Neuroemergencies Management and Transfers (NEMAT): A Systems of Care Approach

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Systems Director, NEMAT
Co-Director ICCM Research
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Disclosures

- Post-ICU Recovery Clinic THRIVE Grant, PI
- CAIRO Post ICU Recovery Collaborative, Founding member
- Freidman Brain Institute Scholar
- Neurocritical care Society INCLINE grant, Co-Investigator
- Bee Foundation Fellowship Grant; Co-Investigator
- University of Connecticut mHealth Institute’s Social Media Pilot Grant
- Site PI: SHINE, iDEF, CHARM, INTREPID, ASTROH
- Consultant for the Stroke Project Inc.
- Speaking Honoraria for Grand Rounds
- Visiting Professor, National Taiwan University
- Visiting Professor, SUNY Downstate (pending)
Objectives

1. To learn how a systems of care approach for neuroemergencies can be implemented and adapted during a pandemic in a large urban health system

2. To understand the impact of a systems of care approach for neuroemergencies on access to multidisciplinary care and patient outcomes

3. To learn how to disseminate evidence-based knowledge about neuroemergencies to different groups of learners such as nurses, advanced practice providers, trainees and colleagues in neurology, neurosurgery, critical care, EM, IM, anesthesiology, radiology and others
Mount Sinai Health System

- 2013: Merger of Continuum Health Partners and Mount Sinai Medical Center
- >2,000 residents and Fellows
- Operating Rooms: 147
- 536,443 ER visits/year, >3.4 million outpatient visits
- 39 Multidisciplinary clinical and research institutes
- **Beds/hospital**
  - Mount Sinai Hospital: 1171 beds
  - Mount Sinai West: 514 beds
  - Mount Sinai St. Luke’s: 495 beds
  - Mount Sinai Beth Israel: 799 beds
  - Mount Sinai Brooklyn: 212 beds
  - Mount Sinai Queens: 235
  - South Nassau Communities: 455 beds
  - NY Eye and Ear Infirmary: 69 beds
New York City

Census tract population density, 2010

Population - 8,175,133

Source: 2010 Census

- > 100,000 people per square mile
- > 50,000 people per square mile
- > 30,000 people per square mile
- > 20,000 people per square mile
- > 10,000 people per square mile
- 0 - 10,000 people per square mile

New York City is the most densely populated city in the United States, with an average density of just under 30,000 people per square mile. In much of Manhattan and the Bronx, and parts of Queens and Brooklyn, the population density for some census tracts is higher than 100,000. Staten Island only has one census tract with a density above 60,000 but in comparison to most of the United States it is still very densely populated.

Photo: Alasdair Rae

Multi-Hub and Multi-Spoke Model
Case 1: Drip and Ship

- 48 M with no known stroke risk factors woke up from a nap not feeling well. His wife found him down in the bathroom with dysarthria and hemiplegia at 19:00 hr
- EMS brought him to Mount Sinai Queens (MSQ) ER and transfer was activated to Mount Sinai Hospital (MSH) ER per protocol
- NIHSS 16
- CTH/CTA: ASPECTS 10, Left M1 clot
- Intravenous rTPA at 21:00 hr followed by thrombectomy with TICI 3 recanalization
- Post embolectomy non-contrast CTH showed evolving left MCA infarct with hemorrhagic transformation
- Hemicraniectomy watch per protocol
Case 1: Drip and Ship

- Intubated for airway protection at 17:11 hr on post-stroke day 1
- Exam improved and extubated on post-stroke day 4
- Modified Rankin Score (mRS) 4 at time of cranioplasty
- mRS 3 at the time of most recent follow-up at one year
Case 2: Trip and Treat

- 92 F, vasculopathy on Xarelto for A. fib
- MSQ ER around 13:15 hr
- CTH/CTA: 13:40 hr
- Thrombectomy at MSQ
- Real time feedback
Case 3: Ship and Treat

- 72 yo M with unknown PMH who was found down on the subway. EMS brought him to MSQ ER. Exam on arrival: Comatose, pupils fixed and dilated 6 mm.

- Intubated for airway protection. CTH showed diffuse SAH and hydrocephalus, HH5, mF4

- **Transferring Hospital:** MSQ ER
  - **Initiated By:** MSHS Transfer Center via NEMAT hotline

- **Time Initiated:** 01/06/2018 15:55
  - **Time of Pick Up:** 01/06/2018 16:15
  - **Declared brain dead at:** 12:55, 1/10/2018
Neuroemergencies Management and Transfers (NEMAT): A Patient Centered Approach

Mission Statement:

- To advance clinical care, research and education for Neuroemergencies Management and disposition in a large urban health system

- Neuroemergencies: Refer to Neurosurgical or Neurological emergencies that need time-sensitive multi-disciplinary management in the hyperacute and acute phases as well as for transition of care and re-integration into life roles

- Examples: Stroke, Traumatic Brain Injury
Inter-hospital Transfers (IHT) for Critically Ill Patients

- 1999, ADT guidelines published by SCCM
- Current Guidelines address several areas including “Transfers of Patients from Outside Facilities”

**Recommendation:**
There are insufficient data to make a recommendation for or against ICU-to-ICU interhospital transfer (no recommendation).
IHT for Critically ill Patients

- Will increase due to
  - Consolidation of care into Health Systems
  - Specialization of care, “centers of excellence”, regionalization of care

- 1.5% of ER patients were transferred to other facilities

- Among the top 10 reasons for transferring patients were:
  - Stroke
  - Aneurysm
  - Older >=65
  - Shock

  (Kindermann D et al. Statistical Brief #155. Healthcare Cost and Utilization Project (HCUP) Statistical Briefs)

- 2% of patients requiring emergent surgeries underwent IHT (Yelverton S et al Amer Journal of Surgery 2018)

IHT for Critically ill Patients

- Conflicting Data
- Critically ill patients undergoing IHT may have:
- Studies have also shown no difference or lower mortality (Newgard CD et al J Trauma 2007)
IHT for Neuroemergencies

- Trauma: TBI, SCI: Brain Trauma Foundation guidelines
- Stroke: AHA/ASA
  - Acute Ischemic Stroke: Recommendations rapidly evolving due to explosion of literature
  - Hemorrhagic stroke (SAH/ICH): Recommendations sparse
- SAH Direct admits via ER had 2 fold greater odds of better outcome as compared to IHT SAH patients
  (Naval N et al J of Crit Care 2012)
- ICH Direct admits via ER versus IHT ICH patients: no difference in outcomes
  - (Naval N et al Neurocrit care 2010)
- SAH, ICH, SDH: IHT patients no difference in outcomes (Catalano A et al Neurocrit care 2012)
- Status Epilepticus
- Neuromuscular
- Meningitis/Encephalitis
IHT for Neuroemergencies

- When should we transfer patients with acute brain injuries?
  - For definitive expert care
  - Systems of care: eg. Trauma, Stroke

- How should we transfer patients with any acute brain injuries?
  - Critical care management on site
    - Airway
    - Hemodynamics
    - Raised ICP
    - Coagulopathy
    - Seizures

- Process and Patient level outcomes: How should we track these? What’s meaningful?
The Mount Sinai Approach to Neuroemergencies

SAH: MSH
ELVO: NYC MIST*
ICH: MSW
Trauma: MSSL
Epilepsy Surgery: MSW

The Pyramid in Action

We are turning rare diagnoses into common ones

In 2016 created an ICH center at MSW, and now transfer all such patients to the center

Slides Courtesy  J Mocco and Joshua Bederson
The Transfer Patient Dilemma: Even in an Ideal Scenario

Neuroemergencies: Recognize, triage, stabilize, escalate
IHT: What Can go Wrong...

EMS takes crew to wrong Unit

Pre-ICU recs not followed
Patient decompensation not communicated

No beds in ER and or unit

Patient Decompensation

No nursing report
NEMAT: Guiding Principles

Right Patient

Right Place

Right Time

Right Care

NEMAT: Clinical care Research Education
NEMAT Hyperacute Phase: Threat to Life/Limb
Acute Phase: Threat to Life/Limb Systemic Complications, Secondary Neurological Injury
NEMAT Transition of Care: Re-integration into Life Roles

Neuroemergencies: Transition of Care

- Neurology
- Neurosurgery
- Case Management
- Social Work
- Nursing
- Physiotherapy
- Occupational therapy
- Speech therapy
- Nutrition
- Spiritual Care
- Palliative Care
- Bed Management

Critical Care Resilience Program (CCRP)

- Peer to peer support group
- ICU diaries
- Humanize the ICU projects
- CC Recovery Clinic

Humanize the ICU projects

ICU diaries

Peer to peer support group

CC Recovery Clinic

#NEMAT
Mount Sinai Health System NEMAT Team

NEMAT Core Team

• Neurosurgery Chair and Vice Chair
• NEMAT Director
• Neurointensivists
• NCC Fellows
• NCC Advanced Care Providers
• NCC Nursing
• NEMAT Data Science team

NEMAT Partners: Disease and Site Specific (MSHS hospitals and Affiliates)

• MSHS Transfer Center
• Cerebrovascular Center
• Stroke Division
• Brain Tumors
• Spine Division
• Epilepsy Division
• Neurotrauma

NEMAT Affiliates

• Emergency Medicine
• Radiology
• Anesthesiology
• Bed Management
• EMS
• Rehabilitation Therapists
• Adult and Pediatric Critical Care
• Environmental services
• Spiritual care
Neurocritical Care Across the Mount Sinai Health System
NEMAT Program Structure

- Disease and Site specific Team members
- Triage Levels and Flowchart
- Tools
- Research and Development
- Checklists/Protocols
- Communication: 24/7 Hotline, Messaging groups
- QA/PI: Database
# MOUNT SINAI HEALTH SYSTEM POLICY & PROCEDURE

**POLICY TITLE:** Transfer Bundle Policy  
**POLICY NUMBER:** PTC-XX  
**LAST REVIEWED DATE:** September 2018  
**EFFECTIVE DATE:** October 2018  
**RELATED POLICIES:**  
- Emergency Treatment, Stabilization, Transfer of Patients and EMTALA (Emergency Medical Treatment and Labor Act)  
- MSHS PTC-3 Patient Transfer Center Policy and Procedure  

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- Centralized Transfer Process  
- Transfer Center  
- Hand-offs  
- Disease specific protocols and checklists  
- Transfer Levels
<table>
<thead>
<tr>
<th>Transfer Level</th>
<th>Departure within</th>
<th>Examples</th>
</tr>
</thead>
</table>
| Life Rescue    | 30 mins          | 1) Ongoing herniation which might become potentially irreversible in an hour  
2) Refractory Shock despite maximum dose of 2 pressors and ongoing resuscitation  
3) ELVO  
4) SAH with hydrocephalus (HH 4 or 5) |
| Level I        | 60 mins          | 1) ELVO  
2) SAH  
3) ICH-surgical decompression or SCUBA  
4) Acute or subacute SDH  
5) SCI/Spinal cord  
6) Brain tumor emergencies |
| Level II       | 4 hours          | 1) Good grade SAH  
2) Potential Scuba ICH  
3) Subacute to Chronic SDH  
4) Non-operative ICH |
| Level III      | Once Bed is available | 1) Brain tumor  
2) Multi-level decompression spine surgery |
Neuroemergency IHT Disease Types (Unpublished Data)

2018

- AMS: 251 (26%)
- ICH: 82 (8%)
- SDH: 84 (8%)
- Other: 65 (7%)
- Stroke: 117 (12%)
- Seizure/Status Epilepticus: 100 (10%)
- TBI: 117 (12%)
- Brain Tumor: 99 (10%)
- Encephalitis/Meningitis/Dissemination: 134 (14%)
- SAH: 1 (1%)

N = 975

2019

- AMS: 279 (25%)
- ICH: 121 (11%)
- SDH: 100 (9%)
- Other: 116 (10%)
- Stroke: 151 (13%)
- Seizure/Status Epilepticus: 146 (13%)
- TBI: 92 (8%)
- Brain Tumor: 23 (2%)
- Encephalitis/Meningitis/Dissemination: 134 (14%)
- SAH: 20 (2%)

N = 1123

2020 YTD

- AMS: 67 (6%)
- ICH: 21 (5%)
- SDH: 39 (9%)
- Other: 38 (9%)
- Stroke: 65 (15%)
- Seizure/Status Epilepticus: 43 (10%)
- TBI: 49 (11%)
- Brain Tumor: 5 (1%)
- Encephalitis/Meningitis/Dissemination: 43 (10%)
- SAH: 1 (0%)

N = 435

#NEMAT
Neuroemergency IHT Accepting Hospitals: Multi-Hub and Multi-Spoke Model

2018

- N = 975
- nn=709 (73%)
- n=201 (21%)
- n=27 (3%)
- n=2 (0%)

2019

- N = 1123
- n=655 (58%)
- n=130 (11%)
- n=224 (20%)
- n=77 (7%)
- n=7 (1%)

2020 YTD

- N = 435
- n=255 (58%)
- n=57 (13%)
- n=130 (11%)
- n=224 (20%)
- n=7 (1%)
- n=1 (0%)
- n=3 (1%)

Legend:
- Other
- Elmhurst Hospital
- MSBI
- MSH
- MSQ
- MSSL/MSM
- MSW
Median Transfer Times by Neuroemergency Type

[Bar chart showing transfer times by neuroemergency type for 2018, 2019, and 2020 YTD.]
Overall Median Transfer Times for Neuroemergencies
2018 Neuroemergency IHT Outcomes (Unpublished Data)

**LOS**

- Hospital Length of Stay
- ICU Length of Stay

**Discharge Destination**

- Home 40%
- Acute Rehab 23%
- SAR/SNF 16%
- Hospice 8%
- LTACH 1%
- Other 8%
- Patient Expired 7%
- Patient Other 8%

**60 Day Mortality**

- Yes (n=80) 77%
- No (n=24) 23%
NEMAT: Pre-COVID-19 and During COVID-19:
Challenge Right care for the Right patient at the Right time
irrespective of COVID19 status
Disease Types - Pre-COVID vs COVID Periods (Unpublished Data)

N = 304

N = 379

N = 374
Accepting Hospitals - Pre-COVID vs COVID Periods

Accepting Hospital - 2018

Accepting Hospital - 2019

Accepting Hospital - 2020

N = 304

N = 379

N = 374
Transfer Times - Pre-COVID vs COVID Periods (Unpublished Data)

Transfer Times - 2019

Transfer Times - 2020

#NEMAT
Trauma systems of care

1965
National Research Council and Institute of Medicine’s Injury in America

1970
1980
1985
1990
1995
2000
2005
2010
2015
2020

1985
Institute of Medicine’s Reducing the Burden of Injury

1999
The National Academies of Sciences, Engineering, and Medicine’s A National Trauma Care System

2004
National Highway Traffic Safety Administration’s Trauma System Agenda for the Future

2007
Institute of Medicine’s Hospital-Based Emergency Care

1994
National Institute of Health’s A Report of the Task Force on Trauma Research

1966
National Research Council’s Accidental Death and Disability

A National Evaluation of the Effect of Trauma-Center Care on Mortality


DO STROKE PATIENTS DESERVE LESS?

Like Trauma, Stroke Patients Need a System That Helps Them Survive

**TRAUMA PATIENT**

**Triage**
Patient evaluated according to standardized criteria.

**Transport**
Patient taken to life-saving trauma center (required by state law).

**Treatment**
Patient receives the right care as rapidly as possible.

---

**SEVERE STROKE PATIENT**

**Triage**
Patient evaluation is not standardized.

**Transport**
Patient taken to nearest hospital.

**Transfer**
Nearest hospital is not equipped to treat severe stroke. Patient requires transfer to a Level 1 stroke center.

**Treatment**
Patient arrives at Level 1 stroke center, but hours have been lost in transfer, jeopardizing recovery.

---

1 Less than 50 percent of severe stroke patients get the most effective treatment.

2 Due to delay, less than 5 percent of severe stroke patients are transferred to timely hospitals for specialized stroke surgery.
Time is Brain: Stroke Care

### Estimated Pace of Neural Circuitry Loss in Typical Large Vessel, Supratentorial Acute Ischemic Stroke

<table>
<thead>
<tr>
<th></th>
<th>Neurons Lost</th>
<th>Synapses Lost</th>
<th>Myelinated Fibers Lost</th>
<th>Accelerated Aging</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per Stroke</td>
<td>1.2 billion</td>
<td>8.3 trillion</td>
<td>7140 km/4470 miles</td>
<td>36 y</td>
</tr>
<tr>
<td>Per Hour</td>
<td>120 million</td>
<td>830 billion</td>
<td>714 km/447 miles</td>
<td>3.6 y</td>
</tr>
<tr>
<td>Per Minute</td>
<td>1.9 million</td>
<td>14 billion</td>
<td>12 km/7.5 miles</td>
<td>3.1 wk</td>
</tr>
<tr>
<td>Per Second</td>
<td>32 000</td>
<td>230 million</td>
<td>200 meters/218 yards</td>
<td>8.7 h</td>
</tr>
</tbody>
</table>

### A Call to Action

Densely packed, intricately patterned, substrate of mind and awareness, the human brain is a wonder of nature. In an acute ischemic stroke, vast numbers of neurons, synapses, and nerve fibers are irretrievably lost every moment in which treatment does not occur. The figures stagger and motivate. Ischemic stroke is a highly treatable neuroemergency. For patients experiencing acute ischemic stroke, and for the physicians and allied health personnel treating them, every second counts.

Saver J Stroke 2003
Stroke Systems of Care: Evidence-Based Medicine

- From tpa to thrombectomy
- Revolution in ELVO treatment
- Tissue Clock: DEFUSE-3 and DAWN

Thrombectomy for Stroke at 6 to 16 Hours

<table>
<thead>
<tr>
<th>MULTICENTER, RANDOMIZED, OPEN-LABEL TRIAL WITH SELECTION BY PERFUSION IMAGING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thrombectomy + medical therapy</td>
</tr>
<tr>
<td>N=92</td>
</tr>
<tr>
<td>Artery occlusion and salvageable tissue</td>
</tr>
<tr>
<td>Disability score at 90 days favoring thrombectomy (P&lt;0.001)</td>
</tr>
<tr>
<td>45% Functional independence at 90 days (P&lt;0.001) 17%</td>
</tr>
<tr>
<td>7% Symptomatic intracranial hemorrhage within 36 hr (P=0.75) 4%</td>
</tr>
</tbody>
</table>

Medical therapy alone
N=90

▶ REVOLUTION IN ELVO TREATMENT
▶ TISSUE CLOCK: DEFUSE-3 AND DAWN

Thrombectomy 6 to 24 Hours after Stroke with a Mismatch between Deficit and Infarct - DAWN Trial

- Multicenter, prospective, randomized, open-label trial
- 206 patients with acute occlusion of the intracranial internal carotid artery or proximal middle cerebral artery who were known to be well 6 to 24 hours earlier
- Randomized to mechanical thrombectomy (N=107) or standard care (N=99)
- Followed up for 90 days
- Modified Rankin Scale Score: 5.5 vs 3.4
- Functional Independence: 49% vs 13%
- Early Response: 48% vs 19%

Among patients with acute stroke who had a mismatch between clinical deficit and infarct, outcomes for disability at 90 days were better with thrombectomy plus standard care than with standard care alone.


Slide Courtesy: Dr. John Liang

#NEMAT
Evolution of Stroke Systems of Care

Recommendations for the Establishment of Stroke Systems of Care: A 2019 Update

A Policy Statement From the American Stroke Association


Table 1. Levels and Capabilities of Hospital Stroke Designation

<table>
<thead>
<tr>
<th></th>
<th>ASRH</th>
<th>PSC</th>
<th>TSC</th>
<th>CSC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Likely rural</td>
<td>Likely urban/suburban</td>
<td>Likely urban</td>
<td>Likely urban</td>
</tr>
<tr>
<td>Stroke team accessible/available 24 h/d, 7 d/wk</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Noncontrast CT available 24 h/d, 7 d/wk</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Advanced imaging (CTA/CTP/MRI/MRA/MRP) available 24 h/d, 7 d/wk</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Intravenous alteplase capable</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Thrombectomy capable</td>
<td>No</td>
<td>Possibly</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Diagnoses stroke pathogenesis/manage poststroke complications</td>
<td>Unlikely</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Admits hemorrhagic stroke</td>
<td>No</td>
<td>Possibly</td>
<td>Possibly</td>
<td>Yes</td>
</tr>
<tr>
<td>Clips/coils ruptured aneurysms</td>
<td>No</td>
<td>Possibly</td>
<td>Possibly</td>
<td>Yes</td>
</tr>
<tr>
<td>Dedicated stroke unit</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Dedicated neurocritical care unit/ICU</td>
<td>No</td>
<td>Possibly</td>
<td>Possibly</td>
<td>Yes</td>
</tr>
</tbody>
</table>

ASRH indicates acute stroke-ready hospital; CSC, comprehensive stroke center; CT, computed tomography; CTA, computed tomography angiography; CTP, computed tomography perfusion; ICU, intensive care unit; MRA, magnetic resonance angiography; MRI, magnetic resonance imaging; MRP, magnetic resonance perfusion; PSC, primary stroke center; and TSC, thrombectomy-capable stroke center.
Currently, only ≈50% to 60% of hospitalized stroke patients arrive at the hospital via EMS

Given poor stroke awareness among US adults, with the lowest awareness among Hispanics and blacks lack of knowledge of the risk factors and of the signs and symptoms of stroke remains a hindrance to timely stroke care
### What did this mean for us?

<table>
<thead>
<tr>
<th>Column3</th>
<th>Column4</th>
<th>Column5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Comprehensive Stroke Center</td>
<td>Maimonides Medical Center</td>
<td>Brooklyn</td>
</tr>
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<td>Advanced Comprehensive Stroke Center</td>
<td>NYU Langone Hospitals</td>
<td>New York</td>
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<td>Advanced Comprehensive Stroke Center</td>
<td>Mount Sinai Hospital</td>
<td>New York</td>
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<td>NewYork-Presbyterian Hospital</td>
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<td>Strong Memorial Hospital</td>
<td>Rochester</td>
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<td>Good Samaritan Hospital Medical Center</td>
<td>West Islip</td>
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<td>University Hospital (Stony Brook)</td>
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<td>Mercy Hospital of Buffalo</td>
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<td>Advanced Comprehensive Stroke Center</td>
<td>Montefiore Health System</td>
<td>Bronx</td>
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<td>Advanced Comprehensive Stroke Center</td>
<td>North Shore University Hospital</td>
<td>Manhasset</td>
</tr>
<tr>
<td>Advanced Primary Stroke Center</td>
<td>NYC Health + Hospitals/Kings County</td>
<td>Brooklyn</td>
</tr>
<tr>
<td>Advanced Primary Stroke Center</td>
<td>Elmhurst Hospital Center</td>
<td>Elmhurst</td>
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<td>Advanced Primary Stroke Center</td>
<td>Geneva General Hospital</td>
<td>Geneva</td>
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<td>Advanced Primary Stroke Center</td>
<td>Kenmore Mercy Hospital</td>
<td>Kenmore</td>
</tr>
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<td>Advanced Primary Stroke Center</td>
<td>White Plains Hospital Center</td>
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<td>Advanced Primary Stroke Center</td>
<td>Mercy Medical Center</td>
<td>Rockville Centre</td>
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<td>Suffern</td>
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<td>Oceanside</td>
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<td>St. Charles Hospital</td>
<td>Port Jefferson</td>
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<td>Advanced Primary Stroke Center</td>
<td>Vassar Brothers Medical Center</td>
<td>Poughkeepsie</td>
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<td>Lincoln Medical and Mental Health Center</td>
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<td>NewYork-Presbyterian Queens</td>
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<td>WSNCHS North, Inc</td>
<td>Bethpage</td>
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<td>Richmond Medical Center</td>
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<td>Smithtown</td>
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<td>Advanced Thrombectomy Capable Stroke Ctr</td>
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<tr>
<td>Stroke Rehabilitation</td>
<td>NYU Langone Hospitals</td>
<td>New York</td>
</tr>
</tbody>
</table>

Mount Sinai / Presentation Slide / December 5, 2012
We changed our protocol rapidly across the health system
CT/CTA without waiting for creatinine
ELVO IHT: ER to ER saves time to recanalization
Conclusions
The Mount Sinai response to the recent surge of evidence supporting IAT for AIS has had a major impact. We have seen a rapid increase in volume, structure, and enthusiasm, which, in turn, has led to improved process times, revascularization, and a modest improvement in clinical outcome at discharge. The most impressive change, however, is the interdisciplinary team effort among neurologists, neurosurgeons, intensive care unit physicians, radiologists, anesthesiologists, ER physicians, nurses, stroke coordinators, and hospital administrators who have together taken up this challenge. These findings demonstrate how a large healthcare system can change rapidly overnight.

Acknowledgments
We acknowledge all members of the stroke team who participated in patient care and improving stroke care at the Mount Sinai Health System. We would like to acknowledge Benazir Ali, Chesney Oravec and Rebecca Apruzzese for their role in writing the institutional review board submission.
Mobile Interventional Stroke Teams Lead to Faster Treatment Times for Thrombectomy in Large Vessel Occlusion.

Wei D1, Dooley TJ2, Nistal DA3, Masciulli JR1, Wilson N2, Stein L1, Liang J4, Turkheimer LM1, Morey JR1, Schwegel C1, Awad AJ5, Shoirah H1, Keliner CP1, De Laay RA1, Mayer SA1, Tuhim S1, Parameswaran S1, Mocco J1, Ffiffi J2.

Mobile Interventional Stroke Teams Lead to Faster Treatment Times for Thrombectomy in Large Vessel Occlusion, Volume: 48, Issue: 12, Pages: 3295-3300, DOI: (10.1161/STROKEAHA.117.018149)

#NYCMIST

#NEMAT
Challenges in IHT: Isn’t Time Brain for all Neuroemergencies?

- Critical care management at transferring hospital
  - Airway and Ventilation
  - Hemodynamics
  - Raised ICP
  - Coagulopathy
  - Seizures

- Closed loop communication

- Critical care management on arrival at destination hospital
  - ER/NSICU
  - OR
Cerebral Perfusion Pressure = Mean Arterial Pressure - Intracranial Pressure
Zone I: optimal compensation

Zone II: compensatory mechanisms have failed

Zone III: irreversible increase in ICP and herniation
Recap Case 3: Ship and Treat

Brief Hx: 72 yo M with unknown PMH who was found down on the subway, patient was brought to Mount Sinai Queens ER. Found to be comatose, pupils fixed and dilated 6 mm.

- What if we were able to place an EVD prior to transfer? *EVD Swat team*

- How would we transfer this pt? EVD closed? Open?

- We found no study or expert consensus that addressed this issue
**NEMAT PROTOCOL FOR INTERHOSPITAL TRANSFER WITH EVD**

**TRANSFERRING HOSPITAL**

- **ACTIVATE** NEMAT HOTLINE
- **INSERT** EVD for CSF Diversion
- **DRAIN** CSF < 20MM Hg
- **POST DRAINAGE** EVD open at
  - SAH: 15 cm H$_2$O
  - ICH: 10 cm H$_2$O

**DURING THE TRANSFER**

- **CLAMP** EVD for Transport.
- **FLUIDS**
  - 1g/kg Mannitol + 1 L Crystalloids
  - If transport > 30 min
    - 0.5 g/kg Mannitol.
- **MONITOR** Patient status

**ARRIVAL AT ACCEPTING HOSPITAL**

- **RELEASE CLAMP** Measure Opening ICP
- **DRAIN** CSF < 20MM Hg
- **CT SCAN** Post EVD Scan
- **FOLLOW NEMAT ICP PROTOCOL**

- FOLLOW NEMAT ICP PROTOCOL AT ALL TIMES
- NOTIFY NEMAT HOTLINE FOR TRANSPORT DELAYS AND CHANGE IN PATIENT STATUS
<table>
<thead>
<tr>
<th>Demographic Variables</th>
<th>INITIAL HOSPITAL N(%)</th>
<th>POST TRANSFER</th>
<th>OUTCOMES</th>
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<td>Gender: N(%)</td>
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<td>Age in Years N(%)</td>
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<td>CT Scan N(%)</td>
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<td>First ICP Reading N(%)</td>
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<td>EVD Complications N(%)</td>
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<td>SOFA Score N(%)</td>
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<td>APACHE II Score N(%)</td>
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<td>Time with EVD N(%)</td>
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<td></td>
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<td>&gt;3 weeks</td>
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<td>Procedures: N(%)</td>
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<td>NSICU Length of Stay N(%)</td>
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<td>1-2 week</td>
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<td>2-3 week</td>
<td>7 (46)</td>
<td></td>
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<tr>
<td>&gt; 3 weeks</td>
<td>4 (27)</td>
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<tr>
<td>Hospital Length of Stay N(%)</td>
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<tr>
<td>&lt; 2 weeks</td>
<td>2 (15)</td>
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<tr>
<td>2-4 weeks</td>
<td>7 (46)</td>
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<td>&gt; 4 weeks</td>
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<td>Discharge Disposition N(%)</td>
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<tr>
<td>Admitted</td>
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</table>
Time is Brain for ICH too!

- Early diagnosis and management of ICH is critical
- The American Heart Association (AHA) and American Stroke Association (ASA) guidelines recommend quick admission to a stroke unit or neuroscience intensive care unit
- Even with established guidelines for the treatment of ICH, hospital management varies greatly and few centers have ICH-specific protocols
- Better Outcomes for ICH patients managed in Neuro-ICUs
- Early Blood pressure control improves outcomes
- Early coagulopathy reversal improves outcomes

Should we remove the blood?

How should we remove the blood?

When should we remove the blood?

Slides Courtesy: Dr. Christopher Kellner
Should we remove the blood?

J Scaggiante et al Stroke 2018
How should we remove the blood?

Slide Courtesy: Dr. Christopher Kellner
ICH Focused Hospital: SCUBA

several days of falling. R thalamus ICH with IVH. 205/117. Intact walking around the ED. ASA getting dDAVP.
Clevipex being ordered for sbp <140

Kellner Christopher

Liang John
I tentatively gave them your name chris but the story (needs confirming) sounds several days old. Punam is aware of the patient and we now have right time stroke PA coverage so if deemed nonsurgical can transition to stroke service

Kellner Christopher
Okay.

Liang John
Thank you John and Chris: This was one of the fastest ICH triages

Kellner Christopher
Thank you John and Chris. This was one of the fastest ICH triages

Welcome to July :)

#NEMAT
Single Center Experience Early Evacuation of ICH by SCUBA

- Goal of the centralized ICH care model is to emulate the success of other centralized care models including those for acute ischemic stroke, severe trauma, and myocardial infarction
- ICH center: IHT coordinated and supervised by NEMAT and has 24/7 Neurosurgical coverage
- SCUBA: Minimally invasive endoscopic evacuation
- Multidisciplinary management
- n=100, 89 IHT and 11 direct admits
- No difference in functional outcomes
- Centralization of IHT improves access to novel therapies for ICH like SCUBA

(Manuscripts under review, Data presented at AANS 2019, WICH 2019)
NEMAT: Challenges and Solutions

**Capacity Creation**
- TeleNeurocritical Care Consults
- Develop Data driven Criteria for Non-transfer
- Physical Resources
- Personnel Resources

**QA/PI**
- EPIC SmartForms: Protocols and Checklists
- Online integrated Personnel and Resource Schedules/Live Updates
- NEMAT Database: Automate
- NEMAT Roadshows

**Research and Development**
- NEMAT EVD Swat team
- Cost Analysis
- AI and Machine Learning
NEMAT Education

- Small groups, intermediate and large groups
- Simulation based
- Web-based: On demand course modules, Webcasts
- Roadshows
- Patients and Families
- Longitudinal NEMAT database
## NEMAT Protocols and Checklists

Purpose: Develop and Disseminate Evidence Based Protocols and Checklists to Standardize the management of Neuroemergencies throughout the health system

<table>
<thead>
<tr>
<th>Vascular Operative</th>
<th>Non Vascular Operative</th>
<th>Neurosurgical Non-Operative</th>
<th>Neurological</th>
<th>Universal Protocols</th>
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</thead>
<tbody>
<tr>
<td>ELVO</td>
<td>TBI</td>
<td>SDH</td>
<td>Status Epilepticus</td>
<td>NEMAT ICP</td>
</tr>
<tr>
<td>SAH</td>
<td>SCI</td>
<td>Vertebral Fractures</td>
<td>Neuromuscular emergencies</td>
<td>NEMAT Airway</td>
</tr>
<tr>
<td>ICH</td>
<td>Brain Tumor Emergencies</td>
<td>Brain Tumors</td>
<td>Meningitis/Encephalitis</td>
<td>NEMAT Coagulopathy Reversal</td>
</tr>
<tr>
<td>AVM and other Vascular Malformation</td>
<td>SDH</td>
<td></td>
<td>Post cardiac arrest</td>
<td>NEMAT Transition of Care and Recovery</td>
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<tr>
<td>Decompressive Craniectomy</td>
<td></td>
<td></td>
<td>Fulminant hepatic failure</td>
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</table>
NEMAT SAH 2018

Neuroemergencies Management and Transfers (NEMAT) SAH Triage Note and Checklist v1.2018

Patient Name and DOB (if not in EPIC already)
Referring Hospital/Attending:
Accepting Attending:
Transfer Co-ordinator:
Notification time:
Level of Transfer:

Brief narrative:

Check list for SAH transfers:
1) Initial Hunt Hess, modified Fisher
2) Last known well (Day of bleed is Day 0)
3) Airway:
4) Access and blood pressure goals, fluids:
5) Reversal needed: any antihypertensives, anticoagulants:
6) ICP precautions: HbH >30, Mannitol +/-Hypertonic saline, Sedation/Analgesia, Hyperventilation
7) EKG and Amicar
8) Keppra prophylaxis
9) Default destination: MSH NSICU, if no bed the EIR to ER, secondary option: MSW NSICU
10) Next of kin phone number
11) Clarify code status
12) Notify: Neurosurgery/Endovascular
13) Notify Bed management

On arrival to destination:
1) Confirm Hunt and modified Fisher
2) Use EPIC SAH order set
3) A-line
4) Foley if not placed already
5) Confirm timing of stopping Amicar
6) Confirm EVD need and at 20 or 15 above head level
7) POCUS including two point compression, adequate fluid resus, ICU panel
8) Prep for Angio/OR: type, screen, pregnancy test

Hunt and Hess grading system for patients with subarachnoid hemorrhage

<table>
<thead>
<tr>
<th>Grade</th>
<th>Neurologic status</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Asymptomatic or mild headache and slight nuchal rigidity</td>
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<tr>
<td>2</td>
<td>Severe headache, stiff neck, no neurologic deficit except cranial nerve palsy</td>
</tr>
<tr>
<td>3</td>
<td>Drowsy or confused, mild focal neurologic deficit</td>
</tr>
<tr>
<td>4</td>
<td>Stuporous, moderate or severe hemiparesis</td>
</tr>
<tr>
<td>5</td>
<td>Coma, decerebrate posturing</td>
</tr>
</tbody>
</table>

NEMAT SCUBA ICH Triage note and Checklist 2018

Neuroemergencies Management and Transfers (NEMAT) ICH Triage Note and Checklist v1.2018

Patient Name and DOB (if not in EPIC already)
Referring Hospital/Attending:
Accepting Attending:
Transfer Co-ordinator:
Notification time:
Level of Transfer:

Brief narrative:

1) Name, Age, MRN, DOB
2) Last known well (Day of bleed is Day 0)
3) Airway
4) Access and blood pressure goals, fluids
5) Reversal needed: any antihypertensives, anticoagulants
6) Video of CTH/CTA
7) EVD, mannitol; if EVD needed, check whether Neurosurg available on site?
8) Labs, if available
9) EKG if available
10) Keppra prophylaxis if Lobar ICH
11) Default destination: MSW NSICU, if no bed the EIR to ER, secondary option: MSH NSICU
12) Next of kin phone number

On arrival:
1) Calculate ICH score within 6 hours of arrival
2) Use EPIC ICH order set
3) A-line
4) Foley if not placed already
5) Confirm need for EVD and how many cm above head level
6) POCUS including two point compression, adequate fluid resus, ICU panel
7) Prep for Angio/OR: type, screen, pregnancy test
NEMAT ROADSHOWS
NEMAT roadshows, #SoME, #NEMAT

Jamie Rumsey @JamieRu... · 2/25/19 One of my favorite inspirational female leaders @drdangayach swung by MSW to review ICP with the @MountSinaiNeuro APP group last week! We couldn’t be more grateful for the continuing education opportunities! Invest in your APPs it makes all the difference.. #neurocriticalcare

Julianne Kleitsch @jkleits... · 5/20/19 What a privilege to present our research at #WICH2019 @drdangayach and @chriskellnerMD!! First medical conference talk 😊
Mount Sinai / Presentation Slide / December 5, 2012

ENLS Nursing Project presented at AANS 2019

Title: Self-reported Knowledge of ICU and PACU Nurses in Managing Neuroemergencies: A Survey Based Study

Authors: Amlani K, Sonia N, Riley E, Hickman Z, Keliner C, Almufti F, Weiss N, Golda B, Bederson J, Mocco J, Dangayach NS.

Keywords: Neurocritical Care, Stroke, PACU, nursing education

Study Design: Cross Sectional Survey Study

COMFORT LEVELS OF NURSES IN TAKING CARE OF NEUROLOGICAL EMERGENCIES

- Acute Ischaemic Stroke
- Post Thrombectomy Patients
- Post TPA patients
- Intra Cerebral Hemorrhage (ICH)
- Sub Arachnoid Hemorrhage (SAH)
- Raised ICP
- Management of EVD
- Status Epilepticus
- MeningoEncephalitis
- Spinal Cord Compression
- Post Craniotomy Patients
- Post Spinal Surgery
- Traumatic Brain Injury
- Traumatic Spine Injury
- Satisfied With Current Level of Education Training
- Need More Dedicated Study time

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<tr>
<th>Condition</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree nor Disagree</th>
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<th>Strongly Disagree</th>
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<td>16.0</td>
<td>26.6</td>
<td>18.9</td>
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<tr>
<td>Post Craniotomy Patients</td>
<td>16.0</td>
<td>16.0</td>
<td>26.6</td>
<td>18.9</td>
<td></td>
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<tr>
<td>Post Spinal Surgery</td>
<td>16.0</td>
<td>16.0</td>
<td>26.6</td>
<td>18.9</td>
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<tr>
<td>Traumatic Brain Injury</td>
<td>16.0</td>
<td>16.0</td>
<td>26.6</td>
<td>18.9</td>
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<tr>
<td>Traumatic Spine Injury</td>
<td>16.0</td>
<td>16.0</td>
<td>26.6</td>
<td>18.9</td>
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<tr>
<td>Satisfied With Current Level of Education Training</td>
<td></td>
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<tr>
<td>Need More Dedicated Study time</td>
<td></td>
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</tbody>
</table>
Critical Care Resilience Program (CCRP)
1st Patient seen: Feb 11th, 2020

The Mount Sinai Critical Care Recovery Clinic

Patients recovering from critical illness may experience a combination of cognitive, psychological and physical signs and symptoms that could last for months to years. This is often referred to as Post-Intensive Care Syndrome (PICS).

<table>
<thead>
<tr>
<th>Physical Symptoms</th>
<th>Cognitive Symptoms</th>
<th>Psychological Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respiratory difficulties</td>
<td>Memory difficulties</td>
<td>Anxiety</td>
</tr>
<tr>
<td>Weakness and balance</td>
<td>Concentration difficulties</td>
<td>Depression</td>
</tr>
<tr>
<td>problems</td>
<td>Slow mental processing</td>
<td>Post-traumatic stress</td>
</tr>
<tr>
<td>Pain</td>
<td>Trouble carrying out tasks</td>
<td>Sleep problems</td>
</tr>
</tbody>
</table>

In the Critical Care Recovery Clinic, our goal is to improve the quality of life for patients recovering from the effects of critical illness.

Who is eligible?
- ICU patients discharged from the hospital and have experienced any of the below:
  - Required mechanical ventilation
  - Were diagnosed with shock, sepsis or delirium
  - Any physical, cognitive or psychological symptoms of PICS

If you think your patient may benefit from our services please contact:
ContactMSCCRP@mountsinai.org

What services do we provide?
- Coordination and referrals to primary care
- Psychiatric and neurocognitive screening and referrals
- Medication review
- Social work
- Spiritual care
- Educational resources on physical, cognitive, emotional and daily living issues experienced by ICU survivors
- Resources and support for caregivers and family members

Intensivists
Pharmacists
Social workers
Spiritual care
Physiatrist
Research Staff
Administrator
Post-COVID19, we anticipate that there will be a higher incidence of problems in different PICS domains...severe ARDS, more sedation, more paralysis, less mobilization, less family visitation...

5.7 million ICU admissions annually
4.8 million ICU survivors annually

Exact prevalence of PICS among survivors is unknown

Almost 50% of ICU survivors suffer from dysfunction in one or more PICS domains.¹

Critical care Recovery Clinic: Telehealth Paradigm

**ATTENTION COVID CARE TEAM:**
Upon hospital discharge, enroll your COVID-19 patients who had an Intensive Care Unit stay seven days or longer into the Critical Care Recovery Clinic.

**TO REFER A PATIENT:**
Email MRN, First Name, and Last Name to ContactMCCRP@mountsinai.org

**Post-Intensive Care Syndrome**
In the Critical Care Recovery Clinic, our goal is to improve the quality of life for patients recovering from the effects of COVID-19 critical illness caused by their care while in the ICU.

Patients recovering from COVID critical illness may experience a combination of cognitive, psychological, and physical signs and symptoms that could last for months to years.

Referred to as Post-Intensive Care Syndrome (PICS), it may be present when the patient is in the intensive care unit and possibly persisting after the patient returns home.

**Help COVID Patients Get on the Right Track To Recovery**
Provide your COVID-19 patients the network of multidisciplinary resources that will support them and their families.

- Coordination and referrals to primary care
- Psychiatric and neurocognitive screening and referrals
- Medication review
- Social work
- Spiritual care
- Educational resources on physical, cognitive, emotional, and daily living issues experienced by ICU survivors
- Resources and support for caregivers and family members

Refer a Patient to the Critical Care Recovery Clinic
Email MRN, First Name, and Last Name to ContactMCCRP@mountsinai.org

This multidisciplinary group of critical care doctors, rehabilitation doctors, advanced practice providers, social workers, spiritual care providers, pharmacists, and specialty consultants helps patients recover from ICU hospitalisations.

We are focused on post-ICU recovery.
NEMAT: AI and Machine Learning Opportunities

- **Patient Data**
  - Outpatient, Inpatient, comorbidities, medications, risk stratification
  - Socioeconomic barriers
  - Psychosocial factors
  - Prognostication

- **NEMAT phase level Data**
  - Procedures
  - Critical Care
  - Trajectory of Recovery
  - EHR integration: Checklists, Protocols, Decision support, Reports

- **Process Data**
  - Interhospital Transfer: Notification to Activation
  - Communication: Inter-team, Patient and Family
  - Resource Optimization: Personnel and Physical resources
  - Traffic

- **Pattern recognition**
  - Disease-specific
  - Regional
  - Global

- **AISinai Collaboration**
  - Prediction of NSICU admission from ED triage
  - Notes (IRB-19-02333)

- **Moberg Collaboration**

- **Smart NSICU**
Collaborative Success: Machine Learning and AI

- **Stroke Systems of Care**
  - Imaging Diagnosis
    - (Lee E et al Jour of Stroke 2017)
  - AI in Stroke and Other Neuro Diseases
    - (Jiang F et al Stroke Vac Neurol 2017)
  - Automated Segmentation
    - (Zaharchuk G et al Amer Jour Neurorad 2018)
  - Prognosis
    - (Asadi H et al 2014 Plos One)
  - Geographic Modeling with GPS
    - (Mullen T et al Stroke 2018)
Case 2: Trip and Treat

- Automated 911 notification and activation of EMS, NEMAT
- Automated Segmentation for Perfusion Imaging Analysis
- All teams activated for Hyperacute and Acute Phases
- Workflow Integrated Communication and Data gathering Platform
- Smart Neuro ICU monitoring for complications for eg. Aspiration Pneumonia, Pulmonary Embolism
- Personalized Ultra-early Rehab
Case 3: Treat and Ship

- 72 yo M coma: Triggers Automated 911 pick-up
- Non-Invasive Rapid Machine Learning Diagnosis by EMS
- ABC in field and NEMAT hotline notification
- All teams activated for Hyperacute and Acute Phases
- Workflow Integrated Communication and Data gathering Platform
- Minimum Time saved: 3 hours
- Time Initiated: 01/06/2018 15:55
- Time of Pick Up: 01/06/2018 16:15
- Admit Time: 01/06/2018 17:52
- Outcome: ?
- Declared brain dead at 12:55, 1/10/2018
- Cross Match patient image and any identifiers with databases across the tri-state area Patient’s family couldn’t be found for 5 days
NEMAT Longitudinal Database with patient-centered outcomes

- N=1746

Challenging to get telephonic outcomes: new opportunities for improvement
Acknowledgements

- Our patients and families
- MSHS NEMAT team and collaborators
- NEMAT data science team: Deeksha Chada, Nicki Mohammadi
- Outgoing research team: Julianne, Natalia, Karan, Rui, Ian
- NEMAT mentor: Dr. Joshua Bederson
To Our Patients and Families: We Do What We Do because of You
Questions

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