1. Central Sensitization and Quantitative Sensory Testing - A Brief History
2. Bedside Method for Quantitative Sensory Testing

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Definition

1. The International Association for the Study of Pain defines central sensitization (CS) by its neurophysiological history. It is, “*Increased responsiveness of nociceptive neurons in the central nervous system to their normal or sub-threshold afferent input.*”

2. CS can present in patients with neuropathic pain and non-neuropathic pain. It mimics symptoms of neuropathic pain causing clinical confusion.

3. IASP goes on to state that:

4. “*Sensitization can include a drop in threshold and an increase in suprathreshold response*”

5. For example, pressure hyperalgesia measured with an algometer in a patient with a painful left sacroiliac joint with overlying central sensitization:
   a. In the normal right buttock she reports pain when the algometer is pushed to 7 k/cm²
   b. In the left buttock, with a reduced threshold, she reports the same pain at 3 k/cm² pressure

6. Suprathreshold response to pinprick, for example, can be measured by using a Neuropen. The Neuropen is necessary to ensure that a standard stimulus is delivered but weighted von Frey hairs could also be used.
   a. In the normal right buttock the patient reports a pain score from a single painful Neuropen stimulus at 2/10 (where 0 is equivalent to no pain and 10 is equivalent to the worst pain imaginable)
   b. In the painful left buttock, she rates the same painful stimulus at 5/10

7. “*Sensitization can cause spontaneous discharges and increases in receptive field size may also occur.*”

8. Spontaneous discharges are felt as spontaneous pain, unrelated to mechanical type stimuli. Increases in receptive field size present as a painful area that is either outside of usual or known referral patterns, such as pain from mid-thigh to mid calf in a patient with OA of the knee (where only peri-articular pain would be expected), or is present at a site distal to the primary site of nociception such as pressure allodynia in the wrist during migraine.

9. “*Clinically, sensitization may only be inferred indirectly from phenomena such as hyperalgesia or allodynia.*”

10. This diagnosis requires the examiner to know both the physiological input and output of the neural system. This is not possible for bedside QST. The nociceptive withdrawal test or nociceptive flexion reflex does allow for measurement of input and output. Stimulation of the sural nerve at the ankle is performed along with recording of the electromyogram at the biceps femoris muscle to detect a withdrawal reflex. This is not widely available and the clinical utility of this test is not yet known.

11. “*This may include increased responsiveness due to dysfunction of endogenous pain control systems. Peripheral neurons are functioning normally; changes in function occur in central neurons only.*”

12. Dysfunctional endogenous or central pain modulation describes the descending, “pain turning off” system. It’s a process whereby ascending projections from one noxious stimulus activates supraspinal structures and trigger descending inhibitory projections to the dorsal horn, which are opioidergic, serotonergic, and noradrenergic in nature. Spontaneous pain after spinal cord injury is described as an example of central sensitization due to abnormal pain modulation. Albu S. Pain 156 (2015) 260–272.
13. The perceptual manifestation of this is believed to be reflected by a testing protocol termed conditioned pain modulation (CPM).

14. CPM measures the reduction in pain from one stimulus (the test stimulus) produced by concurrent application of a second pain stimulus at a remote body site (the conditioning stimulus). Protocols are evolving but generally common nociceptive stimuli include a 30 second tonic heat pain from a thermode or ischemic pain from a blood pressure cuff set to create a patient rated pain score of 6/10. Conditioning stimuli may be ischemic (from a blood pressure cuff) or cold pain with hand immersion in ice water.

15. Sensitization can also occur peripherally, for example, a painful neuroma. Without neurophysiological measurements it can be difficult to clinically differentiate peripheral from central sensitization. For this reason the term pain sensitization is sometimes used.

16. Usually there is an underlying pain generator (for instance a painful cervical facet joint) but sometimes it appears that the initial injury has healed and there is just the abnormal pain. It is not known if the pain is actually gone and the maladaptive software is an entity unto its own or if there is an underlying pain generator but the medical expert and currently available investigations are unable to find it.

Context

17. Peripheral or central sensitization or reduced/dysfunctional pain modulation presents with pain out of proportion to usual clinical findings. The differential diagnosis of this phenomena, assuming there has been an appropriate evaluation and investigations, includes neuralgia, purposeful self-inflicted harm, a somatization disorder, cognitive distortions or issues related to secondary gain. The possibility that there may be another pain generator that has not been identified due to lack of knowledge or appropriate investigations should be considered.

18. The QST examination can help to rule sensitization in or out and has important clinical implications.

19. Treatments that usually cause mild pain, like trigger point injections, massage therapy or even physiotherapy and exercise cause pain out of proportion to the treatment and most patients will stop this treatment.

20. When the diagnosis of sensitization is present but missed or unconfirmed by physicians, other individuals with significant impact on patients lives (insurance adjustors, judges, employers, spouses, other health care workers), conclude the patient has one of the listed differential diagnosis with significant life consequences for that individual. They may be denied disability benefits or in a medical legal context be accused of secondary gain. Psychiatrists often label these individuals with somatic symptom disorder because they appear to be (and in fairness to the psychiatrists, often become) excessively focused and obsessing over their pain.

21. Recent collaborations of sensory profiling networks in Europe are investigating pain related patterns of sensory symptoms and signs to create sensory profiles to see if they might indicate different classes of neurobiological mechanisms. Although neuropathic pain is usually researched based on etiology, etiology is not associated with a single mechanism, but sometimes several. Since medications are directed at mechanisms, profiling neuropathic pain by mechanism rather than etiology may lead to more specific and effective treatment. In the future then, an individuals QST profile would be used to chose the most appropriate medication(s) to trial.

22. A recent article identified three distinct subgroups of neuropathic pain with characteristic sensory profiles “Cluster 1 (sensory loss, 42%) showed a loss of small and large fiber function in combination with paradoxical heat sensations. Cluster 2 (thermal hyperalgesia, 33%) was characterized by preserved sensory functions in combination with heat and cold hyperalgesia and mild dynamic mechanical allodynia. Cluster 3 (mechanical hyperalgesia, 24%) was characterized by a loss of small fiber function in combination with pinprick hyperalgesia and dynamic mechanical allodynia. All clusters occurred across etiologies but frequencies differed.” Baron R, et al. Peripheral neuropathic pain: a mechanism-related organizing principle based on sensory profiles. Pain 2017.Feb;158(2): 261-272

23. **Symptoms:** Patients who experience abnormal central sensitization report symptoms that often mimic neuropathic pain. They may report spontaneous pain. They often describe the pain as burning and state that light touch or pressure is extremely painful and that the area of pain seems to be increasing or spreading.
24. Many state that although they can perform a specific activity but they will "pay for it" and by this they mean they will experience pain and disability out of proportion to what they did. This feels punishing to them and cannot be overcome by repeatedly performing the activity, in fact the opposite usually occurs. The activity generates abnormal pain messages that are excessive both in intensity and duration. Attempting to overcome this pain by "pushing through it" almost always results in even more punishing levels of pain. In an attempt to avoid this level of pain they may stop moving and develop a degree of deconditioning that only adds further pain and dysfunction.

25. There is an overlap between central sensitization and mood problems like anxiety and depression. In addition, multiple other problems commonly occur in individuals with central sensitization including problems with fatigue, short-term memory difficulties, and sleep disturbance.

26. **Signs:** Research has demonstrated that sensitization can be detected by performing a detailed physical examination of the neurological system (quantitative sensory testing), as there are specific findings that support the diagnosis. These findings are not widely known even by most physicians so it is unlikely that patients who intend to malinger would know of them. The physical examination of pain sensitization cannot prove this condition exists (currently this requires expensive research based testing) but we can infer the problem from the testing. This is no different than the strategies used for diagnosing mood disorders when only patient history is used to make the diagnosis. The diagnosis of headache also lacks specific diagnostic physical or laboratory tests but this does not make the diagnosis “theoretical” at least to a neurologist.

**QST Testing Protocols**

27. QST testing protocols have been established to detect sensory abnormalities related to neuropathic pain and sensitization.

28. Research based protocols were first established in Germany by the German Research Network on Neuropathic Pain (DFNS) group ([http://www.neuropathischer-schmerz.de](http://www.neuropathischer-schmerz.de)). The protocol utilized standardized tools and techniques to assess detection thresholds, negative (loss of function) and positive (gain of function) for all parameters. Temporal summation and painful after sensations were recorded.

29. A second testing protocol using bedside technique has been described. The standard clinical bedside QST examination was developed in 2006 and 2007 and published in 2009 by a group of clinical pain experts in the USA who loosely associated as the Neuropathic Pain Research Consortium (NPRC).

30. The experts included:
   a. Dr. Mark Wallace (anesthesiology, chair pain medicine U of C Davis)
   b. Dr. Misha Backonja (neurology, pain medicine U of Washington)
   c. Dr. Ajay Wasan (psychiatry, pain medicine Brigham and Womens Hosp)
   d. Dr Charles Argoff (neurology, pain medicine U of Albany)
   e. Dr Gordon Irving (anesthesiology, pain medicine Swedish Medical Group Seattle)
   f. Dr. David Walk (neurology Univ of Minnesota)

**Publications:**

31. 2009 Backonja, J et al “Quantitative Sensory Testing In Measurement Of Neuropathic Pain Phenomena And Other Sensory Abnormalities. Clin J Pain 2009;25:641–647. This article sought to establish that there is a specific set of valid examination techniques that can quantify loss of sensation and sensory gain using standardized bedside examination techniques and tools for clinical evaluation and research.

32. 2009 Walk D et al, “QST and Mapping of Patients with Neuropathic Pain “Clin J Pain 2009;25:632–640. The article described a protocol that uses tools readily available in clinical practice, that, when established and validated, could be used widely and thus accelerate data collection for clinical research and increase clinical awareness of the features of neuropathic pain. This protocol is the one described in this submission.

**Construct Validity of QST**

33. There are many articles that discuss the relationship between QST and different pain mechanisms.
34. In 2011, Curatolo wrote, “QST can be used in clinical practice to assess the presence of sensory abnormalities in individual patients. Because information on the reliability and validity of the tests is incomplete, the findings should be interpreted with caution. It is still unclear to what extent disturbances in central pain processing are relevant for the determination of symptoms in individual patients. Furthermore, the therapeutic consequences of these assessments remain undetermined. These are challenges of future translational research.” SPINE Volume 36, Number 25S, pp S200–S204

35. In 2015, Curatolo and Lars Arendt-Nielsen reviewed the evidence again and stated, “There is established evidence that many pain states are associated with enhanced sensitivity of central nociceptive pathways, potentially leading to pain amplification and increased disability in human chronic pain. Central hypersensitivity can be evaluated in patients by QST. Evidence of the clinical applicability of these tests has improved with recent research on reliability and reference values.” Central Hypersensitivity and Chronic Musculoskeletal Pain.” Phys Med Rehabil Clin N Am 26 (2015) 175–184

Test-Retest Reliability

36. There is published data suggesting good short-term test-retest reliability. DFNS data on test-retest reliability in pain patients evaluated twelve QST measures that showed at least moderate test-retest and inter-rater reliability (r > 0.60) with most measures having excellent (r > 0.80) reliability coefficients. Only paradoxical heat sensations had poor reliability coefficients. Geber C, et al. Test-retest and inter-observer reliability of quantitative sensory testing according to the protocol of the German Research Network on Neuropathic Pain (DFNS): A multi-centre study. Pain 2011;152(3):548–56.

37. A recent published study sought to investigate the long-term reliability of a multimodal QST assessment in healthy people, with testing conducted on 3 occasions over 4 months. They concluded, “Static QST were stable over a period of 4 months; however, a small systematic decrease over time has been observed for mechanical QST. Dynamic QST showed considerable variability over time; in particular, CPM (conditioned pain modulation) using PPT as the test stimulus did not show adequate reliability, suggesting that this test paradigm may be less useful for monitoring individuals over time. Marcuzzi A, et al. The long-term reliability of static and dynamic quantitative sensory testing in healthy individuals. Pain 2017 Apr 19.[Epub ahead of print])

38. Test-retest reliability data for bedside protocols is not available.

Caveats to Interpretation

39. In 2013, Cruz-Almedia wrote, “It is also important to recognize that QST findings cannot pinpoint specific mechanisms underlying clinical pain in individual patients. For example, findings of generalized hypersensitivity to painful stimuli in a patient with knee OA could reflect multiple mechanisms, including alterations of endogenous opioid function, changes in serotonergic and noradrenergic processes, altered cerebral pain processing, and high levels of pain catastrophizing. Moreover, these mechanisms are not mutually exclusive and likely interact in many cases. Nonetheless, it seems potentially valuable to know whether a patient with knee OA expresses widespread hypersensitivity, as this may indicate the involvement of different pathophysiological mechanisms and thus the need for different treatments compared with a patient with localized pain and normal sensory function.” Pain Med.2014 Jan;15(1):61-72

40. Emphasizing this, a recent abstract published by Schreiber K et al used a bedside QST protocol in over 200 women scheduled to undergo mastectomy. They measured pressure pain threshold (PPT) and tolerance (PPT), temporal summation of pain (TSP) and painful after sensations (PAS) at baseline, 2 weeks and 1 year after surgery. Both baseline TSP and PAS predicted clinical pain at 1 year. TSP was positively correlated with catastrophizing scores, while PAS correlated with somatization scores. J Pain April 2107 Volume 18, Issue 4, S pp S75–76

41. Pain related to muscle overuse is often described as burning. Loss of sensation to touch and pinprick can be reported with non-neuropathic pain, e.g. muscular pain. Patients with nociceptive pain will also report brush and warm allodynia and heat hyperalgesia, such as is described with sunburn. Pressure allodynia, in particular, is common in both nociceptive and neuropathic pain. Allodynia to brush, cold and heat and temporal summation to tactile stimuli, although not pathognomonic, are observed in a much higher frequency in patients with neuropathic pain. Bilateral sensory changes can occur in neuropathic pain conditions regarded as unilateral, e.g. post herpetic neuralgia and cutaneous testing of deeper tissues, e.g. abdominal or pelvic tissues, has not been well validated in cases of nociceptive pain.
42. Although performance of testing for hypoalgesia to pinprick, hypoesthesia to tactile stimuli, allodynia to brush and cold, and presence of temporal summation are highly reproducible, there is currently insufficient evidence for test-retest reliability and variance over time therefore this examination cannot confidently be used as a monitoring tool to document changes over time.

**Bedside Method for Quantitative Sensory Testing**

This protocol is based on the NPRC published papers in 2009 and was initially developed by Dr. Misha Backonja. This teaching document was developed by Dr. Backonja, Dr. Pam Squire and Dr. Mark Ware for presentations between 2009 and 2014 and has been updated for this conference.

Quantitative Sensory Testing (QST) as defined by the Neuropathic Pain Research Consortium (NPRC) does not seek to determine pain thresholds but to measure individual specific intensity ratings of pre-specified suprathreshold stimuli such as brush, pinprick, vibration and thermal stimuli. It also seeks to provide information used to evaluate underlying sensory function and abnormalities but accomplishes this with small, portable tools and in much less time than protocols developed by the DFNS.

Both protocols are psychophysical methods that utilize specific physical stimuli (pinprick, touch, vibration, heat, cold) to activate sensory receptors. Both require active participation and directed attention on the part of the patient. Both the examiner and the patient require instruction and training in the testing procedures of QST.

**The Clinical Role Of QST In The Diagnosis And Treatment Of Neuropathic Pain**

1. In patients with suspected neuropathic pain QST is used to complement a routine neurological exam to define the extent and pattern of sensory abnormalities and to characterize the sensory changes.
   - peripheral – evidence of small fiber/large fiber or both/ quantify areas of sensory loss and sensory gain.
   - central - spinal cord pattern loss of pain and temperature/ loss of touch/vibration
   - central-above spinal cord – identify features of thalamic damage

   To determine whether an individual patient has peripheral or central neuropathic pain a complete picture of the patient’s symptoms and signs is obtained and then on the basis of an emerging pattern the clinician can identify the specific neuroanatomical distribution of abnormalities.

2. To characterize sensory abnormalities in patients reporting pain sensitivity (peripheral/central sensitization)

3. To document response to treatment. Test-retest reliability and variance is unknown for this examination therefore it cannot confidently be used as a monitoring tool.

4. It can be used to complement information from skin biopsies for small fiber morphology and density in patients with suspected small fiber neuropathy.

   The following standard set of verbal instructions and procedures is intended to guide the clinical examination based on commonly available equipment. Feedback to the authors is encouraged to improve the face validity of the procedures.

   The following procedures are recommended:

   1. Have the patient complete a pain diagram with pain descriptors to identify affected areas, and direct the physical exam (see attached sample diagram).

   2. Establish a control site where the patient does not describe any sensory abnormalities or pain; use this as a reference for normal sensation. For the control site, the NPRC suggests using a site that is diagonal to the most painful areas (e.g., if the affected area is an arm, use the opposite leg as normal). Establish that you obtain the expected results when you stimulate the normal area.

   3. Establish the test site. Use the pain diagram and the patient’s reported symptoms to direct the test site. The NPRC suggests testing in the area of worst pain. If there are several sites that are painful, limit testing to three areas. If there are areas where sensation seems reduced or lost and others where there is hypersensitivity, ensure that you test at least one area that represents sensory deficit and one area that represents hypersensitivity.

   4. Conduct the exam for each modality following this algorithm and record in a Quantitative Sensory Testing (QST) Data Sheet.

   5. Testing is always to document both sensory loss and sensory gain

   6. Patients are examined for the following modalities in the order listed or least to most painful stimuli.
**Light brush**

Testing fibers involved: low threshold non-nociceptive large myelinated A Beta fibers that carry touch and vibration which synapse in the spinal cord and are carried in the anterior spinothalamic tract to the cortex

**Suggested testing tool: Somedic brush**

The patient is given the following instructions: “Please close your eyes for a moment. I am going to lightly brush your skin with this brush. I am going to start in an area that is normal for you and then I am going to brush you in your most painful area. If the testing becomes too uncomfortable for you at any time, please tell me and I will stop immediately.”

**To test, apply a single stimulus** as a 1 to 2 cm stroke with a velocity of approximately 5 cm per second. If you need to repeat it, there should be a 3 to 5 second interstimulus interval to avoid testing for summation.

1. Establish in the control site that the brush sensation feels normal by brushing the normal area and ask, “Does this feel like a soft brush?” Verify that the sensation is normal.
2. Apply the stimulus to the abnormal area that is the most painful.
   - Ask, “Does brushing on this side feel different?” If the patient replies:
     - **No**, record as normal and perform the next test
     - **Yes**, ask, “Do you feel it more, less, or is it just different?”

**Less**: Ask if the sensation is decreased or absent. You may help the patient quantify the loss by asking, “If this (while stroking the normal area with the brush) is worth one dollar, how much is this worth (stroking the abnormal area with the brush)?”

- If decreased: record brush hypoesthesia and the rating described
- If absent: record brush anesthesia

**More**: Ask, “Was the brushing painful? If the patient replies:

- **No**, ask the patient to describe the sensation, then, record brush dysesthesia and write a description of the sensation (e.g., numb, pins and needles) in the clinical chart
- **Yes**, ask the patient to rate the intensity of the pain on a numerical rating scale (NRS) between 0 (no pain) and 10 (worst pain ever), record brush allodynia and the NRS score.

**Possible testing results and interpretation:**

1. Decreased or absent threshold and not painful: hypoesthesia
   - mechanism: multiple etiologies including loss or damage (i.e. die back/demyelination) to the A beta fibers alone or in combination with other nerves in the bundle. Consider nerve conduction studies for more information.

2. Decreased or absent threshold and painful: hyperpathia
   - mechanism: since the patient cannot detect the sensation there must be damage to the sensory pathway. If it produces pain there must be abnormal pain processing and therefore central mechanisms

3. Increased and not painful: dysesthesia
   - mechanism: sensory pathway spontaneous activity of the A beta fibers

4. Painful: allodynia
   - mechanism: since the fibers transmitting this sensation do not normally carry painful messages there must be other mechanisms involved to produce pain. These are thought to include central sensitization and/or central disinhibition *(Baron 2000, Treede et al 2004)*

**Vibration**

Testing fibers involved: stimulates the pacinian corpuscles in the skin then transmitting through the large myelinated A Beta fibers to the spinal cord, through the dorsal columns, crossing over to the opposite side in the brainstem before ending in the cortex.
Suggested testing tool: 128 Hz tuning fork

In subjects with distal symmetric polyneuropathy, the tuning fork is placed over the interphalangeal joint of the big toe after the tuning fork has been vibrated maximally. Ask the patient, “Do you feel a vibration?” If the patient answers no, move to the medial malleolus and repeat the exam. If still unable to sense vibration, repeat the test, moving proximally over the following joints until a positive test is recorded: medial aspect of the patella, iliac crest, distal interphalangeal joint of the second finger on the right hand, ulnar styloid, lateral epicondyle, and the acromioclavicular joint. At the most distal site to feel vibration, instruct the patient, “Tell me as soon as you stop feeling it completely.” In patients with focal neuropathic pain syndromes, use the same testing protocol except beginning with the joint distal to the most affected area.

Possible testing results and interpretation:

1. Decreased or absent: hypoesthesia
   mechanism: damage or degeneration to the sensory pathway. Use sensory testing to further delineate the lesion. i.e. if vibration and proprioception are primarily lost and pain and temperature seem normal localization is likely to be in the dorsal columns (B 12 deficiency/MS)

Innocuous cool and warm, cold pain and heat pain
Preferred tool: automated thermal testing devices such as the Medoc Alternative testing tool: 128 Hz tuning fork

Testing options for cool and cold pain:
- For cool detection, hold a tuning fork under cool water or simply apply at room temperature to the most painful area on the skin
- For cold pain, immerse the tuning fork into ice water for five seconds
- Note that when using a thermode there are established normals, which vary according to body site selected. Generally cool is detected between 27-30°C and cold pain is detected between 16-24°C.

Testing fibers involved: the sensation of feeling cold threshold is conducted by cold- and menthol-sensitive ion channel receptors (McKemy 2002, Peier 2002) that transmit the sensation via the thinly myelinated A delta fibers. Cold induced pain at around 20°C is transmitted by both A delta and C fibers.

Possible testing results for innocuous, non-painful cool stimuli:

1. Decreased or absent threshold and not painful: cool hypoesthesia (i.e. cannot tell if the stimulus is cold or cannot feel it at all)
   mechanism: damage or degeneration to the sensory pathway at some level. If associated with cold hyperalgesia it implies central disinhibition. See under cold hyperalgesia for details.

2. Decreased or normal threshold and painful: cool allostynia (i.e. the sensation is not perceived as cool OR is perceived as normally cool but for either, the normally non-painful cool stimulus is painful.
   mechanism: central sensitization. Changes in the synapses in the spinal cord cause the cool sensing A delta fibers to activate hyperexcitable secondary pain sensing (nociceptive) neurons (Baron 2000)

3. Increased and not painful: cool dysesthesia
   mechanism: if there is only loss of the A delta specific fibers then patients develop loss of cool sensation (cold hypoesthesia) which is mediated by these fibers. Paradoxically the threshold for cold-pain, which is mediated by polymodal C-nociceptors (CMH-fibers) decreases (cold hyperalgesia). The pain is stimulated by cold but is described as hot and burning. Neuropathic pain patients with predominate loss of A delta fibers and relative sparing of C fibers have been described. (Yarnitsky 1990) These patients present with cold hypoesthesia, cold hyperalgesia and cold skin, a triad labeled triple cold syndrome (Ochoa 1994)

4. Increased threshold AND painful: cool hyperpathia (in this case the patient can barely detect the stimulus is cool, thus the actual threshold for sensing cool is higher than normal but the patient rates the stimulus as painful.
   mechanism: the lower threshold implies damage or degeneration to the sensory pathway but the pain does not match and is increased relative to the stimulus. Possible mechanisms for this-central sensitization and or central disinhibition.
Testing options for warm and hot pain:

- For warm, heat the end of a 128 HZ tuning fork by immersing it in warm water
- Heat pain testing with the end of a tuning fork is difficult - its hard to know what temperature the fork is at (it needs to be about 45°C, but not so hot that you accidentally burn someone) and hard to sustain a hot temperature over the exam time.
A simple thermode that tests at 2 separate temperatures, 38°C for warm suprathreshold testing and 47°C for heat pain suprathreshold testing.

Testing fibers involved: proteins that are ion channel receptors conduct the sensation of feeling warm. These proteins become activated when they receive the correct stimuli (such as a certain temperature), and this causes them to open and allow electrically charged ions to pass through and cause an electrical potential that signals the brain. There are different receptors for different temperatures as well as one that responds to chemical heat stimuli (capsaicin). Heat pain threshold is around 45°C. Warm thresholds range from 33-43°C depending on the site tested. The receptors transmit the sensation of heat pain via mostly the unmyelinated C fibers with some involvement of A-delta fibers. These synapse in the spinal cord in the lateral spinothalamic tract, cross over to the opposite side of the spinal cord, synapse in the thalamus and then end in projections in the cortex.

Possible testing results for innocuous, non-painful warm stimuli:
1. Decreased or absent threshold and not painful: warm hypoesthesia (i.e. cannot tell if the stimulus is cold or cannot feel it at all)
   mechanism: damage or degeneration to the sensory pathway at some level.

2. Decreased or normal threshold and painful: warm alldynia (i.e. the sensation is not perceived as warm OR is perceived as normally warm but for either, the normally non-painful warm stimulus is painful.
   mechanism: central sensitization (? References)

3. Increased threshold AND painful: warm hyperpathia (in this case the patient can barely detect the stimulus is warm, thus the actual threshold for sensing warm is lower than normal but the patient rates the stimulus as painful.
   mechanism: the lower threshold implies damage or degeneration to the sensory pathway but the pain does not match and is increased relative to the stimulus. Possible mechanisms for this-central sensitization and or central disinhibition
   ? References

Possible testing results for heat pain stimuli:

1. The threshold for sensing painful heat may be normal, decreased or increased but it does not produce pain: heat hypoalgesia
   mechanism: disinhibition of the sensory pathway?

2. Decreased or normal threshold and abnormally painful: heat hyperalgesia (The patient either has a hard time determining the stimulus is hot or can identify it as hot but reports it as more painful than normal areas tested with the same stimulus.)
   mechanism: peripheral sensitization (Jensen and Baron 2003)

3. Summation or after-summation: denote if one or both
   mechanism: implies abnormal pain processing and central sensitization

Apply the stimulus for 5 seconds to areas of abnormalities that were determined by light brush to be the most painful. Check the expected temperature by first applying the heated/cooled tuning fork to yourself.

Ask, “Does this feel different?” If the patient answers:
- **No**, record as normal and perform the next test
- **Yes**, ask “Do you feel it more, less, or just different?” (Does it actually feel cool? In some patients it feels paradoxically hot).

If less, ask, “Do you feel it less or not at all?” Record in the chart either cool or warm hypoesthesia/anesthesia.
If more, ask if the sensation was painful. If the patient answers:
- Yes, ask the patient to rate the pain intensity on an NRS scale

Record one of the following corresponding terms in the chart:
- a) Increased sensation but not painful: record cool or warm dysesthesia
- b) Increased sensation and painful: record cool or warm allodynia

**Pinprick testing:** fibers involved: free nerve endings transmit the impulse in the thinly myelinated A delta and unmyelinated C fibers which synapse in the spinal cord in the lateral spinothalamic tract, cross over to the opposite side of the spinal cord, synapse in the thalamus and the end in projections in the cortex.

**Suggested testing tool: Neuropen**

Give the patient the following instructions: “Please close your eyes for a moment. I am going to gently poke your skin with this pin. I am going to start in an area that is normal for you and then I am going to test you in your most painful area. If the testing becomes too uncomfortable for you at any time, please tell me and I will stop immediately.” You may ask the patient to rate the intensity of the pinprick stimuli on the normal and abnormal sites with an NRS from 0 to 10 to compare pain intensity on both sides.

**To test, apply a single stimulus** by poking the skin with the Neuropen, depressing it hard enough to move the indicator to the white line.
1. In the control site, establish that the pinprick sensation feels normal by applying the Neuropen on the normal area and ask, “Does this feel like a sharp pin?” (see comment below regarding rating the pain intensity on an NRS*)
2. Apply the stimulus to the abnormal area that is the most painful. Ask, “Does the pinprick in this area feel different?” If the patient answers:
   - No, record as normal and perform the next test
   - Yes, ask, “Do you feel it more, less, or just different?”

If less, record **pinprick hypoesthesia**.
For further clarity, ask, “Do you feel it less or not at all?”

Record one of the following terms in the chart:
- a) Pain was less: record **pinprick hypoalgesia**
- b) Patient didn’t feel it at all: record **pinprick analgesia**
- c) Patient felt the stimulus less than the normal site and the patient reports it as painful: record **pinprick hyperpathia** and have the patient rate the pain as an NRS score between 0 and 10.

If more, ask, “Can you rate how painful it is by giving it a number between 0 and 10?”
- Record **pinprick hyperalgesia** if the stimulus produced more pain than the unaffected normal test site and record the NRS pain scale for both the normal and abnormal pain-affected site

**Possible testing results and interpretations:**

1. Decreased or absent threshold and not painful: **mechanical/pinprick hypoalgesia/analgesia** (i.e. cannot tell if the stimulus is sharp or cannot feel it at all)
   **mechanism:** damage or degeneration to the sensory pathway.

2. Decreased or normal threshold and abnormally painful: **Mechanical/pinprick Hyperalgesia** (use those terms to differentiate it from heat or cold hyperalgesia) (i.e. the sensation is not perceived as sharp OR is perceived as normally sharp but for either, the pinprick is rated on the VAS scale as more painful than normal areas)
mechanism possibilities: 1. Peripheral sensitization of the C-fibers (Baron 2003) but if this you should also be able to show hypersensitivity to heat pain (heat hyperalgesia) as the C fibers also sense that. If there is NO heat hyperalgesia (so isolated pinprick (mechanical) hyperalgesia) then the mechanism must be central sensitization (Rolke et al 2006)

3. Increased threshold AND normally or abnormally painful: mechanical/pinprick hyperpathia (in this case the patient can barely detect the stimulus is sharp, thus the actual threshold for sensing pinprick is lower than normal but rates the pain as either the same as normal areas or higher.) mechanism: the increased threshold implies damage or degeneration to the sensory pathway but the pain does not match this. Possible mechanisms for this-central sensitization and or central disinhibition

4. Summation or after-summation: denote if one or both mechanism: implies abnormal pain processing and central sensitization

Temporal Summation Testing
With the Neuropen, apply 10 stimuli to a single location at a rate of 1 per second (rate is important).

Ask, “Does the sensation change as I continue to stimulate it?” If the patient answers:

- Yes, ask if the sensation was both painful and increased with each stimulus:
  - Yes, record as summation and rate the first and final stimulus (NRS pain scale) and have the patient describe the sensation

- No: record as non-painful summation

NOTE: While testing, if the first stimulus was recorded as either decreased or absent but as the stimuli continue the sensation changes to painful, record as hyperpathia.

Painful After Sensation
Following a single pinprick stimulus or the temporal summation testing ask the patient to indicate if they still feel pain and if yes, ask them to indicate when they no longer feel it. Record the time.

The QST is now complete.

QST Examination Tools

A full complement of bedside diagnostic tools is not yet available. Inexpensive standardized tools for thermal testing are not yet commercially available. Somedic is updating and evaluating a SENSEBox that may be interesting. The following suggested tools are available at these websites.

1. Rydel-Seiffer 64/128 Hz graduated Tuning fork available through US Neurologicals 733 7th Ave, Suite 207 Kirkland, Washington 98033 FAX # 425-893-8602 www.usneurologicals.com cost is 95.00 USD

2. Somedic brushes and Somedic Algometer. http://somedic.com/en/. 6 brushes must be ordered at a time (170.00 CAD for 6). The algometer will only be approved for import to Canada as scientific equipment for research use.

3. Neuropens can be ordered from Amazon.ca. Cost is approximately $25.00 CDN
One Neuropens and 100 tips are $50.00

References for the QST exam:

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