Effects of Cathode Direct-Current Electroacupuncture Stimulus of the Proximal Anterior Lower Limbs on Heart Rate and Lumbar Blood Flow

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ABSTRACT

Objective: There has been little research on direct-current acupuncture. This study was conducted to verify the effect of acupuncture current intensity and polarity on heart rate (HR) when applying direct-current electroacupuncture (DCEA) to the proximal anterior part of the lower limbs and to clarify the effect of cathodes (–) on lumbar blood flow.

Materials and Methods: This study was conducted at Teikyo Heisei University, Chiba, Japan. The subjects were 144 healthy male volunteers (21.7 ± 0.6 years' old). These participants were divided into 1 control, 1 manual acupuncture (MA), and 3 DECEA groups ($-25 \mu\text{A}$, $+75 \mu\text{A}$, and $-75 \mu\text{A}$). Acupuncture was performed on the lower limbs (at ST 36), and HR and intertissue blood flow (ITBF) were observed as the main outcome measures.

Results: For intensity, HR was significantly lower in the $-75 \mu\text{A}$ group than in the control ($P < 0.001$), MA ($P < 0.001$), and $-25 \mu\text{A}$ ($P < 0.01$) groups. For polarity, HR was significantly lower in the $-75 \mu\text{A}$ group than in the $+75 \mu\text{A}$ group ($P = 0.0028$). For blood flow, the volume of HbO_2 in the L-4–L-5 region at 1 minute after stimulation was significantly higher in the $-75 \mu\text{A}$ stimulus group than in the MA group ($P < 0.05$). There was no change in the T-7–T-8 region.

Conclusions: A $-75 \mu\text{A}$ stimulus to ST 36 reduced HR and increased ITBF.

Keywords: acupuncture, electroacupuncture, electrode, heart rate

INTRODUCTION

IN CLINICAL PRACTICE, an acupuncture stimulus appears to improve local blood flow. It has been shown that acupuncture stimulation elevates an increased blood-flow response to the skin and muscle in a stimulus-intensity-dependent manner.¹ Stomach 36 (ST 36)² is commonly used as the site of the acupuncture therapy stimulus. This point is located below the knee, on the anterior surface of

the lower limb.² The stimulus site and the lumbar region are both associated with the same spinal-cord segment, and functional magnetic resonance imaging data has shown that ST 36 is one of the segment's most effective acupuncture points.³ This relationship between the spinal-cord segment and the visceral somatic reflex has been demonstrated. However, the effect of improved lumbar blood flow due to an acupuncture stimulus has not been verified in humans.

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As shown in previous studies⁴ and clinical practice in the context of lower-back pain (LBP), ST 36 stimulation can help alleviate LBP by increasing blood flow to L-4–L-5. Local blood flow increases with vasodilation.⁵ Sympathetic nerve fibers⁴ and vasodilators are also involved in the expansion of blood vessels.⁵ As such, the vasodilation response in L-4–L-5 might be caused by the axonal reflex and the somatic sympathetic reflex.

In studies investigating the blood-flow increase response due to manual acupuncture (MA), examinations have been conducted separately for muscles, skin, and nerves. Previous studies¹ have examined the relationship between sympathetic nerves and local muscle blood flow (MBF) resulting from MA. In MBF, as the discharge of noradrenaline (NA) increases, blood vessels with $\alpha 1$ -receptors contract, and blood flow decreases. The $\beta 2$ -receptors cause blood vessels to dilate and increase blood flow.⁶ MBF increases as a result of electroacupuncture (EA); however, the finding that EA ceases to cause an MBF response after excising the sympathetic nerve fibers and the bilateral lumbar vertebra sympathetic trunk suggests that increased MBF with EA is related to sympathetic nerve fibers.⁷

The relationship between an increased MBF response and MA has also been investigated with regard to the axonal reflex, in which local blood flow increases as the result of vasodilation.⁵ In previous studies, the increased blood-flow response has been shown to involve vasodilators from the axonal reflex.⁸ Administration of capsaicin eliminates the increased blood-flow response to MA; therefore, the neurotransmitter associated with the increased MBF response may be calcitonin gene-related peptide (cGRP)⁸ or substance P.⁹ Local skin blood flow (SBF) also shows an increased response to EA, although this response might also result from the increase in cGRP and substance P due to the axonal reflex.⁹

Direct-current EA (DCEA) is a form of acupuncture in which a small (direct) electric current is passed between pairs of acupuncture needles.¹⁰ The direction of the charge and the polarity change in alternating current EA (ACEA), but they do not change in DCEA; this enables examination of the effect of polarity on tissues. The reported effects of polarity on tissues include nerve regeneration and bone fusion.^{11,12} Polarity is expected to become an important element of future EA research.

To date, clinical practice using DCEA has been conducted empirically, with few objective indicators. The present study used heart rate (HR) to investigate the responsiveness of autonomic nerves to DCEA. HR measurement enables quantitative evaluation of autonomic nervous system (ANS) activity in humans and animals. In the reduction of HR, the afferent nerves involved in stimulating ST 36—which reflects stimulation of the sympathetic and parasympathetic nerve fibers—travel from the subcutaneous deep fibular nerve or sensory area of the lateral cutaneous nerve of the calf (which might be a nociceptor with

the sciatic nerve as an afferent nerve) and up the spinothalamic tract from the posterior horn of the spinal cord to reach the brainstem.¹³ Efferent nerves contain the neural pathways by which the cardiac vagus nerve (i.e., the cardiac parasympathetic nerve) reduces HR via the medulla oblongata and the neural pathways of the cardiac sympathetic nerve that control HR with NA. This occurs after the stimulation travels from the spinal cord by sympathetic nerve presynaptic fibers to the sympathetic nerve ganglia (e.g., superior cervical ganglia, medium cervical ganglia, and inferior cervical ganglia), and, finally, to the post-synaptic fibers.¹³

The HR-reduction response due to MA stimuli might involve the cardiac sympathetic nerve and vagus nerve (i.e., the cardiac parasympathetic nerve). This has been shown by administration of propranolol and atropine.⁷ In ACEA, power-spectrum analysis of the frequency component of the periodic fluctuation of HR indicates involvement of the sympathetic and parasympathetic nerves.¹⁴

This study was conducted to verify the effect of EA current intensity and polarity on HR when applying DCEA to the proximal anterior part of the lower limbs and to clarify the effect of cathodes on lumbar blood flow.

MATERIALS AND METHODS

Acupuncture Rationale

The participants were 144 healthy male volunteers (21.7 ± 0.6 years' old). The exclusion criteria were: smoking or taking any medication within the previous month; consuming alcohol the day before the study; consuming caffeinated beverages such as coffee or tea on the day of the study; and ingesting food 2 hours before the study. Measurements were obtained between 11:00 AM and 5:00 PM at room temperature ($\sim 23^{\circ}\text{C}$ – 25°C). Before the experiment, participants were acclimated for 15 minutes. During the experiment, participants were instructed to relax and minimize emotions that could interfere with evaluations of the responsiveness of their autonomic nerves. The stimulus point for the acupuncture intervention was Stomach 36 (ST 36), located on the proximal anterior part of the lower limb.²

Needling Details

Stainless-steel needles, measuring 40 mm in length and 0.25 mm in diameter (SEIRIN[®] acupuncture needle, white tube M type, No. 5; SEIRIN, Inc., Shizuoka, Japan), were inserted to a depth of 10 mm. This depth, at ST 36, extends from the epidermis to the hypodermis of the anterior tibial muscle. For electrodes, the aforementioned acupuncture materials on the right ST 36 and a conductive adhesive manufactured by 3M Co. (Reddad[™] electrocardiogram test electrode; 3M Japan Ltd., Inc., Tokyo, Japan) were affixed to the front central point of the right forearm. Direct electric

current was supplied using an electrical-stimulus device (Neurosofter DS 208; Ryodoraku Institute, Inc., Tokyo, Japan). An electrical current to the stainless steel needle and the site of the conductive adhesive was supplied for 5 minutes by an electric wire. After investigating the responsiveness of the autonomic nerve to the intensity of the DCEA stimulus, the effect of differences in DCEA polarity on HR were examined. Using these results, the intervention stimulus was determined, which was used to examine the effect of cathodal DCEA stimulation on lumbar blood flow to the proximal anterior regions of the lower limbs.

Treatment Regimens

The measured responses of the ANS were expressed as beats per minute (bpm). Sixty-four healthy male volunteers were selected (21.9 ± 1.7 years' old) to examine if the intensity of stimulation at the ST 36 acupoint influenced their HR. Four groups were established: (1) a control group ($n=16$); (2) an MA group ($n=16$); (3) a $-25 \mu A$ group ($n=16$); and (4) a $-75 \mu A$ group ($n=16$). DCEA was performed as the intervention stimulus. As several participants in a preliminary experiment reported discomfort at $100 \mu A$, $75 \mu A$ was chosen as the strong stimulus, which did not cause any discomfort; $25 \mu A$, one-third of $75 \mu A$, was chosen as the weak stimulus.

After investigating the responsiveness of the autonomic nerves to the intensity of the DCEA stimulus, it was explored if differences in DCEA polarity could affect HR. With these results, the intervention stimulus was determined, which was used to examine the effect of cathodal DCEA stimulation to the proximal anterior region of the lower limbs on lumbar blood flow.

To examine if differences in polarity of the DCEA stimulus at ST 36 influenced the HR, 16 other healthy participants (21.2 ± 0.6 years' old) were selected. Based on the results of HR response to the strength of the stimulus, DCEA $75 \mu A$ was selected as the stimulus. Participants were randomly assigned to the cathode ($-75 \mu A$ group ($n=8$)) and the anode ($+75 \mu A$ group ($n=8$)). The same experimental protocol was used.

To measure the effect of DCEA on the cardiac sympathetic nerves, participants underwent an electrocardiogram using a disposable electrode for measurement (Vitrode Bs 150; Nihon Kohden, Inc., Tokyo, Japan). To examine if the intensity of the stimulus influenced lumbar blood flow, 64 additional healthy individuals (21.7 ± 0.6 years old) were allocated to an MA group ($n=16$), or a DCEA $-75 \mu A$ group ($n=16$) to investigate blood flow in the L-4–L-5 region, and an MA group ($n=16$) or a DCEA $-75 \mu A$ group ($n=16$) to investigate blood flow in the T-7–T-8 region.

Other Components of Treatment

The limb position for measurement was determined by placing the individual in the left lateral decubitus position

for 15 minutes and checking the stabilization of the blood flow. The blood flow was then measured for a 5-minute rest period, a 5-minute intervention period, and a 5-minute post-intervention period. Near-infrared spectroscopy was used to measure the optical density (OD) of oxygenated hemoglobin (HbO_2) as an index of blood flow. The converted value was then determined, based on the amount of HbO_2 . Ideally, the individual should maintain the posture during HbO_2 measurement. In order not to cause discomfort, the experimental period was set at ~ 30 minutes. In addition, the intervention stimulus was set as $-75 \mu A$, based on the results of the effect of differences associated with DCEA intensity and polarity.

Intertissue blood flow (ITBF) in the lumbar paraspinal region was measured at 2 cm outside of L-4–L-5 and at 3 cm below the epidermis. For comparison, blood flow was also measured at the T-7–T-8 region. For the measurement, a near-infrared laser light device (BOM—L1 TRW; Omega Wave, Inc., Tokyo, Japan) was set at a depth of 30 mm. The converted value for the amount of HbO_2 was determined by measuring the OD; therefore, HbO_2 was measured noninvasively.

Participants were affixed with a probe (laser-light irradiation; Omega Wave, Inc.) and light detector (Omega Wave) at 2 cm on either side of L-4–L-5 and T-7–T-8. After a 15-minute acclimatization period, HbO_2 was measured during the 5-minute rest, intervention, and postintervention periods. Data were processed using blood-flow analysis software (AD Instruments PowerLab 16/30; Bio Research Center, Inc., Tokyo, Japan).

Practitioner Backgrounds

All researchers who contributed to this study have more than 30 years of clinical experience, as well as experience in academic research.

Control or Comparator Interventions

HR was recorded at rest (control) and during the intervention using a Marquette Holter recorder (LRR-03; GMS, Inc., Tokyo, Japan). HR data were processed using HR analysis software (Crosswell, Inc., Tokyo, Japan).

Statistical Analysis

All data reflected the changes in values relative to the preintervention measurements and were expressed as mean $\pm$ standard deviation (SD). The effect of DCEA intensity on HR was analyzed in each group using a 1-way analysis of variance (ANOVA). The effect of DCEA polarity difference on HR was analyzed using Wilcoxon's signed-rank test. Comparison of the effect of DCEA on blood flow was analyzed using a 2-way ANOVA. SPSS Statistics 19.0.0 (SPSS; IBM Inc., Tokyo, Japan) was used for statistical analysis.

Ethical Approval

The study design was approved by the Teikyo Heisei University (Chiba, Japan) Ethics Review Committee (approval number: 27-067-1) and implemented according to the provisions of the Declaration of Helsinki. All study participants provided written informed consents.

RESULTS

Effect of Differences in DCEA Intensity on HR

A comparative examination of the four groups with regard to the effect of DCEA at ST 36 on HR revealed significant differences between the $-75\ \mu\text{A}$ group and the control group ($P < 0.001$) and the MA group ($P < 0.001$) and the $-25\ \mu\text{A}$ group ($P < 0.001$). HR was reduced in the $-25\ \mu\text{A}$ group, compared with the control group ($P < 0.01$; Fig. 1).

The Effect of Polarity Differences in DCEA $75\ \mu\text{A}$ on HR

When comparing the stimuli to ST 36 in the $-75\ \mu\text{A}$ group and in the $+75\ \mu\text{A}$ group, HR was significantly reduced in the $-75\ \mu\text{A}$ group, compared to the $+75\ \mu\text{A}$ group ($P = 0.0028$; Fig. 2).

FIG. 1. The measured heart rate (HR) values and change in HR values for each group of 16 participants. The vertical axis shows the change in HR values relative to the preintervention values. The HR value at rest is compared with the control group (5-minute rest). The manual acupuncture (Manual) group (5 minutes of manual acupuncture to ST 36), $-25\ \mu\text{A}$ (direct current electroacupuncture [DCEA]-25) group (5 minutes of $-25\ \mu\text{A}$ EA), and $-75\ \mu\text{A}$ (DCEA-75) group (5 minutes of $-75\ \mu\text{A}$ EA); 2 groups were compared at a time. The data are presented as mean $\pm$ standard deviation. A 1-way analysis of variance was conducted. * $P < 0.05$; ** $P < 0.01$. bpm, beats per minute. ST 36, Stomach 36.

FIG. 2. Comparison of heart rate (HR) measurement values and change in HR values for each group of 8 participants. The vertical axis shows the change in HR values relative to the preintervention values. The graph shows the comparison of the changed HR values at 5 minutes after the application of electroacupuncture (EA) current to the direct-current EA (DCEA) $+75\ \mu\text{A}$ group ($n = 8$) and DCEA $-75\ \mu\text{A}$ group ($n = 8$) in acupuncture to ST 36. The data are presented as mean $\pm$ standard deviation. The analysis was conducted using Wilcoxon's signed-rank test. * $P < 0.05$. bpm, beats per minute; ST 36, Stomach 36.

The Effect of $-75\ \mu\text{A}$ on Lumbar Blood Flow

A comparative examination of blood flow response at L-4–L-5 to the intervention stimulus at ST 36 showed a significant difference in the amount of HbO₂ between the $-75\ \mu\text{A}$ and MA groups ($P < 0.05$). In addition, the $-75\ \mu\text{A}$ group showed an increase in HbO₂ at rest and at 1 minute after the intervention. This increased response persisted even during rest after the intervention ($P < 0.05$; Fig. 3)

The T7-8 region showed no significant difference between the 2 groups with regard to the amount of HbO₂ (Fig. 4).

DISCUSSION

Acupuncture stimulation might activate free nerve endings and local cells—such as mast cells, fibroblasts, macrophages, lymphocytes, and keratinocytes—all of which release bioactive factors—such as neurotransmitters; neuromodulators; hormones; cytokines; and inflammatory factors, such as substance P, cGRP, histamine, serotonin (5-hydroxytryptamine), interleukin (IL)-1, IL-4, IL-6, IL-8, tumor necrosis factor- α , and prostaglandin. These factors could, directly or indirectly, affect and influence their neural receptors, target cells, or tissues locally and systematically.^{15–18}

FIG. 3. Continuous measurement value for the amount of HbO₂ as a marker of blood flow in L-4–L-5 by direct current electroacupuncture (DCEA) to ST 36. The vertical axis shows the change in values for HbO₂ (a converted value) for each group of 16 subjects. Data for the manual acupuncture (Manual) and 75 μ A groups, obtained at rest, during the 5-minute intervention to the ST 36 acupoint ($\leftarrow \rightarrow$; during intervention), and during the 5-minute postintervention time, are shown. The data are presented as the 1-minute average $\pm$ standard deviation. A 2-way analysis of variance was conducted. * $P < 0.05$. HbO₂, oxygenated hemoglobin; ST 36, Stomach 36.

In the present study, ST 36 was selected as the intervention stimulation site because it is used frequently in acupuncture and has been used in previous research.⁴ The -75μ A group had a marked decrease in HR, compared to that of other groups. Previous studies have revealed that MA stimulation reduces the HR response due to a somatic cardiac autonomic nerve reflex.¹³ In addition, it has been shown that, as the amount of the stimulus' electric current increases, the compound nerve action potential also in-

creases.¹⁹ These results suggest that the -75μ A stimulation induced the somatic cardiac autonomic reflex strongly (conceivably reducing the HR), even more than MA and -25μ A stimulation.

The polarity (i.e., DCEA- and DCEA+) at 75 μ A intensity was compared. As acupuncture cathodes have an empirical effect in clinical practice, the current authors believed that a difference in the responsiveness of the autonomic nerve function might arise between the acupuncture cathodes and

FIG. 4. Continuous measurement value for the amount of HbO₂ as a marker of blood flow to T-7–T-8 by direct current electroacupuncture (DCEA) to ST 36. The vertical axis shows the change in values for HbO₂ (a converted value) for each group of 16 participants. Data for the manual acupuncture (Manual) and 75 μ A groups, obtained at rest, during the 5-minute intervention to the ST 36 acupoint ($\leftarrow \rightarrow$; during the intervention), and during the 5-minute postintervention time, are shown. Data are presented as 1-minute average $\pm$ standard deviation. A 2-way analysis of variance was conducted. n.s., not significant; HbO₂, oxygenated hemoglobin; ST 36, Stomach 36.

anodes. As expected, the HR-reduction response was greater for acupuncture cathodes than for anodes. Nerves were activated as the amount of electric current stimulus increased. Given that the compound nerve action potential increased in an intensity-dependent manner, afferent nerves could be more responsive to the polarity of cathodes than to that of anodes.

On investigating the effect of $-75\ \mu\text{A}$ stimulation to ST 36 on lumbar blood flow, it was found that $-75\ \mu\text{A}$ increased the amount of HbO_2 in the L-4–L-5 region more than MA did. The β_2 -receptors in blood vessels dilate the vessels through NA, which causes increased blood flow.⁶ In addition, an increased MBF response might be caused by sympathetic nerve fibers.²⁰ Therefore, it is conceivable that the $-75\ \mu\text{A}$ stimulation to ST 36 activated the sciatic nerve, thereby inducing the secretion of NA from the L-4 sympathetic-nerve postsynaptic fibers, which then bonded with β_2 -receptors in the blood vessels and caused the blood vessels to dilate.

Moreover, in studies on the axonal reflex, MBF was increased by an electrical stimulus.²¹ The SBF was increased by an axonal reflex induced by EA stimulation.⁹ Based on these facts, it is conceivable that $-75\ \mu\text{A}$ stimulation causes vasodilation by activating the antidromic fibers or sympathetic nerves (or both) of the spinal nerve in the L-4–L-5 region to release vasodilators. Regarding the fact that $-75\ \mu\text{A}$ increased blood flow to a greater extent than MA, it is possible that the somatic autonomic nerve reflex occurred more prominently with $-75\ \mu\text{A}$ stimulation than with MA.

The increased blood flow response persisted even after the stimulation ended. After the EA stimulus, the increased MBF response persisted for 3–15 minutes. This response is caused by cGRP.⁸ In addition, the response of the vasodilator substance P can last for 30 minutes;⁹ therefore, the persistence of vasodilation by vasodilators can be terminated even after stimulus with $-75\ \mu\text{A}$. Stimulation with $-75\ \mu\text{A}$ might have sustained the increased blood flow until 5 minutes after the stimulation ended.

In this study, no increase occurred in the ITBF in the measurement area around T-7–T-8 in response to $-75\ \mu\text{A}$ or MA stimulus to ST 36. It is conceivable that this result reflected a difference in the segment being measured.

It would be interesting to see how long the increase in the amount of HbO_2 persists. However, measurements in this study lasted for ~ 30 minutes. To obtain accurate measurements, it was necessary for each participant to hold the same posture for at least 30 minutes, until the values returned to the prestimulus level. The measurement of HbO_2 is prone to errors because of posture changes. However, holding the same posture for at least 30 minutes can cause discomfort for study participants. Determining how long the elevation of HbO_2 persists remains a task for future consideration.

ST 36 was chosen as the stimulus point in this study. Previous research had shown that ST 36 elicited a stronger

response to stimulation than other points, including those in the same innervation zone.²² Therefore, the current authors cannot deny the possibility that the results presented in this study are exclusive to ST 36. Future studies should focus on verifying if differences exist between ST 36 and other points in the same innervation area.

Determining whether the same response occurs in other sensory areas remains to be studied. Moreover, clarifying whether the effect on vasodilation is a sympathetic reflex or an axonal reflex will require verification through animal studies using propranolol and capsaicin.

It has been suggested that acupuncture stimulation to ST 36 affects the distal central nervous system.^{3,22} This study also examines the distal part of the insertion site, depending on the method of acupuncture stimulation.

DCEA has been used in clinical practice since the 1950s. However, few objective indicators exist that show the effects of DCEA on autonomic nerves. This study objectively demonstrated the effect of DCEA on autonomic nerves. DCEA does not change the polarity or the direction of current at the time of EA. The vast majority of EA devices are square-wave pulse generators of variable frequencies. The effects of a square-wave pulse generator on autonomic nerves might differ from those of ACEA, and future studies should compare direct current, low-frequency, and high-frequency square-wave pulse inputs. Nevertheless, information on the relationship between DCEA and LBP is lacking. In this study, ST 36 was used as the intervention stimulation site because it is widely used in clinical practice. Information regarding the impact of intervention on the cardiac ANS and blood flow in the lumbar and back areas will be useful for patients undergoing acupuncture and medical treatment.

CONCLUSIONS

Stimulus of $-75\ \mu\text{A}$ to ST 36 reduced HR and increased ITBF at the measurement site 2 cm outward from L-4 to L-5 and 3 cm beneath the epidermis after the stimulus. The increased blood-flow response persisted for 5 minutes after stimulation ended. These results provided empirical evidence regarding DCEA and stimulation site selection.

Although there is a difference in the influence exerted on the anode and cathode when energizing the human body,^{23,24} this study showed differing results depending on the energizing polarity. Thus, further studies are needed to clarify this polarity dependence and to understand the effect of EA.

ACKNOWLEDGMENTS

The authors would like to thank Editage for English-language editing and publication support.

AUTHOR DISCLOSURE STATEMENT

No competing financial interests exist.

FUNDING INFORMATION

This research received no specific grants from any funding agencies in the public, commercial, or not-for-profit sectors.

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Article learning objectives: After studying this article, participants should be able to recognize some important elements of research on electroacupuncture; discuss some of the research evidence on the physiologic effects of acupuncture on tissue blood flow; and evaluate and criticize electroacupuncture research with an understanding of the role that polarity of charge may contribute to the physiologic effects of this therapy.

Publication date: March 10, 2020

Expiration date: April 30, 2021

Disclosure Information:

Authors have nothing to disclose.

Richard C. Niemtzow, MD, PhD, MPH, Editor-in-Chief, has nothing to disclose.

Questions:

1. Please identify the **correct** statement:
 - a. In this paper, the authors present significant results that direct current electric acupuncture stimulus of $-75\ \mu\text{A}$ to ST 36 reduced heart rate and increased inter-tissue blood flow.
 - b. In this paper, the authors present significant data that $-75\ \mu\text{A}$ of direct current electric acupuncture stimulus to ST 36 influenced the pain inhibitory system and caused transient changes in sciatic nerve blood flow.
 - c. In this paper, the authors present significant observations that direct current electric acupuncture stimulus of $-75\ \mu\text{A}$ at ST 36 promote peripheral nerve regeneration and improve microcirculation.
 - d. In this paper, the authors present significant results that $-75\ \mu\text{A}$ of direct current electric acupuncture stimulus to ST 36 induces release of substance P and calcitonin gene-related peptide from peripheral terminal of primary sensory neurons.
 - e. In this paper, the authors presented significant results that cathode direct current electric acupuncture stimulus of $-75\ \mu\text{A}$ to ST 36 increase sensory neuropeptides and improves neuronal morphology in the spinal cord at L4.
2. According to the research article, all of the following statements are true about the cathode direct current electroacupuncture **EXCEPT** (choose one):
 - a. Direct current acupuncture significantly lowered heart rate at $-75\ \mu\text{A}$ stimulus as compared to manual stimulation.
 - b. Direct current acupuncture promoted significantly lower HR in the $-75\ \mu\text{A}$ group than in the $+75\ \mu\text{A}$ group.
 - c. Direct current acupuncture has a significant greater effect on increasing blood flow in the L4-5 region at 1 minute after stimulation of $-75\ \mu\text{A}$ as compared to $+75\ \mu\text{A}$.
 - d. Direct current acupuncture at $-75\ \mu\text{A}$ increased blood flow at L4-5 but had no change at T7-8 region.
 - e. Direct current acupuncture at $-75\ \mu\text{A}$ significantly lowered heart than compared to groups stimulated with $-25\ \mu\text{A}$.
3. The authors suggest in their study (choose one):
 - a. That the vast majority of electroacupuncture devices used by clinicians are direct current electroacupuncture devices.
 - b. That direct current acupuncture of a $-75\ \mu\text{A}$ stimulation strongly induces the somatic cardiac autonomic reflex and reduces the heart rate through this effect.
 - c. That direct current acupuncture stimulation of ST 36 affects the distal central nervous system.
 - d. That the direct current electroacupuncture has been used in clinical practice since 1950's and therefore, the medical literature provides many articles on its usefulness in clinical practice.
 - e. That direct current electroacupuncture study reveals no difference in energizing the human body with either an anode or cathode stimulus.
4. All are true statements about Direct Current Electric Acupuncture **EXCEPT** (choose one):
 - a. Direct current electric acupuncture is expected to become an important element of future research in electric acupuncture.

- b. Direct current electric acupuncture enables the researcher to study the physiologic effects of polarity on tissues.
 - c. Direct current electric acupuncture is a form of acupuncture in which small direct electric currents are passed between a pair of acupuncture needles.
 - d. Direct current electric acupuncture creates a charge that changes in polarity and direction.
 - e. Direct current electric acupuncture techniques have been used in studying the effects of polarity on nerve regeneration and bone fusion.
5. After reading this article, a clinician when comparing the effectiveness of electric acupuncture in various clinical studies should be cognizant of the following readily quantifiable electric stimulation parameters EXCEPT (choose one):
- a. polarity of the stimulus
 - b. frequency of the stimulus
 - c. duration of the stimulus
 - d. intensity of the stimulus
 - e. color source of the stimulus

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Articles in *Medical Acupuncture* will focus on acupuncture research through controlled studies (comparative effectiveness or randomized trials); provide systematic reviews and meta-analysis of existing systematic reviews of acupuncture research and provide basic education on how to perform various types and styles of acupuncture. Participants in this journal-based CME activity should be able to demonstrate increased understanding of the material specific to the article featured and be able to apply relevant information to clinical practice.

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