JOHNS HOPKINS
MEDICINE

Stroke Rehabilitation Workshop
MMDA Conference

Saturday, November 13, 2021
4:00 p.m. to 5:15 p.m.

Dominique Vinh, MD, FACP

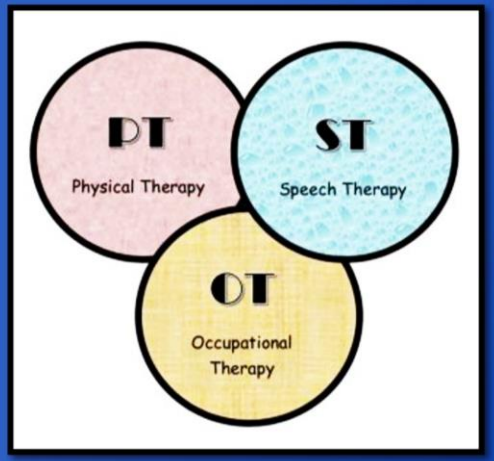
Stroke Rehabilitation Workshop

Post-stroke Motor Recovery and Neuro-Rehabilitation

Stroke Rehabilitation Workshop

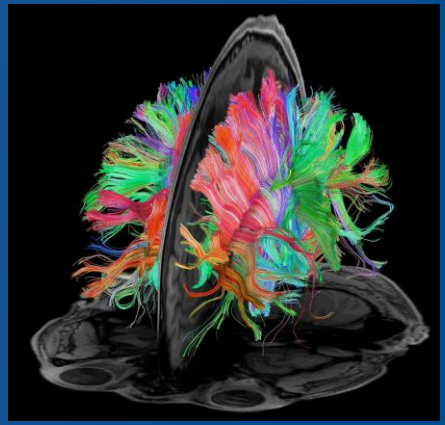
Post-stroke Motor Recovery and Neuro-Rehabilitation

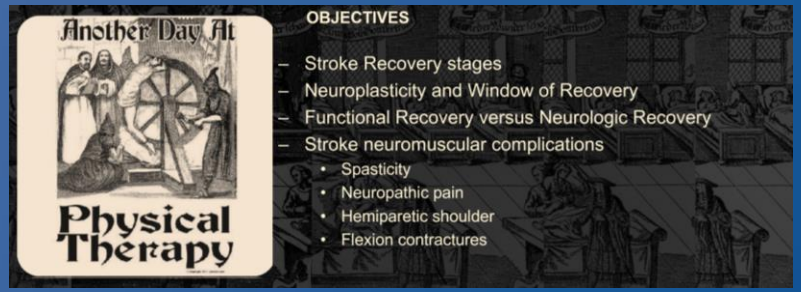
JOHNS HOPKINS MEDICINE



OBJECTIVES

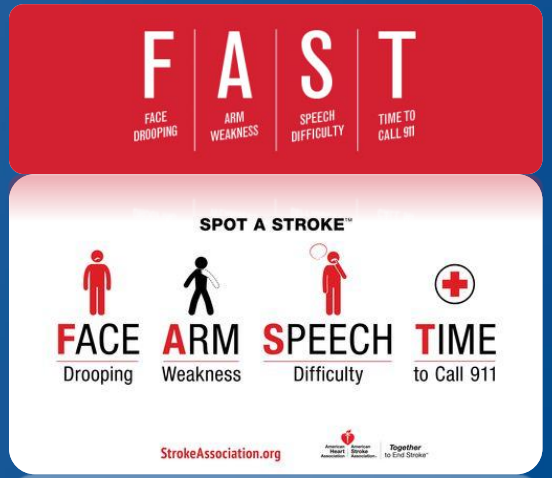
- Gain knowledge in medical direction of rehabilitation services for stroke rehabilitation, including staffing, environment and equipment
- Understand the comprehensive initial evaluation of stroke patients for rehabilitation care planning
- Describe services provided by physical, occupational, and speech therapists to improve functioning of stroke patients.





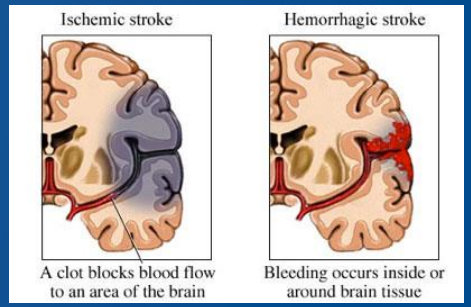
Stroke Rehabilitation Workshop
General introduction

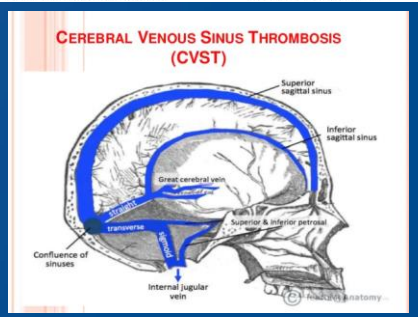
- **USA**
  - Fourth leading cause of death
  - First in chronic disability
  - 85% ischemic, 15% hemorrhagic
- **CDC**
  - Costs $34 billion / year
    - Health care
    - Medications
    - Productivity loss



Stroke Rehabilitation Workshop
General introduction

- Central nervous system (CNS) infarction: brain, spinal cord, or retinal cell death
  - Arterial ischemic stroke: thrombotic, embolic
  - Arterial hemorrhagic stroke: intracerebral, subarachnoid
  - Venous stroke: cerebral venous sinus thrombosis
- Pathophysiology
  - Leading cause of stroke worldwide: Atherosclerosis
  - Modifiable risk factors for atherosclerosis:
    - HTN, HDL, DM2
    - Physical inactivity, obesity, and smoking

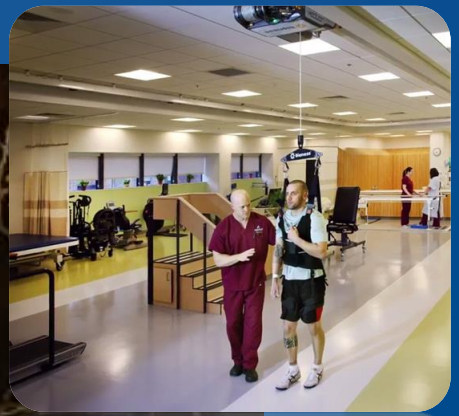




Stroke Rehabilitation Workshop

Post-stroke recovery: Statistics

JOHNS HOPKINS MEDICINE



10% - recover almost completely

25% - recover with minor impairments

40% - survive with moderate to severe impairments

10% - survive with extensive assistant needs

15% - will not make it after the stroke

90% have a neuro deficit

50-70% survivors regain functional independence

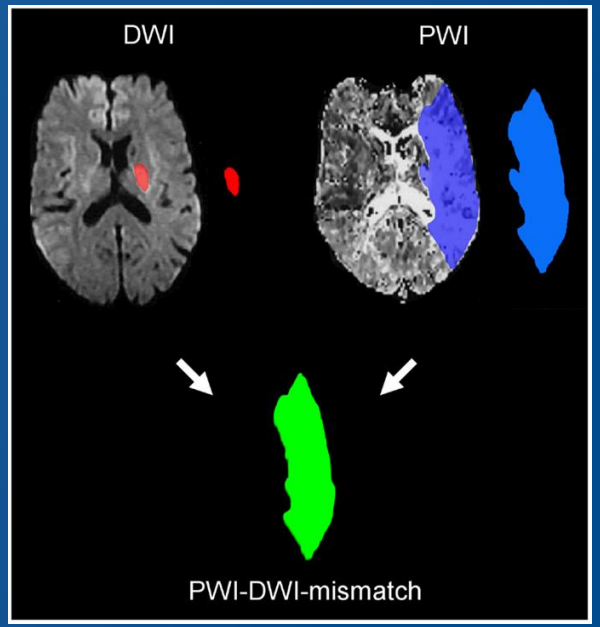
15-30% permanently disabled

20% institutionalized 3 months post-stroke

Stroke Rehabilitation Workshop

Post-stroke recovery: Neurologic Outcome Measures

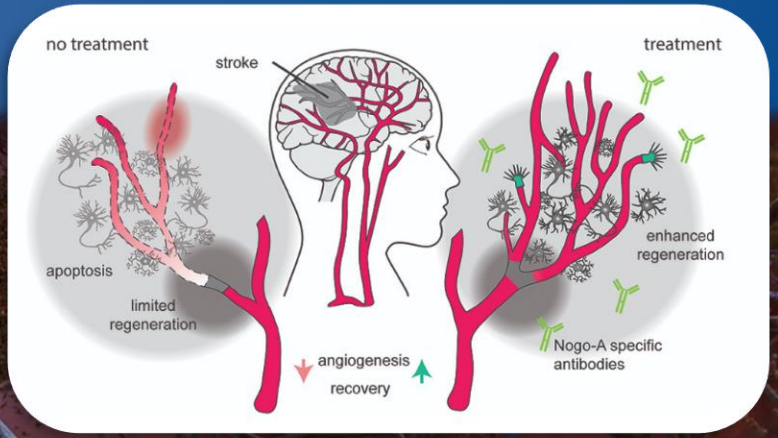
- Smaller strokes have better outcome
- Total Health Risk In Vascular Events (THRIVE) predict neurologic outcomes
  - NIHSS score
  - Age
  - Chronic disease
- Predict Recovery Potential (PREP) algorithm predicts upper extremity motor recovery at 12 weeks

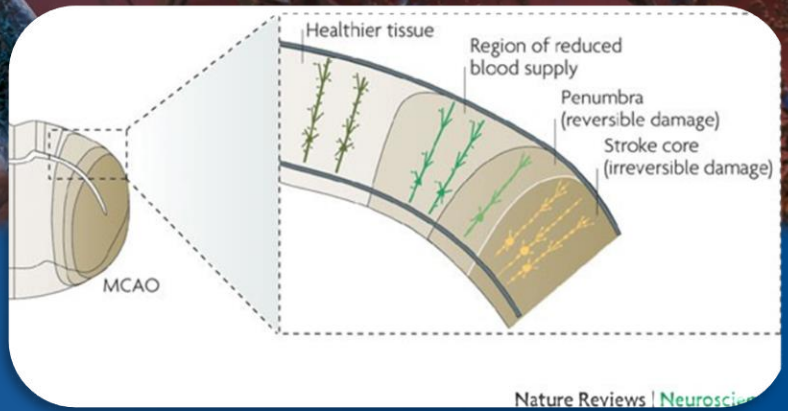


Stroke Rehabilitation Workshop

Post-stroke recovery

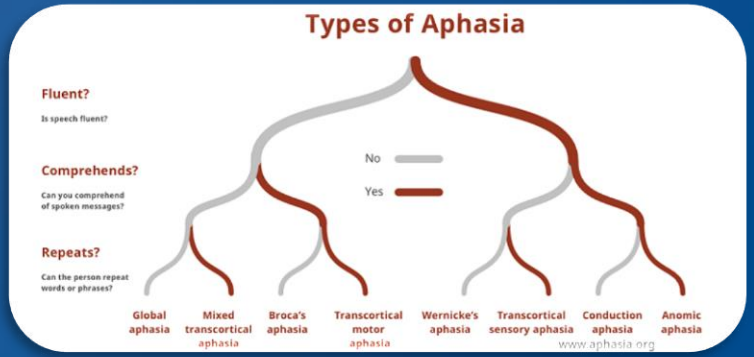
- Theories of recovery
  - Compensation
  - Unmasking of pathways
    - Contralateral
    - Ipsilateral
  - Collateral sprouting
  - Neural plasticity



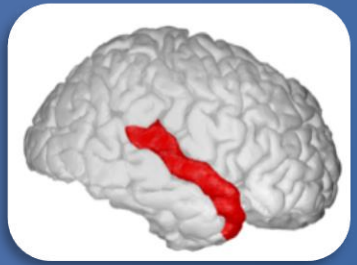


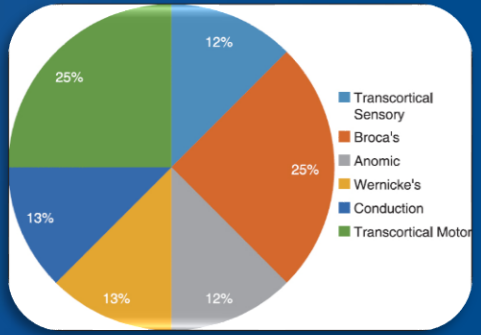
Stroke Rehabilitation Workshop
Post-stroke recovery

JOHNS HOPKINS MEDICINE



- Data on stroke recovery not extensive
  - Aphasia Incidence
    - 21-38%
    - Variable recovery
      - Poor recovery with larger lesions
      - Poor recovery with involvement of Superior Temporal Gyrus
      - Global and anomic aphasia poorest recovery
      - Lesion size does not correlate with language recovery
      - Subcortical lesions better prognosis than cortical
    - Recovery depends on lesion location, size, aphasia type, severity, comorbidities, treatment
    - Predicting post-stroke aphasia recovery is difficult

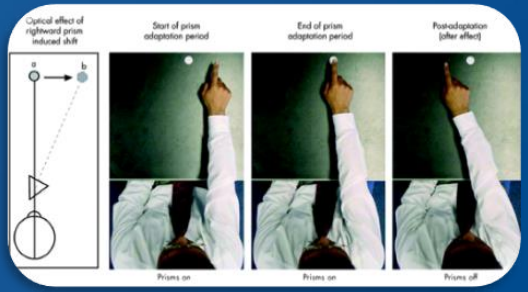


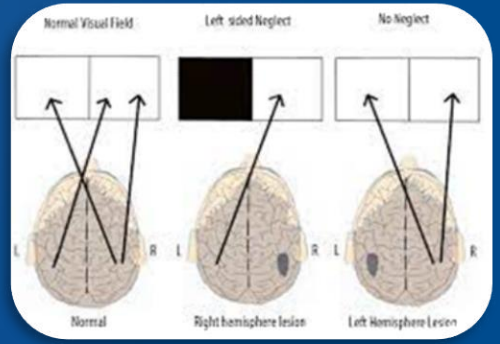


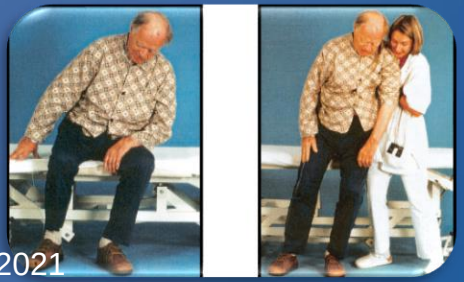
Stroke Rehabilitation Workshop

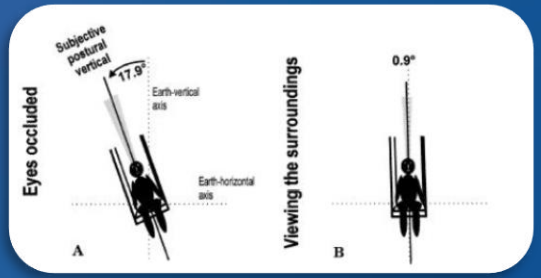
Post-stroke recovery

- Data on stroke recovery not extensive
  - Hemianopsia
    - Poor prognosis after 3 weeks
  - Perceptual dysfunction
  - Visuospatial inattention
    - Recovery peaks within 3-6 months
    - Initial severe visuospatial inattention worst prognosis



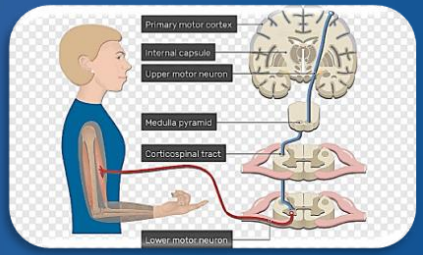




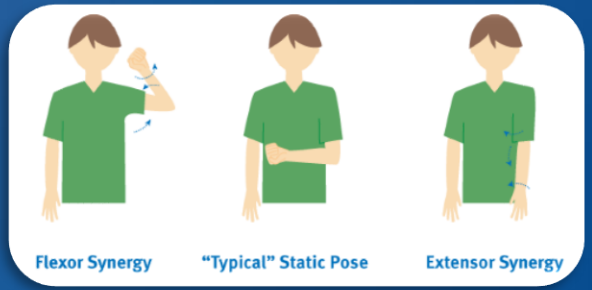


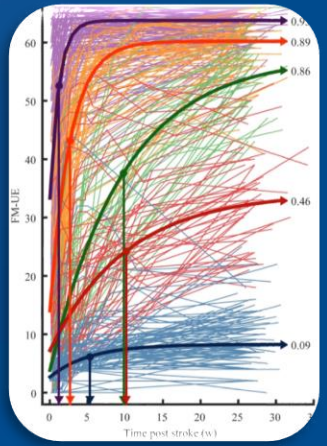
Stroke Rehabilitation Workshop

Post-stroke recovery: Motor



- Motor recovery
  - Best studied of all deficits
- *"The Restoration of Motor Recovery Following Hemiplegia in Man"* (Twitchell, 1951)
  - Observed 121 individuals
  - Followed 25 post-MCA stroke
  - Described patterns of motor recovery
  - Formulated prognostication



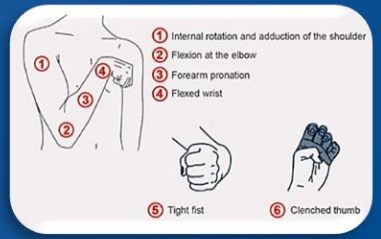


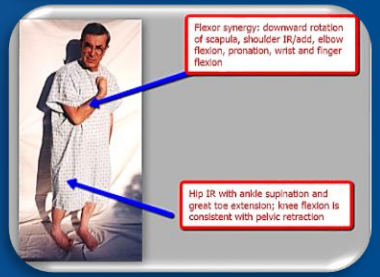
- Twitchell's stages of recovery
  - Movement (quantity) and tone (quality)
    - Tone precedes voluntary movement
    - Mass movements (synergies) precede isolated movement
  - Progress may stop anywhere along the continuum!

Stroke Rehabilitation Workshop

Post-stroke recovery: Motor

- UE and LE synergy patterns
  - Flexor is more common in UE
  - Extensor more common in LE



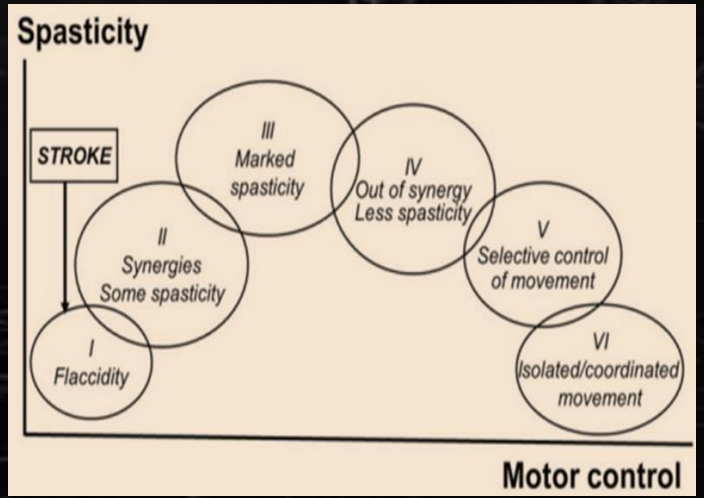


Stroke Rehabilitation Workshop
Post-stroke recovery: Motor

JOHNS HOPKINS MEDICINE

The Seven Brunnstrom Stages of Motor Recovery

1. Flaccid paralysis | Areflexic
2. Mild spasticity | No voluntary movement | Synergies via facilitations
3. Severe spasticity | Synergies with voluntary movements
4. Decreased spasticity | Synergistic movements predominate
5. Waning spasticity wanes | Can break out of synergy patterns
6. Improved isolated and coordinated in slow movement patterns
7. “Normal”



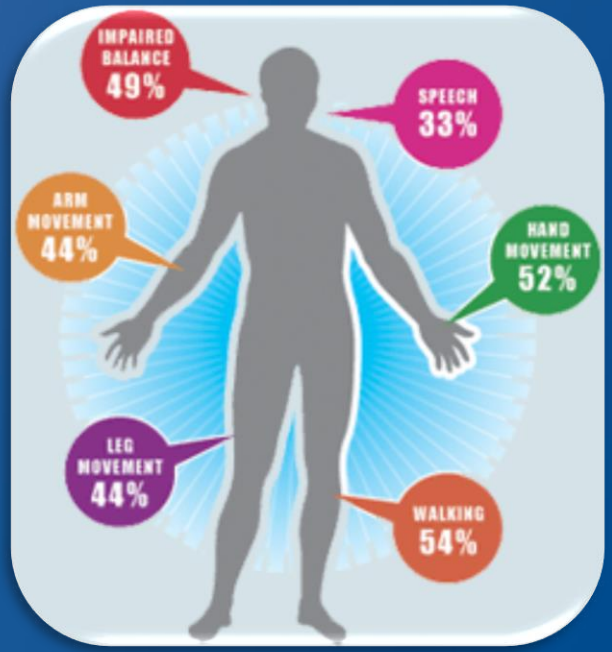
Brain Plasticity

- Excitatory Plasticity
  - Flaccid Paralysis → Return of Reflexes → Emergence of Spasticity
- Inhibitory Plasticity
  - Spastic Co-contraction → Breaking up of Synergy → Isolated voluntary movement

Stroke Rehabilitation Workshop

Post-stroke recovery: Motor

- Patterns of recovery
  - Recovery Leg > Arm
  - Proximal > Distal
- Timeline of recovery
  - Maximal recovery 3 months
  - Minor recovery 3-6 months
  - Progress may stop at any time



Stroke Rehabilitation Workshop

Post-stroke recovery: Upper Extremity Motor

- Poor prognosis for full recovery
  - If no recovery within 3 weeks
  - Isolated segmental recovery
  - No grip strength at 4 weeks
- Some recovery within 4 weeks
  - 70% good recovery
- Complete arm paralysis
  - 9% good recovery

Stroke Rehabilitation Workshop

Post-stroke recovery: Lower Extremity Motor

- Leg paresis
  - 10-33% will ambulate at Mod I
  - 80% will ambulate short distances without cane
  - <50% will ambulate in the community (150ft)
- If LE strength is 3/5 within 1 week, will ambulate
  - Knee flexors important in community ambulation
  - Hip extensors important for home ambulation

Stroke Rehabilitation Workshop

Stroke Community Resources: Stroke Centers

JOHNS HOPKINS MEDICINE

Joint Commission's stroke certifications:

1. Acute Stroke Ready Hospital (ASRH)
2. Primary Stroke Center (PSC)
3. Thrombectomy-Capable Stroke Center (TSC)
4. Comprehensive Stroke Center (CSC)

Stroke Rehabilitation Workshop

Stroke Community Resources: Stroke Centers

JOHNS HOPKINS MEDICINE

FAST

Stroke centers

PRIMARY	COMPREHENSIVE
Patient care: Takes care of most cases of ischemic (blood vessel blockage) types of stroke. 24/7 access to IV tPA.	**Patient care:** Cares for all types of stroke patients, including hemorrhagic strokes, such as those caused by brain aneurysms.
Minimally invasive catheter procedures: Not required.	**Minimally invasive catheter procedures:** 24/7 access to minimally invasive catheter procedures to treat stroke.
Specialized ICU: No requirement for a separate intensive care for stroke patients.	**Specialized ICU:** Dedicated neuroscience intensive care unit for unit stroke patients.
Neurosurgery: Access to neurosurgery within 2 hours.	**Neurosurgery:** On-site neurosurgical availability 24/7 with the ability to perform complex neurovascular procedures, such as brain aneurysm clipping, vascular malformation surgery and carotid endarterectomy.
Patient transfers: Sends complex patients to a Comprehensive Stroke Center.	**Patient transfers:** Receives patients from Primary Stroke Centers.

Stroke Rehabilitation Workshop
Post-stroke recovery

JOHNS HOPKINS MEDICINE

Stroke Recovery Phases

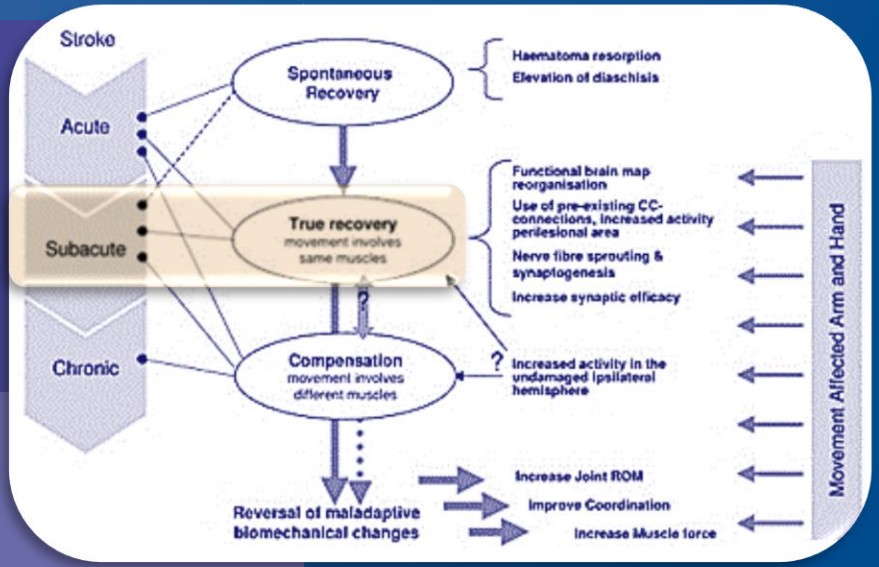
- **Metabolic Recovery**
  - Secondary brain injury
- **Neurologic Recovery**
  - Neurophysiologic restoration
- **Functional Recovery**
  - Learned compensation

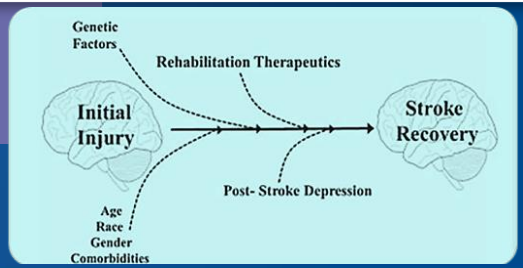
Rehabilitative potentials

- **Degree of corticospinal tract (CST) damage**
  - Neurologic recovery
- **Severity of motor impairment**
  - Functional recovery

Stroke recovery

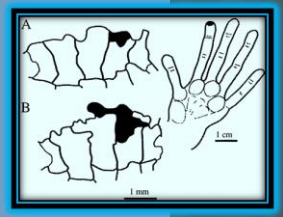
- **Nature:** Comorbidities
- **Nurture:** Environmental influences





Stroke Rehabilitation Workshop

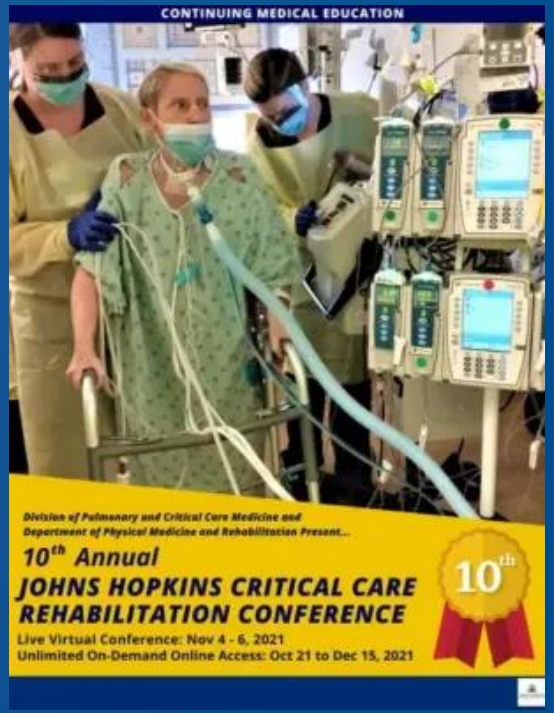
Post-Acute Approach to Neuro-Rehabilitation



- **Brain function**
  - Requires integrative nervous system input
  - Entire brain is affected by input lost from the injured stroke area
- **Neurological Recovery:**
  - Neurophysiologic restoration towards baseline neuro-connectivity
- **Functional Recovery:**
  - Learned compensation
  - Need strategies toward new neuro-connectivity

Stroke Rehabilitation Workshop
Post-stroke recovery

- Early and intense rehabilitation is critical in stroke recovery
- Guidelines recommend 24-48 hrs. post-stroke as soon as medically stable



Pamela W. Duncan, Richard Zorowitz, Barbara Bates, John Y. Choi, Jonathan J. Glasberg, Glenn D. Graham, Richard C. Katz, Kerri Lamberty, Dean Reker. Management of Adult Stroke Rehabilitation Care. A Clinical Practice Guideline. Stroke. 2005;36:e100-e143

Ann Parker. MD, Thiti Sricharoenchai MD, and Dale M. Needham, FCA, MD, PhD. Early Rehabilitation in the Intensive Care Unit: Preventing Physical and Mental Health Impairments. Curr Phys Med Rehabil Reports. 2013 Dec; 1(4): 307–314.

Physical Medicine and Rehabilitation

JOHNS HOPKINS MEDICINE

World Health Organization

- **World Health Organization (WHO) 1980 International Classification of Impairment, Disability, and Handicap**
  - **Impairment:** Functional loss
    - Loss of psychological, physiological or anatomical structure or function.
    - Impairment measures (fatigue severity, MRC, NCAT, grip strength with Vigorimeter)
  - **Disability:** Activity restriction
    - Lack of ability to perform an activity within the normal range for a human being.
    - Disability scales (nine hole peg, 10m walking, ODSS) Hughes scale, Rankin scale).
  - **Handicap:** Societal disadvantage
    - Impairment prevents fulfillment of a normal life role.
    - Handicap scale (Rotterdam handicap scale)

https://jnnp.bmj.com/content/74/1/99

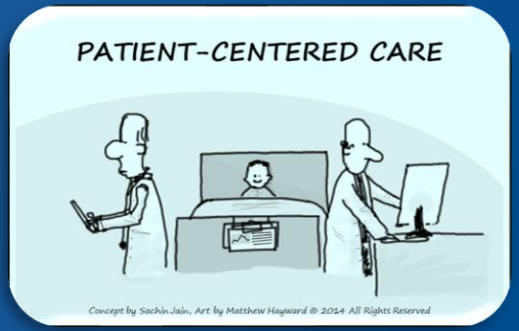
REHABILITATION 2030 a call for action

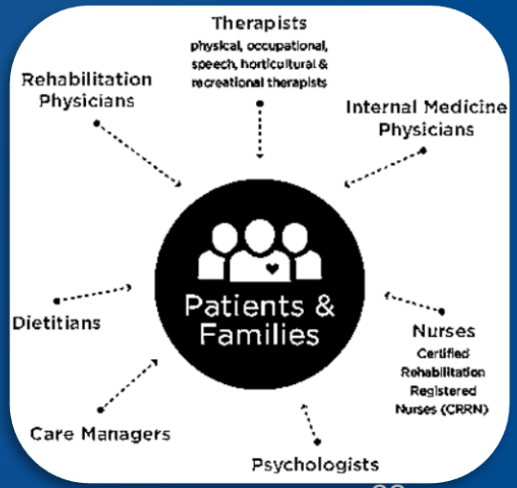
Stroke Rehabilitation Workshop

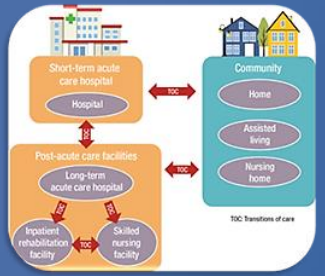
Post-Acute Approach to Neuro-Rehabilitation

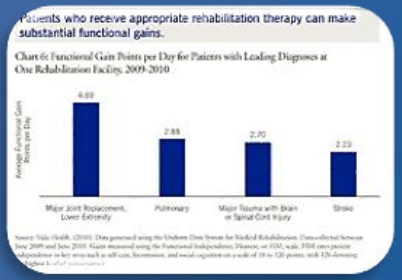
JOHNS HOPKINS MEDICINE

- Levels of Stroke Rehabilitation Programs
  - Acute inpatient IRF
  - Sub-acute SNF
  - Outpatient Day Rehab
- Team-based and patient-centric
  - Effectiveness contingent on patient and family
  - Realistic expectations must be set
  - Small gains can mean home vs. institutionalized!

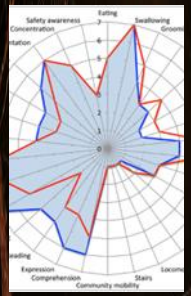








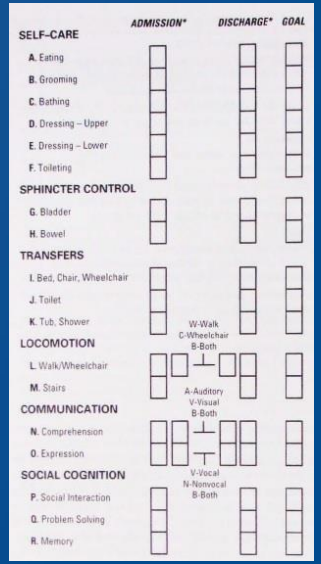
Stroke Rehabilitation Workshop
Post-stroke Rehabilitation Disposition



FIM Levels	Description
FIM Level "0"	No activity **(Complete *Dependence*)**
FIM Level "1"	**Total assistance** (patient can perform less than 25% of the task or requires more than one person to assist) **(Complete *Dependence*)**
FIM Level "2"	**Maximal Assistance** (patient can perform 25% to 49% of taks) **(Complete *Dependence*)**
FIM Level "3"	**Moderate Assistance** (patient can perform 50% to 74% of task) **(Modified *Dependence*)**
FIM Level "4"	Minimal **Contact Assistance** (patient can perform 75% or more of task) **(Modified *Dependence*)**
FIM Level "5"	**Supervision or Setup** **(Modified *Dependence*)**
FIM Level "6"	**Modified *Independence*** (patient requires use of a device, but no physical assistance)
FIM Level "7"	**Complete *Independence***

Garraway et al. (1981, 1985) classified patients in to 3 groups based on early FIM scores during the acute phase (first 5-7 days)

- **Mild Strokes:**
  - FIM > 80: Early plateauing with "ceiling" effect
  - Outpatient rehab
- **Moderately Severe Strokes:**
  - FIM 40-80: 85% discharged to community
  - Best group for inpatient rehab
- **Severe Strokes:**
  - FIM < 40: Poor functional outcome
  - Risk of being institutionalized



Stroke Rehabilitation Workshop

Post-Acute Approach to Neuro-Rehabilitation

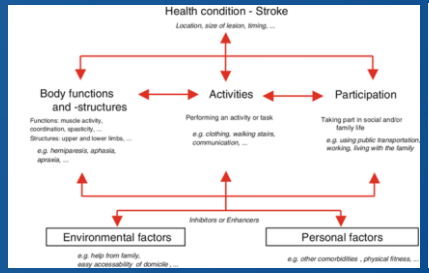
JOHNS HOPKINS MEDICINE

- Rehabilitation
  - Latin ***Habilitas*** = “To make able again”
- Physiatrist
  - Greek ***Physis Iatreia*** = ***Physiatrist***
    - “A physician who employs physical agents.”
- Stroke Rehabilitation goals
  - Regain maximum possible independence
  - Restore well-being
  - Minimize caregiver’s burden

Stroke Rehabilitation Workshop

Post-Acute Approach to Neuro-Rehabilitation

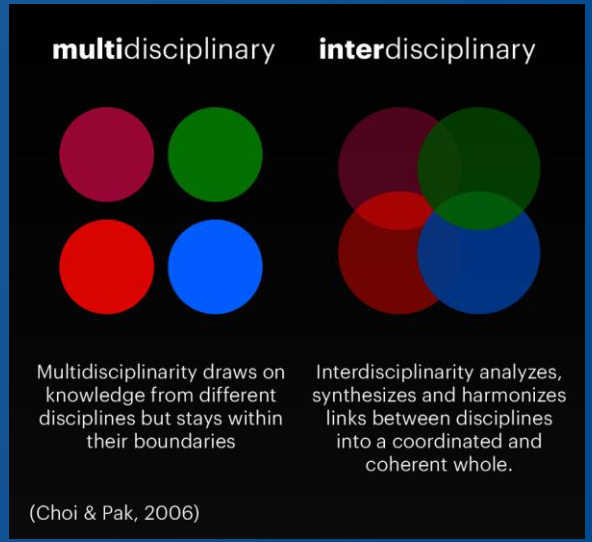
- Stroke rehabilitation program
  - Managing medical stroke risks
  - Treating the functional disability
  - Adaptive tools and environment
  - Patient and family education
- Rehabilitation approach is individualized
  - Cause, location, severity of stroke
  - Types of impairments
  - Degree of disability
  - Medical complexity and stability
  - Availability of post-discharge suppor



Stroke Rehabilitation Workshop

Post-Acute Approach to Neuro-Rehabilitation

- **Inter-disciplinary team** communication is hallmark
  - Physiatrist
  - Rehab nurses
  - Rehabilitative / Neuro-psychologists
  - Physical Therapists
  - Occupational Therapists
  - Speech and Language Pathologists
  - Registered Dietitians
  - Social Workers / Case Managers
  - Chaplains



Stroke Rehabilitation Workshop

Post-Acute Approach to Neuro-Rehabilitation

JOHNS HOPKINS MEDICINE

- **Post-stroke disabilities**
  - **Muscle control:**
    - Impaired gait, balance, swallowing
  - **Sensory alteration:**
    - Impaired touch, pain, temperature, or position
  - **Speech / Language deficits:**
    - Dysarthria, Aphasia
  - **Cognitive deficits:**
    - Thought and memory impairments
  - **Mood disturbances:**
    - Emotional lability

Stroke rehab programs assessment and goal setting:

- **Self-care:** ADLs, feeding, grooming, bathing, dressing, toileting
- **Mobility:** Ambulation, transfers, WC mobility
- **Communication:** Speech, writing, reading, comprehension
- **Cognition:** Memory, concentration, judgment, problem solving, organizational skills
- **Social Integration:** Interacting with families and others in the community
- **Pain management:** Multimodal Pain Management, including spasticity management
- **Rehabilitation / Neuro Psychology:** Thinking, behavioral, and emotional issues
- **Family Training:** Adaptation, lifestyle, finance, and discharge planning
- **Education:** Setting realistic expectations for patient and family about stroke

Stroke Rehabilitation Workshop

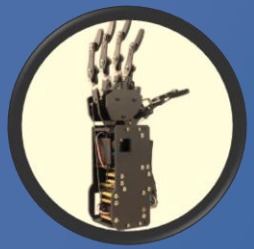
Post-Acute Approach to Neuro-Rehabilitation

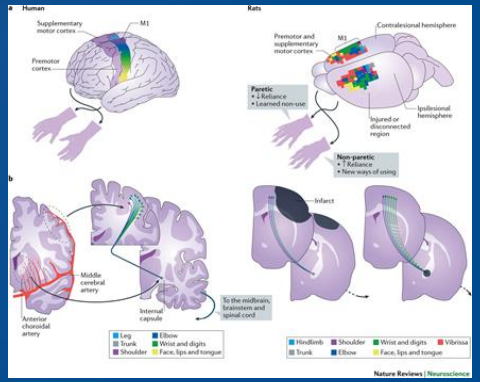
- **Examples of techniques in stroke rehabilitation**
  - **Constraint-induced movement therapy** – Forced use of affected arm and restricted use of normal arm
  - **Therapeutic Rehabilitation Exercise** – Capitalizing on neuroplasticity to rewire the brain
  - **Task-Specific Gait Training** – Capitalizing on neuroplasticity to target specific neural pathways
  - **Passive Range-of-Motion Exercise** – Maintains muscles and joints flexible and minimizes contractures
  - **Sensory Reeducation** – Cognitive-behavioral therapy to minimize post-stroke dysesthesia
  - **Electrical stimulation of muscles** – Helps reeducate weakened muscles
  - **Robotic technology** – Repetitive motions helps limbs to regain strength and function
  - **Virtual reality** – simulation of real-time environment
  - **Mental Practice** – Visualization of moving paralyzed or weak muscles
  - **Motor imagery** – Helps improve arm use
  - **Mirror therapy** – Helps improve hand mobility
  - **Biofeedback exercises** – Helps regain mobility and reduce pain

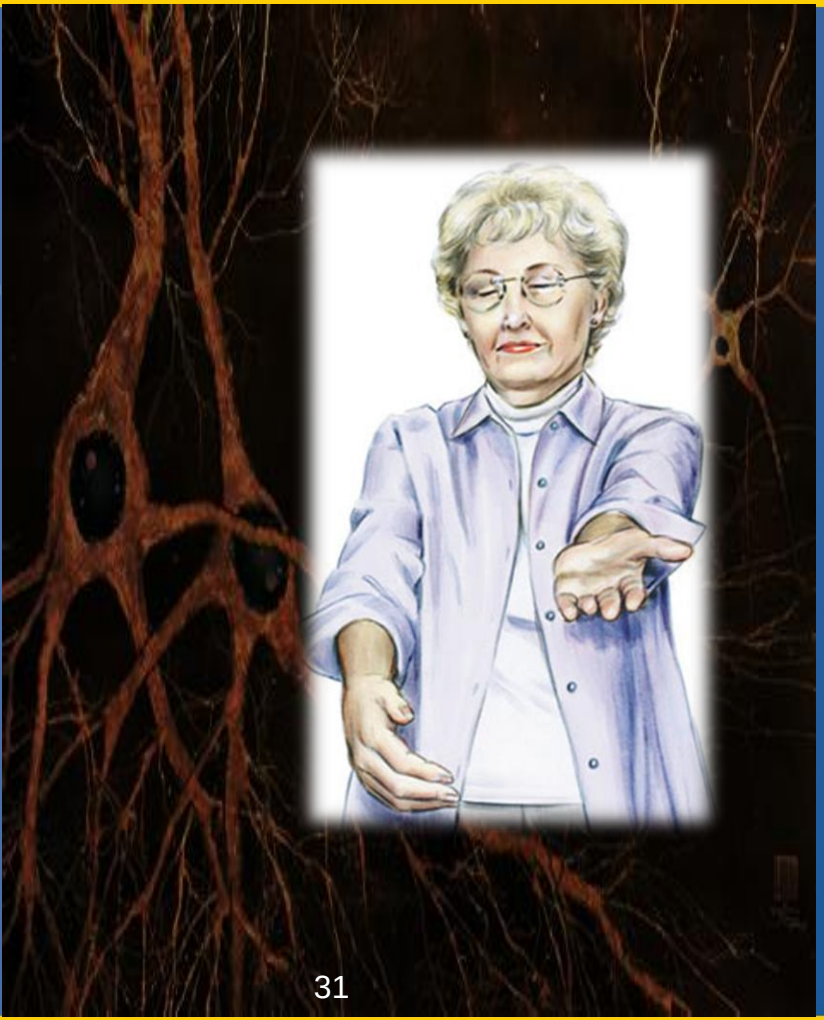
Stroke Rehabilitation Workshop

Post-Acute Approach to Neuro-Rehabilitation

- Post-stroke motor recovery
  - Learned non-use
  - Learned bad use
  - Forgetting
- Post-stroke management goals
  - Maximize functional recovery
    - Optimizing the window of recovery
    - Preventing post-stroke neuromuscular complications
    - Minimizing discomfort







Stroke Rehabilitation Workshop

Post-Acute Approach to Neuro-Rehabilitation

JOHNS HOPKINS MEDICINE

Case

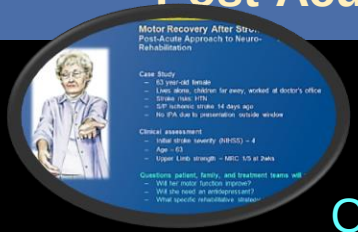
- 63 year-old female
- Lives alone, worked at doctor's office, children far away
- Stroke risks: HTN
- S/P ischemic stroke 14 days ago
- No tPA due to presentation outside window

Clinical assessment

- Initial stroke severity (NIHSS) – 4
- Age – 63
- Upper Limb strength – MRC 1/5 at 2wks

Stroke Rehabilitation Workshop

Post-Acute Approach to Neuro-Rehabilitation



Can we predict how much her motor function will improve?

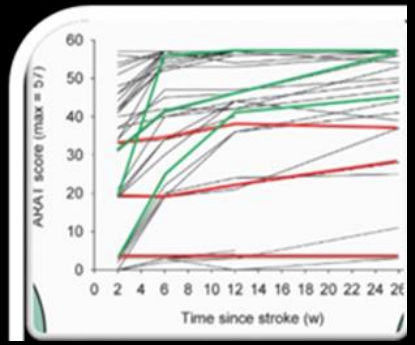
Predictive factors for post-stroke long-term impairments

- Severity of stroke on initial presentation (NIH Scores)
  - The most powerful predictor of rehabilitative potentials
- Age and motor function at stroke onset
  - Affects neurological reconnections
  - Affects completeness of recovery

General post-stroke functional ability

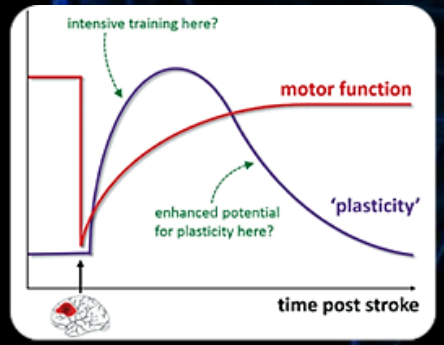
Predictive factors for post-stroke long-term impairments

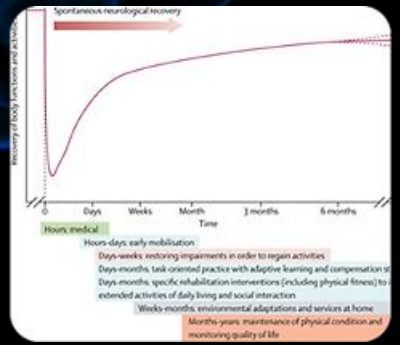
- **Immediately post-stroke**
  - Shoulder abduction and finger extension → arm recovery potentials at 12 wks
  - Mild-to-moderately severe disability → 70% baseline recovery
  - Ambulation ability → long-term independence
  - Sitting balance → independent walking
  - Predictive values of only 59%!
  - There are no reliable predictive mechanism for neuro-recovery!



Neuro-recovery rehabilitative concepts

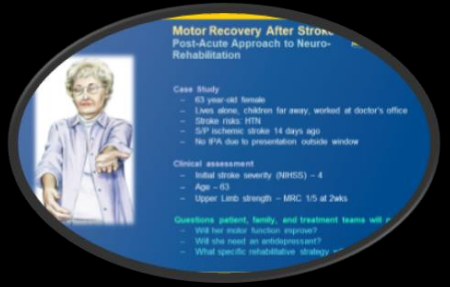
- Functional recovery is influenced by, but not dependent on, neurologic recovery
- Functional improvement continues after the completion of neurologic recovery

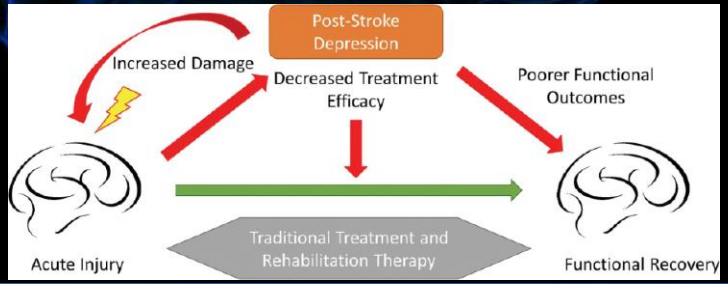




Should she be on an antidepressant?

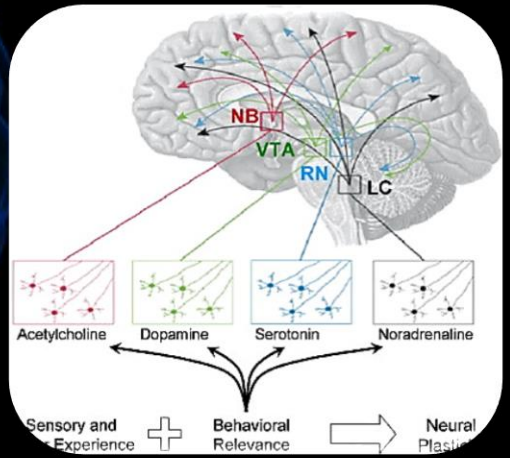
- **Post-stroke depression (PSD)**
  - PSD prevalence ≥ 30%
  - Literature suggests association with left frontal lesions
  - Often difficult to differentiate from effects of stroke itself
  - PSD can hinder rehabilitation progress





Should she be on an antidepressant?

- Fluoxetine for motor recovery after acute ischemic stroke (FLAME): a randomized placebo-controlled trial, 2011, in Toulouse, France
  - If fluoxetine was prescribed early along with OT/PT enhanced, motor recovery was observed after 3 months
  - Cortical over-stimulation as possible mechanism in modulation of brain plasticity



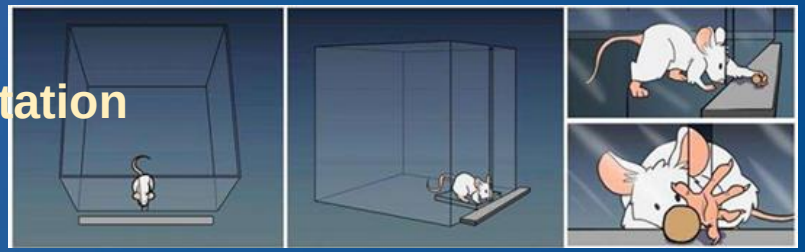
FLAME Trial

Strengths
- Double blinded placebo-controlled trial
- Standardized screening
- Intervention/timing in line with clinical practice vs. previous studies
- Strong adherence (88.3/87.4 out of 90 tablets)

Weaknesses
- Small
- Extensive clinically important exclusion criteria
- FMMS does not measure "function"

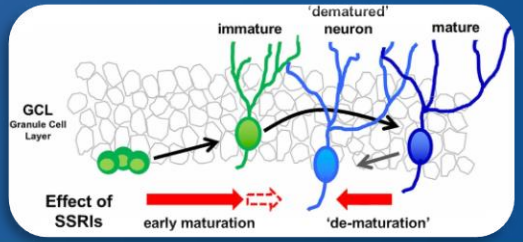
Stroke Rehabilitation Workshop

Post-Acute Approach to Neuro-Rehabilitation



Fluoxetine Maintains a State of Heightened Responsiveness to Motor Training Early After Stroke in a Mouse ModelKwan L. Ng, MD, PhD, Ellen M. Gibson, BA, Robert Hubbard, BS, Juemin Yang, BS, MS, Brian Caffo, PhD, Richard J. O'Brien, MD, PhD, John W. Krakauer, MD, and Steven R. Zeiler, MD, PhD. 20 Aug 2015https://doi.org/10.1161/STROKEAHA.115.010471Stroke. 2015;46:2951–2960

- Intensive Stroke Rehab initiation within 24-48 hours of admission to Neuro-ICU
  - Early rehabilitation maximizes motor return potentials through "Window of Recovery"
- SSRIs (ex: Fluoxetine/Prozac) prescribed within 24-48 hours of the stroke
  - Early stroke motor recovery involves healthy brain tissues
  - SSRIs prolongs the "Window of Recovery"

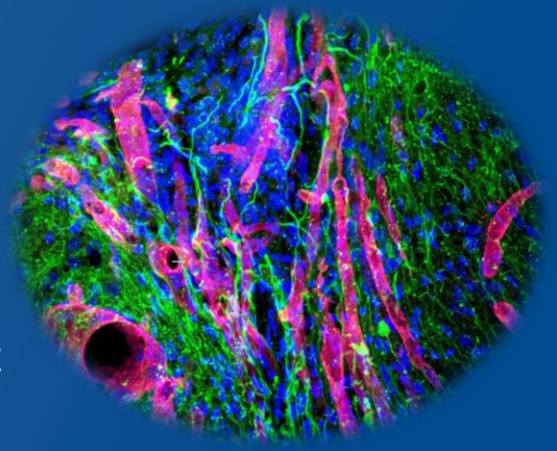


Stroke Rehabilitation Workshop
Post-Acute Approach to Neuro-Rehabilitation

JOHNS HOPKINS MEDICINE

Quinn TJ. Fluoxetine in stroke (FOCUS) trial—reasons to be cheerful about antidepressants in stroke? Ann Transl Med 2019;7(Suppl 3):S131. doi: 10.21037/atm.2019.05.85

- The Fluoxetine or Control Under Supervision (FOCUS) double-blinded randomised controlled trial with 3127 stroke patients from 107 hospitals in the UK. Half were randomly assigned to receive fluoxetine, while the other half received a placebo.
- The results indicated that fluoxetine did not appear to improve functional outcomes after stroke, and although it may have reduced depression in the short-term, it did not appear to have a significant long-term effect.

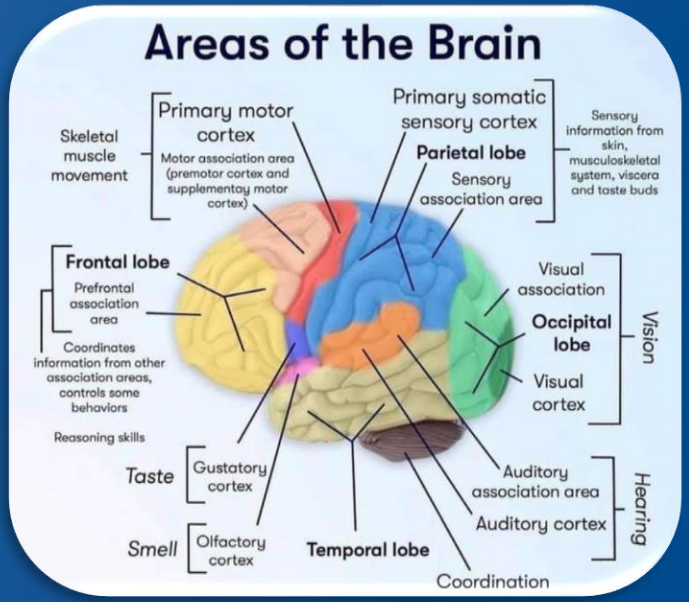


Stroke Rehabilitation Workshop

Post-Acute Approach to Neuro-Rehabilitation

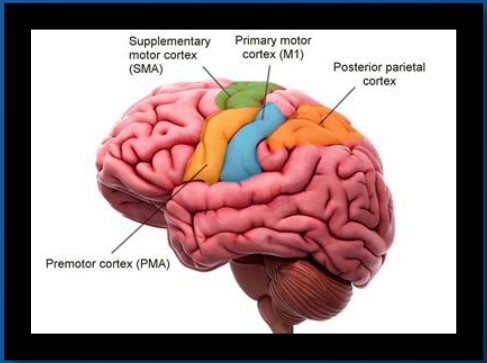
Beckwée D, Lefeber N, Bautmans I, Cuypers L, De Keersmaecker E, De Raedt S, Kerckhofs E, Nagels G, Njemini R, Perkisas S, Scheys E, Swinnen E. Muscle changes after stroke and their impact on recovery: time for a paradigm shift? Review and commentary. Top Stroke Rehabil. 2021 Mar;28(2):104-111. doi: 10.1080/10749357.2020.1783916. Epub 2020 Jun 26. PMID: 32588773.

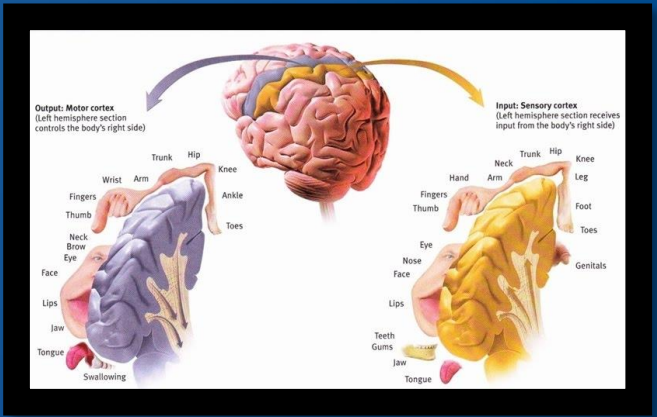
- Stroke is heterogeneous, not all patients have the same potential to recover
- Current research projects focus on potential biomarkers in stroke rehabilitation

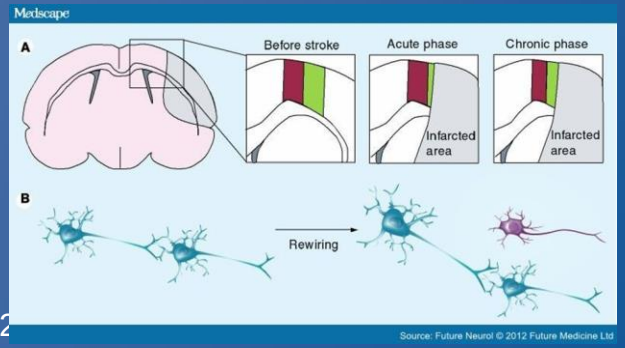


Stroke Rehabilitation Workshop
Post-Acute Approach to Neuro-Rehabilitation

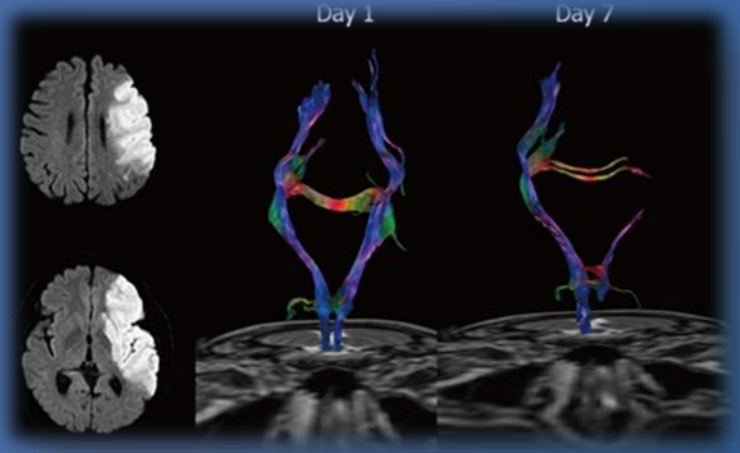
- **Neuroplasticity of motor cortex**
  - Compensation through reconnections and remapping by undamaged areas
  - Adaptability is the ability to learn new processes, which generates more connections

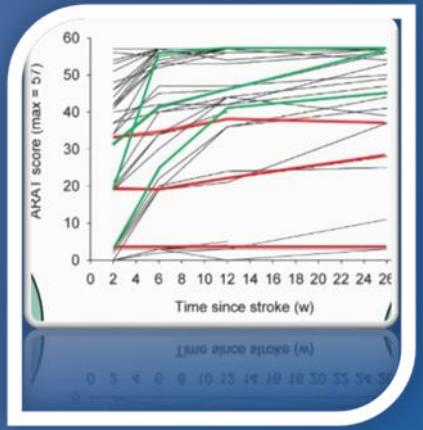






EVIDENCE-BASED Rehabilitation





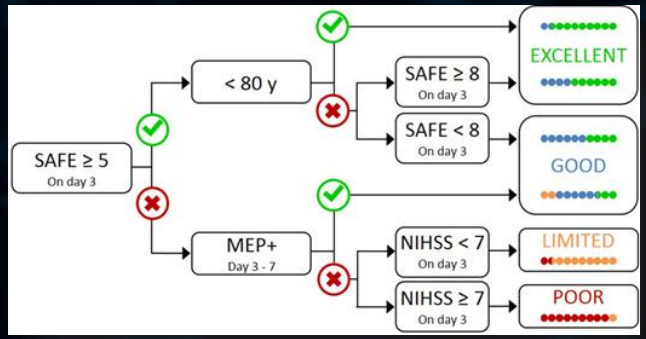
- Severity of initial CST injury will predict
  - Motor impairment
  - Functional outcome
- Clinical trial re: strategies for focused rehabilitation through predictive recovery potentials of the Corticospinal Tract (CST)
  - Using biomarkers to predict recovery
  - Identification of patients with imperceptible potentials
  - Tailor rehab based on above prediction
- Predictive values
  - Up to 83%

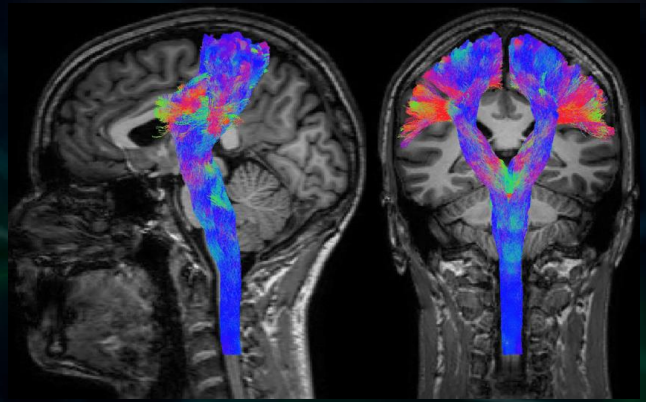
Predicting Recovery Potential for Individual Stroke Patients Increases Rehabilitation Efficiency. Cathy M. Stinear, Winston D. Byblow, Suzanne J. Ackerley, P. Alan Barber, Marie-Claire Smith. Stroke. 2017;STROKEAHA.116.015790

PREP Research Protocol

Predicting REcovery Potential for the hand and arm

- Outcome of UE recovery is predicted based on three measures:
  - Physical movement ability
  - Age
  - Motor evoked potential
- Recovery categories are classified into:
  - Excellent
  - Good
  - Limited
  - Poor Recovery categories
- Movement ability is measured by SAFE (Shoulder Abduction Finger Extension) score
  - Excellent prognosis for UE motor recovery at 12 weeks post-stroke
    - A SAFE score of ≥5 in a person < 80 years, or
    - A SAFE score of ≥8 in a person > 80 years

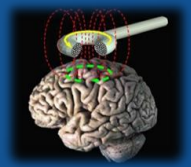


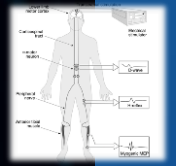


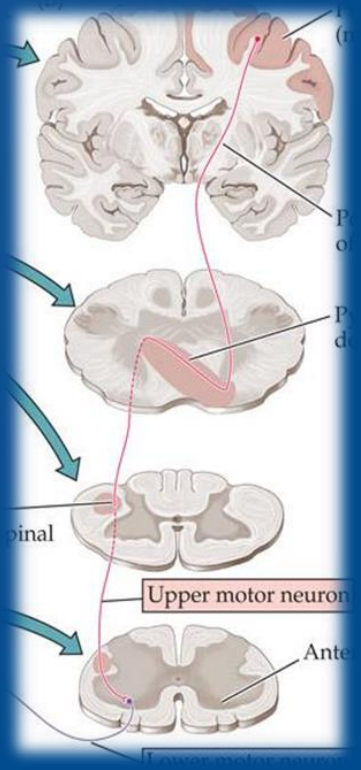
PREP Research Protocol

Predicting REcovery Potential for the hand and arm

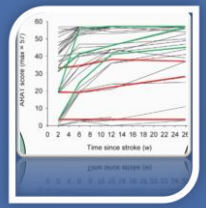
- **Protocol of 3**
  - Start within 3 days after the stroke
  - Requires 3 simple steps
- **Patient selections**
  - 18+ years old S/P stroke w/ UE weakness
  - Exclusion: cerebellar stroke
- **Scoring**
  - SAFE (Shoulder Abduction Finger Extension) scores
  - Predicting motor recovery potential at 3 months
  - Recovery potential-focused rehabilitation
- **Technologies engaged**
  - Transcranial Magnetic Stimulation (TMS)
  - Motor Evoked Potential
  - Diffusion-Weighted Magnetic Resonance Imaging (DWI or DW-MRI)

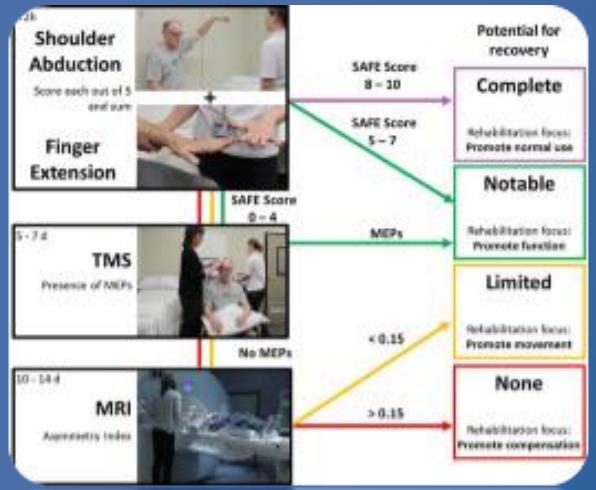


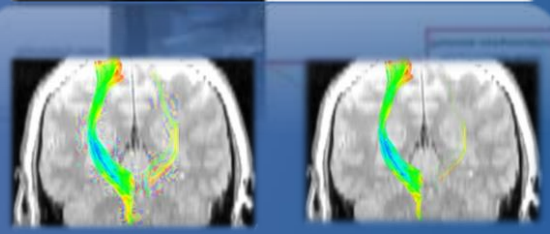




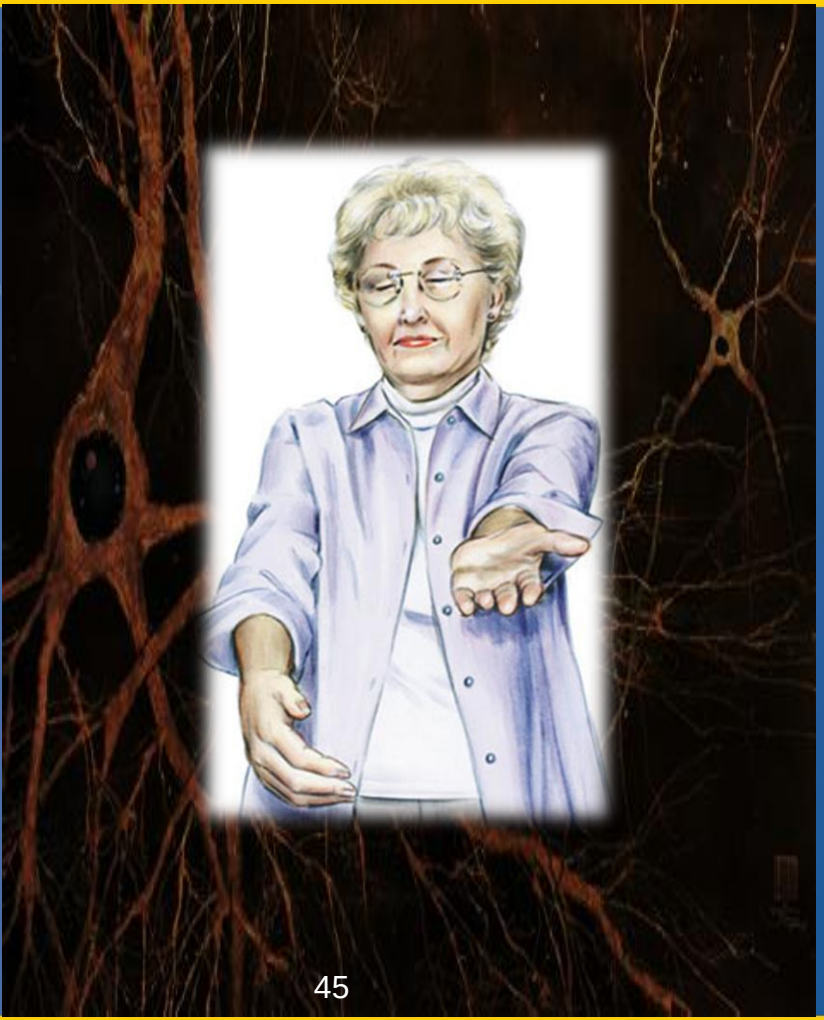
Using PREP to Focus Rehabilitation Efforts Based on Neurologic Recovery Potentials







- **COMPLETE RECOVERY POTENTIAL: Promote Normal Use**
  - Carrying out a prescribed program of self-directed arm and hand exercise gives the patient about a 90% chance of reaching this potential.
- **NOTABLE RECOVERY POTENTIAL: Promote Function**
  - Arm and hand rehabilitation should focus on improving function by increasing strength, coordination and fine control.
- **LIMITED RECOVERY POTENTIAL: Promote Movement**
  - Arm and hand rehabilitation should focus on maintaining and improving the strength and flexibility of the affected arm and hand.
- **NO RECOVERY POTENTIAL: Promote Compensation**
  - Arm and hand rehabilitation should focus on prevention of secondary complications, such as pain and tightness, and helping the patient to do everyday activities with the stronger arm and hand.



Using PREP to Focus Rehabilitation Efforts Based on Neurologic Recovery Potentials

JOHNS HOPKINS MEDICINE

Will her motor function improve?

This patient's recovery assessment was determined to be:

- **Category: NOTABLE RECOVERY**
  - Good potential with affected UE for most ADLs within 12 weeks
- **Rehabilitative focus: promote function**
  - Rehabilitation focusing on strength, coordination, and fine motor
  - Caution to minimize compensation with opposite hand

Stroke Rehabilitation Workshop

Post-Acute Approach to Neuro-Rehabilitation

JOHNS HOPKINS MEDICINE

Addressing Medical issues

- ✓ **Secondary stroke prevention**
  - Antiplatelets/ Anticoagulation agents
  - Antihypertension agents
  - Antihyoperlipidemia agents
  - Antihyperglycemia agents
- ✓ **Post-stroke complications prevention**
  - DVTs / PEs
  - Limb contractures
  - Bowel / Bladder dysfunctions
  - Pressure ulcers
  - Dysphagia / Aspiration pneumonia
  - Depression / Agitation

Addressing Functional issues

- ✓ **Recognition of barriers to neuro-recovery**
  - Spasticity
  - Flexion contractures
  - Neuropathic pain
  - Hemiparetic shoulder
  - Other musculoskeletal complications of stroke
- ✓ **Prevention is better than treatment**
  - The above barriers will limit patient's maximal recovery potentials

Stroke Rehabilitation Workshop

Post-Acute Approach to Neuro-Rehabilitation: Spasticity

JOHNS HOPKINS MEDICINE

ONE rehabilitation issue IM / Geriatricians can actively address at SNF

- **Spasticity management**

This will minimize risks for numerous other secondary post-stroke complications

- Pain
- Limb contractures
- Skin breakdown

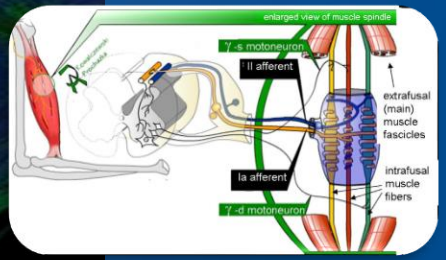
This will facilitate the progression of the rehabilitative process

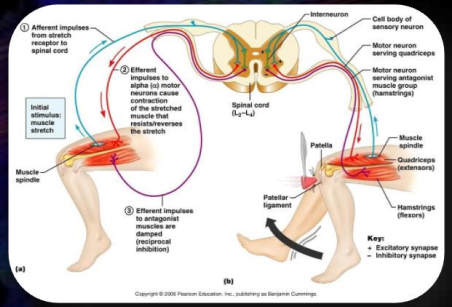
- Therapists to establish more advanced goals
- Patients to participate more effectively

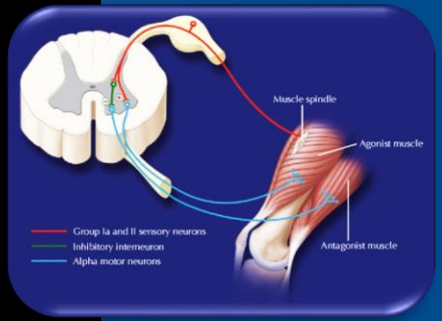
Stroke Rehabilitation Workshop

Post-Acute Approach to Neuro-Rehabilitation: Spasticity

- **What is Spasticity?**
  - Motor disorder due to hyper-excitibility of the stretch reflex
    - Velocity and directional dependent
  - Upper Motor Neuron process
    - Exaggerated tendon jerks clonus (phasic stretch reflex)
    - Hypertonicity (tonic stretch reflex)
  - Basic neuro-circuitry involve
    - Ib afferent
    - Ia/II afferent
    - α-motor neuron
    - γ-motor neuron



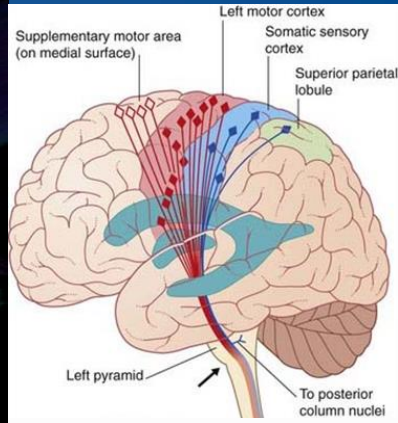


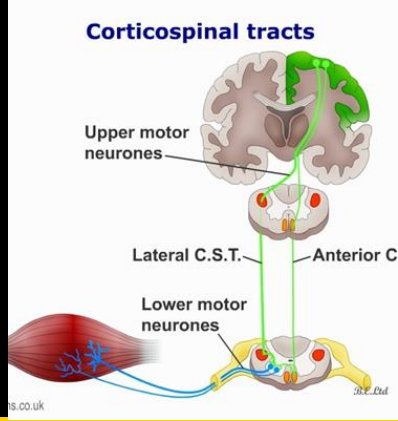


Stroke Rehabilitation Workshop

Post-Acute Approach to Neuro-Rehabilitation: Spasticity

- **Significance of post-stroke spasticity**
  - Post-stroke spasticity prevalence
    - 25% - 43% within the first year
    - 33% will develop upper limb spasticity over the first 3 months
  - Barriers to stroke recovery
    - Can interfere with movement, speech, or create pain
    - Can interfere with rehabilitation and interferes with daily activities



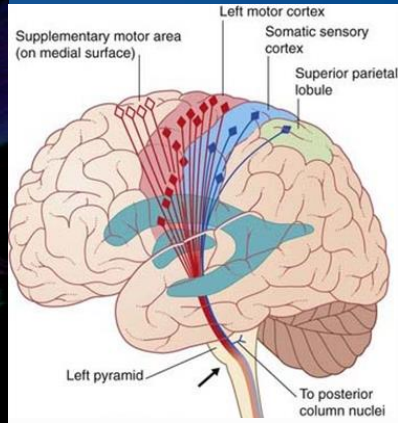


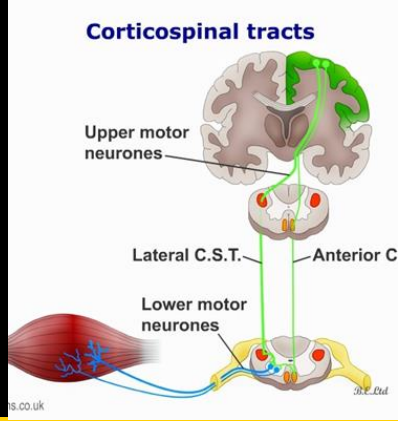
Stroke Rehabilitation Workshop

Post-Acute Approach to Neuro-Rehabilitation: Spasticity

JOHNS HOPKINS MEDICINE

- **How does spasticity manifest?**
  - Increasing stiffness with faster muscle motion
  - Clasp-knife phenomenon
  - Phasic spasticity (hyper-reflexia and clonus)
  - Tonic spasticity (hypertonicity)
  - Positive symptoms
    - Hyperreflexia, clonus
    - Muscle stiffness, co-contractures
    - Abnormal posture, spastic gait
  - Negative symptoms
    - Weakness
    - Incoordination
    - Fatigue
    - Pain

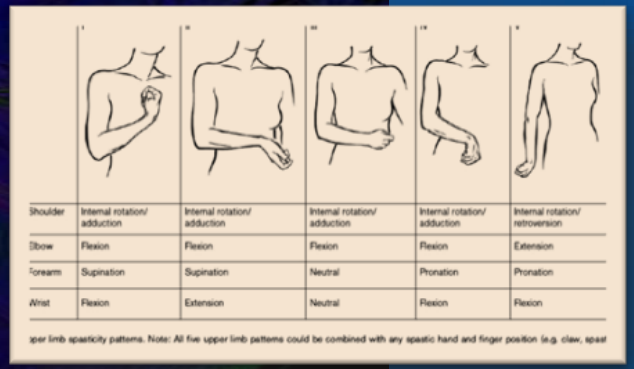




Stroke Rehabilitation Workshop

Post-Acute Approach to Neuro-Rehabilitation: Spasticity

- **Clinical Features**
  - Upper limbs:
    - Shoulder adductors
    - Elbow, wrist and finger flexors
    - Forearm pronators
    - Thumb adductors
  - Lower limbs:
    - Hip adductors
    - Knee and plantar flexors
    - Ankle invertors

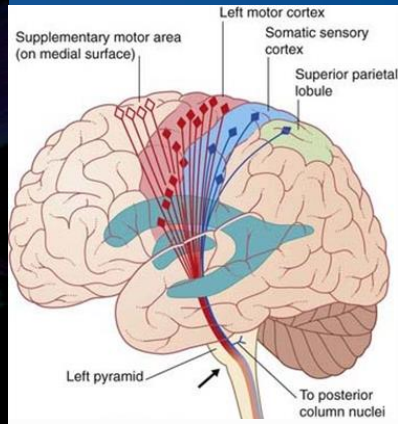


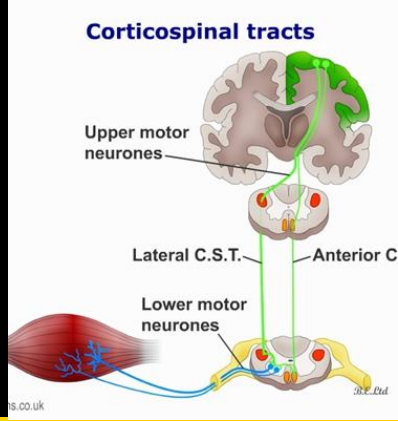
Shoulder	Internal rotation/ adduction	Internal rotation/ adduction	Internal rotation/ adduction	Internal rotation/ adduction	Internal rotation/ retroversion
Elbow	Flexion	Flexion	Flexion	Flexion	Extension
Forearm	Supination	Supination	Neutral	Pronation	Pronation
Wrist	Flexion	Extension	Neutral	Flexion	Flexion

pper limb spasticity patterns. Note: All five upper limb patterns could be combined with any spastic hand and finger position (e.g. claw, spast

Stroke Rehabilitation Workshop
Post-Acute Approach to Neuro-Rehabilitation: Spasticity

- **How does spasticity affects patient care?**
  - Barriers to recovery
    - Can interfere with movement, speech, or create pain
    - Can interfere with rehabilitation and interferes with daily activities
  - Increases cost of care
    - Spasticity can escalates cost up to 4x
    - Spasticity treatments negates the savings
  - Risks of contractures
    - UE spasticity in first 4 months → risks of elbow contractures
    - 60% develop hemiparetic contractures in 1 year
    - Wrist contractures most common in nonfunctional hand



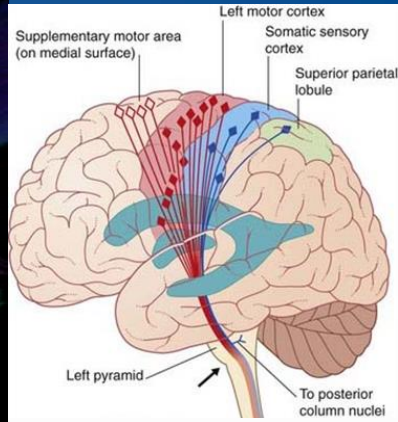


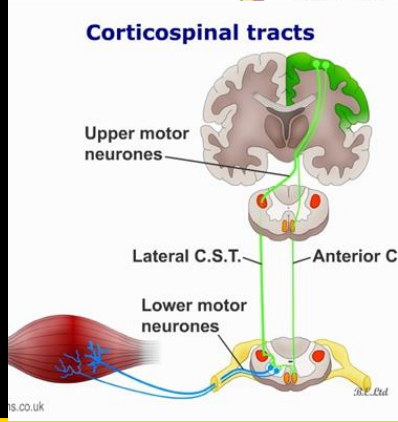
Stroke Rehabilitation Workshop

Post-Acute Approach to Neuro-Rehabilitation: Spasticity

JOHNS HOPKINS MEDICINE

- **Untreated spasticity**
  - Pain and contractures
  - Difficulty with positioning and fall risk
  - Skin breakdown
  - Functional impairment
  - Unrecognized risks
    - Hygiene
    - Urinary tract infections
    - Chronic constipation
    - Fever or other systemic illnesses
    - Psychological, social, vocational





Stroke Rehabilitation Workshop

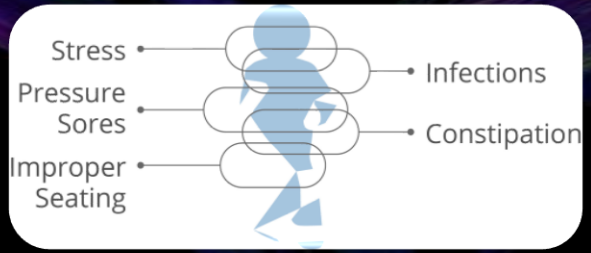
Post-Acute Approach to Neuro-Rehabilitation: Spasticity

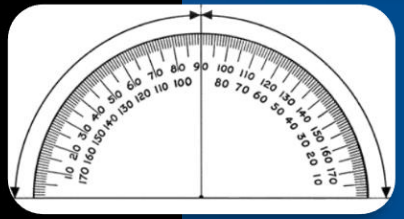
- **Diagnostic Approach**
  - Spasticity is a clinical diagnosis
  - Look for reversible causes
    - UTI, stool impaction, pressure sore
  - Assess impact on mobility, self-care and ADLs
  - Measurement scales to quantify and monitor severity

Modified Ashworth Scale

Grade	Description
0	No increase in muscle tone
1	Slight increase in muscle tone, manifested by a catch and release or by minimal resistance at the end of the range of motion when the affected part(s) is moved in flexion or extension
1+	Slight increase in muscle tone, manifested by a catch, followed by minimal resistance throughout the remainder (less than half) of the ROM*
2	More marked increase in muscle tone through most of the ROM, but affected part(s) easily moved
3	Considerable increase in muscle tone, passive movement difficult
4	Affected part(s) rigid in flexion or extension

- While still supporting the elbow passively flex and extend the elbow
- Use same technique on both arms
- If tone is normal there will be no resistance to these movements





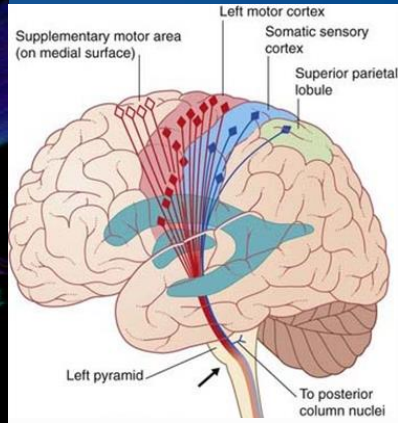
Stroke Rehabilitation Workshop

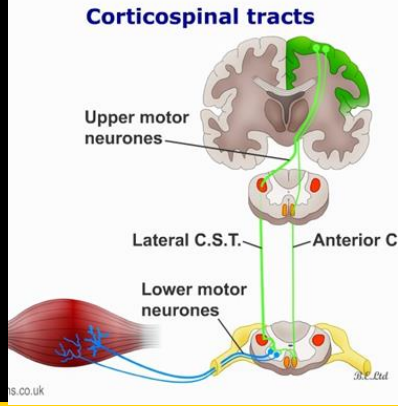
Post-Acute Approach to Neuro-Rehabilitation: Spasticity

- How to manage spasticity?

Step scheme of spasticity treatment

- Neurosurgical treatment
- Orthopedic treatment
- Intrathecal therapy
- Invasive methods (Botox)
- Oral medication
- Physiotherapy
- Anti-spastic positioning and other methods
- Avoiding stimuli triggering spasticity



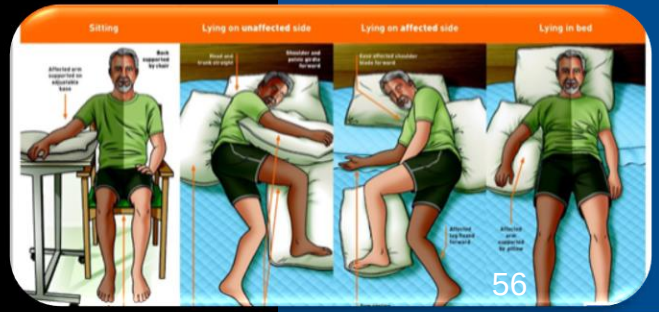


Stroke Rehabilitation Workshop
Post-Acute Approach to Neuro-Rehabilitation: Spasticity

JOHNS HOPKINS MEDICINE

- **Management**
  - Individualized with realistic and meaningful expectations
  - Stretching, PROM
  - Proper positioning in bed and wheelchair
  - US, FES, and biofeedback can be used as adjunctive treatments

  - Treatment of spasticity per se is not recommended!
  - Treatment should be initiated <u>only</u> when spasticity
    - Interferes with function
    - Causes skin breakdown and pain

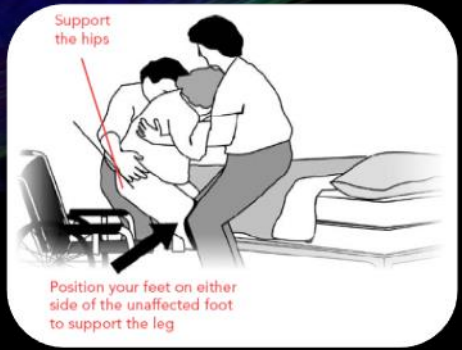


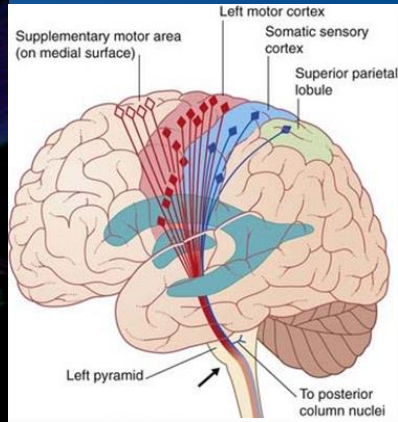
Stroke Rehabilitation Workshop

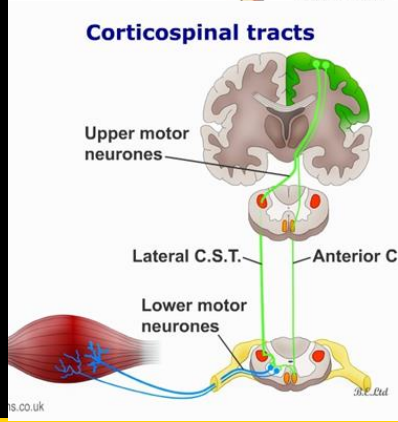
Post-Acute Approach to Neuro-Rehabilitation: Spasticity

JOHNS HOPKINS MEDICINE

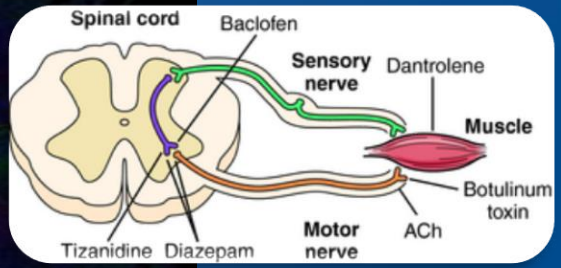
- **Benefits of spasticity**
  - Spasticity as a strategy to compensate for weakness
    - Sitting and standing stability
    - Maintains muscle bulk
    - Improves venous return
    - Improves cough
    - Improves functional capacities
      - ADLs (dressing)
      - Mobility (transfer, ambulation)
      - Sitting stability, standing, and walking







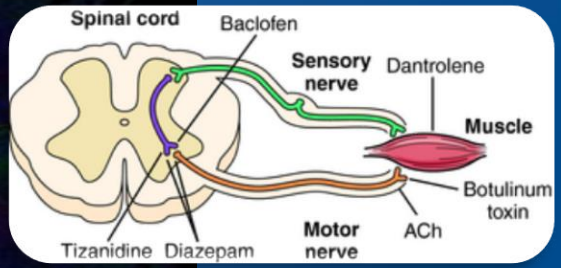
Stroke Rehabilitation Workshop
Post-Acute Approach to Neuro-Rehabilitation: Spasticity



- **Pharmacotherapy**
  - Centrally Acting Medications
    - Baclofen:
      - Spinal level pre- and postsynaptic gamma aminobutylic acid (GABA) B agonist
      - Common first-line treatment
      - Side effects include systemic muscle relaxation, sedation, and lethargy
      - Liver function tests should be monitored due to the risk of hepatotoxicity
    - Tizanidine:
      - Imidazoline alpha-2 agonist presynaptic inhibition of motor neurons
      - Common second-line agent used in conjunction with other oral medications
      - Side effects are somnolence, xerostomia, and hypotension
      - Liver function tests should be monitored due to the risk of hepatotoxicity

Stroke Rehabilitation Workshop

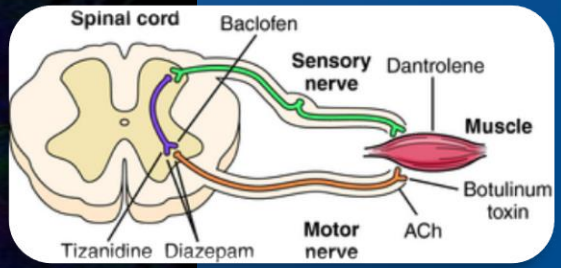
Post-Acute Approach to Neuro-Rehabilitation: Spasticity



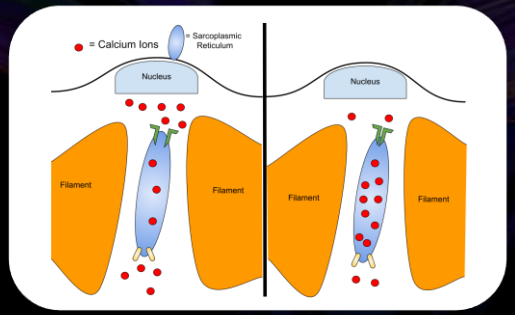
- **Pharmacotherapy**
  - Anticonvulsants
    - Benzodiazepines:
      - Post-synaptic GABA-A agonist
      - The most commonly used benzodiazepines are diazepam and clonazepam
      - Side effects include respiratory depression and significant sedation
    - Gabapentin:
      - A structural GABA analog indirect calcium channel blocker
      - This medication is rarely used as monotherapy in the treatment of spasticity
      - Side effects include somnolence, tremor, and nystagmus

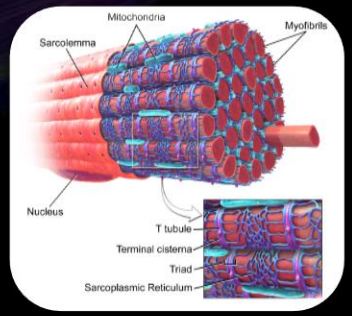
Stroke Rehabilitation Workshop

Post-Acute Approach to Neuro-Rehabilitation: Spasticity



- **Pharmacotherapy**
  - Peripherally Acting Medications
    - Dantrolene
      - Calcium release inhibitor at the sarcoplasmic reticulum
      - Side effects include general muscle weakness.
      - Risk of hepatotoxicity and liver failure

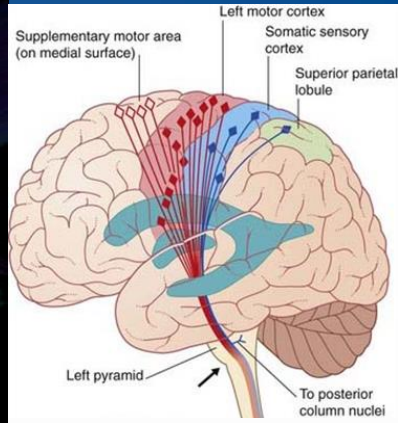


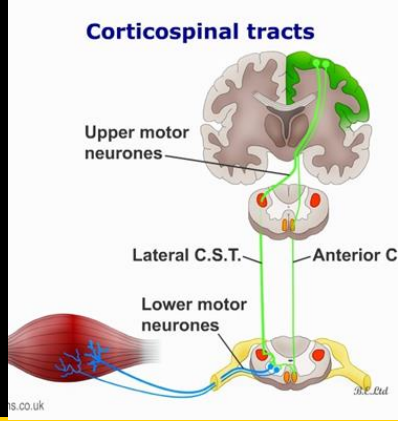


Stroke Rehabilitation Workshop
Post-Acute Approach to Neuro-Rehabilitation

JOHNS HOPKINS MEDICINE

- **Anti-spasticity Medications Dosing**
  - Baclofen
    - 5mg TID x 3d, → 10mg TID x 3d, → 15mg TID x 3d, → 20mg TID
    - Max dose: 20mg QID. Check LFT
  - Tizanidine
    - 2mg TID – QID, titrate by 2 to 4mg at intervals of 1 to 4 days
    - Max single dose: 16mg; Max daily dose: 36mg / 24 hrs
    - Caution in elderly; Renal dose adjustment needed; Check LFT
  - Dantrium Sodium
    - 25mg qD x 7d, → 25mg TID x 7d, → 50mg TID x 7d, → 100mg TID
    - Max dose: 100 mg QID.
    - Highest liver risks first 3-12 months, avoid in elderly.

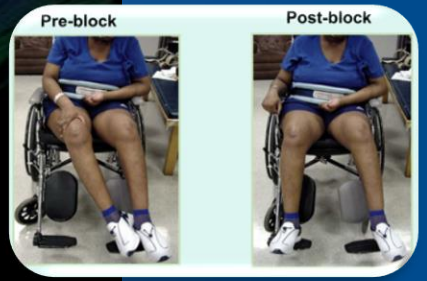




Stroke Rehabilitation Workshop

Post-Acute Approach to Neuro-Rehabilitation: Spasticity

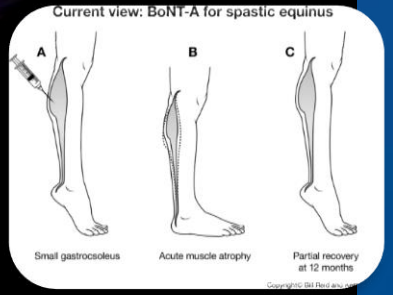
- **Pharmacotherapy**
  - Injectable Medications
    - Botulinum toxin
      - Blocks presynaptic acetylcholine release
      - Type A and Type B most used
      - Peak therapeutic effects 2-3 weeks, lasting 3-4 month
      - FDA Black Box warning re: botulism toxicity
      - Antibodies if too frequent injection (< 12 weeks, high doses)



    - Phenol / Alcohol
      - Chemical neurolysis of the nerve that is causing spasticity
      - Effective 6-12 months, dependent on degrees of nerve regeneration and sprouting
      - Adverse events include painful dysesthesias, DVT, muscle fibrosis

Stroke Rehabilitation Workshop
Post-Acute Approach to Neuro-Rehabilitation: Spasticity

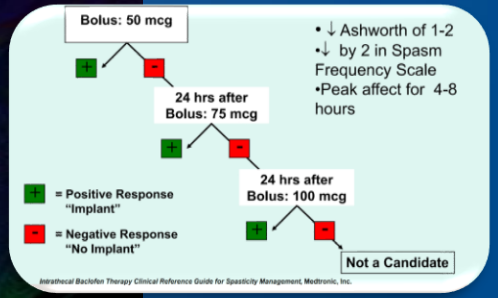
- **Positioning/Orthotics**
  - Serial casting helps restore proper biomechanics to the joint
    - Often use post Botox injection
  - Possible complications serial casting
    - Pressure injuries and circulation impairment
  - Taping, orthotics, and bivalve casts can support the joints



Stroke Rehabilitation Workshop

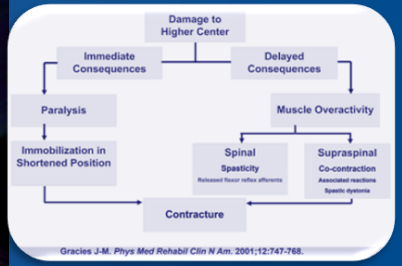
Post-Acute Approach to Neuro-Rehabilitation: Spasticity

- **Surgical Interventions**
  - Intrathecal baclofen (ITB)
    - Baclofen delivered directly into CSF
    - Higher concentrations without systemic effects
    - ITB trial prior to surgical pump implantation
    - Risks of device failure
      - Overdose - respiratory depression and coma
      - Withdrawal - hyperthermia, rhabdomyolysis, and DIC



Stroke Rehabilitation Workshop
Post-Acute Approach to Neuro-Rehabilitation

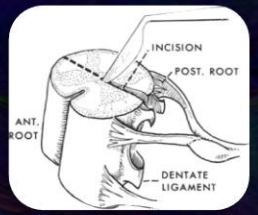
- **Post-Stroke Contractures Prevention**
  - Contractures cause pain affecting self-care and ADLs
    - Daily stretching may prevent contractures
  - Effectiveness of resting hand splints has not been established
    - Resting hand splints will not reduce spasticity, or prevent contracture
      - *Splinting the wrist in either the neutral or extended wrist position for 4 weeks did not reduce wrist contracture after stroke. These findings suggest that the practice of routine wrist splinting soon after stroke should be discontinued* (Lannin 2006, *Stroke*)
    - Resting hand splints (+) stretching (+/o) botulinum toxin may help
      - Injection of botulinum toxin lowered resistance to muscle stretch

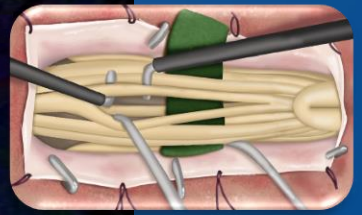


Dr. No

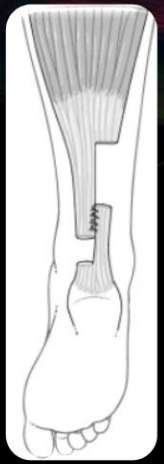
Stroke Rehabilitation Workshop

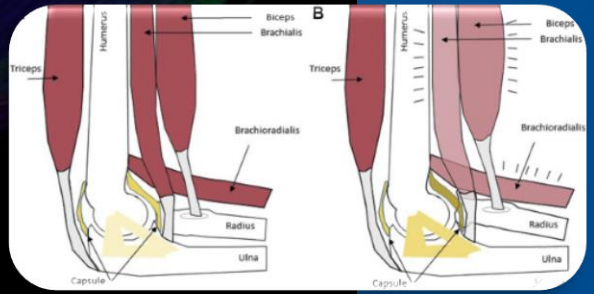
Post-Acute Approach to Neuro-Rehabilitation: Spasticity





- **Surgical Interventions**
  - Severe spasticity and pain
    - Neurosurgical resection of peripheral nerves interrupting signal transduction
      - Selective dorsal rhizotomies
      - Myelotomies
  - Severe contractures, limb deformities
    - Neuro-orthopedic procedures
      - Tendon release
      - Tendon lengthening
      - Tenotomy
      - Joint fusion





Stroke Rehabilitation Workshop

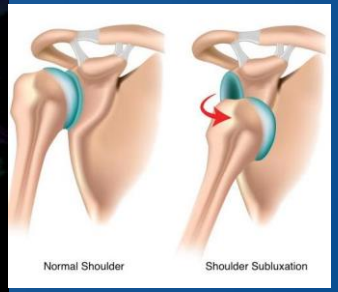
Post-Acute Approach to Neuro-Rehabilitation: Spasticity

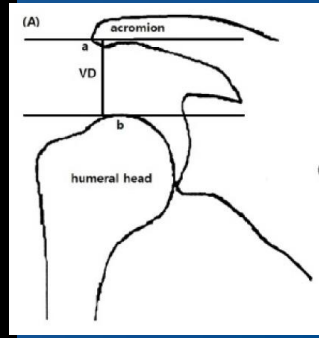
- **Functional Prognosis and Outcome**
  - Physical limitations
    - Joint contractures – Permanent loss of ROM
    - Poor posture - Pressure ulcers
  - Functional limitations
    - Poor positioning
      - Wheelchair sitting
      - Pressure relief positioning
      - Daily hygiene of hand, axilla, perineum
      - Sexual positioning
    - Pain
      - Cannot progress with self care, mobility, ADLs

Stroke Rehabilitation Workshop
Post-Acute Approach to Neuro-Rehabilitation: Hemiparetic Shoulder

Hemiparetic Shoulder

- Occurs in 16% to 72% of stroke patients with hemiplegia
- Hemiplegic shoulder subluxation occurs during the first 3 weeks
  - Humeral head is displaced inferiorly and anteriorly
  - Loss or normal supraspinatus and posterior deltoid functions
  - UE weight pulls and stretches the joint capsule, muscles, tendons, and ligaments leading to pain
- If not addressed early, fibrotic changes will affect alignment of humerus and scapula.
- Severe pain, risks of contractures
- The ideal management is prevention



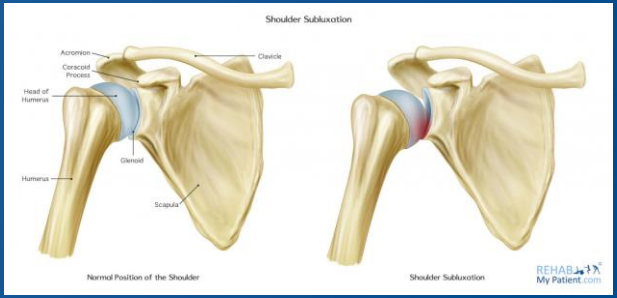


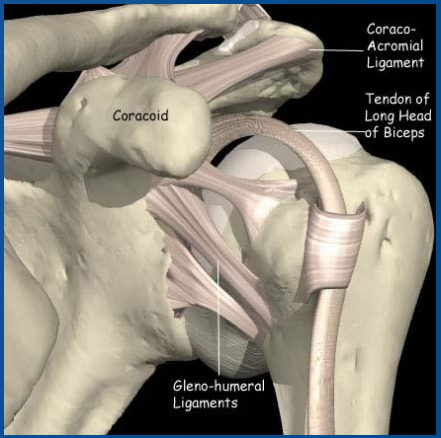
Stroke Rehabilitation Workshop

Post-Acute Approach to Neuro-Rehabilitation: Hemiparetic Shoulder

Hemiparetic Shoulder Etiologies

- Premorbid
  - Pre-existing musculoskeletal issues – capsulitis, tendinitis
- Peri-stroke
  - Injuries incurred while experiencing a stroke – rotator cuff, plexus injury
- Post-stroke
  - Neuromuscular impairments – GH sublux, shoulder-hand, central pain
  - Iatrogenic injuries – mishandling during transfer





Stroke Rehabilitation Workshop

Post-Acute Approach to Neuro-Rehabilitation: Hemiparetic Shoulder

JOHNS HOPKINS MEDICINE

Hemiparetic Shoulder Management

- Prevent contractures
  - Positioning, ROM
  - Sling / Strap
- Reduce pain
  - Modalities / TENS
  - Analgesic, NSAIDs
- Reduce spasticity
  - Botox, Anti-spasticity meds
  - Shoulder injections
- Contractures
  - Surgical release

Stroke Rehabilitation Workshop

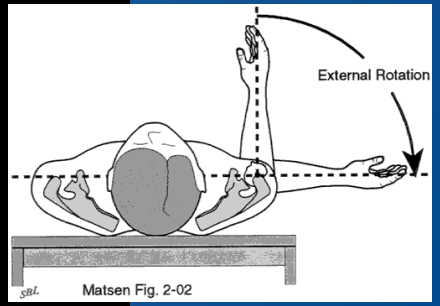
Post-Acute Approach to Neuro-Rehabilitation: Hemiparetic Shoulder

JOHNS HOPKINS MEDICINE

Hemiparetic Shoulder Management

- Contractures Prevention
  - Hemiplegic shoulder positioned in maximum external rotation for 30 minutes each day while in bed or sitting in a chair

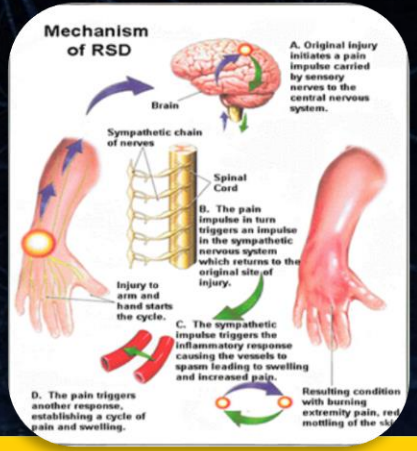
- Minimize subluxation
  - Arm trough in WC



Stroke Rehabilitation Workshop

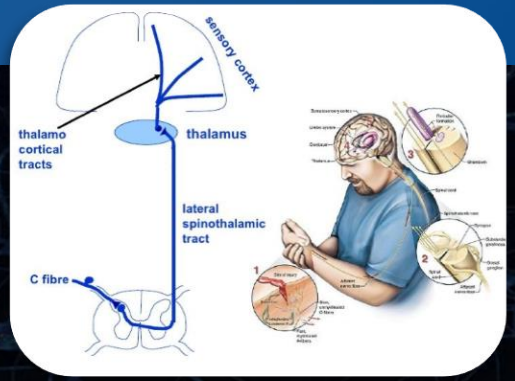
Post-Acute Approach to Neuro-Rehabilitation: Shoulder-Hand Syndrome

- **Shoulder-hand syndrome after stroke**
  - Affecting up to 27% of patients post stroke
    - Sudomotor changes in the paretic arm
  - A complex regional pain syndrome
    - An exaggerated response to a traumatic lesion, nerve damage, or a central neurologic process
    - CRPS of upper limbs after stroke is frequently referred to as shoulder-hand syndrome (SHS)
  - Pathophysiology is elusive
    - Unclear if sympathetically mediated vs. CNS reorganization
    - C-fibers discharges causing increased medullary excitability
    - Trauma to shoulder joint capsules
  - Treatment
    - Steroid, antidepressants, anti-inflammatory drugs, vasodilators
    - GABA analogs, alpha- or beta-blockers
    - Opioid analgesics
    - Sympathetic block



Stroke Rehabilitation Workshop

Post-Acute Approach to Neuro-Rehabilitation: Central Pain



- **Post-Stroke Central Pain**
  - General
    - Affects 7% to 8% of patients
    - Days to months after a thalamic stroke (Dejerine-Roussy syndrome)
  - Diagnostic criteria
    - Post stroke pain
    - Rule out nociceptive or peripheral neuropathic etiologies
  - Symptoms
    - Burning, aching, allodynia
  - Difficult to treat
    - Typical approach: Pharmacotherapy + Therapeutic exercise + Psychosocial support
    - Best: Amitriptyline 75 mg at bedtime (Watch out for anticholinergic side effects)
    - Good: Lamotrigine
    - Maybe: Pregabalin, Gabapentin, Carbamazepine and Phenytoin

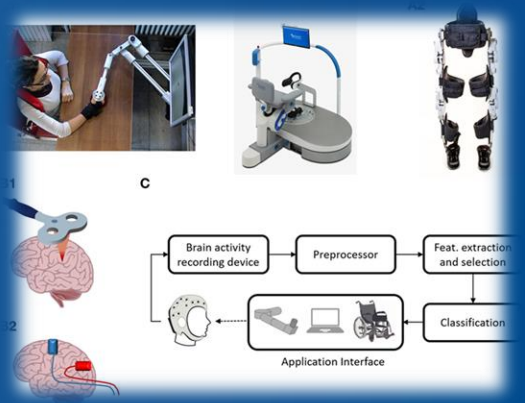
Stroke
Rehabilitation Efficacy

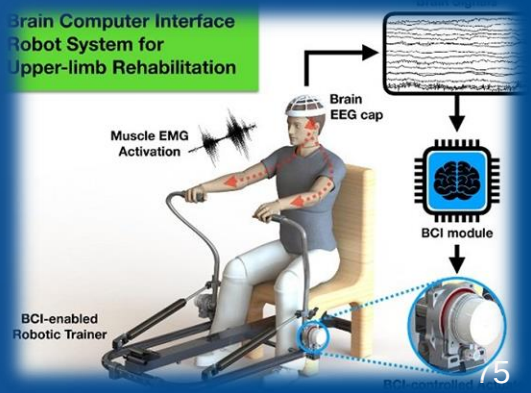
The patient has improved after rehab, and went back to her job part-time after 6 month…

- Where does she go from here after the completion of her stroke rehabilitation?
  - Functional outcomes 5-year post-stroke
    - Plateau +/- decline
  - Functional outcomes 10-year post-stroke
    - Significant decline due to
      - Age
      - Health
      - Comorbidities

Motor Recovery After Stroke

Post-Acute Approach to Neuro-Rehabilitation: Robotics





Robotic Technologies: Robotic Gait Training

Motor Recovery After Stroke

Post-Acute Approach to Neuro-Rehabilitation

Thank You!

Motor Recovery After Stroke

Post-Acute Approach to Neuro-Rehabilitation

- Chae, JohnCelnik, Pablo A. et al. Stroke Rehabilitation. Physical Medicine and Rehabilitation Clinics , Volume 26 , Issue 4 , xv – xvi
- Zeiler, S. R., Gibson, E. M., Hoesch, R. E., Li, M. Y., Worley, P. F., O'Brien, R. J., Krakauer, J. W. Medial Premotor Cortex Shows A Reduction In Inhibitory Markers And Mediates Recovery In A Mouse Model Of Focal Stroke. Stroke. 2013 Feb;44(2):483-9.
- Duncan PW, Goldstein LB, Matchar D, Divine GW, Feussner J. Measurement of motor recovery after stroke. Outcome assessment and sample size requirements. Stroke 1992;23(8):1084–1089)
- Prabhakaran S, Zarahn E, Riley C, et al. Inter-individual variability in the capacity for motor recovery after ischemic stroke. Neurorehabil Neural Repair 2008;22(1):64–71
- Stinear, Cathy & Ackerley, Suzanne & Byblow, Winston & Barber, Peter. (2014). PREP algorithm for stroke recovery.10.13140/2.1.4812.9607