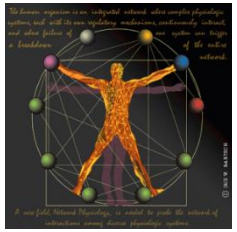
Second International Summer Institute on Network Physiology (ISINP)

Lake Como School of Advanced Studies - 28 July - 02 August, 2019



Developing a Data Collection System for the Injured Brain to Enable Network Physiology Research

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ICU Solutions

Topics

- Intro to TBI and the need for big data
- MRI: Technology and Future
- Device Data Collection: Problems and solutions
- Integration of other data: EMR, Imaging, Biomarkers
- Trends: FDA panel, etc.
- Clinical examples of utility
- Future

Topics

- Intro to TBI and the need for big data
  - Sheila story, TRACK TBI, etc.
  - We need better data
- MRI: Technology and Future
  - Challenges to getting that data (devices, standards, databases, etc.)
- Device Data Collection: Problems and solutions
  - Challenges
- Integration of other data: EMR, Imaging, Biomarkers
- Trends: FDA panel, etc.
- Clinical examples of utility
  - Cases (Brandon)
- Future
  - and DOD project

- There are a couple of weeks left till the start of the International Summer Institute on Network Physiology (ISINP-2019) in Como.
- Could you please send PDFs of your lecture(s) at your earliest convenience. We would need to have them latest by July 25.
- The PDFs form the package of materials for the ISINP participants and will be made available only to the participants.
- Lectures duration is 30 min plus 5 min for questions.
- Please note that lectures present diverse topics, and there is very little or no overlap in the background and expertise of speakers. Participants are Ph.D. and M.D. students, postdoctoral fellows, university faculty, physicians and industry researchers with diverse backgrounds in medicine, neuroscience, exercise physiology, computer science and applied mathematics, physics, and biomedical engineering.
- Correspondingly, each lecture should provide clear definitions, background, general concepts, results, and vision for the future in a way that is understandable for non-specialized audiences.
- Note that although the general focus of ISINP is Network Physiology, the meeting is not a narrowly specialized workshop or conference -- it is intended as an institute/school where experts across fields learn from each other. Talks given at conferences to peers in your specific fields may not be quite suitable for this meeting.

Goals of Talk

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- Describe the **need** for comprehensive, high-resolution data in critical care
  - We will use the care of acute brain injury as an example
- Describe the **challenges** of collecting data in a usable form
  - We will describe the state of medical device connectivity and data interoperability
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State of Brain Injury

We know a lot
But compared to other areas of medicine
we don't even know what we don't know

Variability in Traumatic Brain Injury

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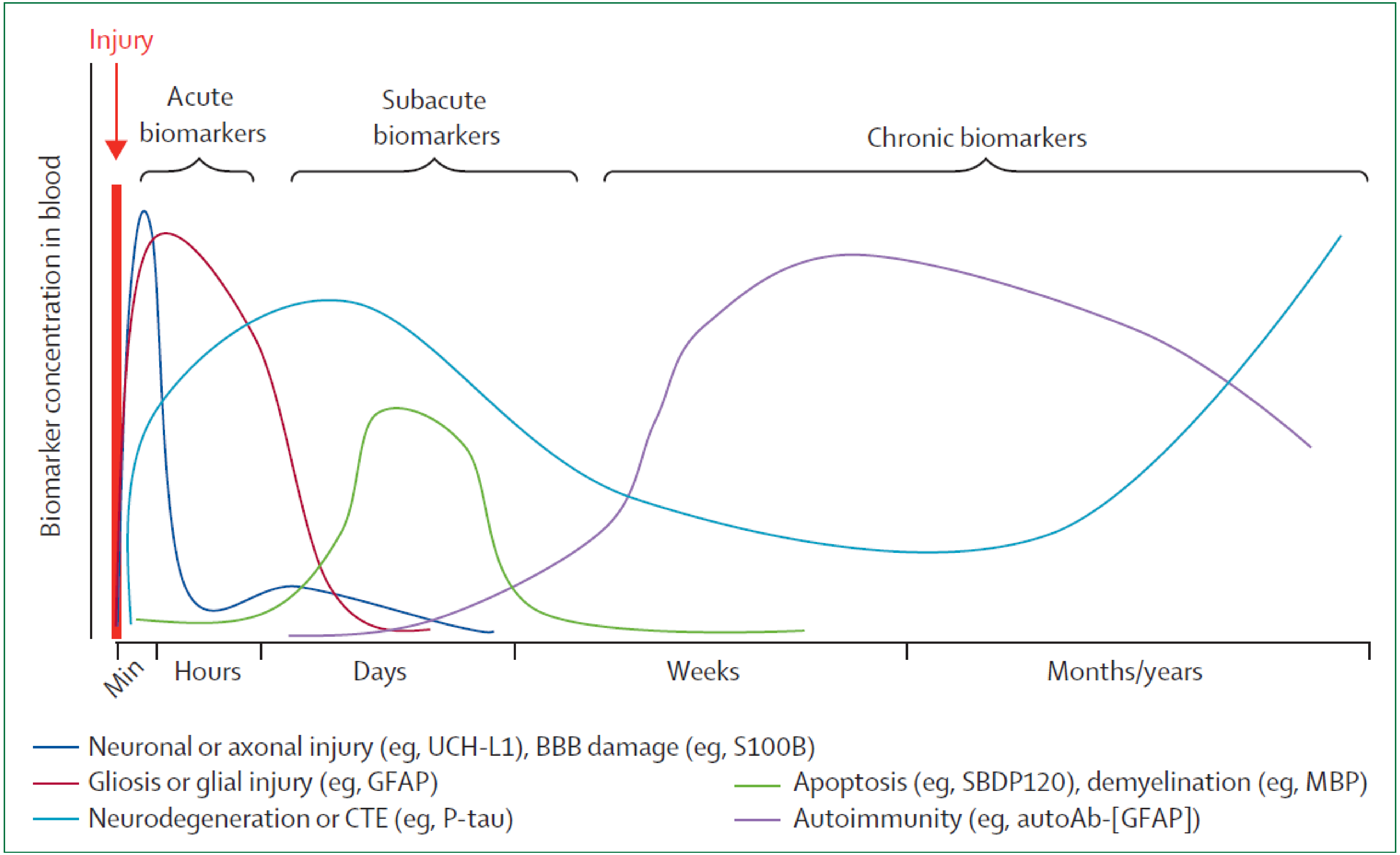
Kevin Pearce – snowboarder
Fall on half-pipe – severe TBI
26 days ICU, 5 months rehab
Slight memory & visual loss

Sarah Burke – skier
Fall on half-pipe – severe TBI
9 days ICU
Died

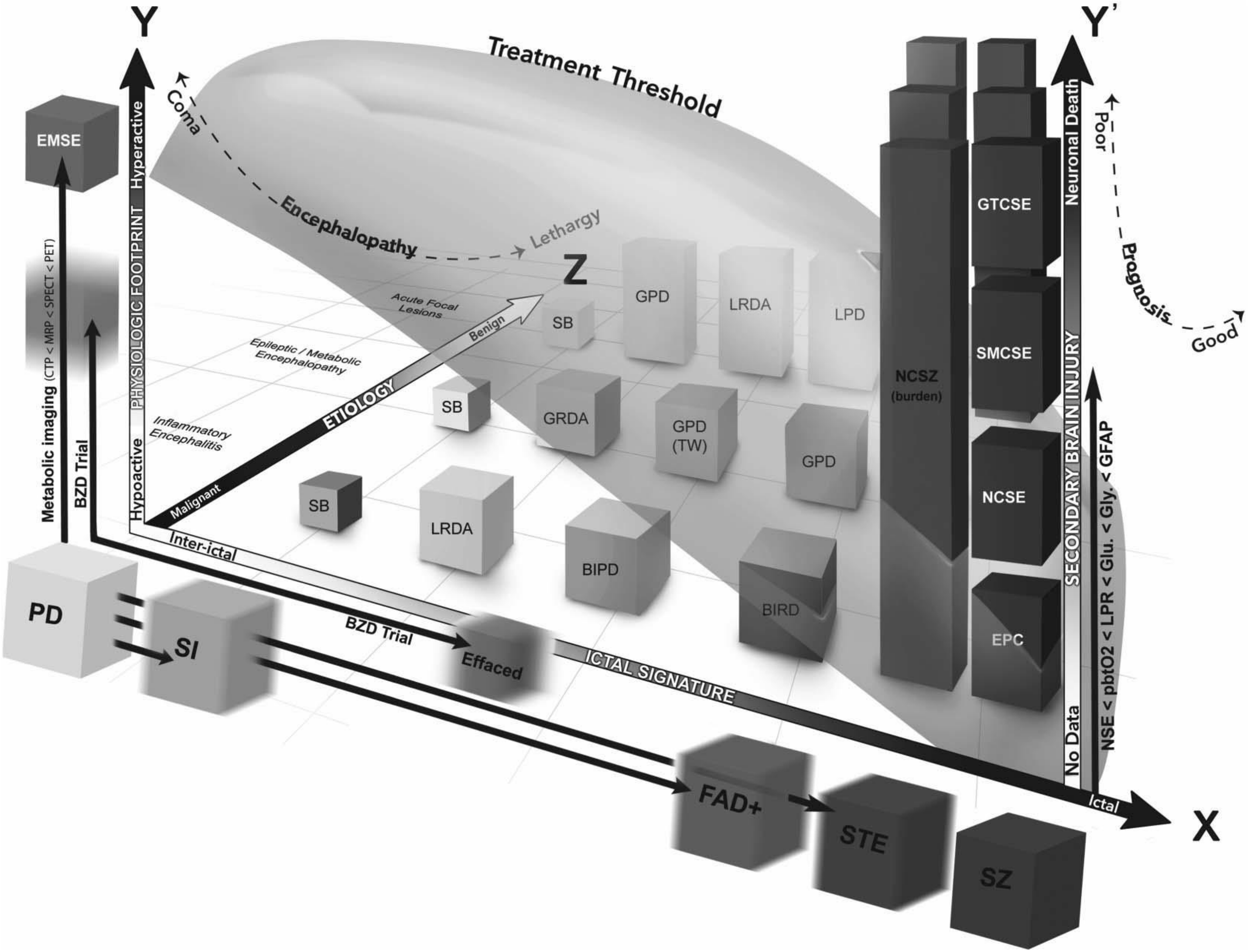
Sara Hall - arborist, runner
Jogger vs. bicycle – mild TBI
6 days ICU, 6 months rehab
Slight hearing & memory loss

High variability in TBI outcomes due to the extreme complexity of the brain

Complexity of Traumatic Brain Injury



Complexity of Traumatic Brain Injury



Complexity of Traumatic Brain Injury

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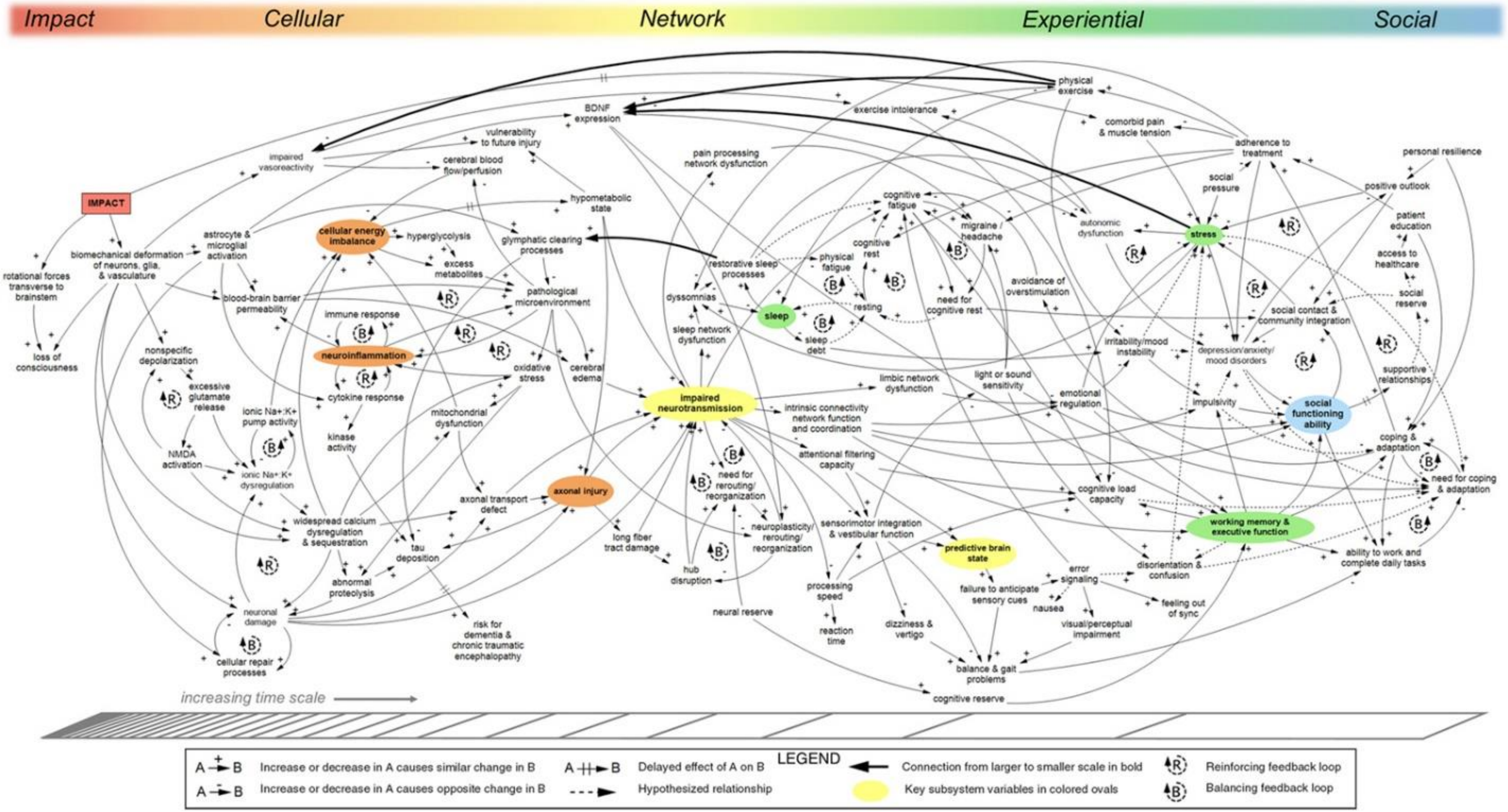

After 30 years of failed trials, we realize we can't treat the brain the same way as the heart or liver or lungs…with one guideline or drug

The field is doing a "re-start" in its approach to brain injury

- Better definition of TBI
- Better endpoints

Prediction and Data

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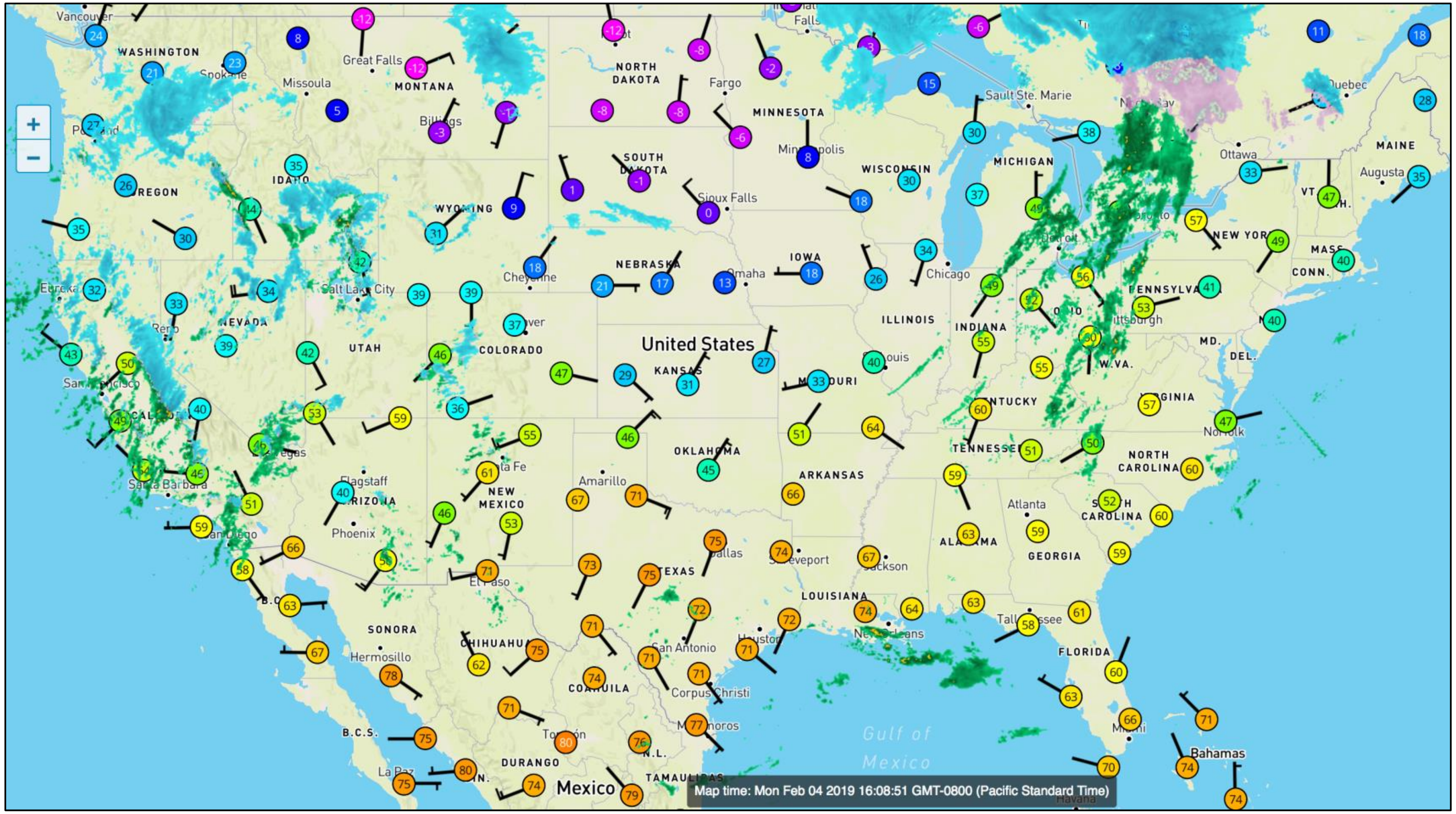
We can predict the weather because we have massive amounts of localized data.

- Satellite imaging
- Localized temperatures, barometric pressure, wind speed & direction, humidity, dew point, etc.
- Sophisticated models



Current State of Data in the Neuro ICU

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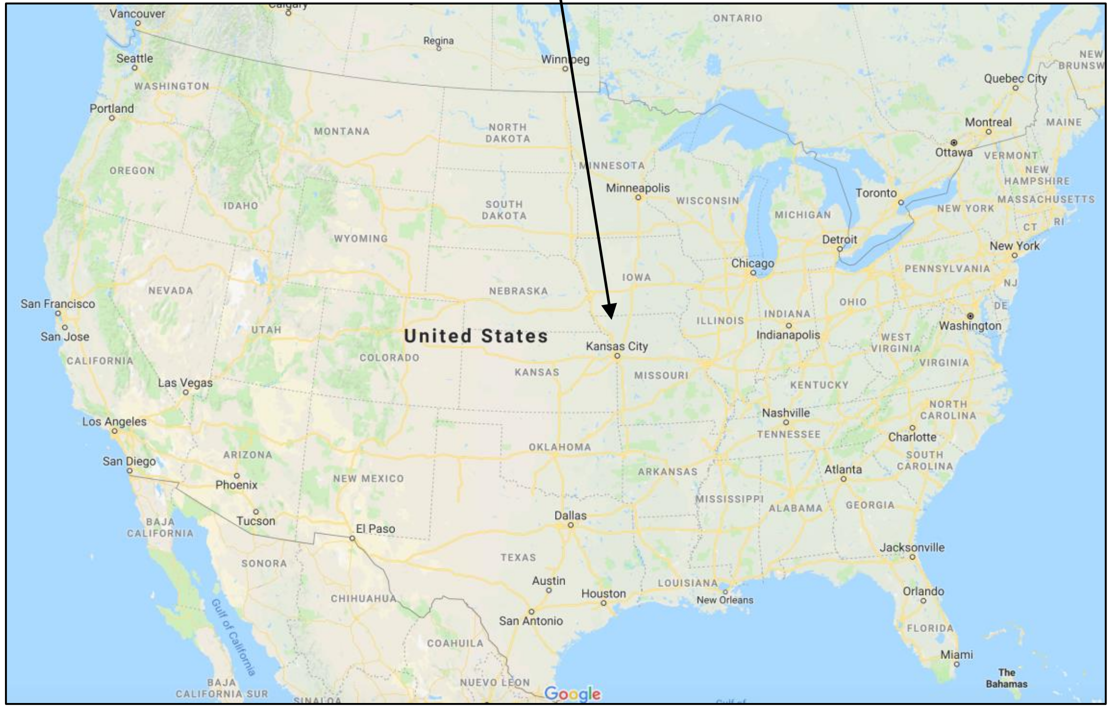
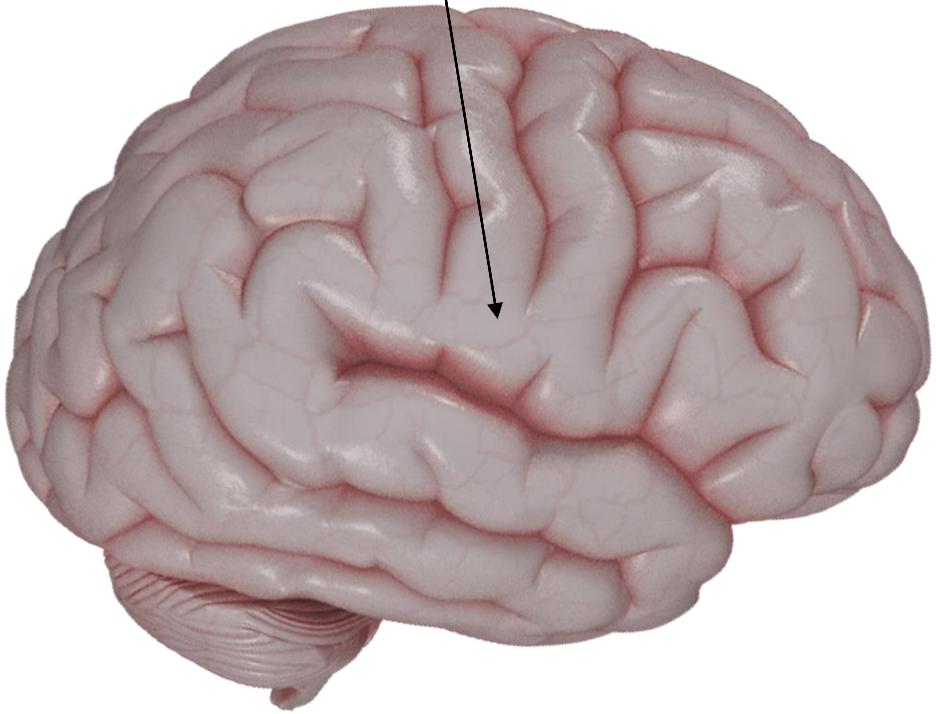
Predicting changes in neurocritical care today is like trying to forecast the national weather with only an hourly temperature from Kansas City.

Temp = 72°



ICP = 8 mmHg



Defining the Disease – Observational Trials

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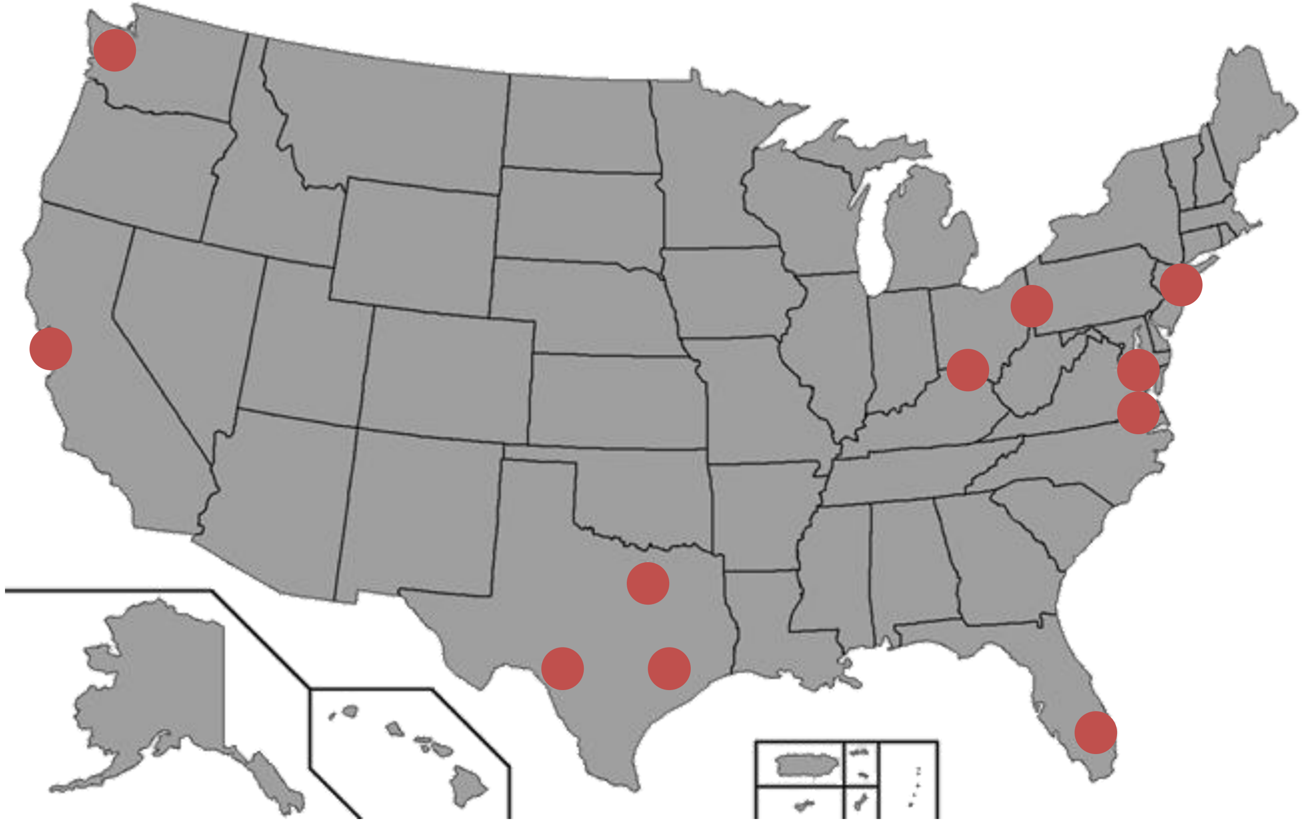
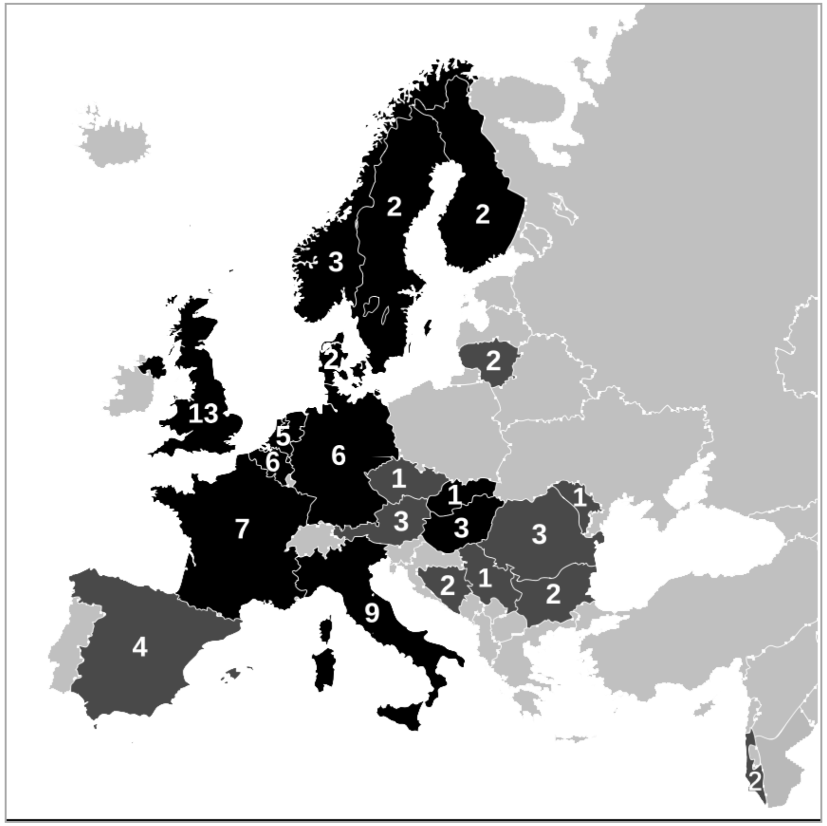
TRACK-TBI
Transforming Research and Clinical Knowledge in Traumatic Brain Injury
International Traumatic Brain Injury Research Initiative

11 sites
3,000 subjects



CENTER-TBI

80 sites, 21 countries
5,400 subjects



Bookend Projects

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On Admission Better Definition of TBI		More Accurate End Points
Glasgow Coma Score Imaging Biomarkers Genomics Proteomics	→	Glasgow Outcome Score Psychometric Testing Eye Tracking Biomarkers

Bookend Projects

MOBERG ICU Solutions

On Admission
Better Definition of TBI

- Glasgow Coma Score
- Imaging
- Biomarkers
- Genomics
- Proteomics

Overlooked

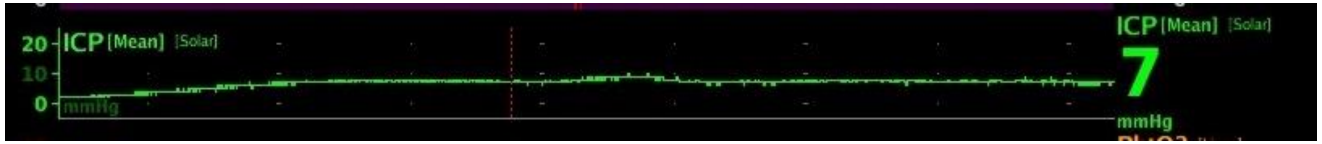
- How was the patient managed?
- Physiology
- Blood Pressure
- ICP
- Seizures
- Brain oxygen

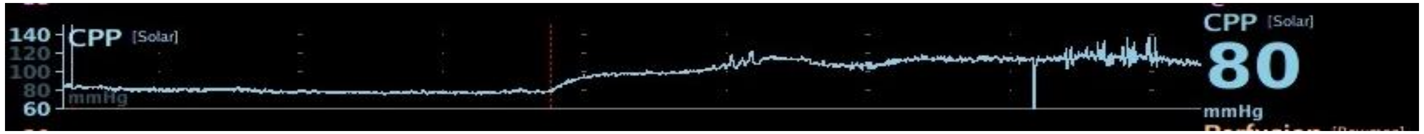
This is what we need
But this is difficult to get

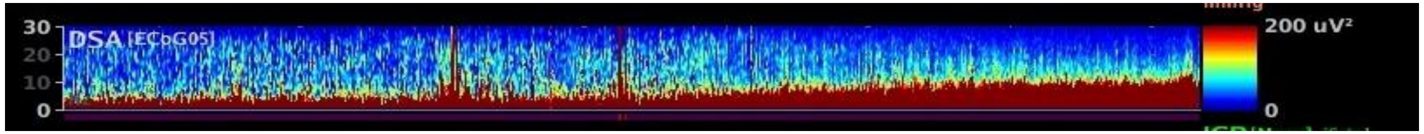
More Accurate
End Points

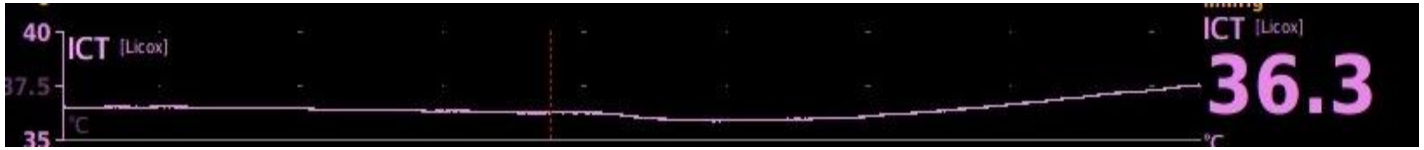
- Glasgow Outcome Score
- Psychometric Testing
- Eye Tracking
- Biomarkers

Disparate Data



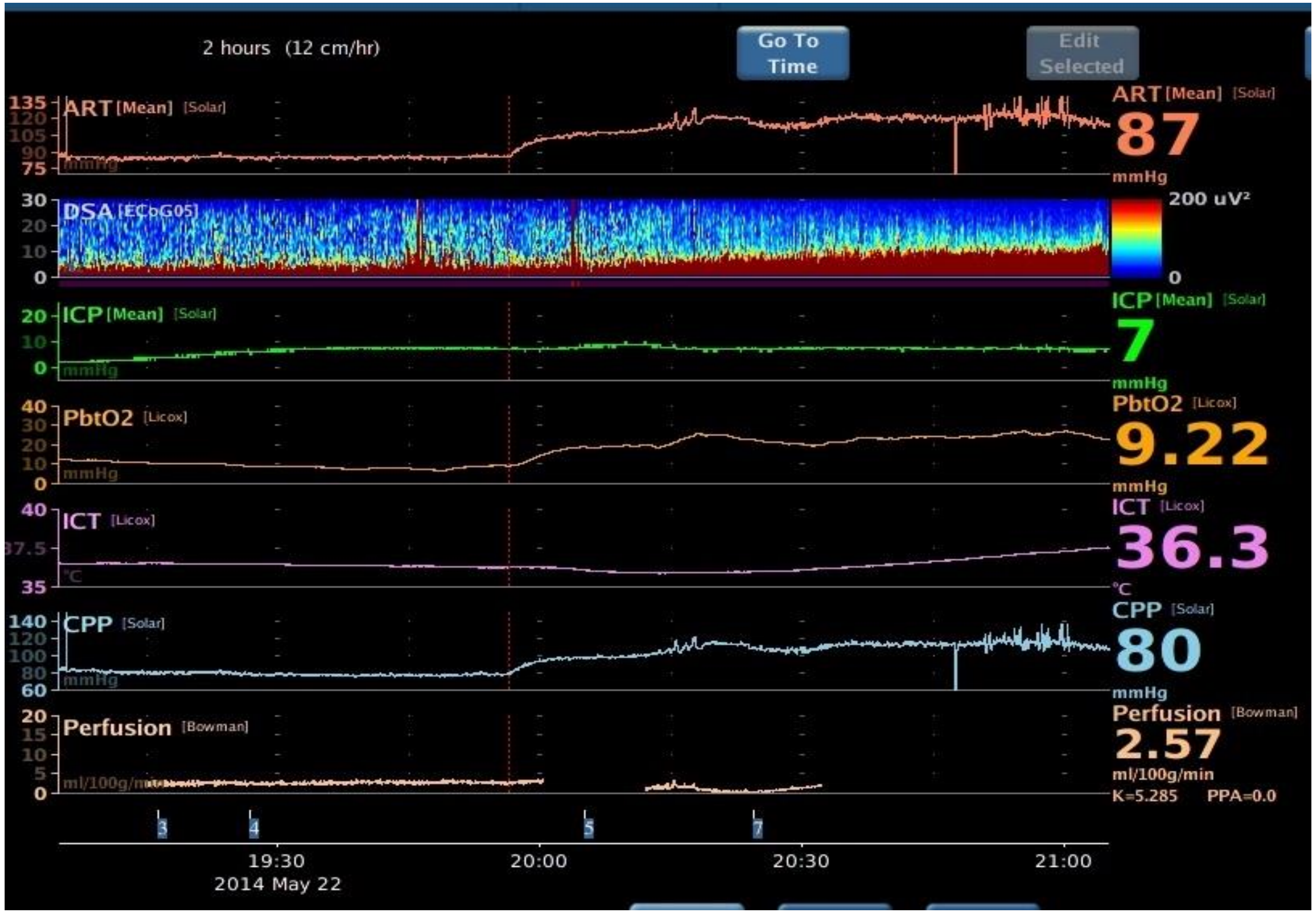






Combined, Time-synchronized Data

The data tells a story when consolidated and time-synchronized



Goals of Talk

MOBERG ICU Solutions

- Describe the **need** for comprehensive, high-resolution data in critical care
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Medical Device Connectivity - Problems

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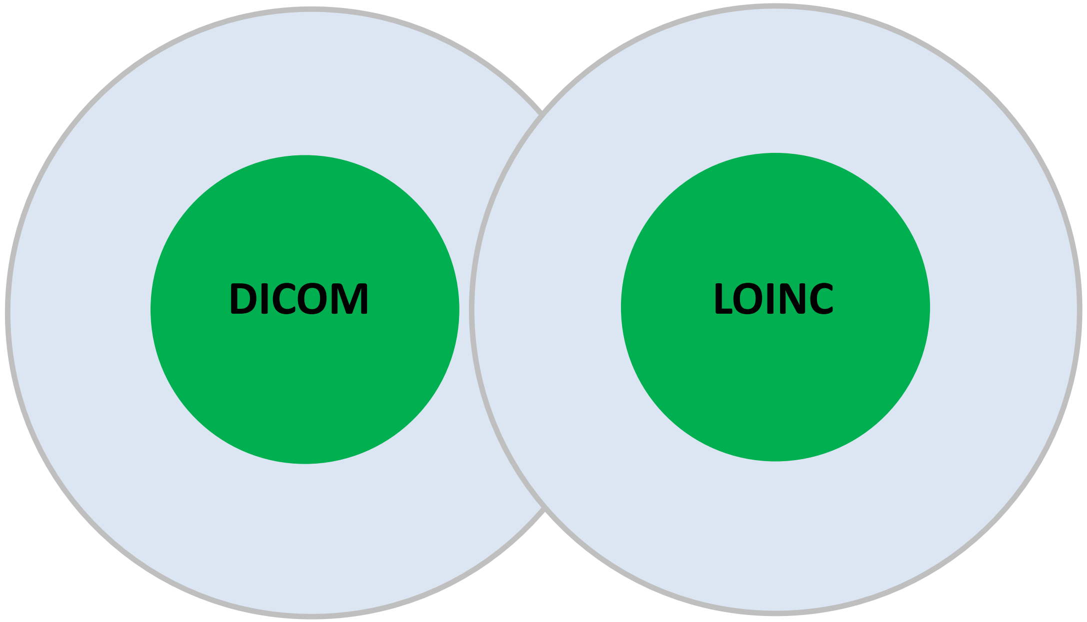
- Device Communications
  - No widely adopted communication standard
  - No widely used nomenclature
  - “Quirks” in every device
    - We had to compensate for the bad designs of others
- Low Resolution Data
- Device Adapters
  - Several attempts, none widely adopted
- Systems of Devices
  - Time synchronization
  - Regulatory - Who is liable in a “closed loop system”

- Standards organizations
  - Lots of them….they all want to get into each others domains
  - DICOM (started as imaging standard) and LOINC (started as lab data standard)…each are growing into the other's territory



Nomenclature – No Standard

- Intracranial Pressure
  - What we have IEEE 11073-10101
  - What we need (location, etc. – other metadata)

Problem: Lack of Standard Nomenclature

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Pupilometer

Reactivity

Size

Symmetry

Medical Record

Glucose
Blood Gases
Heart Rate
Size ??
Blood Pressure
Urine Output
Medications

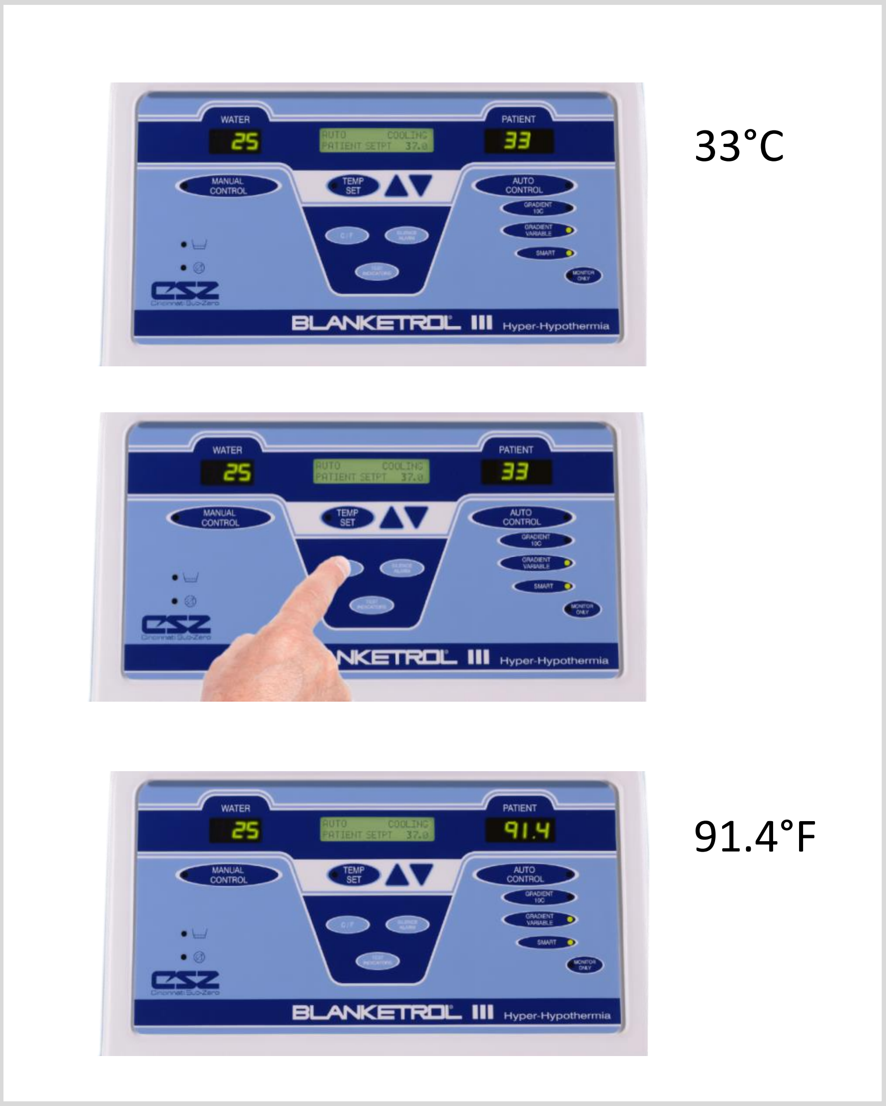
Problem: Label Confusion

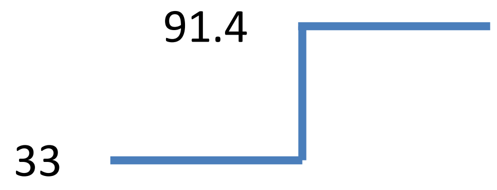
PbtO2

P1??

No internal
labels for PbtO2

Problem: Inadequate Device Protocol

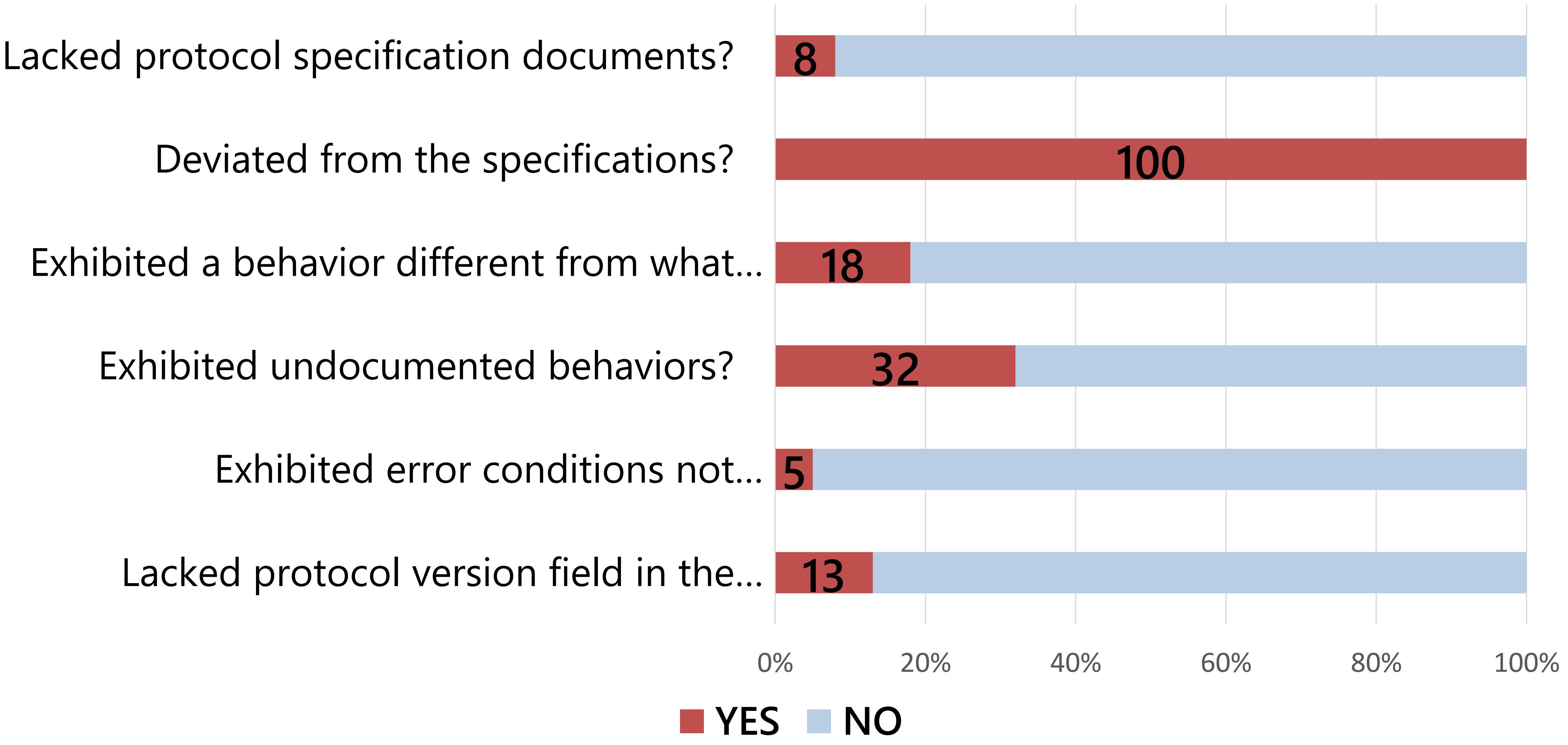




Mirrors the display

No units sent with the data!!

Problem: Adherence to Specifications



Problem: No Standard Communication Protocol

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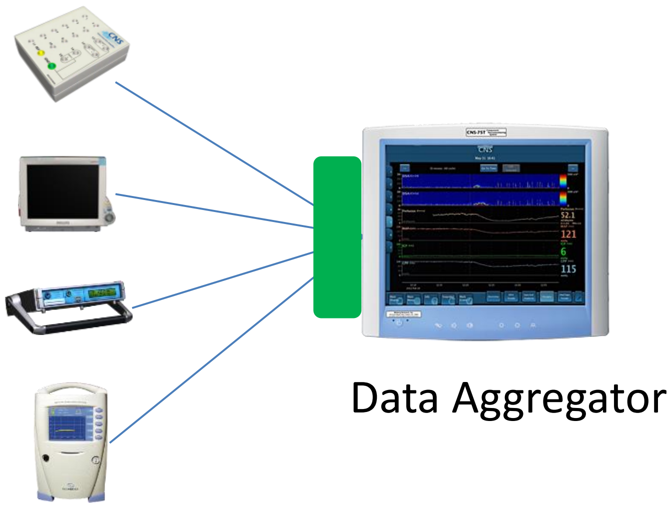
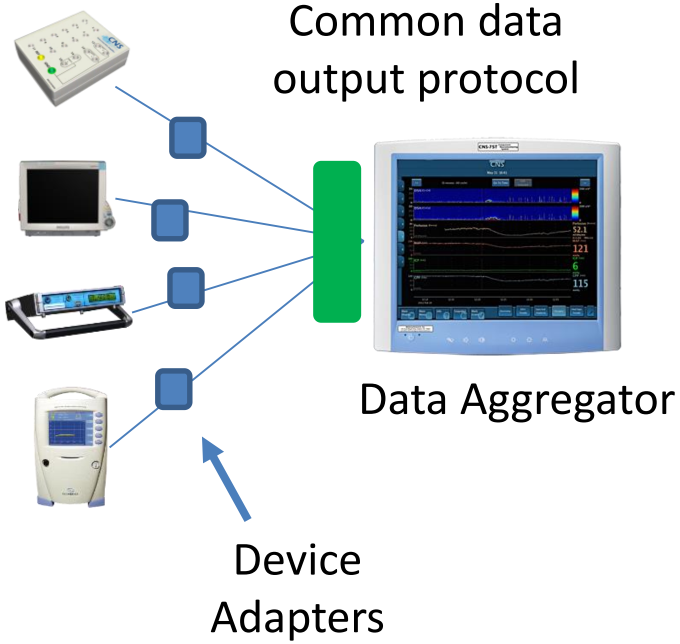
What we want

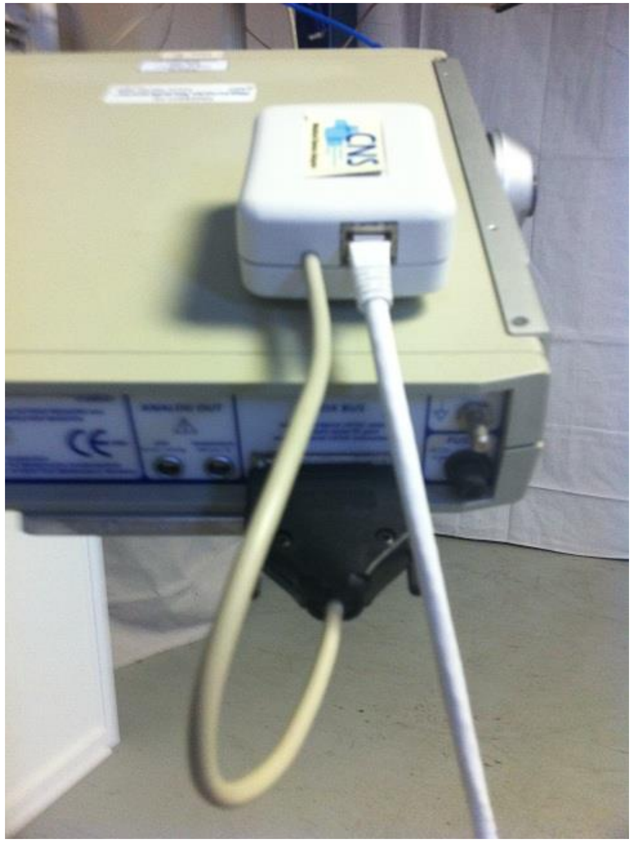


Plug and Play
Just like your PC

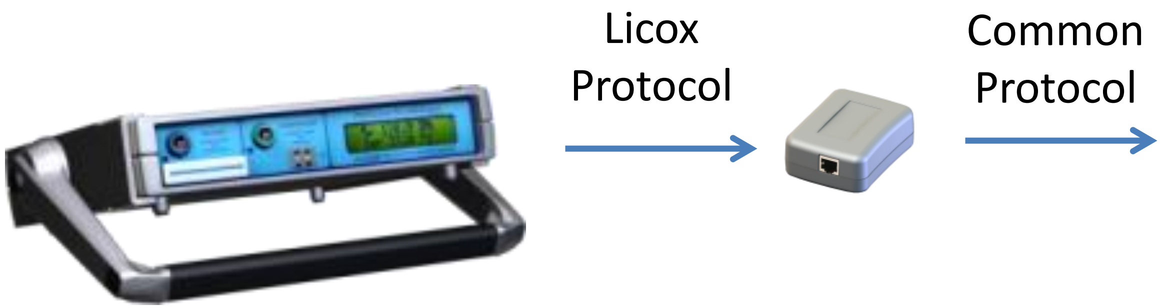
One way to do this



Solution: Device Adapters



Digital Device Adapter



- But…..there was no commercial market for an adapter
  - Unless the market scaled up
- So….it was cheaper for us and for us to write a software driver and for customers to buy just a cable

Lack of Definitive Guidelines

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Traumatic Brain Injury Management Algorithm Consensus Conference
Seattle, Washington
April 5-7, 2019

Still debating what to monitor and how to manage TBI.
RCTs hard to do.
Lack of good evidence.
So reverting to consensus conferences.

Intracranial Pressure in the Medical Record vs. Reality

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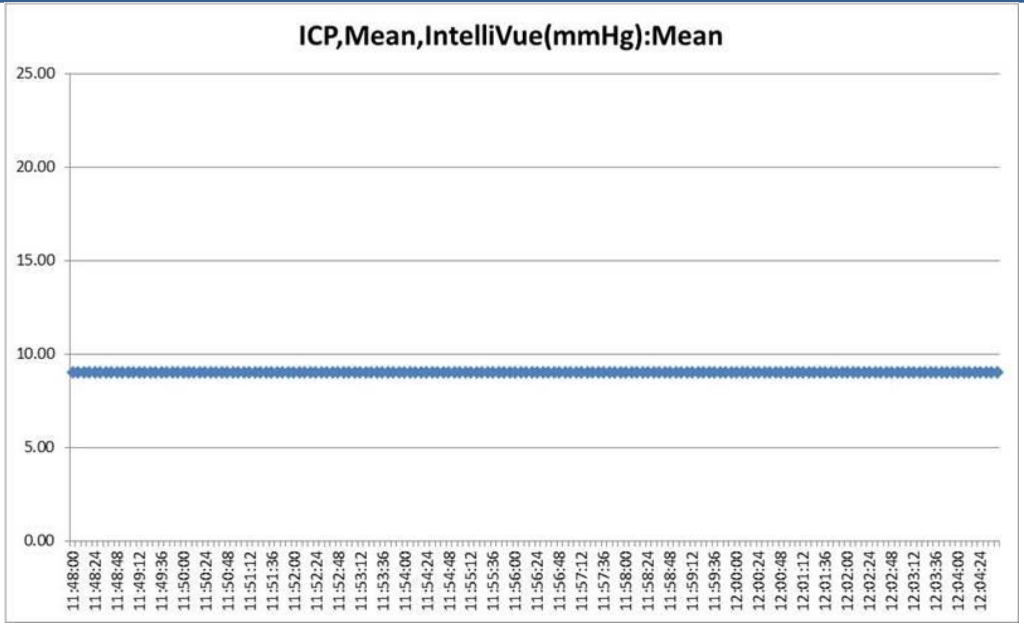
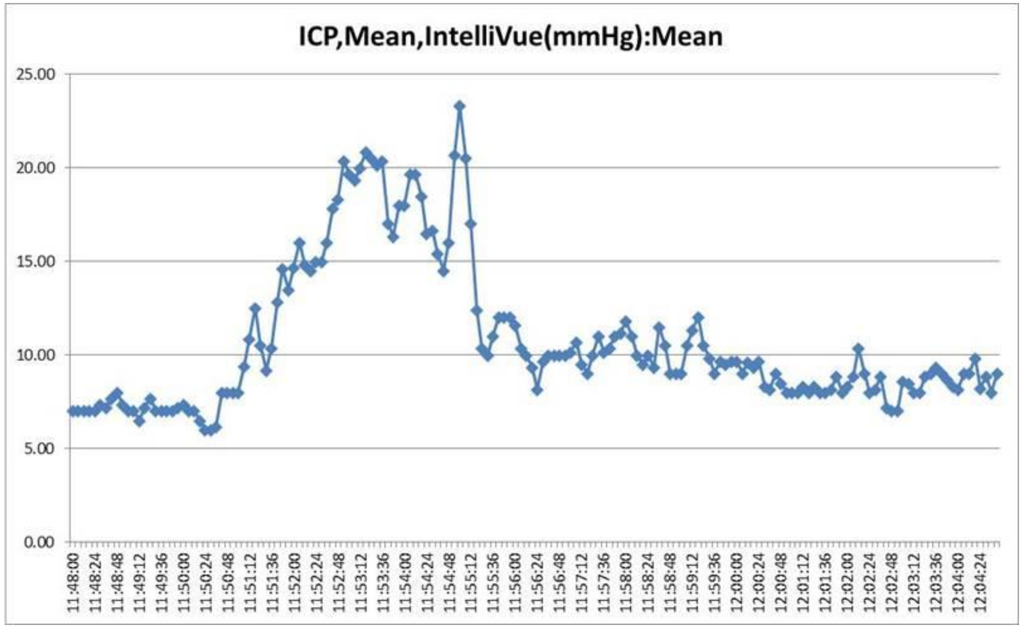
Intracranial Pressure



What the medical record showed

Medical Record



Reality

What really happened.

Courtesy Daiwai Olson, PhD

Medical Record vs. Continuous Monitoring

Total from 34 Patients with Severe TBI

	Incidence of intracranial hypertension (SCM / EMR)	Incidence of intracranial hypertension (CNS Monitor)	Incidence of cerebral hypoperfusion (SCM / EMR)	Incidence of cerebral hypoperfusion (CNS Monitor)
Mean	23.4	63,020.4	22.2	703.0
Median	15	23,553	9.5	264

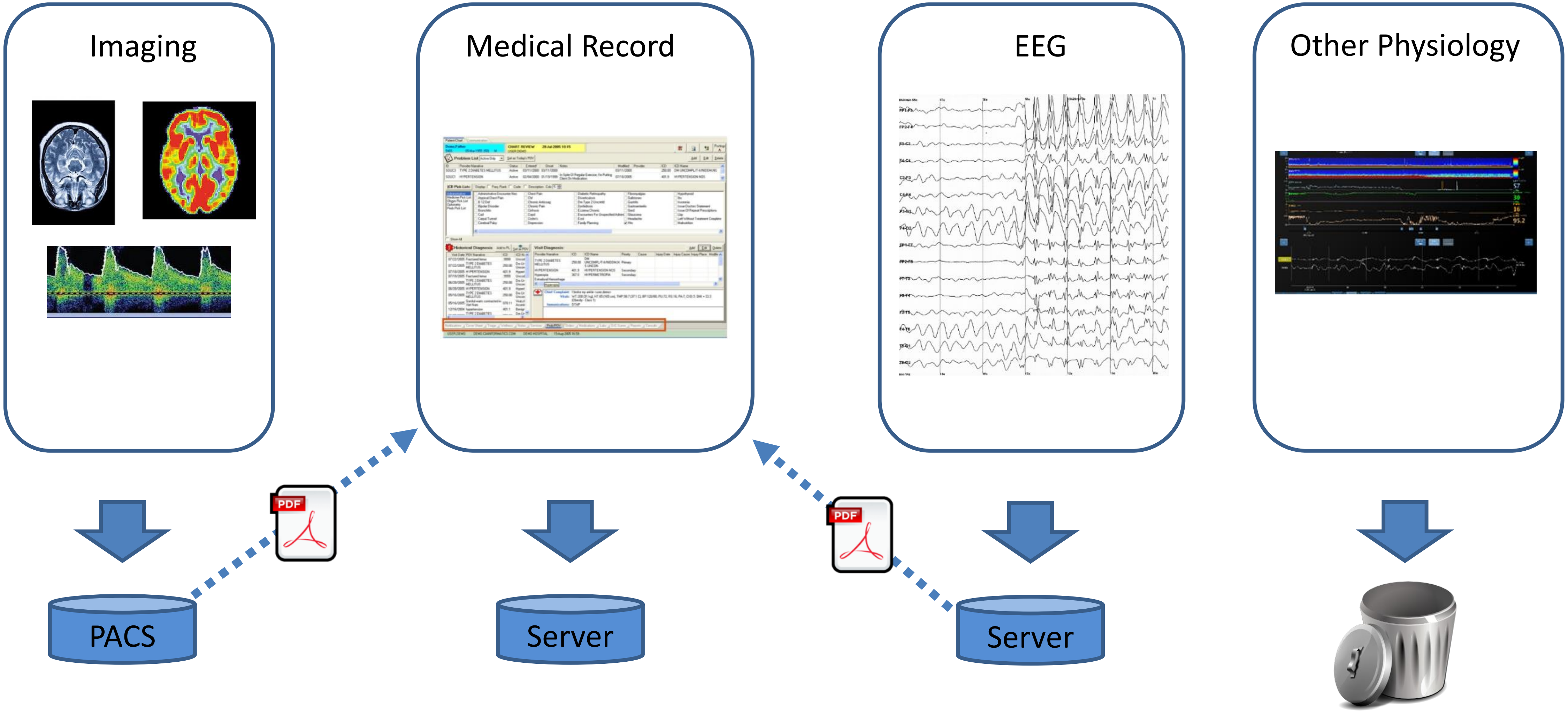
Courtesy Brian Appavu, MD

Problems with Electronic Medical Records

Data in the EMR can be inaccurate, missing, or difficult to obtain.

Data Chaos

Data is not collected in a way that enables further use



Information Technology

The biggest problem we have is dealing with the Information Technology (IT) groups at each hospital

The biggest problem we have is dealing with the Information Technology (IT) groups at each hospital

What we need…

The Apple TV
for Hospital IT

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Current Data Management Tools

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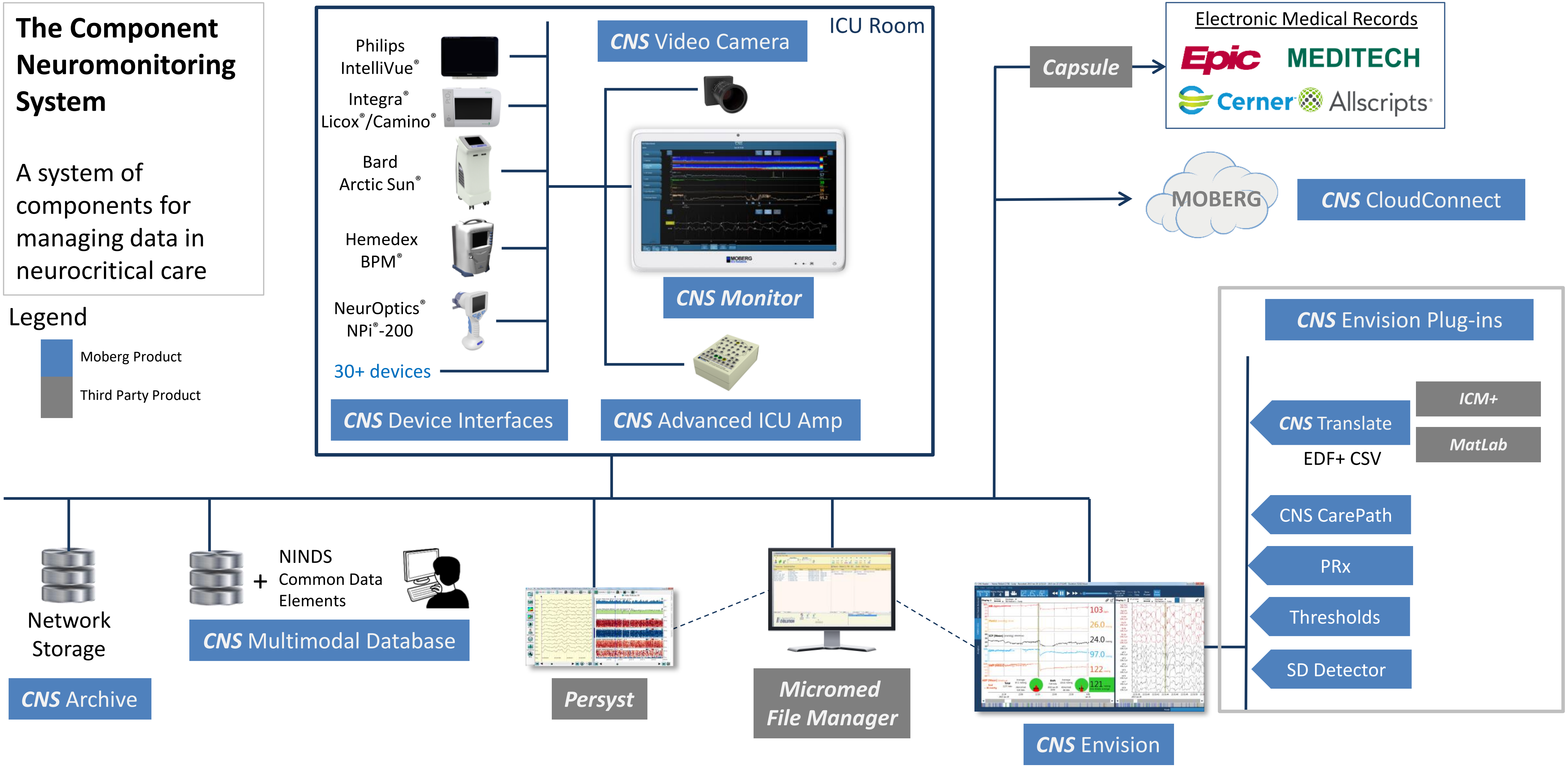
The Component Neuromonitoring System

A system of components for managing data in neurocritical care

Legend

- Moberg Product
- Third Party Product



Group the Technologies

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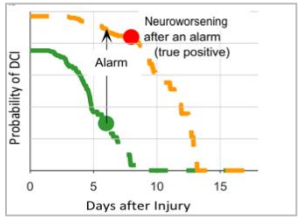
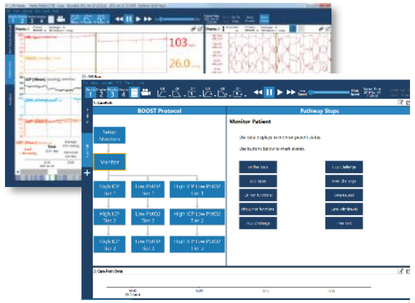
Data Aggregation → **Analytics** → **Visualization Guidance** → **Archiving & Reporting**

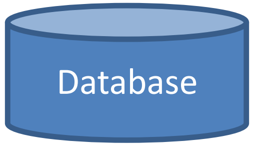
CNS Monitor



Apps



CNS Envision
CNS CarePath



Multimodal Database

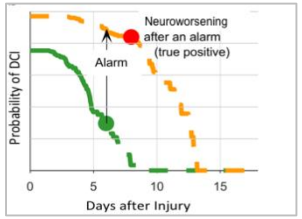
Epic

Envision Reports

Data Aggregation

Data Aggregation → **Analytics** → **Visualization Guidance** → **Archiving & Reporting**

CNS Monitor



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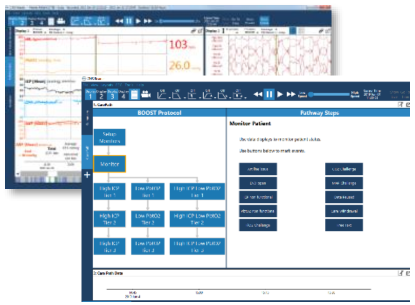
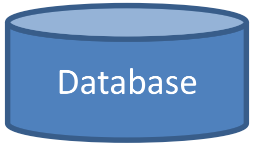


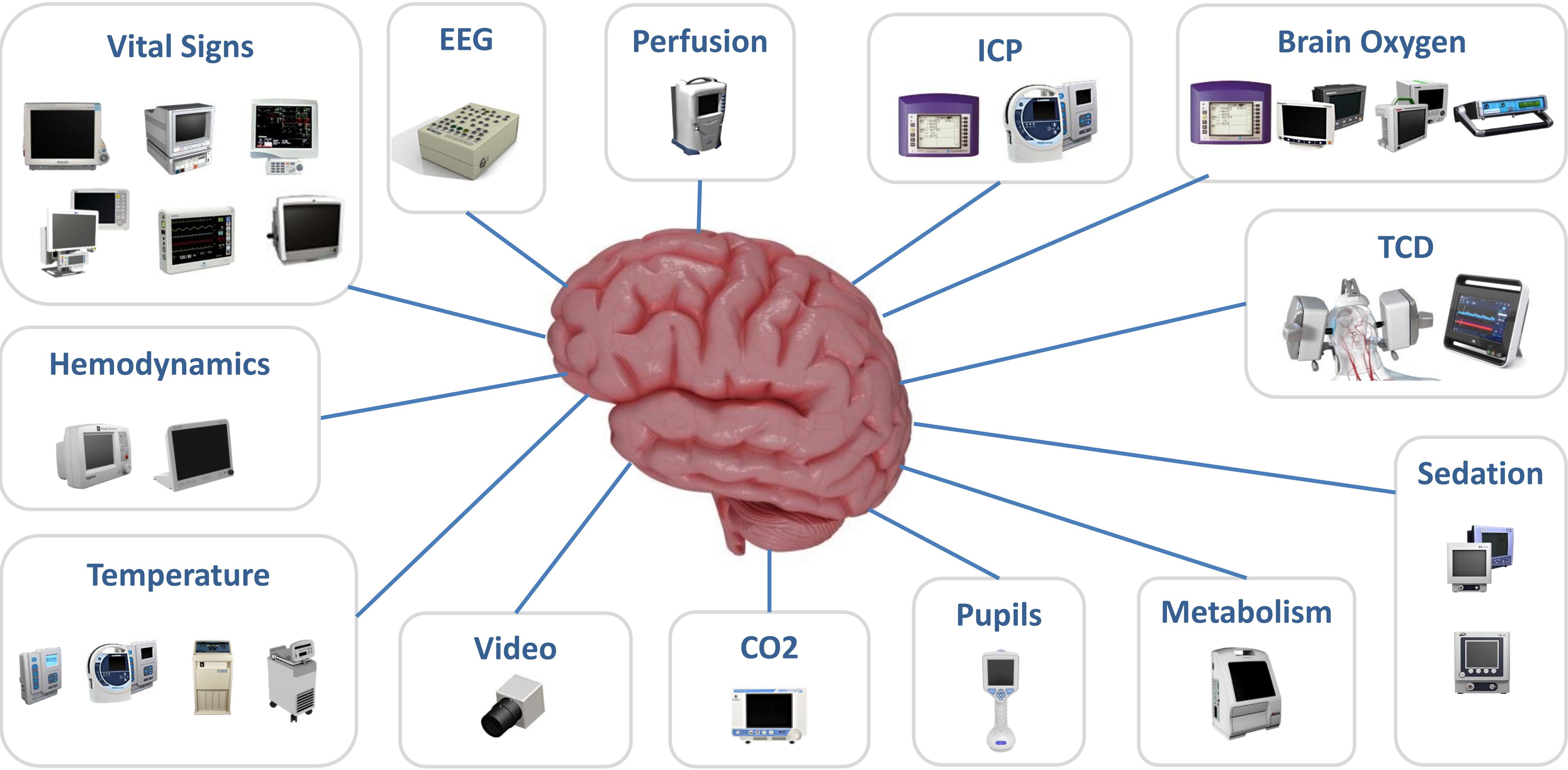
CNS Envision
CNS CarePath



Multimodal Database

Envision Reports

Strength - Device Data Collection



Opportunity - Expanding Data Aggregation

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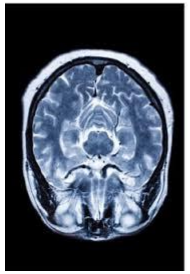
Supported by a grant from the Department of Defense

Time synchronized physiological data

Imaging descriptors



Phenotypic data

Epic

Databases
Common Data Elements

Database

Data

Standards
Nomenclature
Archiving formats
Annotations

Analytics

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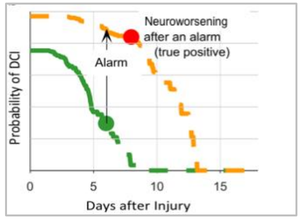
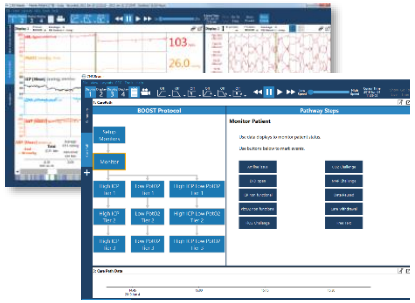
Data Aggregation → **Analytics** → **Visualization Guidance** → **Archiving & Reporting**

CNS Monitor



Apps



CNS Envision
CNS CarePath

Database

Multimodal Database

Epic

Envision Reports

Opportunity – Informatics/Analytics

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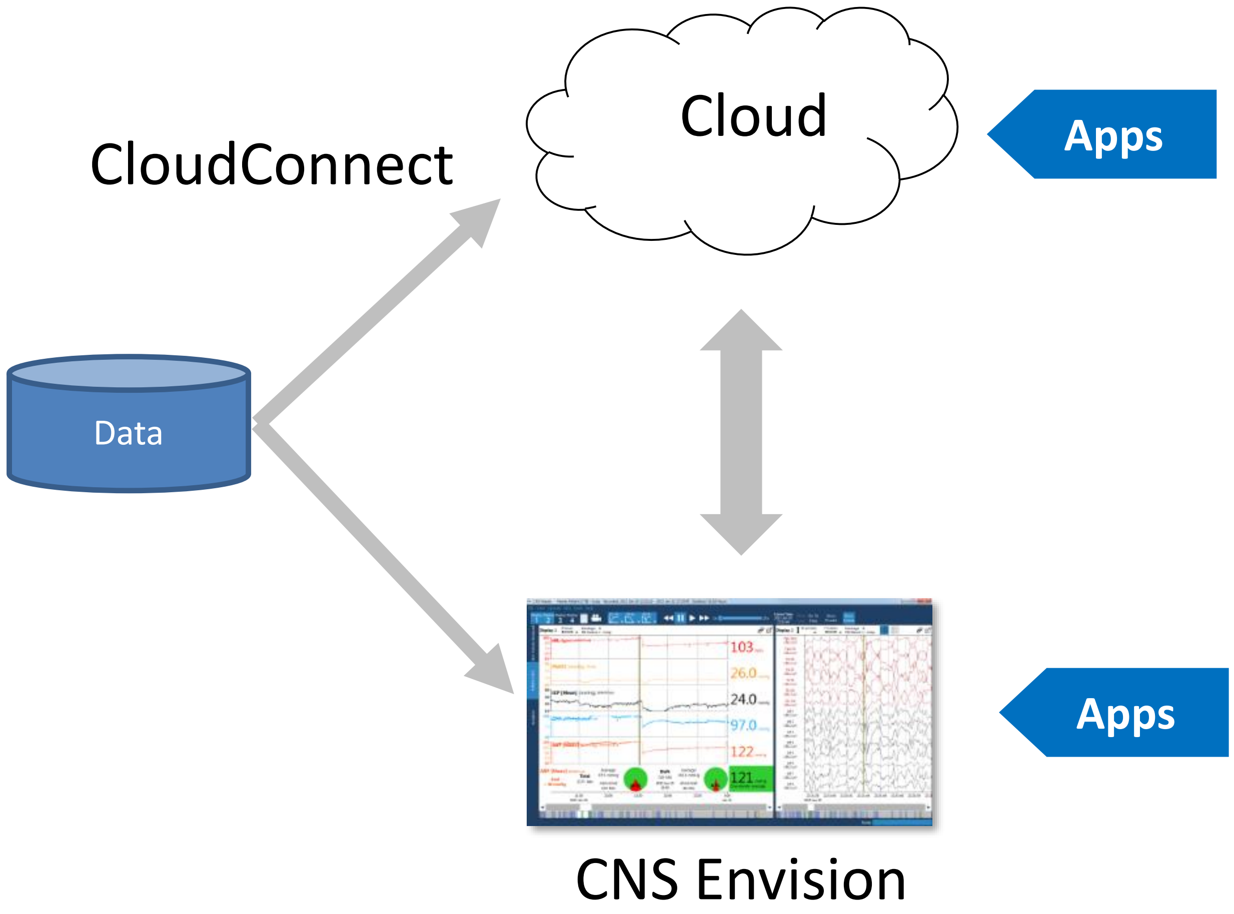
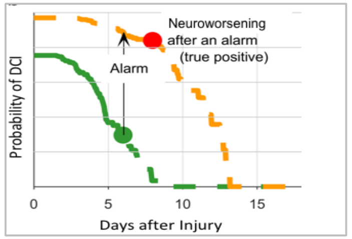
Prediction and detection algorithms based on real-time and retrospective data

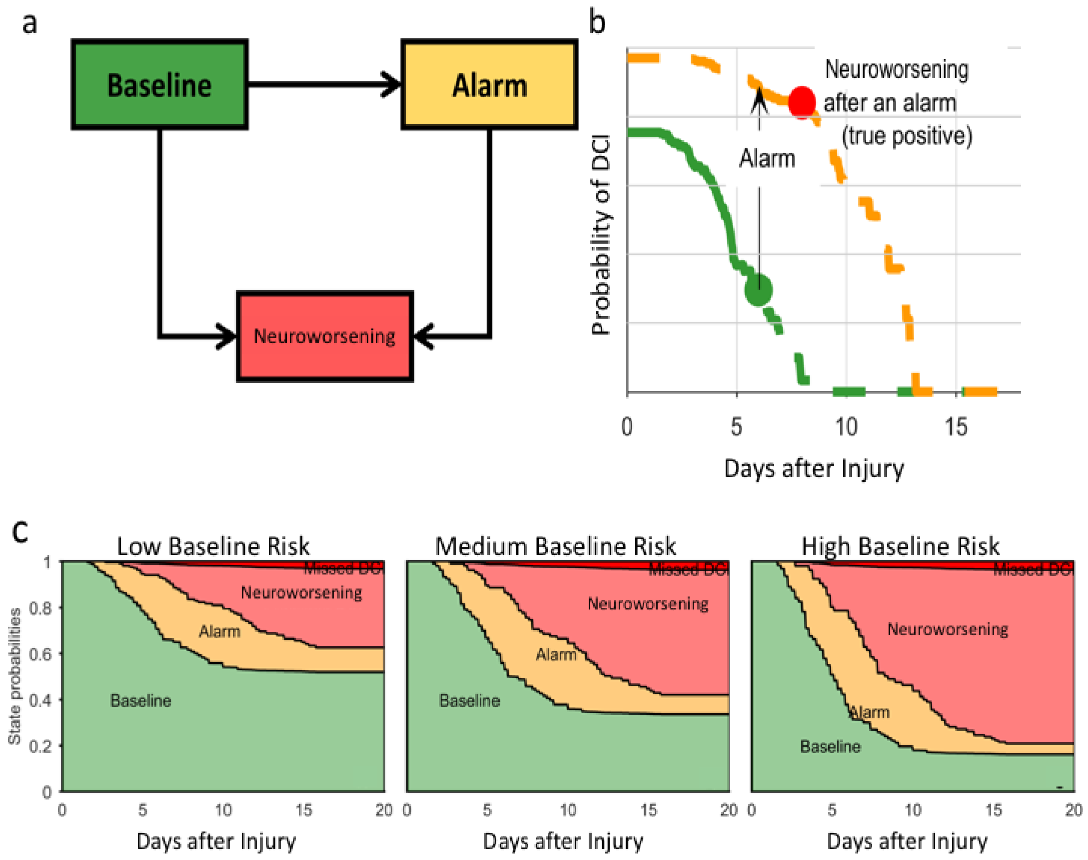


Apps
Data cleaning
Even detection
Prediction
Classification
Machine learning
Data mining



Analytics - Example

Multi-state Predictive Models of Neuroworsening

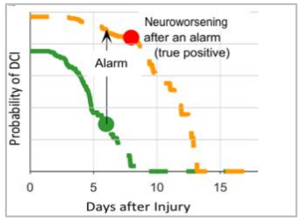


Courtesy Eric Rosenthal, MD, MGH

Visualization and Guidance

Data Aggregation → **Analytics** → **Visualization Guidance** → **Archiving & Reporting**

CNS Monitor



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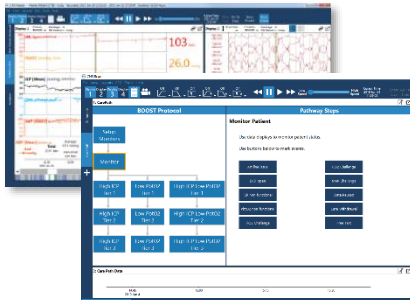

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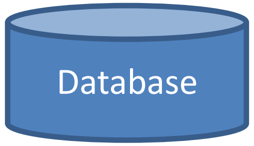
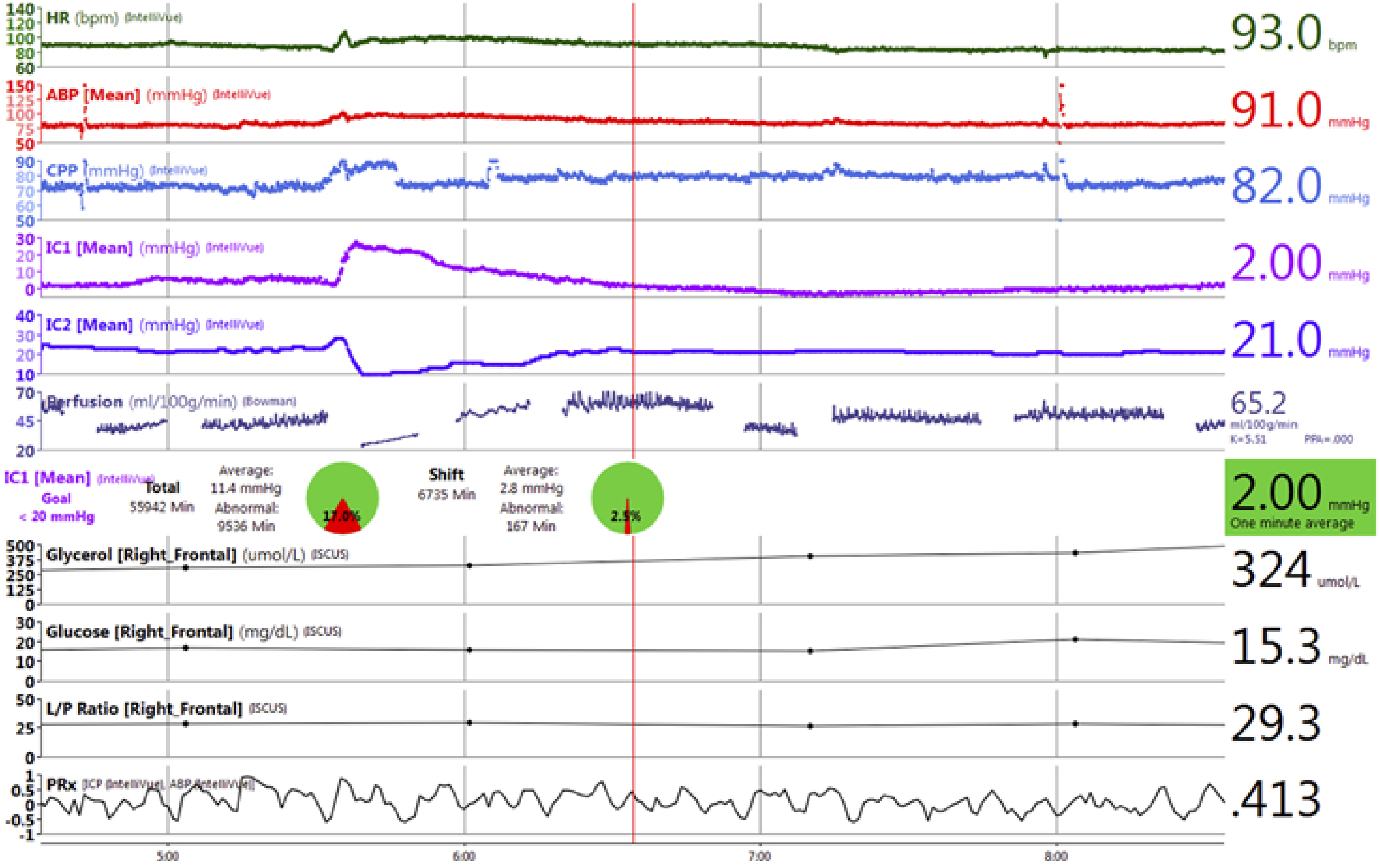


Multimodal Database

Envision Reports

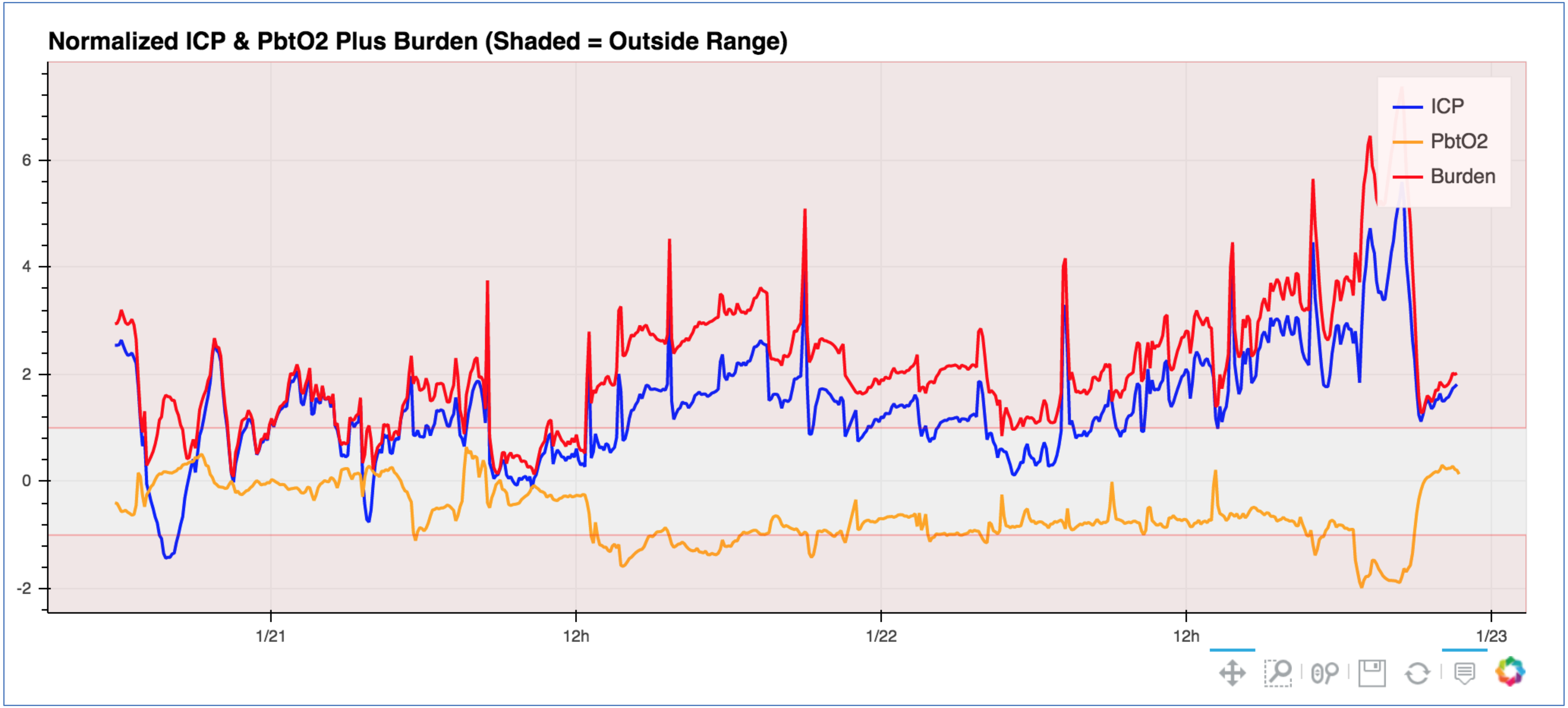
Visualization

Medical Record Using Comprehensive Data



Dr. Ramani Balu
Univ. of Pennsylvania

Threat Mitigation - Burden Scores



Example Dashboard

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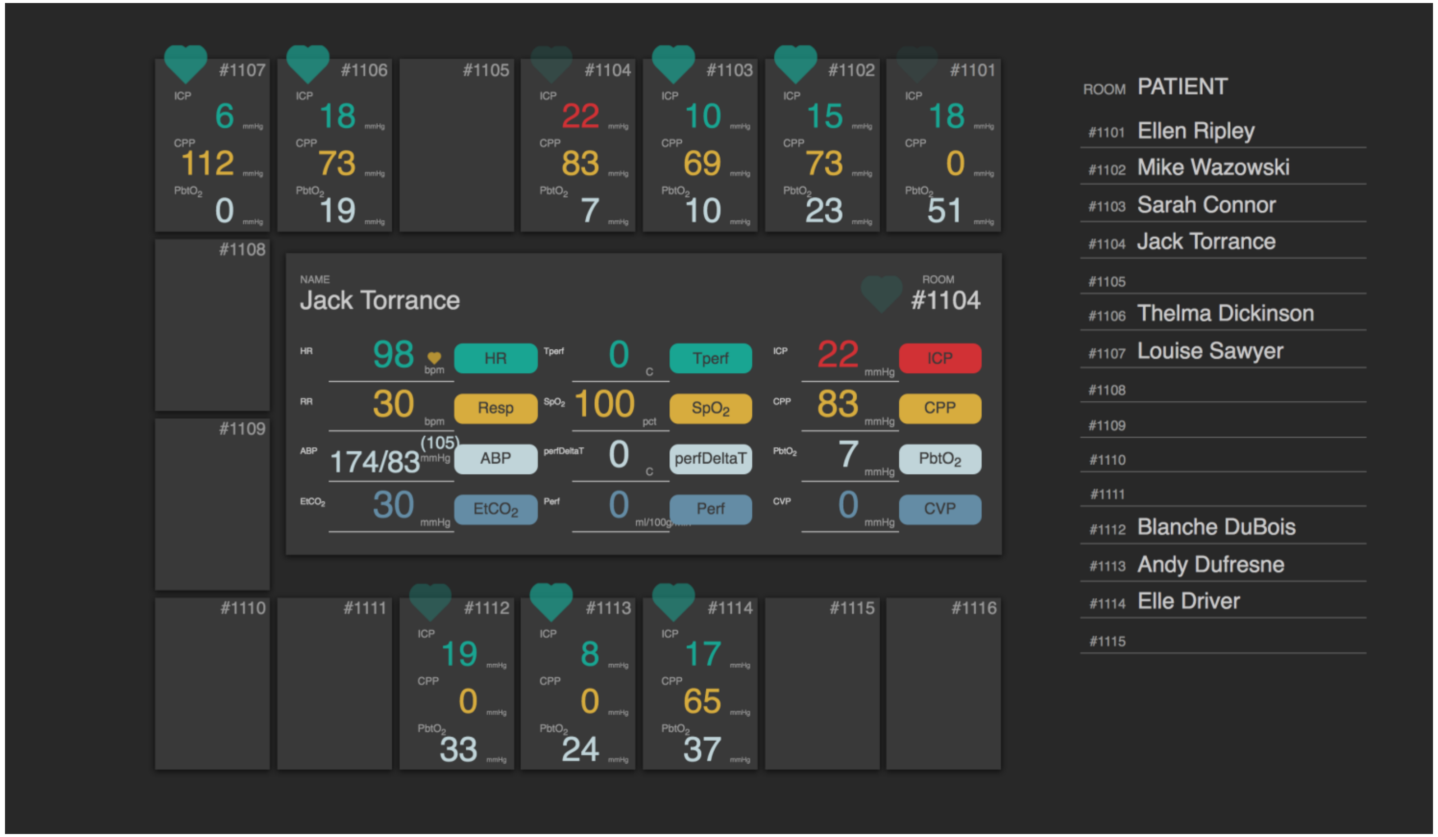
The Problem:

- 72 bed pediatric ICU
- 12 of those patients have neuro issues
- Pediatric neurologist has to individually click into Epic for each patient to get the status

The Solution

- Separate neuro dashboard for subset of patients
- Connects to Epic for some data
- Bypasses Epic for patient review



Floorplan Dashboard

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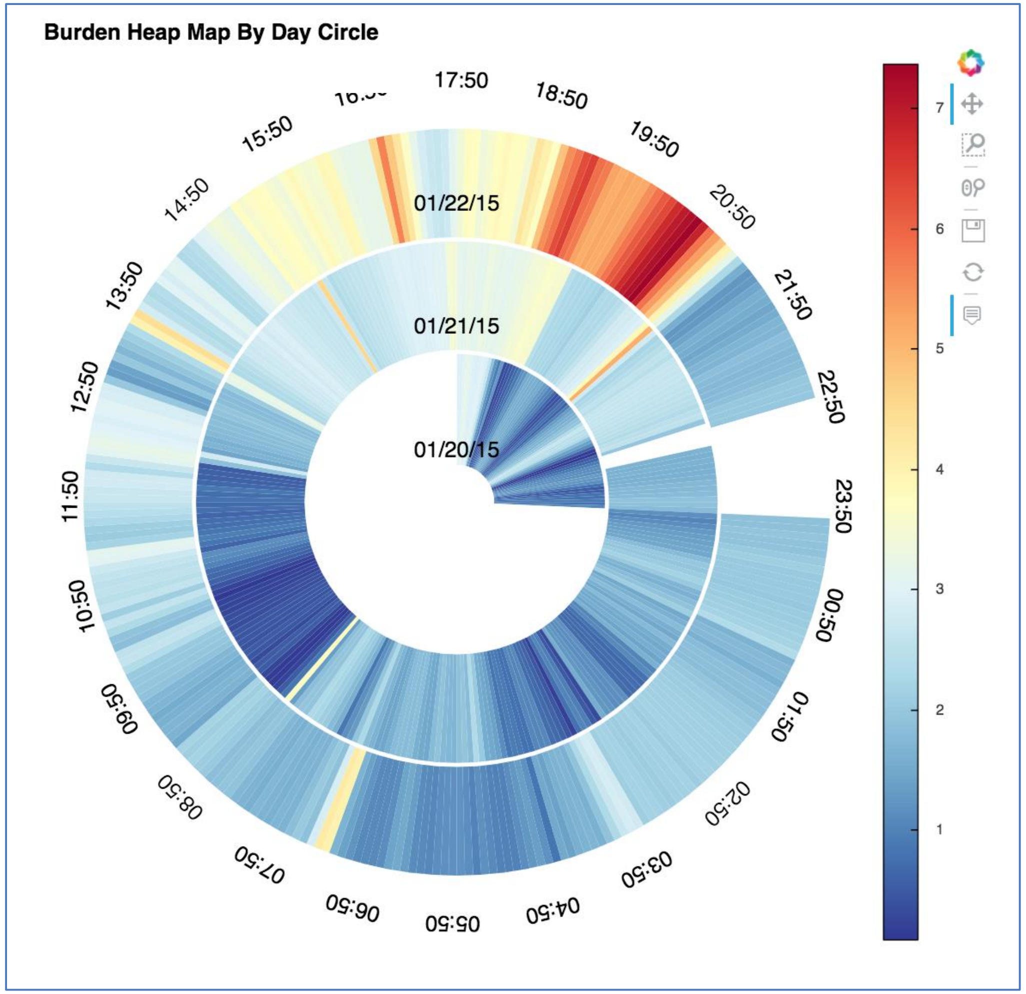
Analytics determine patient state. Circles (size and color) show those requiring urgent care.

Interesting reports – using Big Data Tools

Radial heat map showing daily correlations of ICP burden.



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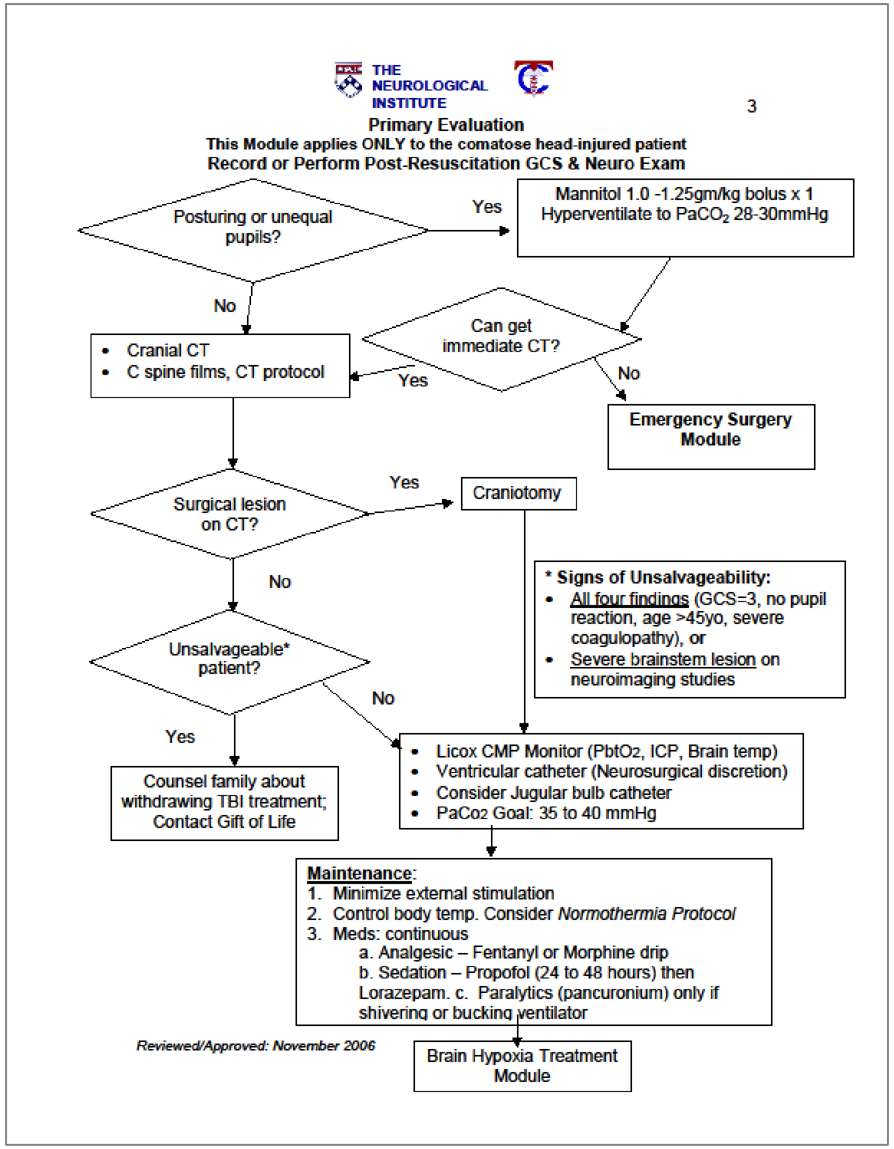
Clinical Pathway

Problems Addressed by CarePath

Compliance to Guidelines/Pathways
Consistency of Care across Providers
Continuous Learning in the ICU
Compiling a Record of Actions



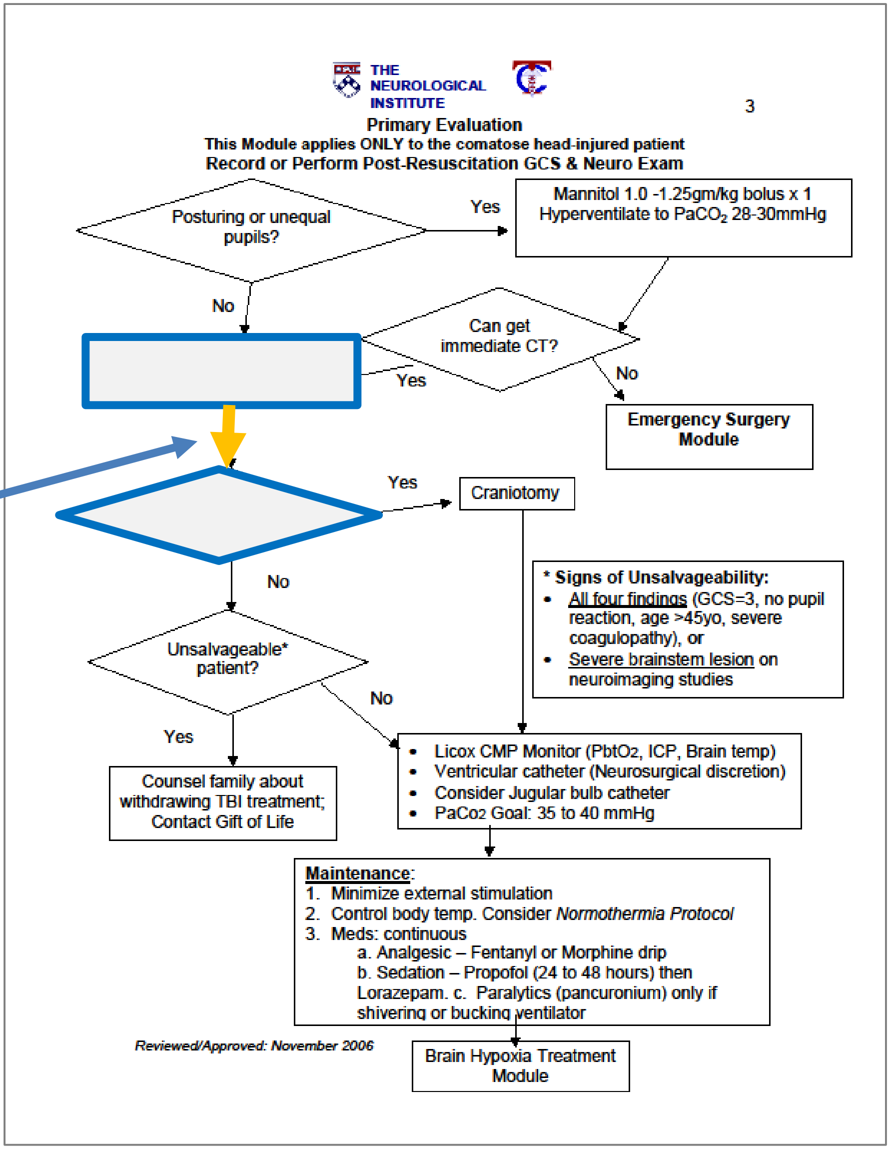
What Does CarePath Do?

MOBERG ICU Solutions

CarePath drives you through a clinical pathway based on changes in a patient's "state".

Patient State

Clinical Pathway



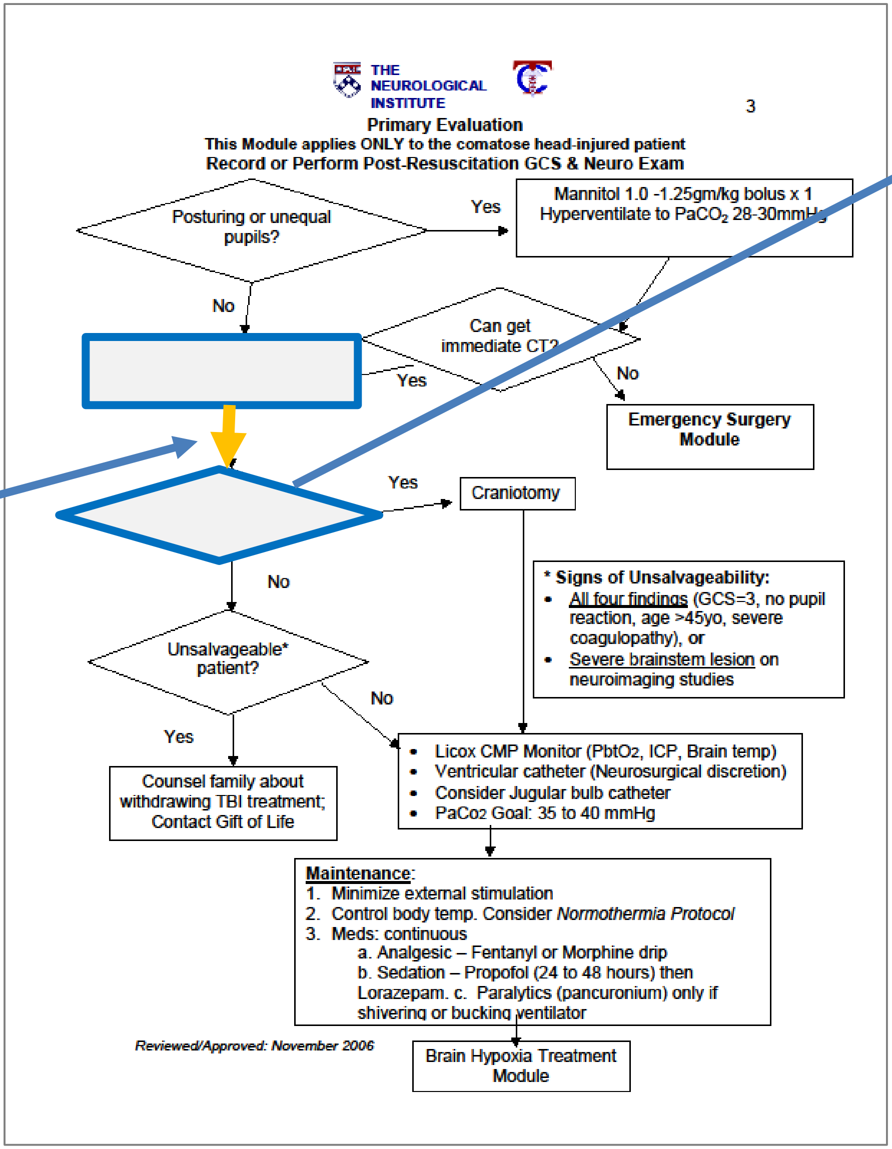
What Does CarePath Do?

MOBERG ICU Solutions

Clinical Pathway

CarePath drives you through a clinical pathway based on changes in a patient's "state".

Patient State



It provides instructions along the way

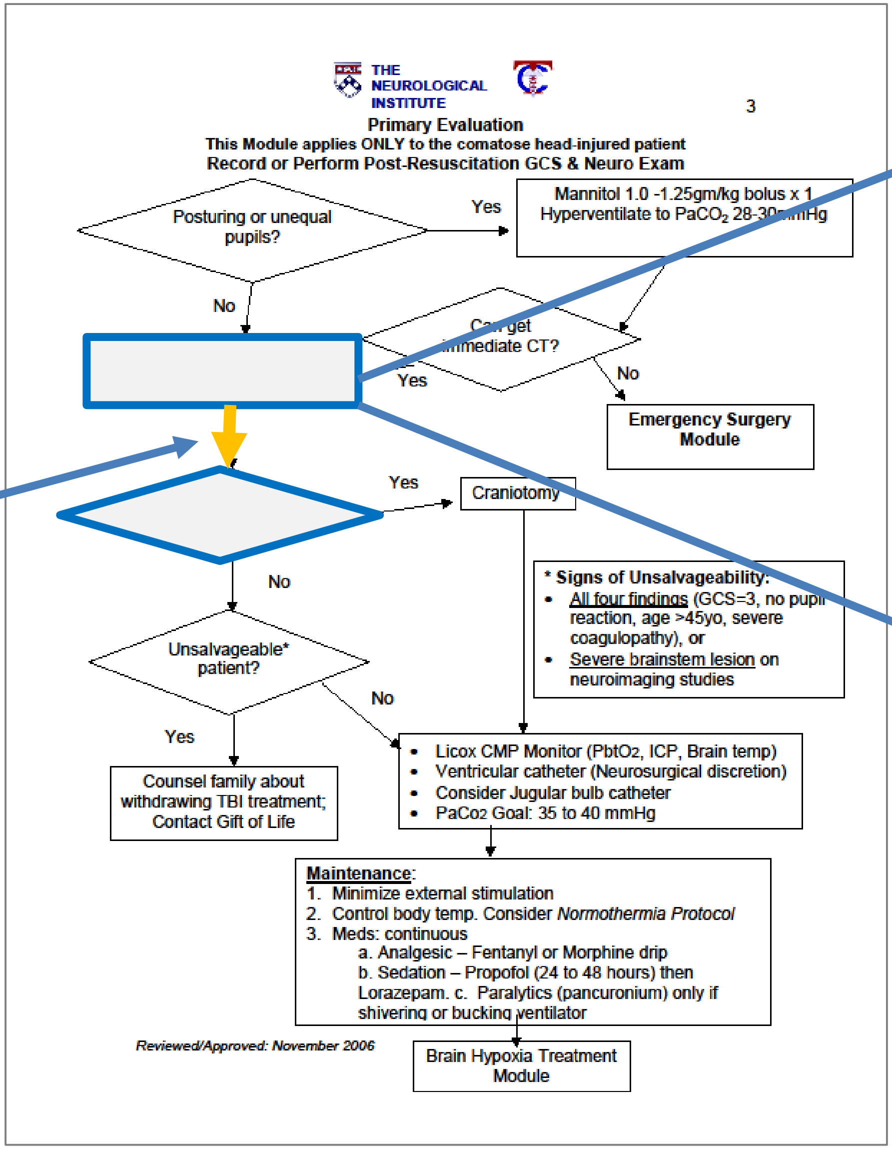
What Does CarePath Do?

MOBERG ICU Solutions

Clinical Pathway

CarePath drives you through a clinical pathway based on changes in a patient's "state".

Patient State



It provides instructions along the way

It provides annotations on what was done

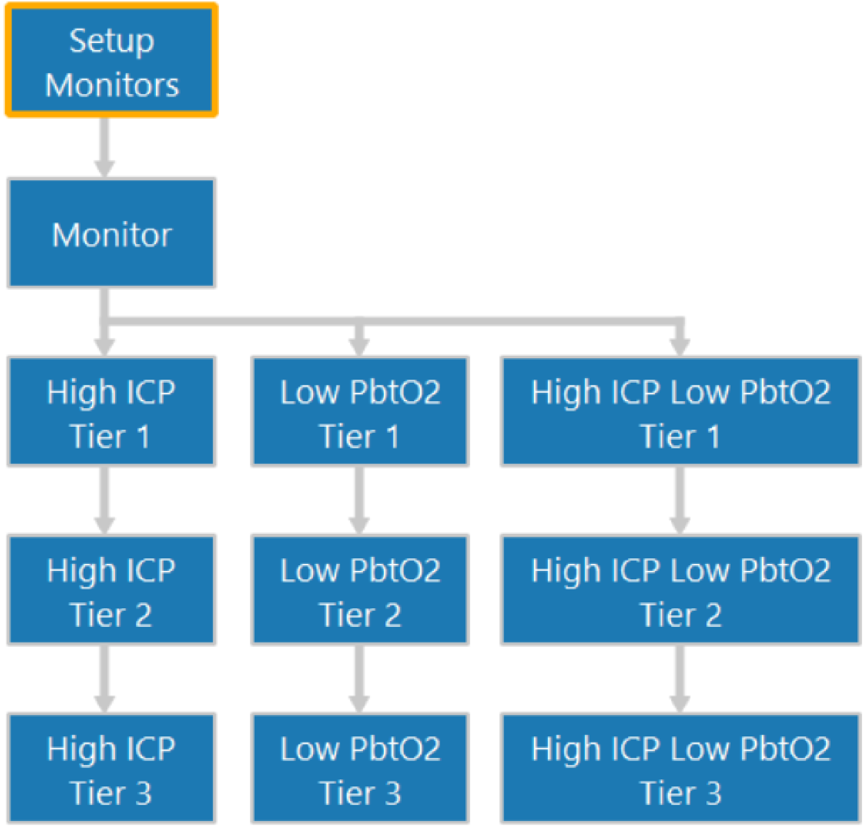
CarePath and BOOST3

CarePath: BOOST3 Protocol

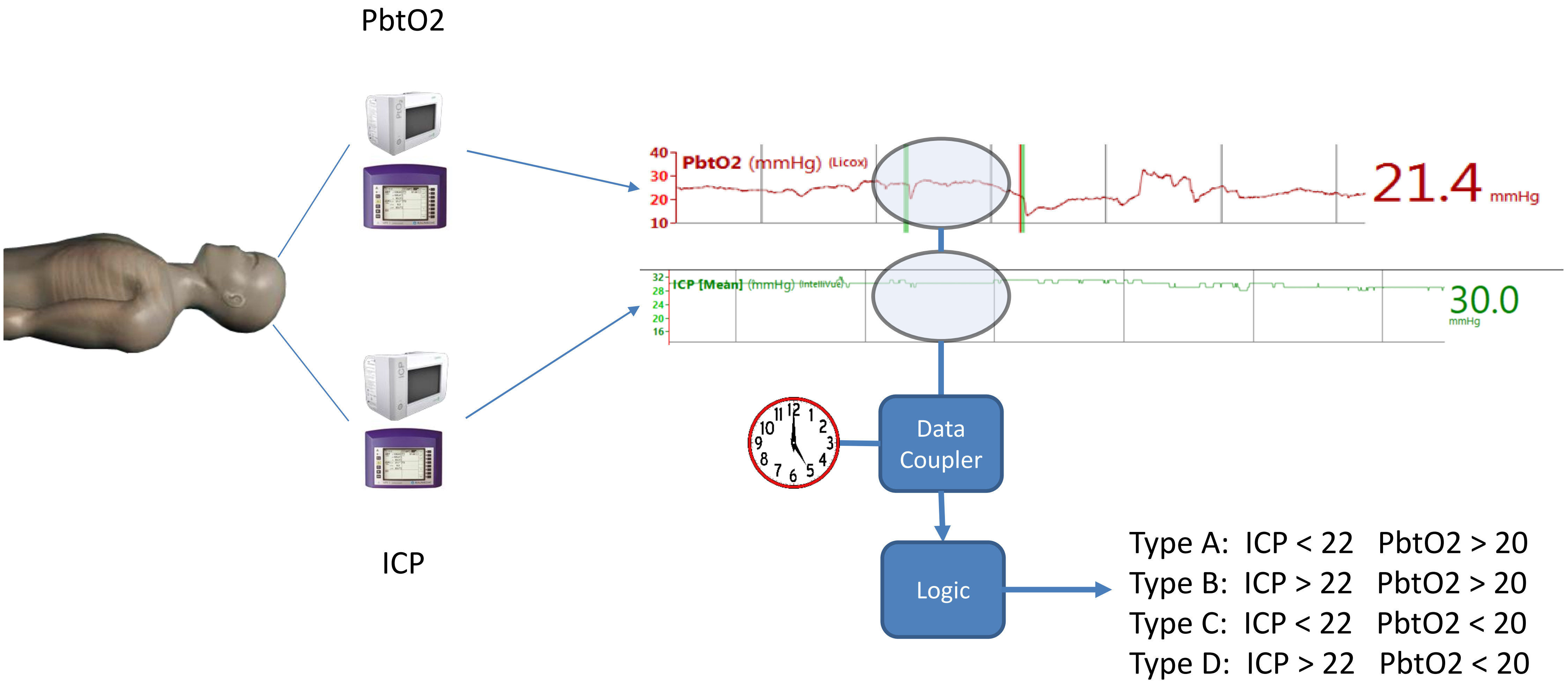
MOBERG
ICU Solutions

BOOST Protocol

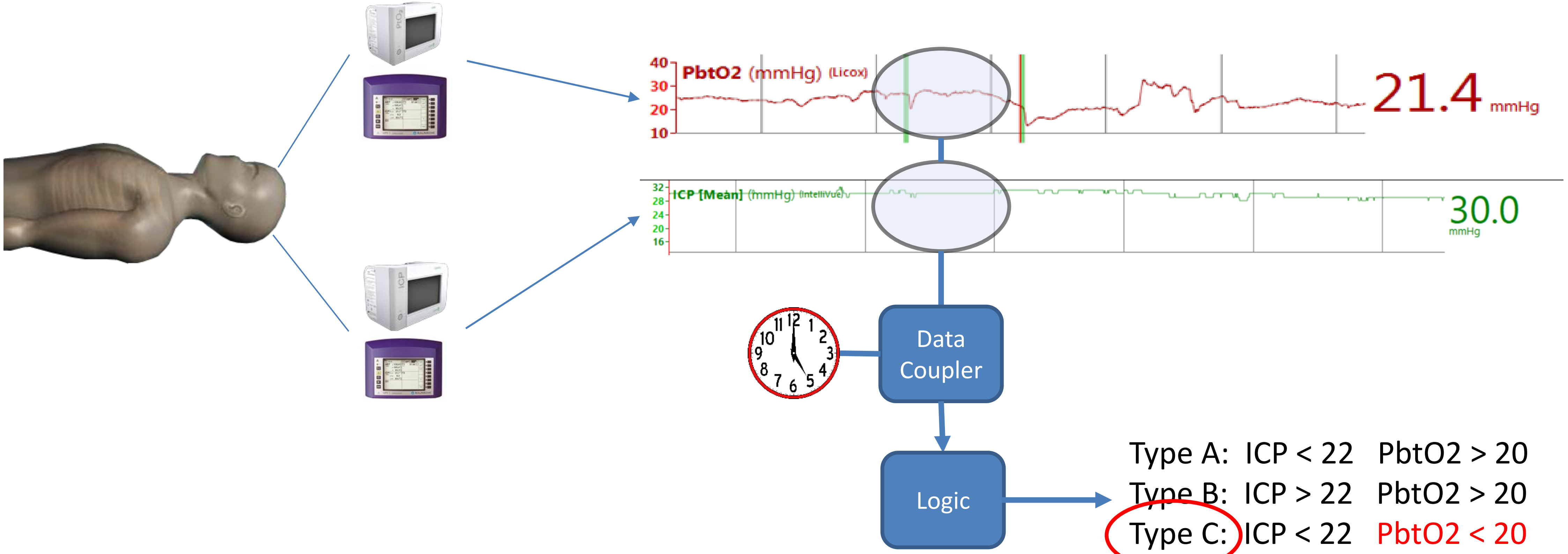
BOOST3 Clinical Pathway



CarePath: Detecting a Patient State

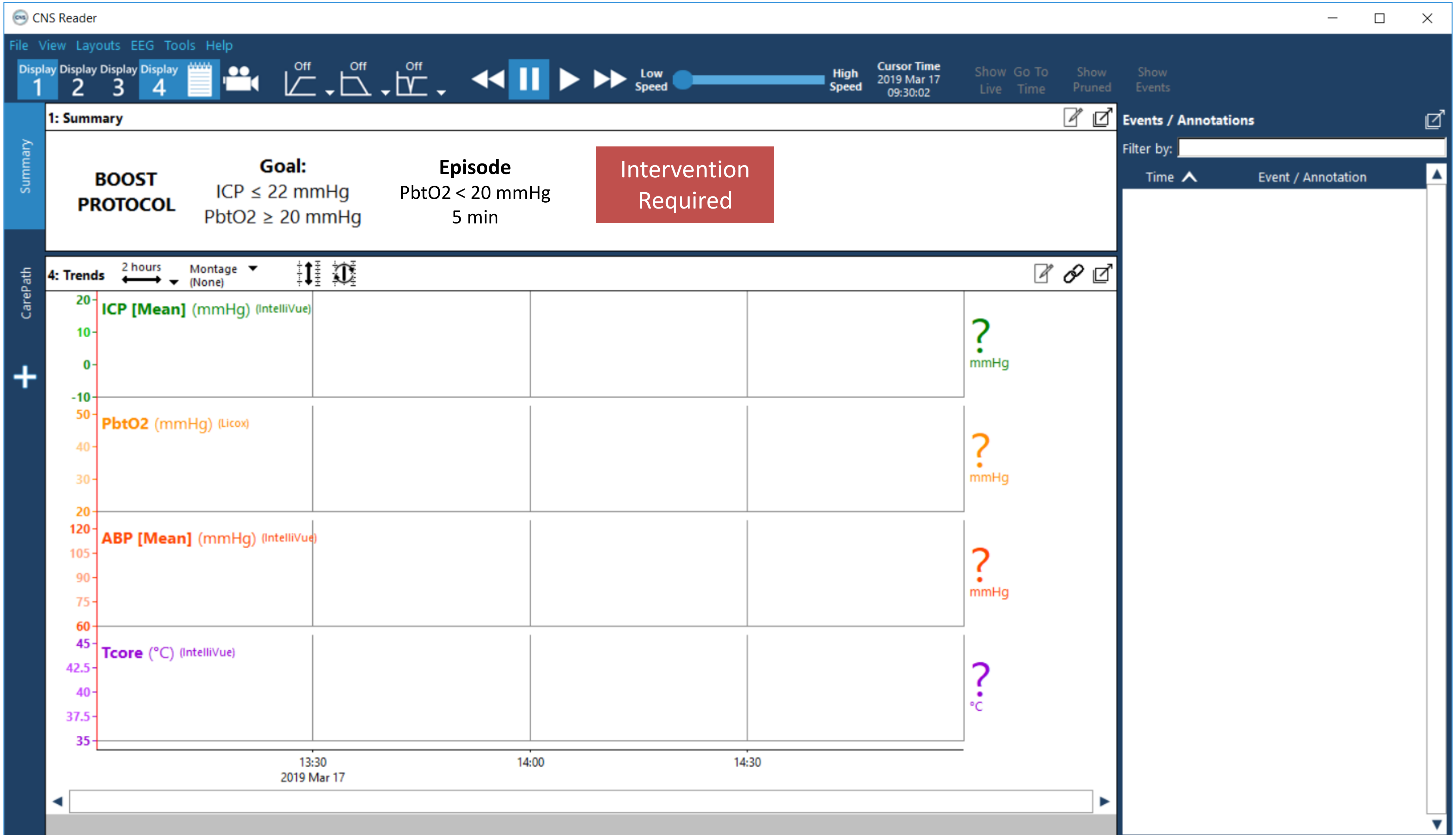


CarePath: Detecting a Patient State



Type A: ICP < 22 PbtO2 > 20
Type B: ICP > 22 PbtO2 > 20
Type C: ICP < 22 PbtO2 < 20
Type D: ICP > 22 PbtO2 < 20

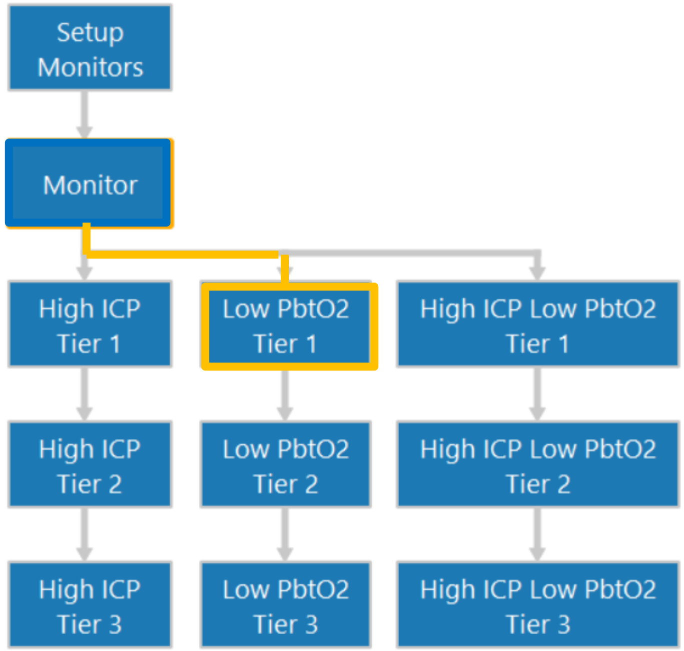
Summary Display



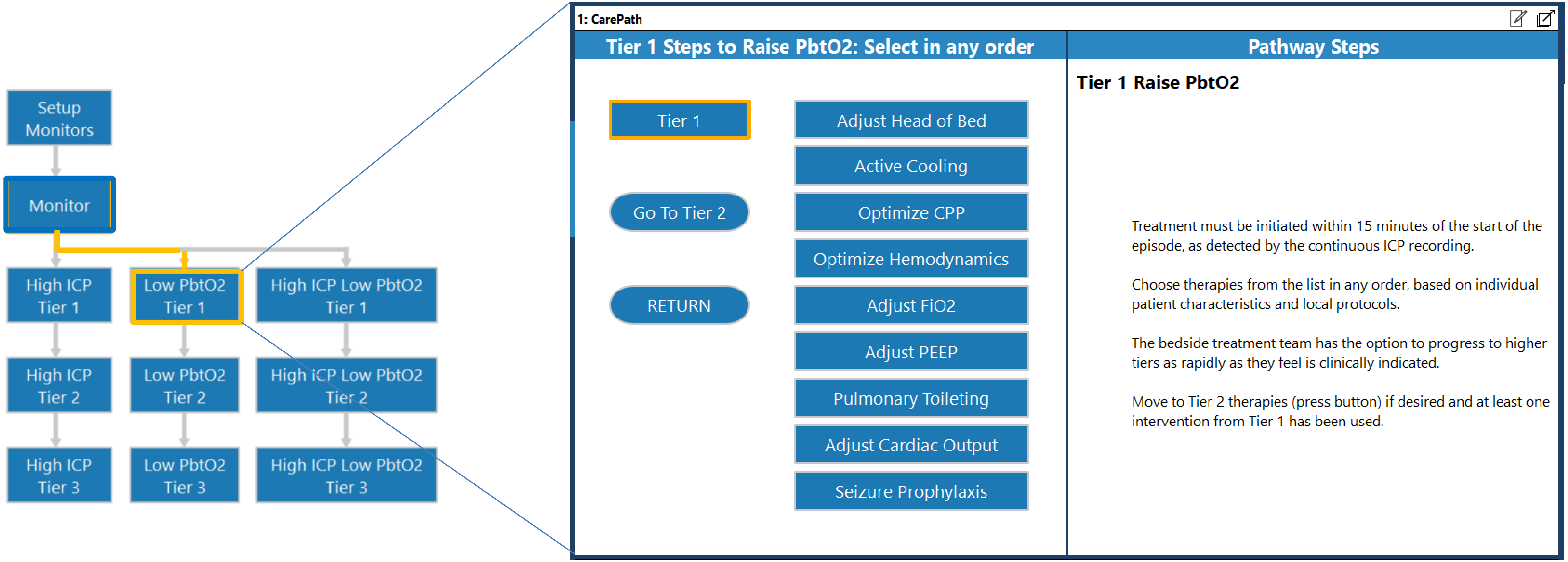
CarePath: Where Am I in the Pathway

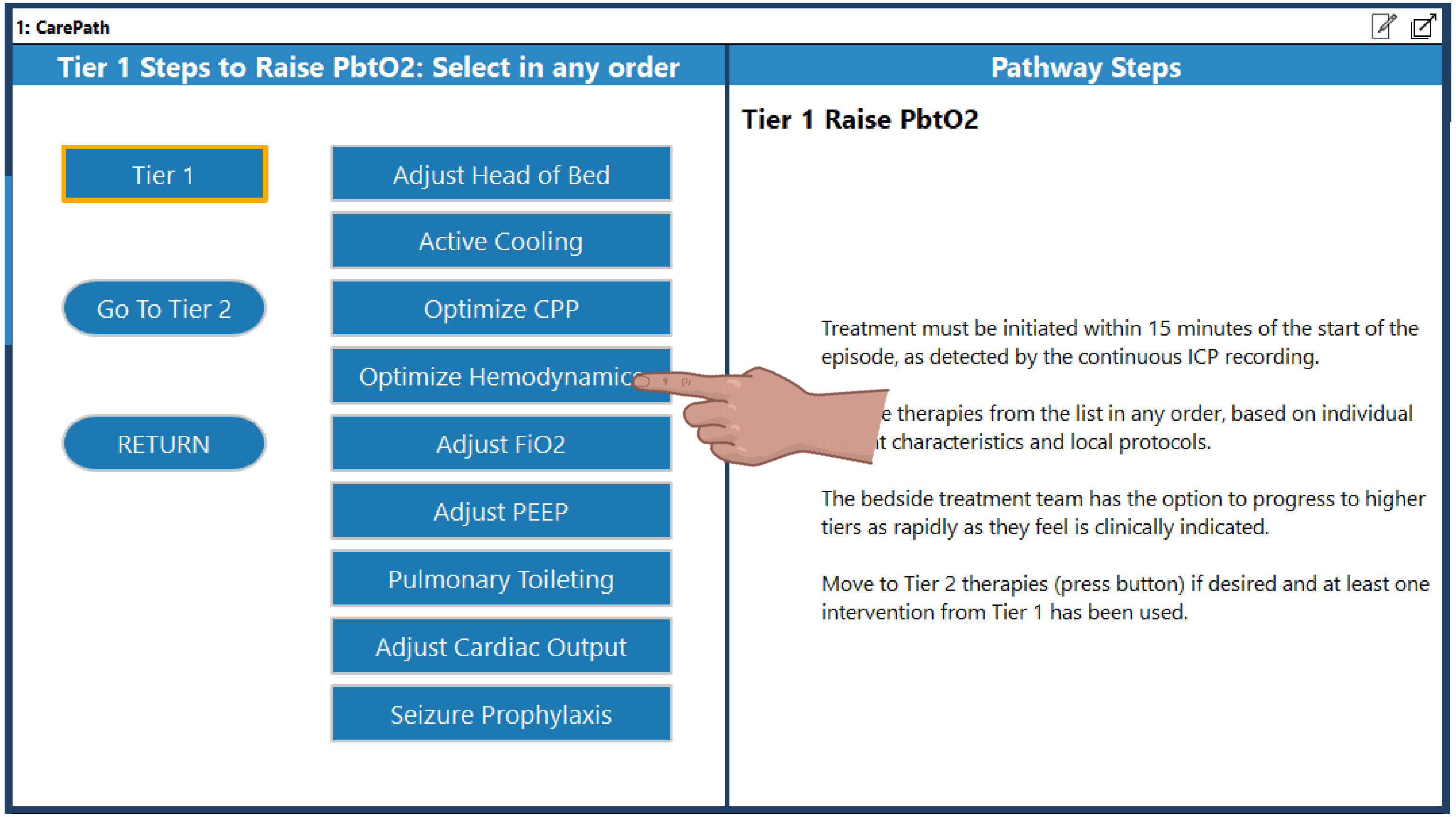
MOBERG ICU Solutions

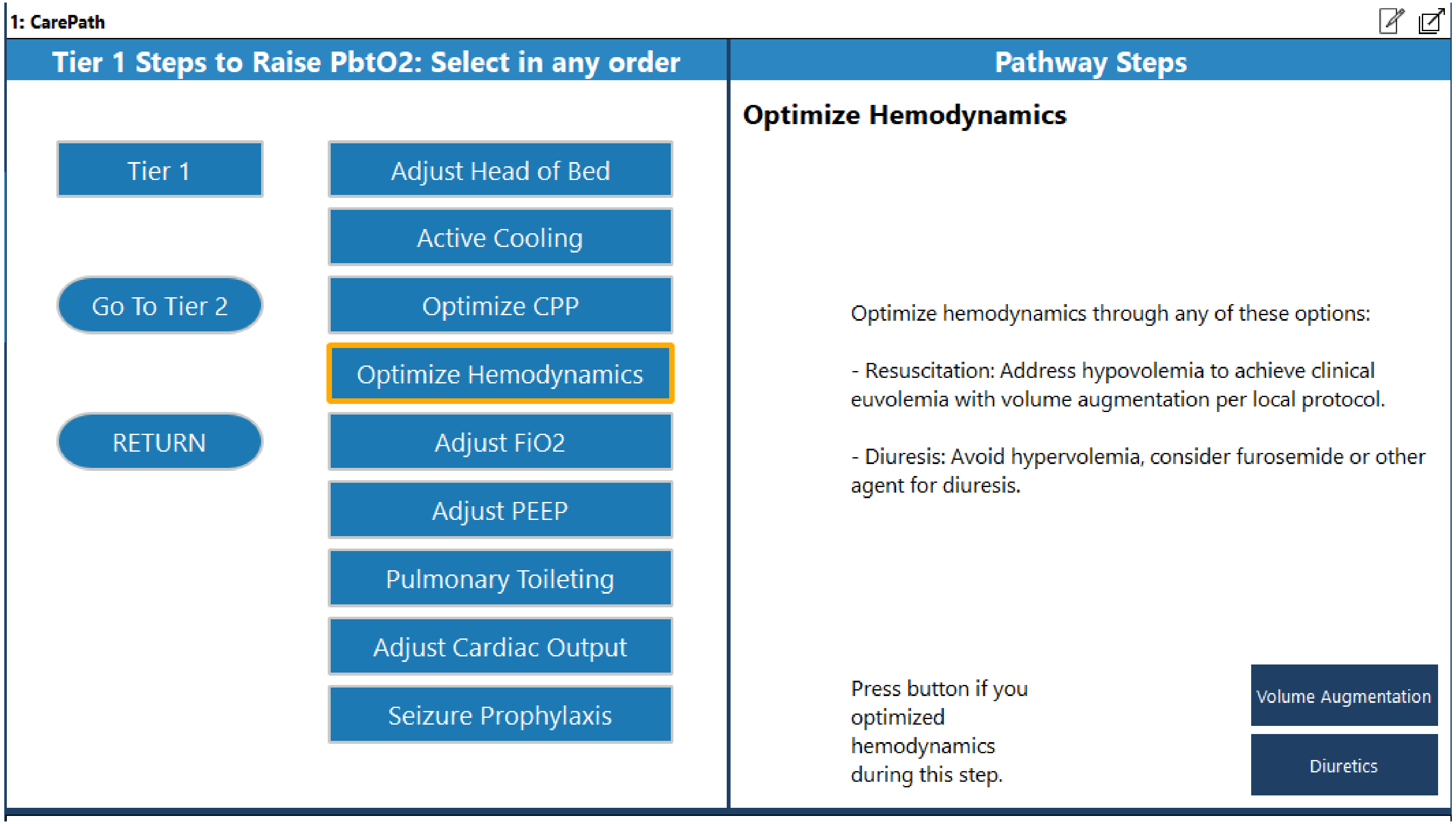
BOOST3 Clinical Pathway



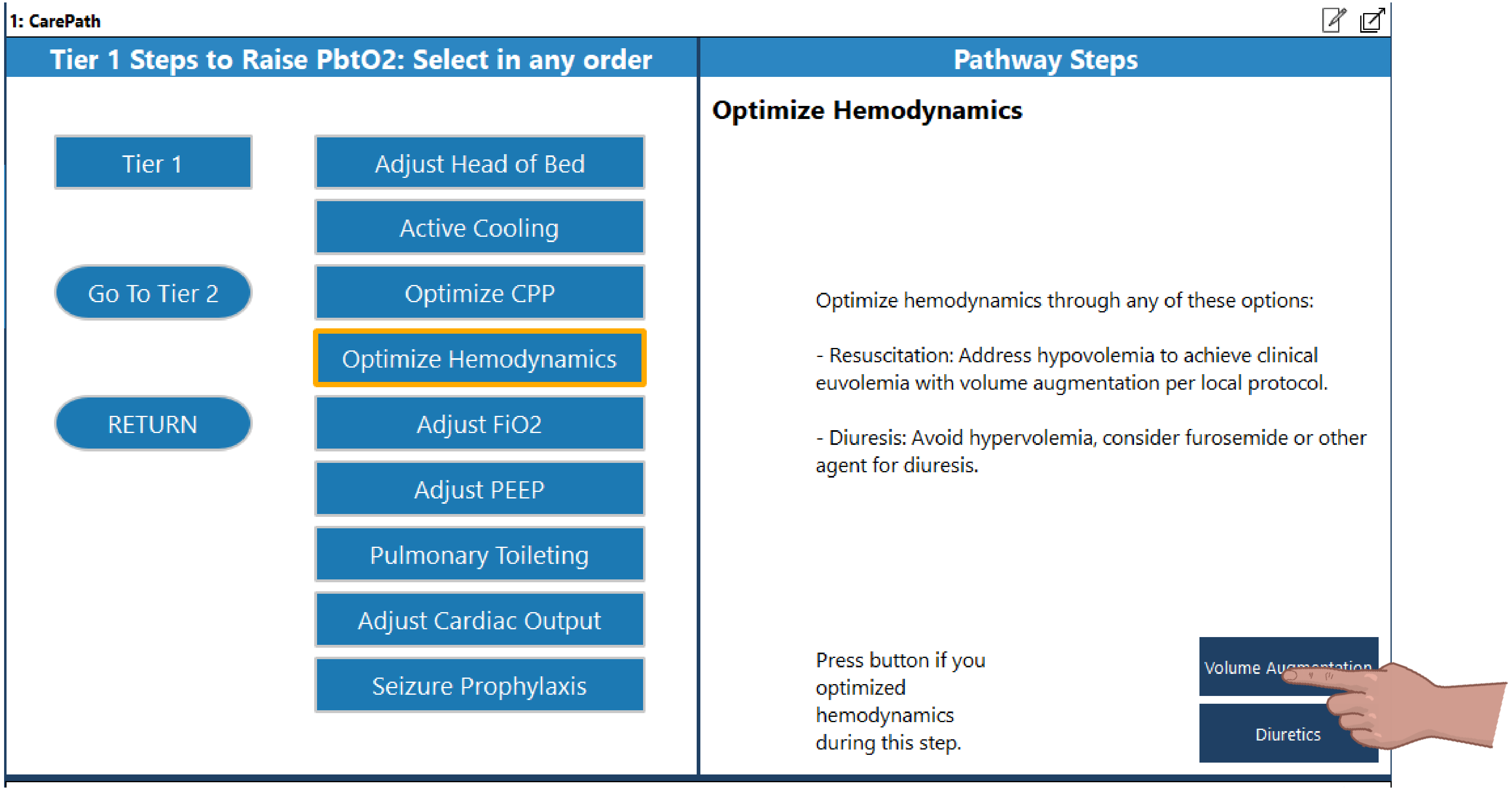
From the BOOST Protocol

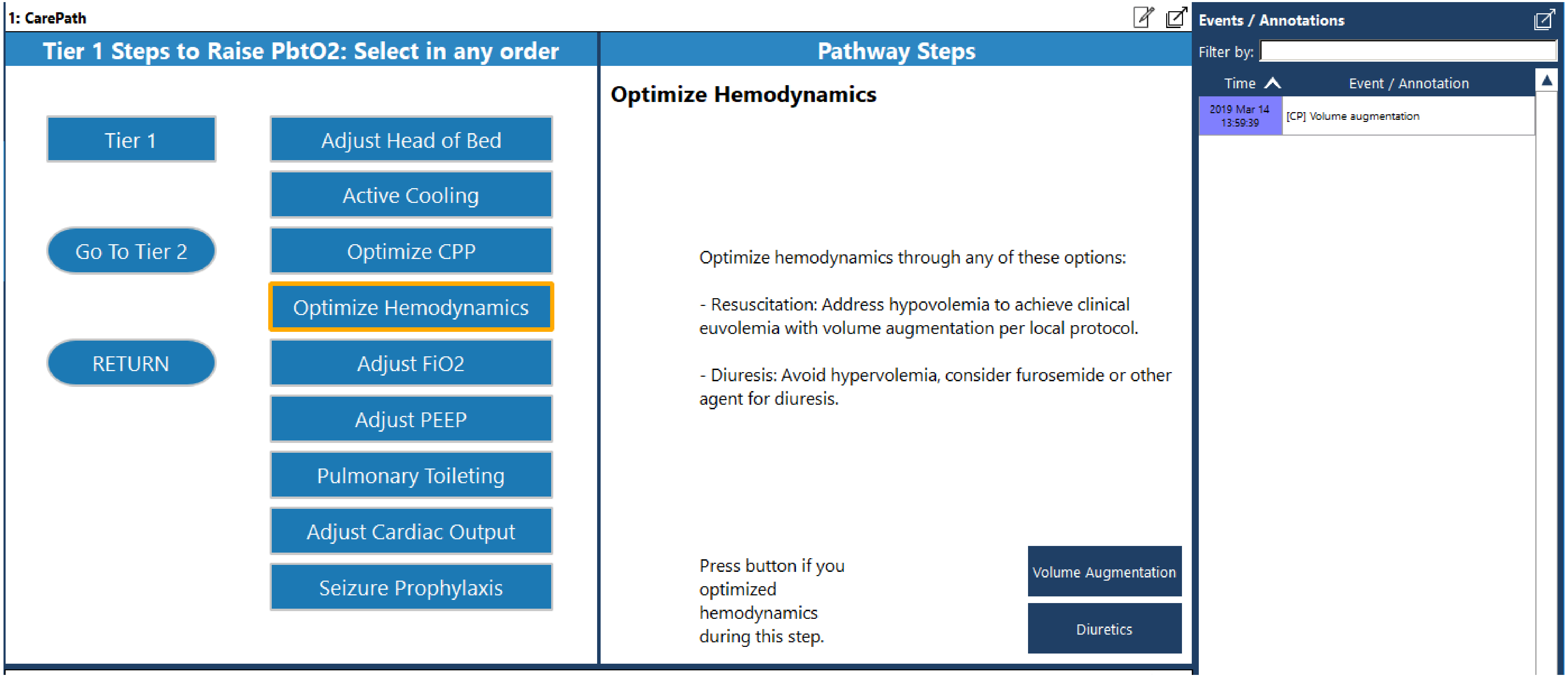



1: CarePath
Tier 1 Steps to Raise PbtO2: Select in any order
Tier 1
Go To Tier 2
RETURN
Adjust Head of Bed
Active Cooling
Optimize CPP
Optimize Hemodynamic
Adjust FiO2
Adjust PEEP
Pulmonary Toileting
Adjust Cardiac Output
Seizure Prophylaxis
Pathway Steps
Tier 1 Raise PbtO2
Treatment must be initiated within 15 minutes of the start of the episode, as detected by the continuous ICP recording.
e therapies from the list in any order, based on individual
it characteristics and local protocols.
The bedside treatment team has the option to progress to higher tiers as rapidly as they feel is clinically indicated.
Move to Tier 2 therapies (press button) if desired and at least one intervention from Tier 1 has been used.



From the BOOST Protocol


1: CarePath
Tier 1 Steps to Raise PbtO2: Select in any order
Pathway Steps
Tier 1
Go To Tier 2
RETURN
Adjust Head of Bed
Active Cooling
Optimize CPP
Optimize Hemodynamics
Adjust FiO2
Adjust PEEP
Pulmonary Toileting
Adjust Cardiac Output
Seizure Prophylaxis
Optimize Hemodynamics
Optimize hemodynamics through any of these options:
- Resuscitation: Address hypovolemia to achieve clinical euvolemia with volume augmentation per local protocol.
- Diuresis: Avoid hypervolemia, consider furosemide or other agent for diuresis.
Press button if you optimized hemodynamics during this step.
Volume Au
Diuretics


1: CarePath
Tier 1 Steps to Raise PbtO2: Select in any order
Tier 1
Go To Tier 2
RETURN
Adjust Head of Bed
Active Cooling
Optimize CPP
Optimize Hemodynamics
Adjust FiO2
Adjust PEEP
Pulmonary Toileting
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Pathway Steps
Optimize Hemodynamics
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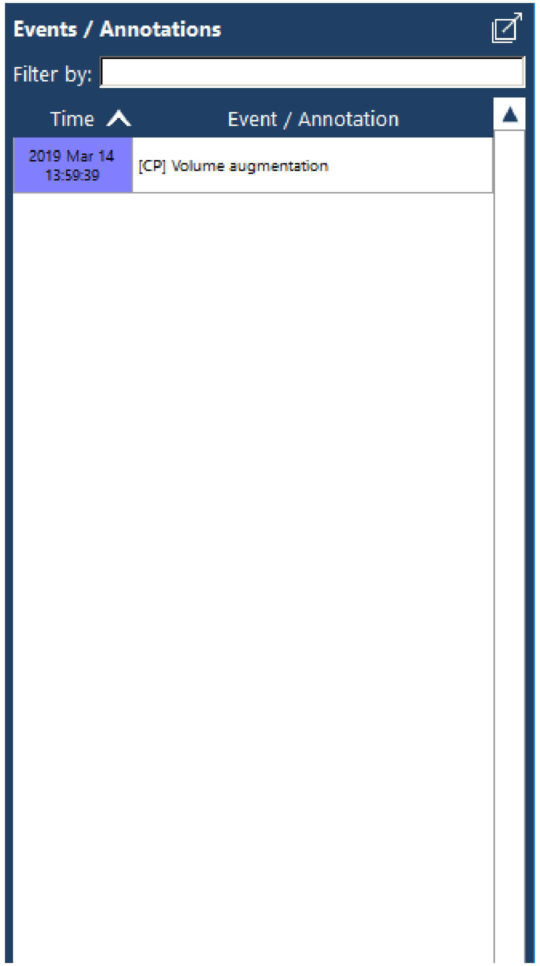
Press button if you optimized hemodynamics during this step.
Volume Augmentation
Diuretics
Events / Annotations
Filter by:
Time
Event / Annotation
2019 Mar 14 13:59:39
[CP] Volume augmentation

A “high resolution” nursing record

Machine learning
Clinical trials



Goals

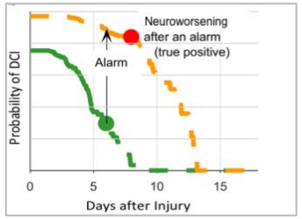
Compliance to Guidelines/Pathways
Consistency of Care across Providers
Continuous Learning in the ICU
Compiling a **Record of Actions**

Archiving and Reporting

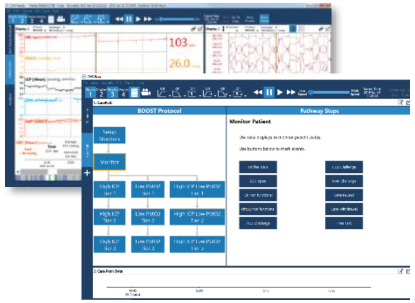
MOBERG ICU Solutions

Data Aggregation → **Analytics** → **Visualization Guidance** → **Archiving & Reporting**

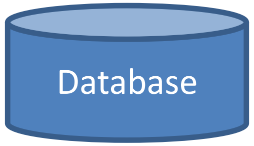
CNS Monitor



Apps



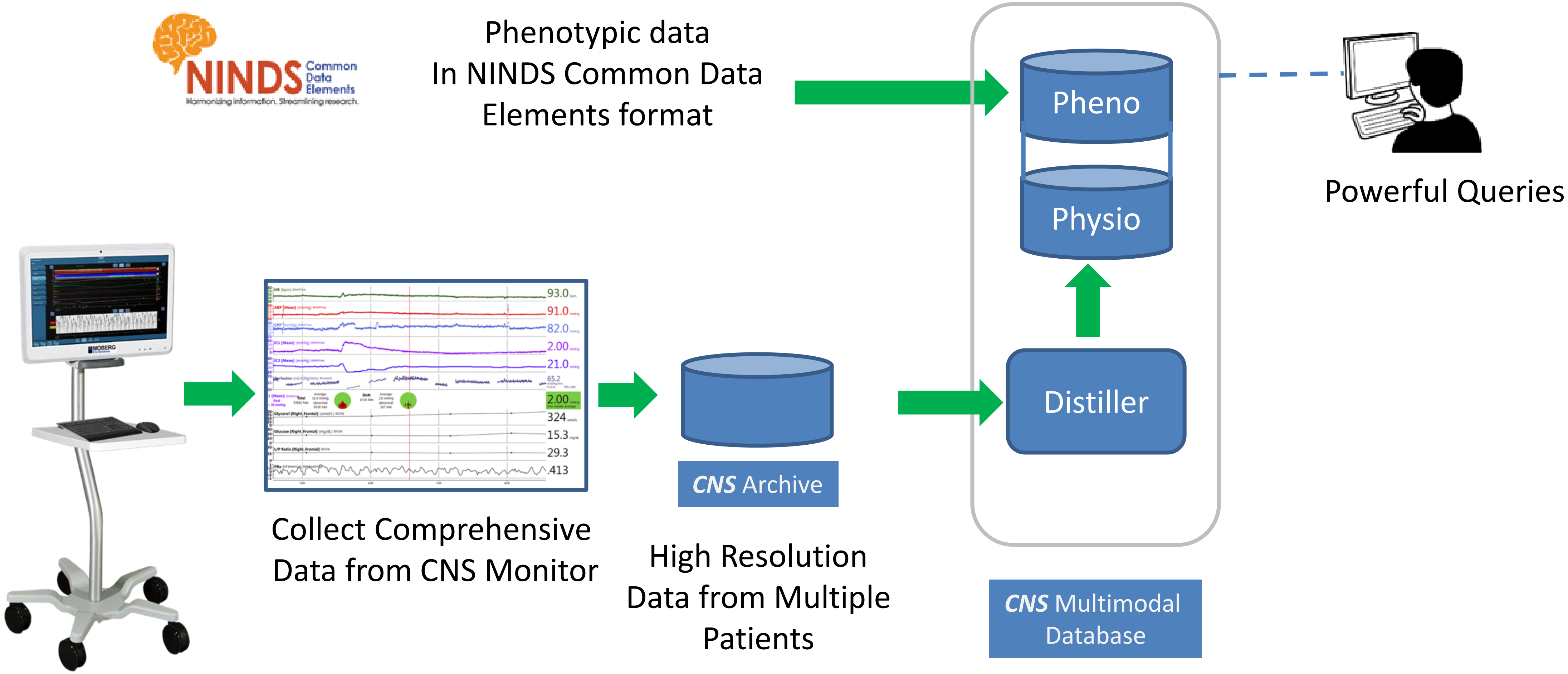
CNS Envision
CNS CarePath



Multimodal Database

Envision Reports

Threat Mitigation - Multimodal Database

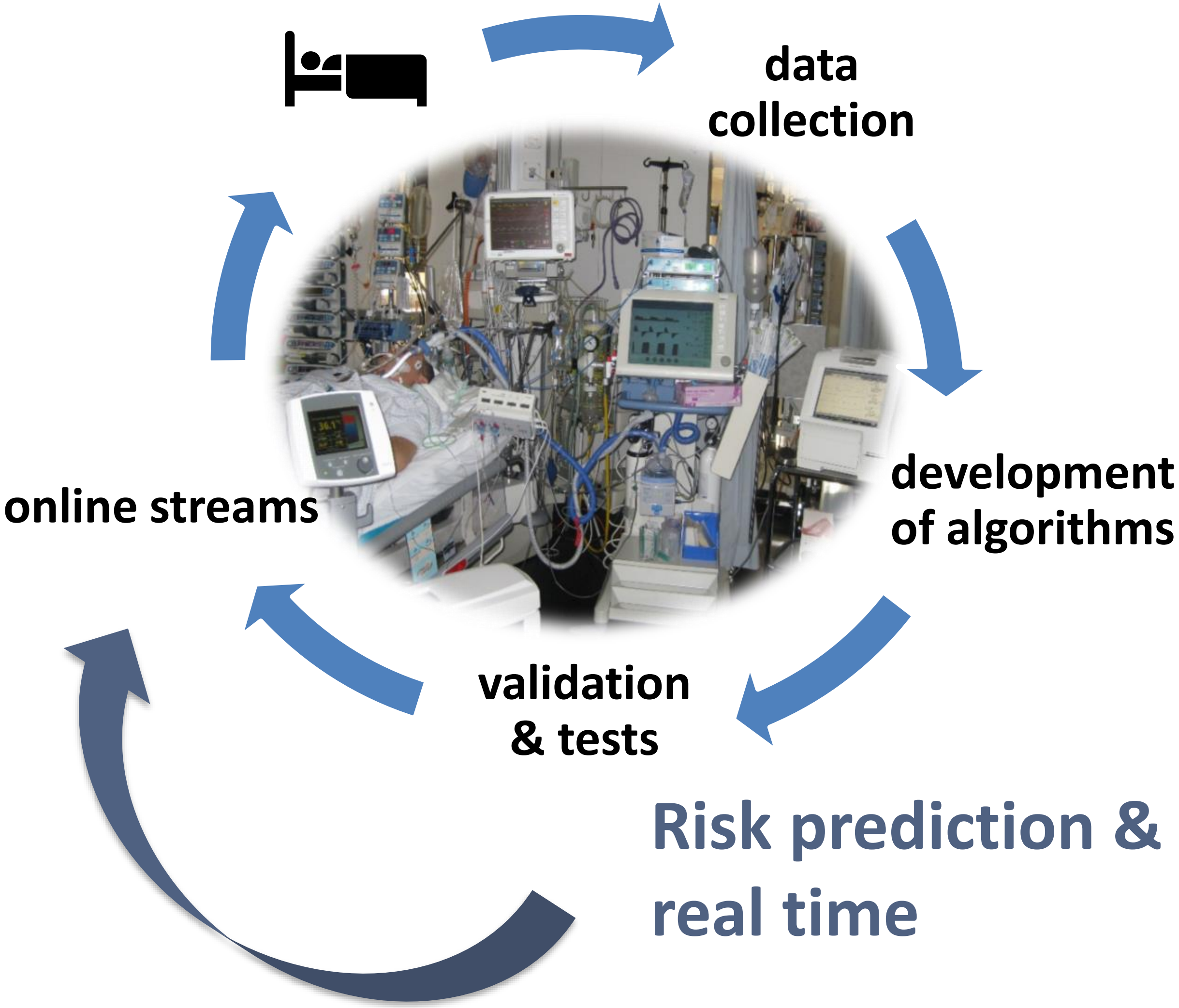


Goals of Talk

MOBERG ICU Solutions

- Describe the **need** for comprehensive, high-resolution data in critical care
  - We will use the care of acute brain injury as an example
- Describe the **challenges** of collecting data in a usable form
  - We will describe the state of medical device connectivity and data interoperability
- Describe **progress** to overcome the challenges
  - We will use our work (and others) as examples
- Describe the **future** with "Smart ICUs"
  - We will show examples of what can be done

Next steps



Risk prediction & therapy support real time

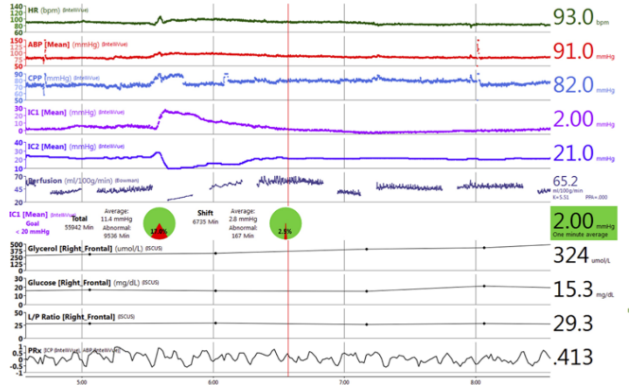
Two Projects

- Project for Precision Management of TBI
- Multi-center Trial: BOOST3

Project: Precision Management of TBI

MOBERG ICU Solutions

- Project
  - A More Meaningful Medical Record for the Brain to Enable Precision Management of TBI
  - Three year, DOD-funded, collaborative project
- Goals:
  - Standards: nomenclature, annotations
  - Architecture: Standardized data pathways, API
  - Define what should be in the medical record (and monitoring) that makes it useful for managing brain injury
- Organizations:
  - Moberg Research, MGH, U Cincinnati
  - Large group of collaborators and stakeholders

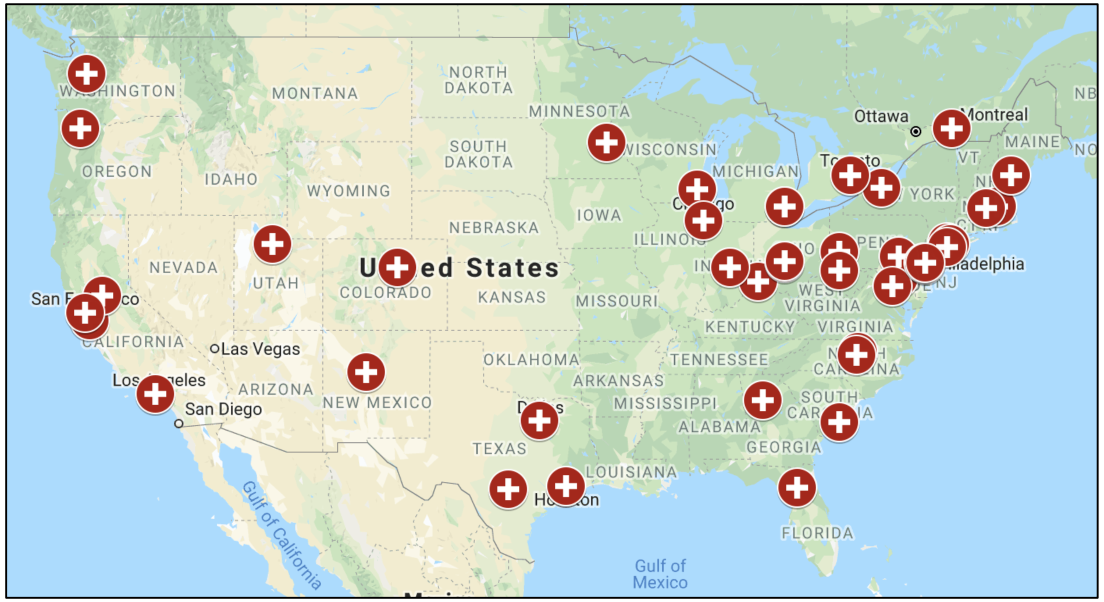


Project: BOOST3 – A Multicenter Trial

MOBERG ICU Solutions

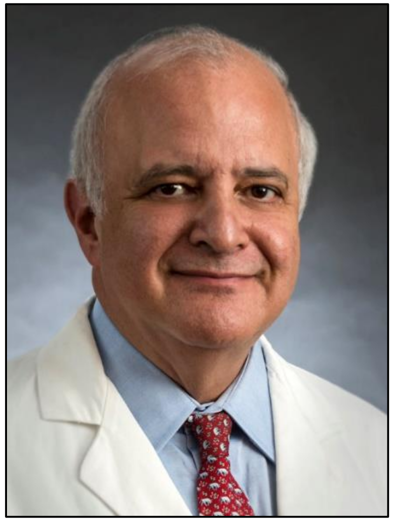
BOOST-3 Clinical Trial

- > 1000 Patients
- ~46 Participating Sites
- Compare TBI Treatment Strategies
  - ICP-only vs. ICP + PbtO2



Baylor College of Medicine
Harvard Medical School
University of Maryland
University of Cincinnati
Columbia University Medical Center
Duke University Medical Center
Emory University
University of North Carolina School of Medicine
Henry Ford Health System
Indiana University (IU Health Methodist Hospital)
Medical College of Wisconsin
University of Chicago
Regions Hospital (Sub-Hub for U of Minnesota)
University of Montreal
North Shore University Hospital
Oregon Health & Science University
University of Rochester Medical Center
Ohio State University Wexner Medical Center
Penn State Hershey Milton S. Hershey Medical Center
University of Pittsburgh
Riverside Methodist Hospital - OhioHealth
Stanford Medical
Kings County
Cooper University Hospital
Washington Hospital Center/Georgetown University
University of Texas Health Science Center at San Antonio
University of Texas Health Sciences Center at Houston
St. Michaels- University of Toronto
Maine Medical Center
UC Davis Medical Center
University of California, Los Angeles
Queen's Medical Center, HI
University of California, San Francisco
University of Massachusetts
University of Pennsylvania
University of Utah
Parkland Hospital
University of Washington
Wayne State University
University of New Mexico Hospital
Medical University of South Carolina
West Virginia University
Thomas Jefferson University Hospital
University of Florida
University of Colorado School of Medicine

BOOST-3



Ramon Diaz-Arrastia, MD, PhD

Penn Medicine

https://siren.network/clinical-trials/boost-3

Two Projects

MOBERG ICU Solutions

Develop a standardized platform for data used in precision management

Develop a new medical record for the brain

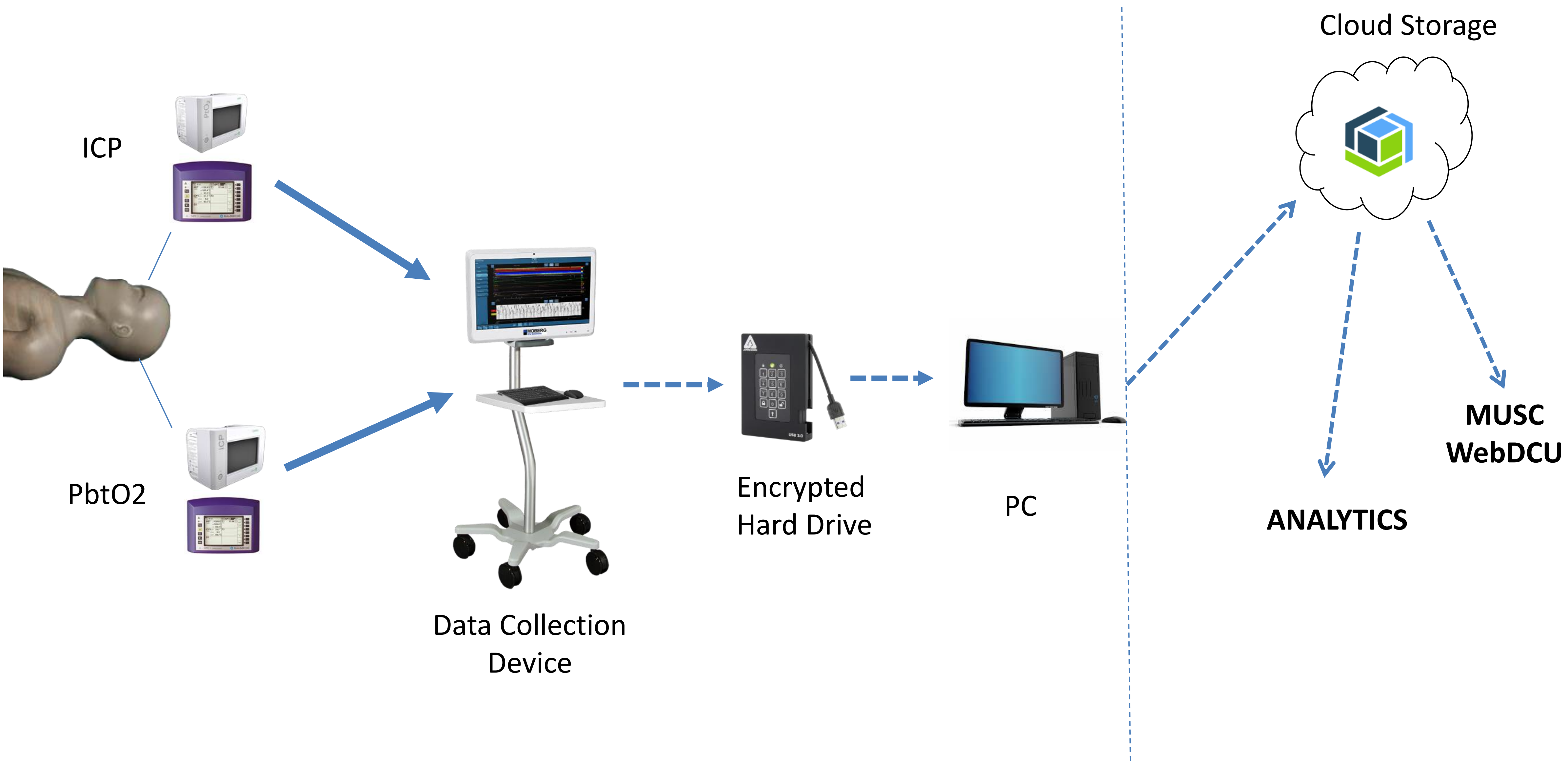
BOOST-3

Collect comprehensive data from 1,000 TBI patients

Test the platform

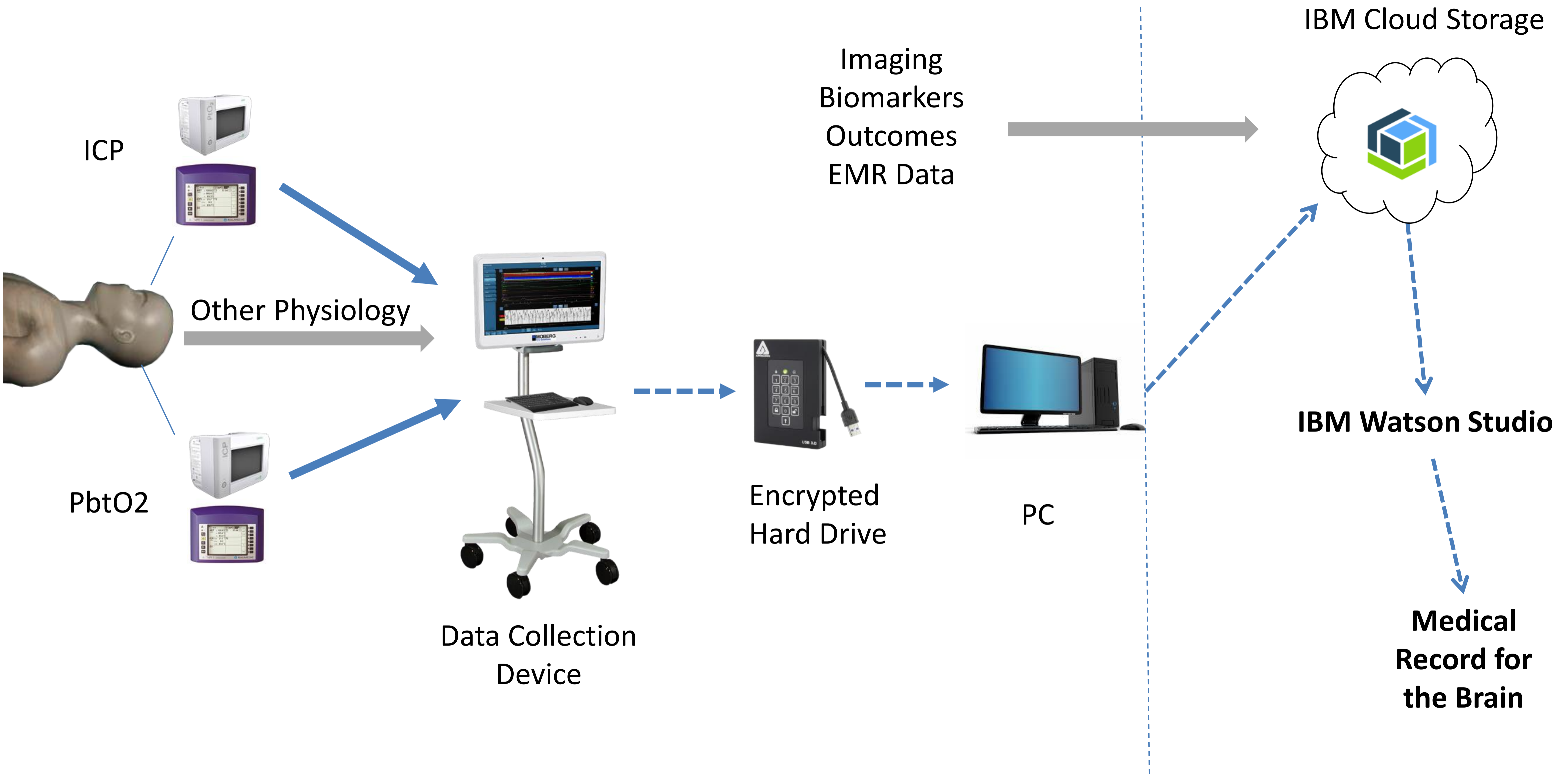
Collect outcomes from 1,000 TBI patients

The Data Pathway for BOOST3



The Data Pathway for BOOST3 – Ancillary Projects

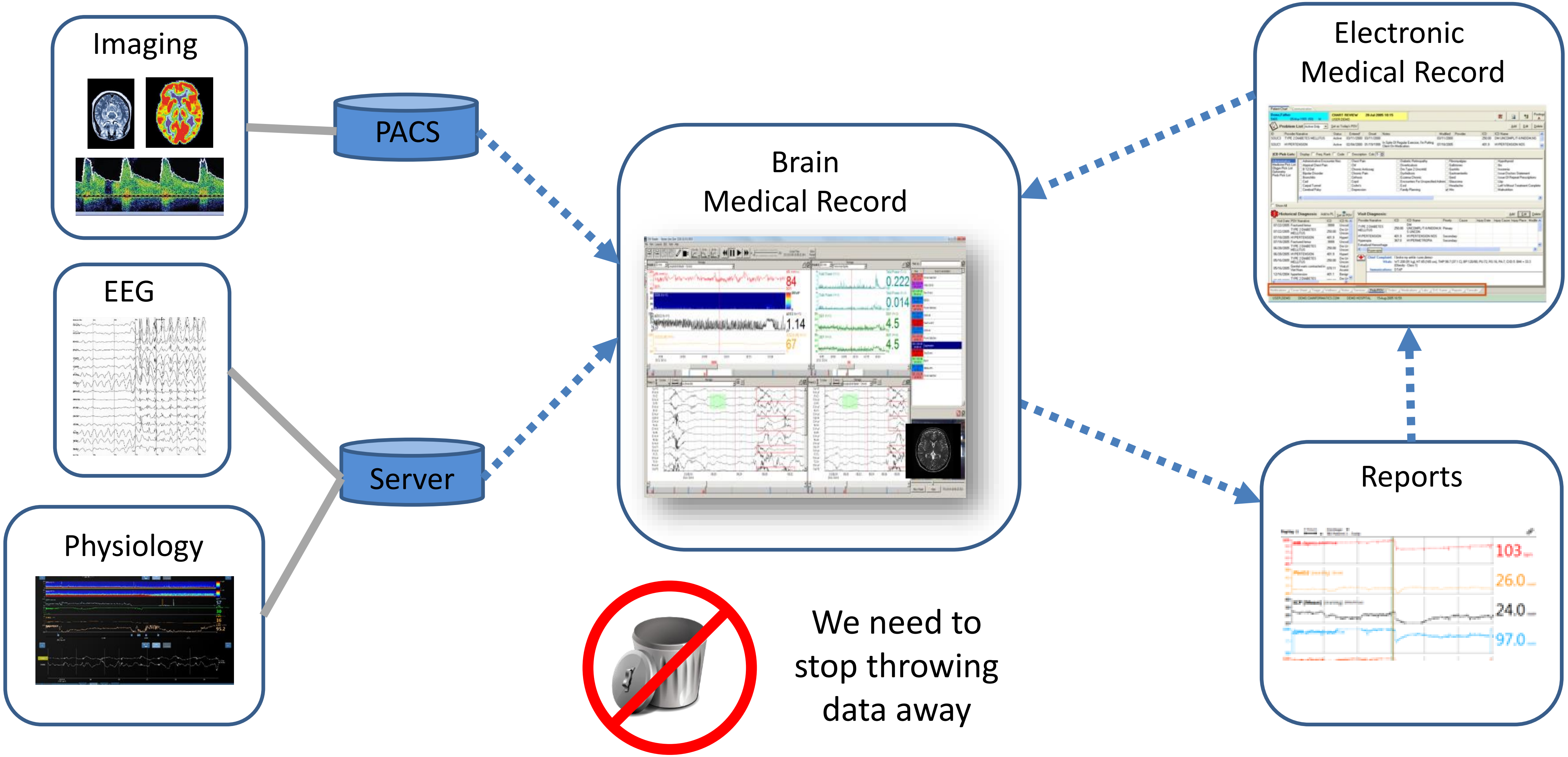
MOBERG ICU Solutions



A More Meaningful Medical Record for the Injured Brain

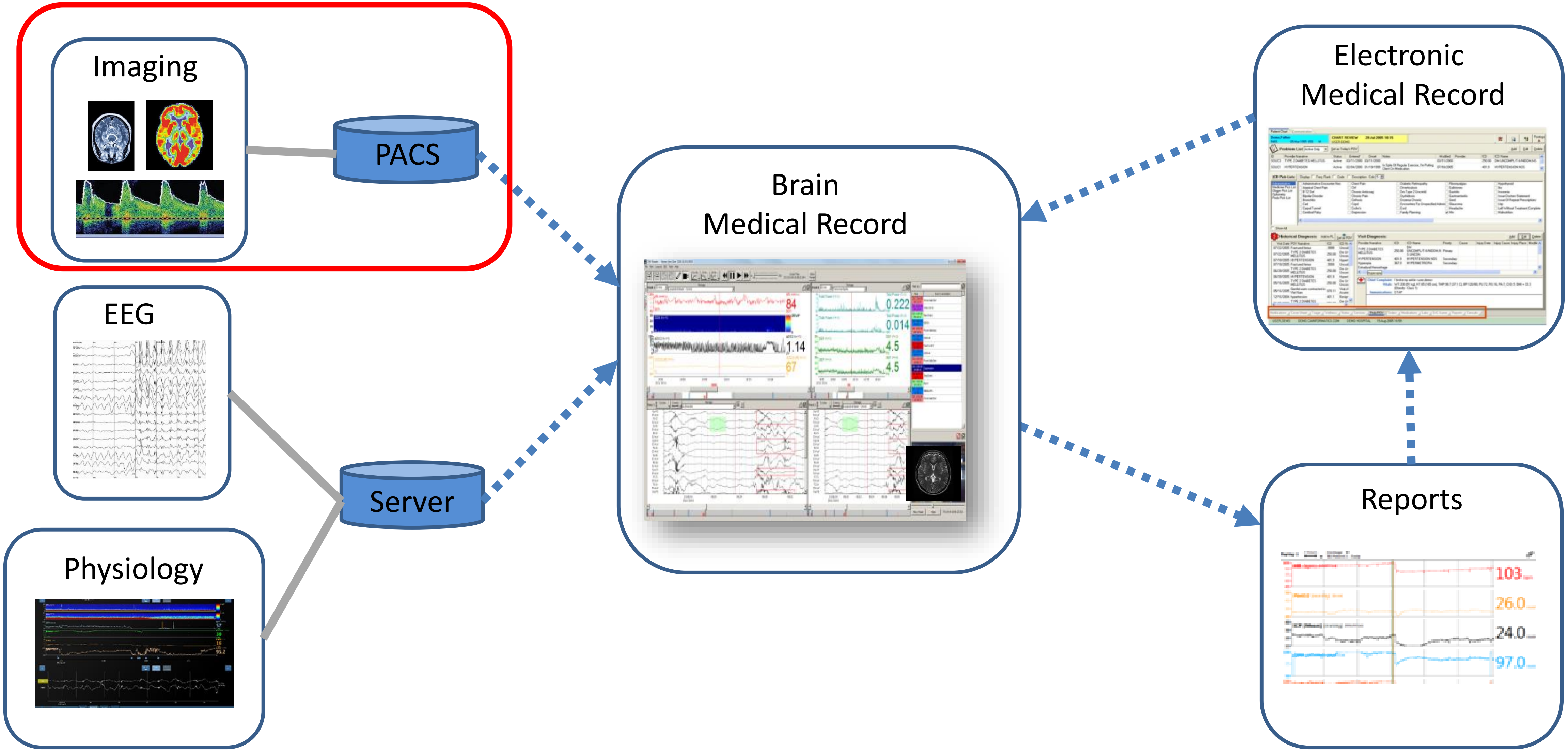
MOBERG ICU Solutions

We need to collect data in a way that enables further use



A New Medical Record for the Brain – Data Collection

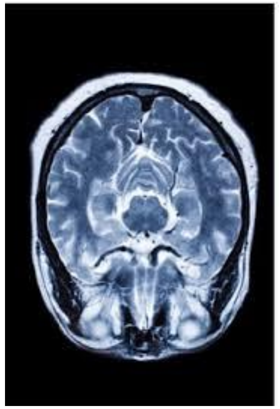
MOBERG ICU Solutions



Transform Image Data to a Usable Format

MOBERG ICU Solutions

Max Wintermark
Stanford

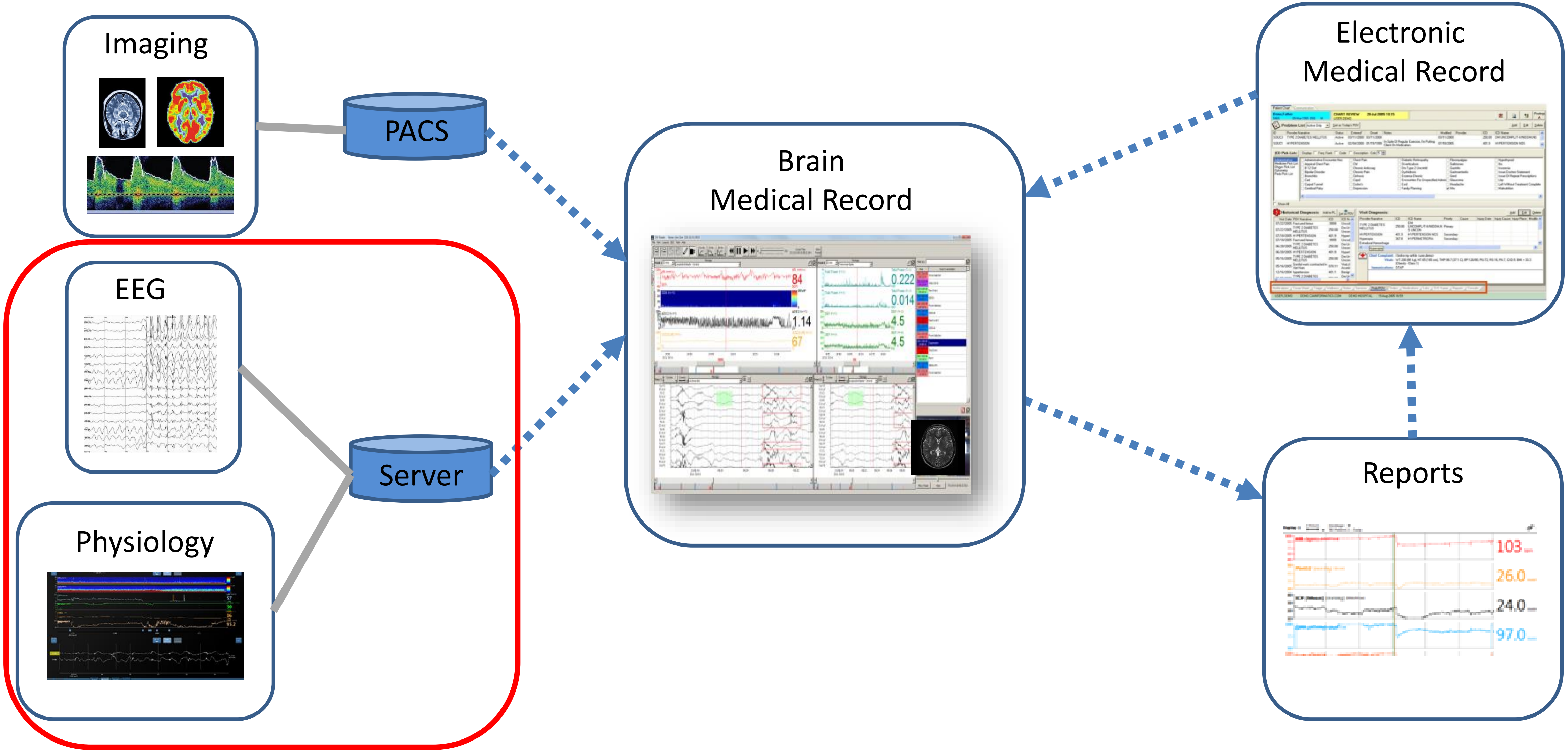


Automated Medical Image Description

Argonne's IBM Blue Gene/Q Supercomputer
U.S. Dept of Energy

A New Medical Record for the Brain – Data Collection

MOBERG ICU Solutions



Transform Data to a Usable Format

MOBERG ICU Solutions

EEG

Automatic Detection of Significant Descriptors

BOOST-3

Ancillary Study

CCEMRC Critical Care EEG Monitoring Research Consortium

DICOM Digital Imaging and Communications in Medicine

Database

ECG

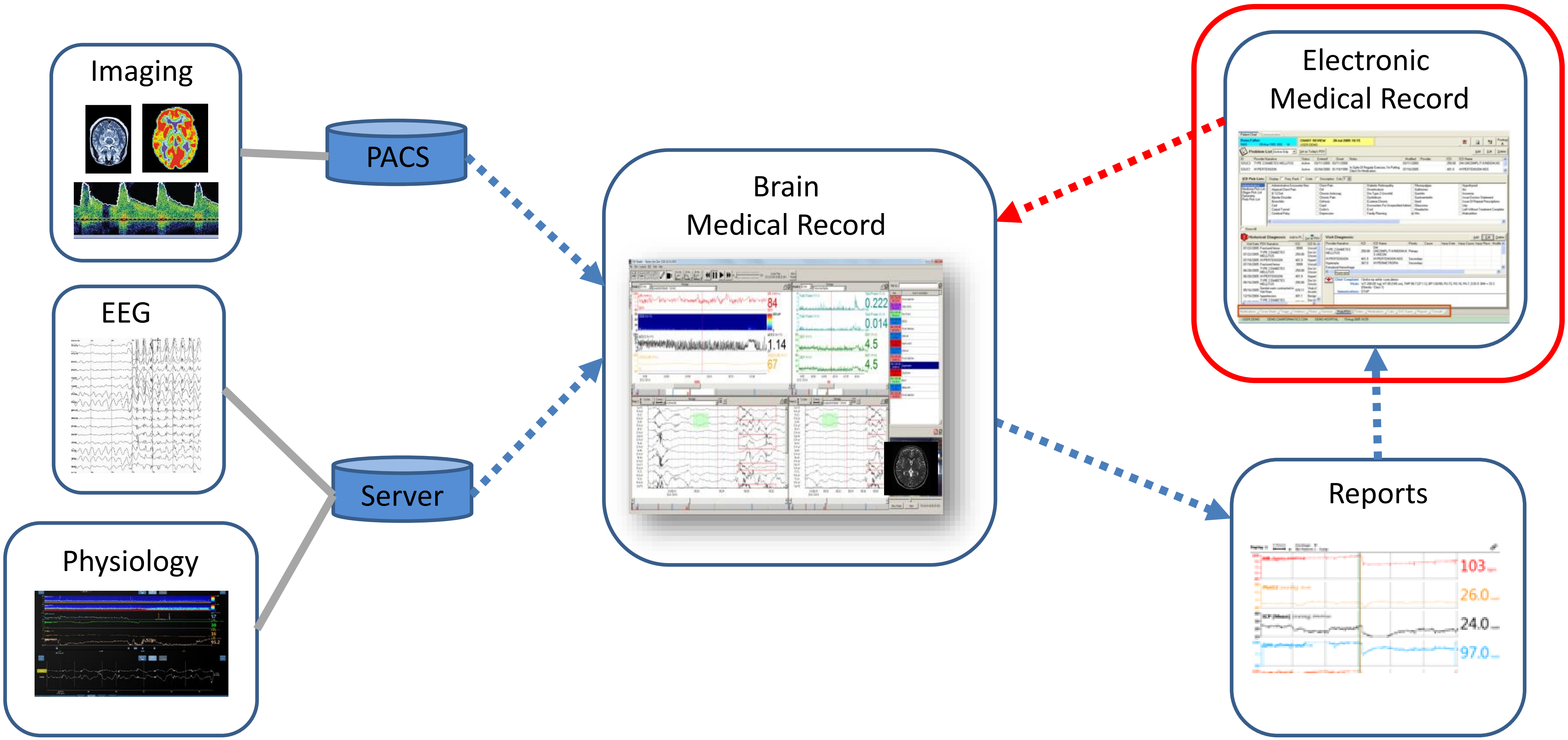
MIMIC/PhysioNet
National treasure
30 years of funding

Multimodal Neuro Database

Start to develop annotated multimodal neurotrauma database with BOOST data

A New Medical Record for the Brain

MOBERG
ICU Solutions



EMR Connectivity

MOBERG
ICU Solutions

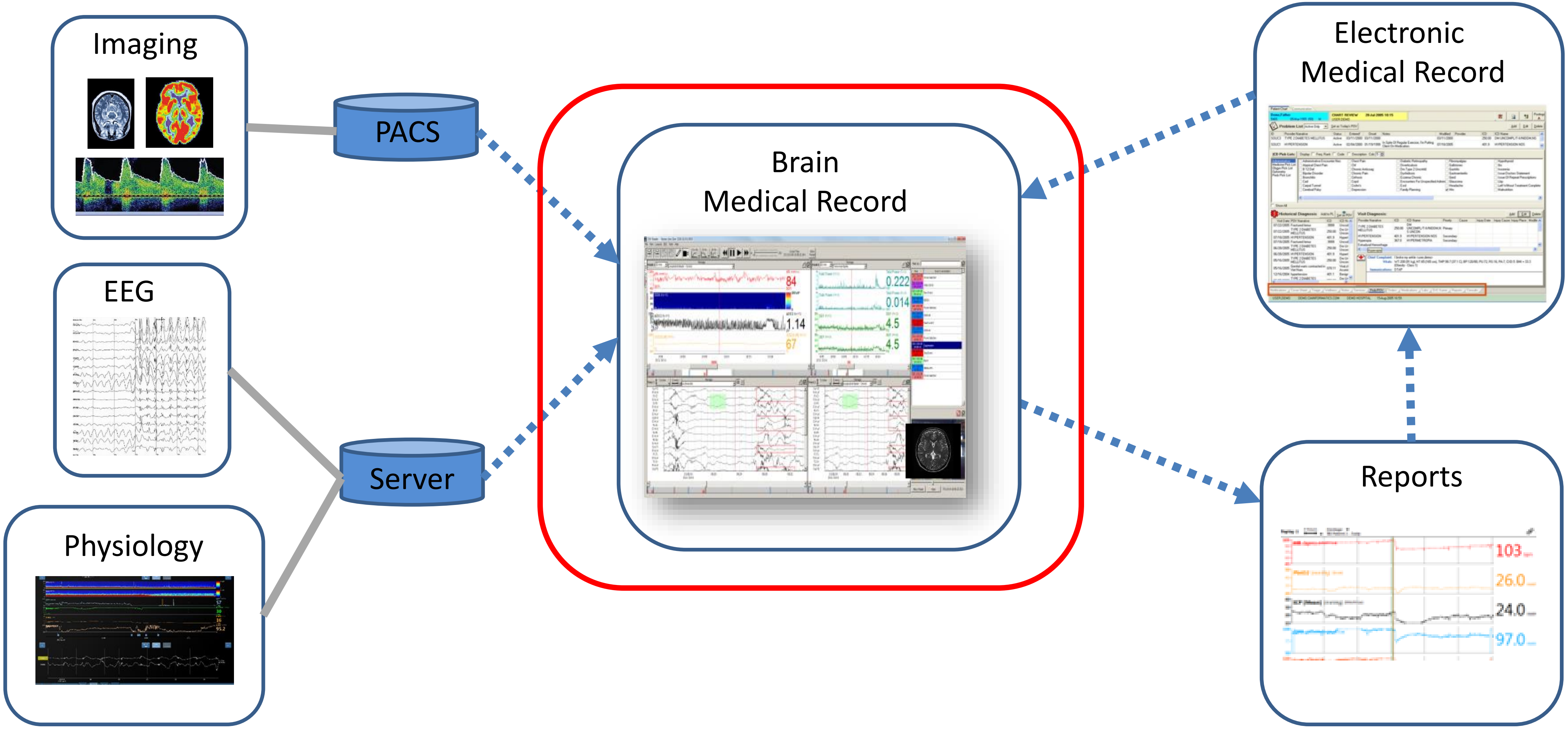
Epic

Redox
FHIR

ADT
Medications
Lab Data
Nursing Interventions

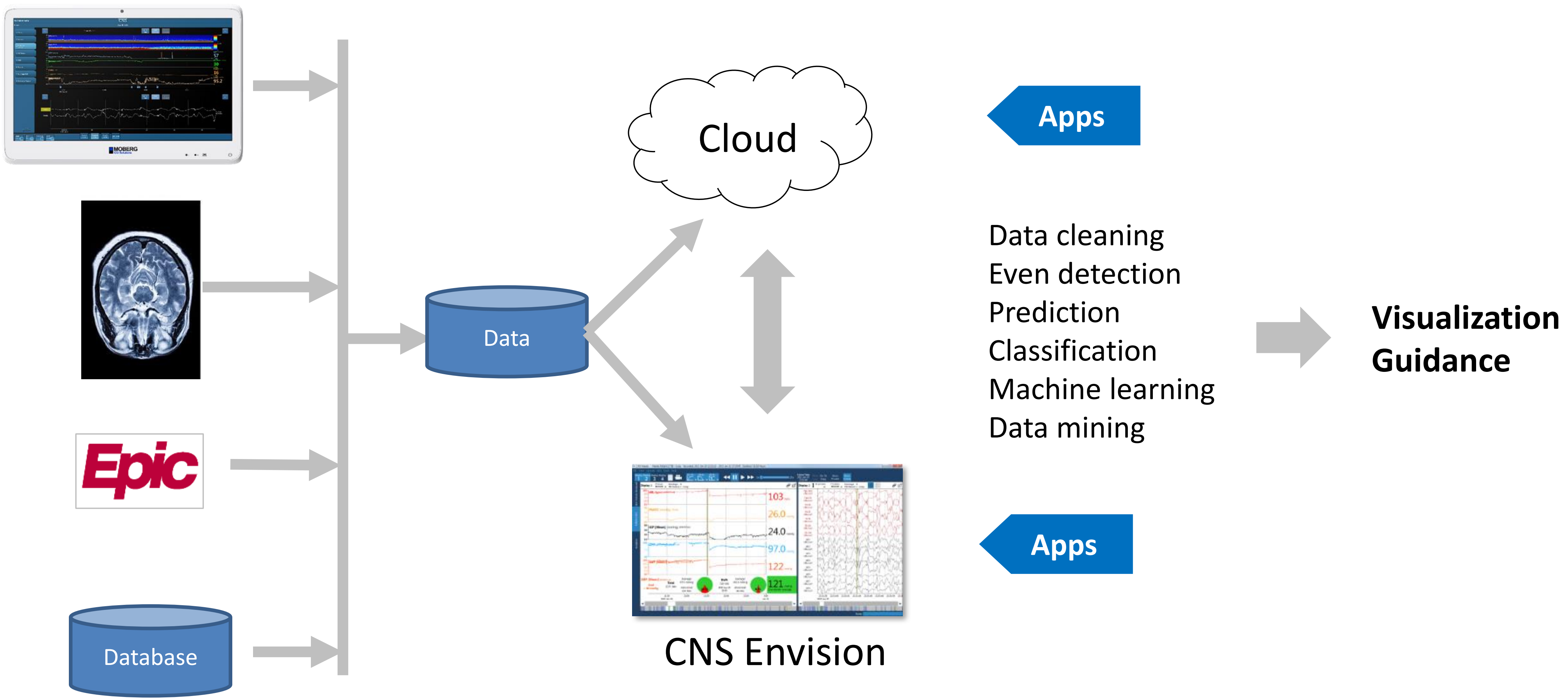
A New Medical Record for the Brain

MOBERG
ICU Solutions

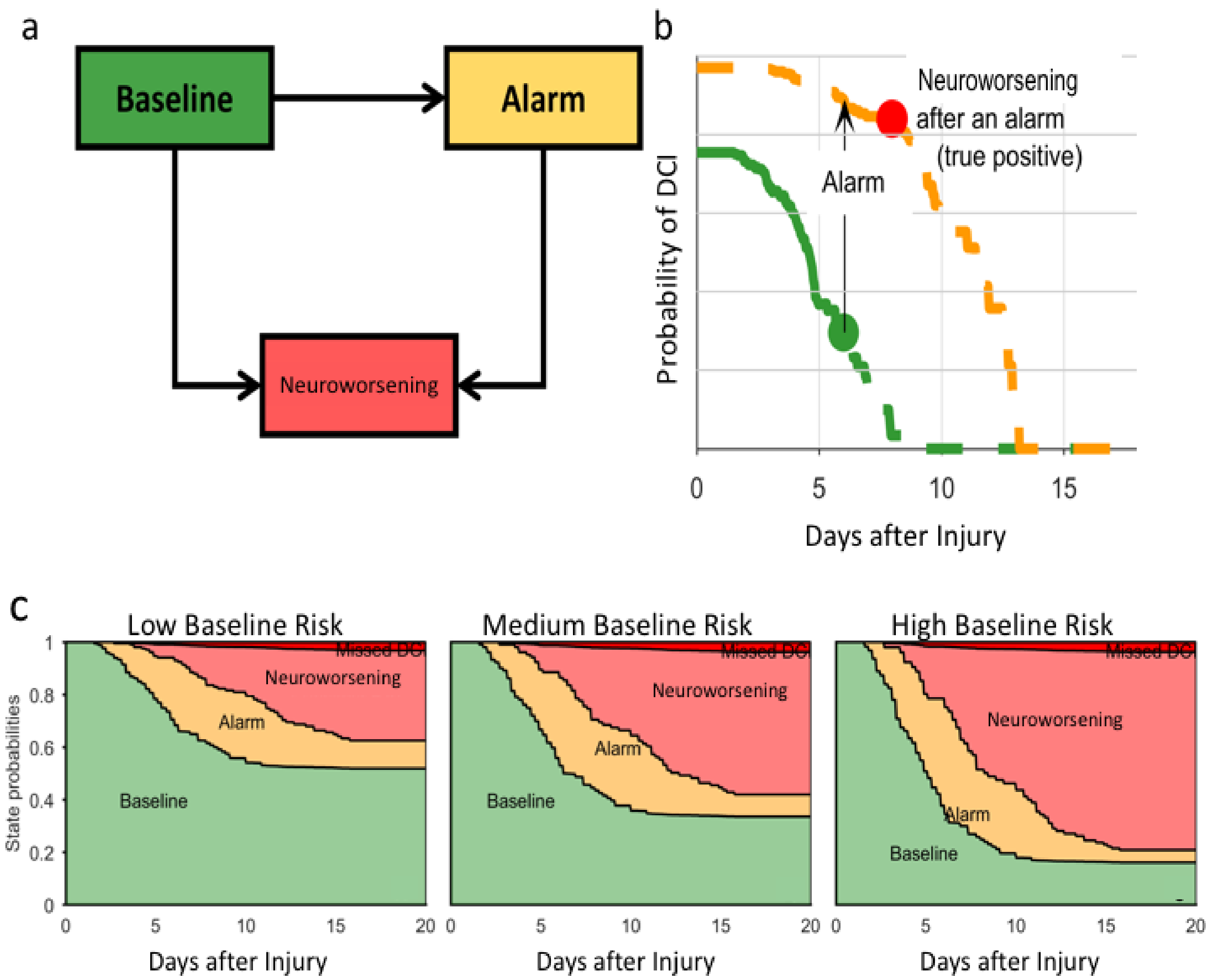


Our Approach

Contextual Data | Patient State Determination | Guidance

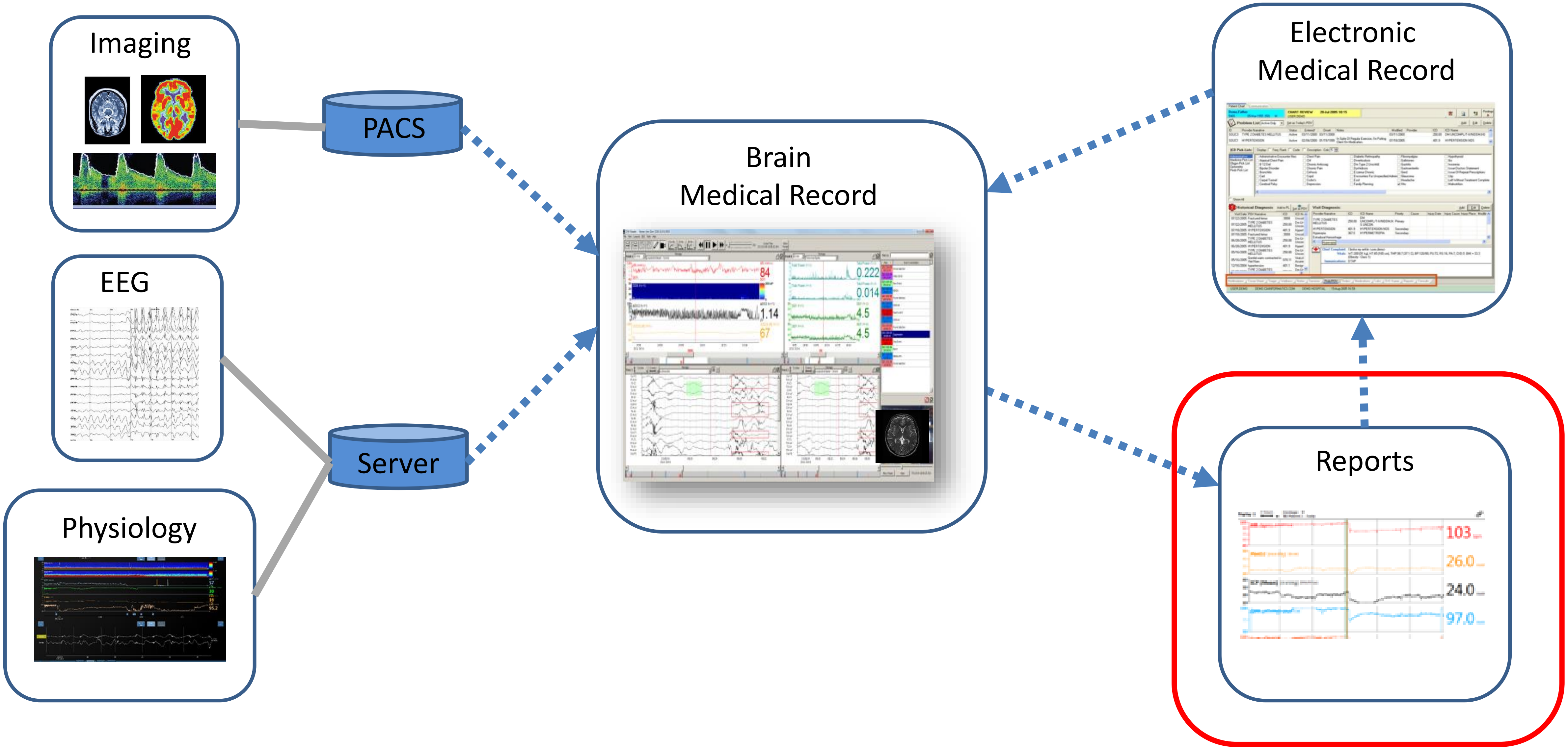


Multi-state Predictive Models of Neuroworsening



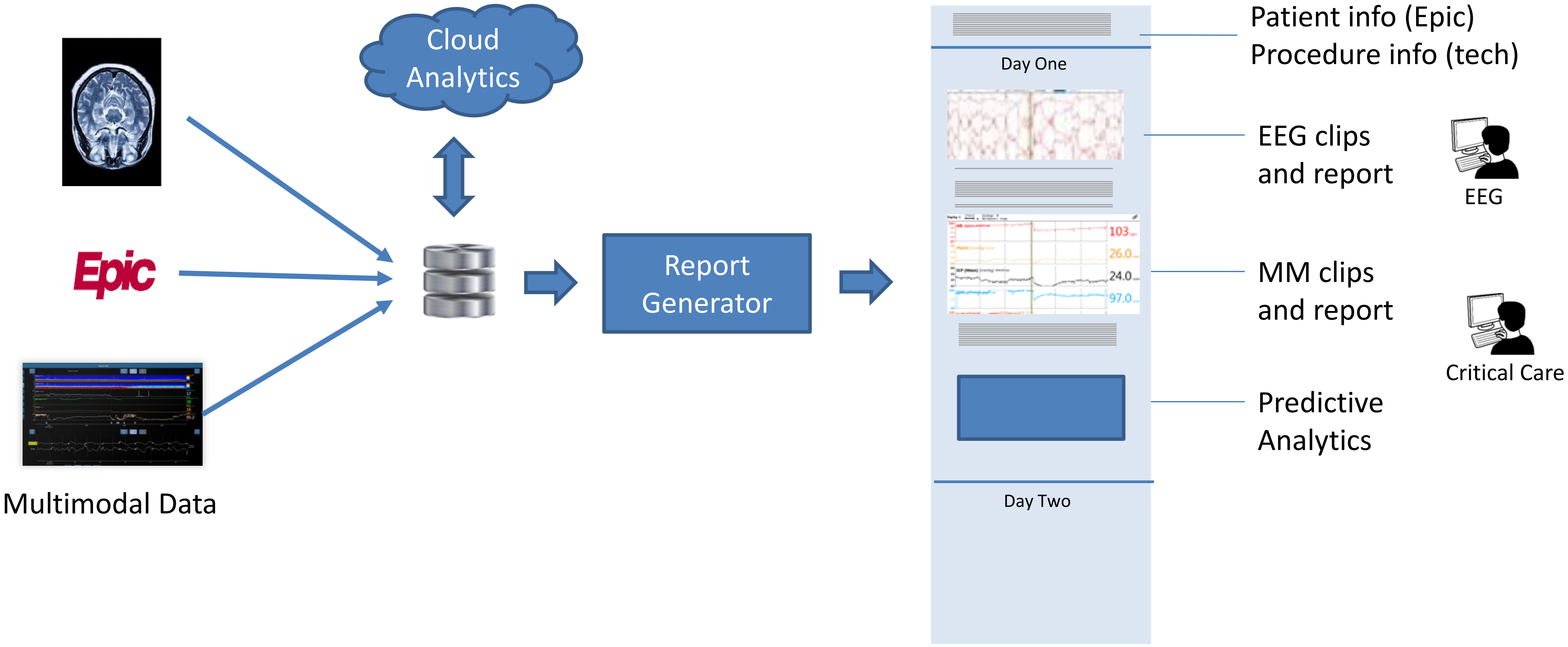
Courtesy Eric Rosenthal, MD MGH

Reports



Imaging
PACS
EEG
Server
Physiology
Brain
Medical Record
Electronic
Medical Record
Reports
103
26.0
24.0
97.0

Automated Comprehensive Reports



Threat Mitigation - Semi-automated Reports - Physiology

MOBERG ICU Solutions

BACKGROUND:
1. Normal features: None.
2. Abnormal features: The background activity is poorly organized, with no discernable posterior dominant rhythm. Eye blinks are absent. The EEG is not reactive.

SLEEP FEATURES: Rudimentary sleep architecture is present.

ATTENUATION: None

SLOWING: Mild generalized slowing is present.

HYPERVENTILATION: None

PHOTIC STIMULATION: None

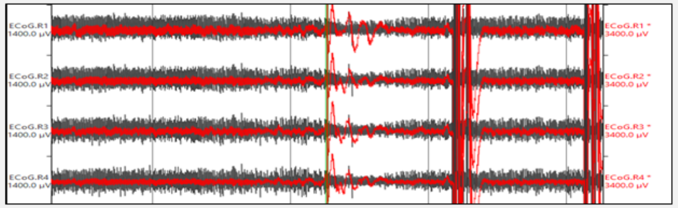
TECHNOLOGIST'S IMPRESSION: None

EPILEPTIFORM DISCHARGES, RHYTHMIC OR PERIODIC PATTERNS:
1. Abundant spikes, most prominent in the left fronto-temporal regions.

SEIZURES OR CLINICAL EVENTS:
1. Electrographic seizures: Seizures occurring about 10 times per hour. The majority are subclinical. Clinical: Patient lying in bed. After a minute or two there is right facial twitching followed by head turn and gaze deviation to the right. There is head twitching to the right and sometimes the entire face right > left appears to be twitching. Toward the end of the seizure, she has a head turn to the left.

   During some of the seizures she will have only facial pulling to the right. No head or eye deviation.

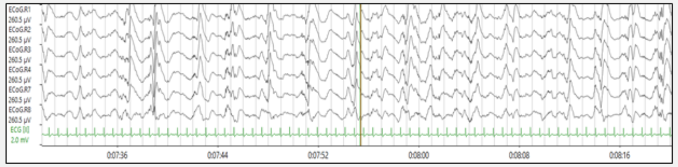
   Electrographic: There is rhythmic delta over the left hemisphere. This evolves into left LRDA+S at 2-2.5z over the left fronto-centro-temporal region. At times there is left hemisphere fast activity during the seizure. The right hemisphere shows polymorphic slowing during this time. During the clinical seizures there is muscle artifact that obscures the right > left sided electrodes. Typically, during the clinical seizures after the muscle artifact ends the electrographic seizure continues for several seconds consisting of LRDA+FS throughout the left hemisphere that slows from 3Hz to 2Hz.
2. The patient is having frequent left foot jerking which is not suppressible. This has no EEG correlate.
3. Patient exhibits characteristics of spreading depolarization, which indicates a dangerous level of brain inactivity. Depolarization was observed on ECoG and was found to impact relevant multimodal measurements at the time of the spike / compression.

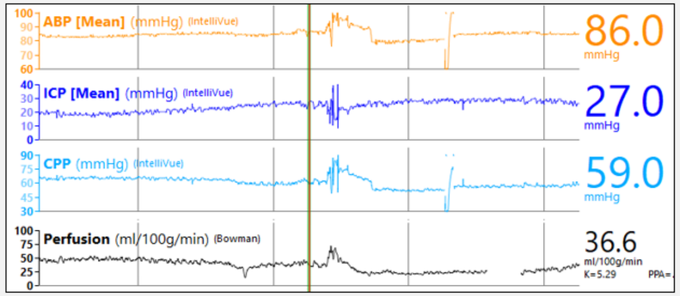


MULTIMODAL DATA:
1. **ABP:** ABP was also affected by the spreading depolarization, as levels can be seen to rise shortly after the event.

   ABP was found to be above 85 mmHg for 73.1% of the shift, while it remained increased for 71.3% of the total measurement time.
2. **ICP:** ICP averaged 5.9+/-3.8 mmHg. The ICP waveform demonstrated P2>P1. ICP was monotonous with very brief (<15 min) spikes to 30 mmHg at 16:00, 17:00, 20:15. There were scattered very low-amplitude b-waves with no plateau waves.

   ICP measurements were averaged per minute. Each average measurement was compared to the goal range of <20 mmHg. In total, 86% of measurements were above 20 mmHg, while the current period had 85.8% of the ICP measurements above 20 mmHg, indicating that the patient's status is critical.
3. **CPP:** The CPP averaged 78.2+/-8.5 mmHg. There were no sustained periods of hypoperfusion (CPP<60) throughout the recording. There was reciprocal decrease in CPP with ICP spikes described above transiently as low as 50 mmHg. However, ICP remained stable across a range of CPP. However, PbtO2 and CBF correlated with CPP.
4. **rCBF:** The PPA remained <2 throughout the recording. During brain fever (>39C) there were no CBF readings 2/2 technical limitations of the probe. CBF initially related to sedation and was as low as 6 ml/100g/min; after temperature was controlled overnight (after 22:00), the CBF ranged from 15-40 ml/100g/min and was correlated with CPP and linked by sedation. K value gradually increased from 4.99 at insertion to 5.10 at the end of the recording, consistent with <75% brain water content.





Combined multimodal physiology and cEEG.

Neuroworsening metrics

Threat Mitigataion - Semi-automated Reports - Quality

BACKGROUND:

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ATTENUATION: None

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1. Electrographic seizures: Seizures occurring about 10 times per hour. The majority are subclinical. Clinical: Patient lying in bed. After a minute or two there is right facial twitching followed by head turn and gaze deviation to the right. There is head twitching to the right and sometimes the entire face right > left appears to be twitching. Toward the end of the seizure, she has a head turn to the left.

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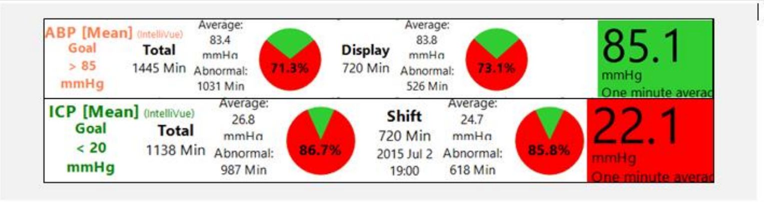

How well did nursing meet the target?

What improvements have we achieved?