Transcutaneous Electrical Nerve Stimulation at the Acupuncture Points to Relieve Pain of Patients Under Mechanical Ventilation: A Randomized Controlled Study

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Available online 20 July 2018

Abstract
Background and objective: Electrical stimulation and acupuncture points as nonpharmacological methods have been the focus of pain reduction in different patients. This study is aimed at determining the effects of transcutaneous electrical nerve stimulation (TENS) on the acupuncture points of pain in patients under mechanical ventilators.

Materials and methods: This randomized double-blind clinical trial study was conducted on 50 patients undergoing mechanical ventilation in intensive care units of Imam Reza hospital in Kermanshah, Iran, in 2017. The patients were randomly allocated into intervention and placebo groups. In the intervention group, TENS electrodes were placed on points Hegu and Zusanli. Pain severity was measured using the Care Pain Observation Tool scale, and the
1. Introduction

Critically ill patients, particularly those under intubation and mechanical ventilation (MV), often feel pain [1]. Pain is a common and distressing symptom of patients admitted to the intensive care unit (ICU). Pain can also be generated due to different causes. Unconscious patients experience pain related to invasive procedures, mechanical ventilation, and physical condition of the ICU [2]. For mechanical ventilation, it is well known that patients require adequate analgesics and sedatives because of painful or uncomfortable experiences in the course of treatment [3, 4].

Pain increases the activity of the neuroendocrine system and sympathetic tone with tachycardia, which in turn increases myocardial oxygen demand, suppresses the immune system, and increases coagulation and catabolism, motor constraints, pulmonary problems, and retardation in patients [5].

Current approaches to pain management include pharmacological agents (drugs) and a number of nonpharmacological agents. Analgesic and sedative medications are widely used to achieve patient comfort through pain elimination and tolerance of the ICU environment [6]. Most of the pharmacological interventions are restricted by their modest effectiveness or potential complications. In the ICU, analgesia and sedation drugs are complex due to several comorbidities, drug interactions, and organ dysfunctions [7]. Pain relief is essential for patients to ensure adequate recovery, and one of the main duties of the treatment team is relieving the pains of patients hospitalized in the ICU [8].

Transcutaneous electrical nerve stimulation (TENS) is a nonpharmacological method of analgesia. It is the application of electrical current through electrodes placed on the skin for pain control. On the other hand, transcutaneous electrical acupoint stimulation (TEAS), which is an alternative method of acupuncture, has been suggested by Xing et al [9]. Acupuncture, a physical intervention that involves the placement of small needles in the skin at different acupoints, has been practiced for thousands of years and is commonly used for the treatment of different types of pains [10, 11]. In recent years, acupuncture has rapidly developed and gradually become part of mainstream medicine, both in the West and globally [12]. The gate control theory, central endorphin, supraspinal serotonergic and noradrenergic descending projection systems, spinal γ-aminobutyric acid, and opioid neurotransmitters have been suggested as explanations for the apparent analgesic effect of acupuncture [13-15]. Acupuncture-point stimulation can be achieved using modalities such as electrical acupuncture [16]. Acupuncture therapy has been lauded as a promising alternative approach for pain relief [17].

TEAS is noninvasive as it does not involve the actual insertion of needles into the body and has comparable effects to acupuncture therapy [18]. Acupuncture and related techniques can be complementary or alternative to conventional sedatives, antiemetics, and analgesics for prophylaxis and treatment [19]. The application of acupuncture in combination with TENS to treat low back pain has been studied [20]. TEAS can reduce the consumption of intraoperative anesthetics and general anesthesia–related side effects [21]. There is growing research evidence to support the effectiveness and efficacy of acupuncture for the relief of numerous types of pain [22].

In recent times, various methods of pain relief have been investigated for patients in the ICU, but the study of TENS at the acupoints on the pain of these patients is lacking. The objective of this study was to assess the efficacy of TENS at the acupuncture points (Hegu and Zusanli) to relieve pain in patients under MV.

2. Materials and methods

This study was performed on patients with pneumonia under MV who were admitted to the ICU of Imam Reza hospital in Kermanshah, Iran, in 2017. This study is registered on IRCT.ir (Ref. No IRCT2016050927819N1) in the Iranian Registry of Clinical Trials.

2.1. Inclusion criteria

The inclusion criteria included having an endotracheal tube, being a pneumonia patient requiring MV devices, being aged between 30 to 50 years, having healthy skin in the electrode area, having systolic blood pressure greater than 100 mmHg, obtaining a nonzero surface on the Critical Care Pain Observation Tool (CPOT) scale, not having a history of smoking and drug addiction, not taking corticosteroid medications that affect pain, being a newly admitted patient in the ICU for less than 48 h, as well as having Glasgow coma scale (GCS) greater than 7.

2.2. Exclusion criteria

The exclusion criteria included having a cardiac pacemaker, being pregnant, having defective sensation, with extubation of the trachea tube during the study period, and dosages of narcotics and sedation intake were recorded. Data were analyzed using the Statistical Package for the Social Sciences (SPSS) software, version 19.

Results: The level of pain in patients decreased in the intervention group in comparison with the sham group, and this decline was significant during certain hours (p < 0.05). The amount of analgesic and sedation drugs used was less significant in the intervention group than in the sham group (p = 0.01; p = 0.04).

Conclusion: The results showed that the use of TENS on acupuncture points can decrease the level of pain and opioid consumption in intubated patients under a mechanical ventilator.
with the occurrence of any bad condition or complication during the examination.

2.3. Recruitment/randomization

Fifty patients who satisfied the inclusion criteria were randomized into two groups: treatment (real acupuncture) and placebo (sham acupuncture). The patients were then randomly divided according to even and odd numbers of patient’s record in two groups.

2.4. Study design

This randomized, double-blind, placebo-controlled clinical trial was performed on patients under MV. Neither the studied samples who had no previous history or familiarity with TENS nor the researcher was aware of the treatment group they were in (double blind).

The time of intervention for all patients was limited to 30 minutes, four times in 24 h. The TEAS-Sham group treatment followed the same protocol as the TEAS treatment, except the device was inactivated.

Two acupoints were selected for TEAS treatment after consultation with acupuncturists. These acupoints included LI4 (Hegu), on both the sides between the thumbs and fingers pointing between the first and second metacarpal bone joints, and ST36 (Zusanli), at four fingers lower than the knee to the outside [23, 24]. The LI4 and ST36 points in the body play a key role in controlling pain [25].

Patients with pain and agitation were given midazolam (2–3 mg/IV) and fentanyl (2 cc/IV) as directed by the physician. The amount of pain and sedation dosage were recorded every 2 h in the two groups.

2.5. Acupuncture intervention

In this study, the TENS treatment was carried out using a TENS device, ES-160 model (ITO CO, Tokyo, Japan). Acupuncture points were found by electrical stimulation using an acupoint finder. Each channel was then connected to a pair of electrodes with disposable rubber electrode pads (30 mm × 30 mm) placed at bilateral points. The device was set on continuous current, 1–10 Hz frequency, and 200 micrometer wavelength. The intensity at 5–10 microamps was adjusted to cause a maximum tolerable buzzing or pricking sensation without muscle contractions in patients.

2.6. Pain assessment

Pain was recorded by the researcher every 2 hours, during a 24-hour period in the two groups using a CPOT. The CPOT scale includes four behavioral indicators: facial expression, body movements, muscle tension, and compliance with the ventilator. Each item is scored from 0 to 2 for a possible total score ranging from 0 to 8 points [26].

Scoring the CPOT scale is as follows: A. Facial expression—relaxed: 0, tensed: 1, and grimacing: 2; B. Body movement—absence of movements or normal position: 0, protection: 1, and restlessness/agitation: 2; C. Compliance with the ventilator—talking in normal tone or no sound: 0, sighing/moaning: 1, and crying out/sobbing: 2; D. Muscle tension—relaxed: 0, tense/rigid: 1, and very tense or rigid: 2.

2.7. Statistical analysis

The data collected in the present study were analyzed using statistical package for the social sciences (SPSS) software, version 18. The qualitative results were reported at an absolute and relative frequency, whereas the quantitative results were expressed as mean ± standard deviation (SD). The data analysis was performed using the independent t test and repeated measures. The level of significance was set at \( p < 0.05 \).

2.8. Ethical consideration

This study was approved by the ethics committee of Kermanshah University of Medical Sciences (approval no. IR.kums.REC.1395.533). Written informed consent was obtained from the first-degree relatives, and they were assured of the anonymity and confidentiality of their information.

3. Results

The participants consisted of 28 (56%) males and 22 (44%) females. The mean and SD of their ages were 40.76 ± 5.42 and 42 ± 6.07 years in the intervention and sham groups, respectively. There was no significant difference between the two groups in age \( (p = 0.45) \). The degree of pain is shown at different hours in Table 1 and Chart 1. Table 2 shows the dosage of sedative and analgesic drugs.

In the sham group, the Greenhouse-Geisser test did not show a significant difference between the repeated measures of pain at different hours \( (p = 0.85) \). However, there was a significant difference between the repeated measures of pain in the intervention group \( (p < 0.001) \). These changes were significant at a linear decline \( (p < 0.001) \).

Regarding the research goals, the dosage of sedation (midazolam) and opioid (fentanyl) was compared in the two groups within 24 h, and the results are shown in Table 2.

4. Discussion

Pain in patients undergoing MV is one of the major challenges in the ICU and is capable of affecting the care and treatment needs of patients. This occurrence increases the stress of hospital staff and results in various side effects.

The findings revealed that the use of TEAS method resulted in a decrease in pain and usage of opioid and sedation drugs in ICU patients without any side effects. Pain relief and efficacy improved with increasing frequency of TEAS usage (Table 1).

Peng et al reported the results of their research that the application of TENS on acupuncture points only reduced labor pain [27]. Fox et al used the combination of TENS and acupressure for back pain and found that the combination of TENS and acupressure had better results than either alone [28]. Chen et al reported that the electric stimulation
The results of the present study are similar to those of the study by Zheng et al in which electroacupuncture can noticeably reduce the midazolam dosage required in critically ill patients with MV [30]. In this study, surface electrostimulation of LI4 and ST36 points was used. These points were used for sedation and anxiety relief [31]. These points are easy to locate and convenient to use in the ICU [32]. The results of the study by Feeny et al showed that most patients reported a benefit from acupuncture on symptoms of pain and an anxiolytic effect in the ICU, and in addition, there was a significant decrease in morphine usage after each treatment [33]. These findings are in fact consistent with those of the present study.

Based on the data obtained in the present study, analgesic use was significantly less in the experimental group than in the placebo group. Thus, the finding in the present study is consistent with the results of the study by Borup et al in which acupuncture reduced the need for analgesic drugs and invasive methods for pain relief [34].

In a study of the effectiveness of acupuncture in treating pain in a military cohort study, at a United States Air Force medical center, it dramatically decreased the use of opiates and other pain medications among personnel [35].

The TEAS is a combination of TENS and traditional Chinese acupuncture. Compared with electroacupuncture, TEAS has no risk of broken needles, low occurrence of procedural pain, and contamination. Electroacupuncture blocks pain by activating a variety of bioactive chemicals through peripheral, spinal, and supraspinal mechanisms such as the prompt release of β-endorphin and met-enkephalin [36, 37]. Corticotropin-releasing factor and prostaglandin E2 are also involved in electroacupuncture analgesia [37]. The effectiveness of acupuncture for pain management has been strongly verified by large randomized controlled trials (RCTs) and meta-analyses. Consequently, an increased number of patients with pain have accepted acupuncture treatments globally [38].

In addition, different points of acupuncture for pain control have been introduced. According to the results of previous studies, two points LI4 and ST36 could be more commonly used in these patients. The Food and Drug Administration released proposed changes to its opioid prescription guidelines in early May 2017. The guidelines
now recommend that doctors become informed about nonpharmacological options for pain control to prevent the overuse of opioids [39]. It systematically summarizes the evidence of the clinical benefits of acupuncture in treating different pain conditions and provides an overview of some of the basic science underlying its mechanisms in pain management [40].

In conclusion, according to the results proven in this study, acupuncture in patients who underwent MV recorded reduced pain severity and opioid requirement. Proper analgesia is the important adjunct therapy for critically ill patients in the ICU, especially for those with MV, but using TENS in the same typical treatment protocol as in acupuncture treatments may be as effective as invasive acupuncture in pain management.

Disclosure statement

All authors played an equal role in the design, data collection, statistical analysis, and manuscript writing. The authors declare no conflict of interest.

Acknowledgments

This study was approved by the research councils of Kermanshah University of Medical Sciences (No 95690). The authors also express their gratitude to the nurses who helped in conducting this study.

References


