Transcutaneous Electrical Nerve Stimulation Reduces Acute Low Back Pain during Emergency Transport

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Abstract

Background: Patients with acute low back pain may require emergency transport because of pain and immobilization. Transcutaneous electrical nerve stimulation (TENS) is a nonpharmaceutical therapy for patients with low back pain. **Objective:** To evaluate the efficacy of paramedic-administered TENS in patients with acute low back pain during emergency transport. **Methods:** This was a prospective, randomized study involving 74 patients transported to hospital. The patients were randomly assigned to two groups: group 1 ($n = 36$) was treated with true TENS, while group 2 ($n = 36$) was treated with sham TENS. The authors recorded pain and anxiety as the main outcome variables using a visual analog scale (VAS). **Results:** The authors recorded a significant ($p < 0.01$) pain reduction (mean ± standard deviation) during transport in group 1 (79.2 ± 6.5 mm VAS to 48.9 ± 8.2 mm VAS), whereas pain scores remained unchanged in group 2 (75.9 ± 16.4 mm VAS and 77.1 ± 11.2 mm VAS). Similarly, the scores for anxiety were significantly reduced ($p < 0.01$) in group 1 (81.7 ± 7.9 mm VAS to 69.2 ± 12.1 mm VAS) after treatment. No significant change was noted (84.5 ± 5.8 mm VAS and 83.5 ± 8.9 mm VAS, respectively) in group 2. **Conclusions:** TENS was found to be effective and rapid in reducing pain during emergency transport of patients with acute low back pain and should be considered due to its ease of use and lack of side effects in the study population. **Key words:** transcutaneous electrical nerve stimulation (TENS); acute low back pain; paramedics; emergency transport. ACADEMIC EMERGENCY MEDICINE 2005; 12:607–611.

Low back pain (LBP) is the second most common reason for which patients seek medical attention.[1] The impact of surgery on the management of acute LBP is low. Only 0.5% to 1% of LBP patients reach the requirements for surgical intervention, based on traditional indications.[2] For the majority of nonsurgical patients, activity modifications, analgesics, muscle relaxants, education, spinal manipulation therapy, and epidural injections are recommended to shorten recovery time and as symptomatic therapy.[3]

In contrast to these well-established concepts for in-hospital management of LBP in Europe and in the United States, out-of-hospital care of these patients is insufficient because paramedics and emergency workers are restricted in or, as in Austria, even banned from administering oral and intravenous (IV) drugs. Therefore, patients with acute LBP who require emergency transport suffer pain and anxiety until they get to a physician who administers analgesic/muscle relaxant therapy.[4,5]

An interesting nondrug therapy may be transcutaneous electrical nerve stimulation (TENS). For more than four decades, TENS has been applied in the treatment of acute as well as chronic pain syndromes.[6–8] Despite the growing success of TENS in clinical use, the use of electrotherapy in rescue care is limited to pain relief through TENS in trauma patients during emergency care.[9] Therefore, the aim of this prospective, randomized study was to evaluate the efficacy of paramedic-administered TENS in acute LBP patients during emergency transport.

METHODS

Study Design. With the approval of our institutional ethics committee, 100 patients aged 19 years or older were screened for participation in this randomized, placebo-controlled, double-blind study.

Study Setting and Population. All patients suffering from a first episode of acute LBP were accompanied by paramedics who were not permitted to administer any IV drugs. We included patients with acute severe pain >60 mm on a visual analog scale (VAS; 0 mm = no pain to 100 mm = most intense pain imaginable) in

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the low back without radiation to the legs and a duration of less than six hours before the arrival of the emergency team. Patients who took analgesics within the previous 48 hours were excluded, as were patients who had any kind of neurologic impairment of the legs observable by the paramedics. Further exclusion criteria were cognitive impairment and/or inability to communicate with the paramedics; finally, we excluded all patients with potentially dangerous internal illness (American Society of Anesthesiologists score >3). The day after admission, we obtained the patient's diagnosis, based on clinical examination, from the hospital records and, if needed, radiographs and magnetic resonance imaging/computed tomography (MRI/CT) scans. Patients with LBP from causes other than spinal or musculoskeletal disorders were excluded from the final data analysis.

Study Protocol. At the emergency site, an investigator (paramedic A) determined whether the patient was suitable for this study and obtained verbal and written informed consent for participation. Paramedic A recorded all baseline parameters and measurements. Then paramedic A left the site and paramedic B entered. Paramedic B performed TENS in accordance with the following procedure in the absence of paramedic A: Patients were randomly assigned to two groups; those in group 1 received real TENS, while those in group 2 received sham TENS and were not stimulated. The randomization was obtained with computer-generated codes, which were sealed in sequentially numbered opaque envelopes. The patients were told that the device would transfer electric energy to their backs and that they might or might not feel sensations on the skin.

For stimulation of group 1, we used the dual-channel TENStem eco stimulator (TENStem eco, Pierenkemper GmbH, Ehringshausen, Germany). This portable device weighs 170 g, measures 114 × 59 × 27 mm, and is powered by a commercially available 9-volt battery (technical data: output voltage: 70 mA, frequency range: 0.5–120 Hz, pulse width: 60–300 μs, power input: 15 mA; cost approximately $300 US). Patients from both groups were connected to the same TENS device using two adhesive 50 × 130-mm electrodes (Pierenkemper GmbH; cost approximately $15 US) positioned paravertebrally at the low back (Figure 1). The device was run by the TENStem eco program 1: frequency (channel 1 and 2): 100 Hz, pulse width: 200 μs, voltage: 2 mA, time: 30 minutes. The randomized treatment began at the emergency site, before transfer to the ambulance vehicle. Once positioned, the TENS was left in place until the patients arrived at the hospital.

Duration of transport was recorded. Since no cases were urgent, the patients' choices of hospital were taken into consideration; consequently, patients were not necessarily transferred to the nearest facility. At the end of transportation, paramedic A performed data collection, again in the absence of paramedic B.

This blinding scenario had been well rehearsed before starting the trial and was controlled through five audits by two physicians of our university hospital during the data-collection phase.

Measurements. Morphometric characteristics, including oscillometric blood pressure and heart rate, were measured immediately after entering the ambulance and once again upon arrival at the destination hospital. Each patient was asked to rate his or her pain and anxiety level on paper-based VASs (0–100 mm).

Data Analysis. In the a priori study plan for a per-protocol analysis, our intention was to detect a 30% reduction in pain by VAS with a common standard deviation equal to the difference at the $p = 0.05$ level with a power of 85% using an analysis of variance (ANOVA). The calculated sample size required 20 patients per group. Considering the uncertain drop-out rate, we decided to screen at least 100 patients. A two-way repeated-measures ANOVA was used to test both a trial effect and a group effect (SPSS 11 for Macintosh, SPSS Inc., Chicago, IL). Data were presented as mean ± standard deviation (±SD), with 95% confidence intervals (95% CIs). A $p < 0.05$ was considered statistically significant.

RESULTS

We screened 100 patients of white ethnicity who fulfilled the entry criteria. Twenty-eight patients refused to participate; 72 patients signed the informed consent and were enrolled in this study. Each group contained 36 patients. After obtaining the final diagnosis from hospital the day after data collection, six patients in group 1 and three patients in group 2 had to be excluded from data analysis because of pain from other than spinal or muscular disorders (Table 1). Consequently, the data from 30 patients in group 1 and 33 patients in group 2 were analyzed.

Demographic data were comparable between the groups with regard to age and gender. No significant difference in potentially confounding factors, such as external circumstances of the rescue, was found among the groups before treatment (Table 2).

TABLE 1. Diagnoses Resulting in Post-hoc Exclusion from Data Analysis

Diagnosis*	Group 1 ($n = 6$)	Group 2 ($n = 3$)
Pyelonephritis	1	0
Dysmenorrhea	2	1
Colitis	1	0
Urolithiasis	2	2

*Diagnosis is based on clinical and imaging results in the hospital within 24 hours after the emergency.

TABLE 2. Baseline Data before Transport*

	Group 1 ($n = 30$)	Group 2 ($n = 33$)
Age—mean ± SD	47 ± 7 yr	49 ± 14 yr
Gender—male/female	16/14	17/16
Height—mean ± SD	164 ± 14 cm	164.3 ± 16.5 cm
Weight—mean ± SD	79 ± 11 kg	74 ± 13 kg
Duration of pain before emergency call—mean ± SD	2.2 ± 1.7 hr	1.9 ± 1.7 hr
Duration of transport—mean ± SD	24.8 ± 8.1 min	26.2 ± 9.3 min
Heart rate—mean ± SD	102 ± 8 beats/min	100 ± 10 beats/min
Systolic blood pressure—mean ± SD	136 ± 23 mm Hg	144 ± 22 mm Hg
Diastolic blood pressure—mean ± SD	83 ± 14 mm Hg	87 ± 8 mm Hg
Pain score on VAS—mean ± SD (95% CI)	79 ± 7 mm (75, 82)	76 ± 16 mm (71, 80)
Anxiety score on VAS—mean ± SD (95% CI)	82 ± 8 mm (77, 86)	85 ± 6 mm (79, 89)

*None of these factors differed significantly. VAS = visual analog scale.

Outcome variables are shown in Table 3. The pain scores upon arrival at the hospital differed significantly between group 1 and group 2 ($p < 0.01$). In group 1, pain reduction was noted between departure from the emergency site and arrival at the hospital, whereas pain scores remained nearly unchanged in group 2 (Figure 2).

Similarly, the scores for anxiety were significantly reduced in group 1 after treatment. No significant change was noted in group 2. Upon arrival at the hospital, there was a significant difference in anxiety scores between group 1 and group 2 ($p < 0.01$).

We also observed a significant ($p < 0.01$) drop in heart rate in group 1 after treatment. No significant change was noted in group 2. Upon arrival at the hospital, the difference in heart rate noted between group 1 and group 2 was significant ($p < 0.01$). There was no significant change in blood pressure in either group.

DISCUSSION

Low back pain patients calling for emergency transport usually suffer from severe pain and are not able to see the general practitioner without help. Any body movement—the transfer to the stretcher, the transport to the emergency vehicle via stairs or escalator, and the transport in the emergency vehicle itself, probably along rough roads—can aggravate the pain. In addition, the pain is usually accompanied by anxiety and the fear of possible disability. Therefore, early pain relief is of crucial importance.

The results of this trial suggest that TENS helps reduce pain in the acute phase of severe LBP. In our emergency study population, application of TENS resulted in a significant and clinically relevant reduction in pain. Anxiety was also reduced, as was the heart rate, indirectly suggesting the effectiveness of the TENS therapy. In summary, the TENS-stimulated patients benefited from TENS as an acute emergency intervention.

In Europe, paramedics are banned by law from using most IV drugs for pain treatment[10]; in the United States, there also are restrictions on pharmacologic pain treatment by paramedics.[11] Because of this, out-of-hospital patients often suffer unnecessary pain from the time they call for emergency transport and during transport, until they get to a physician and receive standard LBP medication.[5] This situation is uncomfortable for both the patient and the paramedic. Aside from this important emotional component, pain also provokes autonomic responses that markedly increase adrenergic neural activity and plasma catecholamine levels.[12] Increased heart rate, hypertension, and arteriolar vasoconstriction[13] are the result, and these can adversely affect elder and multimorbid patients on their way to the hospital.

Obviously, therefore, patients with acute LBP benefit from a rapid, safe, noninvasive, non-drug-based, and well-tolerated analgesic treatment during emergency transport that can be administered by nonphysicians. We have shown that TENS fulfills these criteria.

TABLE 3. Outcome Data after Transport

	Group 1 ($n = 30$)	Group 2 ($n = 33$)
Heart rate—mean ± SD	67 ± 10 beats/min	99 ± 7 beats/min*
Systolic blood pressure—mean ± SD	136 ± 23 mm Hg	144 ± 21 mm Hg
Diastolic blood pressure—mean ± SD	83 ± 14 mm Hg	87 ± 8 mm Hg
Pain score on VAS†—mean ± SD (95% CI)	49 ± 8 mm (43, 54)	77 ± 11 mm (73, 81)*
Anxiety score on VAS—mean ± SD (95% CI)	69 ± 12 mm (62, 75)	84 ± 9 mm (79, 81)*

*Values differ significantly, $p < 0.01$.
†VAS = visual analog scale.

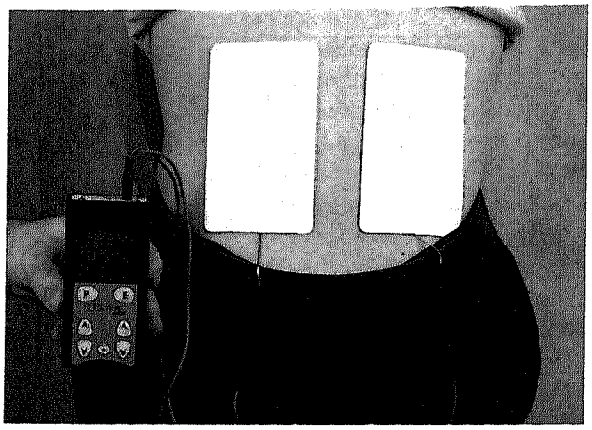

Figure 1. The transcutaneous electrical nerve stimulation (TENS) system.

Transcutaneous electrical nerve stimulation is a safe procedure and is contraindicated only in patients with implanted electronic devices such as pacemakers, cardiac defibrillators, or spinal cord or deep brain stimulators. The mechanism of action was originally thought to be a modification of pain perception via counterstimulation of the peripheral nervous system under the premise of the gate-control theory of pain.[14] Later investigations attributed the mechanism of pain relief to inhibiting nociceptive C-fibers through stimulating different A-fibers, depending on the amplitude of stimulation at segmental spinal cord levels.[15–17] Another possible mechanism of action is the activation of efferent inhibiting pathways from subcortical brain structures.[18,19] The release of endorphins through electrical stimulation plays an additional, important role in pain relief through TENS.[18,20] The efficacy of TENS has been discussed, controversially, for many years, especially since Deyo et al. and Hermann et al. found no additional benefit of TENS compared with a standard rehabilitation program in the treatment of acute as well as chronic LBP.[21,22] In contrast to these findings, Ordog proved that TENS was effective as a combination of acetaminophen and codeine in the treatment of acute traumatic pain.[9] For LBP, other authors found a significant pain improvement after TENS treatment compared with sham treatment.[6,7] A recent systematic Cochrane review of the limited data available found evidence that TENS reduced pain and improved the range of motion in chronic LBP patients, at least in the short term.[8]

We were encouraged to test the use of TENS during emergency transport by the findings of two studies that showed immediate pain relief after the use of a single application of TENS. Cheing and Hui-Chan used 60 minutes of single-shot TENS, compared with placebo stimulation, in chronic LBP patients and found the VAS score significantly reduced to 63% of the prestimulation value during treatment and up to one hour after treatment.[23] They found that 60% of patients had a reduction of >30% in VAS score. Similar results were achieved by Hsieh and Lee, who used 15 minutes of single-shot TENS in acute as well as chronic LBP patients, and demonstrated immediate pain relief with a 28% reduction in the pain score.[24]

LIMITATIONS

The study is limited to the acute-phase treatment of LBP. Whether this may be beneficial for any long-term outcome could be the aim of further investigation. It is without doubt that all these patients will require further therapy according to standard procedures for LBP.

CONCLUSIONS

We found TENS to be an effective and fast-acting therapy for patients with acute low back pain being transported by out-of-hospital personnel. Due to its simplicity and lack of side effects, this method should be considered in these patients.

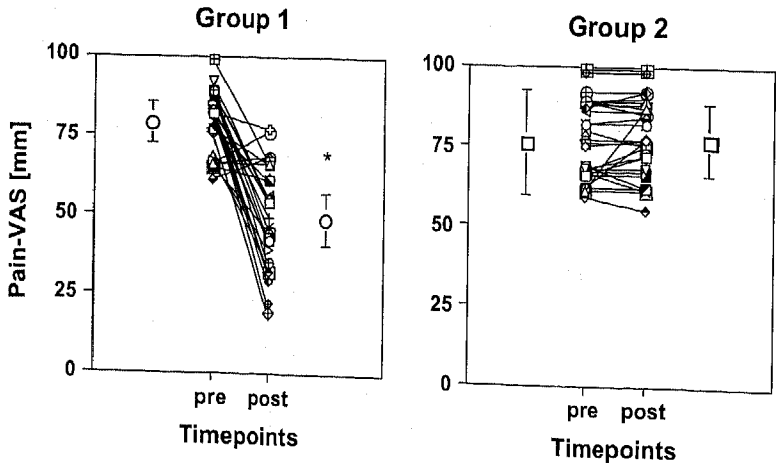

Figure 2. Individual and mean ± standard deviation pain scores pre- and posttreatment in group 1 (true TENS) and group 2 (sham TENS). TENS = transcutaneous electrical nerve stimulation; VAS = visual analog scale score. *$p < 0.01$.

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