flow increased obviously. Panel b shows the same unqualified Paw-t curve shown on the ventilator screen. We did not find the unstable flow during on-site visual inspection. At the bedsides, an abrupt elevation in Paw-t waveform might suggest an unstable inspiratory flow pattern.

Table E1 Off-Line Software Determined Stress Index and Classification in the First 50 Assessments

	No. of assessments	No1	No2	No3	No4	No5	No6	No7	No8	No9	No10
SI value	single breath	0.81	0.90	0.95	0.98	1.04	0.86	0.79	0.92	0.95	1.11
	2-min mean value	0.76	0.90	0.94	1.07	1.03	0.86	0.87	0.91	0.99	1.12
classification	single breath	downward concavity	linear	linear	linear	linear	downward concavity	downward concavity	linear	linear	upward concavity
	2-min mean value	downward concavity	linear	linear	linear	linear	downward concavity	downward concavity	linear	linear	upward concavity

	No. of assessments	No11	No12	No13	No14	No15	No16	No17	No18	No19	No20
SI value	single breath	0.97	1.01	1.03	0.92	0.78	0.91	1.00	0.95	1.18	0.94
	2-min mean value	1.08	1.08	1.04	0.91	0.78	0.90	0.91	0.91	1.26	0.91
classification	single breath	linear	linear	linear	linear	downward concavity	linear	linear	linear	upward concavity	linear
	2-min mean value	linear	linear	linear	linear	downward concavity	linear	linear	linear	upward concavity	linear

	No. of assessments	No21	No22	No23	No24	No25	No26	No27	No28	No29	No30
SI value	single breath	0.89	0.93	0.95	0.96	0.81	0.97	0.94	0.87	1.07	1.02
	2-min mean value	0.87	0.93	0.99	0.94	0.79	0.98	0.94	0.84	1.05	1.05
classification	single breath	downward concavity	linear	linear	linear	downward concavity	linear	linear	downward concavity	linear	linear
	2-min mean value	downward concavity	linear	linear	linear	downward concavity	linear	linear	downward concavity	linear	linear

	No. of assessments	No31	No32	No33	No34	No35	No36	No37	No38	No39	No40
SI value	single breath	0.99	1.04	0.85	0.88	0.88	1.05	1.05	0.87	0.88	0.98
	2-min mean value	1.05	1.06	0.81	0.88	0.88	1.09	1.03	0.89	0.89	0.95
classification	single breath	linear	linear	downward concavity	downward concavity	downward concavity	linear	linear	downward concavity	downward concavity	linear
	2-min mean value	linear	linear	downward concavity	downward concavity	downward concavity	linear	linear	downward concavity	downward concavity	linear

	No. of assessments	No41	No42	No43	No44	No45	No46	No47	No48	No49	No50
SI value	single breath	1.16	0.94	0.93	0.86	0.87	1.13	0.90	1.11	0.97	1.21
	2-min mean value	1.14	0.92	0.93	0.88	0.88	1.14	0.91	1.15	0.91	1.28
classification	single breath	upward concavity	linear	linear	downward concavity	downward concavity	upward concavity	linear	upward concavity	linear	upward concavity
	2-min mean value	upward concavity	linear	linear	downward concavity	downward concavity	upward concavity	linear	upward concavity	linear	upward concavity

In the first 50 off-line analyses, the stress index (SI) from the single breath and the 2-min mean value before the single breath were both measured in the off-line analysis.The SI was classification into three types: an SI between 0.9 and 1.1 corresponding to a linear shape; an SI < 0.9 corresponding to a downward concavity shape; an SI > 1.1 corresponding to a upward concavity shape.An identical SI classification was found in each assessment.

Table E2 Accuracy of visual stress index classification among different reference stress index classifications and among different ventilator brands

		Accuracy (95% confidential interval)
Reference stress index	Linear	94% (89%-98%)
	Downward concavity	91% (83%-99%)
	Upward concavity	95% (79%-100%)
	p	0.20
Ventilator brands	Servo-I	91% (85%-98%)
	AVEA	92% (88%-97%)
	PB 840	93% (86%-100%)
	p	0.68

Table E3 Contingency table for diagnostic accuracy analysis

		Reference SI classification by off-line analysis		Total
		Downward concavity	Linear	
Visual SI classification	Downward concavity	50	2	52
	Linear	5	123	128
	Total	55	125	180
		Upward concavity	Linear	
	Upward concavity	19	6	25
	Linear	1	119	120
	Total	20	125	145
		Combined downward and upward concavity	Linear	
	Combined downward and upward concavity	69	8	77
	Linear	6	117	123
	Total	75	125	200

Training Manual for Visual Classification of Stress Index by Inspecting the Ventilator Screen Waveforms

Version 2017.02.23

Contents

1) Fundamental principle of airway pressure-time (Paw-t) curve profile analysis and its clinical use;

2) Standard method for off-line stress index (SI) fitting by ICU-Lab software and classification;

3) Method for visual SI classification by inspecting the flow-time and Paw-t waveforms on the ventilator screen.

1) Airway pressure-time curve profile analysis and stress index

Lung-protective ventilation, mainly composed of small tidal volume, low plateau and driving pressures and adequate positive end-expiratory pressure (PEEP), has been recommended in mechanically ventilated patients (E1). Evidences suggest that the assessment of elastic properties of the respiratory system is necessary to identify the proper settings of the ventilator and minimize ventilator-induced lung injury (E2).

Since first introduced in 2000 (E3), analysis of dynamic airway pressure-time (Paw-t) curve profile has been investigated to differentiate tidal recruitment and hyperinflation in animal experiments (E3-E8) and clinical studies (E9-E12). The shape of Paw-t curve within the constant inspiratory flow section is related to the change of respiratory system elastance (Ers). A linear, downward and upward concavity shape indicates the Ers remaining constant, decreasing or increasing during tidal inspiration, respectively (E13, E14). Fitting of the Paw-t curve also yields a dimensionless coefficient, i.e. stress index (SI), quantitatively describing the shape of the curve. This method is considered as a non-invasive and real-time respiratory mechanics monitoring at the bedside.

Experiments in pig model with acute lung injury showed that an SI < 0.9 indicated tidal recruitment and an SI > 1.1 indicated tidal hyperinflation (E6, E7). Histological and inflammatory evidences also revealed that markers of injurious ventilation were minimized when ventilator was set to maintain SI range of 0.9 to 1.1 (E3-E5). In patients with acute respiratory distress syndrome, titrating PEEP to obtain SI between 0.9 and 1.1 attenuated alveolar hyperinflation (E9) and improved recruitment volume (E10), lung elastance and oxygenation (E9).

2) Airway pressure-time curve analysis by ICU-Lab software

For off-line Paw-t curve analysis, flow and airway pressure data are collected.

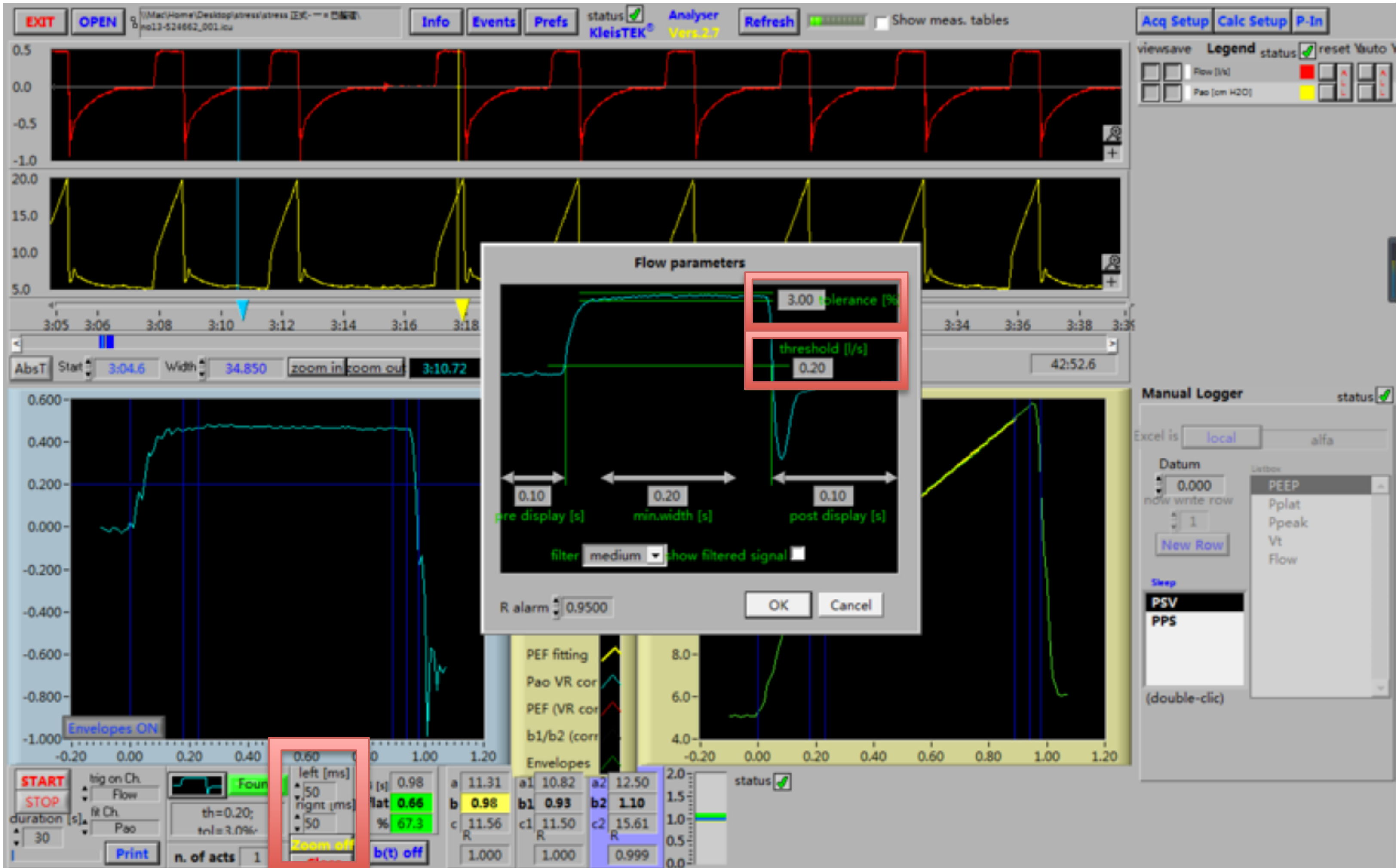
A heated Fleisch pneumotachograph (VitalographInc, Lenexa, KS, USA) is placed between the Y-piece of the ventilator circuit and the endotracheal tube to measure the flow. A KT 100D-2 pressure transducer (KleisTEK, Bari, Italy) is connected proximally to the endotracheal tube to measure the airway pressure. Pressure transducer and Fleisch pneumotachograph are connected to an ICU-Lab Pressure Box by 80 cm rigid tube lines. The pressure transducer is calibrated by a water column, and the pneumotachograph by a 1-L calibration syringe (SN: 554-2266, Hans Rudolph, Inc. Shawnee, KS, USA).

Signals are continuously displayed and saved (ICU-Lab 2.5 Software Package, KleisTEK, Bari, Italy) on a laptop computer for further analysis, at a sample rate of 200 Hz.

Pressure transducer and Fleisch pneumotachograph

ICU-Lab

Downloaded data are analyzed by ICU-Lab.

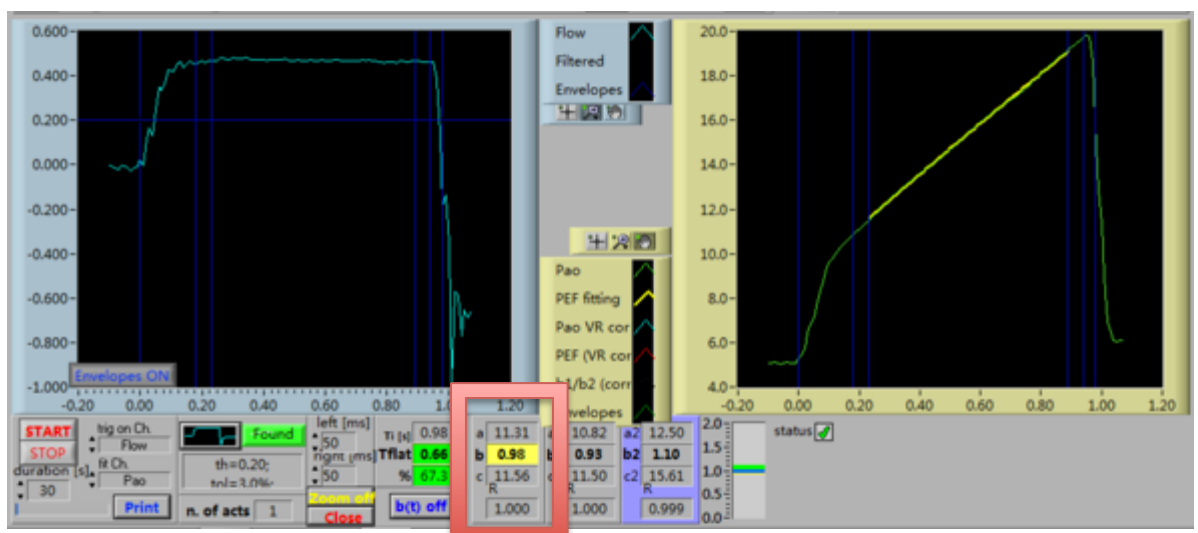


During off-line analysis, the software identifies the beginning and the end of recorded breath by a threshold value in the flow tracing (0.2 L/sec). The constant flow segment is identified as the fluctuation is within ± 3% of the steady value. To eliminate the influence of on-flow and off-flow transients, the segment is further narrowed for 50 ms after the beginning and before the end of the constant flow portion. If a constant segment cannot be found or the length of selected segment is less than one-third of the entire inspiratory phase, data are discarded.

After confirming the qualified constant flow segment, Paw-t curve within the corresponding segment is automatically fitted by the equation:

Airway pressure=$a \times \text{time}^{b} + c$

The R values will be calculated automatically and if lower than 0.95, the data are discarded. In the equation, a represents the slope of Paw-t curve as time equal to 1 s; c is the airway pressure as time of 0 s; and b is a dimensionless parameter named as SI, which reflects the shape of the Paw-t curve and is related to Ers (E3, E6). Assuming that the airway resistive and viscoelastic properties remain invariant, the change of slope along the Paw-t curve is mostly contributed to the change of Ers during tidal inspiration.



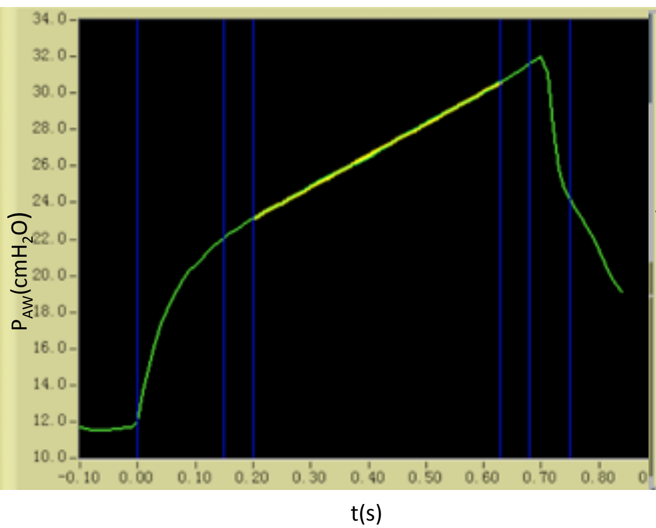
Paw-t curve shape can be classified into three categories (E11):

1) an SI between 0.9 and 1.1 corresponding to a linear shape of qualified Paw-t curve segment that describes an unchanged Ers with time;

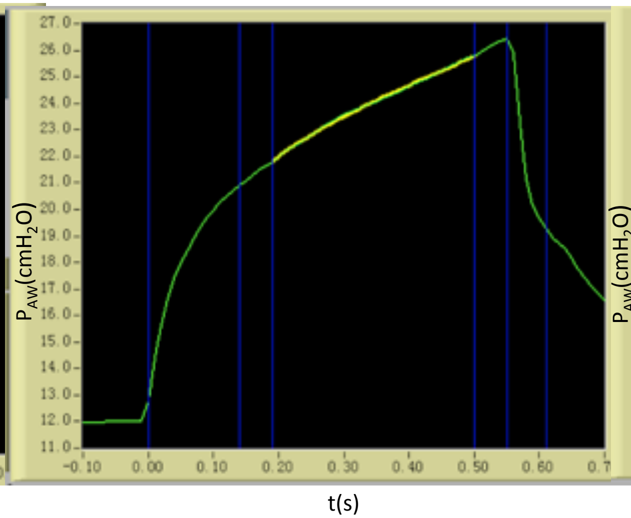
2) an SI < 0.9 corresponding to a downward concavity shape that represents a decreasing Ers with time

3) an SI > 1.1 corresponding to an upward concavity shape that represents an increasing Ers with time.

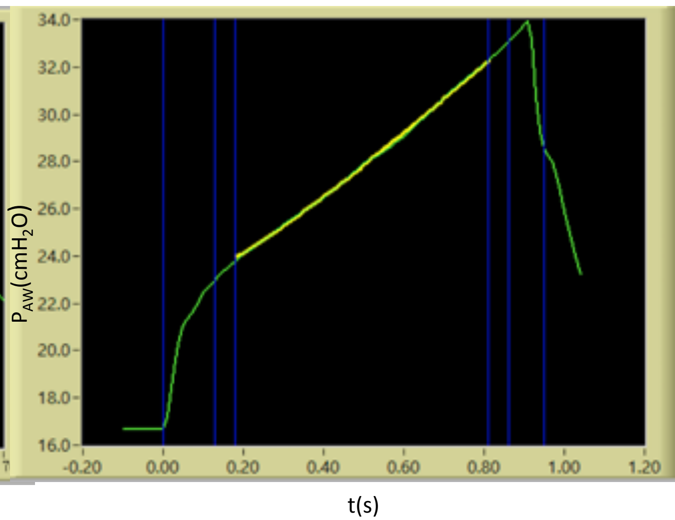
SI=1.00



SI=0.81

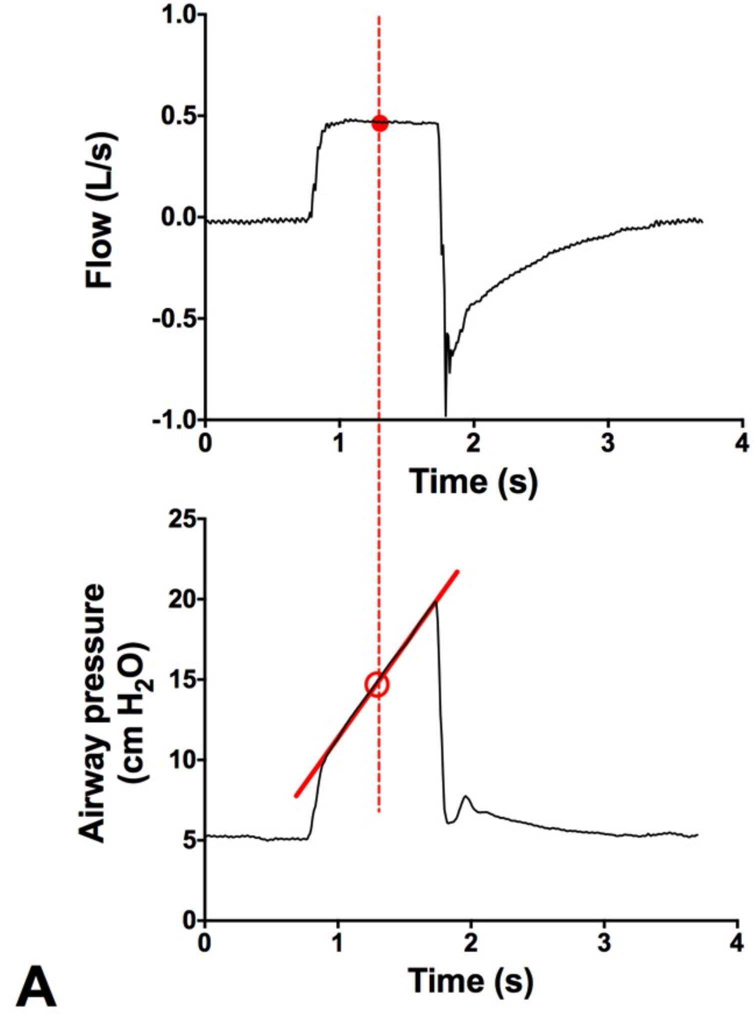


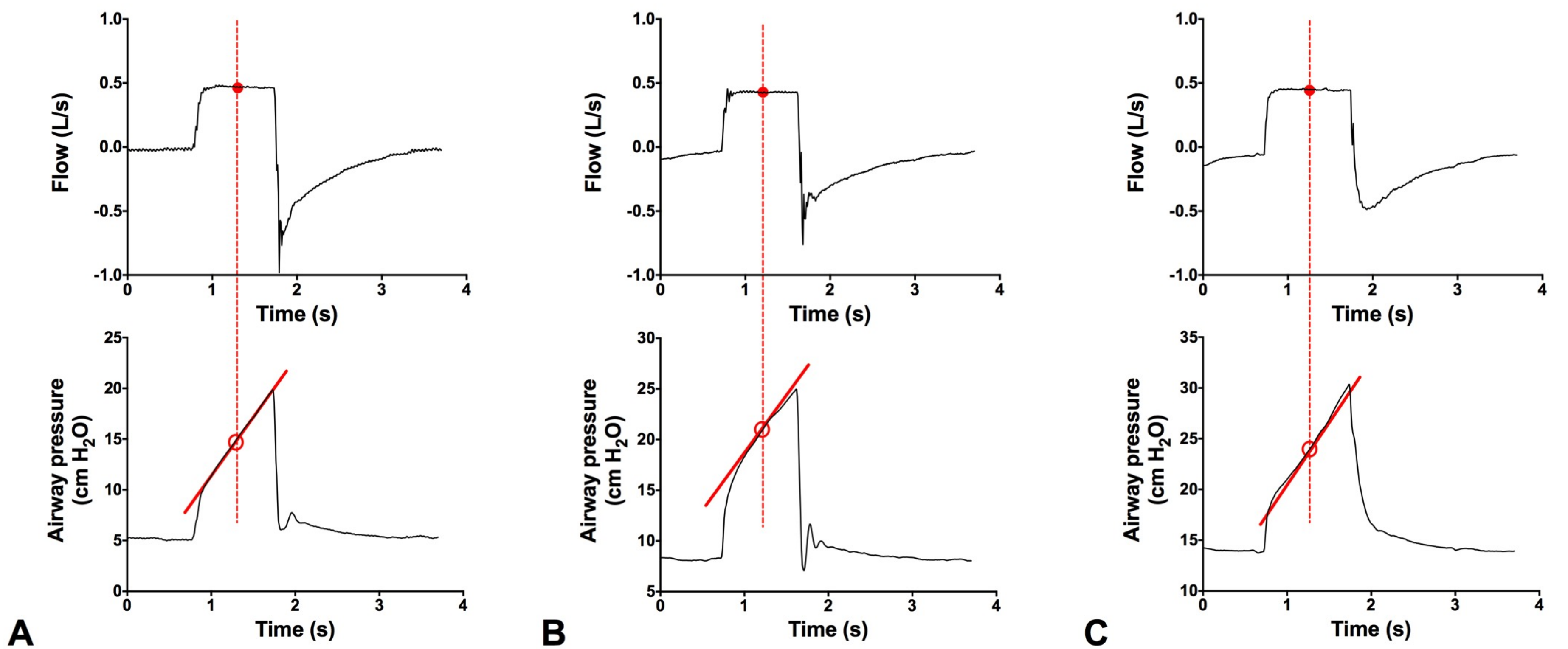
SI=1.20



3) Visual classification of stress index by inspecting the flow-time and Paw-t waveforms on the ventilator screen

The middle point on the constant inspiratory flow is identified (red dot). Then the corresponding point on the Paw-t waveform is confirmed (red circle). Thereafter, a tangent line (red line) passing through the point on the Paw-t waveform is marked using a ruler. The relationship of this tangent line and Paw-t waveform is visually inspected.





The relationship of the tangent line marked by ruler and Paw-t waveform can be classified into three types:
1) the Paw-t waveform almost coincident with the tangent line indicates an SI value between 0.9 and 1.1, and is judged as linear shape (**A**); 2) the two side of Paw-t waveform both deviating downward from the tangent line indicates an SI < 0.9 and is judged as downward concavity shape (**B**); or 3) the two side of Paw-t waveform both deviating upward from the tangent line indicates SI > 1.1 and is judged as upward concavity shape (**C**).

Training tests

For the ongoing slides, please use the method for visual inspection and discriminate the shape of Paw-t waveform shown on the ventilator screen as linear, downward or upward concavity shape.

Please use the full screen function in your computer during the estimation. You can use the ruler to measure the computer screen.

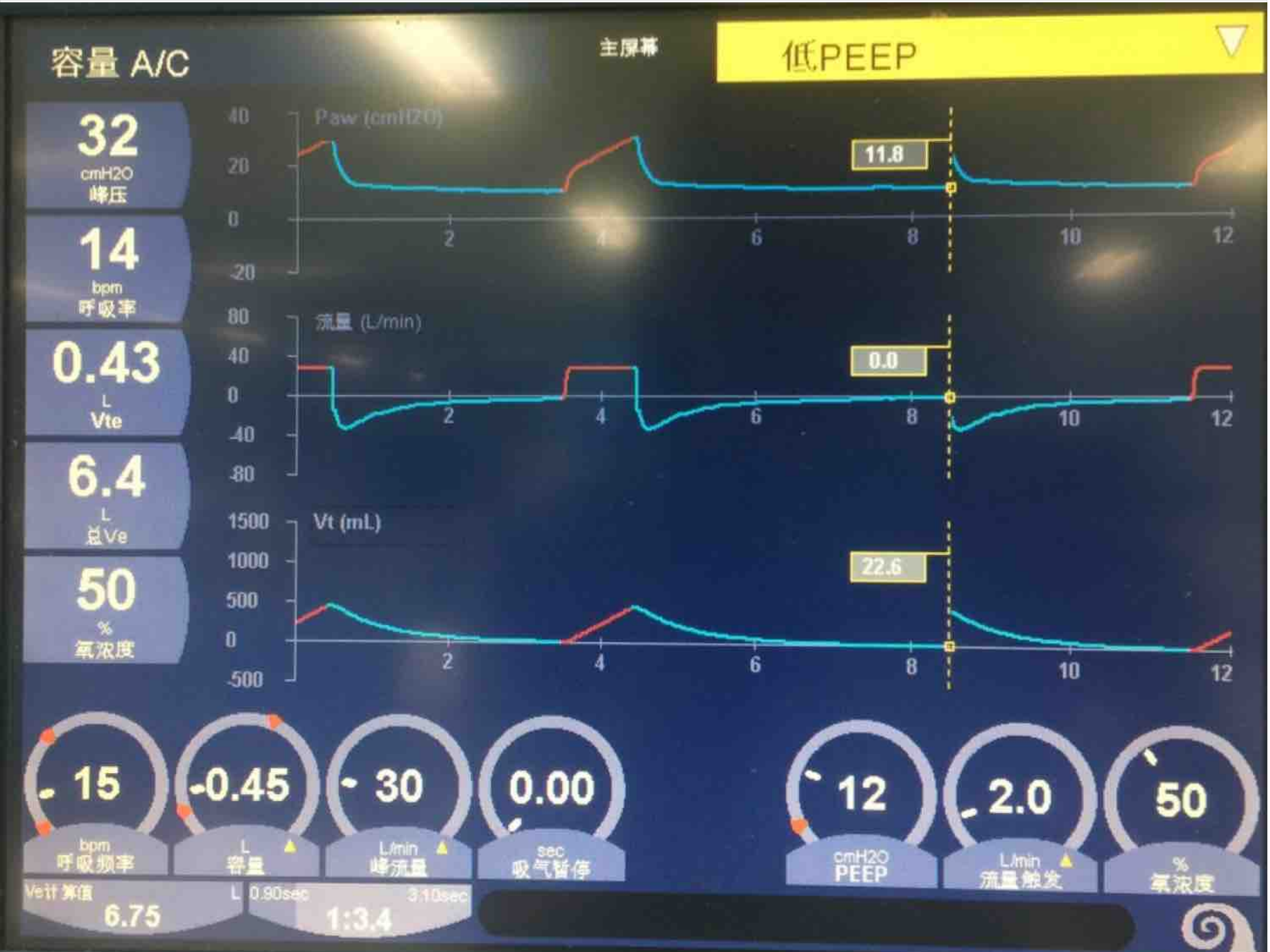
Patient NO1

- Sex: M
- Age: 56
- Diagnosis: ARF
- Ventilator settings
  - RR:20
  - VT (ml): 500
  - PEEP (cmH2O): 15
  - FiO_2: 80%

登记 病人
0:10
检查电池状态
记录的波形 2017-01-06 17:33:48
60 cmH2O
15
cmH2O
200 l/min
-6
l/min
-200
700 ml
-19.8
ml
+1.89s
Ppeak (cmH2O)
44
58
Pmean (cmH2O)
21
PEEP (cmH2O)
15
呼吸频率 (b/min)
20
40
5
O2 浓度 (%)
79
85
75
I:E
1:2.0
MVe (l/min)
11.0
40.0
5.0
VTi (ml)
514
VTe (ml)
553
设置
光标
关闭
各项附加值

Patient NO2

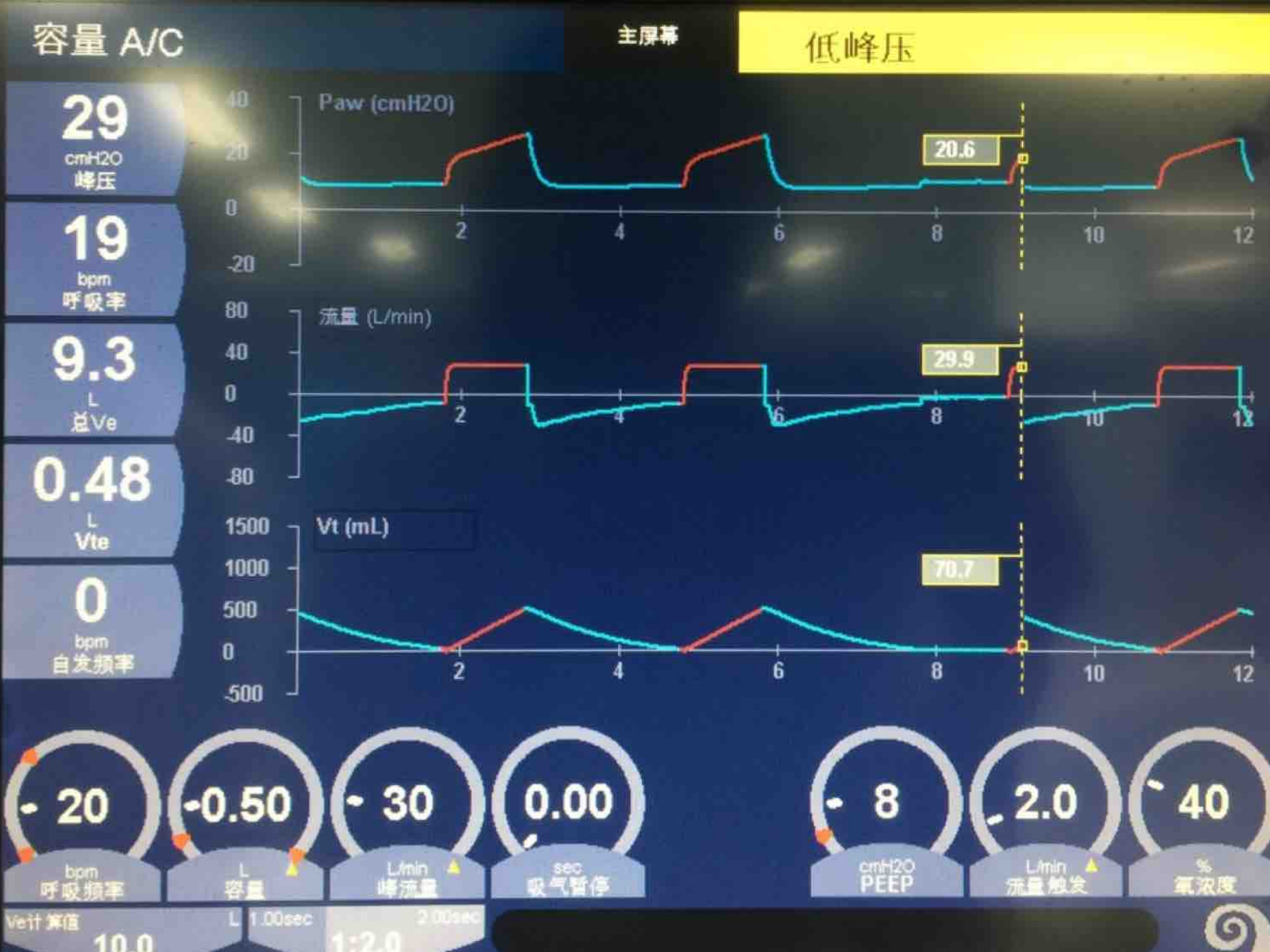
- Sex: M
- Age: 65
- Diagnosis: ARF
- Ventilator settings
  - RR:15
  - VT (ml): 450
  - PEEP (cmH2O): 12
  - FiO_2 : 50%



容量 A/C
主屏幕
低PEEP
32
cmH2O
峰压
14
bpm
呼吸率
0.43
L
Vte
6.4
L
总Ve
50
%
氧浓度
Paw (cmH2O)
11.8
流量 (L/min)
0.0
Vt (mL)
22.6
15
bpm
呼吸频率
-0.45
L
容量
30
L/min
峰流量
0.00
sec
吸气暂停
12
cmH2O
PEEP
2.0
L/min
流量触发
50
%
氧浓度
Ve计算值
L
6.75
0.90sec
3.10sec
1:3.4

Patient NO3

- Sex: F
- Age: 60
- Diagnosis: Glioma
- Ventilator settings
  - RR:20
  - VT (ml): 500
  - PEEP (cmH2O): 8
  - FiO_2 : 40%



容量 A/C
主屏幕
低峰压
29
cmH2O
峰压
19
bpm
呼吸率
9.3
L
总Ve
0.48
L
Vte
0
bpm
自发频率
Paw (cmH2O)
40
20
0
-20
20.6
流量 (L/min)
80
40
0
-40
-80
29.9
Vt (mL)
1500
1000
500
0
-500
70.7
2
4
6
8
10
12
20
bpm
呼吸频率
0.50
L
容量
30
L/min
峰流量
0.00
sec
吸气暂停
8
cmH2O
PEEP
2.0
L/min
流量触发
40
%
氧浓度
Ve计算值
L
10.0
1.00sec
2.00sec
1:2.0

Patient NO4

- Sex: M
- Age: 50
- Diagnosis: Postoperative
- Ventilator settings
  - RR:25
  - VT (ml): 600
  - PEEP (cmH2O): 5
  - FiO_2 : 30%

容量 A/C
主屏幕
管路脱落
27 cmH2O 峰压
24 bpm 呼吸率
9.5 L 总Ve
0.44 L Vte
0 bpm 自发频率
Paw (cmH2O)
20.6
流量 (L/min)
44.6
Vt (mL)
211.6
25 bpm 呼吸频率
0.60 L 容量
45 L/min 峰流量
0.00 sec 吸气暂停
5 cmH2O PEEP
2.0 L/min 流量触发
30 % 氧浓度
Ve计算值 L 15.0
0.80sec 1.60sec 1:2.0

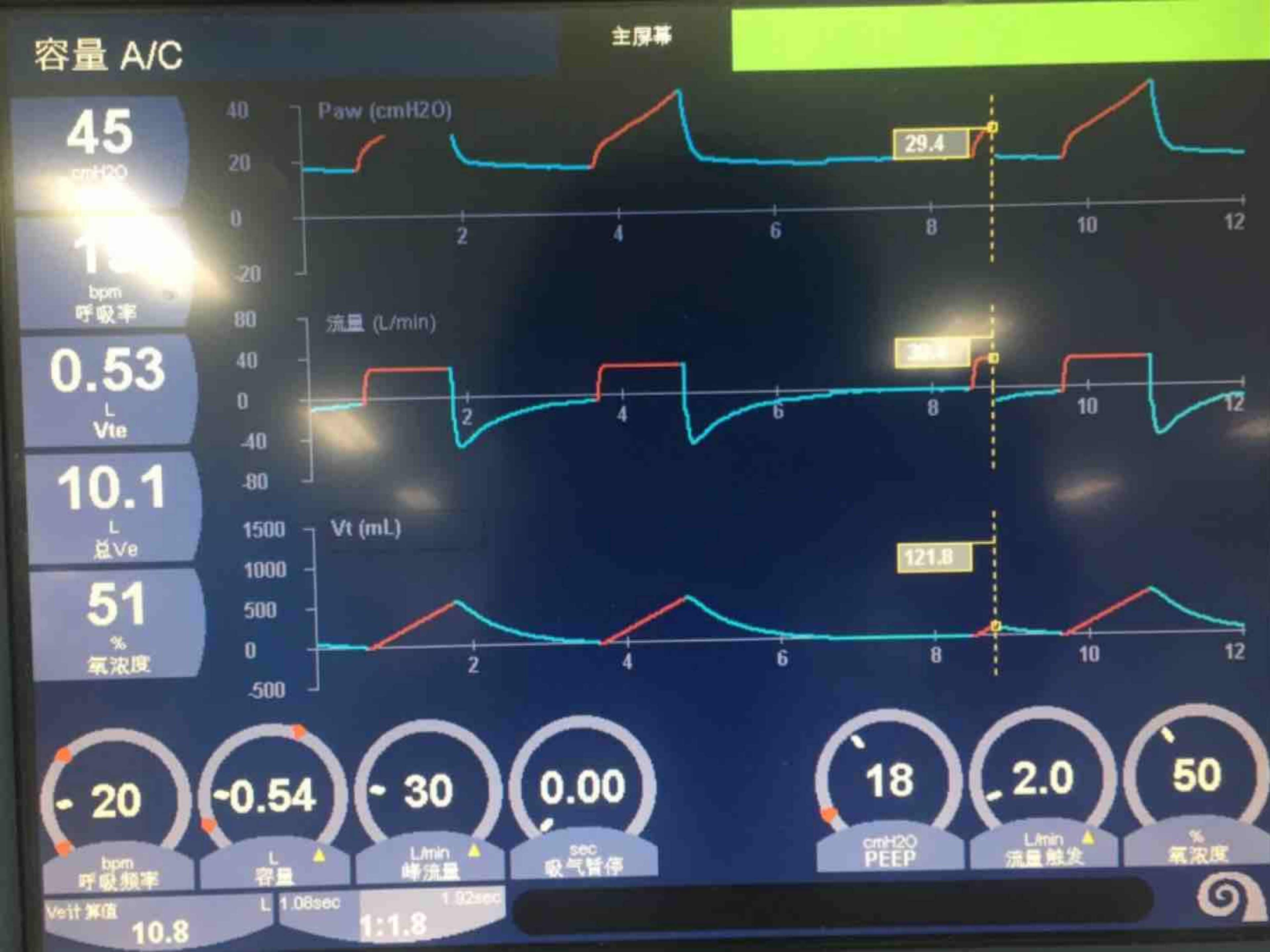
Patient NO5

- Sex: M
- Age: 51
- Diagnosis: TBI
- Ventilator settings
  - RR:20
  - VT (ml): 500
  - PEEP (cmH2O): 8
  - FiO_2 : 50%

容量 A/C
主屏幕
36
19
bpm
呼吸率
0.50
L
Vte
9.3
L
总Ve
51
%
氧浓度
Paw (cmH2O)
流量 (L/min)
Vt (mL)
10.8
0.0
9.0
20
bpm
呼吸频率
-0.50
L
容量
30
L/min
峰流量
0.00
sec
吸气暂停
8
cmH2O
PEEP
2.0
L/min
流量触发
50
%
氧浓度
Ve计算值
10.00
1.00sec
2.00sec
1:2.0

Patient NO6

- Sex: M
- Age: 58
- Diagnosis: ARF
- Ventilator settings
  - RR:20
  - VT (ml): 540
  - PEEP (cmH2O): 18
  - FiO_2 : 50%



容量 A/C
主屏幕
45
cmH2O
bpm
呼吸率
0.53
L
Vte
10.1
L
总Ve
51
%
氧浓度
Paw (cmH2O)
29.4
流量 (L/min)
Vt (mL)
121.8
20
bpm
呼吸频率
-0.54
L
容量
30
L/min
峰流量
0.00
sec
吸气暂停
18
cmH2O
PEEP
2.0
L/min
流量触发
50
%
氧浓度
Veit 算值
L
10.8
1.08sec
1.92sec
1:1.8

Patient NO7

- Sex: F
- Age: 48
- Diagnosis: SAH
- Ventilator settings
  - RR:20
  - VT (ml): 500
  - PEEP (cmH2O): 12
  - FiO_2 : 40%

容量 A/C
主屏幕
31
cmH2O
峰压
19
bpm
呼吸率
8.9
L
总Ve
0.48
L
Vte
0
bpm
自发频率
Paw (cmH2O)
19.6
流量 (L/min)
29.6
Vt (mL)
50.7
20
bpm
呼吸频率
-0.50
L
容量
30
L/min
峰流量
0.00
sec
吸气暂停
12
cmH2O
PEEP
2.0
L/min
流量触发
40
%
氧浓度
Ve计算值
L
10.0
1.00sec
2.00sec
1:2.0

Patient NO8

- Sex: M
- Age: 38
- Diagnosis: Glioma
- Ventilator settings
  - RR:20
  - VT (ml): 350
  - PEEP (cmH2O): 5
  - FiO_2 : 40%


容量控制
登记 病人
状态
检查电池状态
0:33
记录的波形 2017-01-11 14:26:20
30 cmH2O
70 l/min
-70
500 ml
5
cmH2O
-9
l/min
43
ml
0.00s
Ppeak (cmH2O)
20
62
Pmean (cmH2O)
9
PEEP (cmH2O)
5
呼吸频率 (b/min)
19
30
5
O2 浓度 (%)
41
45
35
I:E
1:2.0
MVe (l/min)
7.1
40.0
5.0
VTi (ml)
347
VTe (ml)
380
设置
关闭
各项附加值

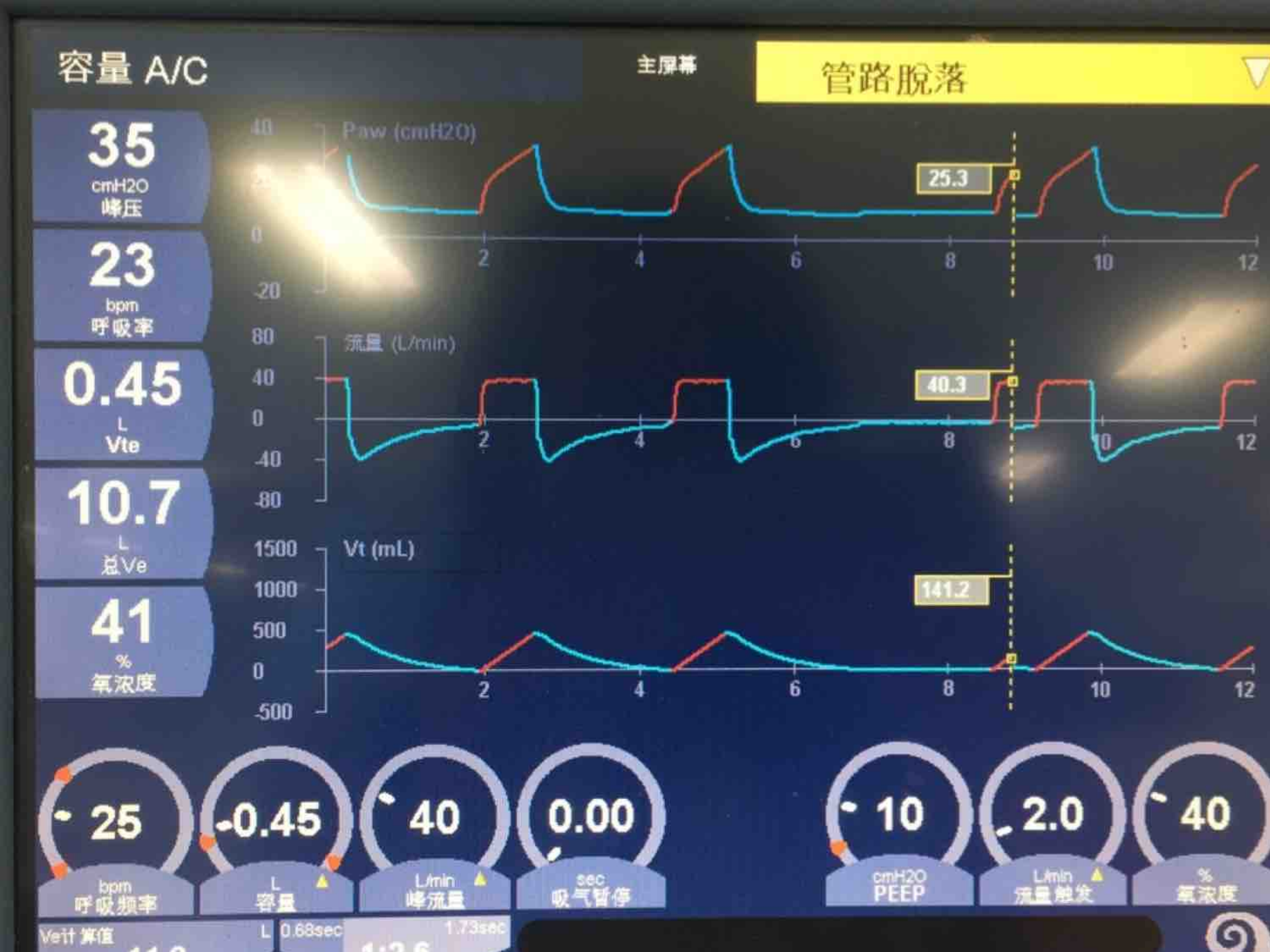
Patient NO9

- Sex: F
- Age: 60
- Diagnosis: TBI
- Ventilator settings
  - RR:20
  - VT (ml): 350
  - PEEP (cmH2O): 6
  - FiO_2 : 50%


容量控制
查记 病人
检查电池状态
0:34
记录的波形 2017-01-12 12:14:43
30 cmH₂O
7
cmH₂O
90 l/min
-20
l/min
-90
500 ml
210
ml
0.00s
Ppeak (cmH₂O)
62
22
Pmean (cmH₂O)
10
PEEP (cmH₂O)
6
呼吸频率 (b/min)
30
19
5
O₂ 浓度 (%)
55
50
45
I:E
1:2.3
MVe (l/min)
40.0
7.0
5.0
VTi (ml)
347
VTe (ml)
375
设置
光标
关闭
各项附加值

Patient NO10

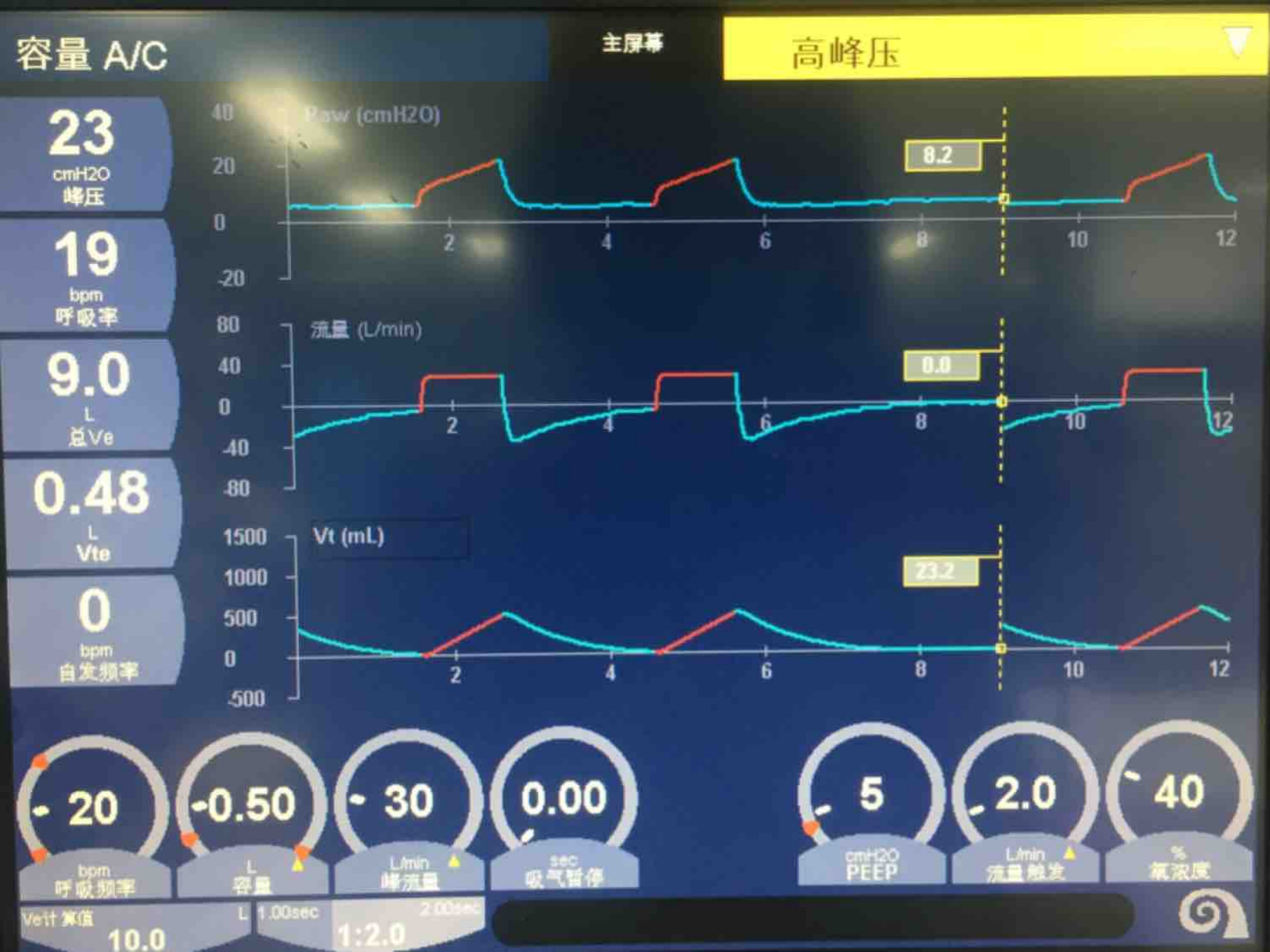
- Sex: M
- Age: 28
- Diagnosis: TBI
- Ventilator settings
  - RR:25
  - VT (ml): 450
  - PEEP (cmH2O): 10
  - FiO_2 : 40%



容量 A/C
主屏幕
管路脱落
35
cmH2O
峰压
23
bpm
呼吸率
0.45
L
Vte
10.7
L
总Ve
41
%
氧浓度
Paw (cmH2O)
25.3
流量 (L/min)
40.3
Vt (mL)
141.2
25
bpm
呼吸频率
-0.45
L
容量
40
L/min
峰流量
0.00
sec
吸气暂停
10
cmH2O
PEEP
2.0
L/min
流量触发
40
%
氧浓度
Ve计算值
0.68sec
1.73sec

Patient NO11

- Sex: M
- Age: 42
- Diagnosis: Postoperative
- Ventilator settings
  - RR:20
  - VT (ml): 500
  - PEEP (cmH2O): 5
  - FiO_2 : 40%


容量 A/C
主屏幕
高峰压
23
cmH2O
峰压
19
bpm
呼吸率
9.0
L
总Ve
0.48
L
Vte
0
bpm
自发频率
Raw (cmH2O)
8.2
流量 (L/min)
0.0
Vt (mL)
23.2
20
bpm
呼吸频率
0.50
L
容量
30
L/min
峰流量
0.00
sec
吸气暂停
5
cmH2O
PEEP
2.0
L/min
流量触发
40
%
氧浓度
Ve计算值
10.0
1.00sec
2.00sec
1:2.0

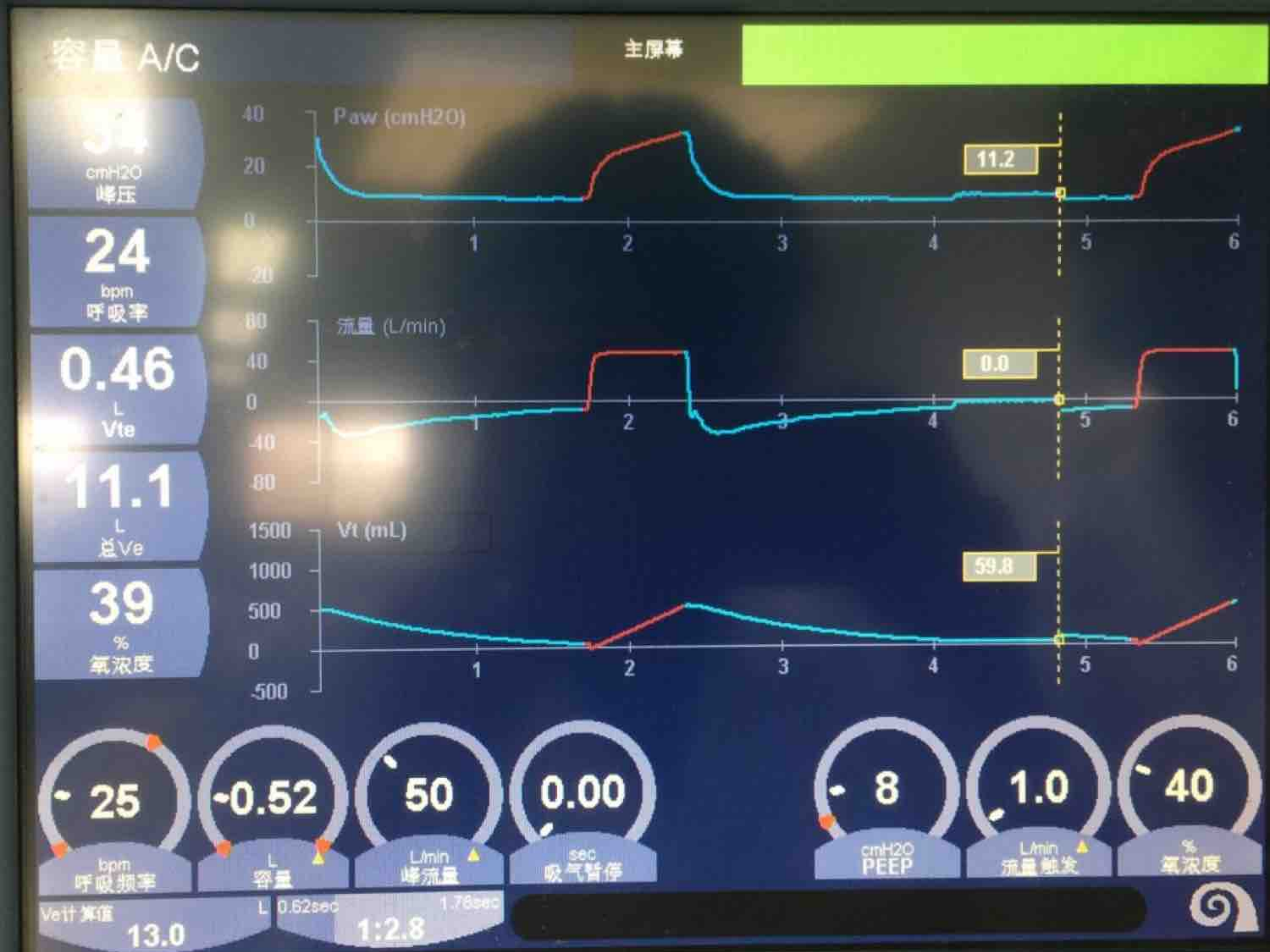
Patient NO12

- Sex: F
- Age: 72
- Diagnosis: SAH
- Ventilator settings
  - RR:18
  - VT (ml): 500
  - PEEP (cmH2O): 6
  - FiO_2 : 40%

容量 A/C
主屏幕
24
cmH2O
峰压
17
bpm
呼吸率
0.49
L
Vte
8.7
L
总Ve
38
%
氧浓度
Paw (cmH2O)
17.2
流量 (L/min)
44.6
Vt (mL)
99.5
18
bpm
呼吸频率
-0.50
L
容量
45
L/min
峰流量
0.00
sec
吸气暂停
6
cmH2O
PEEP
1.0
L/min
流量触发
40
%
氧浓度
Ve计算值
L
9.00
0.67sec
2.67sec
1:4.0

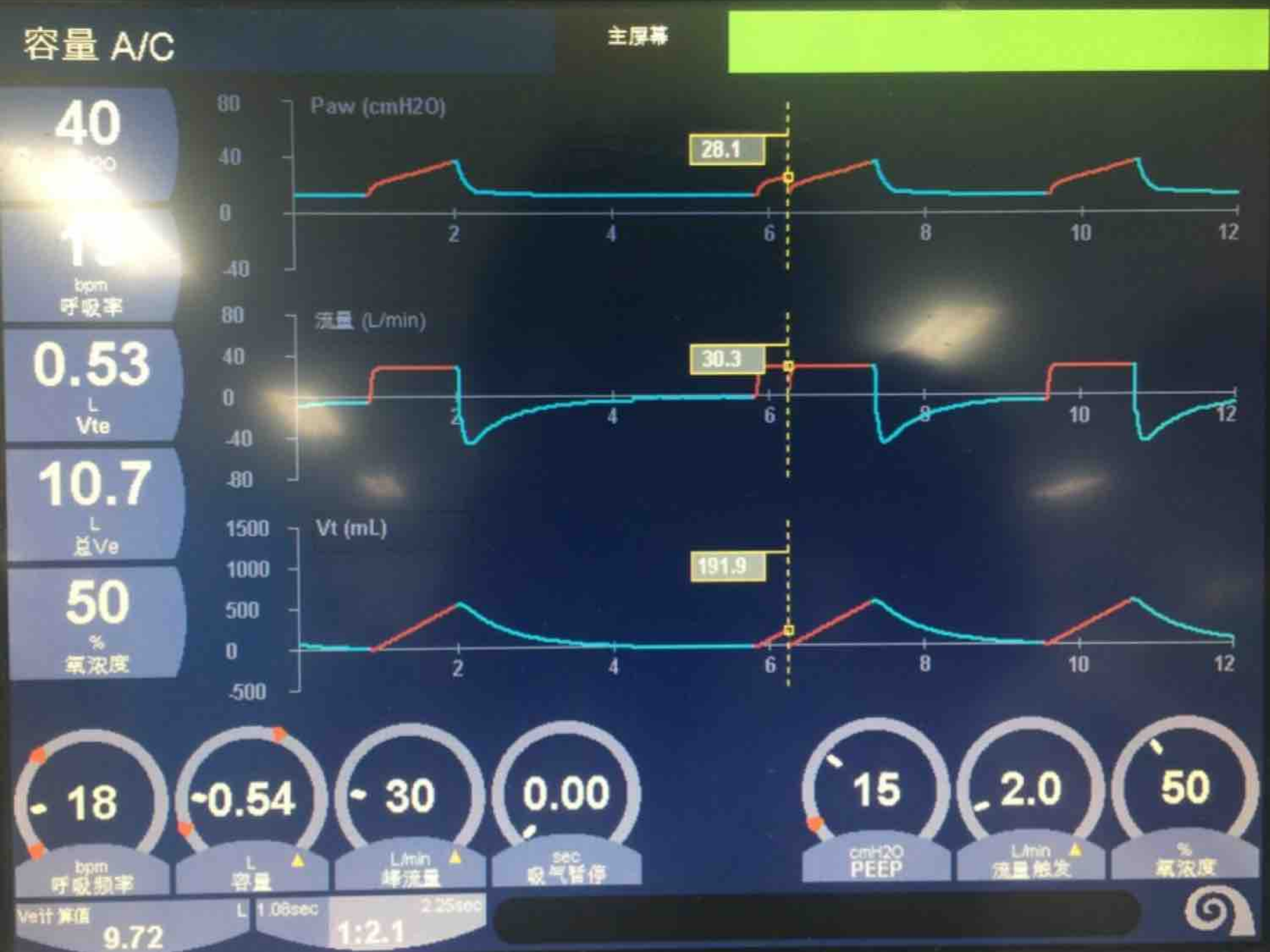
Patient NO13

- Sex: F
- Age: 32
- Diagnosis: ARF
- Ventilator settings
  - RR:25
  - VT (ml): 520
  - PEEP (cmH2O): 8
  - FiO_2 : 40%


容量 A/C
主屏幕
34
cmH2O
峰压
24
bpm
呼吸率
0.46
L
Vte
11.1
L
总Ve
39
%
氧浓度
Paw (cmH2O)
40
20
0
-20
11.2
流量 (L/min)
80
40
0
-40
-80
0.0
Vt (mL)
1500
1000
500
0
-500
59.8
1
2
3
4
5
6
25
bpm
呼吸频率
-0.52
L
容量
50
L/min
峰流量
0.00
sec
吸气暂停
8
cmH2O
PEEP
1.0
L/min
流量触发
40
%
氧浓度
Ve计算值
L
13.0
0.62sec
1.78sec
1:2.8

Patient NO14

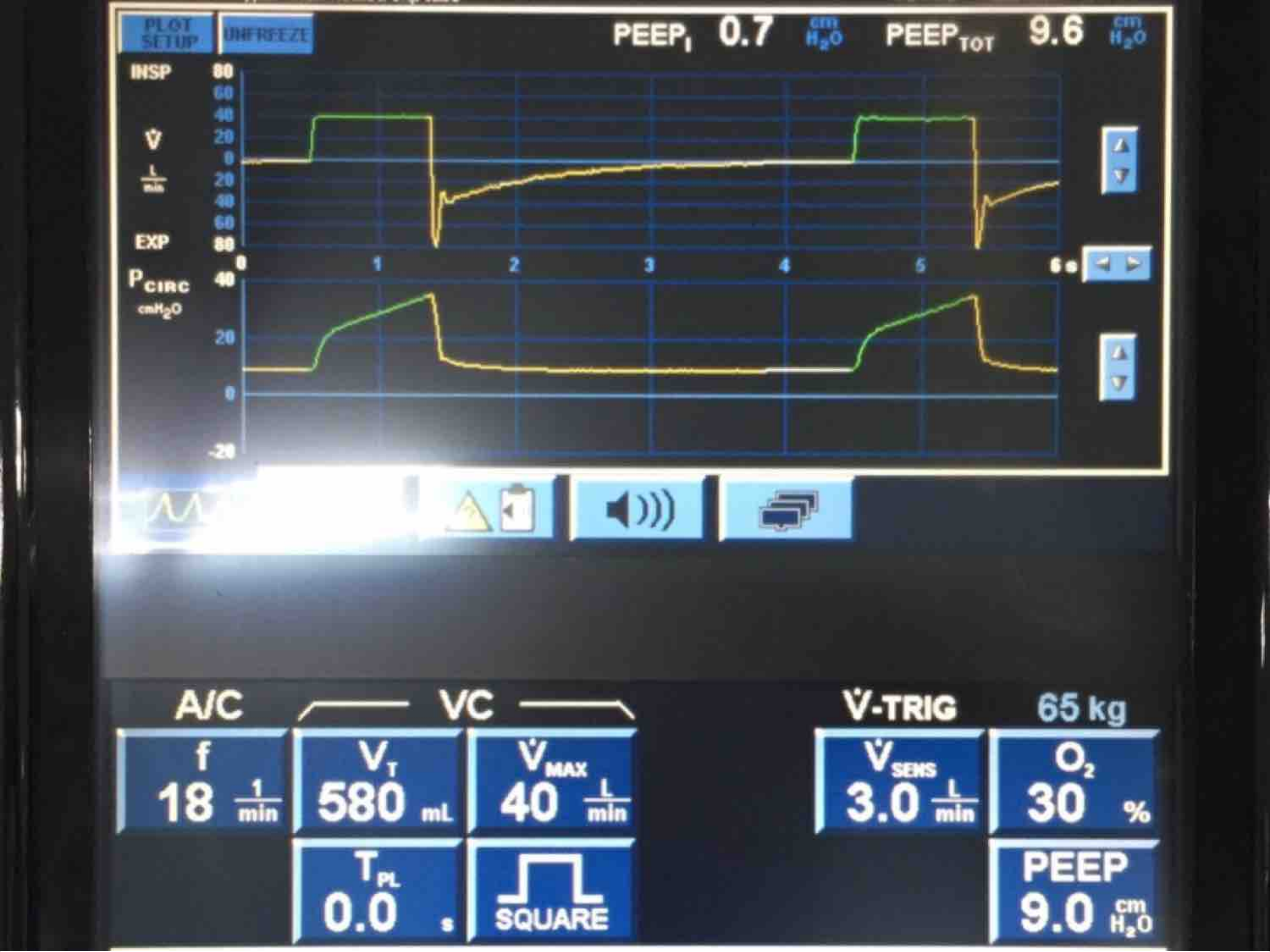
- Sex: M
- Age: 54
- Diagnosis: TBI
- Ventilator settings
  - RR:18
  - VT (ml): 540
  - PEEP (cmH2O): 15
  - FiO_2 : 50%



容量 A/C
主屏幕
40
呼吸率
bpm
0.53
L
Vte
10.7
L
总Ve
50
%
氧浓度
Paw (cmH2O)
28.1
流量 (L/min)
30.3
Vt (mL)
191.9
18
bpm
呼吸频率
0.54
L
容量
30
L/min
峰流量
0.00
sec
吸气暂停
15
cmH2O
PEEP
2.0
L/min
流量触发
50
%
氧浓度
Ve计算值
L
9.72
1.08sec
2.25sec
1:2.1

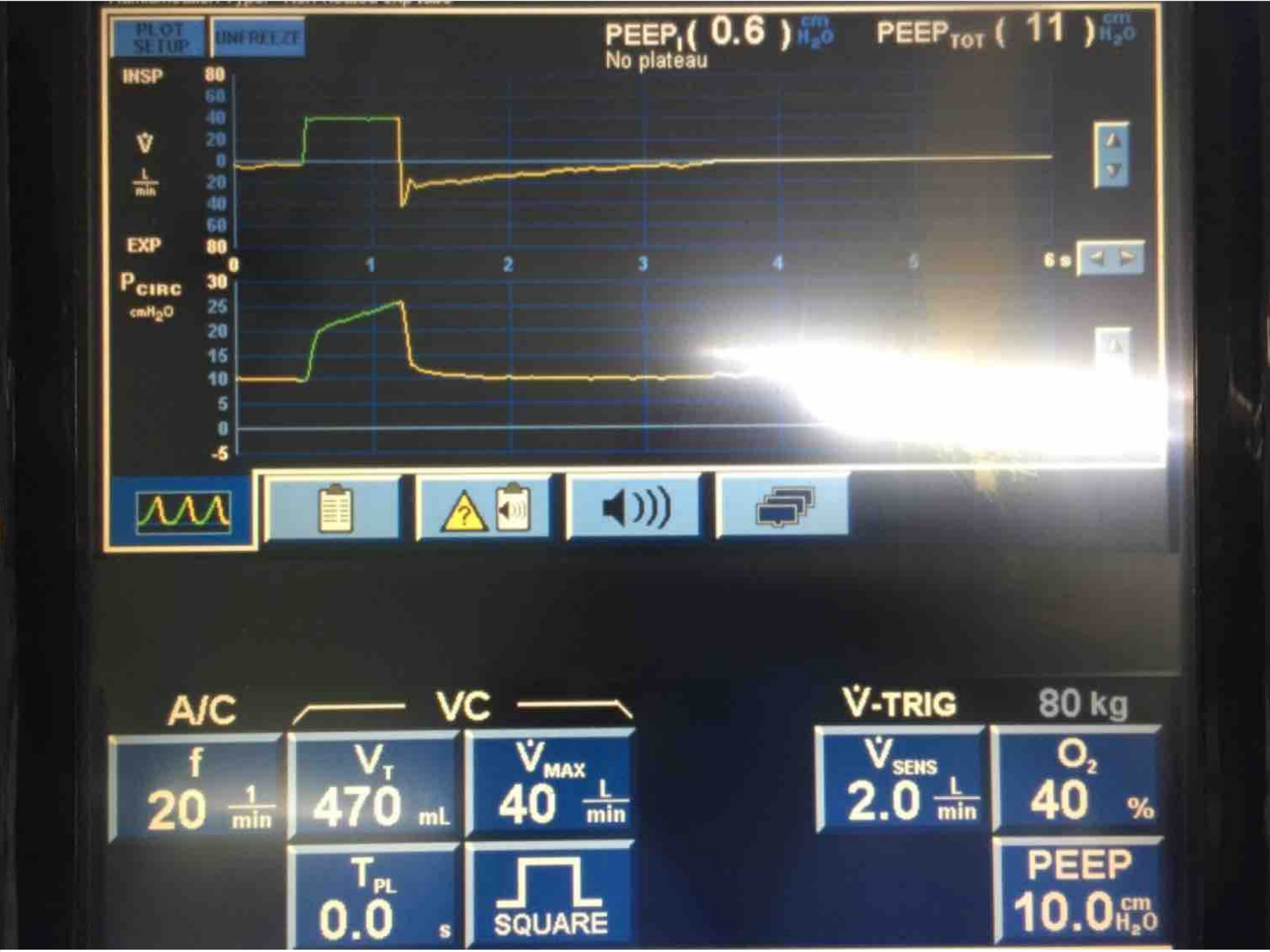
Patient NO15

- Sex: M
- Age: 63
- Diagnosis: SAH
- Ventilator settings
  - RR:18
  - VT (ml): 580
  - PEEP (cmH2O): 9
  - FiO_2 : 30%


PLOT SETUP
UNFREEZE
PEEP$_I$ 0.7 cm H$_2$O
PEEP$_{TOT}$ 9.6 cm H$_2$O
INSP
EXP
L/min
P$_{CIRC}$ cmH$_2$O
A/C
VC
V-TRIG
65 kg
f 18 1/min
V$_T$ 580 mL
V$_{MAX}$ 40 L/min
V$_{SENS}$ 3.0 L/min
O$_2$ 30 %
T$_{PL}$ 0.0 s
SQUARE
PEEP 9.0 cm H$_2$O

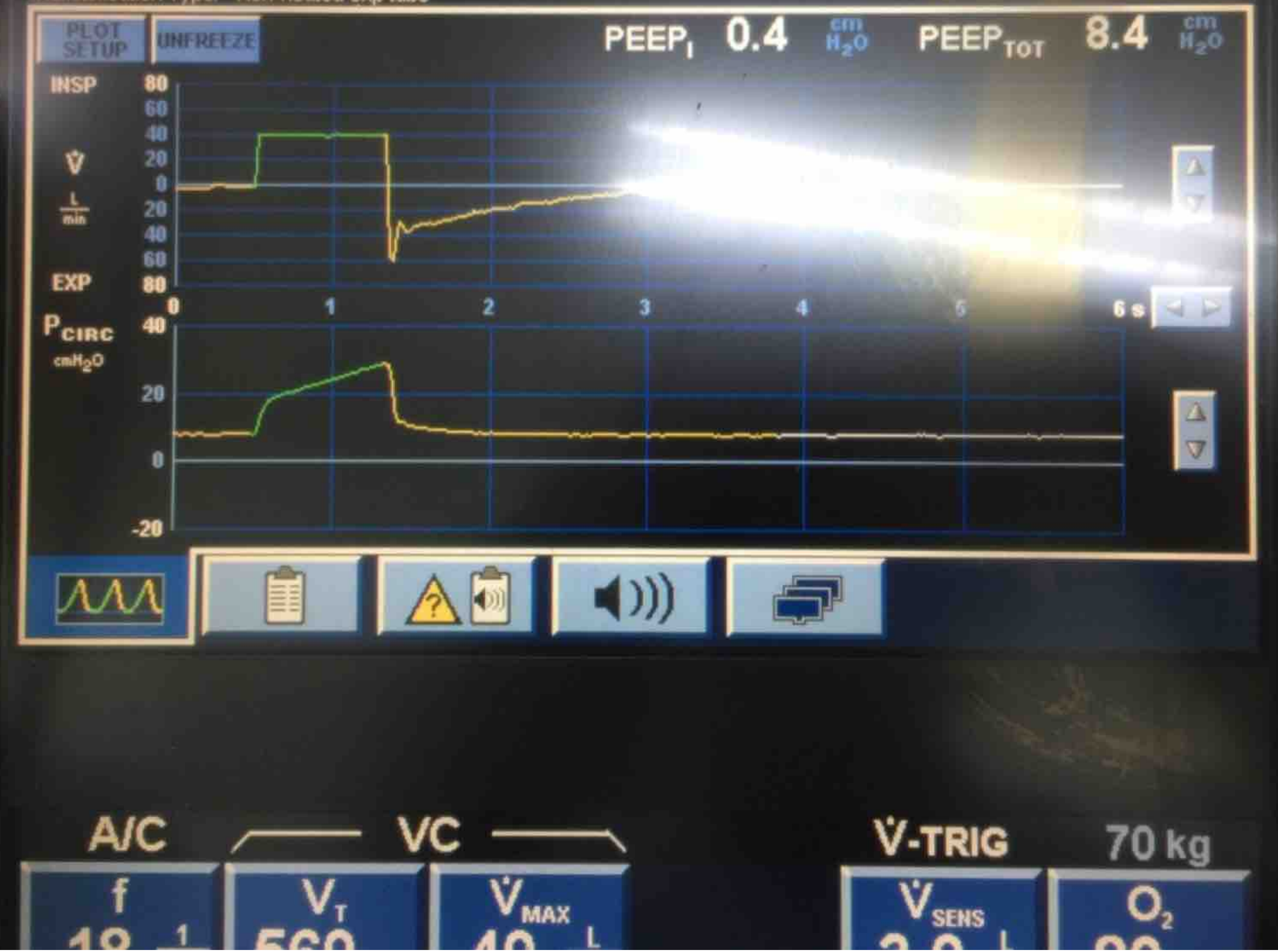
Patient NO16

- Sex: F
- Age: 50
- Diagnosis: TBI
- Ventilator settings
  - RR:20
  - VT (ml): 470
  - PEEP (cmH2O): 10
  - FiO_2 : 40%


PLOT SETUP
UNFREEZE
PEEP_I (0.6) cm H2O
PEEP_TOT (11) cm H2O
No plateau
INSP
V̇
L/min
EXP
P_CIRC
cmH2O
6 s
A/C
VC
V̇-TRIG
80 kg
f
20 1/min
V_T
470 mL
V̇_MAX
40 L/min
V̇_SENS
2.0 L/min
O2
40 %
T_PL
0.0 s
SQUARE
PEEP
10.0 cm H2O

Patient NO17

- Sex: M
- Age: 53
- Diagnosis: Glioma
- Ventilator settings
  - RR:18
  - VT (ml): 560
  - PEEP (cmH2O): 5
  - FiO_2 : 30%



PLOT SETUP
UNFREEZE
PEEP_I 0.4 cm H2O
PEEP_TOT 8.4 cm H2O
INSP
V̇
L/min
EXP
80
60
40
20
0
20
40
60
80
0
1
2
3
4
5
6 s
P_CIRC
cmH2O
40
20
0
-20
A/C
VC
V̇-TRIG
70 kg
f
V_T
V̇_MAX
V̇_SENS
O2

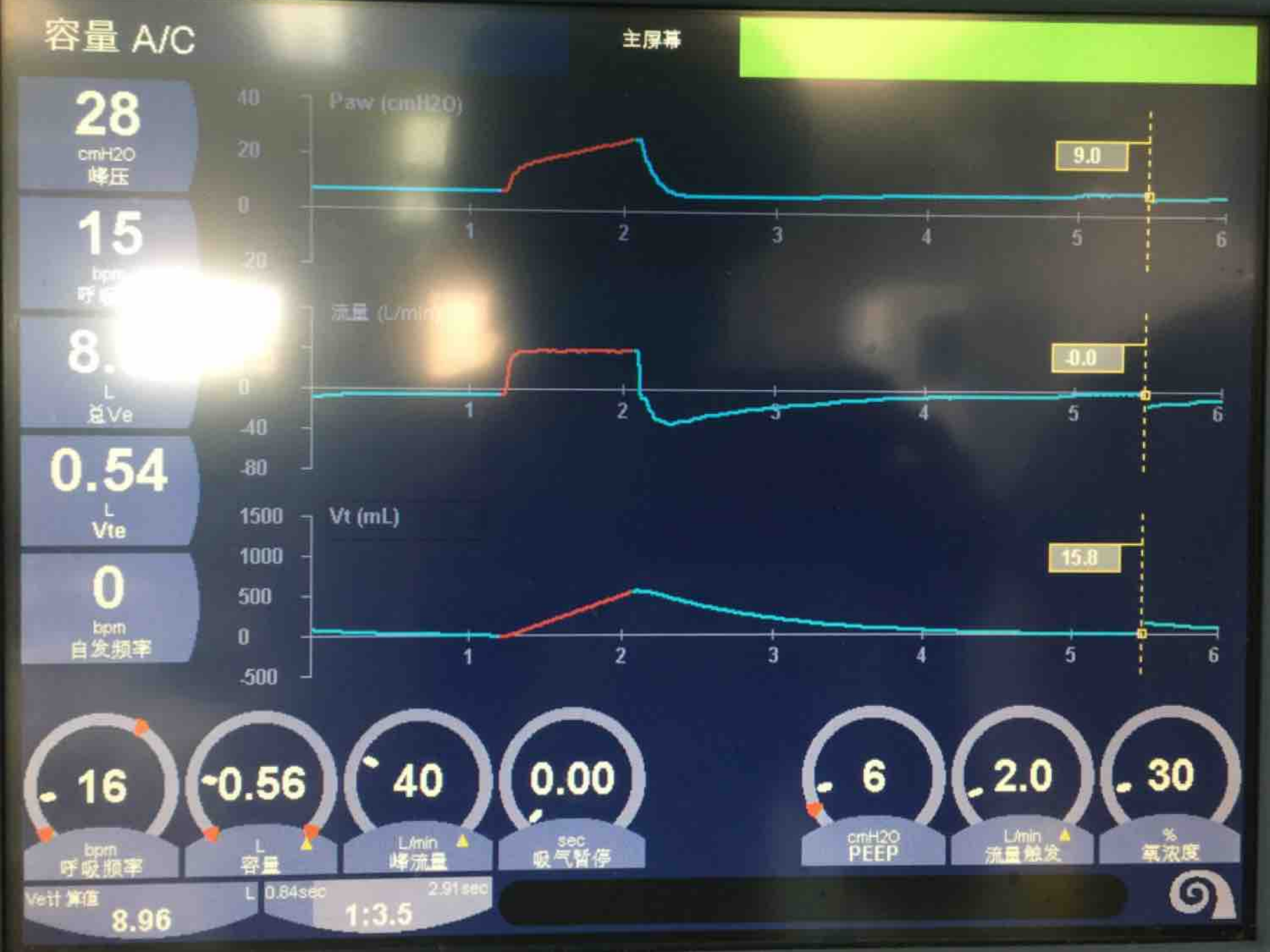
Patient NO18

- Sex: M
- Age: 58
- Diagnosis: TBI
- Ventilator settings
  - RR:16
  - VT (ml): 520
  - PEEP (cmH2O): 8
  - FiO_2 : 40%


PEEPI (1.1) cm H2O
PEEPTOT (9.1) cm H2O
No plateau
INSP
EXP
L/min
6 s
A/C
VC
V-TRIG
65 kg
f 16 1/min
VT 520 mL
VMAX 38 L/min
VSENS 3.0 L/min
O2 40 %
TPL 0.0 s
SQUARE
PEEP 8.0 cm H2O

Patient NO19

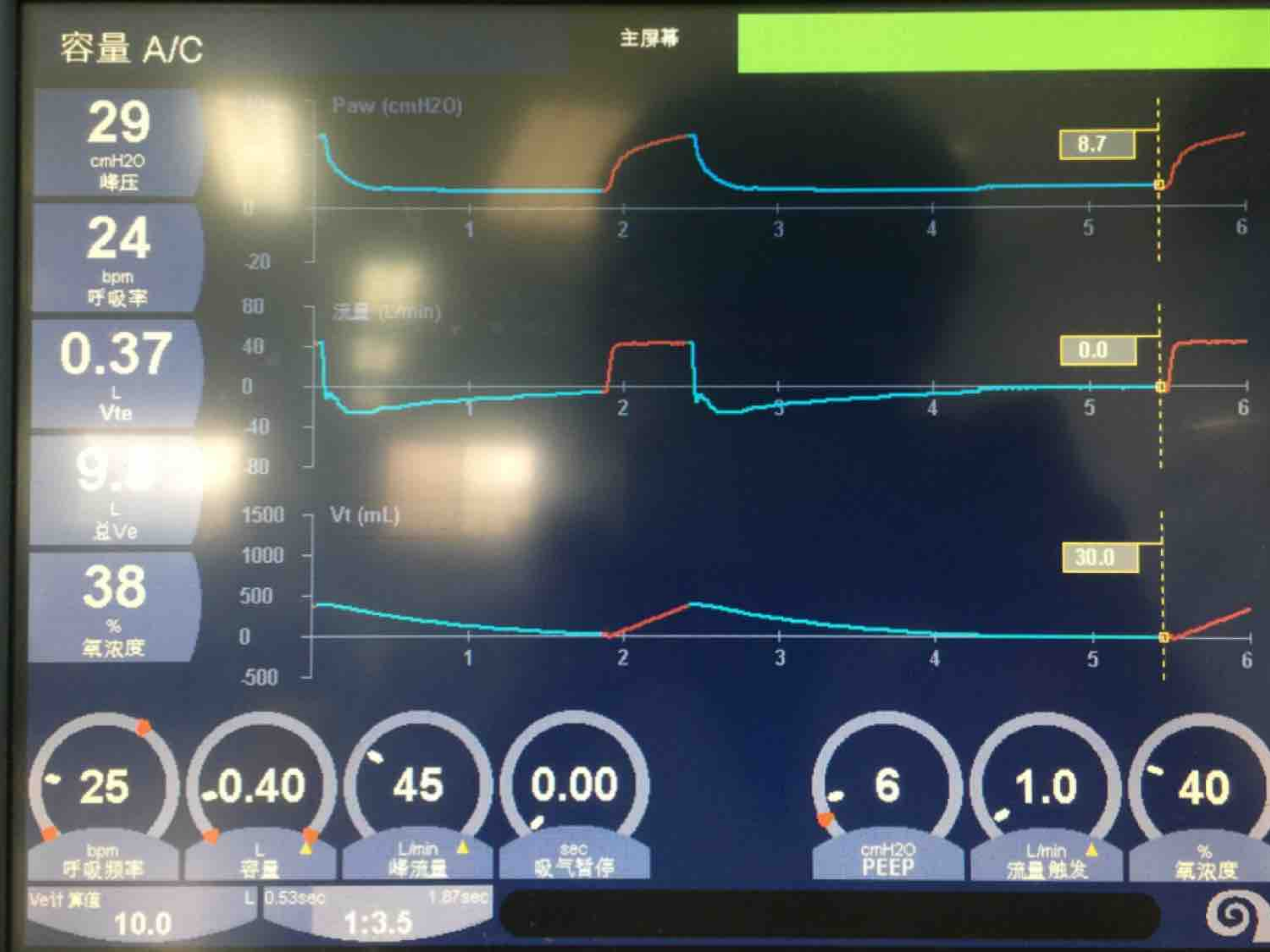
- Sex: M
- Age: 40
- Diagnosis: postoperative
- Ventilator settings
  - RR:16
  - VT (ml): 560
  - PEEP (cmH2O): 6
  - FiO_2 : 30%



容量 A/C
主屏幕
28
cmH2O
峰压
15
8.
L
总Ve
0.54
L
Vte
0
bpm
自发频率
Paw (cmH2O)
9.0
流量 (L/min)
-0.0
Vt (mL)
15.8
16
bpm
呼吸频率
0.56
L
容量
40
L/min
峰流量
0.00
sec
吸气暂停
6
cmH2O
PEEP
2.0
L/min
流量触发
30
%
氧浓度
Ve计算值
8.96
0.84sec
1:3.5
2.91sec

Patient NO20

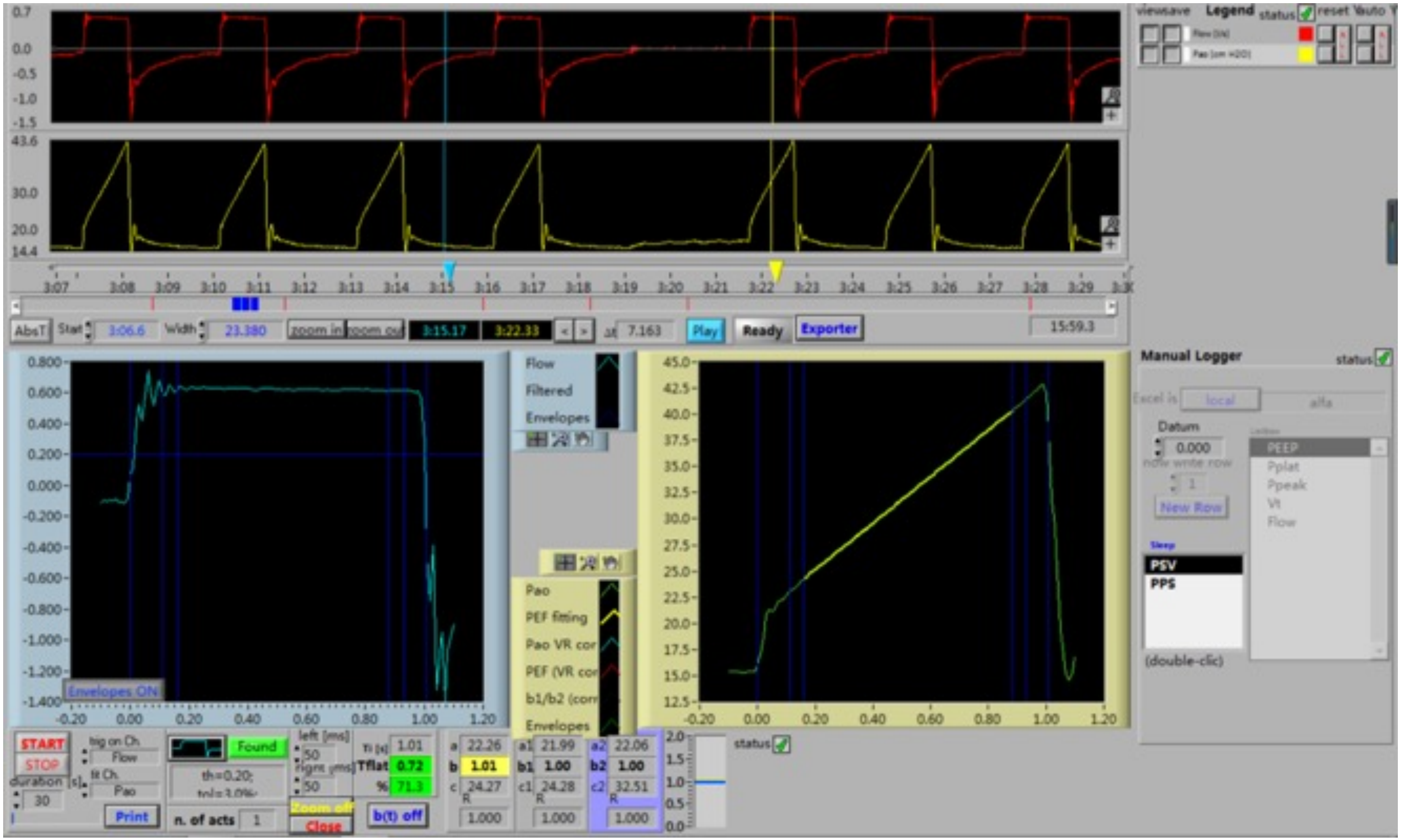
- Sex: F
- Age: 65
- Diagnosis: SAH
- Ventilator settings
  - RR:25
  - VT (ml): 400
  - PEEP (cmH2O): 6
  - FiO_2 : 40%



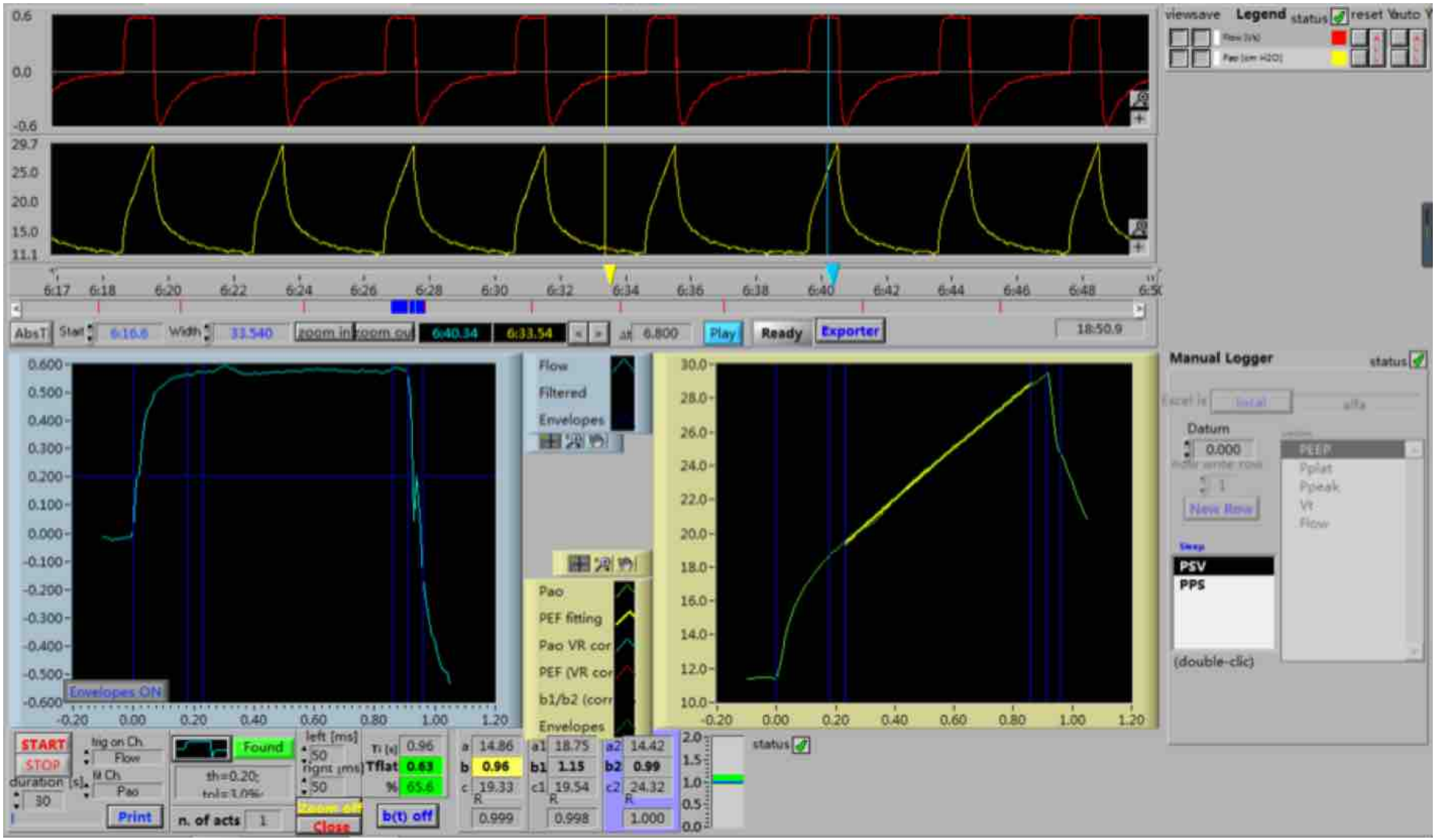
容量 A/C
主屏幕
29
cmH2O
峰压
24
bpm
呼吸率
0.37
L
Vte
L
总Ve
38
%
氧浓度
Paw (cmH2O)
8.7
流量 (L/min)
0.0
Vt (mL)
30.0
25
bpm
呼吸频率
0.40
L
容量
45
L/min
峰流量
0.00
sec
吸气暂停
6
cmH2O
PEEP
1.0
L/min
流量触发
40
%
氧浓度
Ve计算值
L
10.0
0.53sec
1.87sec
1:3.5

ICU-Lab pictures for each patients

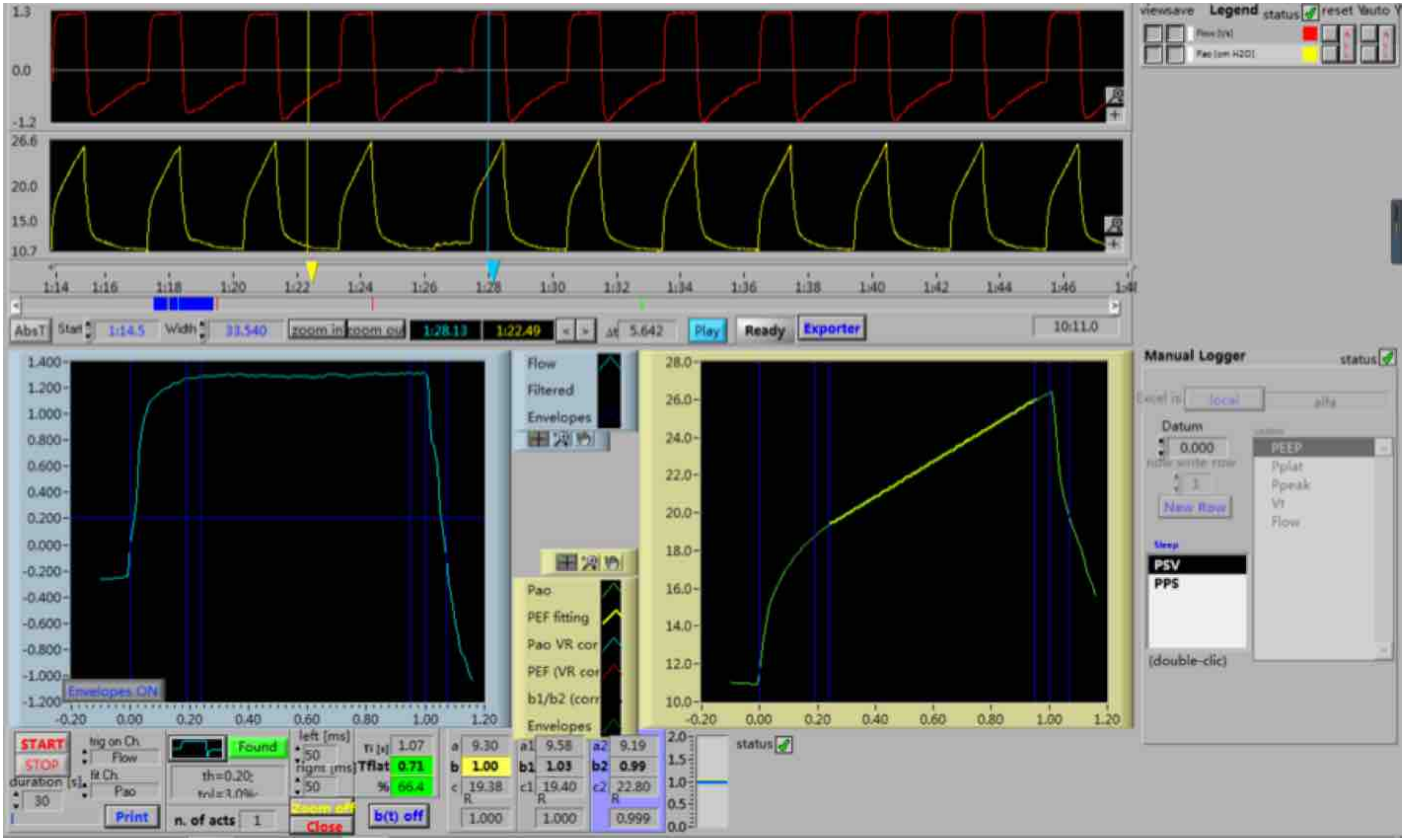
Patient NO1 SI=1.01 linear shape



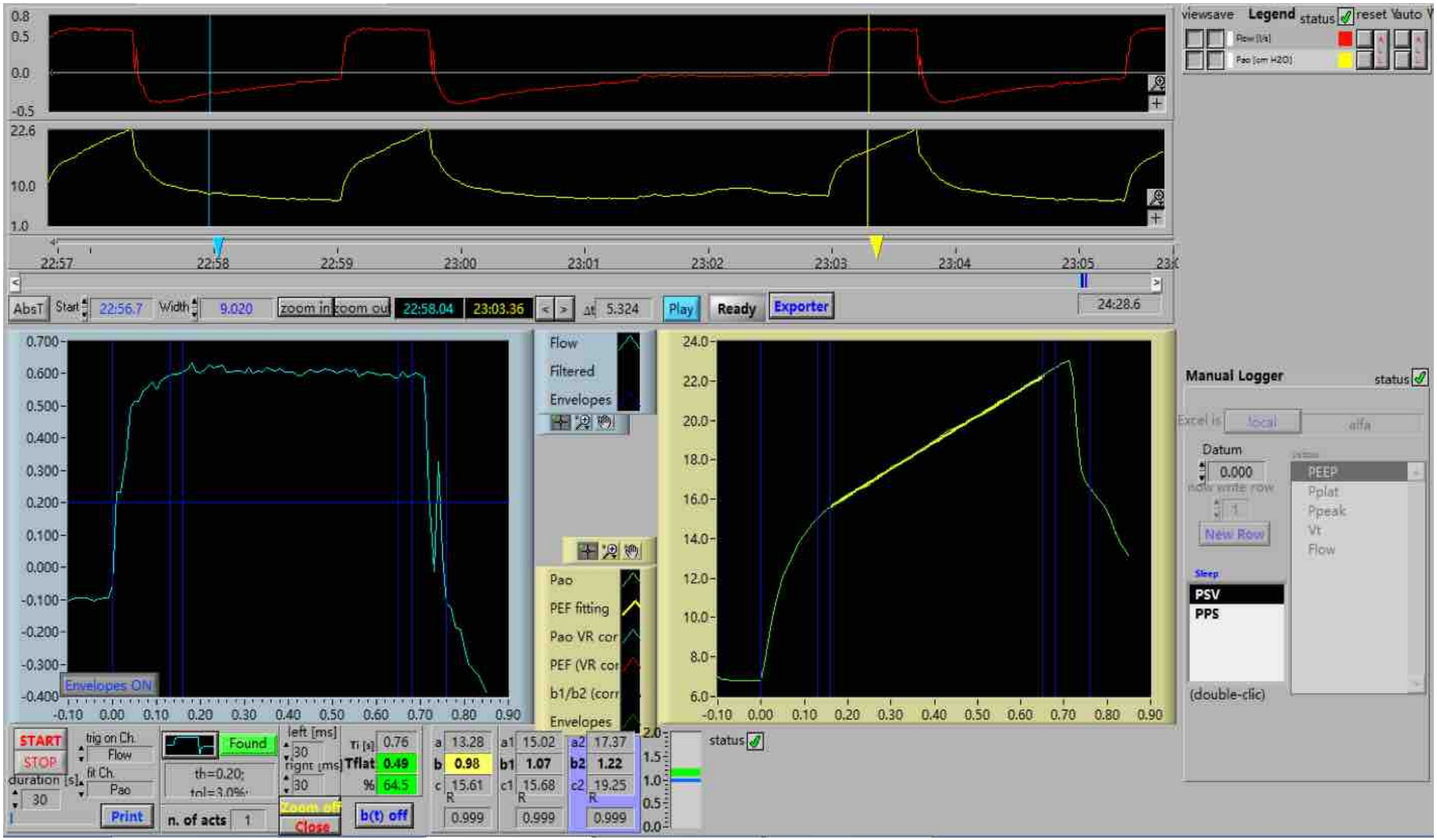
Patient NO2 SI=0.96 linear shape



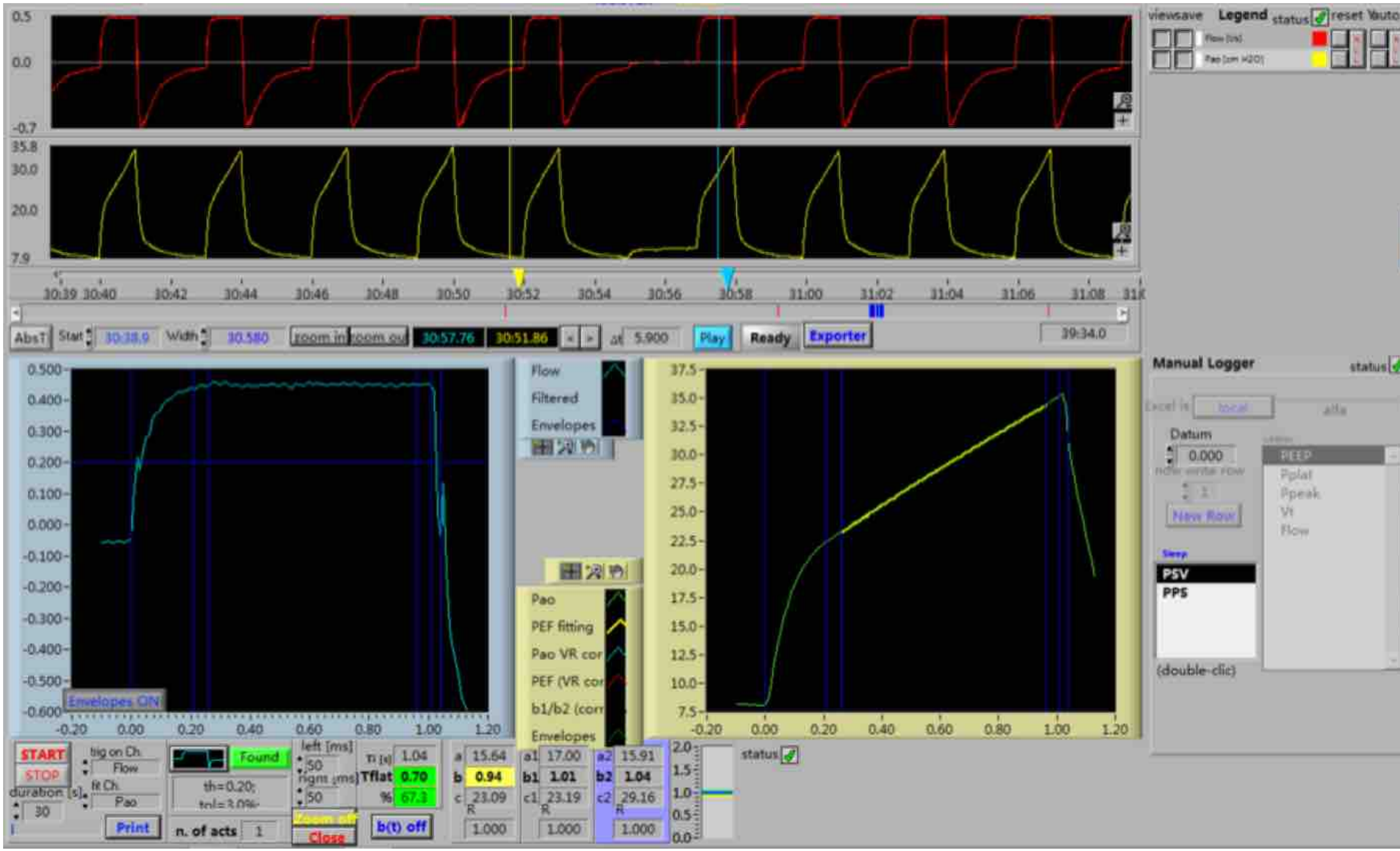
Patient NO3   SI=1.00 linear shape



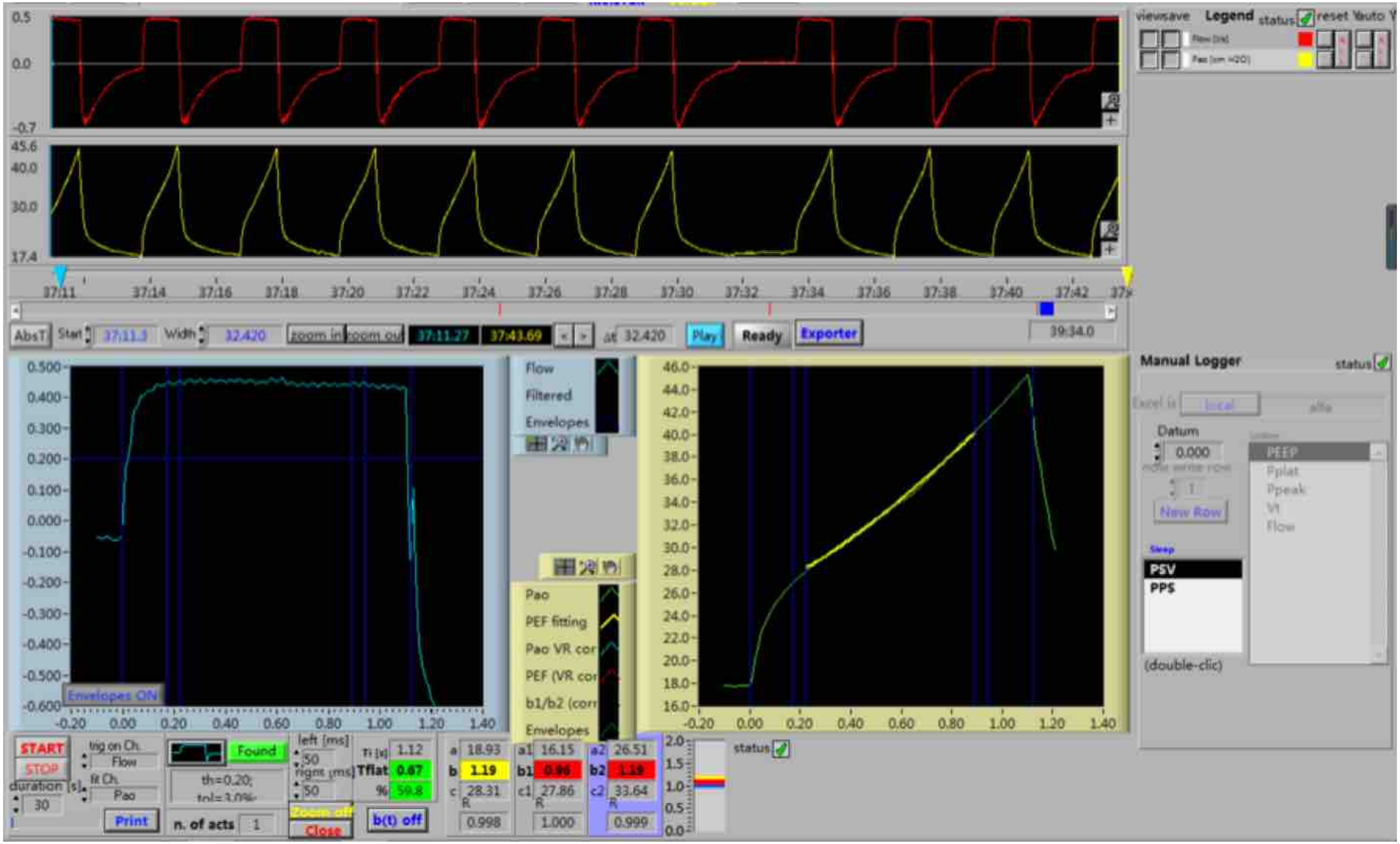
Patient NO4   SI=0.98 linear shape



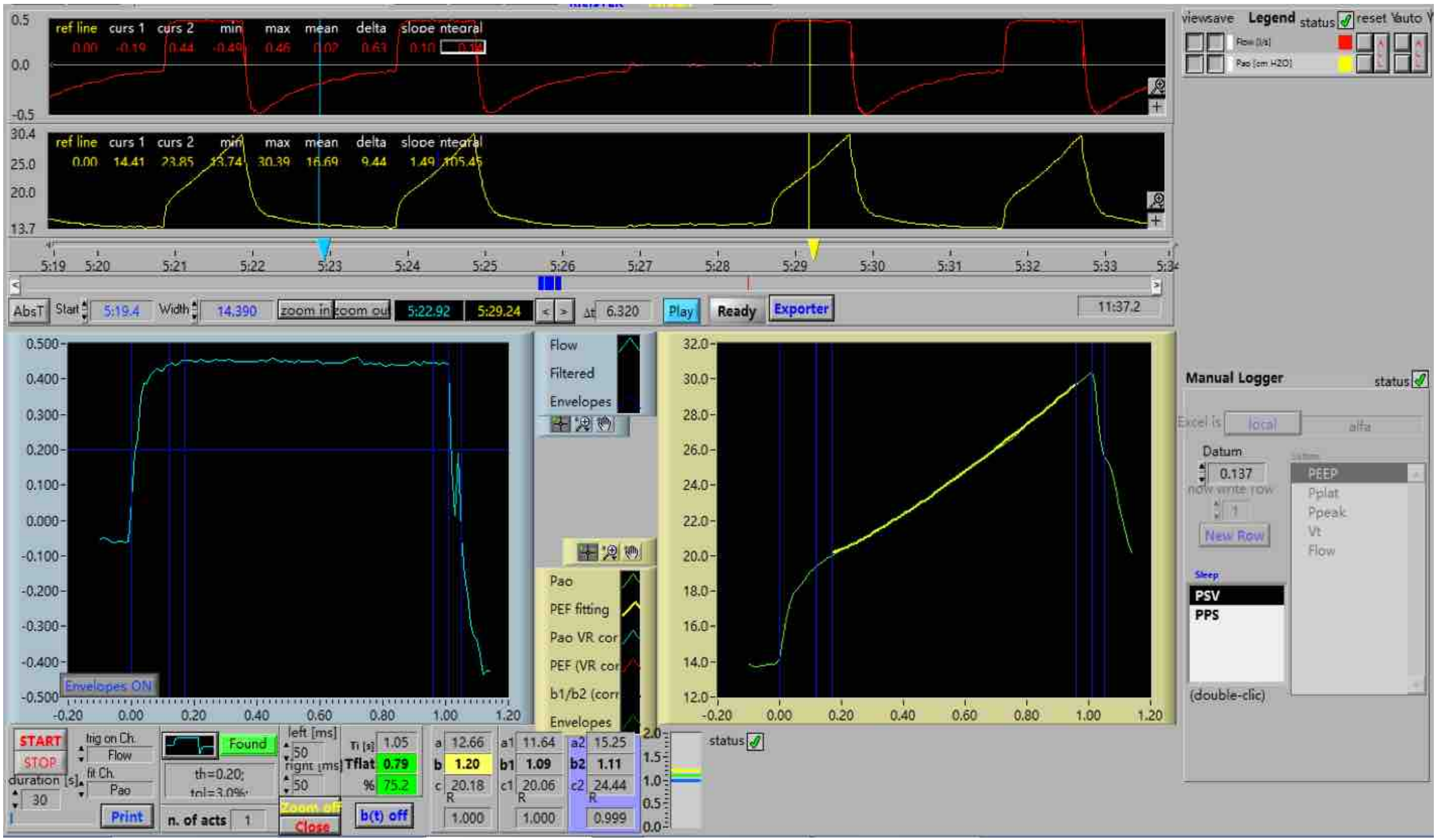
Patient NO5   SI=0.94 linear shape



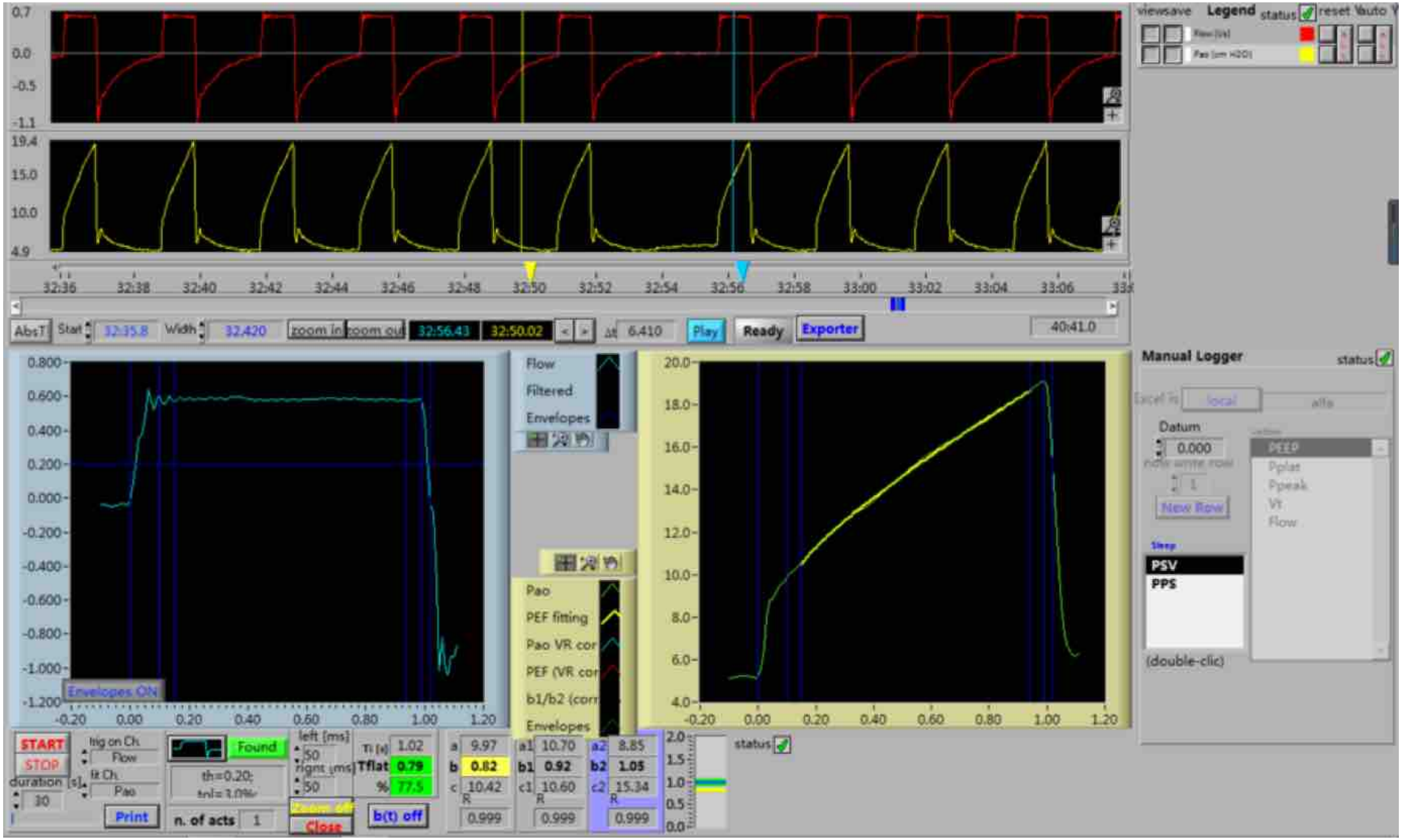
Patient NO6   SI=1.19 upward concavity shape



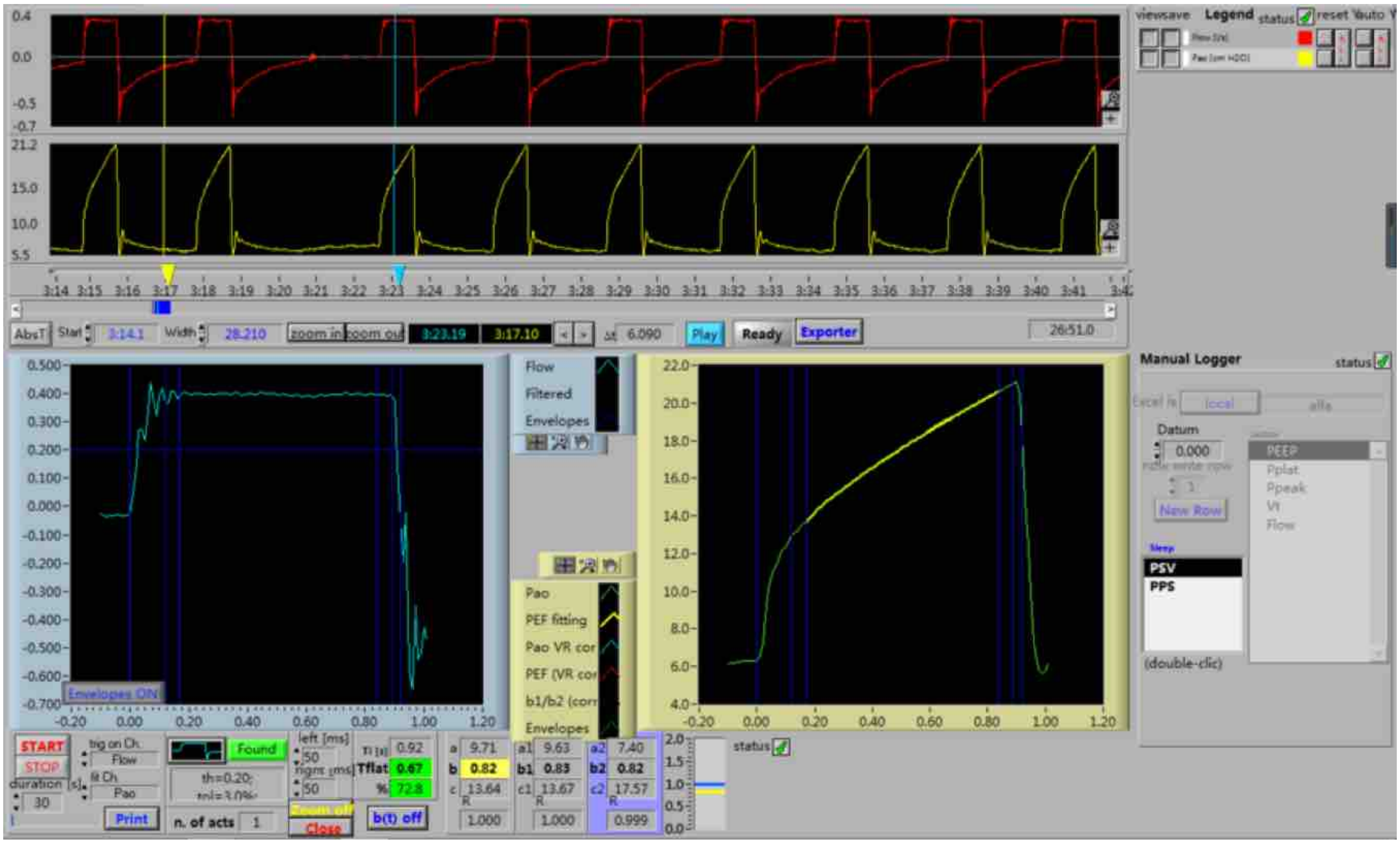
Patient NO7   SI=1.20 upward concavity shape



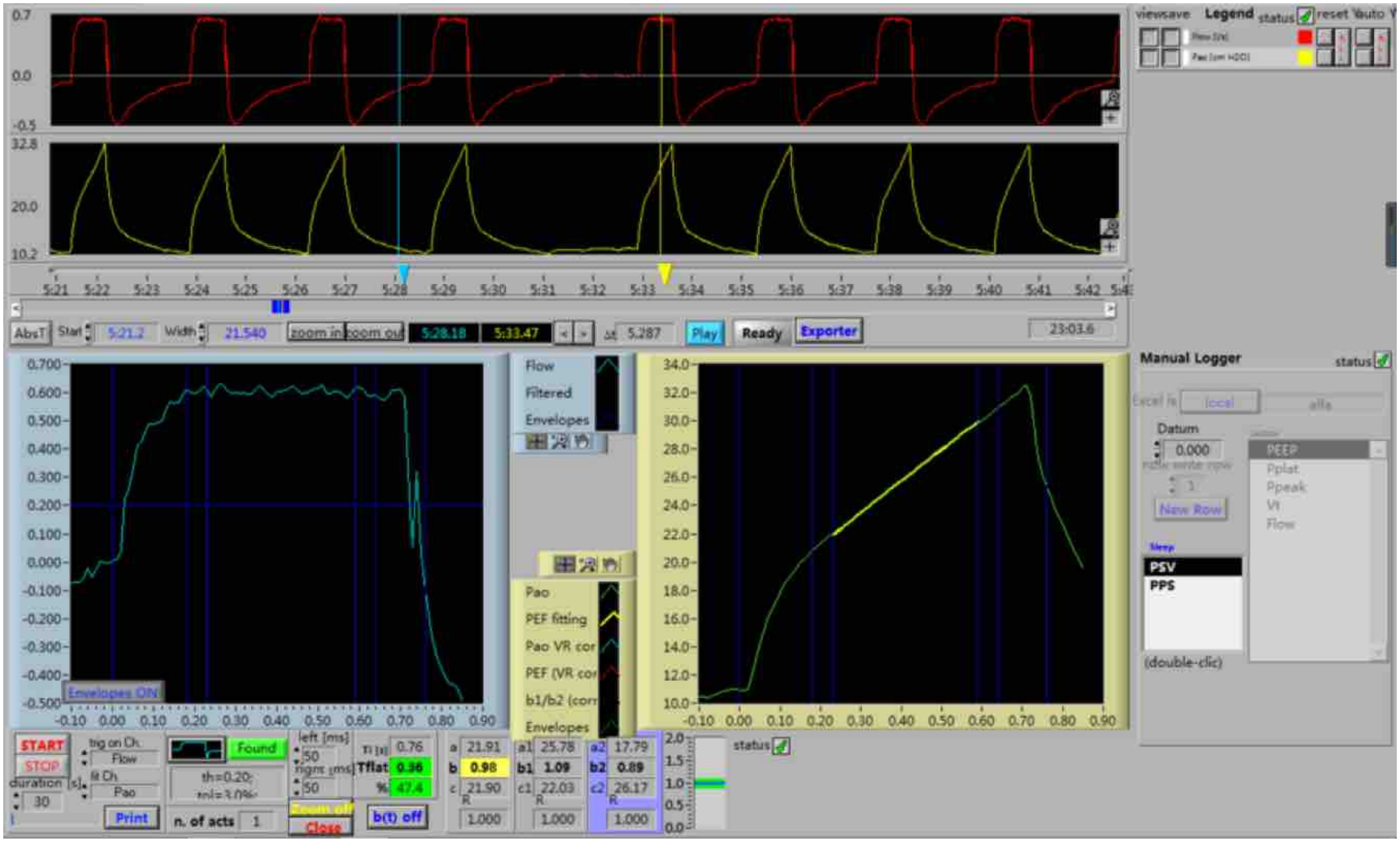
Patient NO8 SI=0.82 downward concavity shape



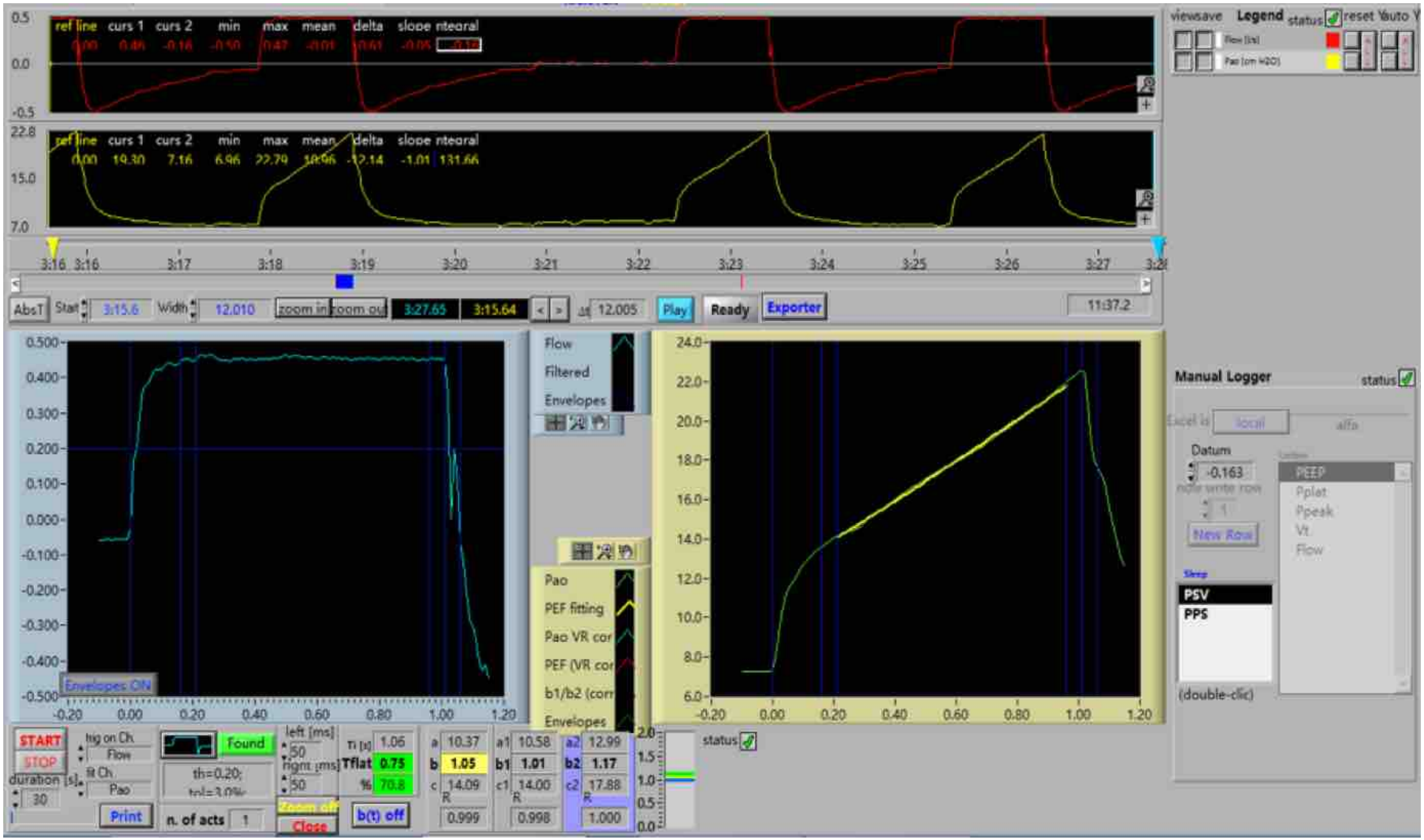
Patient NO9   SI=0.82 downward concavity shape



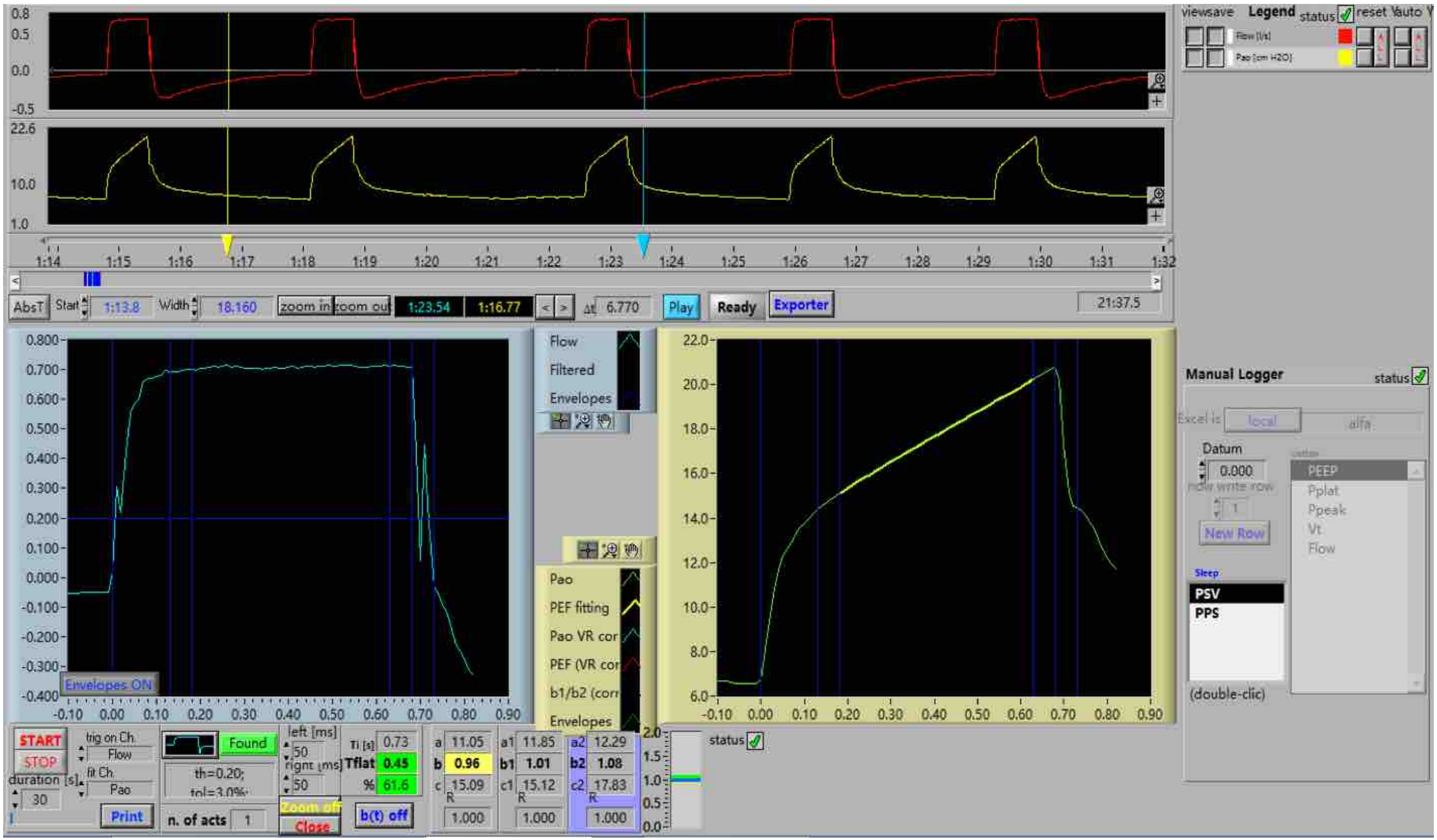
Patient NO10   SI=0.98 linear shape



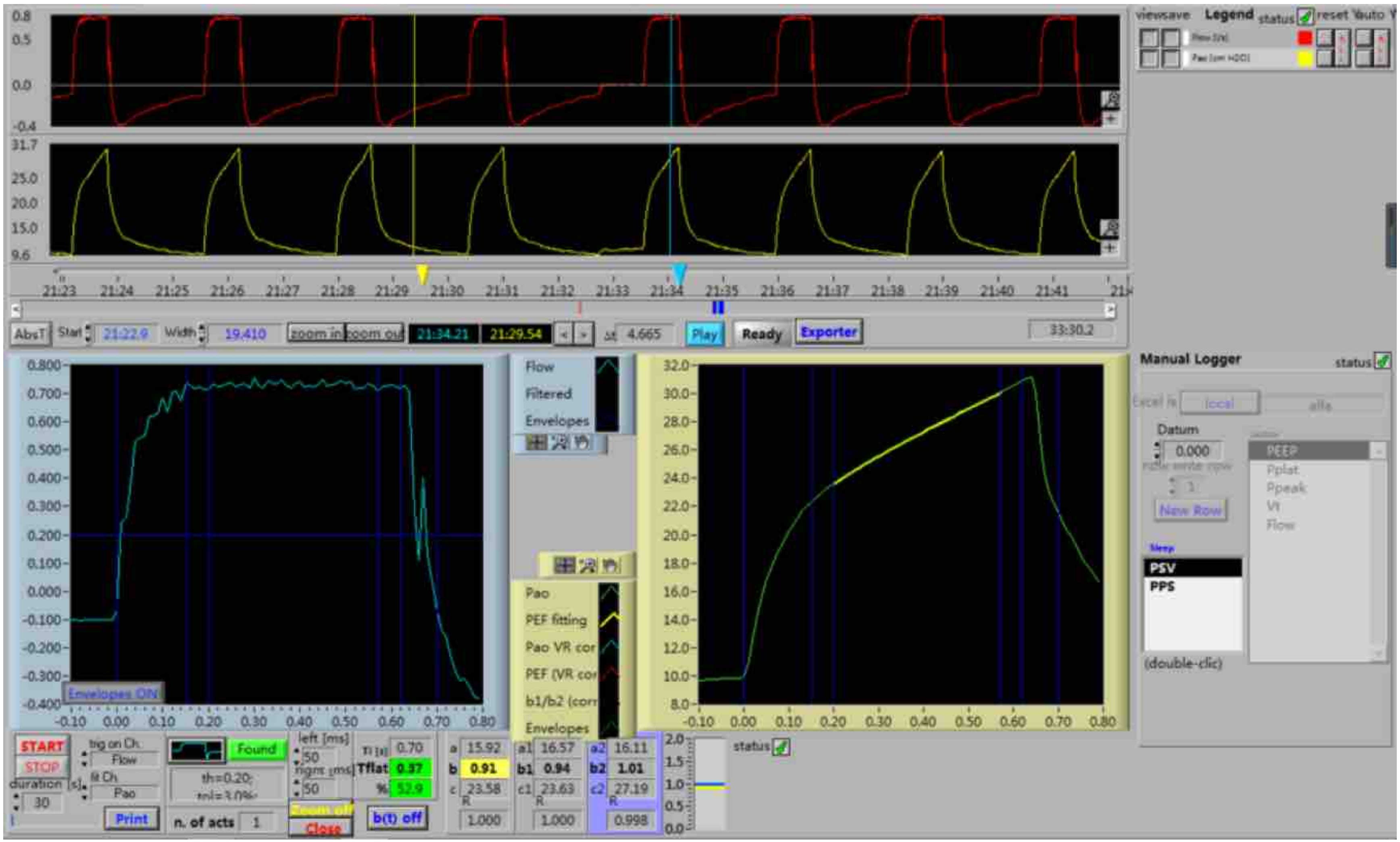
Patient NO11 SI=1.05 linear shape



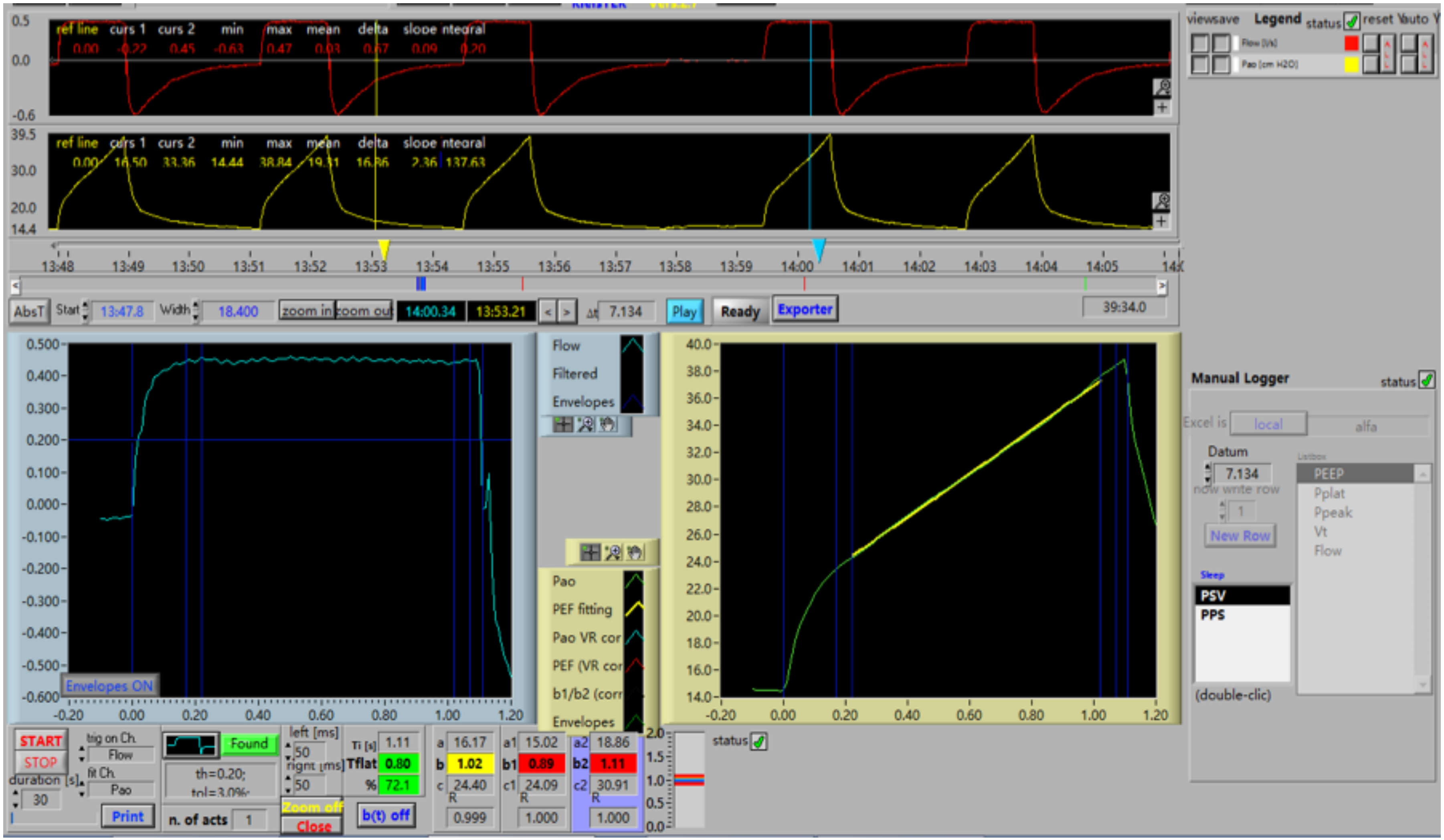
Patient NO12 SI=0.96 linear shape



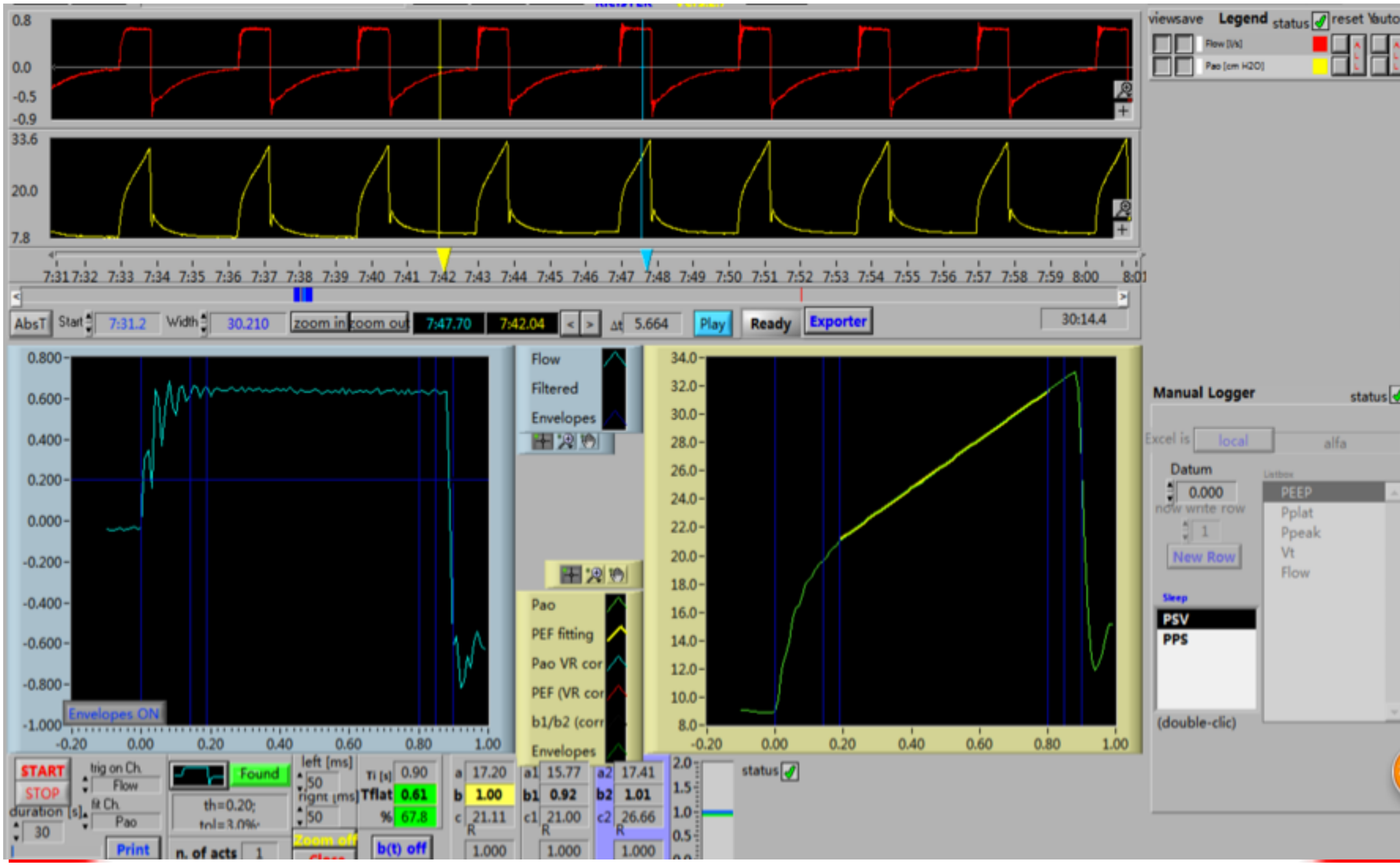
Patient NO13   SI=0.91 linear shape



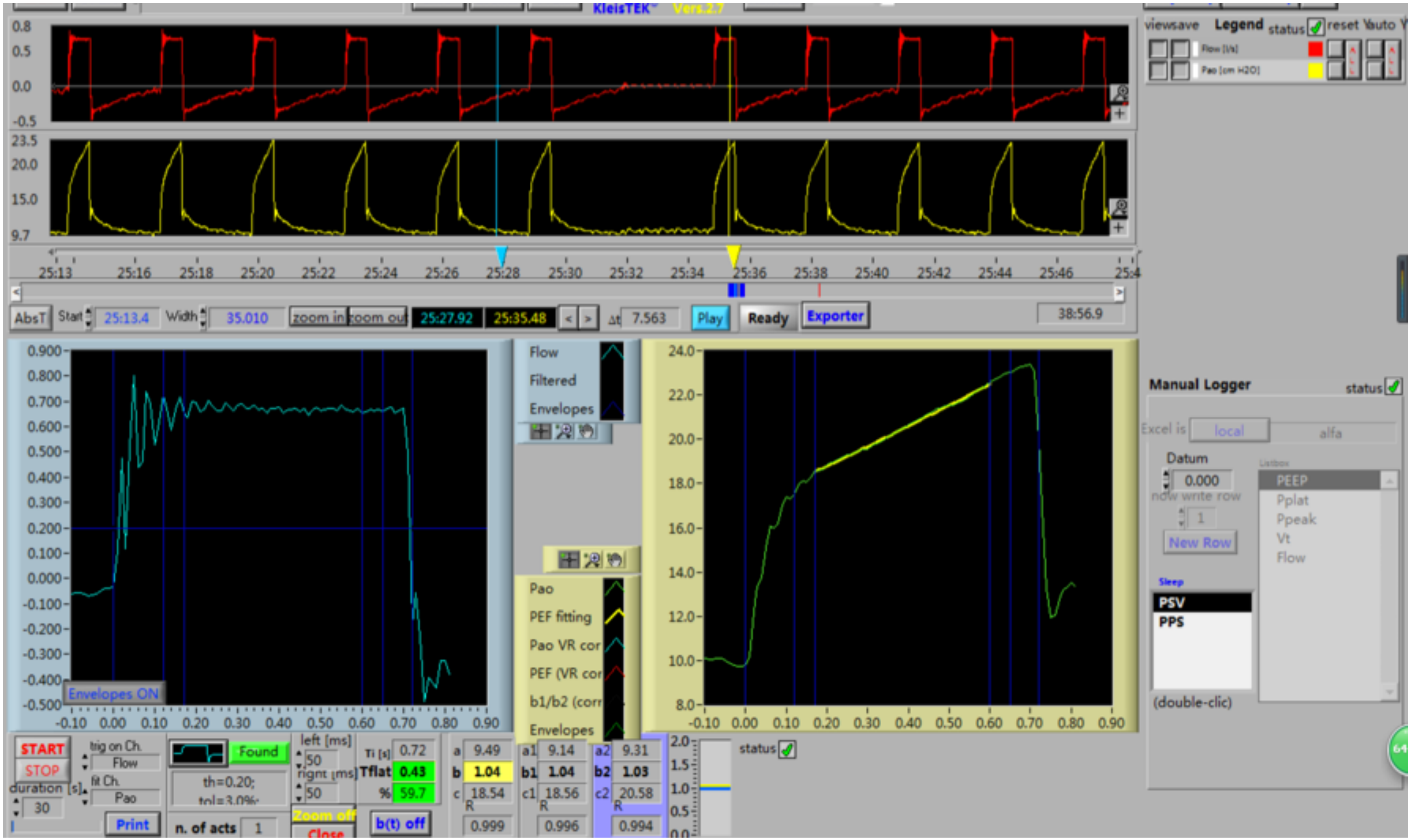
Patient NO14 SI=1.02 linear shape



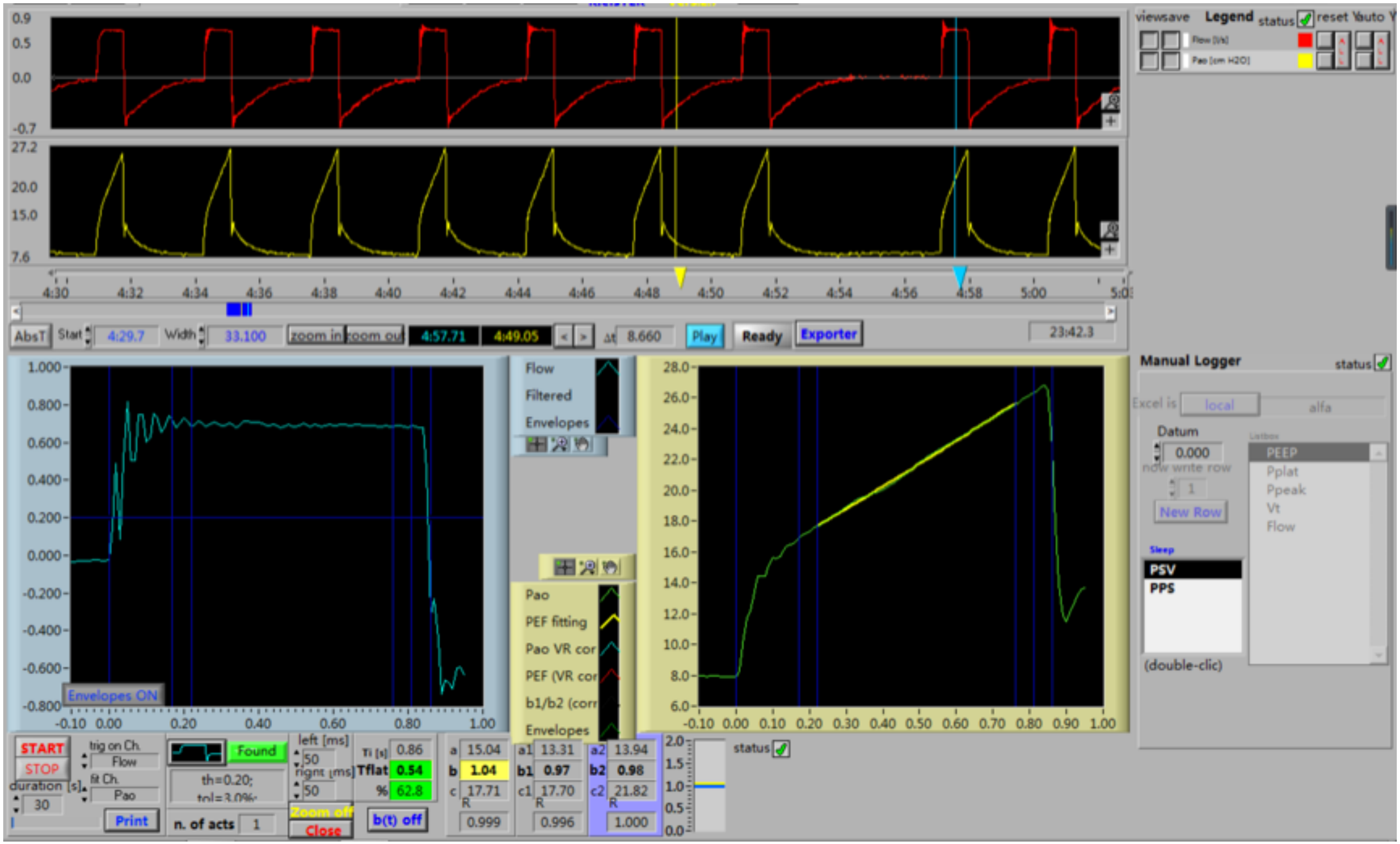
Patient NO15   SI=1.00 linear shape



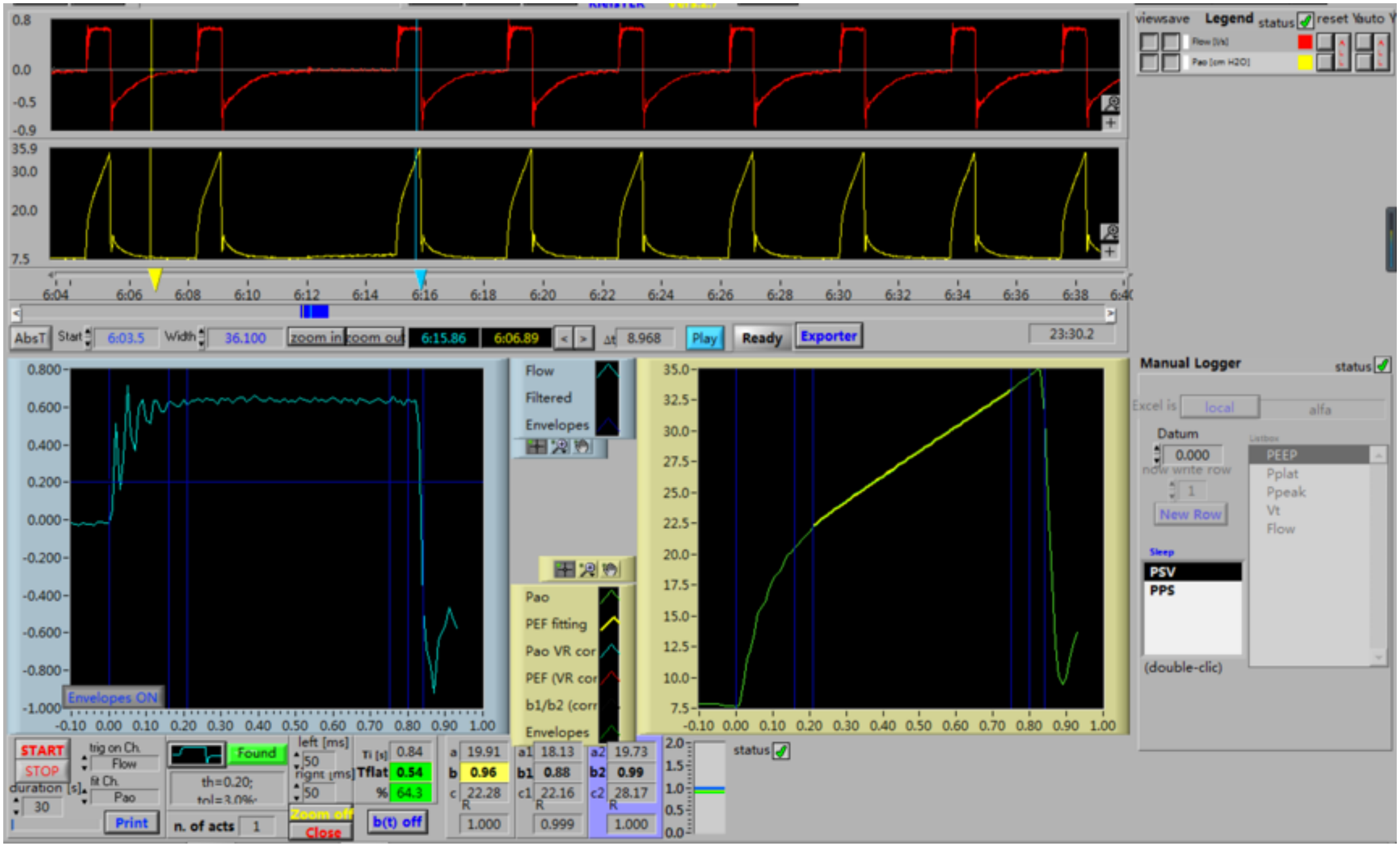
Patient NO16 SI=1.04 linear shape



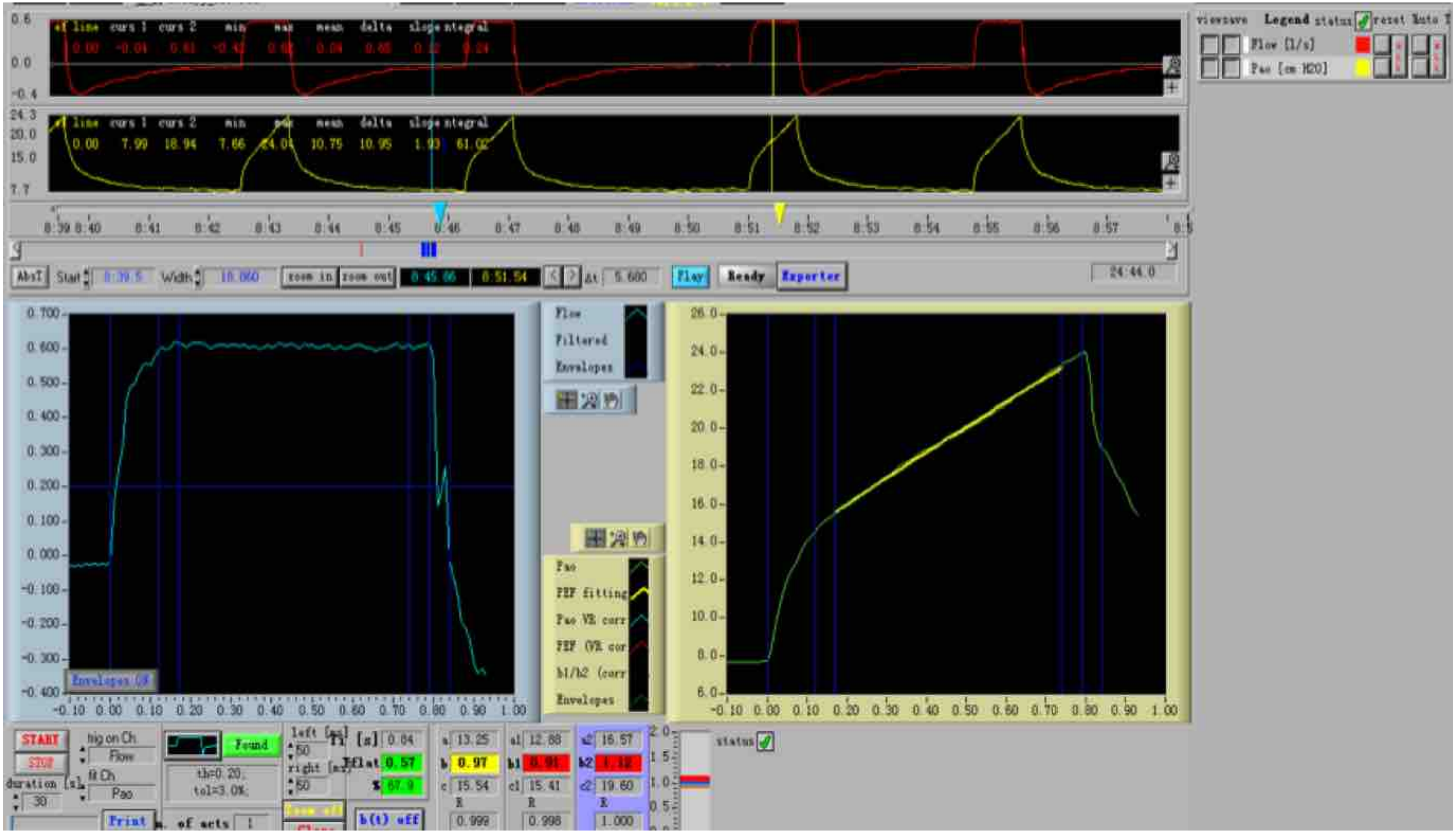
Patient NO17 SI=1.04 linear shape



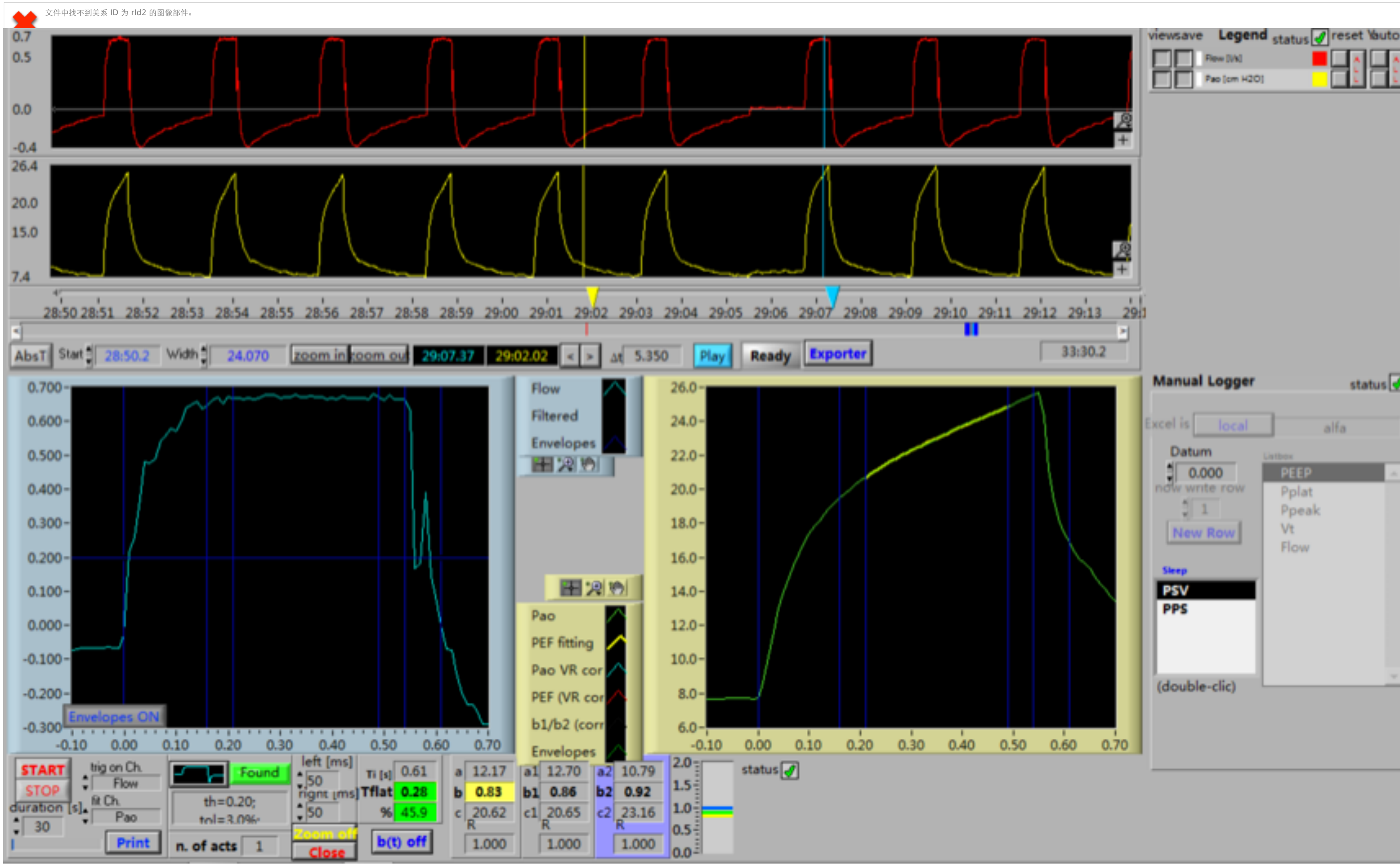
Patient NO18 SI=0.96 linear shape



Patient NO19   SI=0.97 linear shape



Patient NO20 SI=0.83 downward concavity shape



The characters of 20 assessments

	Linear shape	Downward concavity shape	Upward concavity shape
Numbers	15 (75)	3 (15)	2 (10)
SI (range)	0.91-1.05	0.82-0.83	1.19-1.20

Data are presented as number of patients (%)

References

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E2. Henderson WR, Chen L, Amato MB, et al: Fifty years of research in ARDS. Respiratory mechanics in acute respiratory distress syndrome. *Am J Respir Crit Care Med* 2017, online first

E3. Ranieri VM, Zhang H, Mascia L, et al: Pressure-time curve predicts minimally injurious ventilatory strategy in an isolated rat lung model. *Anesthesiology* 2000; 93:1320-1328

E4. De Perrot M, Imai Y, Volgyesi GA, et al: Effect of ventilator-induced lung injury on the development of reperfusion injury in a rat lung transplant model. *J Thorac Cardiovasc Surg* 2002; 124:1137-1144

E5. Gama de Abreu M, Heintz M, Heller A, et al: One-lung ventilation with high tidal volumes and zero positive end-expiratory pressure is injurious in the isolated rabbit lung model. *Anesth Analg* 2003; 96:220-228

E6. Grasso S, Terragni P, Mascia L, et al: Airway pressure-time curve profile (stress index) detects tidal recruitment/ hyperinflation in experimental acute lung injury. *Crit Care Med* 2004; 32:1018-1027

E7. Carvalho AR, Spieth PM, Pelosi P, et al: Ability of dynamic airway pressure curve profile and elastance for positive end-expiratory pressure titration. Intensive Care Med 2008; 34:2291-2299

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E8. Pan C, Tang R, Xie J, et al: Stress index for positive end-expiratory pressure titration in prone position: a piglet study. *Acta Anaesthesiol Scand* 2015; 59:1170-1178

E9. Grasso S, Stripoli T, De Michele M, et al: ARDSnet ventilatory protocol and alveolar hyperinflation: role of positive end-expiratory pressure. *Am J Respir Crit Care Med* 2007; 176:761-767

E10. Huang Y, Yang Y, Chen Q, et al: Pulmonary acute respiratory distress syndrome: positive end-expiratory pressure titration needs stress index. *J Surg Res* 2013; 185:347-352

E11. Terragni PP, Filippini C, Slutsky AS, et al: Accuracy of plateau pressure and stress index to identify injurious ventilation in patients with acute respiratory distress syndrome. *Anesthesiology* 2013; 119:880-889

E12. Chiumello D, Cressoni M, Carlesso E, et al: Bedside selection of positive end-expiratory pressure in mild, moderate, and severe acute respiratory distress syndrome. *Crit Care Med* 2014; 42:252-264

E13. Terragni PP, Rosboch GL, Lisi A, et al: How respiratory system mechanics may help in minimising ventilator-induced lung injury in ARDS patients. *Eur Respir J Suppl* 2003; 42:15s-21s

E14. Terragni PP, Bussone G, Mascia L. Dynamic airway pressure-time curve profile (Stress Index): a systematic review. *Minerva Anestesiol* 2016; 82:58-68