TENS

Transcutaneous Electrical Nerve Stimulation

McGill Lecture Notes – January 22nd, 2002

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OUTLINE

- TENS OVERVIEW
- HOW DOES TENS WORK --- 4 THEORIES
- CLINICAL JUDGEMENT
- PARAMETERS AND CONTRAINDICATION
- RESEARCH EVIDENCE
- THE BOTTOM LINE

TENS

Transcutaneous Electrical Nerve Stimulation

What is it?

It is a form of electrical stimulation with surface electrodes to modulate pain perception.

Why do physical therapist use it?

- To reduce pain perception
- To reduce spasticity
- To reduce nausea and vomiting (cancer patients or post-op)

What stages of healing can we use TENS?

1. acute stage
2. sub-acute
3. chronic

What conditions would benefit from TENS?

- Arthritis
- Osteoarthritis
- Cervical spondylosis
- Low back pain
  Fibrositis/Myofascial pain syndromes
- Tendinitis/Bursitis
- Carpal Tunnel syndrome
  Radiculopathy
- Peripheral nerve injuries
  Phantom limb pain
- Post operative pain
- Spinal cord disorders
- Pain in the terminally ill
  Labour pain

How often do we use TENS?

According to the Canadian technology assessment paper [1] in which the authors surveyed TENS use across Canada. After surveying 50 hospitals with 200 or more beds they estimated over 450,000 uses of TENS take place in Canadian hospitals each year with widespread use in physiotherapy

- acute pain (used by 93% of hospitals),
- labour and delivery (43%)
- chronic pain (96%).

How does TENS reduce pain perception?

There are 4 theories about the physiological effects of TENS:

1. Gate control theory
2. Opiate-mediated control theory
3. Local vasodilatation of blood vessels in ischemic tissues
4. Stimulation of acupuncture points causes a sensory analgesia effect

Does TENS increase blood flow or skin temperature?

- It depends on whether muscle activity is induced.
- Sensory TENS does not increase blood flow.
- Low-frequency TENS applied above the motor threshold significantly increases local cutaneous blood flow.
- Skin temperature does not change following sensory or motor stimulation.

THE 4 THEORIES

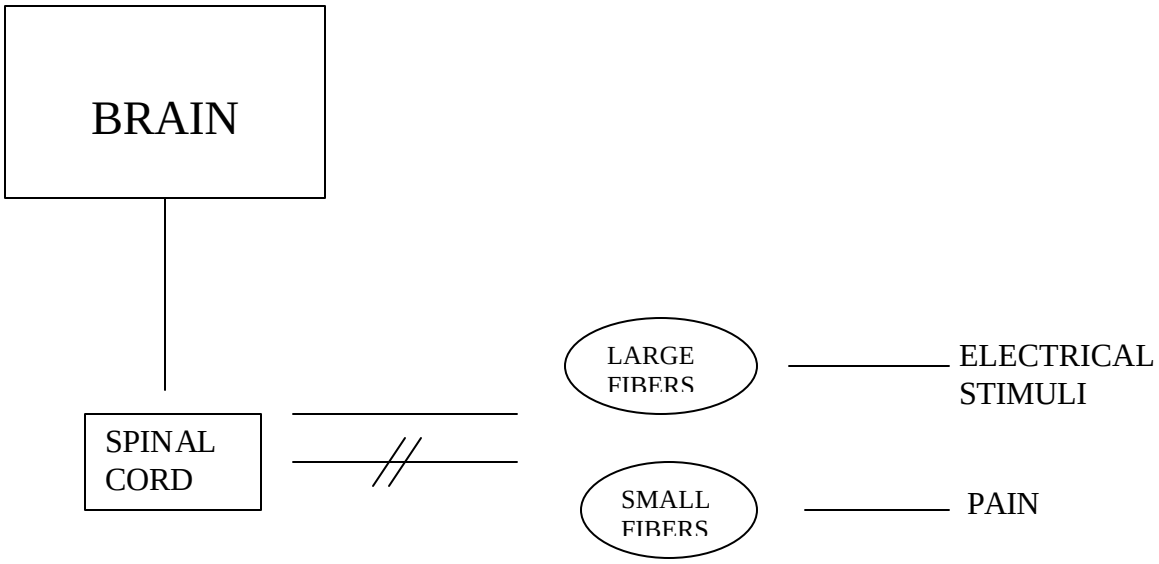
1. Gate control theory (Melzack and Wall, 1985)

Neurophysiology background: the CNS can only interpret and transmit one form of sensory stimulus at a time. There a two sets of afferent (incoming) nerve fibers that enter the spinal cord:

- A-beta fibers – larger diameter (faster) – carry touch sensation
- C and A-delta fibers – smaller diameter (slower) carry pain sensation

Theory: When an electrical current is applied to a painful area, transmission of the perception of pain (via small diameter fibers) to the brain in inhibited by the activity of the large diameter, fast-conducting highly myelinated, proprioceptive sensory nerve fibers --- closing the gate to the pain perception to the brain.

*stimulated by CONVENTIONAL or HIGH-RATE TENS – short term effect



Evidence that ES can modulate transmission of impulses (Ma et al, 2000 and studies listed in your book)

1. Studies on nonhuman primates and other animals have found decreases noxious evoke nociceptive activity in dorsal horn and spinothalamic tract cells, and flexion reflex (1985, 1988, 2000)
2. Studies on human showed decreases in the pressor response mediated by small-diameter, slow-conducting fibers (1997).

2. Opiate-mediated control theory

Neurophysiology background:

- The brain can secrete its own analgesic substance such as endorphins to modulate pain.
- Endorphins are neuropeptides that act on the CNS and peripheral nervous system to reduce pain. They have the similar pharmacological effect as morphine.

ES is thought to relieve pain to some degree by promoting endorphin release.

Evidence of this theory (Studies listed in your book, p.387)

1. ES reduces the activity of the nociccptive flexion reflex and transmission in the spinothalamic tract in cats and nonhuman primates by opiate mediated mechanism.

2. ES has been shown to increase the levels of endorphins circulating in the CSF of patients with neurological disorders.

3. Local vasodilatation of blood vessels in ischemic tissues (Leandri et al, 1986)

Myofascial pain background:

- Trigger points develop in a muscle or fascia when there is a loss of local blood flow (ischemia) due to an acute insult or scar tissue remaining from an earlier injury.

- Trigger points appear to be involved in a variety of pain phenomena, particularly those associated with muscles and fascia that covers them.

- They have been implicated in conditions such as muscle pain, muscular rheumatism, muscular inflammation, and inflammation of the fibrous tissue that compromises muscle sheaths.

Leandri et al found that

TENS causes local vasodilation to the ischemic area and therefore is thought to relieve pain through this mechanism.

4. Stimulation of acupuncture points causes a sensory analgesia effect (Melzack, 1988)

Acupuncture background: Acupuncture is based on energy lines (meridian) and entry points (acupuncture points).

Melzack theorizes that stimulation of these points using TENS causes a sensory analgesia effect by inhibiting or changing the pain evoked nerve impulses at several levels in the nervous system.

How does TENS reduce spasticity?

Neurophysiology background:
A normal stretch reflex is modulated, inhibited or facilitate by the higher centers of the brain; but if this connection is damaged, spasticity is the result. Spasticity is therefore mostly due to an excess of impulses from a-motor neurons due to a SCI or brain injury.

TENS is thought to reduce spasticity by reducing / inhibiting excessive a-motor neuron activity. (Goulet e al, 1996; Joodaki et al, 2001)
This inhibition is accomplished by stimulating the Ia afferent nerve of the muscle that is antagonist to the spastic muscle.
For example, stimulate the peroneal nerve to inhibit soleus/gastrochnemius spasticity

Parameters used are that of conventional TENS.

How does TENS reduce nausea ?

Acupuncture TENS applied to acupuncture point PC06 (median nerve at the wrist level) have been shown to reduce nausea (Dundee, 1990, 1991)

Theories proposed:

- Stimuli to PCO6 sends messages to specific areas in the spinal cord and brain to interfere with nerve processes key to producing nausea and vomiting.
- Stimuli to PC06 facilitates productions of neurotransmitters that may inhibit other neurotransmitters that are responsible for nausea and vomiting.
- Stimuli at PC06 may cause the release of endogenous endorphins. When released in response to nerve stimulation, the endorphins have the effect of blocking nausea vomiting symptoms.

Parameters used are that of acupuncture TENS.

CLINICAL JUDGEMENT

1. Does the history show any indication for using TENS?

2. Does the history and associated condition show any contraindication for using TENS?

3. Have you established a problem list?

4. Have you assessed the problem and determine the source of the problem?
   - What stage of healing is the condition?
   - Acute Inflammatory (1 to 6 days), Proliferative (3-20 days), chronic inflammation
   - How irritable is the condition?
   - Is there pain at rest, pain with movement or pain at end range of movement?

5. If there is no pain at rest and only with movement or end of movement then an exercise program would be more beneficial.

6. TENS may be used after the exercise program to control pain post-exercise.

7. TENS is considered more so when there is pain at rest and this pain prevents your patient from doing much exercise / activity:
   - Acute LBP
   - Acute neck pain
   - Chronic LBP and neck pain
   - Chronic arthritic / osteoarthritic pain
   - Myofascial pain (polymyalgia / fibromyalgia)
   - Peripheral nerve injuries with radiculopathies
   - Phantom pain
   - RSD
   - Labour pain
   - Pain in the terminally ill (with consent)

CONTRAINDICATION

- Someone with a pacemaker (3,6,8)
- Someone with undiagnosed pain.
- Someone with a heart condition (3,8,10)
- On head or neck of someone with epilepsy (3,6)
- Someone with venous or arterial thrombosis or thrombophlebitis
- Someone with indwelling phrenic nerve or urinary bladder stimulators
- Near operating diathermy device
- Around the head (3)
- On the eyes
- Over mucosal surfaces
- Using electrodes on infected (inflamed) skin (3,4)
- Electrodes across the chest of a patient with cardiac disease
- Electrodes should not be placed near carotid artery (sinus) (3,6,9) in the anterolateral region of the neck. There is a potential risk that stimulation at this sit might cause heart block by exciting the vagus nerve.

PRECAUTIONS

- Areas of skin irritation, damage or lesions
- Areas with impaired sensation
- Over abdominal, lumbosacral or pelvic regions during pregnancy other than for labor/delivery (3,6,8,10,12)
- Tissues vulnerable to hemorrhage or hematoma
- Athletes should not be permitted to participate in sports while under the influence of TENS analgesia
- Extreme caution is needed with patients taking narcotic medication or who are known to have hyposensitive areas.
- Incompetent patients may not be able to manage the device and it must be kept out of reach of children.
- For patients with diagnosed malignancies that have been diagnosed as terminal, TENS can be used for pain control with informed consent of the patient. Otherwise, TENS should not be used when malignancies are present.

DOSAGE AND PARAMETERS

Parameters used for TENS:

1. **Waveforms**
2. **Frequency or Rate**
3. **Pulse width or Duration**
4. **Amplitude or Intensity**

1. Waveforms (Kahn, 1991)

Square / rectangular

1. Instantaneous rise
2. Less skin irritating as approaches sine wave form
3. For nerve damage associated with pain pathology
4. For hypersensitive and chronic pain patients
5. Delayed, long-lasting analgesia

Triangular / spike

1. Rapidly rising, but not instantaneous
2. More skin irritating therefore requires frequent movement of electrodes or shorter treatment times to avoid skin irritation
3. For acute pain or resistant tissue
4. Immediate, short lasting pain relief

NOTE:

- There has been little or no clear evidence of physiologic benefit of any specific waveform.
- Current TENS models favor BIPHASIC waveforms which contain both positive and negative phases.
- Contemporary TENS units now have symmetrical biphasic waveforms to maintain a zero net direct current with no polar effect, reducing skin irritation. There is no (+) or (-) poles noted on the lead wires.
- Units having monophasic waveforms can produce polar effects associated with active and "indifferent" electrodes. There are (+) and (-) poles on the lead wires.

2.Frequency or Rate (Currier & Nelson 1991; Kahn, 1991)

Definition: number of stimuli per second (Hz)

Low Frequency (1-20):

- Small unmyelinated fibers respond effectively at <100Hz
- Increase endorphin production, thus analgesia following stimulation
- **Chronic** pain (associated with reduced autonomic factors and increased psychological factors)

High Frequency (80-120):

- Large myelinated fibers respond effective > 100Hz
- Immediate relief of pain
- **Acute** pain (pain of less than 4-6 months, associated with sympathetic nervous system ie trauma, active inflammation)

3. Pulse width or Duration (Kahn, 1991; Hecox et al, 1994)

Definition: the length of time the current is actually acting on the patient in each individual pulse (unit=microseconds).

Pulse width	Indications
50µs	Large myelinated fibers respond more effectively (sensory-touch)
100 - 150µs	Normal neuromuscular system
200 µs	Small myelinated fibers respond more effectively
200 – 300 µs	Patients with neurological damage

4. Amplitude or Intensity

- TENS units intensity ranges form 1 mA to 100 mA
- "Ideal intensity" = patient perceived comfortable sensation
- TENS is only effective when the patient actually feels the stimulus
- Patients need to increase the intensity when the body accommodates to the stimulus (when they don't feel the stimulation anymore)
- Dying batteries can cause fading intensities

Modulation of Parameters

To minimize accommodation, TENS unit manufacturers also offer 2 pre-programmed modes where all 3 parameters vary about 10% periodically.

Pulse-Burst Mode: a burst is a packaging of several stimuli groups and is sensed by the patient as a single stimulus. This is also known as the extrinsic frequency.

Wave-Train Mode: a combining and mixing of several frequencies, widths, intensities and modulations of each, to provide multiple parameters in preset patterns. Its physiological benefits have not been established.

Stimulation Mode of TENS (ranked in descending order of comfort for patients)

1. Conventional
2. Modulated
3. Pulsed-Burst
4. Strong-Low rate
5. Brief-intense
6. Hyperstimulation

Which mode to choose in clinic?

1. Conventional TENS is usually the mode of first choice for the following reason:
   - Most comfortable due to low amplitude
   - Produces a rapid onset of pain relief – right after treatment

2. Try other modes in the above order if first one fails
   See attached chart for details.

   - Keep in mind that most patients do not like to feel their muscles contract during TENS application.
   - **Duration** of treatment depends on the mode you choose.

IS TENS EFFECTIVE?
WHAT DO RESEARCHES SHOW?

TENS in acute pain

The Canadian study [1] included randomised and non-randomised studies, though it split them for descriptive analysis. They reviewed 39 studies in postoperative pain, dental pain, dysmenorrhoea and cervical pain.

	TENS EFFECTIVE	TENS INEFFECTIVE
Randomised trials	2	15
Inadequate randomized Or not randomized	17	2

In a review limited to randomized studies in acute postoperative pain [2], TENS was judged by the reviewers to be no better than placebo in 15 out of 17 randomized studies. Of 19 trials with pain outcomes that were not randomized, 17 of 19 the authors of the original papers had concluded that TENS had a beneficial effect. This is another good example of bias in non-randomized studies.

TENS in labour pain

The Canadian review [1] summarized 6/9 randomised trials as reaching negative conclusions. This is a similar result to the second review [3], which examined eight reports, of which five were judged to have a negative result with TENS no better than placebo or sham-TENS. However, the three studies which were judged to be positive were positive only on weak outcomes like additional pain relieving measures and increased time to epidural local anaesthetic.

	TENS EFFECTIVE	TENS INEFFECTIVE
Randomised trials In the Canadian Review	3 (weak)	6
British Review	3 (weak)	5

Four studies reported that additional analgesic interventions were significantly less likely with the use of TENS [3], with a number-needed-to-treat of 14 (95%CI 7 - 119) for one woman in labour to be spared an epidural or intramuscular injection.

2 smaller trials (23 subjects) were statistical significant
2 larger trials (208 subjects) were NOT statistical significant

A randomised trial of 94 women in the first stage of labour published since the reviews were done [4] undermines even this possible level of benefit. It found no difference in analgesic requirement between active TENS and disabled TENS equipment, nor any difference on pain scores.

TENS in chronic pain

The Canadian review found 20 randomised trials, of which nine were definitely positive for TENS on some measure, but eight were negative for TENS.

	TENS EFFECTIVE	TENS INEFFECTIVE
Randomised trials In the Canadian Review	9	8

A disappointing review limited to chronic low back pain [5] included just six papers. Two of the original studies were of electroacupuncture, which is not the same as TENS. One trial had only ten patients randomised, six patients to TENS and four to placebo. **TENS was not significantly different from placebo**. Electroacupuncture was significantly better than placebo, but in only two studies with 30 patients given electroacupuncture.

UP TO DATE REVIEWS, YEAR 2001 !!!

1. Review of 5 randomized controlled clinical trials of TENS for the treatment of patients with a clinical diagnosis of chronic LBP [6] reveal that there **is no evidence to support the use of TENS in the treatment of chronic low back pain**. These reviewers also feel that clinicians and researchers should consistently report the characteristics of the TENS device and the application techniques used. New trials on TENS should make use of standardized outcome measures. This meta-analysis lacked data on how TENS effectiveness is affected by four important factors: type of applications, site of application, treatment duration of TENS, optimal frequencies and intensities

2. Review of 18 studies to determine the effectiveness of TENS in chronic pain found **inconclusive evidence** [7]. The published trials do not provide information on the stimulation parameters that are most likely to provide optimum pain relief, nor do they answer questions about long-term effectiveness. Large multi-centre randomised controlled trials of TENS in chronic pain are urgently needed.

3. Review of 7 studies to determine the effectiveness of TENS of knee OA [8] find that **TENS and AL-TENS (acupuncture like TENS) are shown to be effective in pain control over placebo**. Heterogeneity of the included studies was observed, which might be due to the different study designs and outcomes used. More well designed studies with a standardized protocol and adequate number of participants are needed to conclude the effectiveness of TENS in the treatment of OA of the knee.

THE BOTTOM LINE

1. **Methodological considerations**: adequate blinding of TENS is extremely difficult, so that most trials should best be regarded as open even if described a blinded. This must confer some degree of bias towards TENS.

2. Tendency in all these reviews to point to an overall lack of methodological rigour in the original studies (but acknowledging that these trials are difficult). **The trials with the best methods tended to produce negative results.**

3. **Statistical validity**. Put simply, many of these trials make a number of different measurements, only some of which show statistical benefit. So choosing just those measurements which are significant, and ignoring those that are not significant, can give a spurious weight to a review. This is especially true when statistical benefit is of dubious clinical value. Reviewers and readers should always make up their own minds, not just take a headline result chosen because of statistics.

So our reading of these reviews should be **skeptical**, especially when, as in acute postoperative pain, there are adequate alternatives. For labour pain there may just be an argument for good quality trials which examine the issue of delay or avoidance of interventions like epidurals or intramuscular opiates which carry some risk to mother or baby.

Chronic pain is a different matter. Where the **evidence is not clear cut, where some patients are seen to benefit**, and where alternatives may not work for all patients, then carrying on using TENS until there is some clarification makes sense. That does put some heat on getting well-designed studies of sufficient power to provide practically useful answers underway.

IF INDICATED, TRY IT OUT, IF IT DOESN'T WORK, TRY SOMETHING ELSE!!!

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LABORATORY

Case 1

HPI: 28 y.o female c/o acute neck pain yesterday when she woke up. Does not recall doing any particular exacerbating activity. Reports pain is 10/10 and is unable to keep her head straight b/c it hurts too much. Denies numbness or tingling to BUE's.
PMHx: hypothyroidism, allergies to cortisone, diabetes under control.
O/E: Posture: rounded shoulders, shrugged up with neck flexed by 10% and rotated to the R. and SB to the L.
ROM: Flexion 50%, Extension unable to bring head to neutral, R. Rotation 100%, L. Rotation unable to bring to neutral, R. SB unable to bring to neutral, L. SB 100%.
Neurological: Dermatomes and myotomes intact.

1. Would you ask the patient any other question?
2. Is TENS appropriate for this patient?
3. How would you set her up? Parameters and electrode positions?
4. What would you tell the patient to put her at ease with this kind of treatment? How would you determine pre-treatment pain level?
5. How would you go about removing the TENS unit, how would you put your patient at ease during the procedure? How would you assess if treatment was effective?
6. What if pain increased after treatment?
7. What if pain did not change?

Case 2

HPI: 64 y.o male reports insidious onset of LBP beginning 6 months ago for no apparent reason. He tried taking anti-inflammatory medication without much result. Pain is a constant 7-8/10. He has difficulty sitting >10 minutes, walking >30 minutes and has difficulty putting on socks and pants in the morning.
PMHx: HTN, generalized arthritis
O/E: Posture: flattened low back
ROM: extension 10%, flexion 50%, R and L SB WNL.
Neurological: Dermatomes and myotomes intact

1. Answer all questions as in case 1.
2. What would you suggest if he thought that TENS reduced his pain by 50% but found that relief only lasts for 45 minutes; and he'd like to have it for home?
3. What would you do if at the end of 6 sessions he tells you he is not getting any positive results from the first set of parameters?
4. What would you do if he told you that he was undergoing treatment for his prostate cancer?
5. What if he tells you he had cardiac arrhythmias?

Case 3

HPI: 35 y.o female sustained a Colles' fracture of the L. wrist 8 wks ago. X-rays show excellent healing and her cast was removed this morning.
O/E: wrist and fingers are moderately edematous. She refuses PROM of her wrist because it hurts too much. She is extremely tender to palpation. We are unable to fully assess due to pain.

1. Answer first set of questions in case 1
2. What would you do if on evaluation, she told you that her hand feels numb at time?
3. How would you decide when to stop using TENS?

Free practice session

Practice placing electrodes on different body parts and try out the 6 modes.

1. Shoulder
2. Elbow – lateral epicondylitis
3. Knee pain (OA)
4. Ankle pain (s/p ORIF)
5. Pain due to rhomboid strain
6. Hip pain on someone has bone cancer and who is terminally ill
7. Cancer patient who is nauseous
8. Peroneal nerve to reduce gastrocs/soleus spasticity