PAIN CONDITIONS OF THE UPPER EXTREMITY: ADVANCEMENTS IN THE NEUROSCIENCE OF PAIN AND CLINICAL APPLICATION

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PAIN

PAIN IS NOT A SIMPLE PROCESS AND IT IS NOT A DIRECT RESPONSE TO INJURY OR PATHOLOGY.

RESEARCH

WHICH STATEMENT ARE CORRECT ABOUT PAIN?

- PAIN IS AN OUTPUT OF THE PAIN
- THE BRAIN DETERMINES IF THERE IS DANGER
- PAIN IS NOT SIMPLE IT IS COMPLEX AND MULTIFACTORIAL
- TO TREAT PAIN EFFECTIVELY ONE MUST UNDERSTAND PAIN MECHANISMS

PERIPHERAL AND CENTRAL NERVOUS SYSTEM
CORTICAL REORGANIZATION

- IMMOBILIZATION
- INFLAMMATORY
- NERVE INJURY
- PERSISTENT PAIN

EVIDENCE BASED SIGNS AND SYMPTOMS

NOCICEPTIVE PAIN
- Pain localized to the area of injury or dysfunction
- Clear, proportionate mechanical/anatomical nature to aggravating and easing factors
- Usually intermittent and sharp with movement or mechanical provocation
- Dull ache or throb at rest

PERSISTENT PAIN AND INFLAMMATION

ACUTE INFLAMMATION
- Increase sensory input
- Inflammatory cells deplete protein of healing
- End stimulus: Healing

CHRONIC INFLAMMATION
- Increase sensory input
- Immune hyper-reactive to stimuli
- Hyperesthesia increases sensory input
- Immunological and changes to cells
- Repetitive cycle: Increased toxicity

nociception : The simplest path

- Everyday experience that occurs in discomfort in response to simple insult or injury
- Protective state that warns us to move away from the cause and take care of the trauma
- Afferent nerve transfer sensory input from PNS to CNS
- When Information transferred to parts of the brain responsible for perception the actual sensory experience occurs

PATHOPHYSIOLOGY OF PAIN MECHANISMS

- Nociception
- Peripheral Neuropathic
- Neurogenic
- Central Sensitization

PERIPHERAL AND NEUROGENIC

- Pain referred in a dermatome or cutaneous distribution
- History of nerve injury, pathology or mechanical comprise
- Pain/symptoms provocation with mechanical/movement test - Neurodynamic testing, Phailens, Scratch and Collapse etc.
PAIN SYSTEM - DYSFUNCTIONAL

- Too sensitive causing pain that provides no benefit
- Adaptive response occurs after injury
- Pain pathway increase in sensitivity
- After body has healed no value so manifestation of pathological changes in nervous system
- Cortical Reorganization

ABNORMAL PAIN STATE

- Allodynia: Pain response to non-noxious stimuli
- Hyperalgesia: Exaggerated or spontaneous response to noxious stimuli

CENTRAL SENSITIZATION

NERVOUS SYSTEM AND MECHANISM OF PAIN SENSATION

WHAT HAPPENS IN CENTRAL SENSITIZATION

- Exhibit lower pain threshold due to altered Central Processing
- Produces pain hypersensitivity by changing the sensory response elicited by normal input
- Net effect of Central Sensitization - recruiting sub-threshold synaptic inputs to NOCICEPTIVE NEURON GENERATORS
- Pain memories which fire erratically so maladaptive pain

PAIN DRIVER HAS MOVED INTO THE CENTRAL NERVOUS SYSTEM

CENTRAL SENSITIZATION
PERSISTENT PAIN
SYMPTOMS SPREAD
ABNORMAL SYMPTOMS
ABNORMAL MOVEMENT

HOMONCULUS
SMUDGING

Brain areas normally devoted to specific body parts or functions start to overlap. In the motor cortex this may make it more difficult to isolate and move that body part, in the sensory cortex too sensitive to move, perhaps as protective strategies.

DARK SIDE OF PLASTICITY-MALADAPTIVE NEUROPLASTICITY

- Changes in CNS function compared to non-injured
- Longer you have pain the better your system gets at producing it.
- Pain is triggered more easily
- Painful events such as hyperalgesia become more painful
- Actual increase sensitivity with decreased precision
- Abnormal intracortical inhibitory mechanisms

REBIRTH-IMAGING (FMRI)

> What is FMRI?
  Functional MRI is based on the increase in blood flow to the area that is being activated which accompanies neural activity in the brain. (Functional Brain Imaging)

Magnetic resonance imaging can be used to map changes in brain hemodynamics that correspond to mental operations of neural activity as detected by a blood oxygen level dependent signal.

CENTRAL SENSITIZATION FOLLOWING NERVE INJURY

- Following peripheral inflammation and nerve injury there is a change in some dorsal root neurons causing non-nociceptors to induce central sensitization. ALLODYNIA
- This results in light touch inducing a progressive tactile pain hypersensitivity which can last for hours.
- Activated microglia in dorsal horn fire thus causing additional neuropathic pain
- All the above changes the somatosensory and motor cortex so cortical reorganisation

EVIDENCE BASED SIGNS AND SYMPTOMS

CENTRAL SENSITIZATION
Disproportionate non mechanical, unpredictable pattern of pain provocation in response to multiple nonspecific aggravating/easing factors

Pain disproportionate to the nature and extent of injury or pathology

MULTIPLE BRAIN CONNECTIONS
**BRAIN INVOLVEMENT**

- Amygdala- fear, addiction and fear conditioning
- Sensory cortex- sensory discrimination
- Thalamus and Hypothalamus-stress response, autonomic and motivation

**PAIN NEUROTAGS**

- Neurtag is network of interconnected neurons/brain cells that are distributed throughout brain.
- Neurtag is activated and produces output

  Example: smells of brownies cooking

**BRAIN INVOLVEMENT**

- Cerebellum-movement and cognition
- Hippocampus-memory, special cognition, fear conditioning
- Spinal Cord-gating from the periphery

**PAIN CONDITIONS**

- Leads to bio mechanical and central nervous system changes
- Decrease afferent input to somatosensory area due to injury
- Have mechanical instability and nervous system de-afferentation
- Treatment must include neuro-cognition, visual processing, and sensory motor function

Evidence from neuroscience, motor control, and psychology

**BRAIN INVOLVEMENT**

- Premotor/motor cortex -organize to prepare movement.
- Cingulate cortex -concentrating and focus
- Prefrontal cortex - problem solving and memory

**CENTRAL SENSITIZATION**

- With Central Sensitization tissue injury leads to a constellation of changes in spinal excitibility. Which includes elevated spontaneous firing, increased response amplitude and duration decreased threshold, enhanced discharge to repeated stimuli and expanded receptive fields.
- Clinically the injury has healed but the PAIN persists

Woolf, CJ, 2011 Pain 152;92-915
NEUROPLASTICITY
"Retrain the Brain"
- Repetitions
- Challenging
- Facing
Rewiring occurs when new connections (synapses) are formed.

KEEP THE AMYGDALA UNDER CONTROL
- THREAT
- FEAR
- STRESS
- ANGER

BIO-PSYCHO-SOCIAL
Provide education that knowledge and movement are the greatest pain and stressor liberators. David Butler
Educate ➔ Educate ➔ Educate
BUTLER D, MOSELEY L, EXPLAIN PAIN

RECONCEPTUALIZE – MOSELEY, L
- PAIN RESULTS FROM A BRAIN OUTPUT
- BRAIN DECIDES IF THIS IS A THREAT
- MULTIPLE FACTORS GENERATE PAIN AND CAN BE MANIPULATED TO CHANGE AND MODULATE.
- PAIN IS NOT JUST A NOCICEPTIVE SENSATION

SCIENCE OF PAIN
- TEACHING PATIENTS THAT PAIN DOESN'T MEAN HARM, YOU SHOULD MOVE DESPITE PAIN, AND THAT PAIN IS UNAVOIDABLE, BUT SUFFERING IS AN OPTIONAL
- SHIFT ONES CONCEPTUALIZATION OF PAIN FROM FOCUSING ON TISSUE DAMAGE TO PERCEIVED NEED TO PROTECT TISSUE.

EVIDENCE FOR MODULATING PAIN : PAIN 2016
MECHANISMS BY WHICH PAIN RECONCEPTUALIZATION RESULTS IN LESS PAIN AND BETTER FUNCTION ARE UNKNOWN.
VALUE OF A NOXIOUS INPUT BY CHANGING THE MEANING: NEUROSCIENCE EDUCATION REDUCE CATASTROPHIZING
THE CLINICAL APPROACH FOCUSES ON:

- Decreasing all inputs that imply that body tissue is in danger
- Then on activating components of the pain neuromatrix without activating its output
- Rehabilitation progresses to increase exposure to threatening input across sensory and non-sensory domains


Using Mirror Therapy to Improve Sensorimotor Recovery After Stroke: Current Evidence & Clinical Considerations

- Analysis of 14 Studies: 12 RCTs & 2 cross-over designs; total of 567 participants
- Mean age range: 51-79 years
- 55% left hemiparesis
- c 57% female
- d) Mean time post-stroke range: 5 days – 5 years
- e) Stage of Recovery: Acute/sub-acute (4 studies)
- Chronic (8 studies)

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TREATMENT

- Mirror therapy and Graded Motor Imagery for non fearful intervention by using vision of uninvolved part

GRADED MOTOR IMAGERY

- GMI is a rehabilitation brain based treatment used to treat pain and movement dysfunction.
- The dysfunction is related to an altered nervous system.
- By exercising the brain in measured/graded and monitored steps as well as progressing to functional activities helps reorganize cortical networks.

MIRROR THERAPY

- One method that has been used to activate cortical network representations
- Theory:
  - Reconciles motor output and sensory feedback (Ramachandran 1995)
  - Activates pre-motor cortices which is associated with activation of the visual processing areas. (Seitz 1998)

GRADED MOTOR IMAGERY PROGRAM (GMIP)

- Top Down Training
  - Laterality stimulates premotor areas
  - Visual Imagery used for relearning cognitive and planning aspect of movement
  - Mirror and motor imagery used to re-educate or retrain the brain for basic motor skills by concentrating on the non-painful movement
  - Smooth and controlled movements must act as example for brain to re-establish circuits that mediates voluntary movement
GMI-MONITORED STEPS

- LATERALITY OR RIGHT /LEFT IDENTIFICATION
- IMAGERY
- MIRROR THERAPY

RIGHT/LEFT IDENTIFICATION LATERALITY

- HANDS AND FEET; R OR L
- SHOULDERS AND ARMS, WHICH WAY ARE THEY TURNING
- KNEES; R OR L

MIRROR THERAPY

Visual Illusions
Tricks the Brain

RESEARCH

- Mistaken P, McDevitt A, Puentesdura R, Louw A.

RESEARCH

- The effects of graded motor imagery and its components on phantom limb pain and disability in upper and lower limb amputees: a systematic review protocol. 2016 Limakatsos et al
- Effects and changes of FMRIs of motor imagery on acute cerebral infarction in upper extremity paresis. 2013
- Receptive barrage or deafferentation alters the cortical reorganization of S1 and S2. Acerra 2007,1192008

Mental Imagery
Capacity to imagine objects or events that are not there

Motor Imagery
Covet Cognitive
Process of imagining a movement of your own body without actually moving your body

Movement Observation
Perception of action of others
RETRAIN THE BRAIN -

- Educate and reconceptualize
- Bio/psychosocial approach - knowledge, understanding, and skills
- Calm down the nervous system - manage it
- Evaluate patients' behavioral activities
- Develop relationship of trust
- Remind patients they can move and pain isn't harm
- Remove the threat fear by progressing from non-threatening to threatening

OUR ROLE GOOD NEUROPLASTICITY