A Vision for Critical Care Monitoring and Ventilation

Dr Cliff Morgan

Consultant in Anaesthesia and Critical Care, Director of Critical Care and Anaesthesia

Royal Brompton & Harefield NHS Foundation Trust

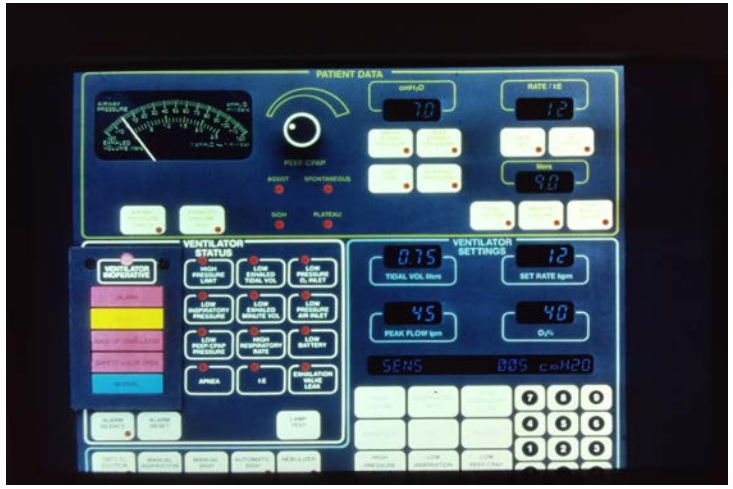
Show the Video

- Never work with
  - Children
  - Animals
  - Or embedded video

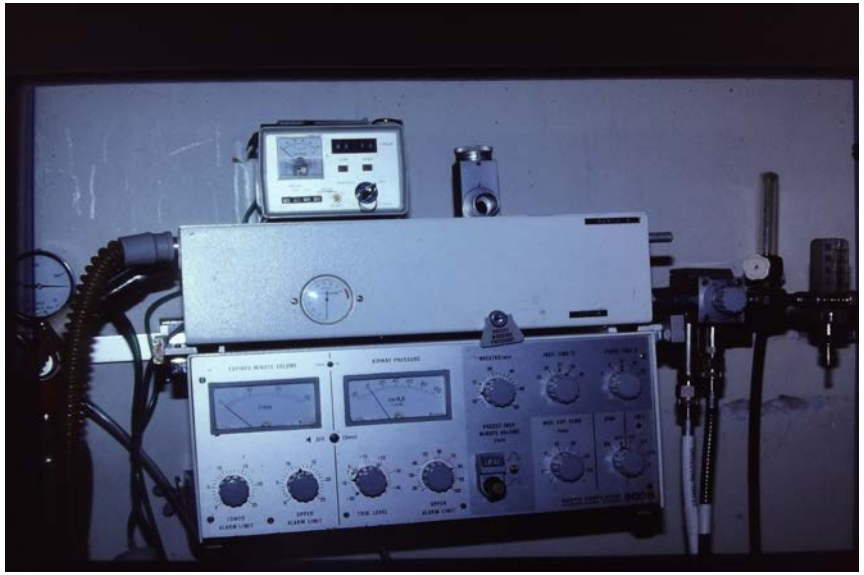
- https://www.youtube.com/watch?v=fUusXpXECsA

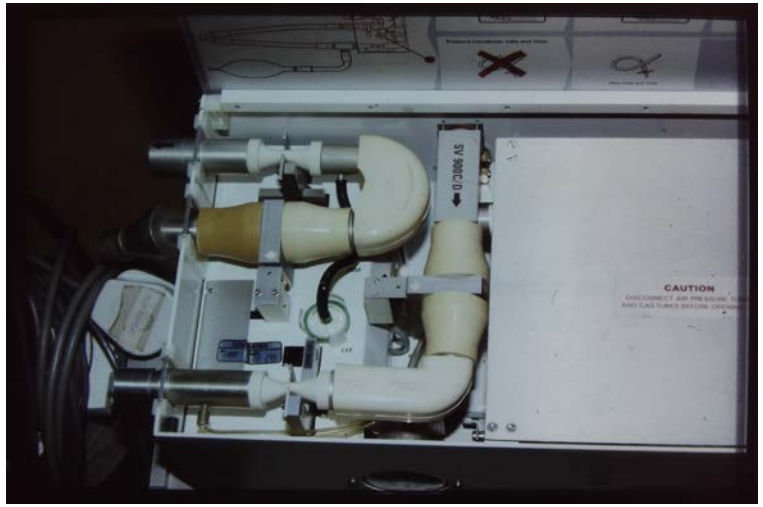
Foreign experience matters – is FORMATIVE

- Three things from Canada
  - Physical restraints for delirious patients better than sedation
  - Specialist pharmacists dedicated to Critical Care
  - 24/7 Ward Clerk for all wards
  - Ice Hockey, Baseball and Grid Iron
  - The importance of technical support for Critical Care
    - Respiratory therapists



What it looked like ----------



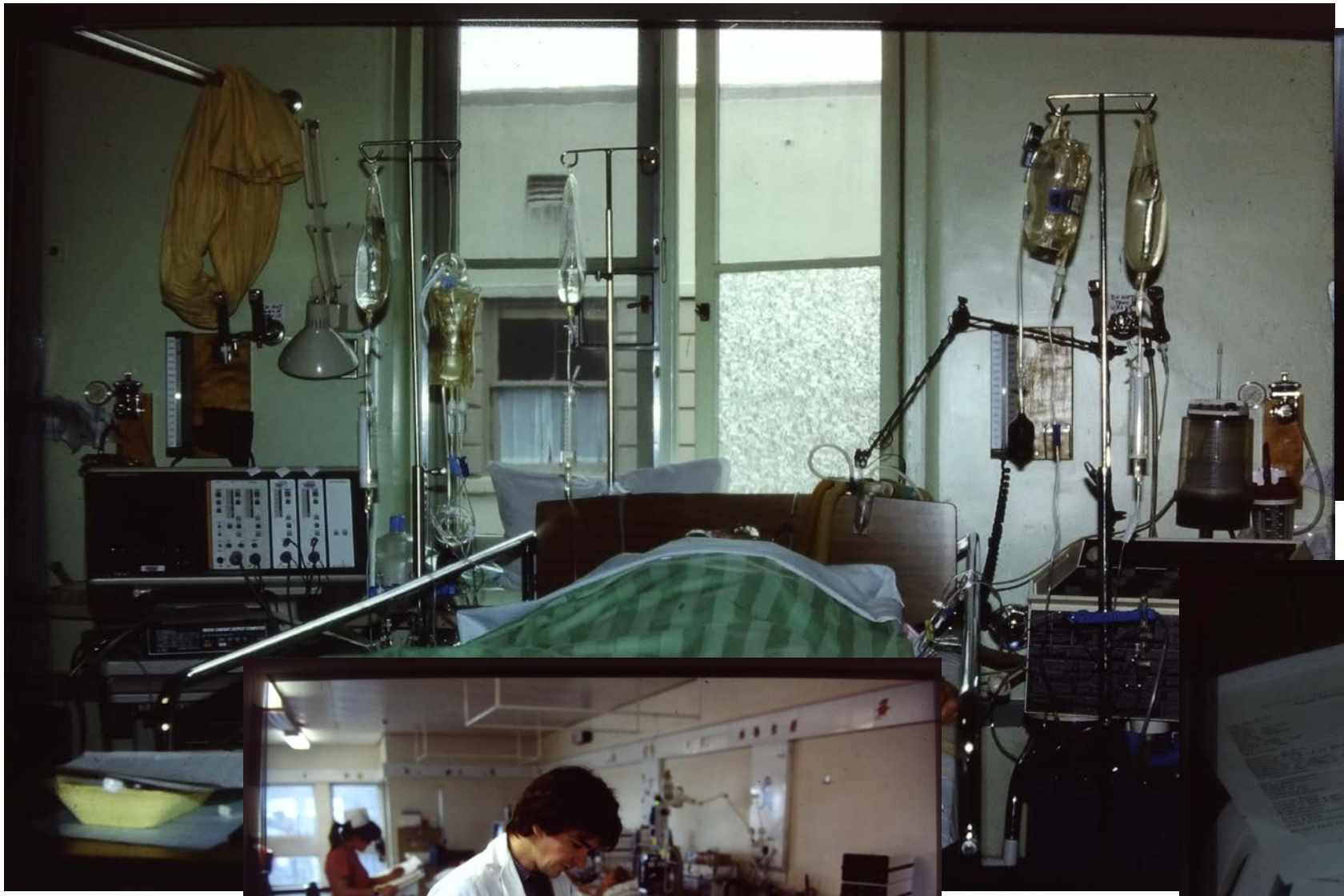


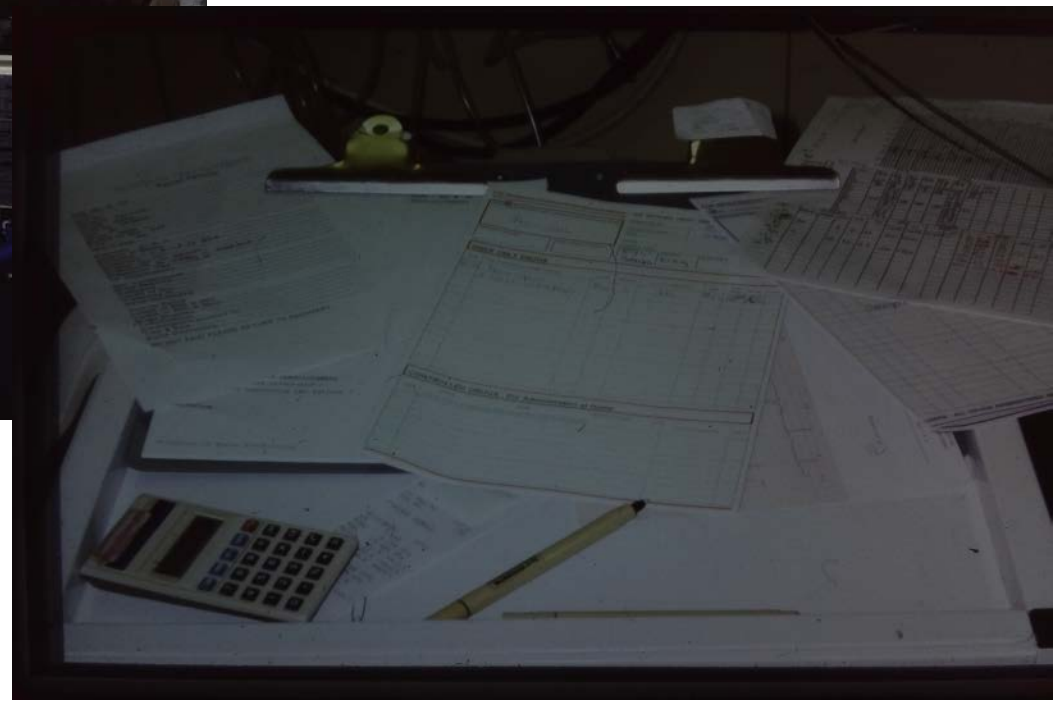
Priorities as new consultant

- Modernise the ICU
- Prepare for major merger
- Refresh all the medical equipment
- Build or procure a Clinical Information System
- Establish renal replacement therapy
- Prepare to move into new build
- Establish Clinical Engineering Service 24/7

Priorities as old consultant

- Modernise the ICU
- Prepare for major merger
- Refresh all the medical equipment
- Build on Clinical Information System and Informatics
- ~~Establish renal replacement therapy~~ – get more machines
- Prepare to move into new build
- ~~Establish~~ Defend Clinical Engineering Service 24/7





The challenge of progress

- Vietnam War – terrible trauma but immediate transfer to hospital on the nearest aircraft carrier
- Unprecedented trauma survival
- But – survivors lived long enough to have complications
  - Ventilator associated complications
  - ARDS
- Similarly – initial survival after complex / complicated cardiac surgery lead to significant increase in acute renal failure
  - We had to become sufficient in renal replacement therapy

St Thomas' ITU Renal Replacement

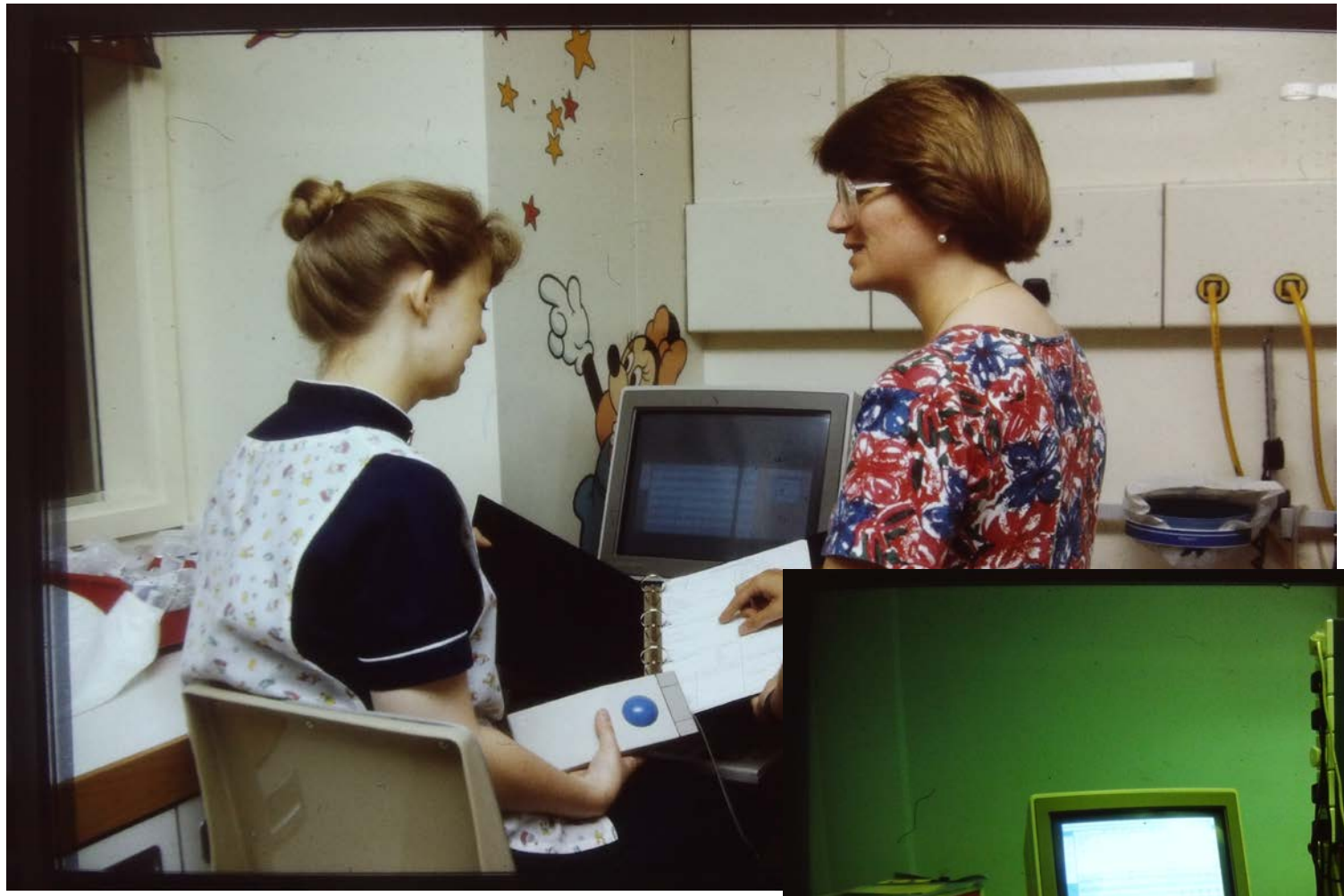
- Way ahead of the rest
- Safe adoption of "pumped" VV filtration / dialysis
- In house system for monitoring the substantial volumes in and out
- And combining other fluid shifts to an automated and continuous fluid balance chart on screen (and printed reports)
- Using a BBC micro, written in BBC Basic and using the on board A-D interface

St Thomas' ITU Renal Replacement 2

- Made renal replacement therapy
  - Safer
  - Easier
  - More potent – we could push for more "aggressive" exchange rates
- Lots of support to the critical care nurses from me and Clinical Engineering
  - Because they were computer naïve
  - Perceived risk of introducing new technology to the ICU bedside
- All the them said "why cant we do this for all the patients?"

The Drive Towards ICU CIS

- Definition of needs and requirements
- Scope – ICU, PICU, Anaesthesia
- Champions
- Support from CEO, staff, CFO
- Market survey
  - HP CareVue 9000
  - Emtec
  - Marquette EPIC
- Selection – HP CareVue and ……. Big bang Go Live

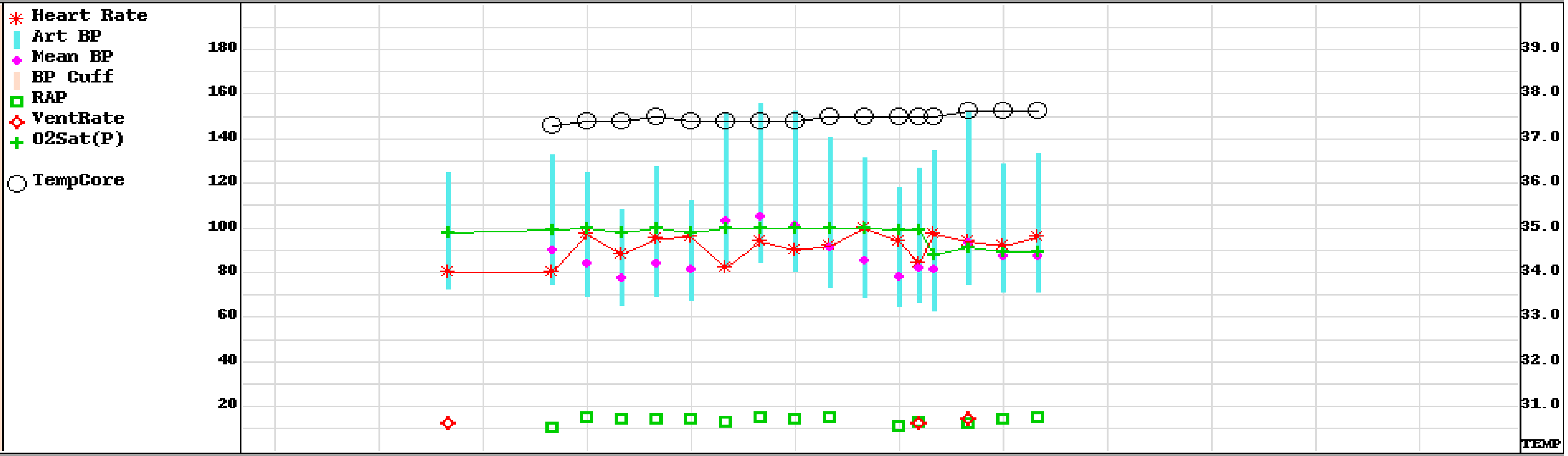



B2WS10

Main Menu | Actions | View | Print | Add Rows... | Store(Morgan | Archive | View Archive | Patient Search | ?

GRAPH VITALS
VITAL SIGNS
INPUT OUTPUT
MEDS
BIOCHM HAEM
ANAES INDUCT
ANAES COND

q15min Time — 12Nov97



StatD	1115	1130	1145	1200	1215	1230	1245	1300	1315	1330	1345	1400
Propof mg IV		200mg										
Fent mcg IV		250mcg										
Vec mg IV		10mg						4mg				
Papaver mg IM												
Morph mg IV			10mg									
Cepha gm IV		1gm										

ent	1115	1130	1145	1200	1215	1230	1245	1300	1315	1330	1345	1400
Ventilator Type		Narkomd					Narkomd					
Ventilator Set Rate		12					12					
FiO2		0.50					0.50					
Tidal Volume (Vent)												
Circuit		0					0					
Comp/Fresh Gas Flow		OA 4.0										
Maint Agent Inhal		Iso					Iso					
O2 Saturation (P)		98	99	100	98	100	99	89				
End Tidal CO2			4.7				4.9	5.9				
H+			37.3				42.9					
pH (from H+)			7.43				7.37					
pCO2			5.8				6.1					
pO2			22.9				6.9					
HCO3			29				26					
Events – Thoracic							OLV					
Events – General		IND	TTH									


GET WELL SOON
DISPOSABLE GLOVES


GET WELL SOON
N. H.
PROPERTY
CLINICA
WASTE
DISPOSABLE GLOVES

Hewlett Packard CareVue 9000 at RBH

- Unix – Servers and clients
- Dedicated network for computers
- Dedicated and separate network for the monitors
  - To collect all monitored data for ingestion into CIS
  - And – connected other devices
- Fantastic system performance and stability

THE IMPACT OF INFORMATION SYSTEMS IN CRITICAL CARE A VEHICLE FOR DOING MORE WITH LESS RESOURCES

Nancy J. Gantz
Good Samaritan Hospital and Medical Center
1015 N.W. 22nd Avenue, T230
Portland, Oregon 97210 U.S.A.

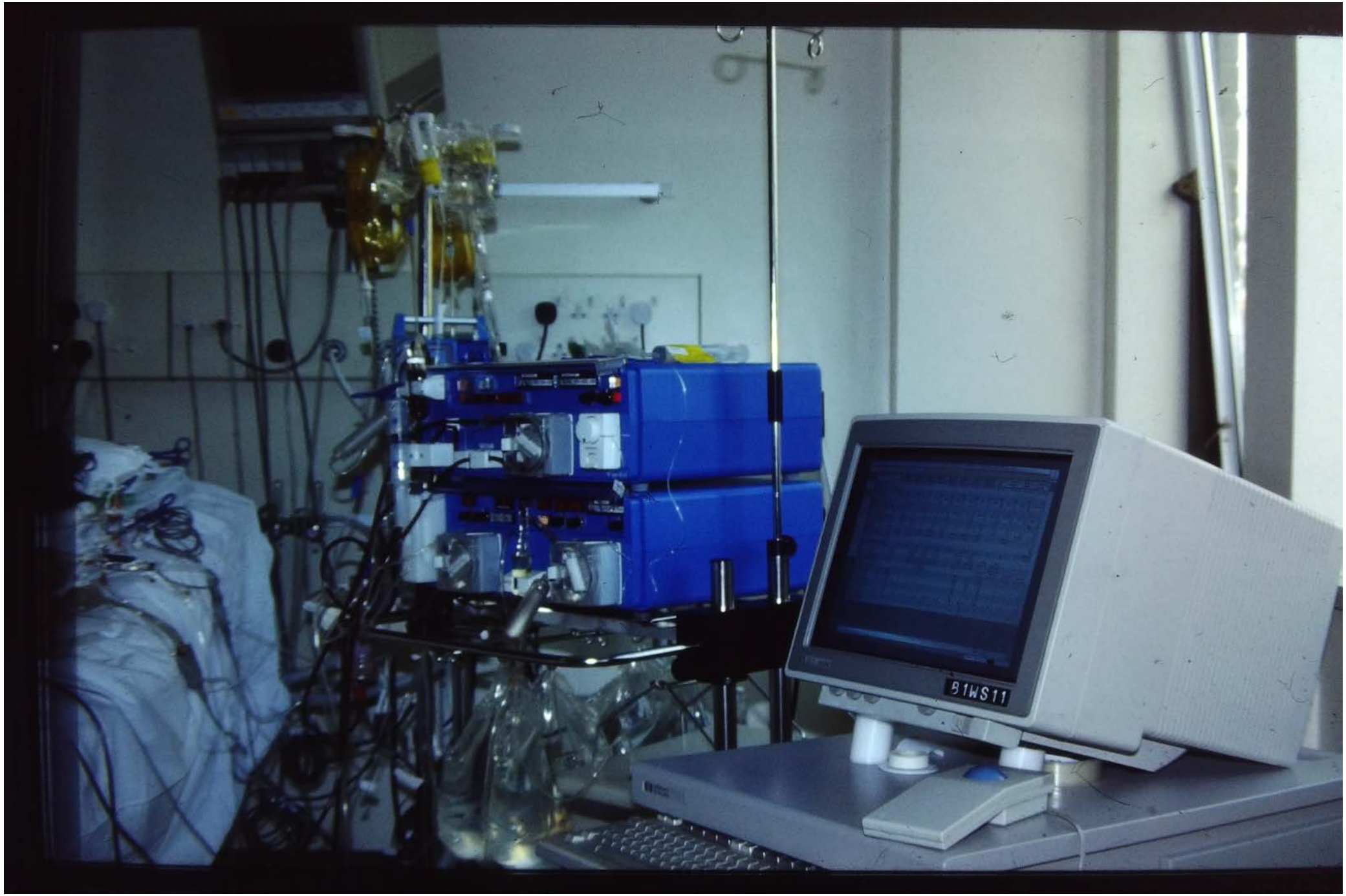
Historically, very little has been done to eliminate the paper that is generated from critical care units by nurses on their hour-to-hour, minute-to-minute care of the critically ill patient. There have been order entry computers in the medical/surgical areas; however, in critical care, there have only been the physiological monitoring computers that document

time spent with paperwork and putting the nurse at the bedside with the patient.

Approximately four years ago the hospital that I am employed at became involved with Marquette Electronics in providing input into the software development for the electronic patient information chart, or otherwise called the EPIC. One of the initial focuses was on nursing practice in critical care units, and that being based on assessment - a very thorough, detailed assessment. Some of the critical components are vital signs,

innovations in critical care productivity and
ization. The goal of the EPIC system is computer
unication into other areas of the hospital such as admitting,
ogy, laboratory, dietary, pharmacy, and other ancillary
that are computerized.
s clearly being shown at Good Samaritan how a system
as the EPIC with its speed, accuracy and efficiency is
ling more hands-on patient care for the critically ill, and
lecreasing the length of stay in the critical care unit and
erring patients to the less acute areas of the hospital and

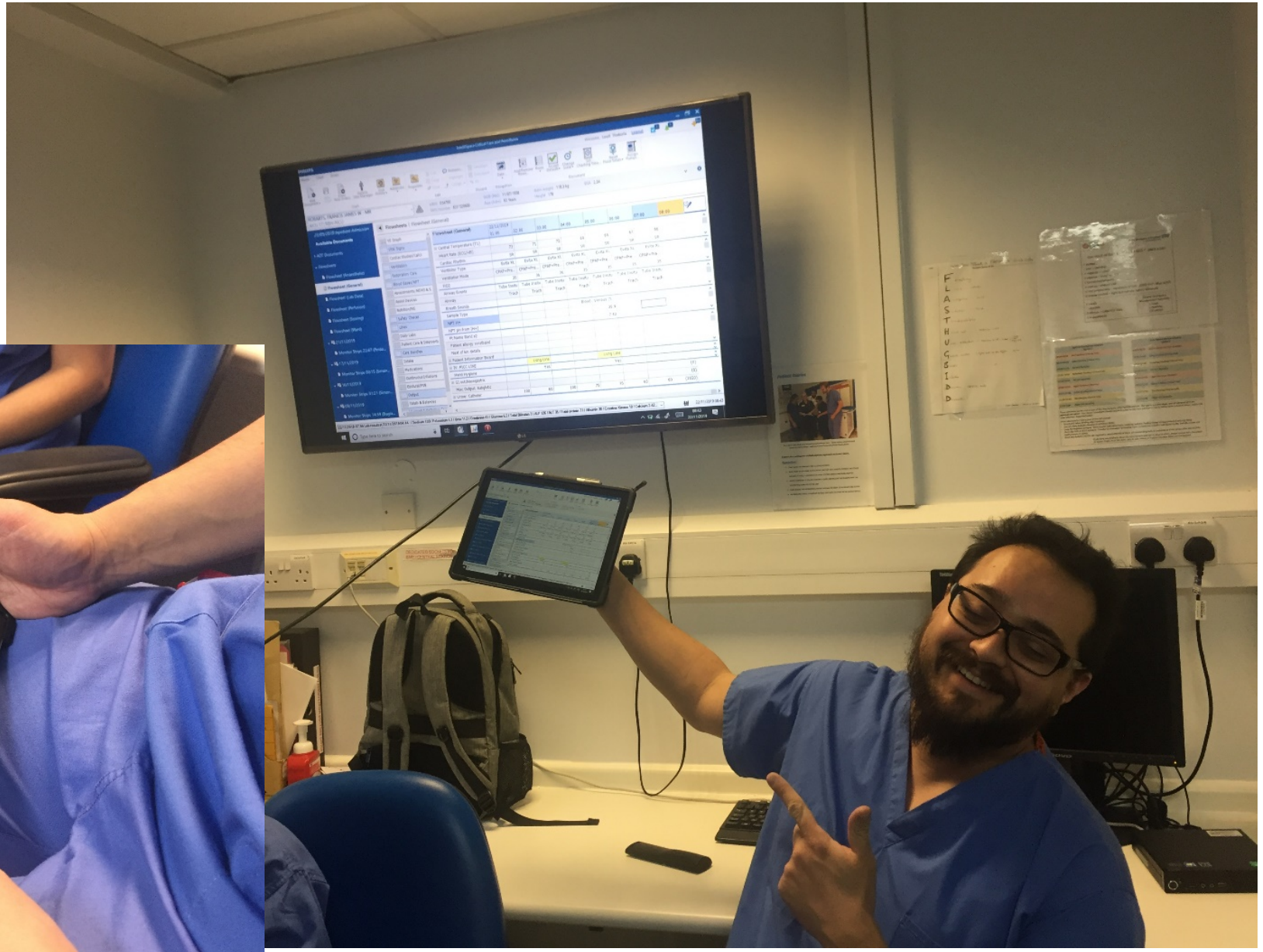

UnoRack


B1WS11

Developments in CIS

- Upgrades – increased scope
- Merge with Harefield – extended to Harefield
- HP got out of medicine – acquired by Philips
- CareVue enhanced and renamed to ICCIP – ICCA
  - We still call it CareVue
- Prescription
- Level II and even some Level I use and outreach
- Data – we use a SAS Data Warehouse and tools

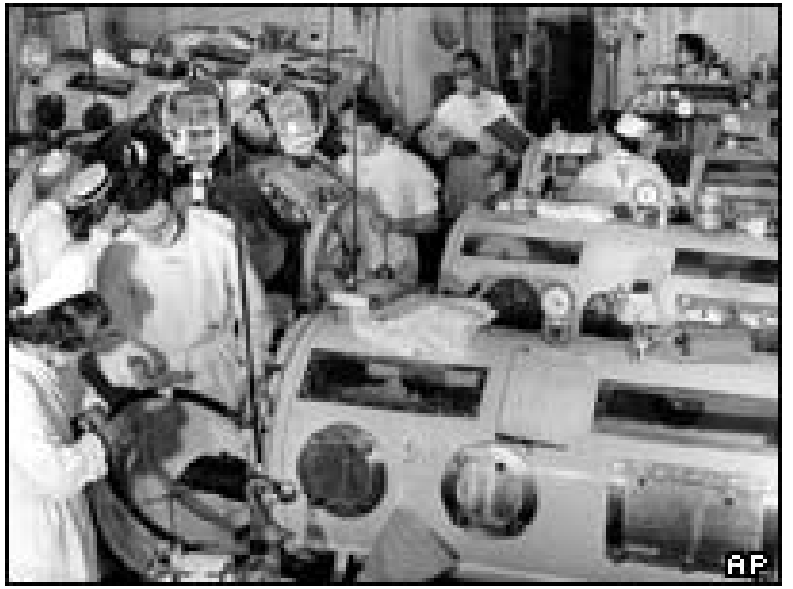
Windows 10 Tablet
And viewing on big screen



Future of CIS

- Better integration with the other systems that have evolved
- Enhanced configuration to reflect modern workflow
- Integration across hospital boundaries
- Collection of massive amounts of consistent and high quality data
- To support QI, Audit, AI, Machine Learning and Decision Support
- E-ICU in the UK?

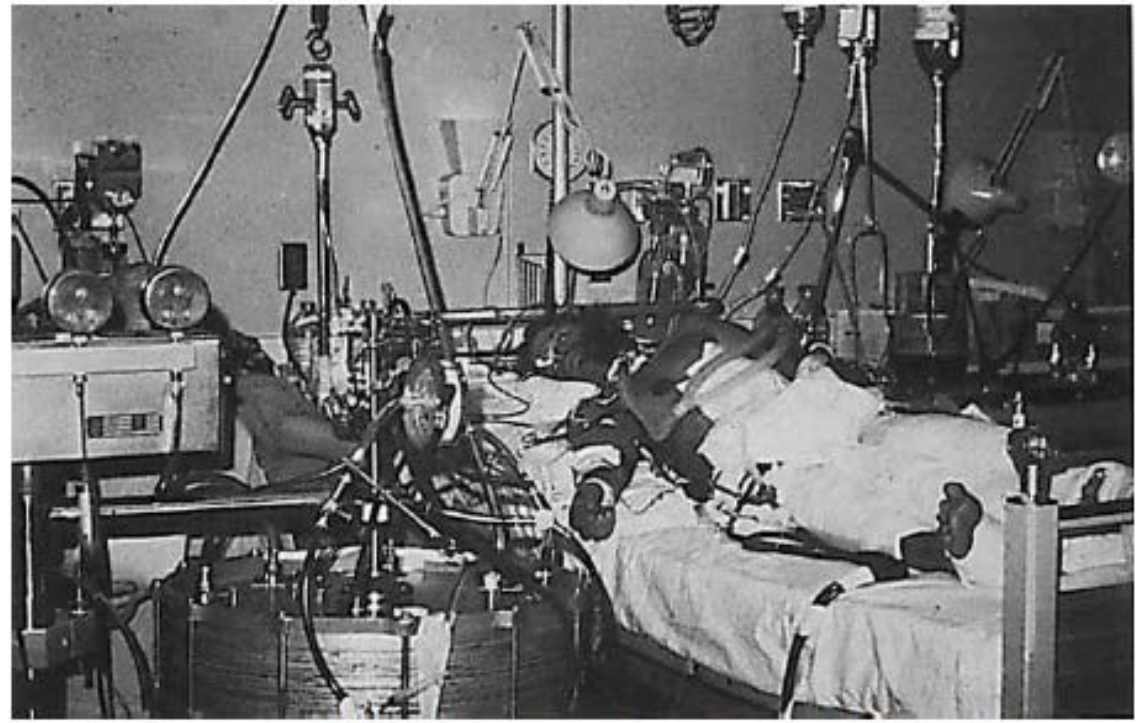
Severe Respiratory Failure



- Always involved in complex and specialist respiratory care
- Long history of taking referrals of “difficult ARDS”
- Commissioned ECMO Centre since the flu pandemic of 2009
- The pandemic was yet another example of pressure driving beneficial change

Early ECMO

- 1972 – first report of successful use of extracorporeal circulation to treat acute hypoxaemia respiratory failure in an adult patient



Hill JD et al. J Thorac Cardiovasc Surg 1972; 64: 551-562

What is so bad about lung failure?

- Lung has limited range of response to injury
  - Trauma
  - Smoke inhalation
  - Infection – eg Flu
- Endothelial permeability massively increased
- Gets massively congested
- Stiff to ventilate
- Requires high pressure ventilation and high concentration of oxygen to compensate
- But ------

The oxygen paradox

- Life on Earth depends on oxygen
- It is oxygen that kills all life eventually
  - Oxygen is cumulatively toxic to cells and DNA
  - Lose the ability to fix and replace tissue
  - So we age and degenerate

- Much more so in inflamed tissue exposed to abnormally high oxygen tension
  - With decreased oxidative stress resistance
- Eg Lung Injury supported by high pressure / high oxygen ventilation

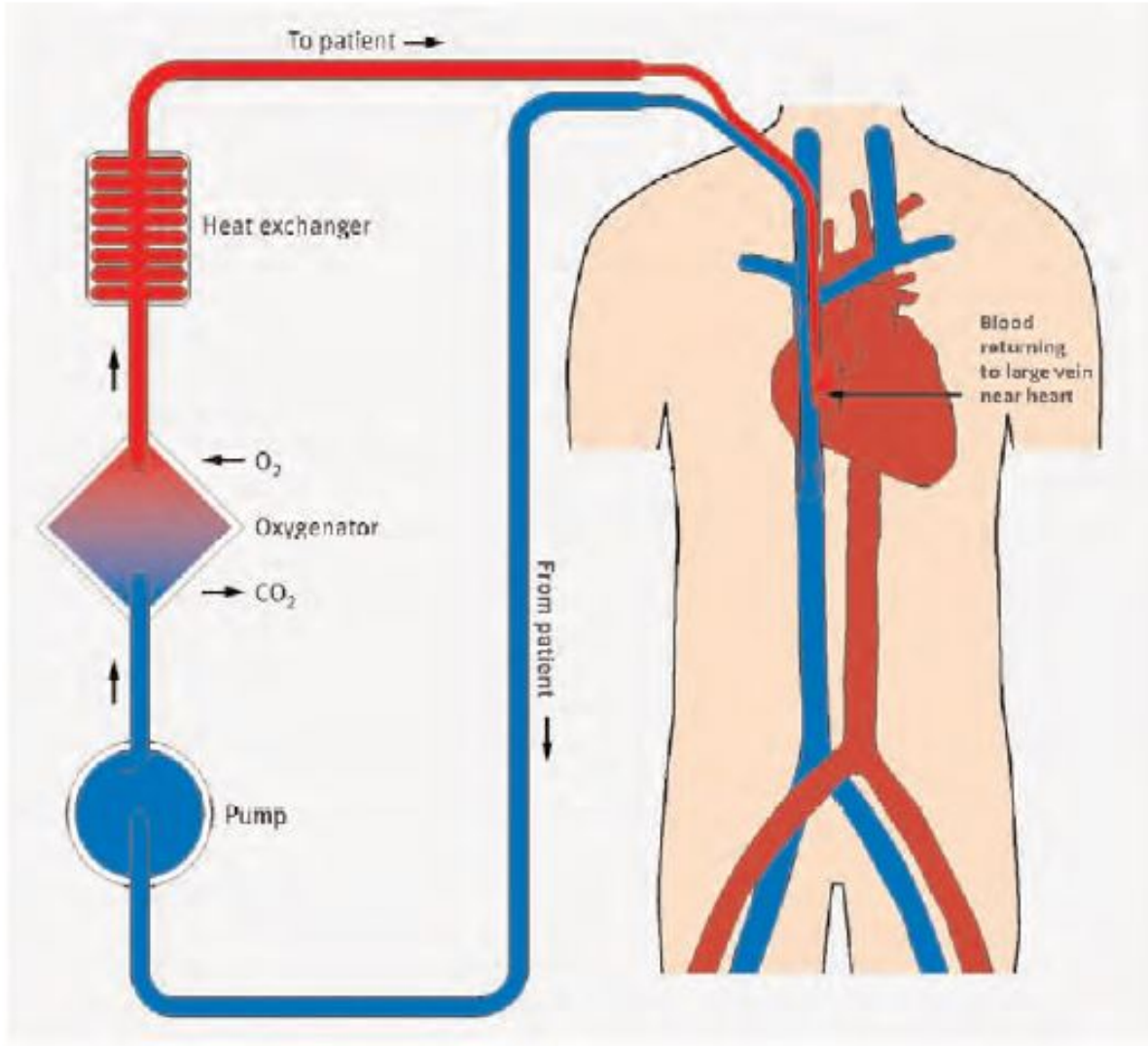
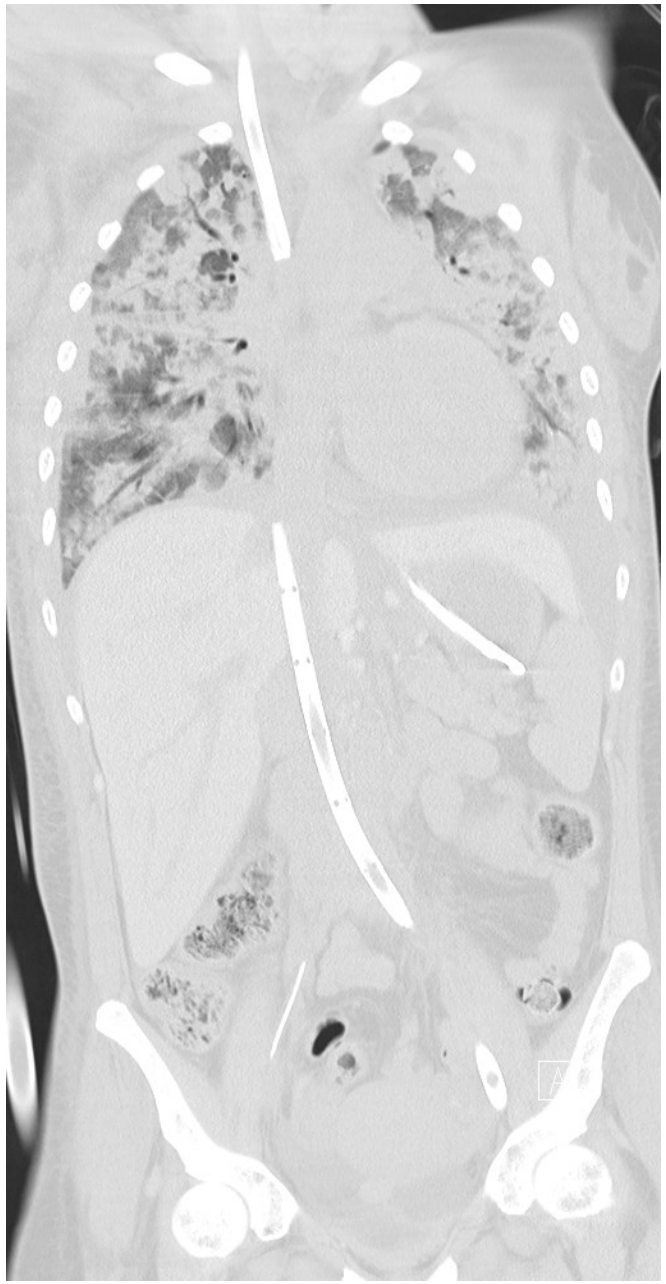
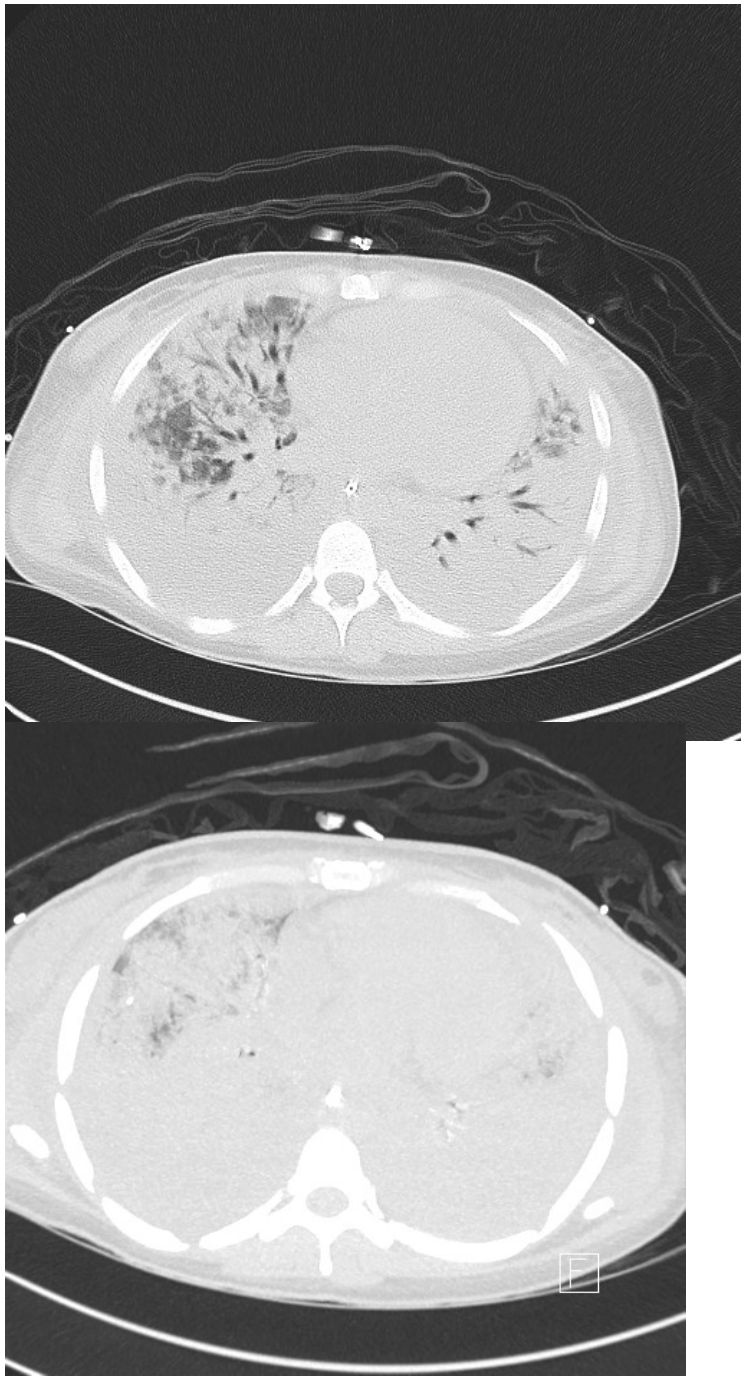


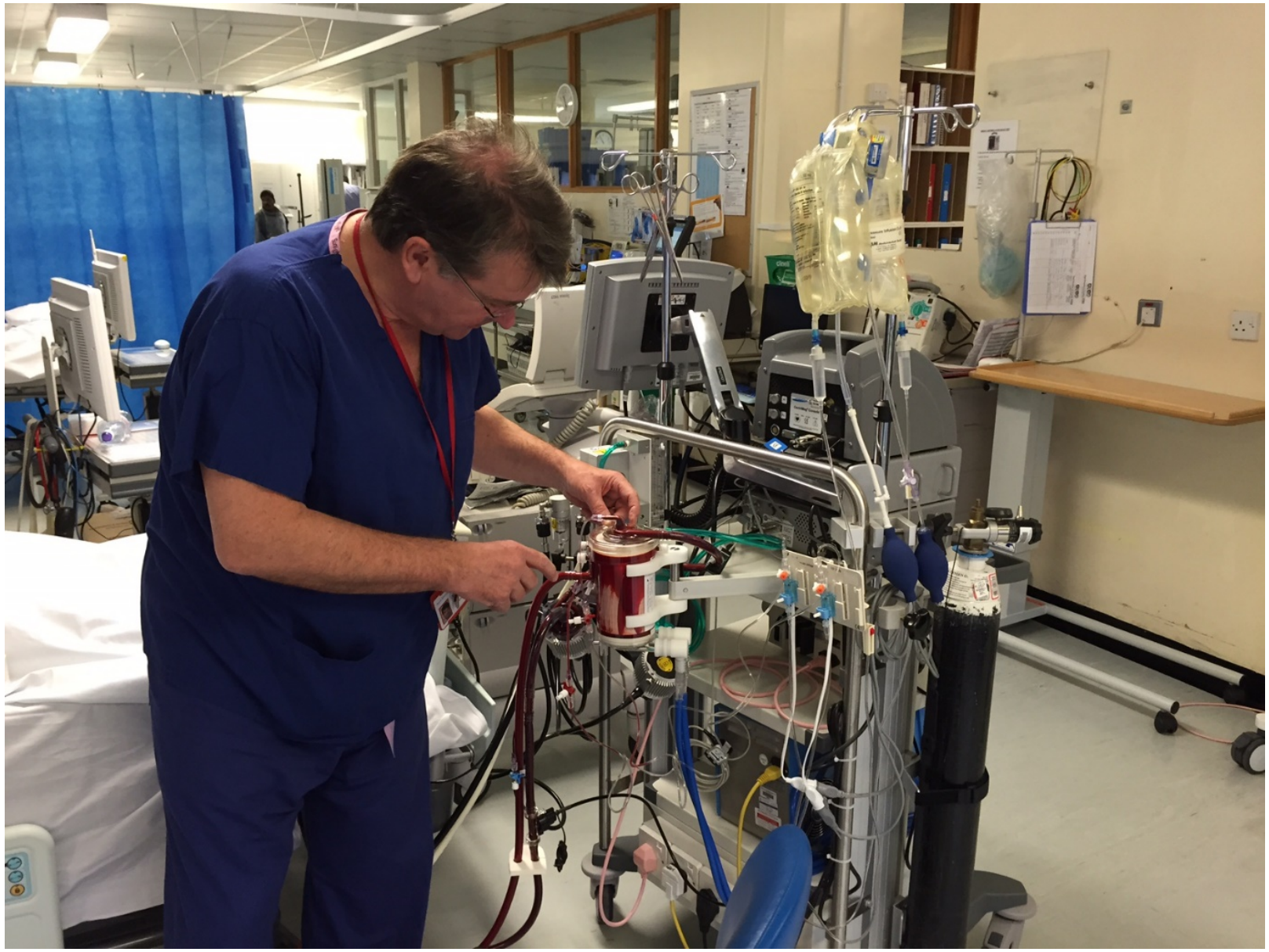
Figure 1 adapted with permission from BMJ Publishing Group Limited. Extracorporeal life support Gaffney et al, BMJ 2010;341:c5317






FERNO


CORDA
AMBULANCE



Results from VV ECMO

- From a group of adult patients with unmanageable severe respiratory failure – failing on maximal “conventional therapy” > 60% mortality
- Overall - > 70% survival to discharge from hospital

Best results
Younger
Briefer
No comorbidities
Asthma
Flu

Worst results
Older
More prolonged conventional ventilation phase
Significant comorbidities
Interstitial lung disease

So what’s next re ECMO

- Increased experience
- Simpler technology
- Wider availability - ? All major centres?
- Better prevention?

- Regional Respiratory Decision Support ---

Imperial College London

Bedside artificial intelligence for multi-organ management in the ICU

Dr Brijesh Patel MRCP FRCA FFICM PhD

Clinical Senior Lecturer in Cardiothoracic Critical Care

Anaesthesia, Pain Medicine & Intensive Care, Faculty of Medicine, Imperial College London

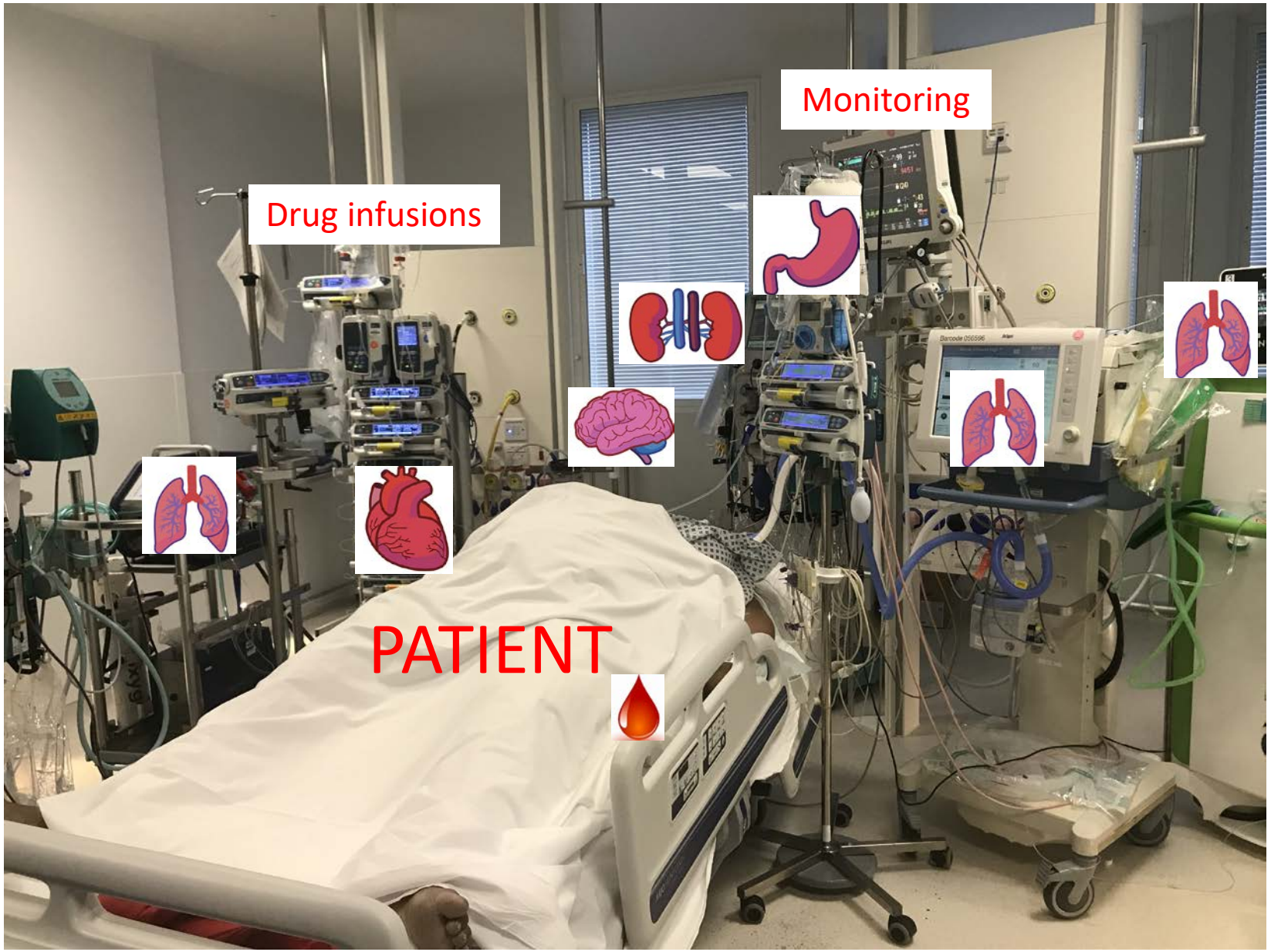
Consultant, Research Lead, Department of Anaesthesia & Critical Care

Royal Brompton & Harefield NHS Foundation Trust, London

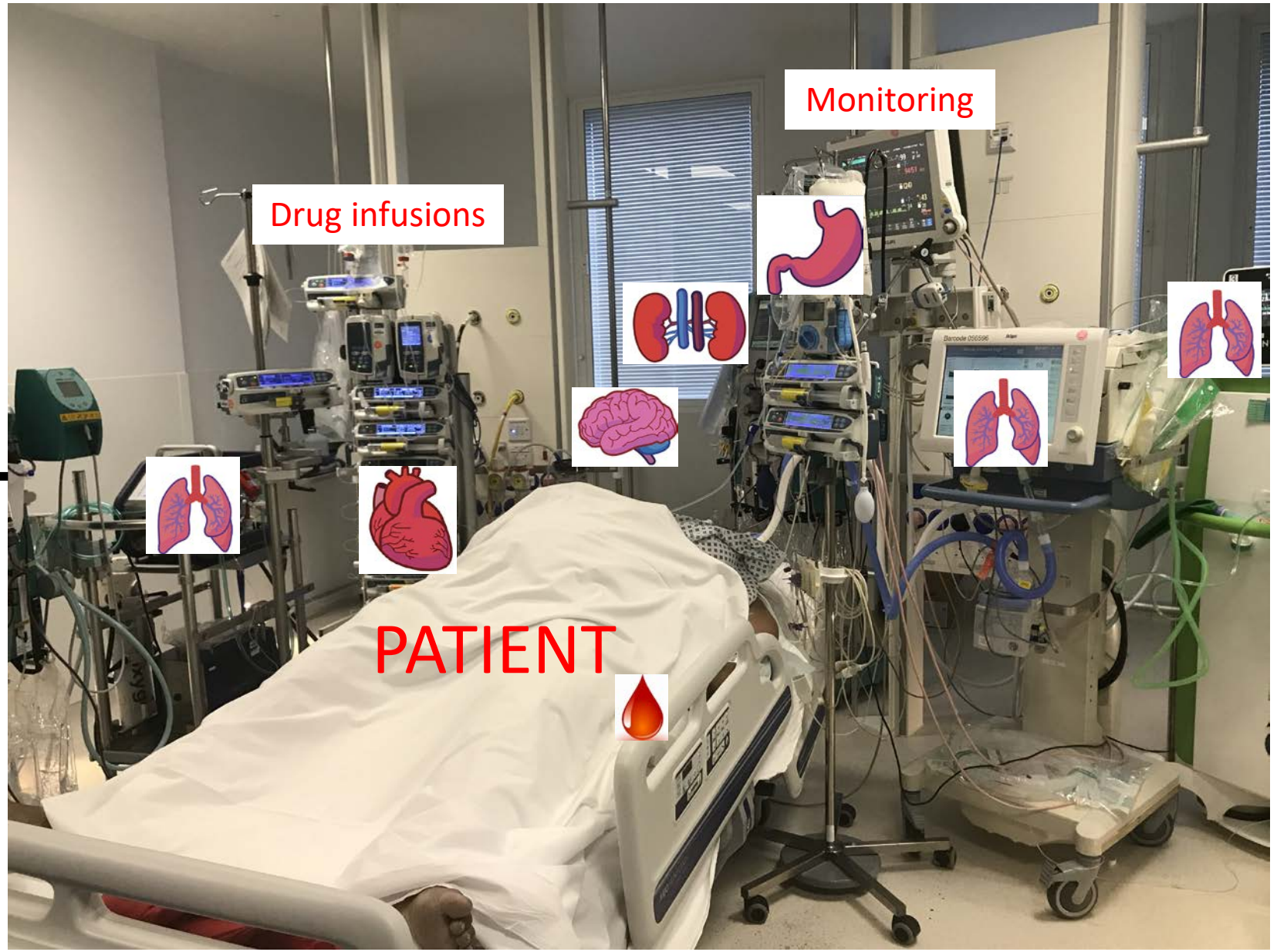
brijesh.patel@imperial.ac.uk

Clinical challenges: Unmet need

1. Doctors visit periodically
2. Visits can be time pressured
3. Need to make decisions on
   - Patient data
   - Patient history
   - Best practice
   - Clinical Experience
4. Residents or junior doctors
5. The number of experts is decreasing – a 20% shortage of intensivists expected by 2020.
6. Introduction of specialist nurse practitioners.
7. Therapy required at night
8. Expensive, 0.5 to 1% GDP, 5% of all healthcare costs.



Bedside monitoring
Digital Data
Remote monitoring
Smart Alarms



THE FRAMEWORK PROGRAMME FOR RESEARCH AND INNOVATION

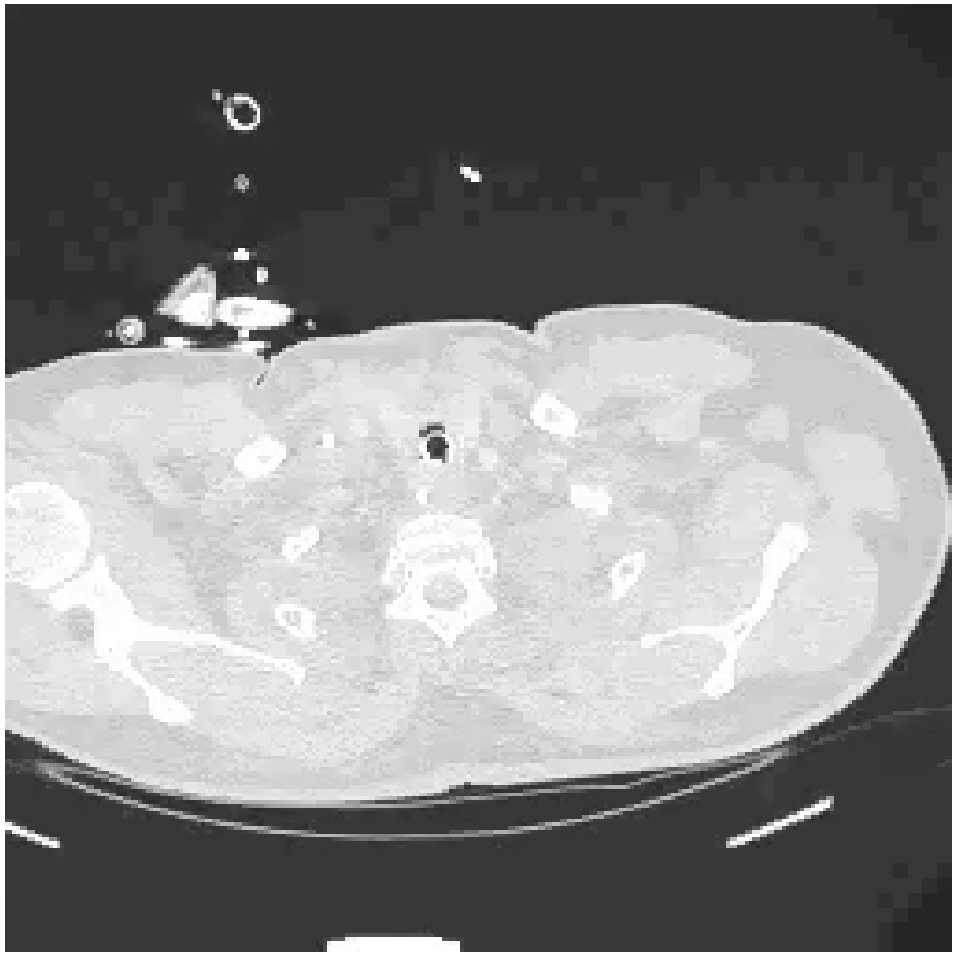
HORIZON 2020

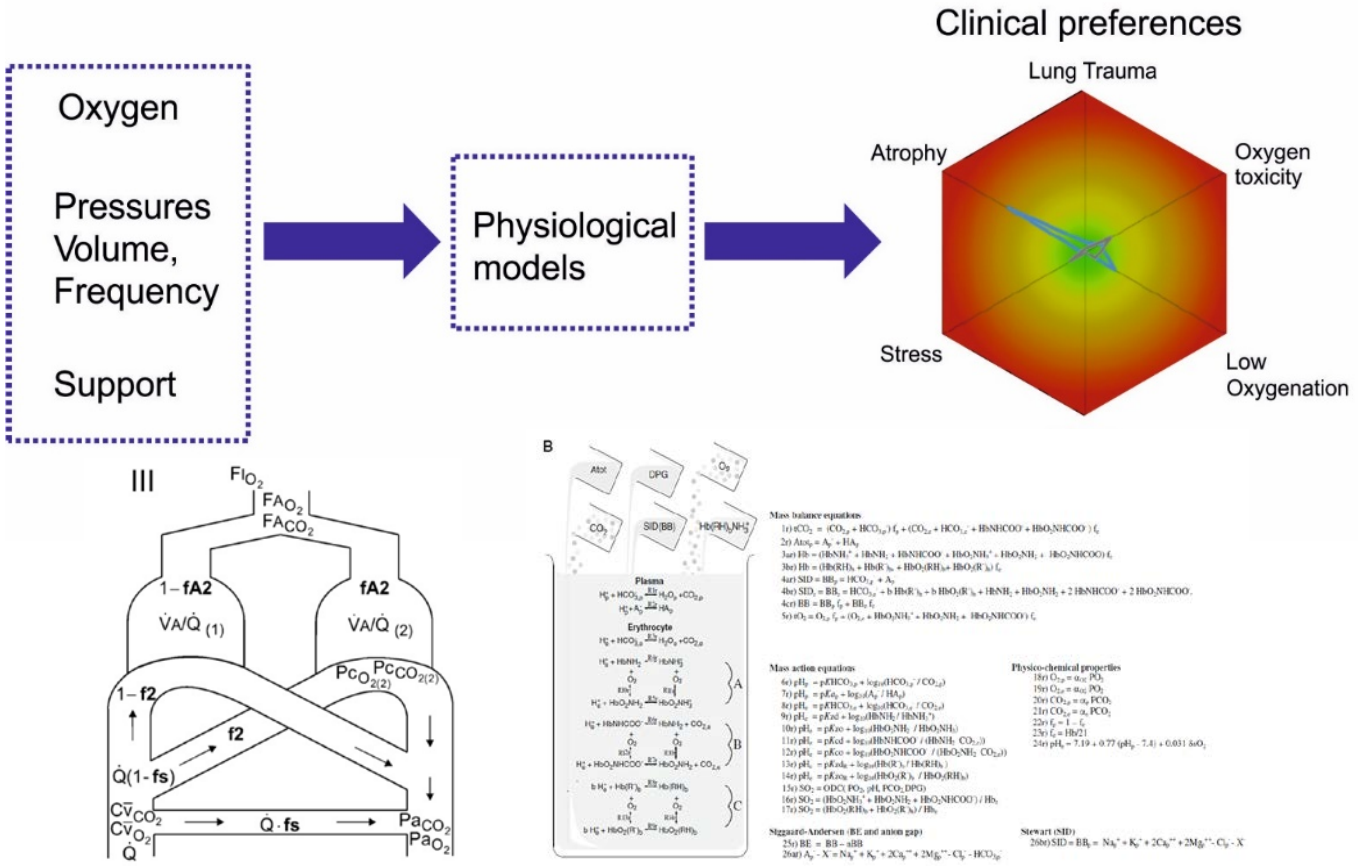
Imperial College London

Royal Brompton & Harefield NHS
NHS Foundation Trust

MERMAID CARE

BEACON® CARESYSTEM





Mathematical Models tuned to individual data

Mathematical models of clinical preference

Imperial College London

Royal Brompton & Harefield NHS
NHS Foundation Trust

NHS

The NHS Long Term Plan

Practical priorities will drive NHS digital transformation

- Create straightforward digital access to NHS services, and help patients and their carers manage their health.
- Ensure that clinicians can access and interact with patient records and care plans wherever they are.
- Use decision support and artificial intelligence (AI) to help clinicians in applying best practice, eliminate unwarranted variation across the whole pathway of care, and support patients in managing their health and condition.
- Use predictive techniques to support local health systems to plan care for populations.
- Use intuitive tools to capture data as a by-product of care in ways that empower clinicians and reduce the administrative burden.
- Protect patients' privacy and give them control over their medical record.
- Link clinical, genomic and other data to support the development of new treatments to improve the NHS, making data captured for care available for clinical research, and publish, as open data, aggregate metrics about NHS performance and services.
- Ensure NHS systems and NHS data are secure through implementation of security, monitoring systems and staff education.
- Mandate and rigorously enforce technology standards (as described in The Future of Healthcare) to ensure data is interoperable and accessible.
- Encourage a world leading health IT industry in England with a supportive environment for software developers and innovators.

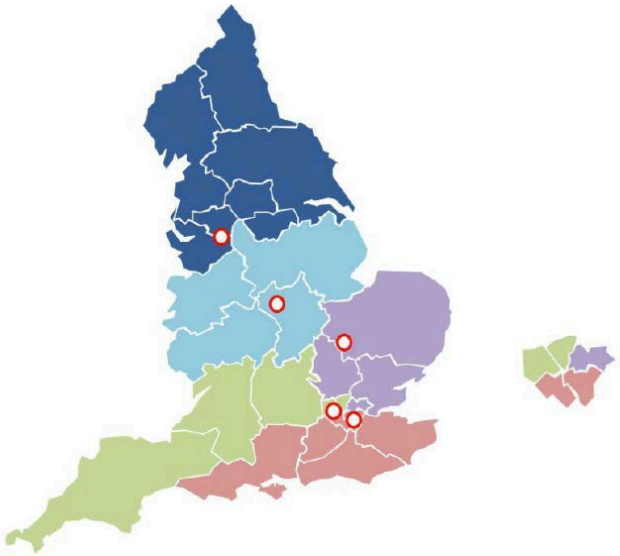
The NHS Long Term Plan, January 201

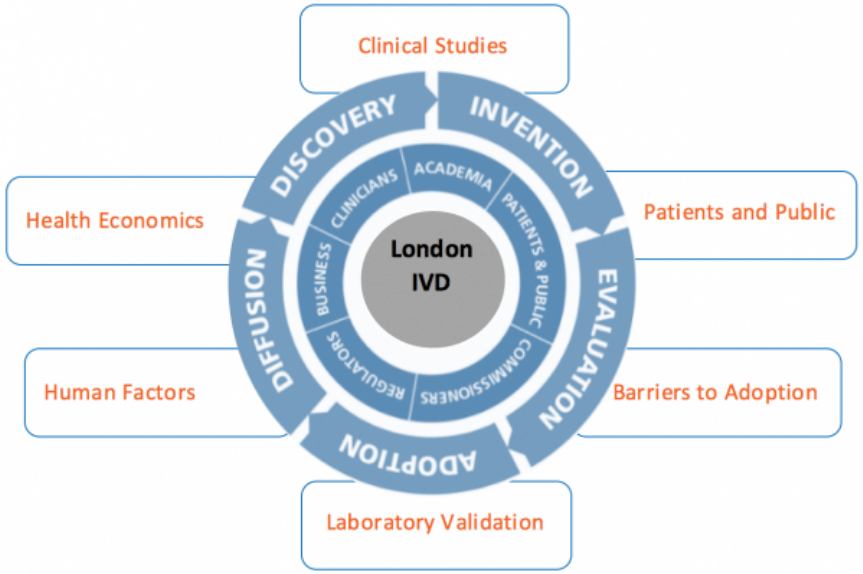
Surveillance and Early detection of Respiratory and Ventilatory Compromise in the UK (The SERViCe UK study)

Imperial College London

Royal Brompton & Harefield NHS
NHS Foundation Trust

NHS England Severe Respiratory Failure Network





NIHR | London In Vitro Diagnostics Co-operative

MERMAID CARE

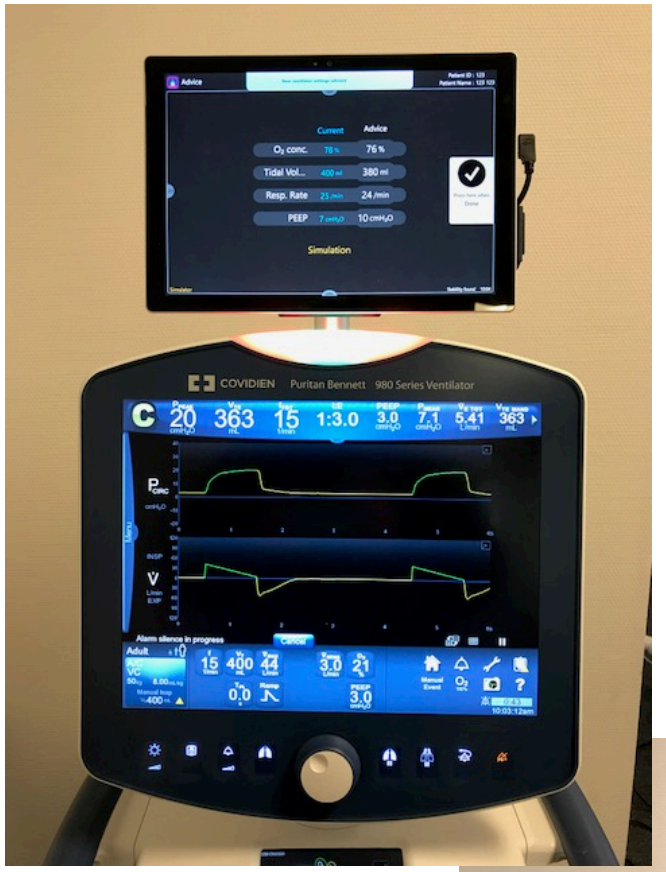
Imperial College Academic Health Science Centre

Data Science Institute
Imperial College London

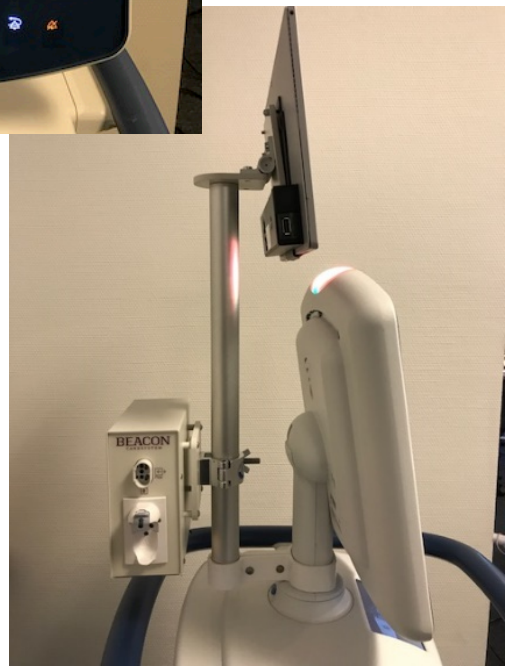
AiiC

BEACON CARESYSTEM

Mounted on the PB840 on side arm including gas module

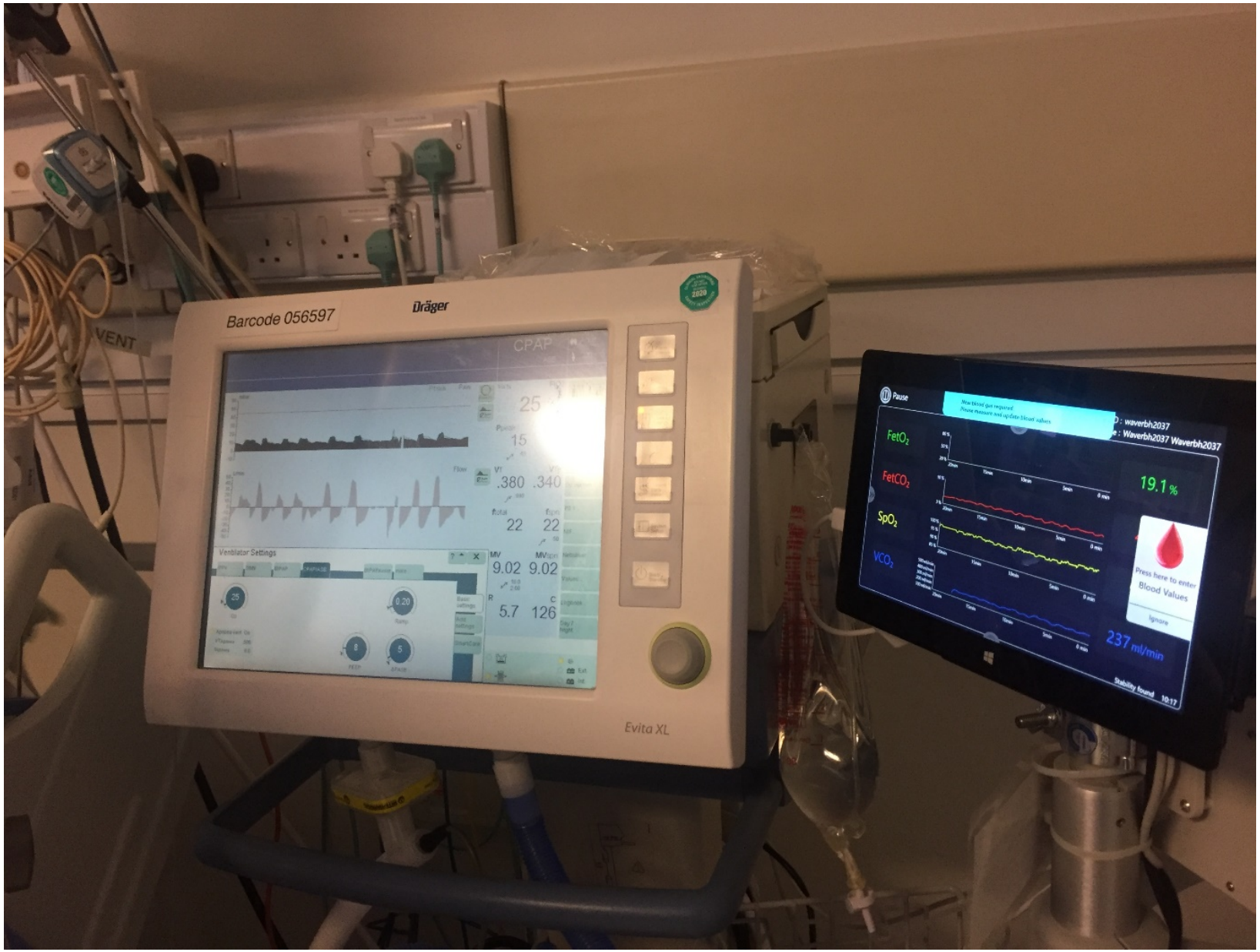


Mounted on the PB980 with gas module behind screen



Actual use – Nov 22

Just before extubation



Patient example – reducing ventilator support

Before Beacon

Ventilator settings
FiO2 = 45 %
Ps = 10 cmH2O

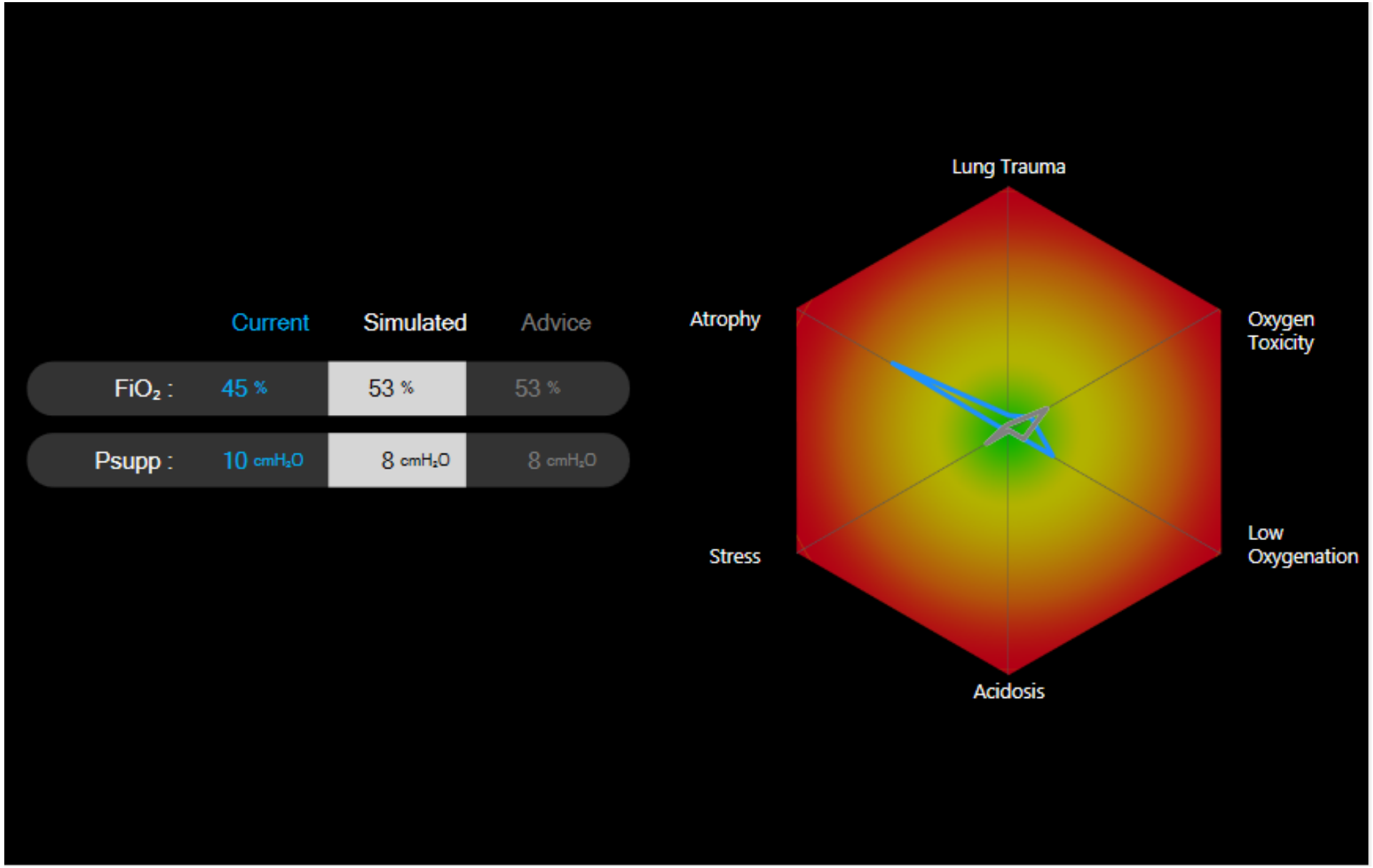
Continuous measurements
Ppeak = 18 cmH2O
EtCO2 = 6.0 %
Rf = 12 breaths/min
SpO2 = 93 %

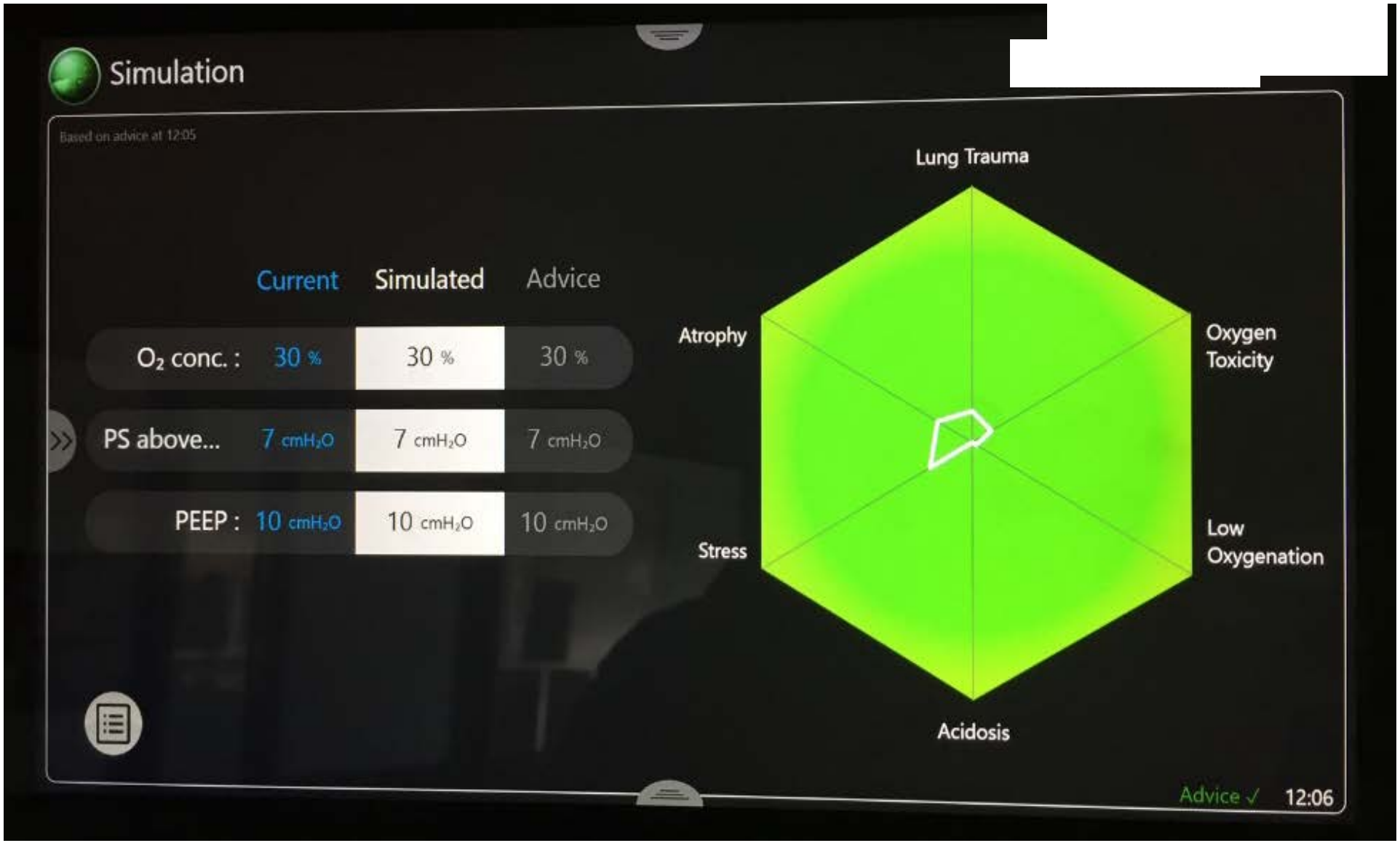
After Beacon

Ventilator settings
FiO2 = 48 %
Ps = 7 cmH2O

Continuous measurements
Ppeak = 14 cmH2O
EtCO2 = 6.3 %
Rf = 23 breaths/min
SpO2 = 95 %

Swipe to the right – explanation/simulation




Simulation
Based on advice at 12:05
Current
Simulated
Advice
O2 conc. : 30 % 30 % 30 %
PS above... 7 cmH2O 7 cmH2O 7 cmH2O
PEEP : 10 cmH2O 10 cmH2O 10 cmH2O
Lung Trauma
Oxygen Toxicity
Low Oxygenation
Acidosis
Stress
Atrophy
Advice ✓
12:06

Results

- Sorry – still recruiting

- BUT – already planning regional roll out of next stage
- All the ECMO referral sites will have the option of a hub and spoke version of respiratory decision support
- +/- other aspects of telemedicine

And then

- Already looking at other organ system support options
  - Cardiac and cardiovascular
  - Antimicrobial selection
  - Others……..

Conclusion

- A bit if the history of me, my hospital and the amazing technology developments
- The vital dependence of clinical excellence on technical support staff
- Further progress will have to be technology dependent
- How to pay for it all????

Clearly the future is

- Integrated digital
- Extensive use of AI / Decision Support / Machine Learning

- Thank You – Questions?