Pharmacogn J. 2024; 16(3): 670-676
A Multifaceted Journal in the field of Natural Products and Pharmacognosy
www.phcogj.com

Research Article

A Study is Examining How Postpartum Pain after Cesarean Section (SC) Can be Reduced by Boosting Levels of β-endorphin Through Electroacupuncture Stimulation at The Specified Points LI4 and SP6

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ABSTRACT

Background: The physical healing process following a cesarean section surgery can induce anxiety and physiological stress due to wound pain, potentially impairing patient mobility and necessitating the administration of analgesic therapy. Pharmacological treatment sometimes proves insufficient or contraindicated for postpartum cesarean section patients, highlighting the need for non-pharmacological alternative therapies. **Objective**: This study aims to investigate the impact of electroacupuncture (EA) stimulation at specific points SP6 and LI4 using frequencies of 30, 50, and 100 Hz on reducing pain intensity and increasing levels of the hormone β-endorphin in postpartum cesarean section patients. **Method**: In this research, 144 postpartum cesarean section participants meeting inclusion criteria are divided into 8 groups, comprising intervention and control groups, utilizing a randomized control trial (RCT) technique. Pain intensity is measured using the pain numeric rating scale (PNRS), while levels of β-endorphin are analyzed through blood samples using the enzyme-linked immunosorbent assay (ELISA) method to compare outcomes before and after intervention. **Result:** The analysis of the intervention group receiving electroacupuncture at specific points LI4 and SP6 has demonstrated effectiveness in reducing pain by increasing levels of the hormone β-endorphin, in comparison to the control group, with significant findings. **Conclusion**: The findings of this study show that electroacupuncture intervention in postpartum cesarean section patients can stimulate an increase in β-endorphin hormone levels and effectively reduce postpartum cesarean section pain intensity.

Keywords: Electroacupuncture, LI4, SP6, Postpartum, Cesarean section.

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History

- Submission Date: 17-05-2024;
- Review completed: 13-06-2024;
- Accepted Date: 17-06-2024.

DOI : 10.5530/pj.2024.16.112

Article Available online

http://www.phcogj.com/v16/i3

BACKGROUND

Cesarean sections may result in issues like postoperative discomfort due to alterations in tissue continuity following surgery. A study involving 300 patients revealed that 86% experienced postsurgical pain, with 75% reporting moderate-to-severe pain and up to 74% experiencing discomfort after discharge.[1] The discomfort may result in early mobilization and lactation issues [2].

Post-cesarean section pain poses challenges to maternal mobility, necessitating the administration of analgesic therapy. Pharmacological interventions often result in allergies and complication.[3]The associated side effects prompt the exploration of non-pharmacological treatments, known for their low side effects, cost-effectiveness, and ease of implementation, as an alternative for managing post-caesarean section patients.[4]Various interventions, including massage, distraction techniques, relaxation techniques, aromatherapy, and herbal remedies, have proven highly effective in alleviating anxiety and pain.[5]

Non-pharmacological techniques have been developed to address pain, with acupuncture being one such option for decreasing or eliminating pain with safety, minimal side effects, and ease of use, thereby potentially reducing narcotic use by up to 80%.[6] The mechanism of action of acupuncture at local, segmental, and central levels involves the stimulation of the hypothalamus-pituitary axis through needle insertion, resulting in the secretion of endogenous opioids, namely oxytocin and β-endorphin, into the bloodstream and brain fluid.[7]

Electroacupuncture (EA) is a needle stimulation technique that utilizes electricity and has been proven effective as a complement therapy to treat postoperative pain.[8–10] EA interventions have been proven effective in reducing pain, cumulative opioid use, and opioid-related side effects. Previous clinical research on animals has indicated that electroacupuncture analgesia plays a crucial role in endogenous opioid release, with low frequency (2 Hz) being highly effective in triggering endorphin release.[11,12] Electroacupuncture has the potential to serve as an adjuvant to mitigate opioid-related side effects during the postoperative period.[13,14] Previous research studies have confirmed that electroacupuncture therapy in the perioperative is safe and effective in reducing analgesic requirements and postoperative morbidity.[15,16]

The Hegu point (LI4) is considered the crucial acupuncture point on the human body. Stimulation at this point can alleviate pain in any part of the body, as there is a greater flow of energy closer to the skin's surface, and it can be easily stimulated by needle pressure.[17] The acupuncture point LI4 is located between the second metacarpal bone on its radial

Cite this article: Azizah N, Santoso B, Abdurachman, Hidayati HB, Imandiri A. A Study is Examining How Postpartum Pain after Cesarean Section (SC) Can be Reduced by Boosting Levels of β-endorphin Through Electroacupuncture Stimulation at The Specified Points LI4 and SP6. Pharmacogn J. 2024;16(3): 670-676.

side on the back of the hand.[18,19] The concurrent use of acupuncture on points SP6 and LI4 has been reported in several studies to be effective in decreasing labor pain.[20]

This study aims to inspect the utilization of electroacupuncture therapy, specifically targeting points SP6 and LI4 at frequencies of 30 Hz, 50 Hz, and 100 Hz, in postpartum cesarean section patients to determine whether these interventions can decrease pain intensity and increase β-endorphin levels.

MATERIALS AND METHODS

The data collection process for this research spanned from March to June 2023. The study underwent testing and received ethical approval from the ethical board under reference number 130/KEP/2022 and protocol number UA-01-22150.

A randomized control trial (RCT) using a lottery system allocated 144 postpartum cesarean section patients into intervention and control groups. The subjects were distributed across 8 groups, including specific LI4 intervention groups, namely EA at the LI4 point at 30 Hz (n = 18), EA at the LI4 point at 50 Hz (n = 18), EA at the LI4 point at 100 Hz (n = 18), and a control group without any intervention (n = 18); and specific SP6 intervention groups, namely EA at the LI4 point at 30 Hz (n = 18), EA at the LI4 point at 50 Hz (n = 18), EA at the LI4 point at 100 Hz (n = 18), and a control group without any intervention (n = 18). Inclusion criteria for respondents included postpartum cesarean section patients within 24 hours of hospitalization, those within 24-48 hours post-surgery having passed the effects of anesthesia drugs and receiving paracetamol 500 mg 3x1 analgesic, experiencing pain intensity > 4, aged between 20-40 years, and with parity of < 4. Exclusion criteria included a history of blood clotting disorders, infectious diseases, heart disease, mental disorders, and injuries or wounds at the LI4 and SP6 acupuncture points. Withdrawal criteria were applied if respondents complained of pain during the interventions and were unwilling to continue with electroacupuncture. Patients voluntarily participated in the study, received an explanation of the acupuncture procedure, and provided their signature on the informed consent form without coercion.

Acupuncture Procedure

The electroacupuncture interventions were conducted by an acupuncture specialist from the traditional medicine department. The interventions targeted specific points LI4 and SP6 on different respondents. The interventions commenced with the disinfection of the LI4 point located between the base of the index and thumb finger, precisely in the muscle area. Simultaneously, the SP6 point, located approximately three cun or about four fingers above the ankle at the end of the tibia, underwent the same disinfection process. The electroacupuncture interventions utilized a power supply of 110 V - 220 V, DC 9V, utilizing Huanqiu needles sized at 1 cun. Proper needle insertion ensured a distinctive tingling or numb sensation upon insertion. Electroacupuncture, with frequencies of 30Hz, 50Hz, and 100Hz, was administered for 30 minutes. Meanwhile, the control group received no intervention except from blood sampling.

Subsequent observations were conducted during and after the administration of the electroacupuncture interventions to observe the occurrence of any reactions or effects, including redness, itching, pain, nausea, vomiting, bleeding, or infection at the acupuncture points, allergic reactions to the acupuncture needles, and scar formation at the acupuncture points.

Assessment of Pain Intensity

Pain assessment was conducted before and after patients received electroacupuncture interventions targeting specifically the LI4 & SP6 points with frequencies of 30Hz, 50Hz, and 100Hz. The Pain Numeric Rating Scale (PNRS) was employed as the measurement instrument for comparing pain intensity levels before and after the electroacupuncture therapy.

β-endorphin Analysis

The evaluation of β-endorphin levels involved the collection of blood samples from respondents both before and after the administration of electroacupuncture interventions targeting specifically the LI4 and SP6 points with frequencies of 30Hz, 50Hz, and 100Hz for 30 minutes. Blood samples, approximately ±3 ml, were collected into EDTA tubes as an anticoagulant and stored at a minimum temperature of 2-8 °C for at least one day prior to testing. Subsequently, the blood samples were centrifuged at 1,000 g at 4 °C for 15 minutes to obtain 1 cc of blood plasma for β-endorphin hormone level testing using the enzyme-linked immunosorbent assay (ELISA) method.

Statistical Analysis

The normality testing of data using the Shapiro-Wilk test indicated a normal distribution ($P > 0.05$). Statistical analysis was conducted using the One-Way ANOVA method with a significance level set at $p < 0.05$ to examine changes in mean pre-post test scores in the intervention and control groups. The analysis aimed to identify differences in pain intensity and β-endorphin hormone levels before and after electroacupuncture interventions targeting specifically the LI4 & SP6 points with frequencies of 30Hz, 50Hz, and 100Hz compared to the control group.

RESULTS

The characteristics of all 144 respondents met the inclusion criteria for this study. During the randomization process, they were divided into three intervention groups receiving electroacupuncture at the LI4 & SP6 points with frequencies of 30 Hz, 50 Hz, and 100 Hz, as well as a control group. The following chart outlines the flow of the research process:

Table 1 presents the characteristics of the respondents, where 144 (100%) respondents in each group, aged 20-35 years and categorized as low-risk, signify homogeneity among the research subjects. The table demonstrates comparability in variables such as age, parity, and maternal nutritional status, with p-values > 0.05, indicating homogeneity within each group. This suggests that the data were evenly distributed before the study commenced.

Based on Table 2, the group receiving electroacupuncture intervention at the LI4 point demonstrated significantly effective results in reducing pain intensity compared to the control group, with a significant p-value of < 0.000 ($p < 0.05$). Specifically, in the group receiving electroacupuncture intervention at the LI4 point at 50 Hz, the mean ± SD was 5.00 ± 0.68, indicating the largest difference in decreased pain intensity compared to the other groups.

Based on Table 3, the group receiving electroacupuncture intervention at the SP6 point demonstrated significantly effective results in reducing pain intensity compared to the control group, with a significant p-value of < 0.000 ($p < 0.05$). Specifically, in the group receiving electroacupuncture intervention at the SP6 point at 100 Hz, the mean ± SD was 4.77 ± 0.80, indicating the largest difference in decreased pain intensity compared to the other groups. Among the groups receiving EA at the SP6 point at 30 Hz, 50 Hz, and 100 Hz, the differences in the magnitude of pain intensity reduction were not significantly large.

Based on Table 4, the group receiving electroacupuncture intervention at the LI4 point demonstrated significantly effective results in increasing β-endorphin levels compared to the control group, with

Table 1. Frequency Distribution of Characteristics of Postpartum Cesarean Section Respondents

Characteristics	Intervention (n = 108)		Control (n = 36)		P-value
	n%	Mean ± SD	n%	Mean ± SD	
Age					
Low-risk 20–35	108 (100%)	33.11 ± 3.87	36 (100%)	27.22 ± 4.17	0.784
High-risk < 20 – > 35	0 (0%)		0 (0%)		
Parity					
Primigravida	46 (42.5%)		6 (16.6%)		0.665
Multigravida	62 (47.4%)		30 (83.3%)		
Nutritional status					
Good	73 (67.5%)		26 (72.2%)		
Malnutrition	0 (0%)		0 (0%)		0.701
Obesity	35 (32.4%)		10 (27.7%)		

Table 2. Differences in Mean Pain Intensity in the Intervention and Control Groups Before and After the Electroacupuncture Intervention at the LI4 Point

EA intervention at the LI4 (n = 72) point		N	Mean ± Std. Deviation (β-endorphin)	95% CI	p-value
Pretest	30 Hz	18	8.05 ± 0.72	7.69-8.41	0.236
	50 Hz	18	8.33 ± 0.48	8.09-8.57	
	100 Hz	18	8.38 ± 0.50	8.13-8.63	
	Control	18	8.38 ± 0.50	8.13-8.63	
	Total	72	8.29 ± 0.56	8.15-8.42	
Posttest	30 Hz	18	3.83 ± 0.78	3.44-4.22	0.000
	50 Hz	18	3.33 ± 0.68	2.99-3.67	
	100 Hz	18	3.55 ± 0.51	3.30-3.80	
	Control	18	6.27 ± 0.66	5.94-6.61	
	Total	72	4.25 ± 1.36	3.93-4.56	
Difference	30 Hz	18	4.22 ± 0.94	4.69-3.753	0.000
	50 Hz	18	5.00 ± 0,68	5.34-4.65	
	100 Hz	18	4.83 ± 0.70	5.18-4.48	
	Control	18	2.11 ± 0.75	2.48-1.73	
	Total	72	4.04 ± 1.38	4.36-3.71	

Table 3. Differences in Mean Pain Intensity in the Intervention and Control Groups Before and After the Electroacupuncture Intervention at the SP6 Point

	EA Frequencies at the SP6 point	N	Mean ± Std. Deviation	95% CI	p-value
Pretest	30 Hz	18	8.33 ± 0.68	7.99-8.67	0.844
	50 Hz	18	8.22 ± 0.64	7.90-8.54	
	100 Hz	18	8.27 ± 0.46	8.04-8.50	
	Control	18	8.38 ± 0.50	8.13-8.63	
	Total	72	8.30 ± 0.57	8.17-8.44	
Posttest	30 Hz	18	3.94 ± 0.53	3.67-4.21	0.000
	50 Hz	18	3.83 ± 0.38	3.64-4.02	
	100 Hz	18	3.50 ± 0.51	3.24-3.75	
	Control	18	6.50 ± 0.61	6.19-6.80	
	Total	72	4.44 ± 1.30	3.13-4.75	
Difference	30 Hz	18	4.38 ± 0.91	4.84-3.93	0.000
	50 Hz	18	4.38 ± 0.69	4.73-4.04	
	100 Hz	18	4.77 ± 0.80	5.17-4.37	
	Control	18	1.88 ± 0.83	2.30-1.47	
	Total	72	3.86 ± 1.40	3.19-3.53	

a significant p-value of < 0.000 ($p < 0.05$). Specifically, in the group receiving electroacupuncture intervention at the LI4 point at 50 Hz, the mean ± SD was 250.377 ± 20.258, indicating the largest increase in β-endorphin levels compared to the other groups.

Based on Table 5, the group receiving electroacupuncture intervention at the SP6 point demonstrated significantly effective results in increasing β-endorphin levels compared to the control group, with a significant p-value of < 0.000 ($p < 0.05$). Specifically, in the group receiving electroacupuncture intervention at the SP6 point at 50 Hz, the mean ± SD was 167.357 ± 34.951, proving to be the most effective in increasing β-endorphin levels compared to the other groups.

DISCUSSION

In this study, electroacupuncture interventions were administered at frequencies of 30Hz, 50Hz, and 100Hz, demonstrating a notable

Table 4. Differences in Mean ß-endorphin Levels in the Intervention and Control Groups Before and After the Electroacupuncture Intervention at the LI4 Point

	EA Frequencies at the LI4 point	N	Mean ± Std. Deviation	95% CI	p-value
	30 Hz	18	142.310 ± 18.658	133.032-151.589	
	50 Hz	18	149.747 ± 14.693	142.440-157.054	
Pretest	100 Hz	18	147.6271 ± 22.687	136.345-158.910	0.264
	Control	18	156.476 ± 27.301	142.900-170.053	
	Total	72	149.040 ± 21.515	143.984-154.096	
	30 Hz	18	326.187 ± 47.914	302.359-350.014	
	50 Hz	18	400.125 ± 20.679	389.842-410.409	
Posttest	100 Hz	18	320.132 ± 49.454	295.539-344.725	0.000
	Control	18	148.725 ± 18.782	139.358-158.066	
	Total	72	298.792 ± 99.701	275.364-322.221	
	30 Hz	18	183.876 ± 47.912	160.049-207.702	
	50 Hz	18	250.377 ± 20.258	240.303-260.452	
Difference	100 Hz	18	172.504 ± 54.647	145.329-199.680	0.000
	Control	18	07.7514 ± 36.150	25.728-10.226	
	Total	72	149.752 ± 104.683	125.152-174.351	

Table 5. Differences in Mean ß-endorphin Levels in the Intervention and Control Groups Before and After the Electroacupuncture Intervention at the SP6 Point

	EA Frequencies at the SP6 point	N	Mean ± Std. Deviation	95% CI	p-value
	30 Hz	18	153.046 ± 27.792	139.225-166.867	
	50 Hz	18	155.202 ± 15.273	147.607-162.798	
Pretest	100 Hz	18	152.104 ± 24.853	139.745-164.464	0.013
	Control	18	145.219 ± 16.013	137.256-153.182	
	Total	72	151.393 ± 21.546	146.330-156.456	
	30 Hz	18	307.921 ± 34.860	290.585-325.257	
	50 Hz	18	322.560 ± 35.069	305.120-340.000	
Posttest	100 Hz	18	312.364 ± 37.148	293.890-330.838	0.000
	Control	18	151.006 ± 16.057	143.021-158.991	
	Total	72	273.463 ± 77.943	255.147-291.778	
	30 Hz	18	154.874 ± 50.203	129.909-179.840	
	50 Hz	18	167.357 ± 34.951	149.976-184.738	
Difference	100 Hz	18	160.259 ± 48.129	136.325-184.193	0.000
	Control	18	5.787 ± 24.741	6.516-18.090	
	Total	72	122.069 ± 78.662	103.585-140.554	

increase in β-endorphin hormone levels and a decrease in pain intensity among postpartum cesarean section patients after the interventions. Notably, the four groups receiving electroacupuncture at the SP6 and LI4 points with a frequency of 50 Hz exhibited the highest increase in β-endorphin levels and the greatest reduction in pain intensity compared to the other groups.

These findings align with previous clinical trials indicating that electroacupuncture serves as an effective complementary therapy for postsurgical pain completion.[21–23] Previous research studies have experimented with electroacupuncture at a frequency of 100Hz, which has been found to produce preemptive analgesic effects on post-incision pain.[24–26] It is noteworthy that both high and low-frequency electroacupuncture can induce the release of different opioids from the central nervous system. Studies have indicated that EA at 2/100Hz results in a more substantial increase in endogenous opioid agonists, specifically endorphins, in locally inflamed ankle skin tissue compared to electroacupuncture at a frequency of 2 Hz. Additionally, long-term differences in the endogenous opioid system, including opioid release and opioid receptor expression, have been observed between inflammatory pain and neuropathic pain conditions in the spinal cord and dorsal root ganglia.[27] Therefore, these mechanisms may underlie the effectiveness of electroacupuncture in all types of pain conditions. Along with other findings mentioned, this shows that it is necessary to select the optimal frequency of electroacupuncture first to achieve the best analgesic effect for certain pain conditions.[28]

Our study further revealed that different frequencies of electroacupuncture yielded distinct reductions in pain intensity and variations in ß-endorphin release. Notably, electroacupuncture at a frequency of 50 Hz proved to be the most effective in reducing pain intensity by stimulating ß-endorphin release. This aligns with previous research findings indicating that ß-endorphin and endomorphin exhibit similar characteristics in their induced release profiles. The brain can distinctly and separately distinguish variations in electroacupuncture frequency. Therefore, electroacupuncture can activate enkephalins, ß-endorphin, and endomorphins simultaneously.[29] The effectiveness of electroacupuncture has been proven to reducing the transmission of pain information through the spinal hilar control mechanism, significantly reduce pain sensation, and suppress abnormal electromyography.[30] In addition, Han found that acupuncture applied at certain frequencies to certain parts of the body can also stimulate pain. The release of endogenous opioid peptides in the central nervous system activates opioid receptors to induce antinociception.[31]On the

other hand, in the late stages of inflammation, antinociception is mediated by ß-endorphins alone. As a result of inflammation, opioid-producing leukocytes are progressively recruited to the site of pain, resulting in the constant availability of endogenous opioids and long-term local analgesic effects.[32]

Previous research findings indicate the benefits of postoperative electroacupuncture in decreasing acute postoperative pain in the first 72 hours post-surgery. It can also decrease analgesic consumption and serve as an effective complement therapy for postoperative pain management.[12] Therefore, acupuncture has been concluded as a regulator of pain transmission in the central nervous system through endocrine and neural pathways. However, some research suggests that the effects observed in acupuncture studies are usually temporary. This is proven by the suppression of C-fiber reflexes resulting from electroacupuncture lasting only a few minutes after treatment.[33] Additionally, rapid degradation of endogenous opioid peptides by peripheral blood proteases results in a half-life of approximately 40 minutes for ß-endorphin.[34,35]

After a cesarean section procedure, tissue damage due to pathogen attack causes inflammation and the release of vasoactive substances and chemokines from existing tissue cells. These substances recruit immune cells from the blood vessels to the site of inflammation.[36] Immune cells in the tissue release inflammatory mediators, including lipid mediators, cytokines, and growth factors, which activate sensory neurons (nociceptors) and produce the sensation of pain.[37] Meanwhile, opioid-laden immune cells migrate to the site of pain, releasing opioid peptides that activate opioid receptors on peripheral nociceptive neurons to induce antinociception.[35,38] Endogenous opioid peptides, including ß-endorphins, dynorphins, and enkephalins, have been implicated in peripheral analgesia during the early stages of inflammation. [39]

Electroacupuncture stimulation can relieve muscle pain caused by inflammation by increasing ß-endorphin levels in inflamed tissue.[35] Previous research suggests that the nervous system functions as a target for acupuncture analgesia. Acupuncture has been shown to suppress or block the entry of damaging sensory impulses at every level of the central nervous system, including the dorsal horn of the spinal cord and the PAG (periaqueductal gray), resulting in an anti-pain effect.[34,35] Researchers have found that acupuncture works both centrally and internally. Nervous centers can influence antinociceptive effects during initial inflammation by activating the appropriate receptors. further through interactions between opioid receptor derivatives derived from ß-endorphins and leukocytes.[32]

Previous research studies have shown that acupuncture can mediate analgesia by increasing ß-endorphin levels in peripheral tissues. The sympathetic nervous system is involved in local analgesic effects mediated by electroacupuncture. The sympathetic nervous system stimulates adrenergic receptors on inflammatory cells by producing norepinephrine and releasing electroacupuncture into inflamed peripheral tissues.[40] During inflammation, cells activated by inflammatory mediators and chemokines attach to the walls of blood vessels at the site of inflammation, exit the circulation, and extravasate to the site of inflammation.[41] According to research, it is stated that during the late stages of inflammation, it is endogenous opioid peptides that mediate the effects, and local antinociception originates from macrophages.[42,43] It has been found that acupuncture achieves endogenous pain control by increasing the expression of the chemokine CXCL10 and infiltration of CXCR31-expressing macrophages that produce opioid peptides.[44]

The results of this study indicate that electroacupuncture stimulation has been proven to significantly decrease pain intensity through the increased levels of β-endorphin compared to the control group. The group receiving electroacupuncture therapy at the LI4 point with a frequency of 50 Hz exhibited decrease in pain intensity and increase in β-endorphin levels significatively compared to the other groups. However, this study solely focused on β-endorphin levels, and other pain receptors were not observed. Future research should investigate more extensively the positive effects of electroacupuncture stimulations, especially considering a broader range of pain receptors and a larger sample size.

CONCLUSION

In conclusion, this study demonstrates that electroacupuncture at the SP6 and LI4 points effectively alleviates patients postpartum cesarean section (SC) pain by stimulating an increase in β-endorphin levels. Specific identification of the LI4 and SP6 points with different frequencies yielded varying results, although the differences in pain reduction and increased β-endorphin levels were not significant. Consequently, it is expected that the findings of this study can assist physicians, midwives, and women seeking non-pharmacological pain treatment in decision-making regarding pain management.

FUNDING

We extend our gratitude to Muhammadiyah University of Sidoarjo for their support in the publication of this article

ACKNOWLEDGEMENTS

This article is derived from a doctoral dissertation. The author would like to express gratitude to the supervisors, the hospitals of Universitas Airlangga Surabaya, and the Muhammadiyah University of Sidoarjo, as well as all contributors involved in the implementation of this research.

AUTHOR CONTRIBUTIONS

NA: research concept, research methodology, data collection, manuscript drafting, article drafting, and revision.

BS: research concept, data collection, manuscript drafting.

ABD: research concept, data collection, manuscript drafting.

HB: research concept, data collection, manuscript drafting.

AI: acupuncture intervention, data collection, critical revision of the article.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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Cite this article: Azizah N, Santoso B, Abdurachman, Hidayati HB, Imandiri A. A Study is Examining How Postpartum Pain after Cesarean Section (SC) Can be Reduced by Boosting Levels of β-endorphin Through Electroacupuncture Stimulation at The Specified Points LI4 and SP6. Pharmacogn J. 2024;16(3): 670-676.