New Anesthetic Machine Technology in really practice

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Faculty of Medicine Ramathibodi Hospital
Mahidol University
Anaesthesia

- is one of the few sub-specialties of medicine, which has quickly adapted technology to improve patient safety.
- this application of technology can be seen in
  - patient monitoring
  - intubating devices
  - ultrasound for visualization of nerves and vessels
  - advances anesthesia machines
  - etc.
Anesthesia machines

the improvements being driven by

• patient safety
• functionality
• economy of use
Table 2. Type of Equipments involved and severity of problems

<table>
<thead>
<tr>
<th>Equipment involved</th>
<th>Severity Grade 1 (n)</th>
<th>Severity Grade 2 (n)</th>
<th>Severity Grade 3 (n)</th>
<th>Severity Grade 4 (n)</th>
<th>Total equipment problems n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anesthesia machine</td>
<td>45</td>
<td>1</td>
<td>10</td>
<td>1</td>
<td>57(63.3)</td>
</tr>
<tr>
<td>Non-invasive arterial pressure</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td>2(2.2)</td>
</tr>
<tr>
<td>Monitor blood sugar</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>1(1.1)</td>
</tr>
<tr>
<td>Pulse oximetry</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td>6(6.7)</td>
</tr>
<tr>
<td>Airway equipment</td>
<td>4</td>
<td>1</td>
<td></td>
<td></td>
<td>5(5.6)</td>
</tr>
<tr>
<td>Theater equipment</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td>2(2.2)</td>
</tr>
<tr>
<td>IV access</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td>2(2.2)</td>
</tr>
<tr>
<td>Laryngoscope</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td>15(16.7)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>76</td>
<td>3</td>
<td>10</td>
<td>1</td>
<td>90</td>
</tr>
</tbody>
</table>

Grade 1 = Minor problems  
Grade 2 = Moderately difficult problems with some effect to the patient, but low severity  
Grade 3 = Serious situation difficult causing a serious deterioration in the patient’s state, which may or may not contribute to post-operative morbidity  
Grade 4 = Fatal problems

The Thai Anesthesia Incidents Study (THAI Study) of Anesthetic Equipment Failure/Malfunction: A Qualitative analysis for risk factors
Sireeluck Klanarong MD*, Waraporn Chau-in MD**, Aksorn Pulnitiporn MD***, Wiroj Pengpol MD****
### Table 4. Contributing factors of equipment failure/malfunction (n = 92)

<table>
<thead>
<tr>
<th>Factors*</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ineffective equipment</td>
<td>46</td>
<td>50.0</td>
</tr>
<tr>
<td>Haste</td>
<td>30</td>
<td>32.6</td>
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<tr>
<td>Lack of experiences</td>
<td>15</td>
<td>16.3</td>
</tr>
<tr>
<td>Ineffective monitor</td>
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<td>14.1</td>
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<td>Inadequate equipment</td>
<td>10</td>
<td>10.9</td>
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<tr>
<td>Poor decision making</td>
<td>6</td>
<td>6.5</td>
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<tr>
<td>Lack of knowledge</td>
<td>4</td>
<td>4.3</td>
</tr>
<tr>
<td>Emergency condition</td>
<td>3</td>
<td>3.3</td>
</tr>
<tr>
<td>Communication failure</td>
<td>2</td>
<td>2.2</td>
</tr>
<tr>
<td>Fatigue</td>
<td>2</td>
<td>2.2</td>
</tr>
<tr>
<td>Lack of monitoring devices</td>
<td>2</td>
<td>2.2</td>
</tr>
<tr>
<td>Insufficient manpower</td>
<td>1</td>
<td>1.1</td>
</tr>
<tr>
<td>Unfamiliarity to workplace and environment</td>
<td>1</td>
<td>1.1</td>
</tr>
</tbody>
</table>

*The Thai Anesthesia Incident Monitoring Study (Thai AIMS) of Anesthetic Equipment Failure/Malfunction: An Analysis of 1996 Incident Reports*  
Chaiyapruk Kusumaphanyo MD*, Somrat Charuluxanananan MD**, Dujduen Sriramatr MD*, Aksorn Pulnitiporn MD***, Wimonrat Sriraj MD****
### Table 6. Contributing factors

<table>
<thead>
<tr>
<th>Factors</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Human factors</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Inadequate anesthesiologists</td>
<td>0</td>
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<tr>
<td>2. Inappropriate decision making</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>3. Lack of knowledge</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>4. Haste</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>5. Fatigue</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>6. Inadequate experience</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>7. Communication failure</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>8. Unacquainted environment</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>9. Improper preoperative checking of Equipment</td>
<td>26</td>
<td>26</td>
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<tr>
<td><strong>System factors</strong></td>
<td>66</td>
<td>73.3</td>
</tr>
<tr>
<td>1. Inadequate &amp; inefficient equipment</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td>2. Lack of maintenance system</td>
<td>61</td>
<td></td>
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<td>3. Lack of guideline practice</td>
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<tr>
<td><strong>Patient factors</strong></td>
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<td>2.2</td>
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The Thai Anesthesia Incidents Study (THAI Study) of Anesthetic Equipment Failure/Malfunction: A Qualitative analysis for risk factors
Sireeluck Klanarong MD*, Waraporn Chau-in MD **, Aksorn Pulnitiporn MD***, Wiroj Pengpol MD****
Incorporation of safety features in anesthesia machines and ensuring that a proper check of the machine is done before use on a patient ensues patient safety
System and machine test

• Interactive self-test
  • attendance requiring
  • complicated self test

• Automatic self-test
  • Intelligent Self Test and automatic calibration of all sensors without interaction
IN AN EMERGENCY, select Start Case.

1. Connect scavenging.
2. Open and close cylinders.
3. Connect a patient circuit.
4. Check the absorber and absorbent.
5. Select a check from the menu.
6. Complete instructions and start check.
7. Automatic check beeps if action is required.

Start Case

<table>
<thead>
<tr>
<th>Machine Check</th>
<th>Instructions</th>
</tr>
</thead>
</table>
1. Set Bag/Vent switch to Vent.
2. Open patient “Y”.
3. Set the ACGO switch to Circle.
4. Calibrate (remove, reinsert, latch) flow sensors.
5. Select Start.
Checks: bellows leaks; gas supply pressures; battery backup; and ventilator and flow control operation.
1. Make sure the bellows are fully collapsed.
2. Occlude the patient “Y”.
3. Select Continue.
Checkout

Machine Check - System

- **Verify Bellows Emptied**: OK
- **Circuit Leak**: OK, < 100 ml/min
- **Mechanical Vent**: 
- **Circuit Compliance**: 
- **O₂ Flow Control**: 
- **Air Flow Control**: 
- **N₂O Flow Control**: 
- **Battery and Electrical Power**: 

**System**
- 
**Circuit**
- 
**Circuit O₂ Cell**
- 
**Check Log**
- 
**Start Case**

**Time Remaining**

1:38
<table>
<thead>
<tr>
<th>Feature</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verify Bellows emptied</td>
<td>OK</td>
</tr>
<tr>
<td>Circuit leak</td>
<td>OK, &lt; 100 ml/min</td>
</tr>
<tr>
<td>Mechanical Vent</td>
<td>OK</td>
</tr>
<tr>
<td>Circuit Compliance</td>
<td>0.87 ml/cmH2O</td>
</tr>
<tr>
<td>O2 Flow Control</td>
<td>OK</td>
</tr>
<tr>
<td>Air Flow Control</td>
<td>No air pressure</td>
</tr>
<tr>
<td>N2O Flow Control</td>
<td>No N2O pressure</td>
</tr>
<tr>
<td>Battery and Electrical Power</td>
<td>OK</td>
</tr>
</tbody>
</table>

Time Remaining: 0:00
an automated system checkout
<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Test</th>
<th>Result</th>
<th>State</th>
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</thead>
<tbody>
<tr>
<td>06-29-2004</td>
<td>09:56AM</td>
<td>Self test</td>
<td>partly operable</td>
<td>cancelled</td>
</tr>
<tr>
<td>06-29-2004</td>
<td>09:28AM</td>
<td>Self test</td>
<td>partly operable</td>
<td>cancelled</td>
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<tr>
<td>06-29-2004</td>
<td>08:57AM</td>
<td>Self test</td>
<td>partly operable</td>
<td>cancelled</td>
</tr>
<tr>
<td>06-28-2004</td>
<td>01:55PM</td>
<td>Self test</td>
<td>partly operable</td>
<td>cancelled</td>
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<td>06-28-2004</td>
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<td>06-28-2004</td>
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<tr>
<td>06-28-2004</td>
<td>11:49AM</td>
<td>Self test</td>
<td>partly operable</td>
<td>cancelled</td>
</tr>
</tbody>
</table>
1. Verify auxiliary oxygen cylinder and self-inflating manual ventilation device are available and functioning.
2. Verify patient suction is adequate to clear the airway.
3. Turn on anesthesia delivery system and confirm that AC power is available.
4. Verify availability of required monitors and check alarms.
5. Verify that pressure is adequate on the spare oxygen cylinder mounted on the anesthesia machine.
6. Verify that piped gas pressures are ≥ 50 psig.
7. Verify that vaporizers are adequately filled and, if applicable, that the filler ports are tightly closed.
8. Verify that there are no leaks in the gas supply lines between the flowmeters and the common gas outlet.
9. Test scavenging system function.
10. Calibrate, or verify calibration of, the oxygen monitor and check the low oxygen alarm.
11. Verify carbon dioxide absorbent is not exhausted.
12. Breathing system pressure and leak testing.
13. Verify that gas flows properly through the breathing circuit during both inspiration and exhalation.
15. Confirm ventilator settings and evaluate readiness to deliver anesthesia care. (ANESTHESIA TIME OUT)
• Test scavenging system function
• Verify carbon dioxide absorbent is not exhausted.
Tidal volume (conventional anesthetic ventilator)
conventional anesthetic machines

- each ventilation stroke is made up of the gas volume delivered by the ventilator plus the additional fresh gas volume delivered into the breathing system during the inspiratory phase.

Fig. 21.1 Alteration of minute volume (MV) whilst flow is reduced from 4.4 to 0.5 L/min.
Circuit compliance uncompensated ventilator

Set TV 750
Actual 550

Volume loss 200

Fig. 3: Effect of compliance on delivered tidal volume without compliance compensation. Ventilator set to deliver 750 mls but only 550 mls reaches the patient due to a compliance factor of 5 mls/cmH₂O and peak pressure of 40 cmH₂O. (Schematic of Ohmeda Excel)
Methods for accurate delivery of set Tidal Volume (VT)

- Electronic settings of the new ventilators
-Leaks and system compliance are measured and reported
- Closed loop feedback control of the ventilator performance
- Fresh gas decoupling (FGD)
- Circuit compliance compensation
Servo-controlled volume ventilation, electronic PEEP. (Representing Datex-Ohmeda 7900)
Innovation represented in the Dräger Fabius GS in mechanical ventilation mode.
1. Filling stroke:
   - Fresh gas is directed to the absorber.
   - Gas outlet.

2. Inspiration stroke:
   - Inspiration occurs through the reverse flow.
   - Ventilator.
   - Direction of gas flow indicated.

3. Expiration stroke:
   - Expiration flow directed through the absorber.
   - Gas outlet.
Circuit compliance compensated ventilator

Set TV 750 ml
Compensated 250 ml

Driven volume 1000 ml

Fig. 4: Effect of compliance compensation on delivered tidal volume. Ventilator delivers 1000 mls to insure that 750 mls reaches the patient due to a compliance factor of 5 mls/cmH2O. Note that peak pressure has increased to 50 cmH2O due to the additional delivered volume. (Schematic of Fabius GS)
ADVANCED ANESTHETIC MACHINE

• Digital precision setting and display

• Multiple modes of ventilation
  • Pressure Mode (PCV)
  • AutoFlow
  • Synchronized Volume Mode (SIMV) and Pressure Support
  • Airway pressure released ventilation (APRV)
Conventional flow meter
Conventional flow meter

Total fresh gas flow?
concentration of oxygen?
Electronic flow meter
Electronic fresh gas delivery
Principle of fresh gas mixer

Increased safety fresh gas mixer Principle:

- Supplementary pressure reducers guarantee precise delivery, regardless of fluctuations in the central gas supply system
- The gases AIR and O₂ or N₂O are piped to the mix gas tank through gas inlet valves in the proportions corresponding to the set mixing ratio
- Valves are opened and closed one after another
- Flow and pressure of inflowing gases are monitored to ensure that the mixer is not affected by supply pressures
- The total fresh gas flow is controlled with the aid of a proportional valve (flow control valve)
- Gas mixing takes place regardless of ambient conditions
Electronic gas flow prevents a hypoxic gas mixture (dynamic anti-hypoxic mixture)

- New S-ORC function in conjunction with N₂O, based on typical user behavior
- Easy setting of fresh gas flow, retaining the preset O₂ concentration of 25% up to a fresh gas flow of 800 mL/min.
- If the fresh gas flow is further reduced, a minimum oxygen delivery of 200 ml/min is guaranteed
- With 200 ml/min O₂ concentration is 100%
- The minimum fresh gas flow is 200 ml/min

Fresh gas flow > 0.8 L/min  O₂ content at least 25%
Fresh gas flow 0.2 to 0.8 L/min  O₂ content at least 200 mL/min
Anesthetic machine may also be equipped with monitoring and alarm systems for

- Agent and oxygen concentration
- Inp. & Exp
- Patient-related parameters (e.g. pressure, volume, and flow)
- Batteries status
- Gas cylinder status
Multiple modes of ventilation
Pressure Mode (PCV),
AutoFlow,
Synchronized Volume Mode (SIMV)
Pressure Support

Pressure Support - the core feature of this new upgrade option
Pressure Support can be used in two ways. As stand alone mode and added pressure support in all synchronized volume- and pressure controlled ventilation modes

All PS-ventilation settings (ΔP<sub>PS</sub>, PEEP, T<sub>slope</sub>, Freq<sub>MIN</sub>, Trigger) can be chosen and set directly
• Basic ventilators - 20 years behind ICU

• Most of our patients are healthy
  ↓ SpO2 easily fixed with ↑ FIO2
  CO2, Paw rarely a problem
  Can usually ‘bag’ our way out of trouble
The main problem is lung collapse

Starts at premedication, induction

Contributing factors:
  - relaxations
  - surgical site
  - obesity, advance age, supine, trendelenburg etc.
  - inadequate PEEP / CPAP

Worsens lung compliance by 30 – 60%

• higher airway pressures
• hypoxemia
• increased work of breathing, etc.

leads to post-operative lung dysfunction
Preventing lung collapse

• Avoid apneic episodes in 100% O₂
• Consider PS + CPAP
• Perform recruitment maneuver
  30-40 cm H₂O over 15-20 cm H₂O of PEEP
  hold for 10 breaths or 30s
• Monitor compliance & re-recruit if needed
• Optimize PEEP / CPAP
  to best lung compliance or best PaO₂ or both
• Use pressure-based vent modes
FACILITATE ADVANCED VENTILATION MODES.

The trend in anesthesia ventilator technology is to eliminate the disadvantages of traditional anesthesia ventilator technology:

- Inconsistent Tidal volume

- to increase the availability of intensive care modes of ventilation in the operating room:
  - CPAP/PEEP
  - Assisted spontaneous ventilation
  - Pressure control ventilation
  - Lung recruitment
• Does a multi-modal approach to ventilation improve peri-operative lung function and outcome?

• YES, definitely, in ICU...
  
  but what about Anesthesia?
  with sicker, more obese, older patients
24 children, 6 months - 6 years having MRI, intubated deep without relaxant then spontaneous respiration on ETT.

3 groups: no PEEP, 5 of PEEP and Recruitment + PEEP.

RESPIRATION AND THE AIRWAY

Pressure-controlled ventilation improves oxygenation during laparoscopic obesity surgery compared with volume-controlled ventilation

P. Cadi1, T. Guenoun1, D. Journois1, J.-M. Chevallier2, J.-L. Diehl3 and D. Safran1

1Department of Anaesthesia and Intensive Care Unit, 2Department of Digestive surgery and 3Medical Intensive Care Unit, Assistance Publique–Hôpitaux de Paris (AP–HP), Hôpital Européen Georges Pompidou, 20-40, rue Leblanc, 75908 Paris Cedex 15, France

*Corresponding author. E-mail: pcdi@invivo.edu

Background. We compared pressure and volume-controlled ventilation (PCV and VCV) in morbidly obese patients undergoing laparoscopic gastric banding surgery.

Methods. Thirty-six patients, BMI >35 kg m⁻², no major obstructive or restrictive respiratory disorder, and $P_{a,CO_2}$ < 6.0 kPa, were randomized to receive either VCV or PCV during the surgery. Ventilation settings followed two distinct algorithms aiming to maintain end-tidal $CO_2$ ($E_{CO_2}$) between 4.40 and 4.66 kPa and plateau pressure ($P_{plateau}$) as low as possible. Primary outcome variable was peroperative $P_{plateau}$. Secondary outcomes were $PaCO_2$ ($E_{CO_2}$ at 0.6 in each group) and $P_{a,CO_2}$ during surgery and 2 h after extubation. Pressure, flow, and volume time curves were recorded.

Results. There were no significant differences in patient characteristics and co-morbidity in the two groups. Mean pH, $PaO_2$, $SaO_2$, and the $PaCO_2$/$FiO_2$ ratio were higher in the PCV group, whereas $PaCO_2$ and the $E_{CO_2}$–$PaCO_2$ gradient were lower (all $P<0.05$). Ventilation variables, including plateau and mean airway pressures, anesthesia-related variables, and postoperative cardiovascular variables, blood gases, and morphine requirements after the operation were similar.

Conclusions. The changes in oxygenation can only be explained by an improvement in the lungs ventilation/perfusion ratio. The decelerating inspiratory flow used in PCV generates higher instantaneous flow peaks and may allow a better aëroal recruitment. PCV improves oxygenation without any side-effects.
Emmanuel Futier, NEJM, August 2013

200 patients each group, ≈5 hour major / upper abdominal surgery

Compared 2 Ventilation modes and outcome

pneumonia, ventilation, sepsis, wound infection, LOS etc.

<table>
<thead>
<tr>
<th></th>
<th>Normal</th>
<th>Protective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tidal Volume ml/kg</td>
<td>10 - 12</td>
<td>6 - 8</td>
</tr>
<tr>
<td>PEEP cm H2O</td>
<td>none</td>
<td>6 - 8</td>
</tr>
<tr>
<td>Recruitment</td>
<td>none</td>
<td>30 q 30min</td>
</tr>
</tbody>
</table>
Lung Recruitment Maneuvers

- Recruitment should be performed soon after intubation, periodic during maintenance and prior to intubation.
  
  - Vital Capacity: manual bag “squeeze” and “hold”
  - Cycling: Programmable stepwise increasing and decreasing PEEP levels
Pressure control mode

• Is ideal for both measurement of compliance and performing recruitment maneuvers.
Recruitment / PEEP optimisation

- Pressure Control mode, slow rate, I:E 1:1
- Step PEEP up to say 20, up to 30 if obese
- Hold for say 30s
- Maintain ventilation

Treat hypotension !!

<table>
<thead>
<tr>
<th>PEEP</th>
<th>Vt up</th>
<th>Vt down</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>470</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>550</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>510</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>350</td>
<td>400</td>
</tr>
</tbody>
</table>
Step PEEP up and back gradually; optimal PEEP is at max tidal volume.

Tidal volume increase relates to the extent of lung collapse.

Chest wall compliance remains fixed. A 1.5x increase in Vt at the same pressure means 50% of the lung was collapsed; a twofold increase in Vt means 66% was collapsed.
The use of laryngeal mask or other supraglottic airway is not uncommon in general anesthesia.
The principle of supraglottic ventilation is "acceptable gas exchange without gastric inflation" by

• Limit inflation pressure less than the esophageal opening pressure (\(<\ 20\ \text{cmH}_2\text{O})

Use pressure-based vent modes
PS, PCV
Pressure Support Ventilation versus Continuous Positive Airway Pressure with the Laryngeal Mask Airway

A Randomized Crossover Study of Anesthetized Adult Patients

Joseph Brimacombe, M.B., Ch.B., F.R.C.A., M.D.,* Christian Keller, M.D.,† Christoph Hörmann, M.D.†

<table>
<thead>
<tr>
<th>Table 1. End-tidal CO₂, Oxygen Saturation, Expired Tidal Volume, Leak Fraction, Respiratory Rate, Mean Arterial Pressure, and Heart Rate during Continuous Positive Airway Pressure and Pressure Support Ventilation for the Two Crossover Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group 1</strong></td>
</tr>
<tr>
<td>n</td>
</tr>
<tr>
<td>PETCO₂ (mmHg)</td>
</tr>
<tr>
<td>Spo₂ (%)</td>
</tr>
<tr>
<td>LF (%)</td>
</tr>
<tr>
<td>MAP (mmHg)</td>
</tr>
<tr>
<td>HR (beats/min)</td>
</tr>
</tbody>
</table>
Advanced ventilation capabilities

Does not just mean “having the mode”
Effective innovations
User interface easy
electronic PEEP
(Representing Datex-Ohmeda 7900)
Conventional mechanical ventilation.
(Representing Dräger Narkomed AV2+)
Representation of the Dräger Narkomed 6400 with Divan ventilator.
Representing the Dräger Fabius GS in mechanical ventilation mode.
ZUS® - TurboVent
Spontaneous Ventilation

- Fresh gas
- Absorber
- Blower
- Bag
- Lung
- APL valve
- Pinsp-PEEP Valve
- Exp. valve
- Circuit Flow
- ZUS®-TurboVent
- Spontaneous Ventilation
An ICU type PEEP/CPAP valve is located just after the expiratory valve. (Real PEEP/CPAP)

During Exhalation the low pressure (PEEP/CPAP) level is maintained and will not break down (PEEP loss) if the patient inhale effort
Anesthetic ventilator (drive gas)

- External pressure drive
  - Pneumatic drive (bellow in bottle)
Anesthetic ventilator (drive gas)

- External pressure drive
  - Pneumatic drive (bellow in bottle)
Anesthetic ventilator (drive gas)

- External pressure drive
  - Pneumatic drive (bellow in bottle)
  - Electronic motor drive (piston)
Anesthetic ventilator (drive gas)

• External pressure drive
  • Pneumatic drive (bellow in bottle)
  • Electronic motor drive (piston)
• Internal pressure drive (ICU type)
  • Blower turbine
ZEUS® - TurboVent
Circuit flow / Blower
Cost saving

- **E-Vent™ plus** require “0” = zero (!) driving gas.
  Just driven by cheap electrical power
- Conventional ventilators require medical air
  (serious cost issue as its price is increasing worldwide)

Example, operation 5 h/day, 250 days/year:

**Conventional ventilator:**
- Driving gas approx. 10 L/min
- Driving gas 750,000 L/year
- 375 cylinders/year (10 L at 200 bar)

**E-Vent™ plus:**
- Power input 2 W
- Power consumption 2.5 kWh/year
- 50 cent/year (€)

Just for driving the ventilator!!!

Piston vents reduce significantly the costs of ownership
During the mask or ET tube is taken disconnection, the bellow dump anesthetic gas into the room until it empties the bag.

• When reconnection, it takes time to refill the bellow
• If bellows empty when switching and low gas flows, then no ventilation until circuit full

• This will not happen with the piston and blower type anesthesia ventilator.
FACILITATE ADVANCED VENTILATION MODES.
The trend in anesthesia ventilator technology is to eliminate the disadvantages of traditional anesthesia ventilator technology:

- Inconsistant Tidal volume
- Age specific (neonate, child, adult)

- to increase the availability of intensive care modes of ventilation in the operating room.
  - CPAP/PEEP
  - Assisted spontaneous ventilation (pressure support)
  - Pressure control ventilation
  - Airway pressure relieved ventilation (APRV)
  - Lung recruitment
Advanced anesthesia machine features

- Ergonomic design
- Completely automatic self-checking and calibration
- Integrated flow sensors for tidal volume
- High-fidelity, clinically useful displays
- Circuit compliance compensation
- Fresh gas flow compensation or fresh gas decoupling
- An effective Pressure Support/CPAP mode
- Support for spontaneous efforts
- Volume-preset pressure control mode
- Lung recruitment tools
- FiO2 prediction and Vapor Prediction
- ecoFLOW, econometer
A feature that works really well on one machine can be almost useless on another

• It can do something doesn't mean it can do it well
• It depends on how well they implement the feature
Thank you for your attention.