Big Data in Postoperative Monitoring – What's Changing?

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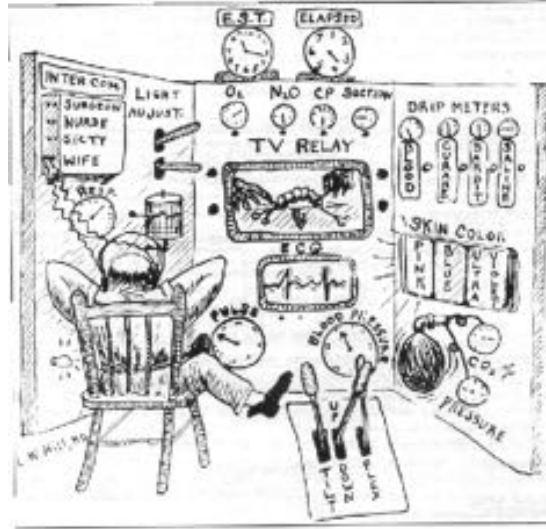
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Disclosures

- Medtronic
- Edwards Lifesciences
- FAER "A randomized pilot trial of continuous postoperative hemodynamic and saturation monitoring"

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The intraoperative period has become safer…

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The postoperative period …(not yet)?

- Death due to diseases of the heart (CDC)
- Death due to malignant neoplasms (CDC)
- Death within 30 days of admission for surgery (NIS)
- Death due to cerebrovascular diseases (CDC)

Bartels, et al. Anesthesiology 2013

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Postoperative complications occur on the general care floor

- Ward hypotension and hypoxemia
  - Common, profound, and prolonged
  - Cannot be reliably predicted
- Acute respiratory events
  - In-hospital mortality of approximately 40%
- Heart attacks occur *postoperatively*
  - 94% within two days
  - 50% of deaths during initial hospitalization
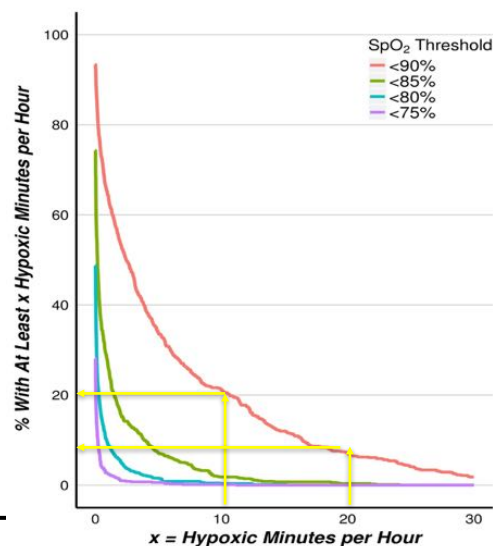
Andersen, et al. Resuscitation 2016

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Postoperative hypoxemia
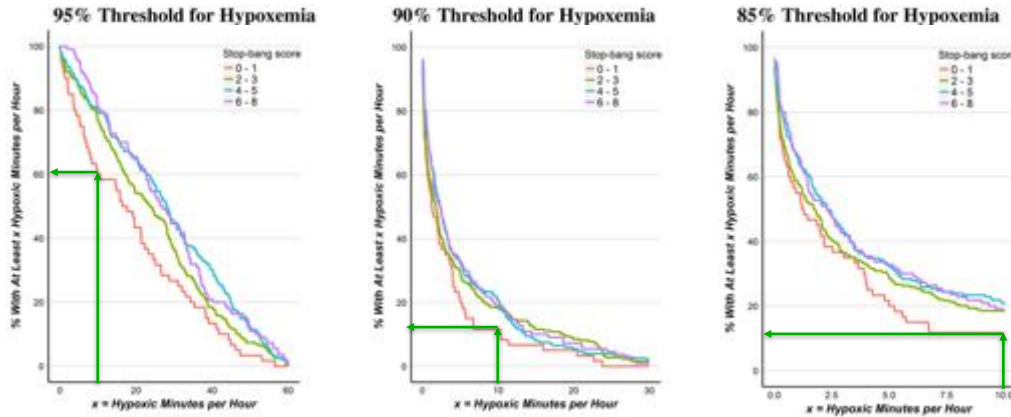
Minutes hypoxemia per hour

Blinded ward monitoring

≈850 non-cardiac surgical patients

Sun, et al. A&A 2015
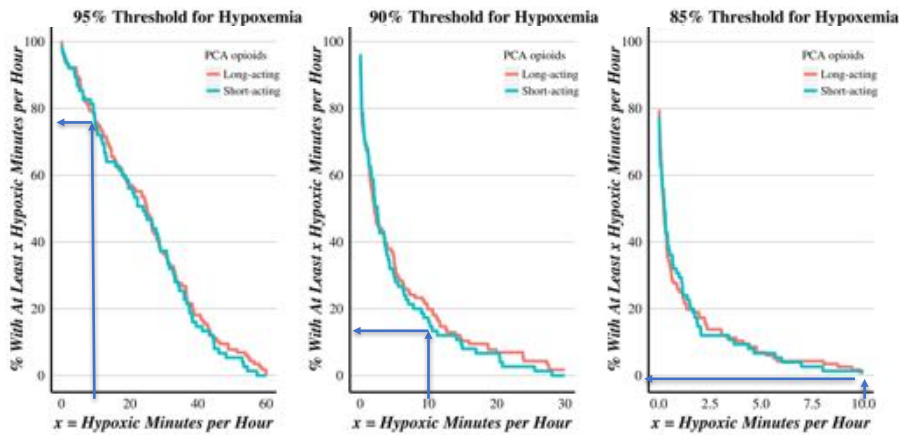
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Postoperative hypoxemia – common, undetected **& difficult to predict (STOP-BANG scores)**
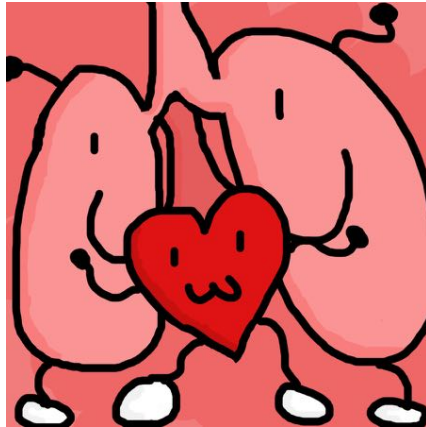

Khanna AK, et al. BJA 2016

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Postoperative hypoxemia – common, undetected **& difficult to predict (long vs short acting opioids)**

Belcher AW, Khanna AK, et al. A&A 2016

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The heart is not too far away from the lungs…

- ✓ **etCO2**
- ✓ **RR**
- ✓ **SpO2**
- ✓ **HR**
- ✓ **? Blood Pressure**
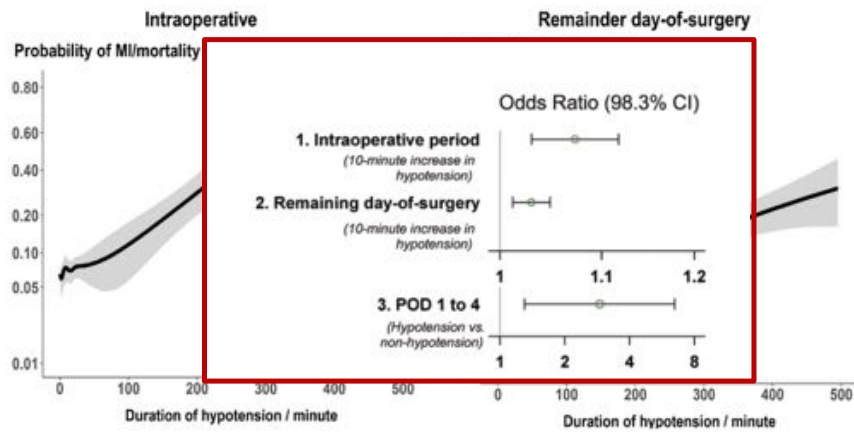
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Postoperative Hypotension Matters!!

Sessler DI, et al. (POISE-2) Anesthesiology

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Postoperative Hypotension Matters!!

Association Between Increase Risk of Harm and Hypotension by Phase of Care

Odds Ratio for MI and Death

~3x the odds of MI/Death compared to patients without postoperative hypotension

Episodes of Hypotension (MAP<65mmHg) by Phase of Care
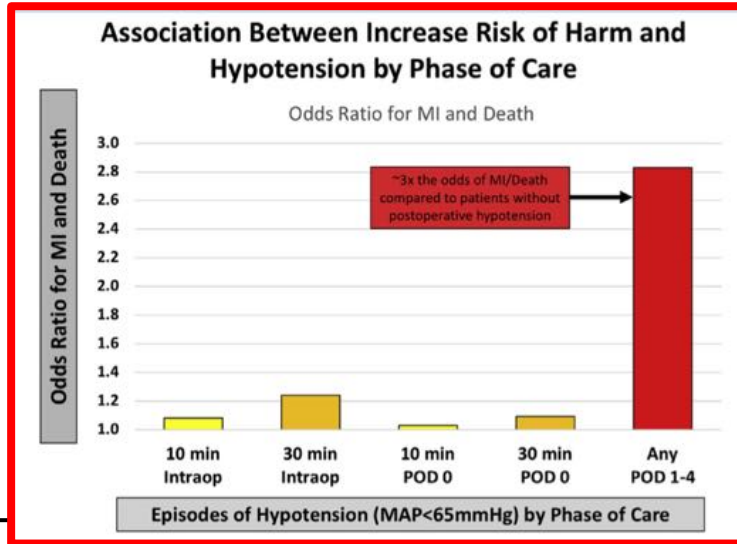
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Postoperative Hypotension & adverse events

Khanna AK et al. (Unpublished data)

Adverse event	Overall		MAP≤55-mmHg		MAP≤65-mmHg		MAP≤75-mmHg		MAP>75-mmHg	
	Number of patients	Number of patients with event (%)	Number of patients	Number of patients with event (%)	Number of patients	Number of patients with event (%)	Number of patients	Number of patients with event (%)	Number of patients	Number of patients with event (%)
30-day MACCE	66,591	1,054 (1.6 %)	2,332	62 (2.7%)	14,976	297 (2.0%)	42,214	702 (1.7%)	24,377	352 (4%)
30-day mortality	67,968	594 (0.9%)	2,411	40 (1.7%)	15,368	193 (1.3%)	43,151	412 (1.0%)	24,817	182 (7%)
90-day mortality	67,968	1,048 (1.5%)	2,411	78 (3.2%)	15,368	338 (2.2%)	43,151	722 (1.7%)	24,817	326 (3%)
30-day AMI	67,317	226 (0.3%)	2,372	16 (0.7%)	15,170	59 (0.4%)	42,692	143 (0.3%)	24,625	83 (3%)
30-day AIS	67,200	362 (0.5%)	2,381	23 (1.0%)	15,178	91 (0.6%)	42,658	232 (0.5%)	24,542	130 (5%)
7-day AKI (II/III)	67,845	986 (1.5%)	2,360	60 (2.5%)	15,214	256 (1.7 %)	42,965	607 (1.4%)	24,880	379 (5%)
30-day readmission	67,580	4,920 (7.3%)	2,387	233 (9.8%)	15,233	1,211 (8.0%)	42,872	3,166 (7.4%)	24,708	754 (1%)

Post-operative hypotension

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The '4am phenomenon'…

What (really) happens prior to a "CODE BLUE"?

Khanna AK et al. Crit Care 2019
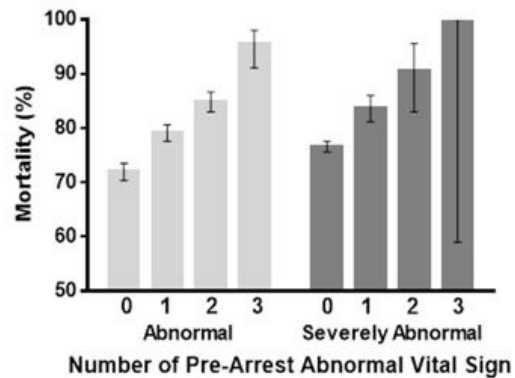
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What's changing?

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How about monitoring?

- 60% patients had at least one abnormal vital sign 1– 4 hours before cardiorespiratory arrest

- Step-wise increase in mortality with increasing number of abnormal vital signs

Andersen, et al. Resuscitation 2016

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Better (smarter) monitoring may be an answer ?

PAIN MEDICINE

Postoperative Opioid-induced Respiratory Depression

A Closed Claims Analysis

Lorri A. Lee, M.D., Robert A. Caplan, M.D., Linda S. Stephens, Ph.D., Karen L. Posner, Ph.D., Gregory W. Terman, M.D., Ph.D., Terri Voepel-Lewis, Ph.D., R.N., Karen B. Domino, M.D., M.P.H.

✓ **97% preventable – better monitoring and response**
✓ **42% - 2hr of last check**
✓ **Multiple prescribers**
✓ **Non-opioid sedatives**

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Monitoring and survival

	Total	ICU	Monitored Ward	Unmonitored Ward	P-Value*
No. of hospitals	445	445	445	445	
Unadjusted event rate, mean (SD)	0.580 (0.325)	0.337 (0.215)	0.109 (0.079)	0.134 (0.098)	<0.0001
Unadjusted survival rate, mean (SD)	0.173 (0.079)	0.162 (0.096)	0.231 (0.171)	0.141 (0.122)	<0.0001
Adjusted survival rate, mean (SD)	0.144 (0.032)	0.140 (0.037)	0.193 (0.074)	0.106 (0.037)	<0.0001

Adjusted survival rate		
ICU	Monitored Ward	Unmonitored Ward
0.140	0.193	0.106

Perman, et al. JAHA 2016

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The '4am' phenomenon

Khanna AK et al. Crit Care 2019

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Continuous (smarter) monitoring for all?

- Better monitoring?
- Who to monitor?
- What to monitor?
- How to monitor?
- Data reliability/validity?
- **Alarm fatigue**
- Convert GCF ->ICU?

- **Terabytes of data**
- **Handling alarms**
- **Prediction of risk**

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Alarm Fatigue – and the case for AI based Optimization

>700k+ hours of patient data

Simulate

Low Threshold

Delay	81	83	85	87
0	0.88	1.60	3.54	8.42
60	0.44	0.87	1.96	4.74
90	0.29	0.56	1.31	3.36
120	0.18	0.41	1.00	2.59

Optimize

Parameter	Alarms/ Patient/ Day
SpO2	1.17
Cardiac Rate	0.31
Resp Rate	0.87
Continuous BP	0.67
TOTAL	**3.04**

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Postoperative Hypotension – common & undetected

Spot checks missed about 50% of episodes of MAP<65mmHg detected by continuous monitoring

Turan A, Khanna AK et al. Anesthesiology 2019

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Postoperative Hypertension – common & undetected

Spot checks missed about 75% of episodes of MAP>110mmHg detected by continuous monitoring

Turan A, Khanna AK et al. Anesthesiology 2019

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Preventing Respiratory Depression

Daniel I. Sessler, M.D.

"It is likely that many catastrophic respiratory events could be prevented by continuous ... monitoring. However, major trials are needed to determine what should be monitored and how."

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Can we predict risk of respiratory depression?

ClinicalTrials.gov
A service of the U.S. National Institutes of Health
Try our beta test site

Find Studies | About Clinical Studies | Submit Studies | Resources | About This Site

Home > Find Studies > Search Results > Study Record Detail

Trial record **1 of 20** for: PRODIGY
Previous Study | Return to List | Next Study »

PRediction of Opioid-induced Respiratory Depression In Patients Monitored by capnoGraphY (PRODIGY)

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PRODIGY Model Derivation – Multivariate Predictors

Clinical Characteristic	Estimate	Standard Error	OR	Pr > |t|	Points if Clinical Characteristic = 'Yes'
AGE (<60)	ref	.	.	.	0
AGE (≥60 - <70)	0.797	0.145	2.218	<.001	8
AGE (≥70 - <80)	1.237	0.180	3.445	<.001	12
AGE (≥80)	1.552	0.363	4.719	<.001	16
Sex (M)	0.772	0.128	2.163	<.001	8
Opioid Naïve	0.290	0.165	1.337	.079	3
Sleep Disorders	0.461	0.199	1.585	.021	5
Heart Failure	0.735	0.401	2.085	.067	7
					Sum = PRODIGY Score

619 patients with at least one RD episode (44.8%)

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PRODIGY Model Derivation – Multivariate Predictors

PRODIGY Score	Low Risk <8 points	Intermediate Risk 8 – 14 points	High Risk ≥15 points	p value
Pts in Risk Category	359	474	471	
Pts with RD in Risk Category	84	195	300	
% Pts with RD in Risk Category	23%	41%	64%	<.001
Sensitivity	---	0.85	0.52	
Specificity	---	0.38	0.76	
OR (95% CI, P value)	OR_{IL} = 2.29 (1.69–3.11, P<.001) OR_{HL} = 5.74 (4.22–7.82, P<.001)	OR_{HI} = 2.5 (1.99–3.26, P<.001)		

619 patients with at least one RD episode (44.8%)
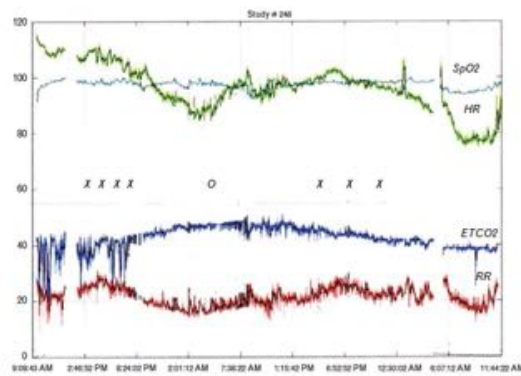
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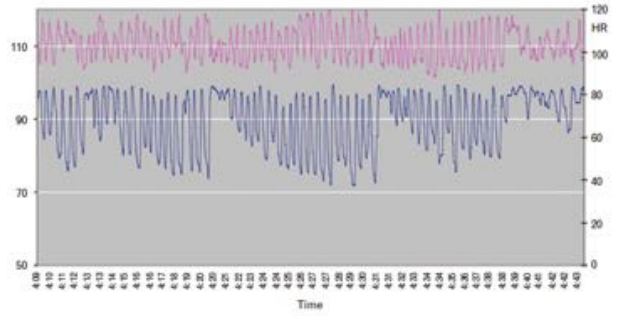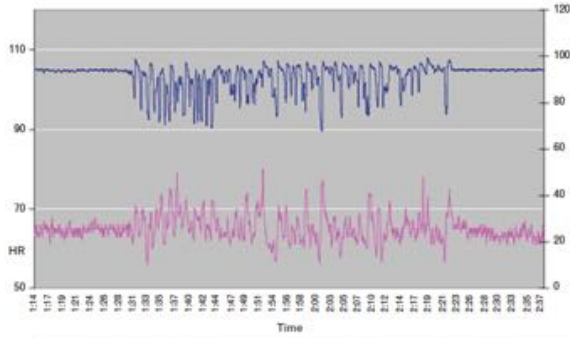School of Medicine

PRODIGY Model Accuracy
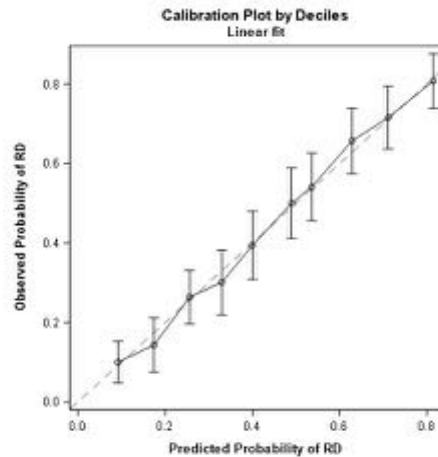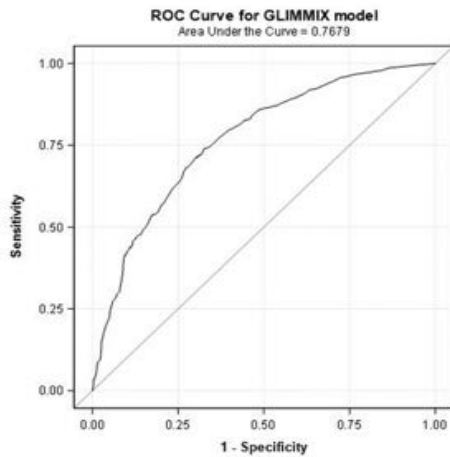
*Statistical significance may be linked to other medical characteristics

All about pattern detection!

J-L Vincent, et al. EJA 2018

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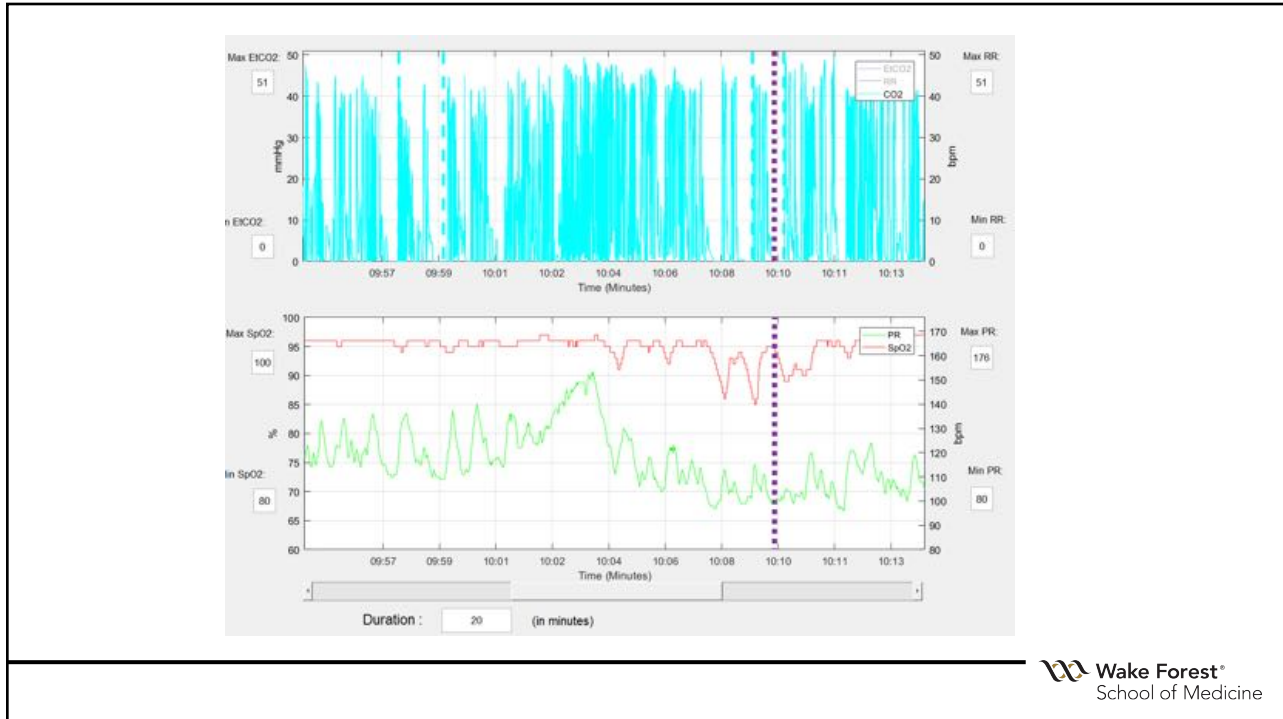
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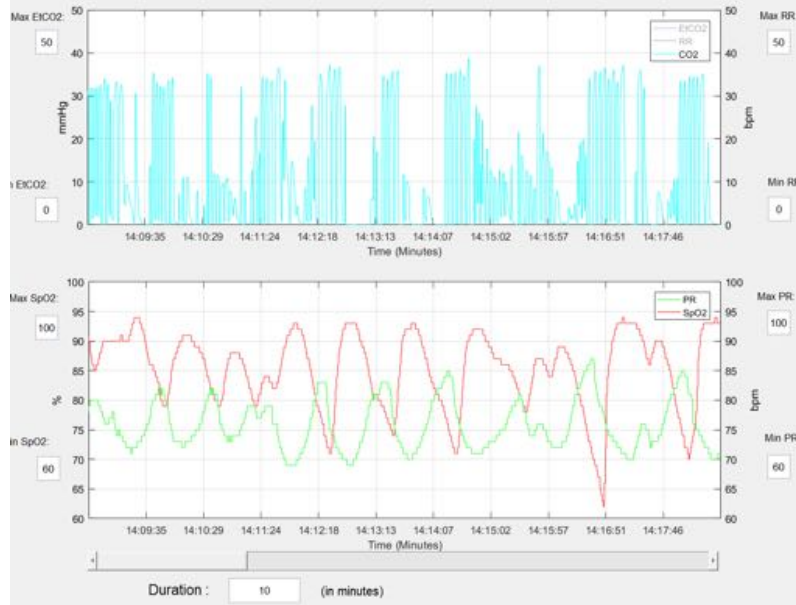
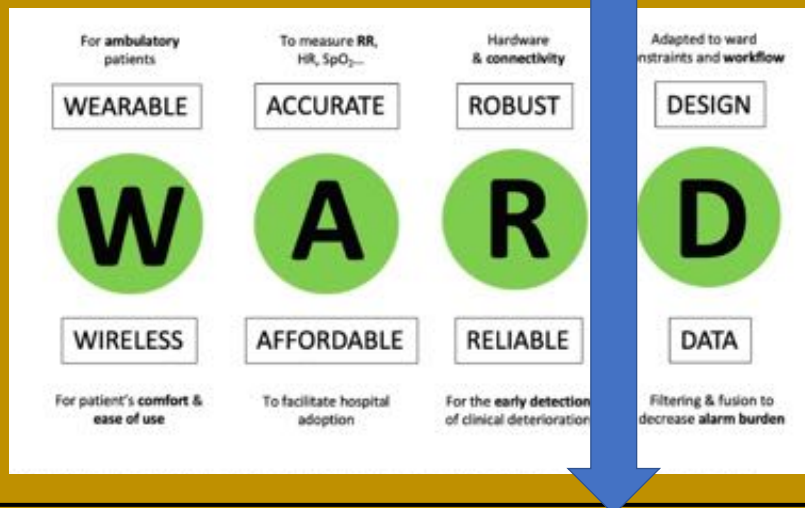## The (big data) challenge... Role for AI

Difficult to predict

Smart monitoring

Continuous monitoring

Big Data in Postoperative Monitoring – What's Changing?

Scoring systems

Proactive RRT

Alarm fatigue & artifact

Central platforms & AI

Culture change

Big Data in Postoperative Monitoring – What's Changing?

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Several 'critical big data points' at home?

Continuous smarter parenting!

Big Data in Postoperative Monitoring – What's Changing?

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