Outline

- Case Study
- Brief look evolution of stroke care
- Technology: current trends and what’s on the horizon
  - Mobile Stroke Units
  - Artificial Intelligence
  - Communication Apps
  - TeleStroke
  - Rehab
  - Diagnostics
- What the future looks like/Jetsons here we come
Case Study 1
A typical day in Bedrock

- Fred and Barney went to work at the Slate Rock and Gravel Company as Dino-Crane Operators.
Early NIHSS: Can you name these objects?
BE FAST?
• Aphasic
• Unsteady Gate/?Dizzy

• Now what?
• They wait....
Case Study #2
Dizzy with Left sided Weakness
A Little History
Some of the first Neurosurgical tools

- This was used for trephination AKA Burr holes
- The Hammer and Chisel for craniectomy
“the blacksmith became a more skilled appliance and device maker, using better quality iron, ore and other materials. Blacksmiths typically forged horseshoes and farming equipment along with cooking instruments mostly designed for cooking and cosmetic uses, and they also forged instruments for the surgeon”
Decompressive Craniectomy$^2, 3$

- First described in 1894 for Tumors
- 1901 for TBI
- Increased mortality
- 1956 first utilized specifically for massive cerebral infarcts
- 1970’s some positive results
Alteplase⁴

- 1996 First approved by FDA for use in Acute Ischemic Stroke treatment
Three positive thrombectomy trials presented at International Stroke Conference 2015 (Nashville, TN)

February 11, 2015 will be an important milestone in the history of Interventional Neuroradiology. Three positive trials (ESCAPE, EXTEND–IA, and SWIFT–PRIME) evaluating mechanical thrombectomy in acute ischemic stroke were presented under the applause of a large audience. Both ESCAPE and EXTEND–IA trials were published online in NEJM the day of ISC presentation (February 11, 2014).
Technology: Current trends and what’s on the horizon
Mobile Stroke Units

- Started in Germany
- 2014 First MSU in the U.S.
- As of July 2018 there were approx 20 MSU in the U.S. most of them cover a 20 mile radius
- > $1,000,000,000 investment
<table>
<thead>
<tr>
<th>Location</th>
<th>Began service</th>
<th>On-board personnel</th>
<th>Operating hours</th>
<th>Catchment area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homburg, Germany</td>
<td>March 2011</td>
<td>UNK</td>
<td>UNK</td>
<td>20 km around the university hospital</td>
</tr>
<tr>
<td>Berlin, Germany</td>
<td>July 2011</td>
<td>paramedic, stroke physician, neuroradiologist</td>
<td>UNK</td>
<td>20 km around the university hospital</td>
</tr>
<tr>
<td>Fredrikstad, Norway</td>
<td>October 2014</td>
<td>neurologist, paramedic, radiology technician</td>
<td>07:00–11:00 daily, Monday to Sunday, randomized weeks</td>
<td>defined by a 75% probability of reaching the emergency sites within 16 min from base, based</td>
</tr>
<tr>
<td>Houston, TX, USA</td>
<td>May 2014</td>
<td>CT technician, paramedic</td>
<td>UNK</td>
<td>Community Medical Licensing</td>
</tr>
<tr>
<td>Cleveland, OH, USA</td>
<td>July 2014</td>
<td>CCN, EMT, par</td>
<td>UNK</td>
<td>Community Health Nursing Center</td>
</tr>
<tr>
<td>Buenos Aires, Argentina</td>
<td>October 2014</td>
<td>UNK</td>
<td>UNK</td>
<td>Community Health Nursing Center</td>
</tr>
<tr>
<td>Denver, CO, USA</td>
<td>January 2016</td>
<td>neurologist, CT technician</td>
<td>UNK</td>
<td>Community Health Nursing Center</td>
</tr>
<tr>
<td>Toledo, OH, USA</td>
<td>January 2016</td>
<td>VN, critical care nurse, critical paramedic, CT</td>
<td>UNK</td>
<td>Community Health Nursing Center</td>
</tr>
<tr>
<td>Memphis, TN, USA</td>
<td>July 2016</td>
<td>stroke fellows doctorally prepared Advanced Neurovascular Practitioner board certified</td>
<td>1 week off</td>
<td>City metro area</td>
</tr>
<tr>
<td>New York, NY, USA</td>
<td>October 2016</td>
<td>neurologist, 2 paramedics, CT technician</td>
<td>UNK</td>
<td>Community Health Nursing Center</td>
</tr>
<tr>
<td>Chicago, IL, USA</td>
<td>January 2017</td>
<td>UNK</td>
<td>UNK</td>
<td>Community Health Nursing Center</td>
</tr>
<tr>
<td>Trenton, NJ, USA</td>
<td>January 2017</td>
<td>UNK</td>
<td>07:00–23:00 daily</td>
<td>Mercer County Medical Center</td>
</tr>
<tr>
<td>Edmonton, AB, Canada</td>
<td>February 2017</td>
<td>VN, 2 paramedics, CT technician</td>
<td>UNK</td>
<td>University of Alberta</td>
</tr>
<tr>
<td>Phoenix, AZ, USA</td>
<td>June 2017</td>
<td>VN and neurologists, EMT</td>
<td>UNK</td>
<td>St. Joseph's Medical Center</td>
</tr>
</tbody>
</table>
2017 – increased competition between hospitals for patients. “They will do anything to get patients into their system. Nothing says ‘high-tech’ like a mobile stroke ambulance or a medical helicopter. They know that once patients have gotten into their hospital system they will stay in the system. This is the real reason behind the introduction of expensive technologies into the prehospital setting that do not pay for themselves. The reasoning, unfortunately, is not altruistic.”
Is it just about money?

- No, I think behind everyone of these MSU is a super committed Stroke team but they had to sell it to their institutions.
The BEST-MSU trial

- 6,000 possible strokes across the three cities. The team is alternating providing either mobile stroke service or regular emergency care for people with possible stroke week-by-week until the middle of 2019.
Telestroke
Telestroke\textsuperscript{8,9}

- Improves the pre-hospital diagnosis of stroke and enhances the supervision of delivery of IV-tPA in AIS
- Stroke Neurologists in pre-hospital stroke response teams reduce time to treatment and increase the rate of treatment
- Patient satisfaction – access to care (at least some care) is not limited by where you live
EMS & The Telephone Game

ED staff remember < 50% of the info they are given by EMS.

Communication failures during transfer of patient care are major contributors to error and harm to patients.
Apps for Communication

- EMS/Hospital communication tools
  - Pre-notification by EMS without a phone call
    - Pre-registration
    - PMH (anti-coag use/recent surgery?)
  - Inter-facility transports → Telestroke
  - In hospital
    - Notify CT/pharmacy/angio suite of intervention
    - Prevent loss of information between handoffs
    - QI metrics
  - EMS Feedback
Fixing Systems Issues

STROKE TEAM mobilizes and prepares to meet patient

EMERGENCY DEPARTMENT prepares for initial critical intervention if needed

RADIOLOGY clears CT scan

PATIENT ARRIVES and proceeds directly to CT SCAN

TEAM EVALUATION

REGISTRATION registers patient prior to arrival

NEUROLOGISTS and NEUROINTERVENTIONALIST review patient information

STROKE PATIENT IDENTIFIED

PHARMACY prepare for possible tPA administration

DEFINITIVE TREATMENT
Apps for Rehab

- Virtual ADL
- Cognition
- Stress
- Speech Therapy & Aphasia
- Lifestyle (meds and scheduling)
- Hand Recovery
- Vision Loss
- Risk Factor reduction/General Health

National Aphasia Assoc - https://www.aphasia.org/aphasia-resources/aphasia-apps/
VisuALS

- “Affordable” assistive communication
- Allows people to communicate by using only their eyes

**VisuALS System**

$2,700.00

<table>
<thead>
<tr>
<th>Mount</th>
<th>Carrying Bag</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheelchair Mount</td>
<td>None</td>
</tr>
</tbody>
</table>

Second Mount: None

**Text-To-Speech**

With an on-screen keyboard and predictive text, users can quickly type what’s on their heart. Along with the keyboard, there are 4 categories of phrases – needs, feelings, conversation and home automation.
Video game interaction
- a computer/webcam/special handle with sensors, which detects movement and exercises
- Virtually a patient is asked to perform tasks
- Allows for therapy at home without a therapist
One retrospective study observed no differences in improvement across specific age groups or time since injury.

Difference in frequency
- Home users utilized the therapy significantly more often than those in the clinic (p < .001).
- Clinic users did complete more items per therapy day than the home users (p < .001).

Artificial Intelligence for Imaging

- Improves accuracy of diagnosis
- Anyone can be notified of results so results at a spoke site and go directly to the Hub
- You’re not paying for a radiologist to read
- Available for CT, CTA, CTP, MRI
- On 2/28 it was released that one company will offer a product for the Angio suite allowing for 3D viewing of the brain and its perfusion (looking at collaterals and the rate of infarct, irreversible and salvageable areas)
Robotic Rehabilitation

- Robotic glove
  - Records performance and sends results to a therapist
- Robotic legs - exoskeleton

**Robot-assisted gait training for stroke patients: current state of the art and perspectives of robotics**

Giovanni Morone, Stefano Paolucci, Andrea Cherubini, Domenico De Angelis, Vincenzo Venturiero, Paola Coiro, and Marco Iosa
Exoskeleton

- Helping stroke patients relearn to walk
Alterg Anti-gravity treadmill

Zerog gait & balance
Robots\textsuperscript{14, 15, 16}

- Robot exoskeleton clinical trials are underway
- At least one is already FDA approved for stroke
- Looking at controlling a computer mouse by thought alone in a quadriplegic
- Home sensors to enhance mobility
“Most studies on walking neurorehabilitation robots focus on their effectiveness, giving controversial results. For instance, Mehrholz and Pohl showed that patients who receive robot-assisted gait training in combination with physiotherapy achieve independent walking more easily than patients trained without these devices. However, clinical trials suggest that manual therapy may still be more effective than robotic gait training in both subacute and chronic phases.”

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Tailor to what the patient needs

<table>
<thead>
<tr>
<th>Robotic devices (examples)</th>
<th>“Static” (training in place)</th>
<th>“Dynamic”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exoskeletons</td>
<td>Lokomat</td>
<td>Rewalk</td>
</tr>
<tr>
<td>End effectors</td>
<td>Gait Trainer</td>
<td>i-Walker</td>
</tr>
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Biomarkers

- A new technology can diagnose a stroke in under 10 minutes using just a drop of blood.
- POC done at the patients bedside
Blood borne biomarker
Neuro-Specific Enolase (NSE)\textsuperscript{19, 20, 21}

- NSE appears in higher concentrations in stroke patients.
  - Can aid in initial diagnosis
  - “serum levels of NSE in first few days of ischemic stroke can serve as a useful marker to predict stroke severity and early functional outcome.”

- “The team coated nanoparticles with immobilized enzymes that naturally bind to NSE. The nanoparticles are then exposed to a small drop of blood, where they are able to detect NSE. When a nanoparticle binds to an NSE molecule, it is designed to emit light that researchers can then measure. The more light emitting from a sample, the higher the NSE concentration levels in the blood. At each step of the way, the signal from the NSE is amplified, so even minute quantities give off enough light for detection”.

### Stroke Prognostic POCT Devices Summary

<table>
<thead>
<tr>
<th>POCT Device</th>
<th>Description</th>
<th>Application</th>
<th>Clinical Value</th>
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</thead>
<tbody>
<tr>
<td>Mobile Stroke Unit (MSU)</td>
<td>Imaging and a variety of Blood-tests. Integration of CT scanners and POCTs in ambulances, IV-tPA treatment can be started on-site</td>
<td>Consists of a registered nurse, paramedic, emergency medical technician, and a CT technologist, in addition, POCT are used, which includes coagulation profile, complete blood count, and blood chemistry</td>
<td>Pre-hospital: Improves stroke diagnosis and reduces time-to-IV-tPA admission</td>
</tr>
<tr>
<td></td>
<td>NSE elevated serum levels in stroke patients assist in distinguishing stroke from mimics, an important first step in expediting the diagnostic process</td>
<td></td>
<td>In-hospital: Improves stroke diagnosis and reduces time-to-IV-tPA admission</td>
</tr>
</tbody>
</table>
proteomic marker cellular fibronectin (c-Fn)\textsuperscript{21}

- Developed by Prediction Sciences LLC.
- This POCT shown in recent studies to predict hemorrhagic transformation in tPA-treated patients with a sensitivity of 100%.
- The amount of c-Fn in the blood of stroke patients at admission can identify if the patient is at high or low risk for a subsequent hemorrhage. This POCT platform is based on lateral flow technology detection of c-Fn, with the ability to obtain results within 10 min.
Valtari Bio™ Inc. is also developing a POCT for the detection of stroke related blood brain-specific biomarkers.

This test takes measurements of blood brain-specific biomarkers associated with immune responses, for better stroke identification. The degree and direction of the immune system activation, following stroke and brain injury, allow the accurate identification of acute stroke from non-stroke.
SMARTChip\textsuperscript{21}

- POCT can measure purines from just a drop of whole unprocessed blood and give the reading within minutes
- The SMARTChip. Purines (e.g., adenosine, inosine and hypoxanthine) are neurochemicals that influence the function of the nervous system and can be used as stroke biomarkers as they are released after stroke onset.
Stroke Related Biomarkers

Summary

- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5618036/table/biosensors-07-00030-t004/?report=objectonly

- Table 4
Transcranial Color-Coded Sonography

- Used to recognize LVO
- Can easily be done in an ambulance
- 98% correlation with hospital imaging
Ultrasound\textsuperscript{23, 24}

- This is a randomized, placebo-controlled, phase 3 clinical trial to evaluate the efficacy and safety of transcranial ultrasound (US) as an adjunctive therapy to tissue plasminogen activator (tPA) treatment in subjects with acute ischemic stroke.

- Neural Analytics’ Lucid System is capable of measuring and displaying LVO with 91% sensitivity and 85% specificity
The Lucid Robotics System

- Combines transcranial Doppler – an ultrasound technology.
  - “Our focus is combining ultrasound technology with medical robotics and artificial intelligence.”

Brain Gains: Neural Analytics Makes Waves With Portable Brain Scan Headset
Innovation Special Report
By Dana Bartholomew
Friday, November 23, 2018
Fred Recovered

Fred is sitting in a chair reading a book titled "Care of the AIS patient." Beside him, another person is assisting him.
In home NIHSS
Hair dryer is also an in-home CT

- Oh and by they find a cure for diabetes and Jane was just dehydrated
Head Transplant?
Does technology always mean it’s better??

SOME WOULD CHOOSE TO LIVE IN THE PAST

THE REST OF US WANT TO GET GOING ON THE FUTURE
RUH ROH!

JANE! STOP THIS CRAZY THING!
"Like" if you think it's ridiculous that you don't have a Rosie of your own yet. The future is now, so where's my robot?

- No Domestic Diva

This is not the future I was promised by cartoons when I was a child. Also, that conveyor belt that George Jetson used sure would make my mornings easier. Come on, science! Let's get to work; the future is now!
How do you know when to invest?

- Does it meet an existing need while using fewer resources?
- Is it intuitive/can it be easily adopted?
- Does it add value to the customer?
- Does it improve efficiency?
- Will it allow for improved collaboration?
- Ask others who have used it
- Trust your gut
If we do nothing else in the future....

- Let’s at least update the NIHSS training videos!
Questions?

Thank You!
odonohue@uw.edu

UW Medicine
NEUROSCIENCES INSTITUTE
COMPREHENSIVE STROKE CENTER
At Harborview Medical Center
References

2. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4771225/
4. https://www.ahajournals.org/doi/10.1161/STROKEAHA.114.007564
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<td>24.</td>
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