Why is accidental lung trauma possible during spontaneous ventilation?

Are ventilators safe in the manual ventilation mode ?

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Aim of the study

The adjustable pressure limiting (APL) valve protects against high airway pressures. At induction the fresh gas flow is set high and the APL valve is turned to maximum facilitating face mask ventilation. This manual mode becomes dangerous after connecting the ventilator to the endotracheal tube without changing the ventilation mode.

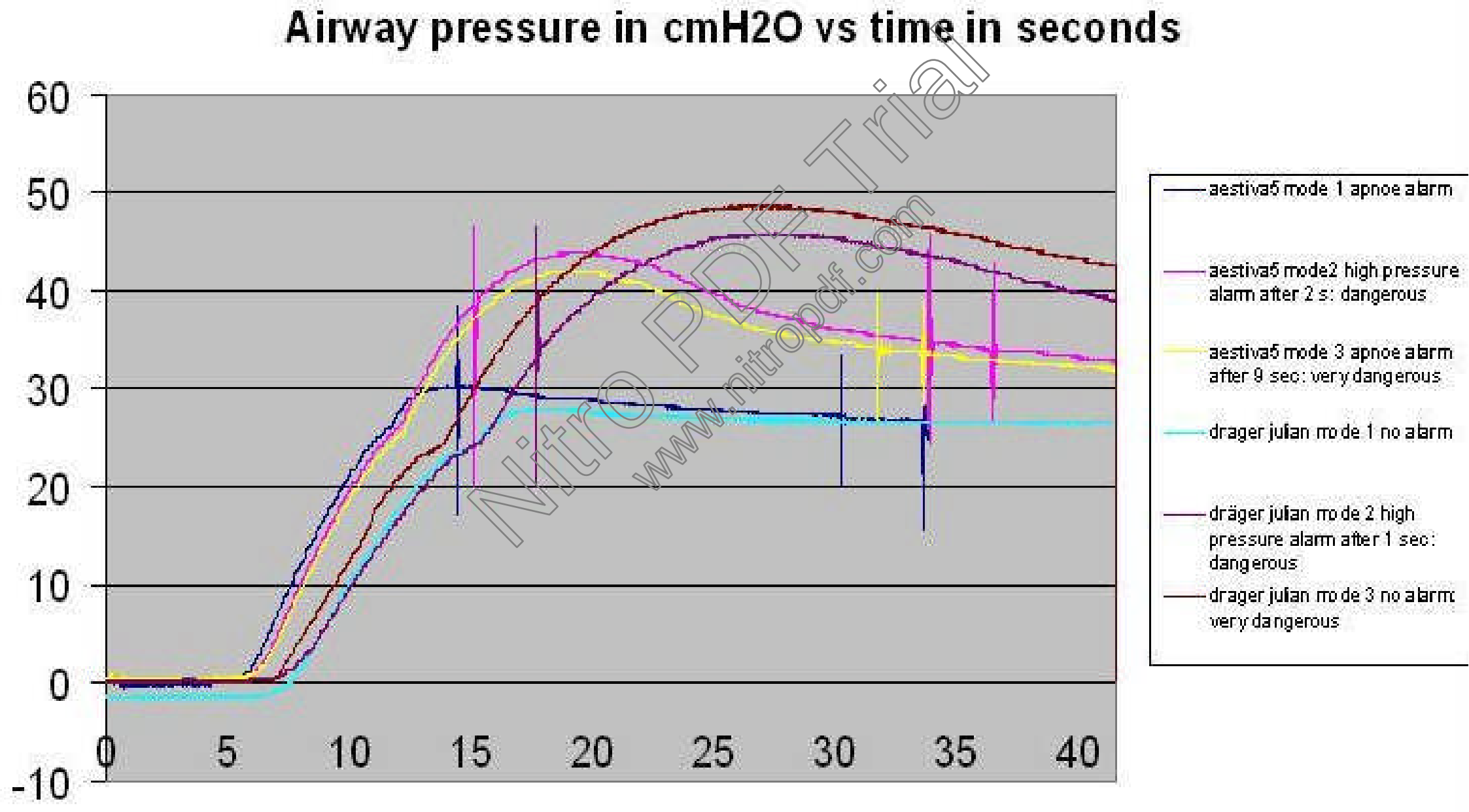
All ventilators have an alarm when airway pressure exceeds a value, however without opening a valve. Airway pressure rises very fast and causes volutrauma if no immediate reaction occurs.

Goal of this study was to evaluate 8 ventilators (Excel 210 SE, Excel 410, Datex AS/3, Aestiva 5, Drager av1, Drager titus, Drager cato, Drager julian) in the manual ventilation mode without manual compression.

Methods and Analysis

- The airway pressure is measured and the time at which an alarm went off. A soft European balloon of 2 litres is connected for the manual ventilation. Fresh gas flow is set at 15 litres per minute. The artificial lung consists of a Siemens test lung 190 with a balloon of 1 litre.
- In the first mode the APL valve and the pressure alarm are set at 30 cm H2O, in the second mode the alarm is set at 30 cm H2O and the APL valve at its maximum level, in the third mode they are both set at their maximum level.
  At time zero the ventilator is switched to a manual ventilation mode without compression of the balloon. The airway pressure is monitored, and the times at which the alarms go off are noted by a high frequency pulse given on the pressure transducer. The recording is stopped when the airway pressure stabilizes or drops.
- A ventilation mode is considered dangerous if the airway pressure stayed above 30 cmH20 for more than 6 seconds and very dangerous if no alarm did go off in that time.
  A ventilator is considered to be dangerous if a dangerous ventilation mode exists.

Results



entilator	L val ve	alar m	first alarm after	risk
x 10	30	30	high pressure	
x 10	75	30	high pressure 1 s	dangerous
x 10	75	100	sustained pressure 17 s	very dangerous
x 410	30	30	sustained pressure 15 s	
x 410	75	30	high pressure 3 s	dangerous
x 410	75	100	sustained pressure 18 s	very dangerous
a as3	30	30	high pressure	
a as3	80	30	high pressure 1 s	dangerous
a as3	80	80	high peep 5 s	dangerous
estiv	30	30	apnoe	
estiv	70	30	high pressure 2 s	dangerous
estiv	70	99	apnoe 9 s	very dangerous

drage r AV1	30	30	high pressure	
drage r AV1	106	30	high pressure 1 s	dangerous
drage r AV1	106	13 3		very dangerous
titus	30	30		
titus	70	30	high pressure 1 s	dangerous
titus	70	99		very dangerous
cato	30	30		
cato	70	30	high pressure 1 s	dangerous
cato	70	98		very dangerous
julian	30	30		
julian	70	30	high pressure 1 s	dangerous
julian	70	98		very dangerous

Conclusion

Mode 1 was safe. Mode 2 was dangerous in all ventilators and mode 3 was very dangerous in most ventilators. All ventilators were considered as dangerous. Correct alarm setting and vigilance remains the cornerstone of safety.