A Computational Model for Prediction of Cardiac Arrest Outcome Using a Large Multi-Center Database

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Problem Introduction

Cardiac Arrest (CA)

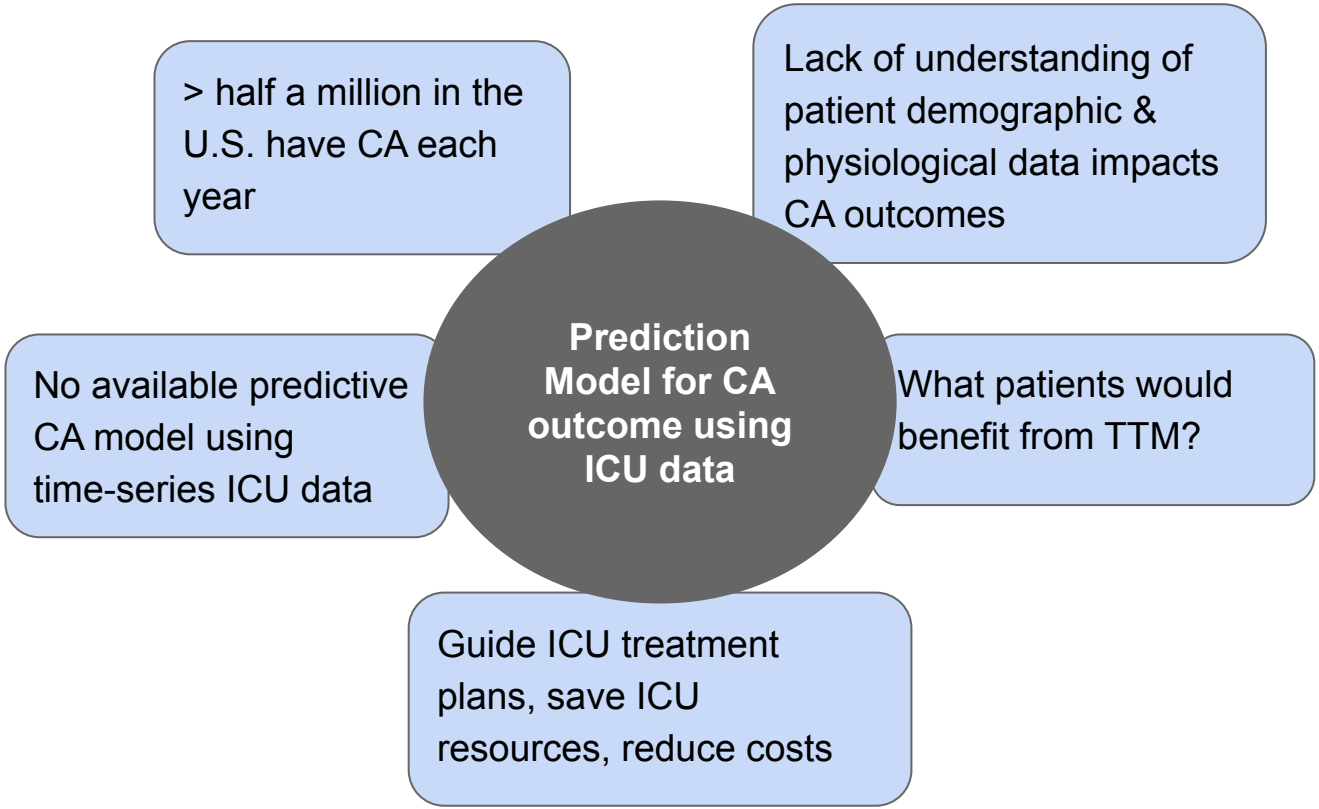
CPR, AED

ICU

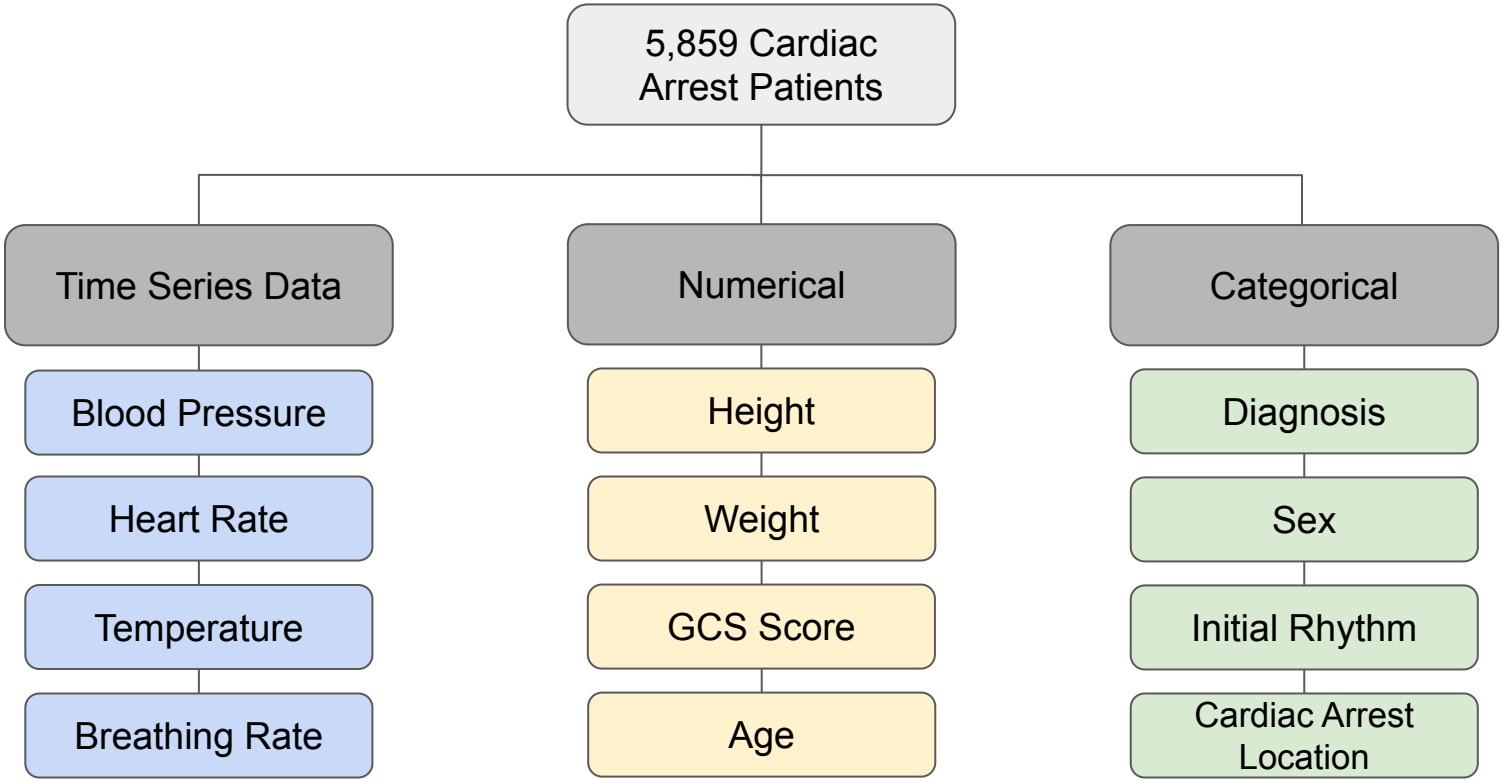
- Wakes up with no major brain injuries
- Stays In Coma
  - Able to return to work
  - Severe brain damage, unable to work
  - Vegetative state
  - Brain death

Target Temperature Management (TTM)

Importance and Significance

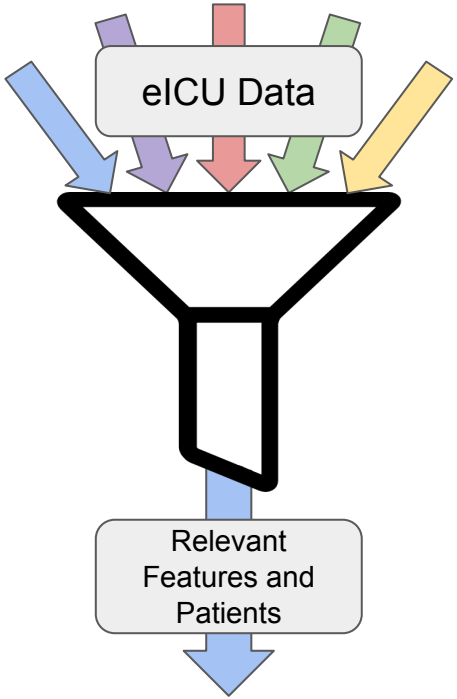


eICU Database

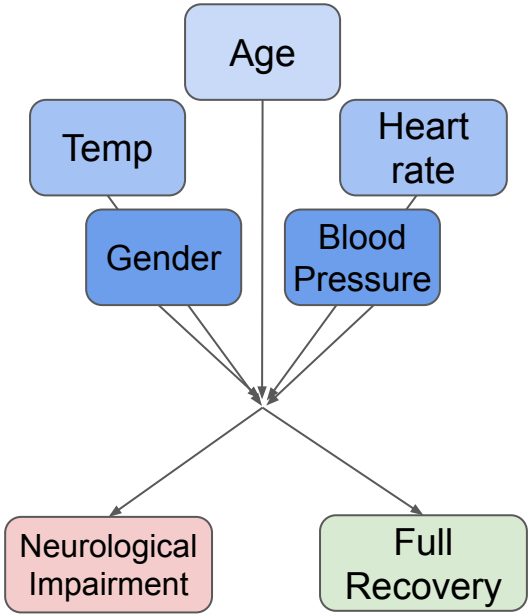


Aims

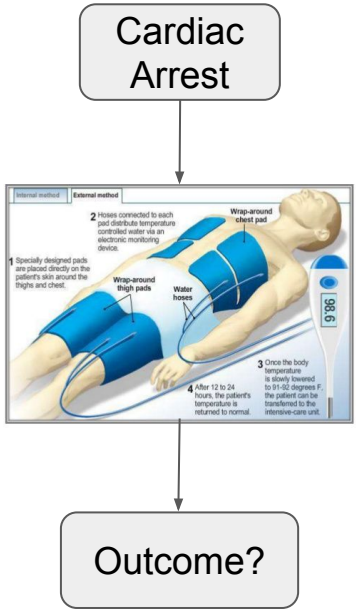
Aim 1: Data preprocessing and data exploration



Aim 2: Prediction of cardiac arrest recovery outcome



Aim 3: Early prediction of favorable recovery outcome if TTM is administered



Feature Space & Label Space

Feature Space

Time-Series (first 48 hours)

- Blood Pressure
- SPO2
- Breathing Rate
- Heart Rate
- Temperature

Numerical

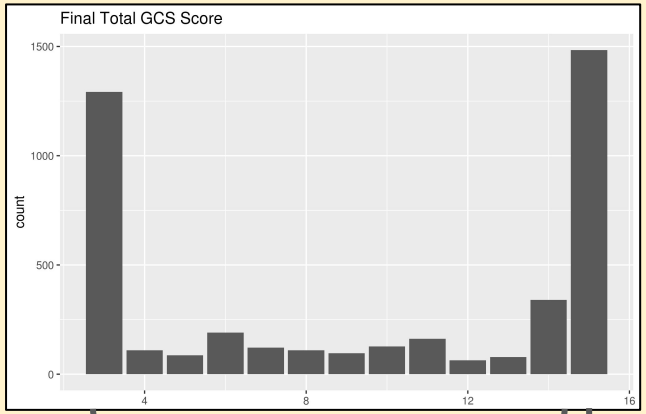
- pH
- Age
- GCS at admission

Categorical

- Cardiac Arrest Location
- Intubation
- Initial Rhythm
- Sex

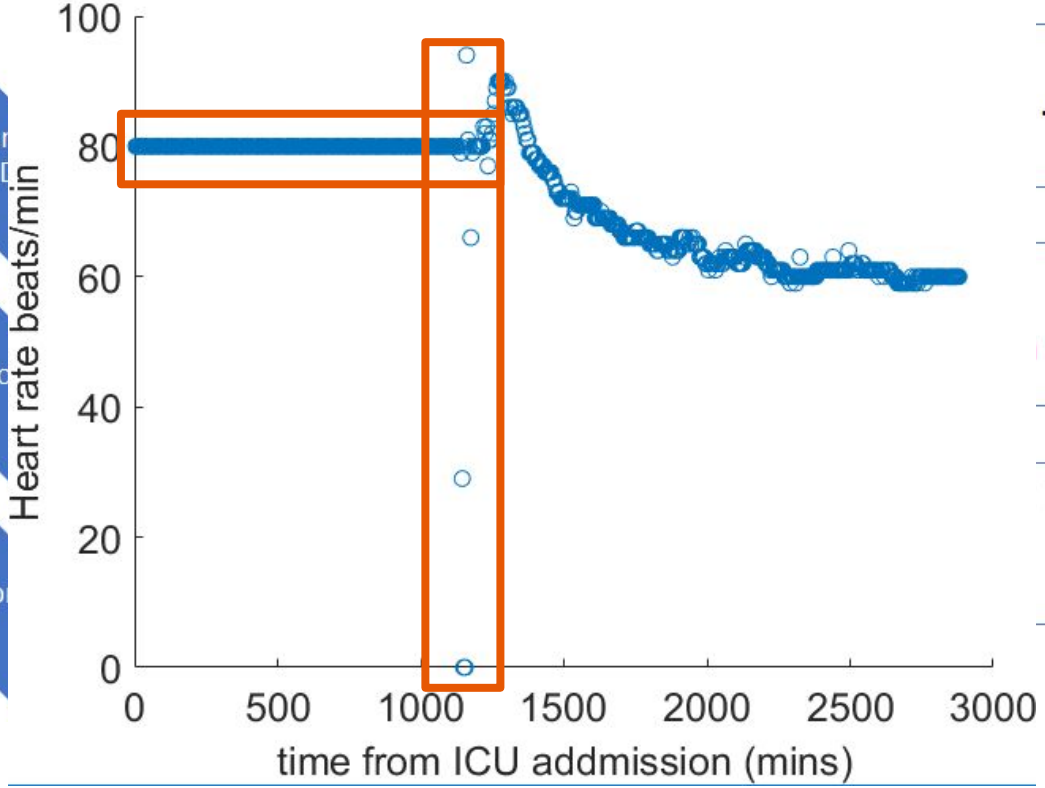
Label Space

GCS Score at Discharge



- Label 1
- Label 2

Aim 1: Data preprocessing



...

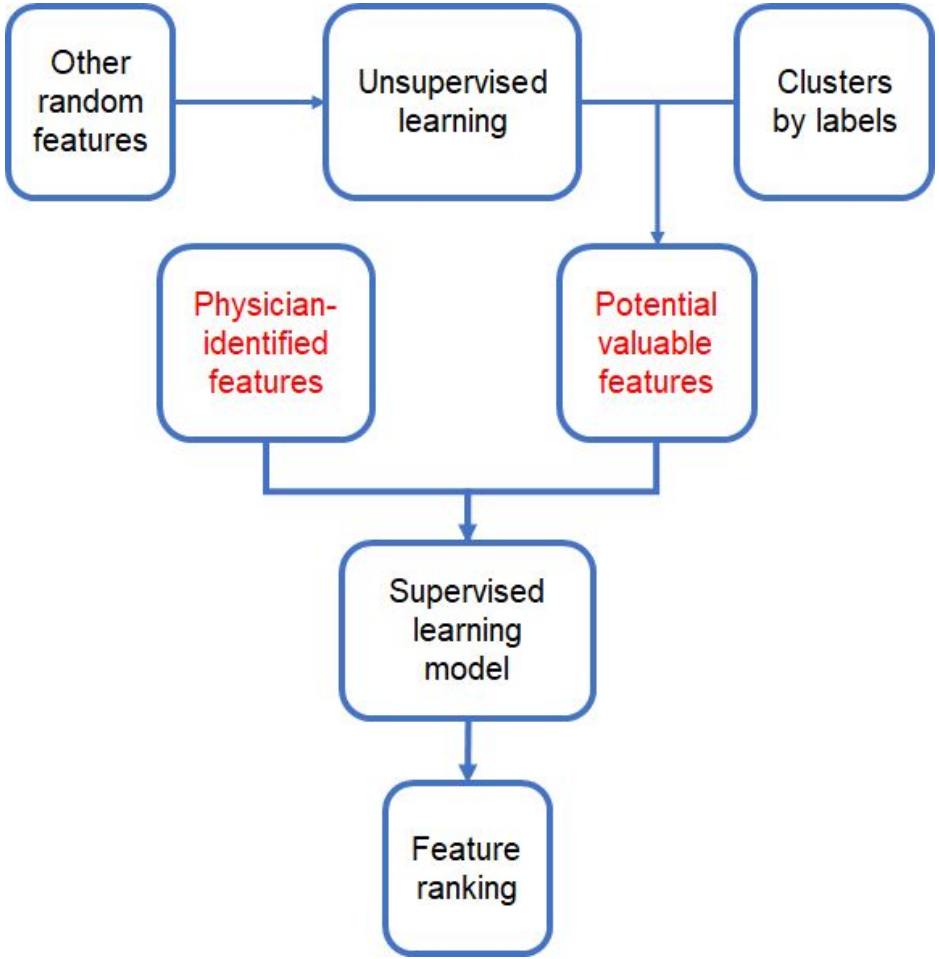
Time-series Data
- Heart rate,
- Blood pressure

Problems
- Missing data
- Abnormal data
- Inconsistency data

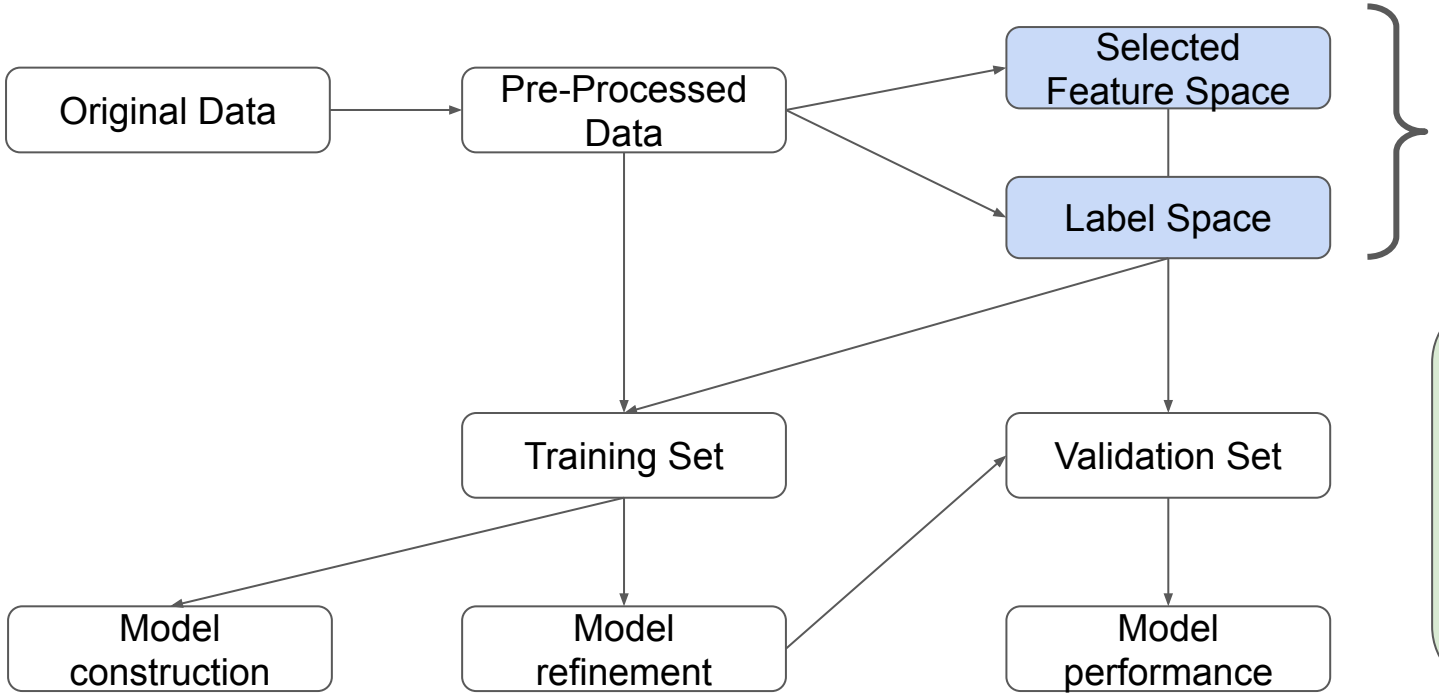
Approaches
- Sliding window methods
- ...

Aim 1: Learning Methods

Unsupervised learning	Supervised learning
• K-means clustering • Spectral clustering • Principle component analysis • …	• Generalized linear model • Random forest • Lasso regression • …



Aim 2: Prediction of Cardiac Arrest Recovery Outcome



Goal: Build prediction model to accurately classifies patients into binary label space

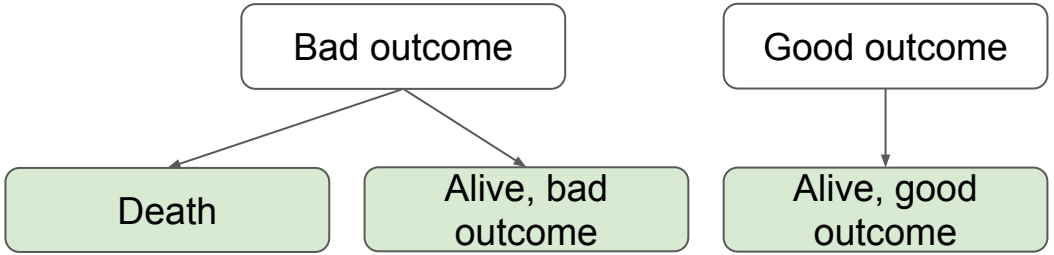
Aim 2: Approaches

Supervised learning techniques

- GLM
- K-nearest neighbors
- Random Forest
- Boosting Algorithms
- Support Vector Machines (SVMs)

Possible improvements:

1. Try multiclass models



2. Try neural networks

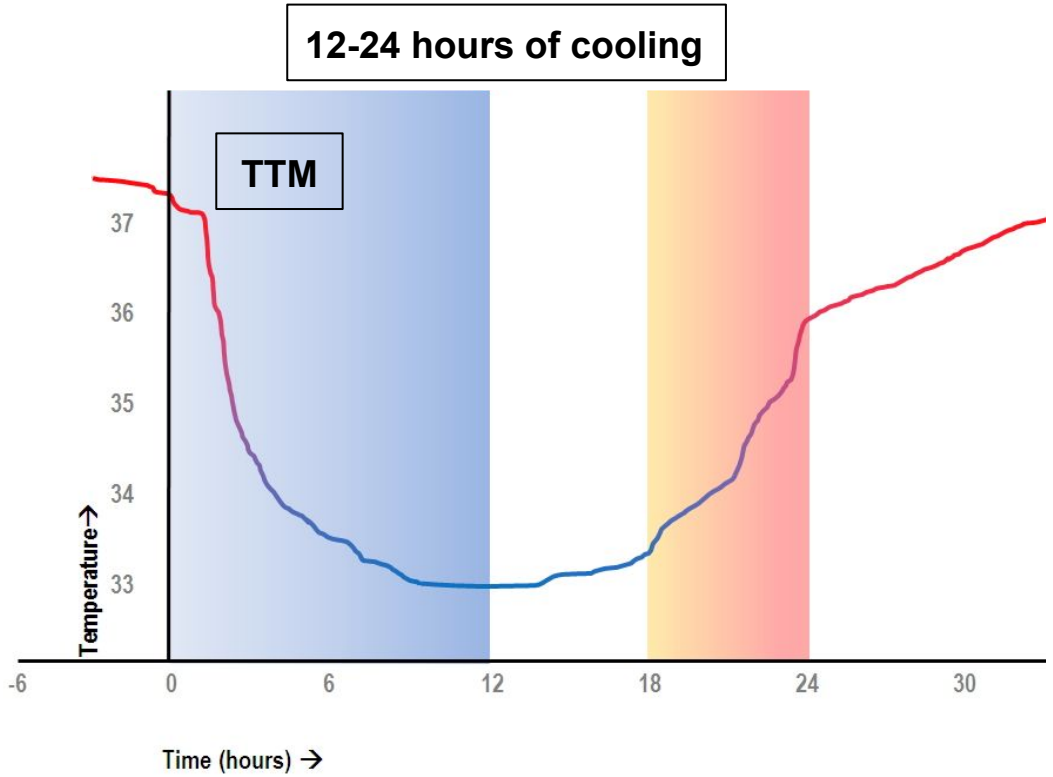
ie. Recurrent Neural network

Gated Recurrent Unit, Long short-term memory

Aim 3: Targeted Temperature Management Efficacy Prediction

Predict which patient will have increased recovery if TTM is administered

- 6-8 hours after admission
- Temperature below 36℃ for at least 12 hours.

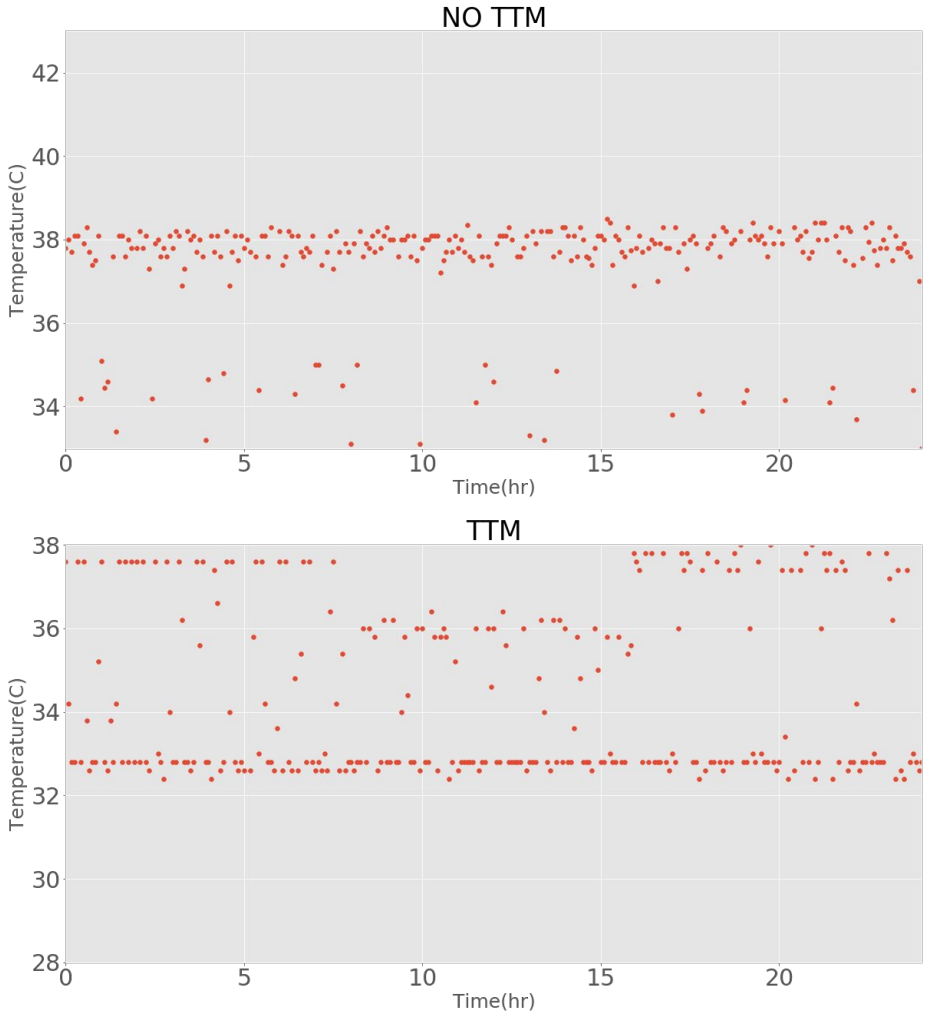


Aim 3 Approaches

1. Locate TTM patients
2. Isolate features from first 6-8 hours
3. Use similar framework from Aims 1 & 2

Identify Patients who will either:

1. Respond favorably to TTM
2. Will not benefit from TTM



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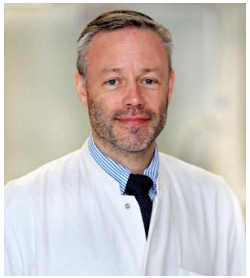

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Thank you for listening!

Questions? Comments? Suggestions?

APPENDIX

Targeted Temperature Management

- Targeted Temperature Management (formerly Therapeutic Hypothermia) is the intentional cooling of a patient to 33-36°C for 18-24 hours post-cardiac arrest.
- Multiple studies have shown induced therapeutic hypothermia improves neurologic function in post-cardiac arrest patients when initiated within six hours of the arrest; starting with two landmark studies in 2002.
- The American Heart Association in 2005 listed induced hypothermia as one of the guidelines for post-cardiac arrest care.

https://cdn.ymaws.com/npofoklahoma.com/resource/collection/C3C77701-15EF-4C38-86ED-993BCB850168/Hypothermia%20in%20Cardiac%20Arrest.pdf

How Does It Work?

- Initial neurologic injury occurs when circulatory collapse impairs oxygen flow to the brain. Without oxygen, the brain switches to anaerobic metabolism, resulting in excessive calcium and glutamate excretion. This makes brain cells more excitable, leading to further hypoxemia, in turn causing mitochondrial and cellular death.
- Cellular death results in cerebral edema, producing further damage.
- The initial injury also disrupts the blood-brain barrier, which increases fluid in the brain and worsens cerebral edema.
- Hypothermia counteracts neuro-excitation in brain cells by stabilizing calcium and glutamate release, reducing the degree of cell death. It also stabilizes the blood-brain barrier and suppresses the inflammatory process, reducing cerebral edema. Cerebral metabolism decreases 6% to 10% for every degree Celsius that body temperature drops. As cerebral metabolism declines, the brain needs less oxygen.
- Hypothermia counteracts many of the destructive mechanisms of cardiac arrest. Similarly, hypothermia halts destructive brain mechanisms and lets the brain reset itself to normal functioning.
- Decard & Ebright (2011).

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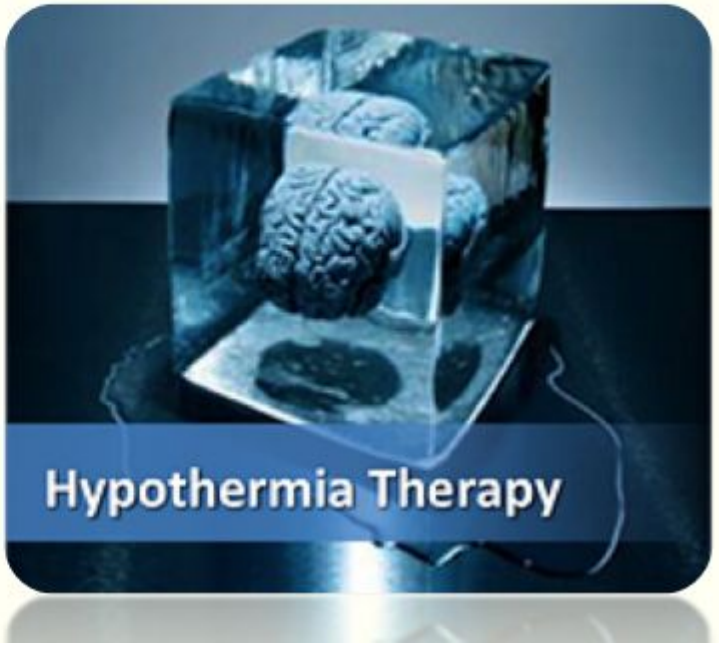
Targeted Temperature Management Review

- After cardiac arrest and successful resuscitation, patient can be determined if he/she is a candidate for TTM
  - Several Inclusion & Exclusion Criteria
- Multiple Cooling Methods
  - Ice Packs
  - Cooled Saline
  - Gaymar Unit
  - Zoll Catheter
- Cooled for 24 hours
- Slowly rewarmed
- Neurological Function assessed



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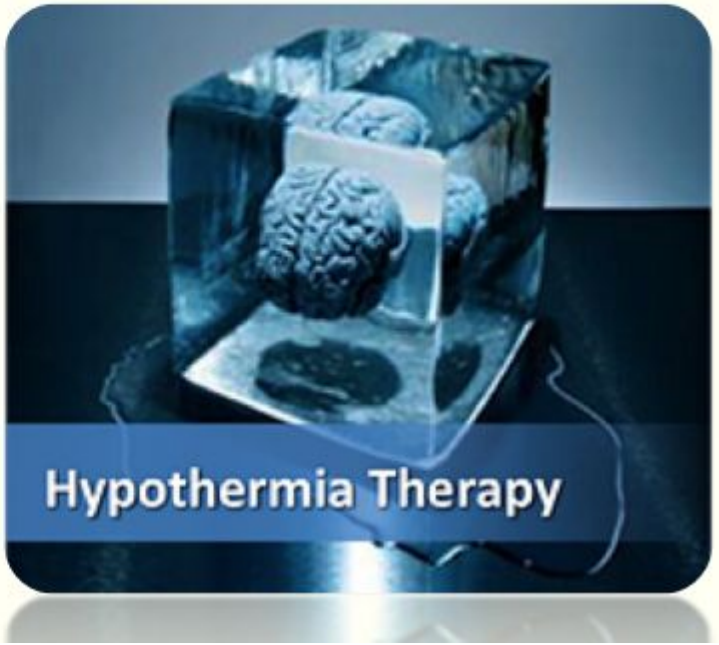

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Targeted Temperature Management

Inclusion Criteria

- Cardiac Arrest/ROSC within 6 Hours
- GCS <8
- SBP ~90
- Mechanical Ventilation
- >16 Year Old Patient

Exclusion Criteria

- ROSC >6hrs Prior
- GCS >8; Purposeful Movements
- Initial Temp <30
- MAP <60 with Interventions
- Terminal Illness
- DNR Standing
- Coagulopathy/Active Bleeding
- Primary Intra-Cranial Event
- Arrest Secondary to Severe Sepsis
- Major Surgery in last 72 Hours
- Trauma Patient at Risk for Bleeding

Cardiac Arrest

- Full Advanced Cardiac Life Support Measure
  - Intubation
  - CPR
  - Defibrillation
  - Medications
    - Epinephrine
    - Bicarbonate
    - Amiodarone
- Correct Abnormalities
  - ABG; pH
  - Acidosis
  - Electrolytes
- Hemodynamic Support
  - Pressors; Inotropes, etc.

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Vegetative state vs. Brain death

For brain death:

1. ***Absence of Brainstem Reflexes:*** Patient should be unresponsive to stimuli that otherwise would trigger an involuntary response (such as dilation of the pupils in the presence of a bright light)
2. ***Apnea Test:*** The patient, when disconnected from a respirator, should not have respiratory movements and will show other measurable signs supporting the diagnosis of brain death.