PAIN NEUROSCIENCE & ITS CLINICAL IMPLICATIONS

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Conflicts of Interest:
Paid for speaking
Practice in Montana
PAIN - THE SIZE OF THE PROBLEM

- More $ than diabetes, heart disease and cancer ... Combined!
- Emotional and time demands on providers
- Losses to individuals – purpose, relationships
- Most burdensome non-fatal condition facing our species
HOW DOES PAIN WORK?
True or False?

1. It is possible to have pain and not know about it.
2. When part of your body is injured, special pain receptors convey the pain message to your brain.
3. Pain only occurs when you are injured or at risk of being injured.
4. When you are injured, special receptors convey the danger message to your spinal cord.
5. Special nerves in your spinal cord convey ‘danger’ messages to your brain.
6. Nerves can adapt by increasing their resting level of excitement.
7. Chronic pain means that an injury hasn’t healed properly.
8. Worse injuries always result in worse pain.
9. Descending neurons are always inhibitory.
10. Pain occurs whenever you are injured.
11. When you injure yourself, the environment that you are in will not affect the amount of pain you experience, as long as the injury is exactly the same.
12. The brain decides when you will experience pain.
HOW DOES PAIN WORK?

- Is it all about input?
OBJECTIVES

• Modern understanding of Pain Science:

  • All pain is real
  • All pain is output of the brain
  • All pain is about protection

• Rational hope for helping patients in pain

• Tools to take with you:
  Videos – as models and resources
  Skills developed through role play
PAIN IS ALWAYS REAL

No matter what is causing it

Associated Press, Wide World Photos. 1/16/05

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2908292/
PAIN IS **NOT** NOCICEPTION

- Nociception does **NOT** hurt
- Can have pain **WITHOUT** nociception
- Can have nociception **WITHOUT** pain
PAIN WITHOUT NOCICEPTION

- Phantom limb pain
- Couvade syndrome: Father experiences labor pain
- Sham stimulator

=> nociception is not necessary for pain
NOCICEPTION WITHOUT PAIN

- Battlefield trauma
- Medical hypnosis for general surgery
- Shark bite
- Mom lifting car off child

=> nociception is not sufficient for pain
That’s gotta hurt! Right?

Case Study from JOSPT

- 32 year old female
- Grade 4 spondylolisthesis
- Minimal to no pain
- Had a healthy pregnancy

PAIN RELIES ON CONTEXT AND CUES
**Always the same stimulus**

- Red light
- Blue light

Pain

Moseley & Arntz 2007 PAIN
Our Brain Hallucinates Our Reality
– Anil Seth, PhD
• Visual illusion of stretching finger/knee improves stiffness and pain in OA

• Recounting being bullied increases pro-inflammatory cytokine released by submerging arm in ice bath

• Rubber hand illusion – autonomic and innate immune changes in real arm!
PAIN IS ALL ABOUT CONTEXT
(neurologically speaking)

Language of Neuroscience is a bridge

Progressive Physical Therapy community is leading this change over the last 15 years.
“NEUROTAG”
(i.e neural network)

“Grandma” is widely distributed in your brain
The brain as a mass of neurotags
ALL BRAIN CELLS ARE
“MULTI-TASKERS”
The brain as a mass of neurotags
EXERCISE:

Try explaining what you’ve learned to your neighbor

- as though (s)he is your patient -
Key points so far: PAIN IS

- Real, always
- Not an input from the body
- A protective output of the brain (widely distributed)
- Context-dependent
NEUROIMMUNE SCIENCE OF PAIN
(Or, what about the input?)

- Neuro: Whole range of detectors via - C, Aδ, and Aβ
  - Primary nociception & “optimal stimulus”
- Immune: How inflammation changes nociception
- Nociceptors go both ways!
- NeuroImmune Coupling
- Dorsal Horn
- Central Sensitization
FREE NERVE ENDINGS
(NOXIOUS MECH, CHEM, TEMP)

- Optimal stimuli - Noxious: byproducts of damaged tissue or something that could damage tissue

- Protection - don’t need receptors:
  - High intensity mechanical (nose hairs)
  - Decreased pH (acid in your butt cheeks right about now),
  - Marked change in temperature

- Not just Aδ and C(aress) - also Aβ (and all this changes)

- Don’t localize very well (referred pain)
NOCICEPTORS GO BOTH WAYS!

Axonal Reflex
(Back out all the other branches)

&

Antidromic Activation
(Starting in DRG)
TRIPARTITE SYNAPSE

- ½ the brain is immune cells
- The immune cells “eavesdrop” on every interaction between nerves
DORSAL HORN

Figure 3: Activation of glia and neurons in the dorsal horn of the spinal cord after peripheral injury. (a) Microglia-neuron interactions. Upon activation, afferent nerve terminals release neurotransmitters, substance P, CGRP, glutamate (Glu), ATP and BDNF, as well as inflammatory mediators including IL-6 and CCL2 and the growth and differentiation factor neuregulin-1 (NRG-1), into the spinal cord. Three examples are shown. (1) Neuronal NRG-1 acts on microglial erbB2, leading to IL-1β release. (2) Microglial cathepsin S (catS) cleaves neuronal CX3CL1, which binds CX3CR1 and stimulates phosphorylation of p38 MAPK in microglia. This pathway may be inhibited by protein-coupled receptor kinase 2 (GRK2). (3) ATP binds P2X4 and induces BDNF release from microglia, which upon binding Trkβ receptor induces a shift in the chloride anion gradient and GABA_A receptor-mediated depolarization in dorsal horn neurons. (b) Astrocyte-neuron interactions. (1) Astrocytes release glutamate and D-serine, which bind extrasynaptic and synaptic NMDA receptors on neurons, respectively. (2) Injury-induced downregulation of astrocytic GLT-1 alters glutamate homeostasis in the synaptic cleft. (3) TNF-α activates the JNK1 pathway, which leads to release of CCL2 and alterations in NMDAR and AMPAR activity. (c) Cross-talk between nerve terminals, astrocytes and glia. (1) TLR priming and purinergic signaling increase IL-1β release by glia, which modulates NMDA receptor activity on postsynaptic neurons. TIMPs in astrocytes inhibit MMP-mediated cleavage of pro-IL-1β. (2) Microglial IL-1β binds IL1βR on astrocytes and induces NF-κB activity and upregulation of inflammatory cytokines. Dashed lines represent multiple intermediate signaling events.
TLR4 & THE IMMUNE SET POINT

- Toll-Like Receptors: ‘remember’ what a dangerous event ‘looks like’ (and they’re over-reactive)
- Pathogen-associated Molecular Proteins (PAMPs) – bacteria, viruses, etc.
- DAMPs (Damage) - cytokines, heat shock proteins, STP, uric and lactic acid
- XAMPs (Xenobiotic) - drugs: exogenous morphine
- BAMPs (Behavior) – Somatic Marker Hypothesis (neural model for economic decision)
- CAMPs? (Cognition)
NEUROIMMUNE COUPLING

COULD INCLUDE
- cytokine storm
- auto-immune disorders
- autoantibody generation
- death by inflammation

Inflammatory overshoot

Increased immune set point

COULD INCLUDE
- Inflammatory responses
  - pro-inflammatory cytokine upregulation
  - anti-inflammatory cytokine downregulation
  - upregulation of spinal neurotugs
  - tissue repair/remodelling
  - enhanced surveillance
  - antibody generation
  - mood change

Normal immune set point

Decreased immune set point

MAGNITUDE OF INFLAMMATORY RESPONSE

CAMP
(eg. bullied at work)

BAMP
(eg. encountering a 2nd angry dog)

PAMP
(eg. virus)

DAMP + CAMP + BAMP
(eg. major car accident)

DAMP
(eg. major MSK injury)

DAMP** + CAMP + BAMP
(eg. major head injury)

MINOR DIM

MAJOR DIM / MULTIPLE DIMs

MAGNITUDE OF THREAT
CENTRAL SENSITIZATION (2.0)

- “a mass of neurotags collaborating and competing for influence” ... think probability gradient
CENTRAL SENSITIZATION (2.0)

- “a mass of neurotags collaborating and competing for influence” ... think probability gradient
- Increased responsiveness of protective neurotags
- Smudging neurotags and lips - Herta Flor
- Tx: Graded Motor Imagery
“PLACEBO"?

- Latin for “I shall please”
- “a kind of loose family of different phenomena that are just yoked together by this term,”
  - Franklin Miller, retired NIH bioethicist

Expectations and Learning

Pain relief is stronger and more immediate when morphine is injected out in the open. Colloca, L. The Lancet Neurology
SACRED HEALING

- In search of a cure, a man makes a journey to a healing place, where he’ll undergo a fasting rite, don ceremonial garb, ingest mind-altering substances and be anointed with liquids before a masked healer takes him through a physical ritual intended to vanquish his pain.

  Aschwanden, Christie  
  Surgery is One Hell of a Placebo  
  19 July 2017

Knee arthroscopy for DJD “Taken together, these findings do not support the practise of arthroscopic surgery for middle aged or older patients with knee pain with or without signs of osteoarthritis.” (2015)
Use of placebo controls in the evaluation of surgery: systematic review

74% of trials had improvement in the placebo arm

In 51%, effect of placebo did not differ from that of surgery.

Serious adverse events were reported in the placebo arm in 18 trials (34%) and in the surgical arm in 22 trials (41.5%)

Wartolowska K. et al. BMJ 2014; 348
Sham surgery for pain: Mean improvement in sham groups relative to active treatment was 78% in pain-related conditions!

Vase I. et al, Specifying the non-specific components of acupuncture analgesia, Pain 2013 Sep; 154(9)
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3981538/
PHARMACOLOGICAL CONDITIONING: ‘A NEUROBIOLOGICAL PHENOMENON’

Colloca, L. will switch drug with placebo and see continued response - in pain drugs, Parkinson drugs, psychiatric meds, etc.!


- OLP enhanced pain reduction by 1.49 points on a 0 to 10 scale compared to a 0.24 point change with continued standard treatment without the added placebo.

- OLP produced approximately 30% additional pain reduction of baseline pain and disability ratings.

- [https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5113234/figure/F2/](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5113234/figure/F2/)
NOCEBO EFFECTS


- Italian ‘lactose’: 44% and 26% had GI sx

- Acupuncture is least effective if performed by a non-Chinese woman on a Chinese man outside China.

- Round pills < square tablets with missing corners < colored tablets < white beads < transparent capsules with colored beads

- This Video Will Hurt
The essential feature of language that heals is empathic communication, eloquently described as language that aides the process of healing by bolstering patient's strengths, validating their perspective, and teaching them how to grow to be more self-reliant.

**Words That Harm, Words That Heal**

Susanna E. Bedell, MD; Thomas B. Graboys, MD; Elizabeth Bedell; et al


doi:10.1001/archinte.164.13.1365
RECOVERY FROM PAIN IS ABOUT LANGUAGE

- Radiologists aren’t talking to patients
- Please don’t let your nurse (or EMR) read MRI reports to patients
- You are talking to patients’ limbic system
WORDS THAT HARM

- Degenerative
- Arthritis
- Stenosis
- Annual tear
- Disc protrusion
- Facet arthropathy
- Bone spur
- “Out of place”
## Consider translating for the patient

<table>
<thead>
<tr>
<th>Words that harm</th>
<th>Words that heal</th>
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<tbody>
<tr>
<td>Degenerative</td>
<td>Candles on your cake</td>
</tr>
<tr>
<td>Arthritis</td>
<td>Wear and tear change</td>
</tr>
<tr>
<td>Stenosis</td>
<td>Less breathing room</td>
</tr>
<tr>
<td>Annual tear</td>
<td>Normal wear</td>
</tr>
<tr>
<td>Disc protrusion</td>
<td>Gravity wins</td>
</tr>
<tr>
<td>Facet arthropathy</td>
<td>“Knuckle joints”</td>
</tr>
<tr>
<td>Bone spur</td>
<td>Calcium inside a tendon</td>
</tr>
<tr>
<td>“Out of place”</td>
<td>Stuck</td>
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</table>
### Table 2: Age-specific prevalence estimates of degenerative spine imaging findings in asymptomatic patients

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The troublesome disconnect between back structure and back pain
Survival Above All

In the absence of information, we jump to the worst conclusions.

~ Myra Kassim
PAIN AND FEAR ARE TWO PROTECTIVE OUTPUTS OF THE THREAT DETECTION SYSTEM

• Fear of Damage
  • Your back is Shot
  • What a Train Wreck
  • Worst I’ve ever seen

• Fear of the Future
  • Lucky to Not be Paralyzed
  • You’ll end up In a wheelchair

• Fear Sells
  • You’ll end up Needing Surgery
Need to Compensate for patients’

- Negative Attention Bias
- Catastrophizing
- Fear-avoidance
- Low self-efficacy
- False beliefs about pain
When explained to patients in a way that doesn't stigmatize or alienate them, current evidence supports that it will reduce pain and improve function and lower disability, reduce psychosocial factors, enhance movement, and minimize healthcare utilization.
<table>
<thead>
<tr>
<th>Target Concept</th>
<th>Explanation</th>
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<tr>
<td>1. Pain is normal, personal and always real.</td>
<td>All pain experiences are normal and are an excellent, though unpleasant response to what your brain judges to be a threatening situation. All pain is real.</td>
</tr>
<tr>
<td>2. There are danger sensors, not pain sensors.</td>
<td>The danger alarm system is just that – there are no pain sensors, pain pathways or pain endings.</td>
</tr>
<tr>
<td>3. Pain and tissue damage rarely relate.</td>
<td>Pain is an unreliable indicator of the presence or extent of tissue damage – either can exist without the other.</td>
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<td>4. Pain depends on the balance of danger and safety.</td>
<td>You will have pain when your brain concludes that there is more credible evidence of danger than safety related to your body and thus infers the need to protect.</td>
</tr>
<tr>
<td>5. Pain involves distributed brain activity.</td>
<td>There is no single ‘pain centre’ in the brain. Pain is a conscious experience that necessarily involves many brain areas across time.</td>
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<td>6. Pain relies on context.</td>
<td>Pain can be influenced by the things you see, hear, smell, taste and touch, things you say, things you think and believe, things you do, places you go, people in your life and things happening in your body.</td>
</tr>
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<td>7. Pain is one of many protective outputs.</td>
<td>When threatened the body is capable of activating multiple protective systems including immune, endocrine, motor, autonomic, respiratory, cognitive, emotional and pain. Any or all of these systems can become overprotective.</td>
</tr>
<tr>
<td>8. We are bioplastic.</td>
<td>While all protective systems can become turned up and edgy, the notion of bioplasticity suggests that they can change back, through the lifespan. It is biologically implausible to suggest that pain can’t change.</td>
</tr>
<tr>
<td>9. Learning about pain can help the individual and society.</td>
<td>Learning about pain is therapy. When you understand why you hurt, you hurt less. If you have a pain problem, you are not alone – millions of others do too. But there are many researchers and clinicians working to find ways to help.</td>
</tr>
<tr>
<td>10. Active treatment strategies promote recovery.</td>
<td>Once you understand pain, you can begin to make plans, explore different ways to move, improve your fitness, eat better, sleep better, demolish DIMs, find SIMs and gradually do more.</td>
</tr>
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EDUCATION AS TREATMENT

- Fifteen Years of Explaining Pain: The Past, Present, and Future

- The efficacy of pain neuroscience education on musculoskeletal pain: A systematic review of the literature.

- The Effect of Neuroscience Education on Pain, Disability, Anxiety, and Stress in Chronic Musculoskeletal Pain
THE ‘TWIN PEAKS’ MODEL

Explain Pain, 2003
Low cost intervention yields remarkable savings, even in post-surgical utilization.

Preoperative pain neuroscience education for lumbar radiculopathy:

Multicenter randomized controlled trial with 1-year follow-up showed 45% less healthcare expenditure compared with the control group in the 1-year follow-up period.

and 37% less in years 2 and 3

Estimated medical expenses in U.S. dollars (means and standard deviations) related to the lumbar surgery after 1 and 3 years.
Pain is a protective feeling, produced by the brain when credible evidence of danger to the body is greater than credible evidence of safety.

All pain is real, but it's not a very reliable indicator of what is happening in the tissues of the body.

Instead, it is a reliable indicator that our brain is trying to protect us.
Table 2: Age-specific prevalence estimates of degenerative spine imaging findings in asymptomatic patients

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The troublesome disconnect between back structure and back pain.
Results of this systematic review are encouraging: simple education interventions may have a positive impact on concerns or worries about low back pain.

The effects contrast favorably with reviews on the effects of MRIs for low back pain, which … may cause harmful effects:

- identification of common but nonspecific degenerative findings.
- negative labeling effects
- contribute to fear avoidance and maladaptive coping strategies
- associated with negative downstream effects such as additional testing and unnecessary (and potentially harmful) treatments, without improving clinical outcomes.

Chou, R. *Reassuring Patients About Low Back Pain*.
Skill Development:

Break into groups of 2-3 and role play a dialogue. Patient asks about the diagnosis of their low back pain (MRI findings?) and proposed treatment.

Physician: Answer the question with new language.

Patient/Observer: Offer feedback on word choice, metaphor, etc.

(“Nuggets” from Explain Pain Supercharged)
There is moderate- to high-quality evidence that patient education increases reassurance more than usual care/control education in the short term and long term. Interventions delivered by physicians were significantly more reassuring than those delivered by other primary care practitioners (eg, physiotherapist or nurse). There is moderate-quality evidence that patient education reduces LBP-related primary care visits more than usual care/control education. The number needed to treat to prevent 1 LBP-related visit to primary care was 17.

OPIOIDS FOR CHRONIC PAIN?

“The titrate-to-effect principle has value when treating acute and end-of-life pain where pain is predictable, short lived, and responds well to opioids. But applying this principle to chronic pain has led to unrealistic and potentially damaging expectations for patients, and therapeutic disappointment for clinicians. It is time to abandon the idea that every high pain score needs to be reduced, and that clinicians are failing in their duty or practicing unethically if they don’t respond to every high pain score with an opioid.”  

Ballantyne 2015
Recommendation 1: Given that most patients with acute or subacute low back pain improve over time regardless of treatment, clinicians and patients should select nonpharmacologic treatment with superficial heat (moderate-quality evidence), massage, acupuncture, or spinal manipulation (low-quality evidence). If pharmacologic treatment is desired, clinicians and patients should select nonsteroidal anti-inflammatory drugs or skeletal muscle relaxants (moderate-quality evidence). (Grade: strong recommendation)

Recommendation 2: For patients with chronic low back pain, clinicians and patients should initially select nonpharmacologic treatment with exercise, multidisciplinary rehabilitation, acupuncture, mindfulness-based stress reduction (moderate-quality evidence), tai chi, yoga, motor control exercise, progressive relaxation, electromyography biofeedback, low-level laser therapy, operant therapy, cognitive behavioral therapy, or spinal manipulation (low-quality evidence). (Grade: strong recommendation)

Recommendation 3: In patients with chronic low back pain who have had an inadequate response to nonpharmacologic therapy, clinicians and patients should consider pharmacologic treatment with nonsteroidal anti-inflammatory drugs as first-line therapy, or tramadol or duloxetine as second-line therapy. Clinicians should only consider opioids as an option in patients who have failed the aforementioned treatments and only if the potential benefits outweigh the risks for individual patients and after a discussion of known risks and realistic benefits with patients. (Grade: weak recommendation, moderate-quality evidence)
YOGA FOR CHRONIC LOW BACK PAIN


- Yoga and PT showed almost the same amount of improvement in pain, activity limitation, satisfaction and quality of life over time, even after 1 year.

- Education was better than Yoga in terms of improvement in pain and activity limitation at 3 months.

- Participants in both the yoga and physical therapy groups were less likely to use pain medications at 3 months compared with the education group.

- Participant Guidebook for Patients

1. It is possible to have pain and not know about it.
2. When part of your body is injured, special pain receptors convey the pain message to your brain.
3. Pain only occurs when you are injured or at risk of being injured.
4. When you are injured, special receptors convey the danger message to your spinal cord.
5. Special nerves in your spinal cord convey ‘danger’ messages to your brain.
6. Nerves can adapt by increasing their resting level of excitement.
7. Chronic pain means that an injury hasn’t healed properly.
8. Worse injuries always result in worse pain.
9. Descending neurons are always inhibitory.
10. Pain occurs whenever you are injured.
11. When you injure yourself, the environment that you are in will not affect the amount of pain you experience, as long as the injury is exactly the same.
12. The brain decides when you will experience pain.
Groups of 2-3:

- How do I know if my pain system is being over-protective?
  - How can I train my pain system to be less protective?
    - How do I know if I am safe to move?
      - Will I re-injure myself?
        - Will I get better?
  - What can I do to help myself recover more quickly?
    - Where can I learn how to best recover?
RESOURCES

Websites
- www.bodyinmind.org
- www.noijam.com
- www.TameTheBeast.org
- TED talks
  - Lorimer Moseley – Why Things Hurt
  - Anil Seth – Our Brains Hallucinate

Podcasts
- abc.net.au/radionational/programs/healthreport/the-brains-role-in-pain/7735610

Blog posts
- https://noijam.com/2015/03/12/dim-sims/

Books
- Explain Pain (2nd edition), and Explain Pain Supercharged - Butler and Moseley
- The Explain Pain Handbook, The Protectometer, by David Butler and Lorimer Moseley
- Painful Yarns, by Lorimer Moseley

Facebook Group
- Explaining Pain Science
ONLINE BEST PRACTICE

- Understanding Pain
- DocMikeEvans (introduction)
- Low Back Pain
OPIOID RESOURCES

- Opioid Taper Support
- Opioid Taper CME
- Brainman stops his opioids
- Opioids
OBJECTIVES

- Modern understanding of Pain science
- Rational hope for helping folks in pain
- Tools to take with you:
  - Videos – as models and resources
  - Skills developed through role play