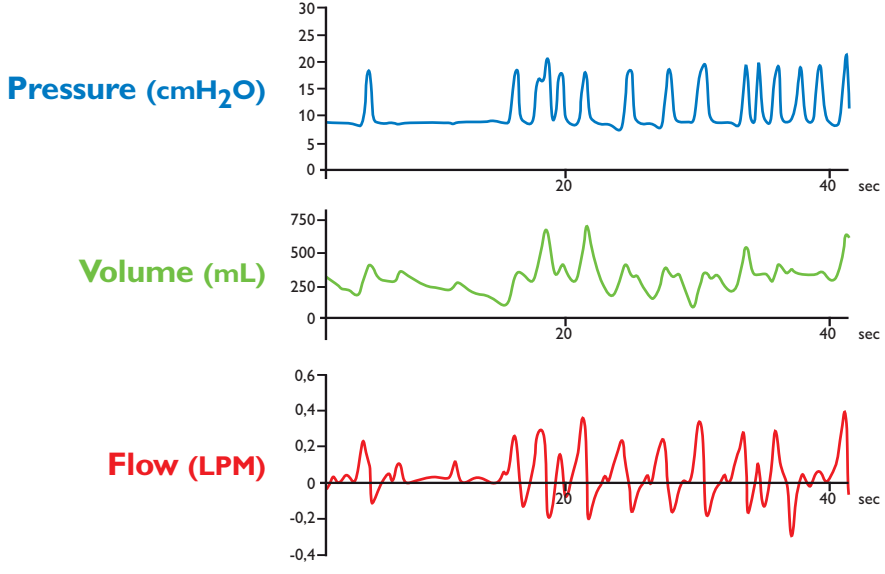
How to read curves for NIV

Monitoring pressure, flow and volume curves during NIV
To assess common problems

- Auto triggering
- Double triggering
- Ineffective triggering
- Leakage

- The proposed interpretation of the proposed curves does not substitute the clinical expertise of the physician and/or respiratory therapist
- These suggestions therefore **do not** substitute the clinical judgment and decision of the physician and/or respiratory therapist

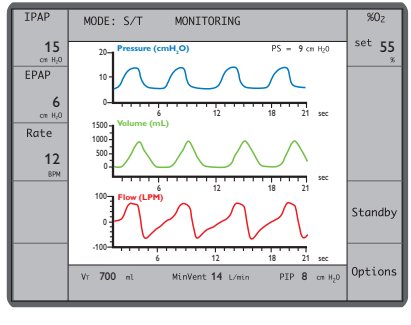
PHILIPS


Pressure (cmH2O)
30
25
20
15
10
5
0
20
40
sec
Volume (mL)
750
500
250
0
20
40
sec
Flow (LPM)
0,6
0,4
0,2
0
-0,2
-0,4
20
40
sec

Main troubleshooting during NIV

- Auto-triggering
- Double-triggering
- Ineffective triggering
- Leakage

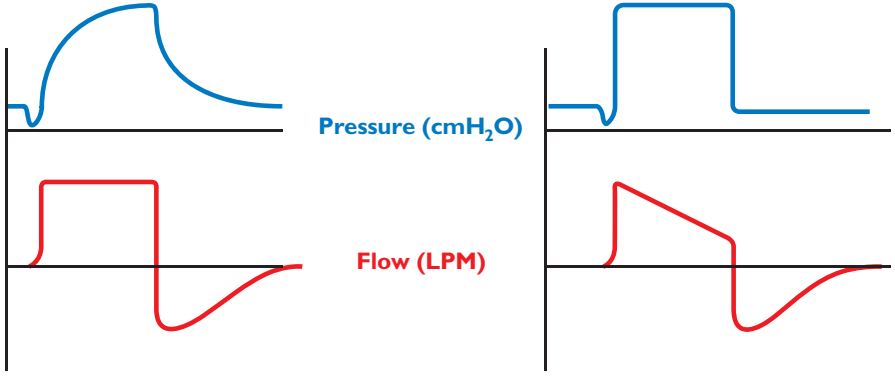
▼ **Complete waveform monitoring facilitates troubleshooting**



- **Pressure**
- **Volume**
- **Flow**

Georgopoulos et al.: Bedside waveforms interpretation. Intensive Care Medicine (2006) 32:34-47

Two main ventilatory modes: pressure and volume mode



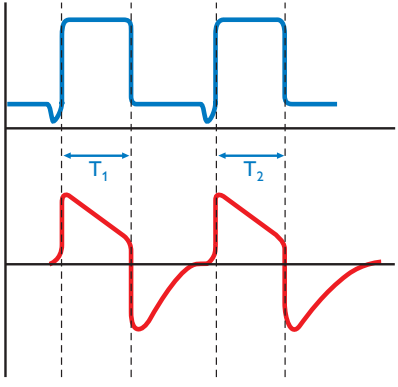
Volume mode

- Independant value is Volume
- Dependant value is Pressure

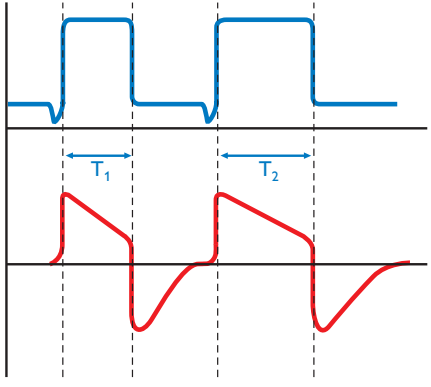
Pressure mode

- Independant value is Pressure
- Dependant value is Volume

Usual pressure modes for NIV: PCV, PSV



Pressure Control Ventilation (PCV)
Fixed Inspiratory Time
$T_1=T_2$

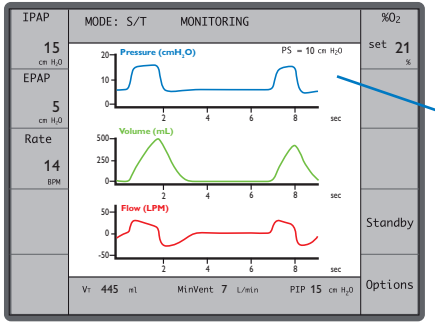


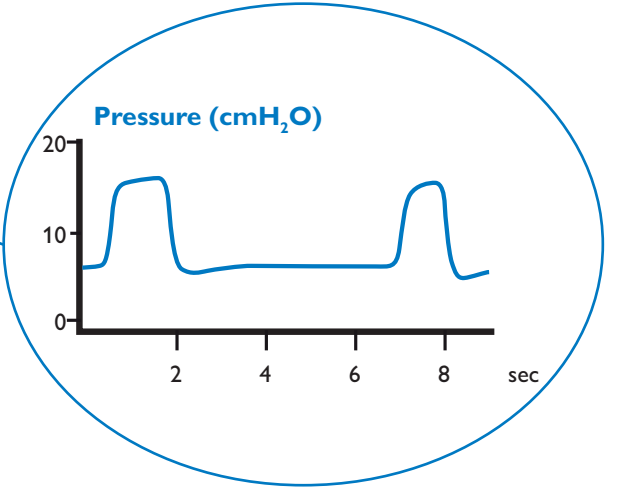
Pressure Support Ventilation (PSV)
Inspiratory Time depends on patient breathing pattern
$T_1 \neq T_2$

NIV requirements:

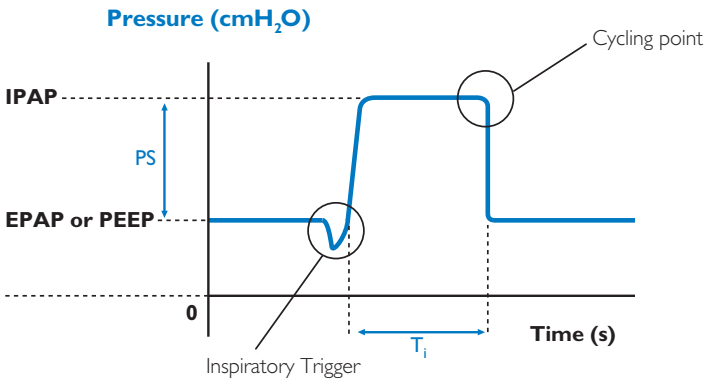
Two breaths for each of the modes

- Pressure Control Ventilation (PCV)
  - ▼ Fixed inspiratory time
- Pressure Support Ventilation (PSV)
  - ▼ Variable inspiratory times


IPAP
15
cm H2O
EPAP
5
cm H2O
Rate
14
BPM
MODE: S/T MONITORING
%O2
set 21
%
PS = 10 cm H2O
Pressure (cmH2O)
20
10
0
2
4
6
8
sec
Volume (mL)
500
250
0
Flow (LPM)
50
0
-50
Standby
Options
Vt 445 ml
MinVent 7 L/min
PIP 15 cm H2O


Pressure (cmH2O)
20
10
0
2
4
6
8
sec

Pressure curve
Points of interest

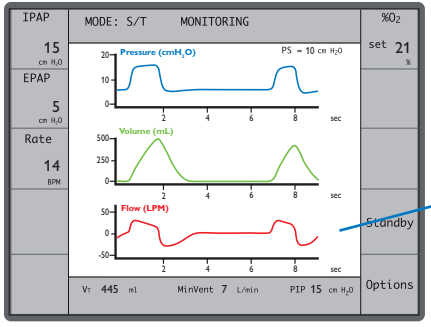


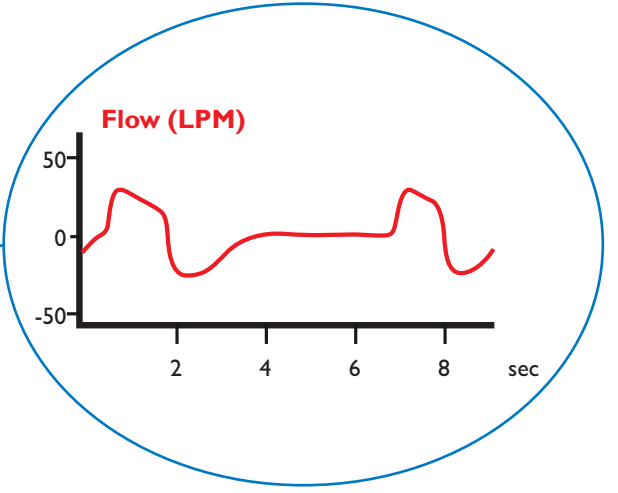
IPAP: Inspiratory Positive Airway Pressure
EPAP: Expiratory Positive Airway Pressure

PEEP: Positive End Expiratory Pressure
PS: Pressure support

T_i: Inspiratory time

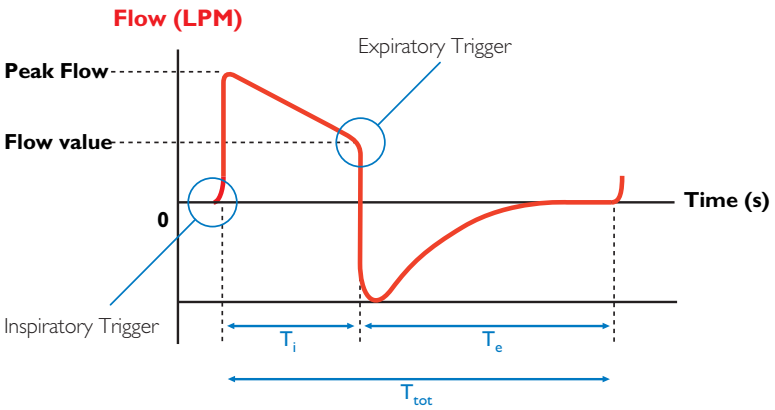
EPAP = PEEP
PS = IPAP - [EPAP or PEEP]
IPAP = PS + [EPAP or PEEP]


IPAP
15
cm H2O
EPAP
5
cm H2O
Rate
14
BPM
MODE: S/T MONITORING
%O2
set 21
%
Pressure (cmH2O)
PS = 10 cm H2O
20
10
0
2
4
6
8
sec
Volume (mL)
500
250
0
Flow (LPM)
50
0
-50
Standby
Options
Vt 445 ml
MinVent 7 L/min
PIP 15 cm H2O


Flow (LPM)
50
0
-50
2
4
6
8
sec

Flow curve

Points of interest



Expiratory Trigger:

- % of Inspiratory peak flow

or

- Absolute value in LPM

or

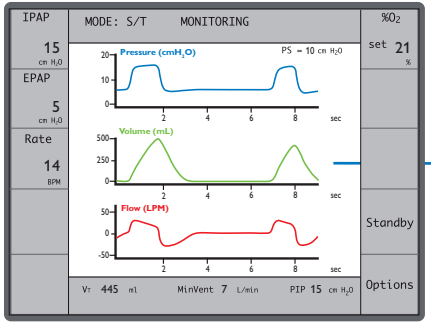
- Set inspiratory time (=T_i)

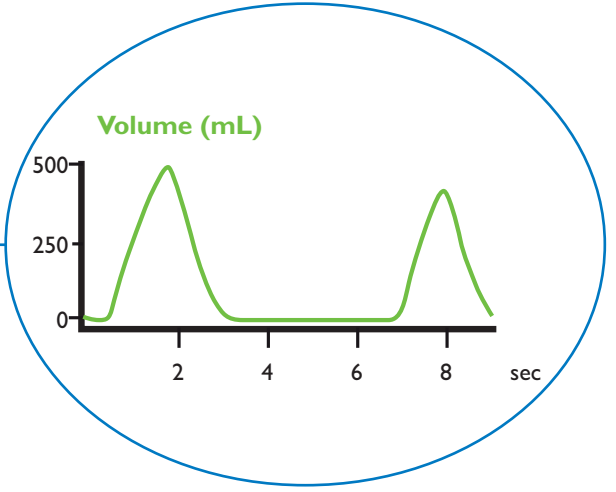
T_i: Inspiratory time

T_e: Expiratory time

T_{tot}: Total breath time

$T_{tot} = T_i + T_e$


IPAP
15
cm H2O
EPAP
5
cm H2O
Rate
14
BPM
MODE: S/T MONITORING
Pressure (cmH2O)
PS = 10 cm H2O
20
10
0
2 4 6 8
sec
Volume (mL)
500
250
0
2 4 6 8
sec
Flow (LPM)
50
0
-50
2 4 6 8
sec
Vt 445 ml
MinVent 7 L/min
PIP 15 cm H2O
%O2
set 21
%
Standby
Options


Volume (mL)
500
250
0
2
4
6
8
sec

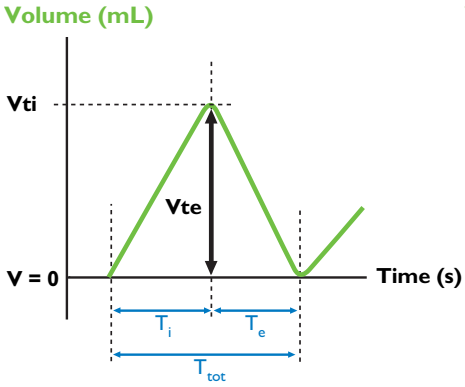
Volume curve

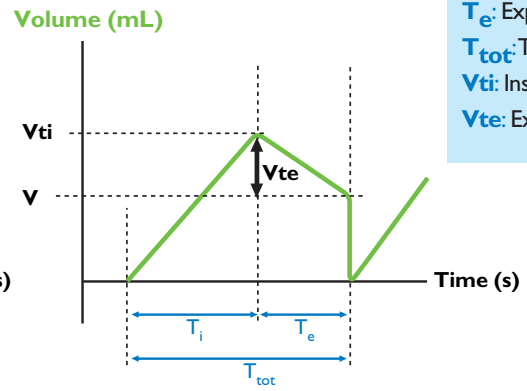
Points of interest

No leak
Vti = Vte

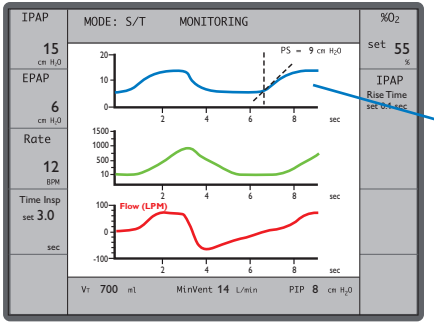
Vte = Vti - V

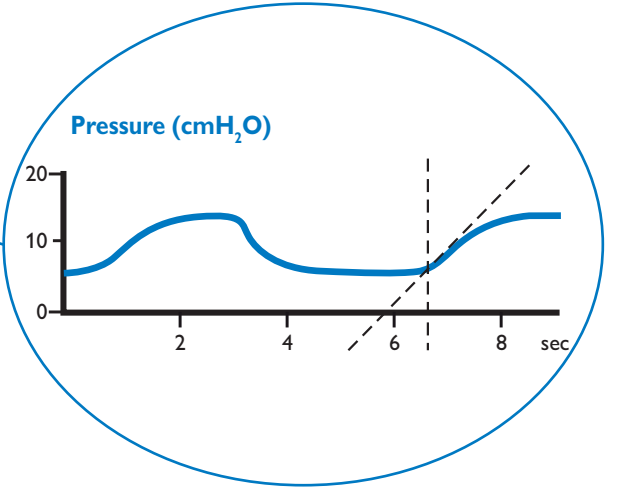
Leak
Vti > Vte



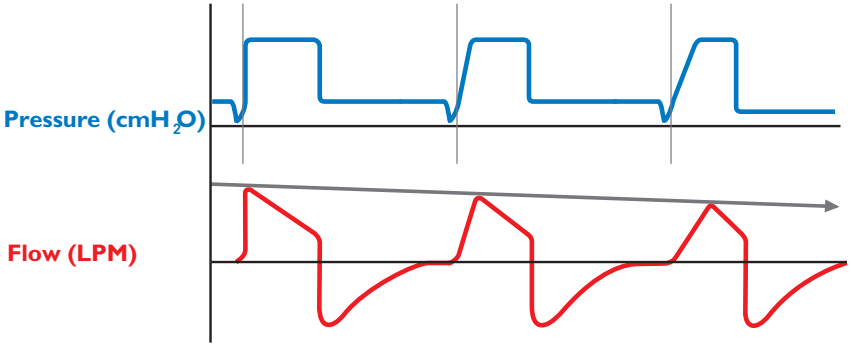


T_i: Inspiratory time
T_e: Expiratory time
T_{tot}: Total time $T_{tot} = T_i + T_e$
Vti: Inspiratory total volume
Vte: Expiratory total volume


IPAP
15
cm H2O
EPAP
6
cm H2O
Rate
12
BPM
Time Insp
set 3.0
sec
MODE: S/T MONITORING
PS = 9 cm H2O
20
10
0
2
4
6
8
sec
1500
1000
500
10
Flow (LPM)
100
0
-100
Vt 700 ml
MinVent 14 L/min
PIP 8 cm H2O
%O2
set 55
%
IPAP
Rise Time
set 0.4 sec

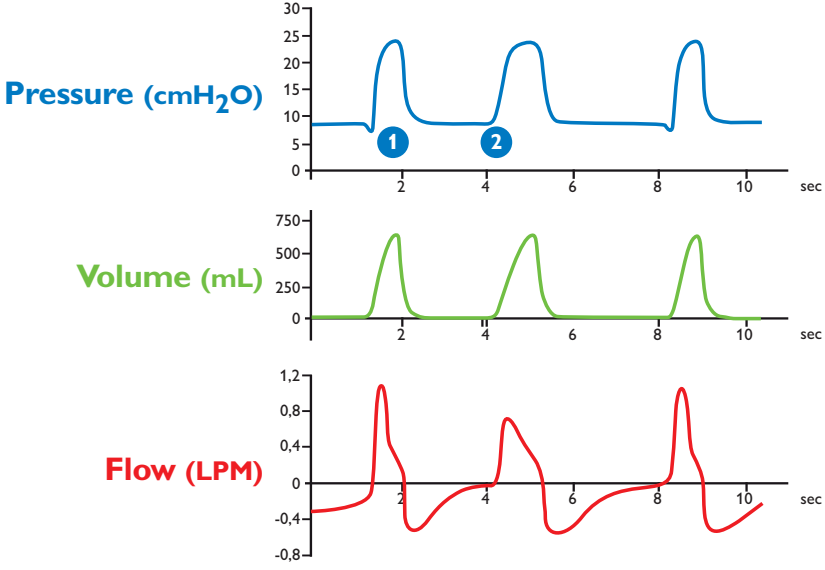

Pressure (cmH2O)
20
10
0
2
4
6
8
sec

Pressure ramp ▼ Flow impact



Slow pressure ramp ➔ Reduced peak flow

Auto triggering



1. **Breath normally triggered**
2. **Auto-triggered breath**

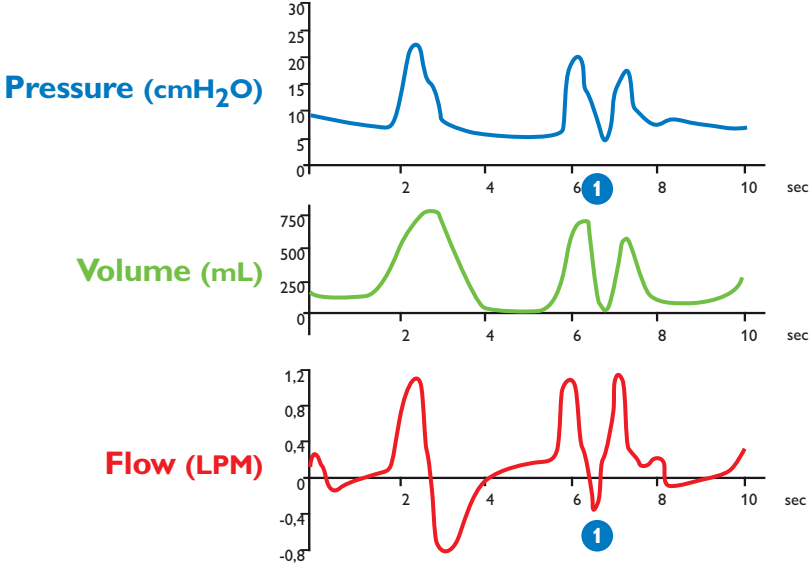
Auto triggering

Breath number 2 is triggered in the absence of patient's inspiratory effort (no abrupt decrease in pressure). This does not represent an automatic change to backup mode.

Autotriggering can occur:

- leakage
- mobile condensation in the circuit
- trigger too sensitive

Double triggering



1 **Double triggering**

Double triggering

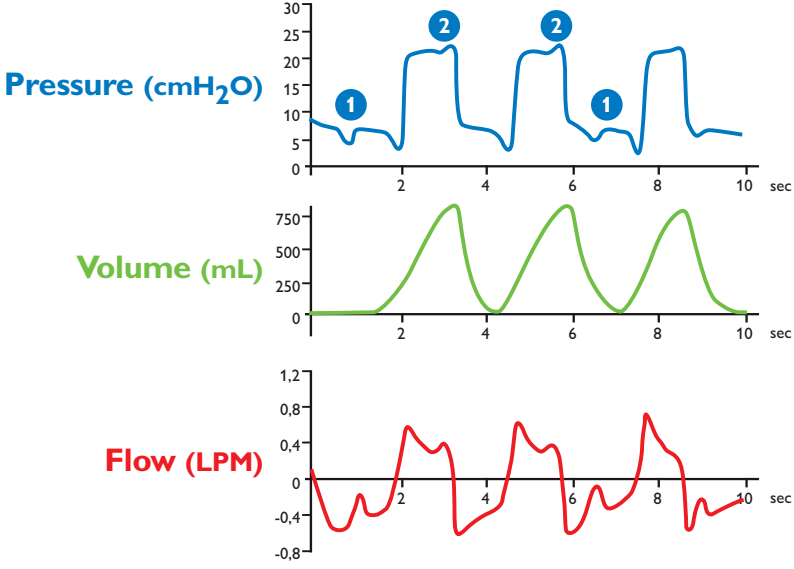
Double triggering defined as two consecutive ventilator cycles separated by an expiratory time less than one-half the mean inspiratory time*.

Double triggering can occur:

- ventilator inspiratory pattern ...
- patient's effort ...
- ventilator settings (insp. time, cycling criteria, ...)

* Thille et al: Patient-ventilator asynchrony during assisted mechanical ventilation. Intensive Care Medicine (2006) 32:1515-1522

Ineffective triggering



1. **Inspiratory ineffective triggering**
2. **Expiratory ineffective triggering**

Ineffective triggering

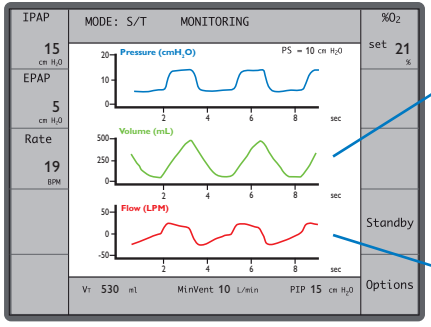
A wasted effort is defined as an airway pressure drop simultaneous to a flow increase not followed by a ventilator cycle*.
Due to patient's active expiration an increase in pressure was not recognized as end inspiration.

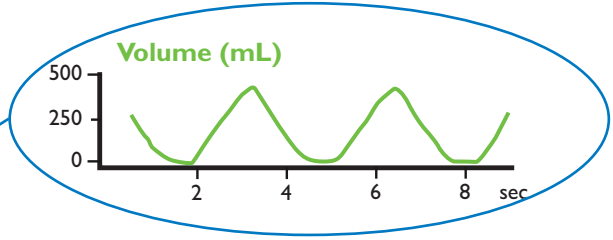
Ineffective triggering can occur:

- patient respiratory system mechanics
- inadequate setting (insp trigger, cycling criteria, ...)
- excessive inspiratory support

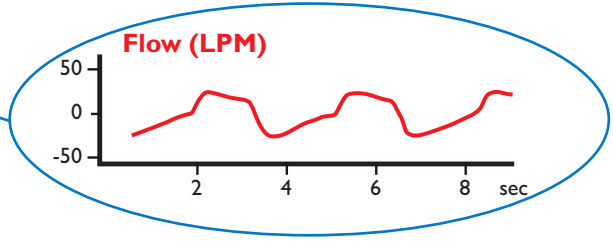
* Thille et al: Patient-ventilator asynchrony during assisted mechanical ventilation. Intensive Care Medicine (2006) 32:1515-1522

No leakage



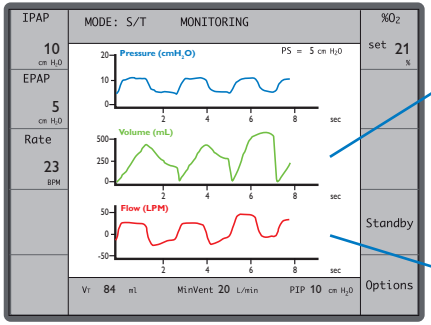


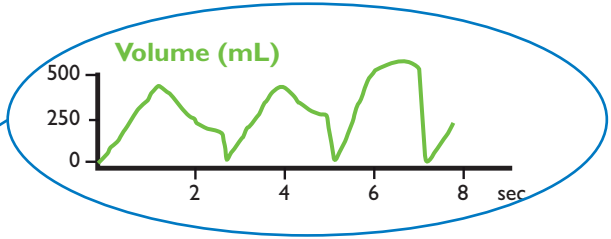
- **End of expiratory volume reach 0 value**



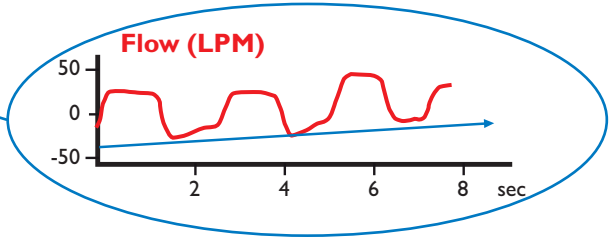
- **Flow curve present no leakage readjustment**

Leakage





- **Volume curve drop suddenly to 0 when breath is triggered**



- **Base line flow is different than 0 during leakage readjustment**

Notes:

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