What our equipment teaches us

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My story

I began my education as an Engineer (Cornell U)
I learned it well
I entered a field of medicine
I chose Anesthesiology because it needed the most engineering
Each problem I encountered led me to an Engineering Solution
I have had the opportunity to Engineer for Life
I have had the opportunity to observe and encourage others to innovate
Practice-Based Learning

PBL is a key element of continuing graduate medical education.

In anesthesia, we can learn from everything we do.

We give medicines and techniques that move in seconds and act in minutes.

Each drug or technique acts on each patient in a variable way.

We are there to act and watch.

If we have the right tools and insights,

We can observe, analyze, synthesize, generalize, and have a model.

We can use what we learn from one patient on the next patient.

We can learn what to look for in each new patient to refine our model.

Eventually we do an IRB-approved study to prove to ourselves and others that what we learned is right, valuable, and should be done and taught by others.

Or to learn to stop doing what we thought was so good.
We have a myriad of tools around us
2017 state-of-the-art USA
Mindray A7

Draeger Perseus

2017 new to the USA
Products to hold ET constant exist in most countries but not yet in USA

Draeger Zeus

GE Aisys ETC

Maquet Flow-i
Innovative companies need to

Meet the Standards
Meet the desires of the market
Meet the needs of the market
Meet the constraints of the payers

Provide the tools for innovative physicians to explore and expand the limits of patient care

If Standards block our path, we must revise them after due consideration of safety
Clinical Situation

Obese female for robot-assisted hysterectomy
General Anesthesia, Steep Trendelenburg position
Peritoneal insufflation 30 mmHg
High CO2 absorption -> Need higher MV (minute ventilation)
VCV with $P_{\text{max}} > 40 \text{ cmH2O}$ sounds $P_{\text{max}}$ alarms and quits breath
How can we ventilate?
Is patient being harmed by the high pressure?
Need to test
Want to know pressure the lung feels and make sure it is safe
Conservative estimate will be Tube Tip Pressure (TTP)
Case is underway and everyone is worried
Pressure connections made for this patient during this case
Volume Controlled Ventilation
VCV

Peak Pressure is maximum pressure reached
Inspiratory pause (% of inspiratory time) is set
Here, Inspiratory Pause is set to 20%

TIP:TI (Time of Inspiratory Pause/Time of Inspiration)
Draeger acronym for pause

Pressure during pause is called
Plateau Pressure (Draeger)
Pause Pressure (GE)
TT and Y Pressure Monitoring

TT Transducer switched on to show TT Pressure

Focus on this

Y Pressure
Note TT pressure reaches Inspiratory Pause pressure and no more.

Also, these pressures are mmHg for vascular monitoring. We are using mmHg for airway pressure. Not the usual cmH2O.
Where is the pressure drop?

Where is the pressure drop between Y and TT?
Pull back the Tube Pressure monitoring tube
Measure pressure at several locations
Most of the pressure drop is at tube connector
Actually known for 40 years, but long forgotten
Resistance should be computed and monitored

Only the machine knows the inspiratory flow rate
Only the machine can compute inspiratory resistance
\[ R = \frac{\Delta P}{\Delta F} \]
Anesthesiologist will be confused each time any of these are changed
  RR, I/E time ratio, Set TV
They all will affect \( PP - TTP \)
None will affect Resistance measured during inspiratory flow, \( R_i \)
If \( R_{\text{insp}} \) does go up, ET Tube is probably kinked and should be adjusted

Note that $P_{TT}$ never reaches $P_Y$. 

PCV Pressure
Plot graph of Cost and determinants
Philip JH. Gas Man® - An example of goal oriented computer-assisted teaching which results in learning. In: J Clin Monit & Comp. 1986;3:165-173. PMID: 3540162

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Show us breath-by-breath when we need it.

High FGF and vaporizer setting.
Second Breath, Inspired = Vaporizer setting
Give us great time-aligned graphic trends to tell most of the story.
A better data set and temporal graphic display might look like this, or might look however the clinician or data analyst wanted to view it on the way to computer analysis.

Careful temporal alignment of graphic trends will uncover causal relationships that the human mind might overlook.
Request of Standards writers

Please keep creating Standards that assure product safety and efficacy

Whenever possible, add additional measures and temporally aligned graphic trend displays that will allow patient care providers the provide the safest, best, and most educational care

Require that machine error logs be readable by Qualified Service Personnel (like Hospital CEs and BMETs)
Thank you

For more information and posted lectures, look here
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