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

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Grand Rounds, Stony Brook University, June 2020



# **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
- 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





#### **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

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- ▶ 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



Mount Sinai / Presentation Slide / December 5, 2012



# **Case 2: Trip and Treat**

- ▶ 92 F, vasculopath on Xarelto for A. fib
- ▶ MSQ ER around 13:15 hr
- ▶ CTH/CTA: 13:40 hr

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- ► 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 multidisciplinary management in the hyperacute and acute phases as well as for transition of care and reintegration into life roles
- **Examples:** Stroke, Traumatic Brain Injury

# Inter-hospital Transfers (IHT) for Critically ill Patients

SPECIAL ARTICLE

#### ICU Admission, Discharge, and Triage Guidelines: A Framework to Enhance Clinical Operations, Development of Institutional Policies, and Further Research

Nates, Joseph L. MD, MBA, FCCM (Chair)<sup>1</sup>; Nunnally, Mark MD, FCCM<sup>2</sup>; Kleinpell, Ruth PhD, RN, FAAN, FCCM<sup>3</sup>; Blosser, Sandralee MD, FCCP, FCCM<sup>4</sup>; Goldner, Jonathan DO, FCCP, FCCM<sup>5</sup>; Birriel, Barbara MSN, CRNP, ACNP-BC, FCCM<sup>6</sup>; Fowler, Clara S. MS<sup>7</sup>; Byrum, Diane RN, MSN, CCRN, CCNS, FCCM<sup>8</sup>; Miles, William Scherer MD, FACS, FCCM<sup>9</sup>; Bailey, Heatherlee MD, FAAEM, FCCM<sup>10</sup>; Sprung, Charles L. MD, JD, MCCM<sup>11</sup> **Author Information**  $\otimes$ 

Critical Care Medicine: August 2016 - Volume 44 - Issue 8 - p 1553-1602 doi: 10.1097/CCM.00000000001856

▶ 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)
- ▶ 525,913 Emergency General Surgery IHT and only 1/3 rd required surgery after transfer (NIS, 2002-2011, Reinke CE et al J Surg Res 2017)

# **IHT for Critically ill Patients**

Conflicting Data

- ▶ Critically ill patients undergoing IHT may have:
  - Longer length of stay (Duke GJ et al. Med J Aust 2001; Huntington CR et al Surg Endosc. 2016)
  - Higher mortality (Gerber DR, et al. J Crit Care 2009; Misercola B et al J Surg Res. 2016)

▶ 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

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### 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



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Slide Courtesy from J Mocco



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Provider (MD/RN) calls Transfer Service

#### IHT: What Can go Wrong...



### **NEMAT: Guiding Principles**



### **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**





# **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

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#### **Neurocritical Care Across the Mount Sinai Health System**



### **NEMAT Program Structure**

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#### MOUNT SINAI HEALTH SYSTEM POLICY & PROCEDURE

Mount Sinai Beth Israel Mount Sinai Brooklyn Mount Sinai Hospital Mount Sinai Queens Mount Sinai St. Luke's Mount Sinai West New York Eye & Ear Infirmary

	1					
POLICY TITLE:	Transfer Bundle Policy					
POLICY NUMBER:	PTC-XX	LAST REVIEWED DATE:	September 2018			
EFFECTIVE DATE:	October 2018					
	Emergency Treatment, Stabilization, Transfer of Patients and EMTALA (Emergency Medical Treatment and Labor Act)					
POLICIES:	MSHS PTC-3 Patient Transfer Center Policy and Procedure					
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C. PRE-TRANSFER HUDDLE						
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APPENDIX B: PRE-TRANSFER HUDDLE CHECKLIST						

- ► Centralized Transfer Process
- ► Transfer Center
- ▶ Hand-offs
- Disease specific protocols and checklists
- ► Transfer Levels

Transfer Level	Departure within	Examples	
Life Rescue	30 mins	<ol> <li>Ongoing herniation which might become potentially irreversible in an hour</li> <li>Refractory Shock despite maximum dose of 2 pressors and ongoing resuscitation</li> <li>ELVO</li> <li>SAH with hydrocephalus (HH 4 or 5)</li> </ol>	
Level I	60 mins	<ol> <li>ELVO</li> <li>SAH</li> <li>ICH-surgical decompression or SCUBA</li> <li>Acute or subacute SDH</li> <li>SCI/Spinal cord</li> <li>Brain tumor emergencies</li> </ol>	
Level II	4 hours	<ol> <li>Good grade SAH</li> <li>Potential Scuba ICH</li> <li>Subacute to Chronic SDH</li> <li>Non-operative ICH</li> </ol>	
Level III	Once Bed is available	<ol> <li>Brain tumor</li> <li>Multi-level decompression spine surgery</li> </ol>	

#### **Neuroemergency IHT Disease Types (Unpublished Data)**



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





#### **Median Transfer Times by Neuroemergency Type**



■2018 ■2019 ■2020 YTD



#### **Overall Median Transfer Times for Neuroemergencies**





#### **2018 Neuroemergency IHT Outcomes (Unpublished Data)**



**60 DAY MORTALITY** 







# **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)**

Disease Type - 2018



January - March 14 March 15 - Apr 30 Disease Type - 2019



January - March 14 March 15 - Apr 30 Disease Type - 2020





#### **Accepting Hospitals - Pre-COVID vs COVID Periods**

Accepting Hospital - 2018



#### **Transfer Times - Pre-COVID vs COVID Periods (Unpublished Data)**



Transfer Times - 2019

Transfer Times - 2020




## **Trauma systems of care**









QUALITY PROGRAMS of the AMERICAN COLLEGE OF SURGEONS

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

Ellen J. MacKenzie, Ph.D., Frederick P. Rivara, M.D., M.P.H., Gregory J. Jurkovich, M.D., Avery B. Nathens, M.D., Ph.D., Katherine P. Frey, M.P.H., Brian L. Egleston, M.P.P., David S. Salkever, Ph.D., and Daniel O. Scharfstein, Sc.D.

### N Engl J Med 2006; 354:366-378

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# DO STROKE DESERVE LESS?

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



**#NEMAT** 

# **Time is Brain: Stroke Care**

Estimated Pace of Neural Circuitry Loss in Typical Large Vessel, Supratentorial Acute Ischemic Stroke							
	Neurons Lost	Synapses Lost	Myelinated Fibers Lost	Accelerated Aging			
Per Stroke	1.2 billion	8.3 trillion	7140 km/4470 miles	36 y			
Per Hour	120 million	830 billion	714 km/447 miles	3.6 у			
Per Minute	1.9 million	14 billion	12 km/7.5 miles	3.1 wk			
Per Second	32 000	230 million	200 meters/218 yards	8.7 h			

### 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.

## **Stroke Systems of Care: Evidence-Based Medicine**

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





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Slide Courtesy: Dr. John Liang

### **Evolution of Stroke Systems of Care**

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

#### A Policy Statement From the American Stroke Association

Opeolu Adeoye, Karin V. Nyström, Dileep R. Yavagal, Jean Luciano, Raul G. Nogueira, Richard D. Zorowitz, Alexander A. Khalessi, Cheryl Bushnell, William G. Barsan, Peter Panagos, Mark J. Alberts, A. Colby Tiner, Lee H. Schwamm, Edward C. Jauch Show less Authors

Originally published 20 May 2019 https://doi.org/10.1161/STR.000000000000173 Stroke. 2019;50:e187-e210

	Table	1. Levels	and Capabilitie	s of Hospital	Stroke I	Designation
--	-------	-----------	-----------------	---------------	----------	-------------

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

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.

#### SEVERITY-BASED STROKE TRIAGE ALGORITHM FOR EMS



Mission:

Lifeline

## **Stroke Systems of Care**

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- ➤ 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?

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

J Neurointerv Surg. 2016 Nov;8(11):1129-1135. doi: 10.1136/neurintsurg-2015-012117. Epub 2016 Jan 8.

#### The impact of evidence: evolving therapy for acute ischemic stroke in a large healthcare system.

Mascitelli JR<sup>1</sup>, Wilson N<sup>2</sup>, Shoirah H<sup>2</sup>, De Leacy RA<sup>1</sup>, Furtado SV<sup>1</sup>, Paramasivam S<sup>1</sup>, Oermann EK<sup>1</sup>, Mack WJ<sup>3</sup>, Tuhrim S<sup>2</sup>, Dangayach NS<sup>1</sup>, Meyer SA<sup>1</sup>, Bederson JB<sup>1</sup>, Mocco J<sup>1</sup>, Fifi JT<sup>1</sup>.

Author information

- ▶ 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

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## **#NYCMIST**



Stroke. 2017 Dec;48(12):3295-3300. doi: 10.1161/STROKEAHA.117.018149. Epub 2017 Nov 16.

## Mobile Interventional Stroke Teams Lead to Faster Treatment Times for Thrombectomy in Large Vessel Occlusion.

Wei D<sup>1</sup>, Oxley TJ<sup>1</sup>, Nistal DA<sup>1</sup>, Mascitelli JR<sup>1</sup>, Wilson N<sup>1</sup>, Stein L<sup>1</sup>, Liang J<sup>1</sup>, Turkheimer LM<sup>1</sup>, Morey JR<sup>1</sup>, Schwegel C<sup>1</sup>, Awad AJ<sup>1</sup>, Shoirah H<sup>1</sup>, Kellner CP<sup>1</sup>, De Leacy RA<sup>1</sup>, Mayer SA<sup>1</sup>, Tuhrim S<sup>1</sup>, Paramasivam S<sup>1</sup>, Mocco J<sup>1</sup>, Fifi JT<sup>2</sup>.



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)

### **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

### NEMAT PROTOCOL FOR INTERHOSPITAL TRANSFER WITH EVD



PATIENT STATUS

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### **INTERIM ANALYSIS: Unpublished data**

CHARACTERISTICS OF PATIETNTS UNDERGOING INTERHOSPITAL TRANSFER WITH EVD IN PLACE							
				_		_	
Demographic Variab	les	INITIAL HOSPITAL N(%)		POST TRANSFER		OUTCOMES	
Gender:N(%)		Elhmurst Hospital	11 (72.5)	CT Scan N(%)		Time with EVD N(%	5)
Male	6 (40)	St Lukes and SinaiWest	3 (20)	EVD Confirmation	15 (100)	< 2 weeks	3 (20)
Female	9 (60)	Others	1 (7.5)	Tract Hemorrhage	4 (27)	2-3 weeks	7 (46)
				Midline shift	7 (46)	>3 weeks	5 (33)
Age in Years N(%)		Intubation N(%)					
< 50 (n)	4 (27)	Yes	15 (100)	First ICP Reading N(%	)	Procedures : N(%)	
>50	11(72.5)			<15	11 (73)	Aneurysm Coiling	11 (72.5)
		Location of EVD Insertion	n N(%)	>15	4 (27)	Craniotomy	4 (27)
BMI : N(%)		Emergency Room	10(65)				
< 30	7 (46)	ICU	2(15)	EVD Complications N	(%)	NSICU Length of Sta	iy N(%)
>30	8 (54)	Operating Room	3(20)	Clots	4 (27)	< 1 week	1 (7.5)
				Replacement	5 (33)	1-2 week	3 (20)
INITIAL PRESENTATIO	N: N (%)	Site of EVD Insetion N(9	6)	Additional EVD	4 (27)	2-3 week	7 (46)
Headache	12 (80)	Right Frontal	11 (72.5)			> 3 weeks	4 (27)
Nausea,Vomitting	9 (60)	Right Parietal	0	CSF Discharge N(%)			
Loss of Conciousness	6 (40)	Left Frontal	1 (7.5)	Serosanguinous	11 (73)	Hospital Length of S	itay N(%)
Seizure Activity	2 (15)	Left Parietal	3 (20)	Pink/Bloody	4 (27)	< 2 weeks	2 (15)
						2-4 weeks	7 (46)
GCS on Presentation		Primary Diagnosis N(%)		SOFA Score N(%)		> 4 weeks	4 (27)
<5	4 (27)	SAH	12(80)	< 5	7 (46)	Admitted	2 (15)
5-10	7 (46)	HH3	4	5-10	8 (54)		
10-15	4 (27)	HH4	3	>10	0	Discharge Dispositi	on N(%)
		HH5	5			Admitted	3 (20)
mRs				APACHE II Score N(%	)	Hospital Transfer	2 (15)
0-3	10 (67)	ICH	3(20%)	<10	3 (20)	Palliative Care	1 (7.5)
>3	5 (33)	ICH Grade III	3	10-20	6 (40)	Home	2 (15)
				>20	6 (40)	Acut Rehab	2 (15)
						Deceased	5 (33)



Icahn School of Medicine at **Mount Sinai** 

# **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

1. Hemphill JC, 3rd, Greenberg SM, Anderson CS, et al. Guidelines for the Management of Spontaneous Intracerebral Hemorrhage: A Guideline for Healthcare Professionals From the American Heart Association/American Stroke Association. *Stroke.* 2015;46(7):2032-2060.

2. Cooper D, Jauch E, Flaherty ML. Critical pathways for the management of stroke and intracerebral hemorrhage: a survey of US hospitals. Crit Pathw Cardiol. 2007;6(1):18-23.



# 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?

	MIS		OT			Odds Ratio	Odds Ratio
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Random, 95% Cl	M-H, Random, 95% Cl
Auer 1989	28	50	37	50	6.0%	0.45 [0.19, 1.04]	
Feng 2016	67	93	77	91	7.7%	0.47 [0.23, 0.97]	
Hanley 2016	19	23	23	26	1.8%	0.62 [0.12, 3.12]	
Hattori 2004	60	121	82	121	12.7%	0.47 [0.28, 0.79]	
Kim 2009	67	204	109	183	16.9%	0.33 [0.22, 0.50]	
Miller 2008	6	6	4	4		Not estimable	
Sun 2010	90	159	93	145	14.9%	0.73 [0.46, 1.16]	
Teernstra 2003	33	36	29	34	2.1%	1.90 [0.42, 8.64]	
Vespa 2016	11	13	23	26	1.3%	0.72 [0.10, 4.93]	
Wang 2009	56	195	82	182	16.4%	0.49 [0.32, 0.75]	
Yang 2016	47	78	63	78	7.8%	0.36 [0.18, 0.74]	
Zhang 2014	10	21	26	30	2.6%	0.14 [0.04, 0.54]	
Zhou 2011	24	90	38	78	9.3%	0.38 [0.20, 0.73]	
Zuccarello 1999	0	4	7	11	0.5%	0.07 [0.00, 1.55]	· · · · · · · · · · · · · · · · · · ·
Total (95% CI)		1093		1059	100.0%	0.46 [0.36, 0.57]	•
Total events	518		693				
Heterogeneity: Tau <sup>2</sup> :	= 0.03; Ch	i <sup>2</sup> = 15.	12, df = 1	2 (P = 1	0.23); I <sup>2</sup> =	21%	
Test for overall effect	: Z = 6.87 (	(P < 0.0	00001)	Ì			U.U1 U.1 1 10 100 Favours MIS Favours OT

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

Lauren will post the scan for us. Being accepted here for monitoring and hydro watch.

Kellner Christopher



#### Iten

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 night time stroke PA coverage so if deemed nonsurgical can transition to stroke service

#### Kellner Christopher

Okay.

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





## 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**



### **#NEMAT**

# **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

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

#### 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 antiplatelets, anticoagulants:
- 6) ICP precautions: HOB >30, Mannitol +/-Hypertonic saline, Sedation/Analgesia, Hyperventilation
- 7) EKG and Amicar
- 8) Keppra prophylaxis
- 9) Default destination: MSH NSICU, if no bed the ER 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 HH 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

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

### 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 antiplatelets, 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 ER 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**



#### Tweets Tweets & replies Media Likes



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



#### Tweets Tweets & replies Media Likes

1 Jamie Rumsey Retweeted



Julianne Kleitsch @jkleitsc... · 5/20/19 ∨ What a privilege to present our research at #WICH2019 @drdangayach and @chriskellnerMD!! First medical conference talk √



# **ENLS Nursing Project presented at AANS 2019**

Acute Ischaemic Stroke

Post tPA patients

Raised ICP

Management of EVD

MeningoEncephalitis

Spical Cord Compression

Post Craniotomy Patiets

Post Spinal Surgery

Traumatic Brain Injury

Traumtaic Spine Injury

Need More Dedicated Study time

Status Epilepticus

Post Thrombectomy Patients

Inctra Cerebral Hemorrhage (ICH)

Sub Arachnoid Hemorrhage (SAH)

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, Kellner 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



Mount Sinai / Presentation Slide / December 5, 2012

Agree

## **Critical Care Resilience Program (CCRP)**





### 1<sup>st</sup> Patient seen: Feb 11<sup>th</sup>, 2020



RP)

## Mount Sinai

### 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).

Physical Symptoms	Cognitive Symptoms	Psychological Symptoms
Respiratory difficulties	Memory difficulties	Anxiety
Weakness and balance	Concentration difficulties	Depression
problems	Slow mental processing	Post-traumatic stress
Pain	Trouble carrying out tasks	Sleep problems

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

### Why is this important?



million ICII admissions

5.7 million ICU admissions annually 4.8 million ICU survivors annually (גבו

Exact prevalence of PICS among survivors is unknown

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

1. Maley, J. H., et al. "Resilience in survivors of critical illness in the context of the survivors' experience and self-reported neuropsychological and physical function." *Ann Am Thorac Soc* (2016)

## **Critical care Recovery Clinic: Telehealth Paradigm**



I≡

#### **Continuing Care for COVID-19 ICU Patients The Critical Care Recovery Clinic Enrollment**

#### **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 ContactMSCCRP@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 cause 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.

 Slow mental processing Trouble carrying out tasks

#### Help COVID Patients Get on the Right Track To Recovery

Provide your COVID ICU patients the network of multidisciplinary resources that will support them and their families.

#### Services provided to COVID critical illness patients:

- · 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 ContactMSCCRP@mountsinai.org

PROBLEMS COVID ICU PATIENTS FACE Physical Symptoms Respiratory difficulties



Anxiety

Depression

Weakness and balance









# **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



- Prediction of NSICU admission from ED triage Notes (IRB-19-02333)
- Moberg Collaboration
- Smart NSICU



# **Collaborative Success: Machine Learning and Al**

- ▶ 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
- Rapid Machine learning (VIPS: Kellner C et al JNIS 2018 or AI driven (viz AI LVO Platform <u>https://www.viz.ai/</u>)
- 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 patientcentered 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











Institute for Critical Care Medicine =



viount Sinai / Presentation Silde / December 5, 2012

### To Our Patients and Families: We Do What We Do because of You





Neha Dangayach
 @drdangayach

@HarpreetSGrewa1 and I are taking #COVID19 call for @RWJBarnabas and @MountSinaiNYC respectively for being my inspiration. Stay safe, calm, informed & prepared so we can keep taking excellent care of all our patients @CCF\_PCCM @ColumbiaNCC @JoshBedersonMD @JMoccoMD @FAkindipe



12:28 PM · Mar 31, 2020 · Twitter for iPhone



### Questions

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 Instagram @drdangayach



#### QQA

 $\square$ 



drdangayach Life is beginning to seem more normal, I can see smiles behind so many masks, I can see joy and hope in many eyes, I can see a new way forward. May we not forget the lessons we learned, may we continue to respect one another, collaborate like our lives depended on how well we work with each other. #COVID19 #INthistogether

. . . . .

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