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High and low frequency transcutaneous electrical nerve stimulation in post-cesarean pain intensity

Estimulação elétrica nervosa transcutânea de alta e baixa frequência na intensidade da dor pós-cesárea

Estimulación nerviosa eléctrica transcutánea, de alta y baja frecuencia en la intensidad del dolor después de la cesárea

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ABSTRACT | The current study aim was evaluate the analgesic effect of TENS modulation for high (100 Hz) and low (4 Hz) frequency in post-cesarean pain. 34 postpartum women were randomly divided into three treatment groups: 100 Hz (G100), 4 Hz (G4) and Placebo (GP) (appliance off). Pain intensity was assessed by the NRS (Numeric Rating Scale) before, immediately after application of TENS, and every 20 minutes until an hour after the eletroanalgesia session. We used the Friedman test and Mann-Whitney U test ($p<0.05$) for statistical analysis. The results showed significant reduction of NRS in G100 only relative to pretreatment condition ($p<0.05$). At intervals after treatment, the G100 had a significant reduction of pain during all intervals ($p<0.05$). The G4 has significantly decreased only in intervals of 40' and 60', and the GP, only in the range of 60' ($p<0.05$). Modulation of TENS for high pulse rate showed greater analgesic effect than the low frequency TENS in post-cesarean mothers.

Keywords | Cesarean Section; Postpartum Period; Transcutaneous Electric Nerve Stimulation.

RESUMO | O objetivo do estudo foi avaliar o efeito analgésico da modulação da TENS em alta (100 Hz) e baixa (4 Hz) frequência na dor pós-cesárea. Participaram 34 puérperas, aleatoriamente divididas em três grupos de tratamento: 100 Hz (G100), 4 Hz (G4) e Placebo (GP) (aparelho desligado). A intensidade da dor foi avaliada pela NRS (Escala de Categoria Numérica) antes, imediatamente após a aplicação da TENS, e a cada 20 minutos, até que completasse uma hora após a sessão de eletroanalgesia. Foram utilizados os testes de Friedman e Mann-Whitney U ($p<0,05$) para a análise estatística. Os resultados demonstraram diminuição significativa da NRS somente no G100 em relação à condição pré-tratamento ($p<0,05$). Nos intervalos pós-tratamento, o G100 apresentou diminuição significativa da dor durante todos os intervalos ($p<0,05$). O G4 apresentou diminuição significativa somente nos intervalos de 40' e 60'; e o GP, apenas no intervalo de 60' ($p<0,05$). A modulação da TENS em alta frequência de pulso apresentou maior efeito analgésico do que a TENS de baixa frequência em puérperas pós-cesárea.

Descritores | Cesárea; Período Pós-Parto; Estimulação Elétrica Nervosa Transcutânea.

RESUMEN | El objetivo del estudio fue evaluar el efecto analgésico de la modulación de la TENS en alta (100 Hz) y baja (4 Hz) frecuencia en el dolor post-cesaría. Participaron 34 puérperas, aleatoriamente divididos en tres grupos de tratamiento: 100 Hz (G100), 4Hz (G4) y Placebo (GP) (aparato en off). La intensidad del dolor fue evaluada por la NRS (Escala de Categoría Numérica) antes, inmediatamente después de la aplicación de la TENS, y a cada 20 minutos, hasta que completase una hora después de la sección de eletroanalgesia. Fueron utilizados las pruebas Friedman y

Study conducted at the Santa Casa de Misericórdia and Hospital Estadual Dirceu Arcoverde (HEDA) – Parnaíba (PI), Brazil.
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Mann-Whitney U (p<0,05) para la análisis estadística. Los resultados demostraron diminución significativa de la NRS solamente en el G100 en relación a la condición pretratamiento (p<0,05). En los intervalos post-tratamiento, el G100 presento diminución significativa del dolor durante todos los intervalos de tiempo (p<0,05). El G4 presento diminución significativa solamente en los intervalos de 40' y 60'; y el GP, apenas en el intervalo de 60' (p<0,05). La modulación de la TENS en alta frecuencia de pulso presento mayor efecto analgésico que la TENS de baja frecuencia en puérperas post-cesaría.

Palabras clave | Cesárea; Período de Postparto; Estimulación Eléctrica Transcutánea del Nervio.

INTRODUCTION

Childbirth is the conclusive stage of pregnancy, and it can either be vaginal or performed by surgery in the transabdominal area[1]. Morbidities can occur regardless of the mode of delivery; however, these complications are significantly more present in cesarean sections. Among the morbidities involved in this type of childbirth, pain at the surgical incision location is common on the first postoperative days.

The continuous post-cesarean pain is a result of the subsequent inflammatory reactions involved in this traumatic process[2]. This has a negative influence on puerperal women, since it makes recovery more difficult, delays early mobility and contributes so that damage is caused to her and her initial relationship with the newborn[3]. Besides, it impacts the breastfeeding process because it inhibits the oxytocin hormone and it becomes more difficult to find a body position to breastfeed[4].

Pain has a subjective and socio-emotional dimension. Because of that, it is relevant to search for full and humanized care to puerperal women after a cesarean section, as well as non-pharmacological conducts to handle pain that can minimize possible risks to health[5], considering the adverse effects that can be caused by medication[6]. The transcutaneous electrical nerve stimulation (TENS) is the most used non-pharmacological resource in physical therapy practice for handling pain. It is a safe and low-cost treatment, easily applied and relatively comfortable for the patient. It is indicated for immediate pain relief without causing any adverse effects, besides reducing the use of medicines and time of hospital stay. It also promotes early mobility[7-9].

The physiological mechanisms of TENS analgesia are not completely clear. Its impulses are known to stimulate myelinated type A fibers, which excite interneurons in the dorsal horn of the spinal cord and inhibit nociceptive impulses of A-delta and C fibers. This mechanism proposed by Melzack and Wall, in 1965, is classically known as the gate control theory of pain. Another mechanism is the liberation of different endogenous opioids, both in high (δ type) and low (μ type) frequency applications, which bond to receptors to block the transmission of the nociceptive stimulus[7,10].

The effectiveness of TENS has been studied in several symptomatological conditions, and its evidence seems to depend on the characteristics of pain[11], disease and parameters of pulse frequency modulation[7]. With regard to postoperative pain, after a cesarean section, conventional TENS presented a significant analgesic effect even one hour after its application[5]. Hollinger[12] assessed 72 postpartum women who underwent cesarean sections and found that the group that used high frequency TENS at immediate puerperium had significant reduction in the intake of analgesic medication in the postoperative period in relation to the control group. Even though these studies confirm the effectiveness of conventional TENS, little attention has been given to pulse frequency modulation.

The use of high or low frequencies leads to different analgesic mechanisms, like the gate control theory of pain and the liberation of opioids, respectively[7,10]. Since postoperative pain after a cesarean section has necessarily acute characteristics, it is expected that high frequency TENS can present superior analgesic effects when compared to low frequency TENS. This study aimed at assessing the analgesic effect of high (100 Hz) and low (4 Hz) frequency TENS modulation on pain in puerperal women after a cesarean section.

METHODOLOGY

Sample

Sample size was calculated based on previous studies, by considering a clinically important minimal difference (10% after the initial assessment) (SD=2.2)[9] in pain intensity between pre and post-treatment conditions. The probability of type 1 (α) or type 2 (β) error was 0.05 and 0.20, respectively. Considering possible sample loss of 15%, the final sample size was estimated in 39 patients.

Puerperal women aged ≥18 years old were included, with pain in the surgical incision location ≥3 in the

Number Rating Scale (NRS). They were literate, time and space-oriented, and underwent spinal anesthesia before the surgical procedure, as well as Pfannestiel incision. They did not present genitourinary pathology, were primiparous or multiparous. Patients with sensitivity changes, demyelinating diseases, spinal cord injury, hemorrhage, infection, fever, anesthetic complications, arterial hypertension, breast intercurrences, irritation or intolerance to the application of TENS were excluded from the analysis. This study was approved by the local Ethics Committee, and all of the volunteers signed the informed consent form.

Experimental design

This is a randomized clinical trial, single-blind, placebo-controlled, conducted at Santa Casa de Misericórdia and Hospital Estadual Dirceu Arcoverde (HEDA), in the city of Parnaíba-PI. Patients were randomly distributed by a software, in blocks of three treatment groups: G100 (TENS 100 Hz; n=13); G4 (TENS 4 Hz; n=12); GP (TENS Placebo; n=9).

The random division and allocation, kept in opaque and numbered envelopes, were performed by a researcher who did not participate in the study. The access to the envelopes by the researcher in charge of the intervention was only allowed at the time of protocol application, after eligibility criteria were met and after the volunteer had agreed to participate in the study. The flowchart is presented in Figure 1. The characteristics of the volunteers are described in Table 1.

Procedures

The initial evaluation was conducted with a minimum eight-hour interval after childbirth to prevent acute interferences in post-anesthetic recovery. All of the participants were enlightened about the procedures that would come afterwards. Then, sociodemographic and obstetric data were conducted by a questionnaire; data from medical records were also used.

Participants were placed in dorsal decubitus position and remained at rest during the whole experiment, so that there would be no intercurrences interfering with the results. TENS was applied with the equipment TENSYS (KLD® Biosistemas, São Paulo) by two channels. For each participant, four silicone rubber electrodes were used (5x3 cm) individually, accounting for 136 electrodes, which were placed in a crossed pattern, one centimeter above and one centimeter below the surgical incision[6]. In order to increase skin adherence to the electrical stimulus, hypoallergenic gel and bands were used.

In groups G100, G4 and GP, TENS was applied with high (100 Hz) and low (4 Hz) frequencies, as well as placebo (appliance off), respectively. Pulse duration was standardized at 100 μs, and intensity was in accordance with the sensory threshold of each patient, characterized by severe paresthesia, comfortable, with minimum or absent muscle activity. Total time of TENS application was 30 minutes for each volunteer, and the whole protocol was conducted in a single session. In order to

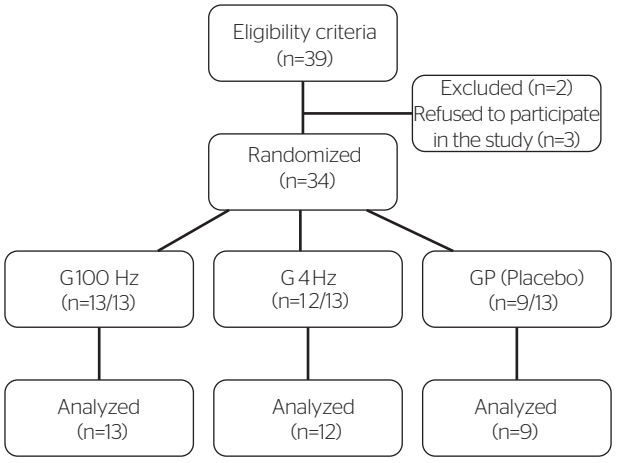


Figure 1. Study flowchart

Table 1. Sample characterization according to sociodemographic and obstetric variables

Variable	G100 (n=13)		G4 (n=12)		GP (n=9)	
	n	%	n	%	n	%
Age (years)						
18-25	7	53.8	8	66.8	4	44.5
26-33	4	30.7	2	16.6	3	33.3
34-42	2	15.5	2	16.6	2	22.2
Marital status						
Single	7	53.8	4	33.3	2	22.2
Married	4	30.7	6	50.0	7	77.8
Consensual union	2	15.5	2	16.7	0	0
Schooling						
Incomplete elementary school	6	46.1	2	16.7	1	11.1
Complete elementary school	2	15.4	2	16.7	1	11.1
Incomplete high school	3	23.1	1	8.3	4	44.4
Complete high school	1	7.7	6	50.0	2	22.2
Incomplete higher educatio	0	0	1	8.3	1	11.1
Complete higher educational	1	7.7	0	0	0	0
Gestational age						
Preterm	10	76.9	7	58.3	7	77.7
At term	3	23.1	5	41.7	2	22.3
Parity						
Primiparous	5	38.4	4	33.3	6	66.7
Multiparous	8	61.6	8	63.7	3	33.3
Number of previous abortions						
None	11	84.6	10	83.3	0	0
One or two	2	15.4	2	16.7	0	0

G100: TENS 100 Hz; G4: TENS 4 Hz; GP: Placebo

minimize the effects of sensory habituation, volunteers were asked, at regular intervals, about the sensation of paresthesia. In case of reduction, the researcher in charge increased the amplitude of the current according to the tolerance of the participants.

Pain intensity was evaluated by NRS before, immediately after and in 20 minute intervals (20, 40 and 60') after the electro-stimulation period. NRS is a unidimensional scale to assess pain. It is easy to apply and understand, and level 0 means the absence of pain, while level 10 represents extreme pain[5,13].

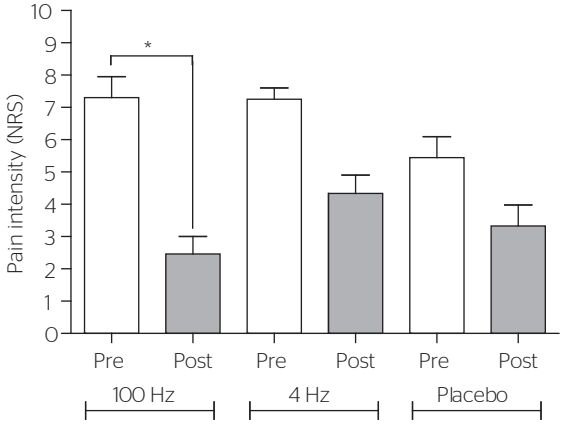
Patients who had prescription for anti-inflammatory medication or analgesics were submitted to assessment and intervention protocols after six and eight hours, respectively to minimize possible interactions between the effects of drugs and TENS. The researcher in charge of the evaluation, as well as the patients, was not familiar with which treatment protocol each participant was allocated in.

Data analysis

Data normality and homoscedasticity were verified by the Shapiro-Wilk and Levene tests, respectively. A descriptive analysis of data was conducted for sociodemographic and obstetric characterization of the volunteers in order to identify intragroup differences between pre and post-treatment values, the Friedman test was used for repeated measures. For the intergroup analysis, the NRS difference between pre and post-treatment values was calculated; afterwards, the Mann-Whitney test was used. All data were analyzed with the software GraphPad Prism 5®, and the adopted significance level was of $p<0.05$.

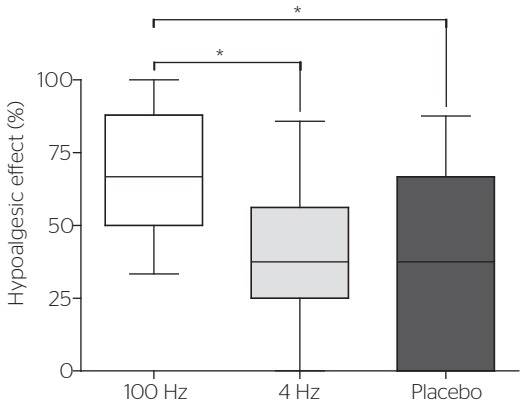
RESULTS

The intragroup data analysis demonstrated decreasing NRS between pre and post-treatment values for G 100 ($p<0.001$) (Figure 2). Intergroup results showed significant NRS reduction between groups G100 – G4 and G100 – GP ($p<0.05$) (Figure 3). With regard to post-treatment intervals, G100 presented significant NRS reduction during 20, 40 and 60' intervals after the pre-treatment period ($p<0.05$). G4 presented significant reduction in 40 and 60' intervals. For the GP, this difference only occurred in the 60' interval (Figure 4). No adverse effects or collateral reactions were reported during and after the application of treatment protocols.



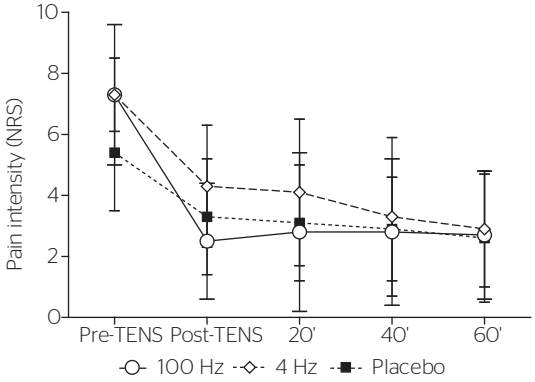
*Friedman test p<0.001; NRS: Numeric Rating Scale

Figure 2. Pain intensity Number Rating Scale pre and post immediate treatment, using 100 Hz, 4 Hz and placebo Transcutaneous Electrical Nerve Stimulation



*Mann-Whitney test, p<0.050; NRS: Numeric Rating Scale

Figure 3. NRS variation (%) between pre and post immediate treatment, using 100 Hz, 4 Hz and placebo Transcutaneous Electrical Nerve Stimulation



NRS: Numeric Rating Scale; TENS: Transcutaneous Electrical Nerve Stimulation

Figure 4. Pre-TENS, post immediate application of Transcutaneous Electrical Nerve Stimulation and 20, 40 and 60 minutes after Transcutaneous Electrical Nerve Stimulation pain intensity Number Rating Scale in groups 100 Hz, 4 Hz and placebo

DISCUSSION

The objective of this investigation was to assess the analgesic effect of high (100 Hz) and low (4 Hz) frequency TENS in post-cesarean pain. The reduced NRS indicated lower perception of postoperative pain, different from the pre-treatment situation, thus showing that acute post-cesarean pain can be attenuated by convention electrotherapy.

Surgical procedures cause tissue damage and generate an inflammatory process, followed by the liberation of chemical mediators and pain[14]. Concerning the relief of postpartum pain, TENS has been effective[15], and its indication is valid for postoperative analgesia and reduction in the intake of medicines[16], thus contributing with the humanization of the puerperal period.

In this study, two pairs of electrodes were placed above and below the surgical incision, with the bipolar crossing technique, and in that case the current is concentrated on the location of the pain[5]. This factor was relevant to obtain good results after TENS, since the placement of electrodes is important to stimulate Aβ fibers that go into the same spinal segment that nociceptive fibers, which are associated with the origin of pain[16,17]. In groups that received electrostimulation (G100 and G4), the pulse duration was standardized at 100 μs, which can be observed in other studies[18-20].

In our study, results obtained by NRS in G100 show significant pain reduction after immediate intervention. The same was demonstrated by Melo *et al.*[9], who assessed 15 puerperal women after a cesarean section who were submitted to high frequency (100 Hz) TENS and 15 women who received the placebo treatment (appliance off) for 50 minutes. It was possible to observe significant pain reduction only in the 100 Hz group. Smith et al.[21] also analyzed 18 postpartum women, who had undergone cesarean section, divided into two groups: an experimental one, with high frequency TENS (85 Hz and 80 μs) and a placebo. Their findings demonstrated significant reduction of superficial pain around the surgical suture only in the experimental group.

Pitangui *et al.*[22] analyzed the response of high frequency TENS (100 Hz and 75 μs) after vaginal delivery with episiotomy and obtained positive results for the group that used electro-stimulation in the immediate treatment, and one hour after its application, in comparison to the control group. Another study[23] obtained a positive response after using high frequency TENS (90 Hz; 90 μs) for pain control during childbirth, suggesting the application of this resource in its early stages delays the need for additional analgesic techniques.

With regard to other surgical procedures, DeSantana *et al.*[24] observed satisfactory analgesia in patients submitted to inguinal herniorrhaphy who used TENS (100 Hz; 50 μs) for 60 minutes at the postoperative period. According to these authors, the analgesic effect provided by high frequency TENS is not only a result of the gate control theory of pain, but also of the activation of the descending analgesic system (activation of type δ opioid receptors), which would explain, in our study, the prolonged analgesia after the conclusion of TENS in 20, 40, and 60' intervals.

In literature, there are only a few studies with low-frequency TENS among puerperal women who underwent cesarean sections, and that can be explained by the acute aspects of pain; because of that, high frequency TENS is more common, but in our results, in G4, there was significant pain reduction after 40 and 60' of the application of TENS, which shows that the analgesic action in this group was not immediate, however, it lasted for a period of time. Electrical stimulation produced by low frequency TENS can work for the activation of the periventricular grey matter, which is part of the hormonal system that actives inhibitory neurons that liberate endorphin, and this effect can last for hours after stimulation is concluded[25,26]. In the 20' after treatment, there was no significant pain reduction. Maybe the concentration of opioids (type μ) in the analyzed time intervals has not been sufficient to saturate its receptors and block the nociceptive transmission.

The results obtained by NRS in the GP showed significant pain reduction after the fourth assessment (60'), which can be explained by the formation and liberation of endorphins by the cerebral cortex due to the women's expectations towards the treatment[2]. Since puerperium is a time when women are more vulnerable, the reduction of pain may have been caused by the attempt to care for her complaint during the assessment period, and by the alternative of solving it without damaging herself or the newborn, thus interfering in her perception of pain[27,28].

There were no difficulties to apply and understand the NRS, so it was well accepted as a unidimensional scale, which was also observed in another study[13]. At the end of the experiment, all of the participants in the placebo group were treated with 100 or 4 Hz TENS.

Postpartum pain is a limiting factor to the mobility of the puerperal women, to self-care and to newborn care. In this period, humanization aims at reducing the risks in the process of functional recovery. Since TENS has proven to be beneficial to relieve such pain, it is possible to observe the importance of implementing this resource in the treatment of the puerperal women after a cesarean section.

CONCLUSION

The analgesic effect of TENS in the postoperative period after a cesarean section depends on the parameters of the choice. High frequency modulation, instead of the low frequency one, is efficient to treat for post-cesarean pain.

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