

# The role of electroanalgesia in patients undergoing coronary artery bypass surgery

## *Papel da eletroanalgesia na função respiratória de pacientes submetidos à operação de revascularização do miocárdio*

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### *Abstract*

**Objective:** To assess the electroanalgesia as an effective method in the reduction of pain and consequent improvement in lung function in patients undergoing coronary artery bypass graft surgery.

**Methods:** During the period of one year were studied 30 patients undergoing surgery for treatment of the ischemic coronary disease. After randomization, 15 patients were allocated in the study group (that received electroanalgesia) and 15 patients from the control group (placebo). From the 1<sup>st</sup> until the 5<sup>th</sup> postoperative day were performed two applications of electroanalgesia or the placebo current, according to the group where the patient was allocated.

**Results:** There was a reduction in the levels of pain in the study group compared to the control group, evidenced by the value  $P < 0,05$ ; however, there is no evidence of statistical difference of the spirometric variables between them.

**Conclusion:** The group that did eletroanalgesia presented reduction in the intensity of postoperative pain, which however did not mean improvement in respiratory function of these patients.

**Descriptors:** Myocardial revascularization, methods. Pain, postoperative. Spirometry. Transcutaneous Electric Nerve Stimulation.

### *Resumo*

**Objetivo:** Avaliar a eletroanalgesia como método eficaz na diminuição da dor e consequente melhora da capacidade pulmonar em pacientes submetidos a operação de revascularização do miocárdio.

**Métodos:** No período de um ano foram estudados 30 pacientes submetidos a operação para tratamento da doença coronariana isquêmica. Após a randomização, 15 pacientes foram alocados no grupo estudo (que receberam eletroanalgesia) e 15 pacientes no grupo controle (placebo). No pré-operatório todos os doentes foram entrevistados e realizaram espirometria. Do primeiro ao quinto dia de pós-operatório foram realizadas duas aplicações diárias de eletroanalgesia ou de corrente placebo, conforme o grupo em que o paciente estivesse alocado, e no quinto dia, nova espirometria.

**Resultados:** Todos os pacientes evoluíram satisfatoriamente, sem complicações inerentes à operação

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de revascularização do miocárdio. Verificou-se que a cirurgia reduziu os valores espirométricos de ambos os grupos ( $P=0,00$ ). Os resultados encontrados demonstraram também redução nos níveis de dor no grupo estudo quando comparado ao grupo controle. Este por sua vez não repercutiu em melhora da função pulmonar como resultado da aplicação da TENS quando comparado ao grupo controle ( $P>0,05$ ).

**Conclusão:** O grupo que realizou eletroanalgesia apresentou redução da intensidade da dor pós-operatória o que não implicou, contudo, na melhora da função respiratória de tais pacientes.

**Descritores:** Revascularização miocárdica/ métodos. Dor pós-operatória. Espirometria. Estimulação elétrica nervosa transcutânea.

## INTRODUCTION

Cardiovascular diseases consist in one of the main causes of mortality in Brazil.

Among the cardiovascular diseases, those which present the higher morbidity and mortality are: the cardiac insufficiency, the cerebrovascular accident and the coronary disease [1].

The increase in the incidence of the ischemic heart disease in the population motivated the emergence of a series of studies aiming the improvement of its treatment, diagnosis and prophylaxis. Despite the great success of angioplasty procedures, the open heart surgery type myocardial revascularization, up to these days consists in the indicated treatment for many of these patients.

The morbidity and mortality of this operation are to a great extent attributed to the use of extracorporeal circulation and cardiac arrest. In addition to these conditions inherent to the surgery itself, several other factors contribute to the increase of postoperative morbidity such as: the respiratory dysfunction, the release of microembolus with systemic inflammatory response, the hemodilution, the heparinization, post-reperfusion myocardial depression and changes in the healing process [2].

The etiology of the pulmonary dysfunction following an open heart cardiac surgery definitely results from the multifactorial association amongst anesthesia, surgical trauma, extracorporeal circulation, cardiac arrest, surgery time, mechanical ventilation time and pain, causing, therefore, decrease in the functional residual capacity, increase of the intrapulmonary shunt and enlargement of the alveolus-artery difference of  $O_2$  [3].

In addition to the medicative analgesia, the electroanalgesia has also been proposed as a mean of relieving the pain, improvement in the mechanics of the chest and, consequently, reduction of possible respiratory complications in cardiac surgeries [4].

The analgesia through the Transcutaneous Electric Nerve Stimulation (TENS) is based on "the theory of control

of the bridge by the pre-synaptic inhibition and by the direct inhibition of an excited nerve" [5].

The bridge theory, previously known by Melzack & Wall, consists in the hypothesis that the perception of pain is regulated by a sluice that can be opened or closed by means of other impulses originated in the peripheral nerves or the central nervous system, thus, regulating the aching sensibility [6].

Taking into account the importance of pain in preventing respiratory complications following cardiac surgeries and, once there is a large variety of parameters used by electroanalgesia found in literature, we have decided to perform a comparative study in order to evaluate the role and importance of this therapeutic modality concerning the pain and, consequently, regarding the pulmonary function of the related patients.

## METHODS

This study consists of a controlled and randomized experimental clinical essay, single blind with transversal, prospective surveying, having a quantitative approach performed at the Hospital Vita Curitiba, in Curitiba - Parana (Brazil). The present study had its project sent to the Committee of Ethics and Research of the Pontificia Universidade Católica of Parana, being approved and registered under the number 1303, on August 31, 2006.

Thirty patients participated in this work undergoing cardiac surgery for myocardial revascularization with extracorporeal circulation and cardiac arrest. The sample was randomized in two groups: Study Group consisted of 15 patients that effectively received the treatment with electroanalgesia by transcutaneous electrical nervous stimulation (TENS) and, the Control Group, consisted of 15 patients treated only with a placebo electrical current. All patients were operated by the same surgeon and were submitted to thoracic drainage by a mediastinal drain and another in the sixth left intercostal space in the anterior axillary line.

Regarding the criteria for the inclusion of patients in this study it was established that these patients should present the following: age range: 30-80 years-old; consciousness level: 15 points according to the ratings of the Glasgow scale; and not having undergone cardiac surgery previously. The following were excluded from this study: the use of invasive mechanical ventilation support for more than 24 hours, the application of cardiac pacemaker, consciousness level equal or below 14 points in the Glasgow scale and, patients with hypersensitivity to TENS.

Once the criteria of inclusion in this study were met, the patients were instructed on their partaking and involvement. And, through the signing of an authorization term, the researcher received permission to perform this work.

On the first five days following the surgery, an electroanalgesia was performed in the study group, in addition to the application of the placebo electrical current in the control group. In this period, the data regarding the intensity of the pain according to the analogical numeric scale were collected. Through this scale the patient is informed on the need of classifying his pain in grades ranging from 0 to 10 according to the intensity of the aching sensation. In the preoperative period and on the fifth day following the surgery, spirometric exams were performed, taking into account for this study the forced vital capacity (FVC), the forced expiratory volume in the first second (FEV1) and expiratory flow peak (EFP).

The technique used for the performance of the spirometry was the same previously known by the "First Brazilian Consensus about Spirometry" of the Brazilian Pneumology and Tisiology Society, the device used was a Micromedical® spirometer, model Microloop, properly tested and approved.

The therapeutics with TENS and with the Placebo Electrical Current on its respective groups was started 24 hours after the conclusion of the surgery and consisted of two daily sessions (for each group) of 50 minutes each, being the first performed at 10 AM and the second at 4 PM. Before and after the application of the TENS and the Placebo Electrical Current, the grades of pain were measured in all patients of both groups.

For the application of the Electroanalgesia and the Placebo Electrical Current, it was used a device model Dualpex 961 by Quark Produtos Médicos (Piracicaba, São Paulo, Brazil); of two channels and four carbon-permeated rubber type electrodes, sized 2.5 x 4.5 cm. The electrodes were attached to the patient's skin using "micropore" type adhesive tapes, applying an electric conductive gel between the electrode and the skin.

Following the parameters previously known by Johnson et al. [3] that established the frequency of the device in 80 Hz with a biphasic square wave, symmetric in 125  $\mu$ s pulses. The intensity of the current (mA) was defined according to

the sensitivity of each patient. The first pair of electrodes was attached 3 cm below the sternum-clavicular articulation, and 3 cm from the thoracic incision; the second pair of electrodes was attached 2 cm above the xiphisternum and 3 cm from thoracic incision. It is relevant to outline that for the patients of the controlled group it was used the same electrode application technique, however, without using electrical current.

All patients studied were submitted to medicative analgesia according to the analgesia protocol of the surgical team that performed the myocardial revascularization surgery.

The Gauss tendency curve of the data was examined applying the Kolmogorov-Smirnof test. This test supplied values "P" higher than 0.05. Therefore, it was indicated the use of the "t" test of Student. It was, also, tested the homogeneity of the variances of both groups and as a result of the value "P" in the F test being higher than 0.05 the indicated version of the "t" test is the classical one, considering the significance level of 5%.

It was, still, verified the correlation of the acquired data; in which the presence or absence of relation between two variables is identified and, in case it exists, it is also quantified by the Pearson's correlation coefficient; which measures the degree of dependence of two or more variables.

## RESULTS

None of the allocated patients of this study died. All patients recovered positively, without inherent complications to the myocardial revascularization surgery.

The mean age of the patients was 61.66 years  $\pm$  9.48 (mean  $\pm$  standard deviation), being five female patients (16.66%) and 25 male patients (83.33%). The mean body mass index was 27.6  $\pm$  3.68.

Eleven patients had smoking addiction until the date of the operation (36.6%) and 19 patients had quit smoking at least a year prior to the surgery (63.33%). According to the European system for evaluation of the risk in cardiac surgery (Euro SCORE), they presented a mean surgical risk of 5.03  $\pm$  2.13.

Considering the variables studied such as: age, gender, body mass index (BMI) and Euro SCORE, it was verified that no statistically significant differences were found between the groups studied.

All patients were monitored during surgery, taking into account for this study the duration time, the extracorporeal circulation time (ECC) and the mechanic ventilation time (MV) until the extubation of the patients. When comparing both groups (study and control) concerning these variables, no statistically significant differences were found, as displayed in Table 1.

Table 1. The values represented in the columns express the surgery time, extracorporeal circulation time and mechanical ventilation time between the study group and the control group.

	Surgery Time		Extracorporeal Circulation Time		Mechanical Ventilation Time	
	Study	Control	Study	Control	Study	Control
Mean	274.26	273.33	73.66	86.4	467.33	510.66
S.D	± 40.54	± 51.81	± 23.36	± 29.45	± 181.14	± 198.47
P	0.957		0.200		0.537	

S.D = Standard deviation

Table 2. The values represented in the columns express the mean result, standard deviation and value of “p” when comparing the expiratory flux peak (EFP), forced vital capacity (FVC) and the forced expiratory volume (FEV1) in the first minute between the Study and Control groups in the preoperative and postoperative moments.

	EFP		EFP		FVC		FVC		FEV1		FEV1	
	Preop.		Postop.		Preop.		Postop.		Preop.		Postop.	
	S.G	C.G	S.G	C.G	S.G	C.G	S.G	C.G	S.G	C.G	S.G	C.G
Mean	106	95.20	71.06	60.07	85.6	81.06	55.6	50.33	92.10	84.13	61.80	50.33
S.D	± 16.7	± 16.29	± 14.50	± 16.09	± 11.7	± 12.18	± 11.8	± 17.65	± 17.30	± 17.90	± 15.10	± 17.65
P	0.124		0.061		0.308		0.268		0.223		0.06	

FVC = forced vital capacity, S.D = Standard deviation, C.G = Control Group; S.G = Study Group, EFP = expiratory flux peak, FEV1 = forced expiratory volume in the first second

It was also verified that the myocardial revascularization surgery had an impact over the spirometric values of all patients when comparing the preoperative and postoperative moments (up to the fifth day). The mean value of the preoperative PFE was  $100.60 \pm$

$16.49$  liters/minute with significant decrease to  $65.56 \pm 15.28$  liters/minute, on the other hand, the FVC in the preoperative was  $83.33 \pm 17.19$  with reduction in the postoperative to  $52.96 \pm 14.61$ , and preoperative VEF1  $88.10 \pm 17.19$  dropping to  $56.05 \pm 16.37$  in the postoperative. This reduction was confirmed by the statistical significance in all the variables with value  $P = 0.00$ .

When comparing the spirometric variables: PFE, FVC and VEF1, before and after the surgery, between the Study Group and the patients in the Control Group, it was observed that these variables did not present statistically significant alterations by using the electroanalgesia instituted as showing values “P” in Table 2.

In regard of the level of pain reported by patients in the control group the mean rating in the pain scale was  $1.86 \pm 1.33$  at the moment prior to the electroanalgesia treatment and,  $0.50 \pm 0.60$  after the application; on the other hand the study group presented mean  $2.13 \pm 1.78$  in the rating of the pain scale at the moment prior to the application and  $2.10 \pm 1.54$  after the electroanalgesia application, it was observed that the Study Group showed statistically significant reduction in the level of pain when compared to the Control Group, with values “P” = 0.03. It was still observed that the patients presented a lower painful sensation after the third day of postoperative presenting similar results in both groups.

The correlation of the variables presented aim mainly the analysis of the influence of the variables of the sample characterization and data during operation and level of pain on the pulmonary capacity of the patients. Decoding the data, it was observed that there is no significant correlation between them, that is, the pulmonary capacity of these patients was not influenced by such conditions.

## DISCUSSION

It is known that the myocardial revascularization surgery causes organic dysfunctions mainly in the respiratory system. Among these dysfunctions, it can be mentioned: paralysis of the hemidiaphragm, atelectasis, hypoxemia, change in the ventilation/perfusion relation, as well as pneumonia and pulmonary edema. According Umeda et al. [2]: “The very incision for accessing the thorax interior determines mechanical alterations in the chest that implicate in the FVC reduction, functional residual capacity (FRC) and VEF1”.

Not only are the mechanical alterations of the chest responsible for the postoperative respiratory complications. The pain, an inevitable consequence of these procedures, limits the thoracic expansibility and mobility, inhibits the deep breathing and efficient coughing and, if not treated properly, it will cause secretion accumulation, collapse of pulmonary segments, infection and a reduction in the pulmonary capacity and volume [7]. Muller et al. [8] observed that 51% of the patients still presented thoracic pain seven days after the cardiac surgery.

Attempting to alleviate the inherent complications of the surgical procedure and aiming the rehabilitation of

patients in the postoperative, physiotherapy applies techniques based on physical resources, such as: kinesiotherapeutic, thermotherapeutic, phototherapeutic and electrotherapeutic resources.

Amongst the physical resources used by physiotherapy, as a complementary procedure to the chemical analgesia, TENS is an alternative for the reduction of postoperative pain, helping the restoration of the respiratory function and the recovery of patients.

TENS also shows some advantages for being a non-invasive and inexpensive method with mild side effects.

Although the use of TENS having been recommended by a series of studies, its efficiency, on the other hand, is disputed by several authors. Kitchen & Bazin [5] claim that the failure of TENS is associated to the misconceived concept that the treatment of pain is something isolated and independent from a complete and comprehensive rehabilitation program. In addition, there is no common opinion found in literature regarding the frequency ideal standards and pulse sequence to be used in TENS for an efficient treatment of pain. It seems that the parameters to be followed must be initially adequate to the clinical conditions of the patients [9].

Foster et al. [10], in the postoperative of a myocardial revascularization surgery, used TENS for a continuous period of 72 hours, with wave frequency set up at 278 Hz and pulse sequence in 60  $\mu$ s. Benedetti et al. [11], in a similar postoperative situation, established the wave frequency at 100 Hz and pulse sequence in 400  $\mu$ s in the electroanalgesia application for one hour, followed by one hour of rest, over a total period of 12 hours.

The present work followed all the criteria defined by Johnson et al. [3], when detecting that the best analgesic effect of TENS over the cold induced pain was achieved when using frequencies between 20 and 80 Hz, being the latter pointed as the most efficient and, pulse sequence in 125  $\mu$ s.

The choice of the aforementioned work as a guideline for our research was due to the fact of its use of values still not applied to the patients submitted to cardiac surgery, that, regardless the skeptical opinions concerning TENS, resulted in a decrease of postoperative pain.

The application of low frequency, low pulse sequence and high intensity, according to Low & Reed [6], would trigger a morphine-like effect on the C-fiber system, following the release of enkephalins produced by interneurons in the posterior cornu, which are stimulated by A-delta pain reception fibers.

Therefore, the applications of electroanalgesia twice a day with such parameters, is based on the principle that initially TENS would block the nervous transmission of pain and the continuity of the analgesia would occur by the release of endogenous opioids.

Being the cardiac surgery postoperative pain considered an aggravating factor in the respiratory function and TENS

being a physiotherapeutic resource to alleviate it, we make use of the electroanalgesia as an analgesic device that, when alleviating the pain, would implicate in the improvement of the respiratory capacity.

The postoperative pain in patients submitted to this type of operation was a variable of extreme relevance for this work. Its measurement, however, is not always possible when it is based solely on criteria strictly subjective and individual.

As a consequence, several criteria have been proposed to describe the levels of pain, not only with more objectivity, but also with more quantitative specificity. Descriptive and categorical verbal scales, numerical image analogical scales (0–10), pictographic (faces, figures, lines, colors) scales and other types of evaluation have been used with this purpose [12].

The Numerical Image Analogical Scale of Pain, used in the present work is objective and quantitative, being largely used and accepted by the world literature. In this scale the patient is instructed on the need of classifying his pain in grades that range from 0 to 10 according to the intensity of the painful sensation.

Through this scale, it was observed that the intensity of pain reported by the patients of both, control and study, groups did not exceed 5 points, corresponding to 'uncomfortable pain'. When comparing the values of pain before and after the application of the treatment, it was observed that the patients submitted to electroanalgesia presented a rather significant reduction of pain ( $P = 0.03$ ). Similar data were found by Foster et al. [10] and Navarathnam et al. [13].

It can still be noticed that the values of pain presented significant reduction in both groups after the third day of postoperative, when the intercostal pleural and subxiphoid drains were removed. This reduction is due to the "time factor" that acted as a natural reducing agent.

The reduction in the intensity of pain occurs, as a matter of fact, because the initial nociceptive stimuli decrease with time, after the surgical intervention, by the reduction of the sternum instability and removal of drains [14].

After observing the effective reduction of pain in the patients that received electroanalgesic treatment, we verified their spirometric variables in order to identify the influence of postoperative pain reduction on their pulmonary capacities.

After analyzing all the patients studied regarding the esferometric variables, EFP, FVC and FEV1 before and after the cardiac surgery, it could be observed the negative impact of the surgery on the pulmonary function. Evidence found that smoking contributed for an even higher reduction in the respiratory function of such patients when compared to non-smoking patients before and after the surgery. This preoperative risk factor must be considered, still, as aggravating of the already compromised respiratory function determined by thoracotomy.

When comparing the same variables aforementioned in

the control group and study group, it can be observed that in the latter occurred an improvement in the respiratory function, however, without statistical significance.

Navarathnam et al. [13] evaluated the pulmonary function in 31 patients submitted to myocardial revascularization surgery or valvar replacement surgery in the first 72 hours of postoperative. The patients were randomized in two groups: TENS group and placebo group. As a result, an improvement in the values of EFP occurred in the group that performed the electroanalgesia with value  $P < 0.005$ ; however, when comparing both groups, there was no statistical difference in the values of FVC and FEV1, which are similar to those of this study.

Similar results were achieved by Foster et al. [10] when studying 45 patients in which TENS was applied as a supportive measure to medicine analgesia in the postoperative of patients submitted to myocardial revascularization surgery. This author performed three spirometric measurements; being the first, 24 hours after the surgery; the second after 48 hours and the third, 72 hours after the operation. It was observed that no significant improvement in the spirometric values occurred in the patients submitted to the treatment by electroanalgesia when compared to the patients that performed the placebo treatment.

Such situation can be explained by the fact that the myocardial revascularization surgery is extremely traumatic and some procedures performed during the operation, as mentioned previously, produce several pulmonary complications. It is not sufficient to consider the pain relief as an essential factor for the reintegration of the patient to his daily routine. The patient rehabilitation is multifactorial and multidisciplinary [14-16].

It is still convenient to stress that the variables: body mass index, age, gender and Euro SCORE had no impact on the pulmonary capacity in the patients submitted to the myocardial revascularization surgery.

## CONCLUSION

Therefore, the conclusion that, despite the electroanalgesia having implicated reduction in the levels of pain in the patients to which it was applied, however, it did not influence the improvement of the expiratory flow peak, the forced vital capacity and the forced expiratory volume in the first second of the patients submitted to cardiac surgery with extracorporeal circulation.

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