CASE SERIES

Cirujano General

January-March 2020
Vol. 42, no. 1 / p. 24-30

Radiofrequency intercostal nerve thermal ablation for pain due to multiple rib fractures

Ablación térmica de nervios intercostales por radiofrecuencia para dolor por fracturas costales múltiples

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Keywords:
Pain, intercostal nerve thermal ablation, blunt chest trauma.

Palabras clave:
Dolor, ablación térmica de nervios intercostales, trauma contuso de tórax.

ABSTRACT

Introduction: Trauma in general and particularly blunt chest trauma continue to be part of the most frequent problems that the physician, surgeon, and emergency systems must face every day. The pain experienced by patients is usually very severe, limiting respiratory mechanics in an important way and consequently, the patient is frequently complicated by pulmonary atelectasis and pneumonic foci due to the lack of good secretion management. The aim of this article is to demonstrate that the use of radiofrequency ablation of intercostal nerves reduces pain in patients with blunt chest trauma, by reviewing 12 cases with blunt trauma and multiple rib fractures treated with radiofrequency guided by fluoroscopy, ultrasound, and impedance to produce thermal ablation of the intercostal nerves involved and thus significantly reduce preoperative or postoperative pain associated with multiple rib fractures. **Material and methods:** Retrospective study of 12 patients with blunt chest trauma and difficulty in ventilating, with a kinematics of: falls from different heights (from 10 to 25 m high), automobile and motorcycle accidents. After informed consent for this type of procedure and under general anesthesia and intubation, intercostal nerve ablation was performed, using fluoroscopy to locate the intercostal nerve involved proximal to the fracture; the correct position of the needle was corroborated by impedance, motor, and sensory stimulation. Ablation was performed at 60 ºC for one minute for each nerve using NeuroTherm® NT 1100 equipment. Qualitative descriptive variables were age, gender, and trauma kinematics. The variables under study were pre-ablation and post-ablation ventilation pain measured with a numerical pain scale (END), and pre-ablation and post-ablation expiratory pain. Quantitative variables were number of fractured ribs, Injury Severity Score (ISS) and Revised Trauma Score (RTS). The quantitative study variables were morphine consumption in mg pre-

RESUMEN

Introducción: *El trauma en general y el trauma contuso de tórax en particular continúan formando parte de los problemas más frecuentes que el médico, el cirujano y los sistemas de emergencia tienen que afrontar todos los días. El dolor que experimentan los pacientes suele ser muy intenso, limitando la mecánica respiratoria de manera importante y por consiguiente, complicándose el paciente con frecuencia por atelectasias pulmonares y focos neumónicos al no contar con un buen manejo de secreciones. El objetivo de este artículo es demostrar que el uso de la ablación por radiofrecuencia de los nervios intercostales disminuye el dolor en el paciente con trauma contuso de tórax, mediante la revisión de 12 casos con trauma contuso y fracturas costales múltiples tratados con radiofrecuencia guiada con fluoroscopia, ultrasonido e impedancia para producir ablación térmica de los nervios intercostales involucrados y de esta manera, reducir de manera importante el dolor preoperatorio o postoperatorio asociado a fracturas costales múltiples.* ***Material y métodos:*** *Tipo de estudio retrospectivo de 12 pacientes con trauma de tórax contuso y dificultad para ventilar, con una cinemática de: caídas de diferentes alturas (de 10 a 25 m de altura), accidentes automovilísticos, y de motocicleta. Previo consentimiento informado para este tipo de procedimiento y bajo anestesia general e intubación se realizó ablación de nervios intercostales, utilizando fluoroscopia para localizar el nervio intercostal involucrado proximal a la fractura, se corroboró la correcta posición de la aguja mediante impedancia, estimulación motora y sensitiva. Se efectuó ablación a 60 ºC durante un minuto por cada nervio empleando el equipo NeuroTherm NT 1100 (marca registrada). Variables: cualitativas descriptivas: edad, sexo, cinemática del trauma. Variables en estudio: dolor a la ventilación preablación y postablación, medidas mediante escala numérica de dolor (END), dolor a la espiración preablación y*

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Received: 02/21/2019
Accepted: 02/05/2020

How to cite: Torres-Méndez R, Vega-Rivera F, Acuña-Prats R. Radiofrequency intercostal nerve thermal ablation for pain due to multiple rib fractures. Cir Gen. 2020; 42(1): 24-30.

ablation and post-ablation. Variables were described as mean and standard deviation. **Results:** There was a 70% decrease of pain on exhalation and a 70.8% decrease in opioid consumption. Complications were mild, and transient allodynia in 41.2% of cases was controlled with gabapentin-like drugs for two weeks. **Conclusion:** Thermal ablation of intercostal nerves by radiofrequency in thoracic blunt trauma is useful, reduces pain significantly and allows better ventilation with less consumption of analgesics. This technique could become a new gold standard in pain control in severe thoracic trauma.

postablación. Variables cuantitativas: número de costillas fracturadas, calificación del Injury Severity Score (ISS) y Revised Trauma Score (RTS). Variables cuantitativas del estudio: consumo de morfina en mg preablación y postablación. Descripción de las variables mediante: media y desviación estándar. ***Resultados:*** *Disminución del dolor a la espiración en 70%, así como del consumo de opioides en 70.8%. Complicaciones: alodinia leve y pasajera en 41.2% de los casos controlada con gabapentinoides durante dos semanas.* ***Conclusión:*** *La ablación térmica de nervios intercostales por radiofrecuencia en trauma contuso de tórax es útil, disminuye el dolor en forma significativa y permite mejor ventilación con menor consumo de analgésicos. Esta técnica podría perfilarse como un nuevo estándar de oro en el control del dolor en trauma torácico severo.*

INTRODUCTION

Worldwide, trauma is a public health problem and a leading cause of mortality in all age groups. Quite often, trauma pain requires opioids and is not uncommonly undertreated.

Blunt chest trauma is a frequent problem, whether due to unrestrained motor vehicle accidents, motorcycles, bicycle falls, or falls from own height and being run over. In these cases, multiple rib fractures occur frequently and may be accompanied by hemopneumothorax or even unstable thorax. Regardless of the risk that these pathologies may represent for the patient's life, once they are resolved in the initial evaluation according to the Advanced Trauma Life Support (ATLS) protocol of the American College of Surgeons, the pain persists. This pain is usually very severe, ranging from 9 to 10 on the numerical pain scale, intensifies on deep inspiration and significantly limits the patient's ventilatory mechanics, delaying extubating time in intensive care units due to pain on inspiration and poor secretion management because of the inability to expectorate.

This pain usually requires high doses of opiates with the side effects that this implies such as nausea, vomiting, headache, respiratory depression, sedation of the patient and delirium, and can also mask other injuries such as cranioencephalic trauma, abdominal blunt trauma, and compartment syndrome, which is not uncommon for the three entities to coincide in this trauma kinematics.

Since 1945 thoracic nerve blocks have been used to reduce pain from thoracic trauma. During World War II it was a valuable resource for reducing pain from fractured ribs.[1,2]

However, although infiltration of anesthetics to the affected intercostal nerves produced significant pain relief and analgesic reduction, its effect was short-lived.[3,4]

The installation of a peridural catheter with continuous infusion of opioids improved analgesia in these patients. However, it presented the problem of mobilizing a polytraumatized patient to perform it, in addition to the hypotension associated with the continuous infusion due to vasodilatation associated in hemodynamically unstable patients or with cranioencephalic trauma, aggravating the state of shock and decreasing cerebral perfusion.[5,6]

Radiofrequency acts by producing thermal ablation of the involved intercostal nerve by means of a needle placed in the subcostal canal guided either by ultrasound or fluoroscopy.[7-10]

This permanent damage to the intercostal nerve provides significant analgesia, can be performed with the patient in dorsal

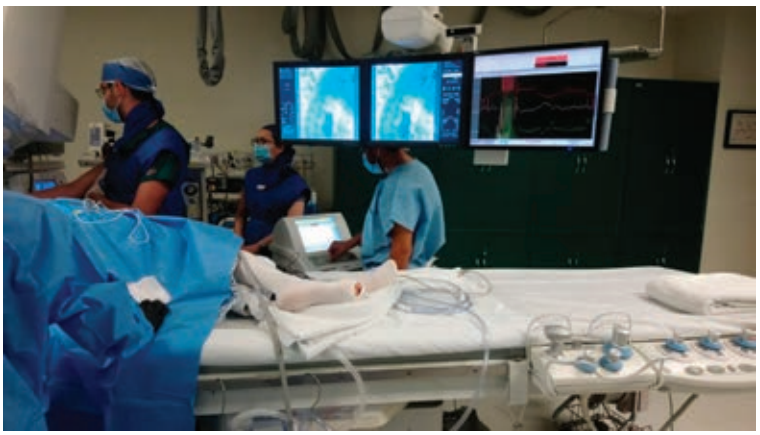

Figure 1: *Fluoroscopic control of intercostal radiofrequency ablation in multiple rib fractures.*

decubitus position without the need for posture changes and may even be carried out in the intensive care unit if ultrasound is used as a guide. The analgesia provided is permanent, which allows the patient to have good respiratory mechanics, prevents pulmonary atelectasis or pneumonia, and reduces the use of analgesics.[11-15]

Based on the above, radiofrequency of the intercostal nerves was started in our hospital to treat pain and improve respiratory mechanics in patients with blunt chest trauma. This work arose from the need to be able to control the severe pain presented by these patients and to improve their respiratory mechanics for early extubating, and it has emerged as an option to traditional medical and surgical treatment of this kind of patients in our hospital. The aim of this article is to describe this case series treated by this method at the Hospital Angeles Lomas in Mexico City, Mexico.

MATERIAL AND METHODS

The physical and, where appropriate, electronic records of patients with blunt chest trauma treated with intercostal nerve radiofrequency at Hospital Angeles Lomas from January 2006 to August 2018 were retrospectively reviewed. During this period, 12 patients were treated with this technique, with prior informed consent of the patient and/or his/her family for the intercostal nerve thermal ablation technique, in addition to the corresponding informed consents signed for other types of surgical treatments that the patient merited due to blunt chest trauma and multiple rib fractures.

Patients were resuscitated according to the ATLS protocol. After their stabilization and having treated priority lesions of other organs (24 to 72 hours later), the patients were subjected, prior intubation, to radiofrequency ablation in the fluoroscopy room, or by ultrasonographic control in the same Intensive Care Unit.

NeuroTherm® thermo-ablation needles, model Simplicity III, were used. The intercostal nerve involved was located proximal to the fracture. The correct position of the needle was corroborated by impedance, motor and sensory stimulation and the intercostal nerves were ablated at 60 ºC for one minute for each nerve using the NeuroTherm NT 1100 equipment *(Figure 1)*.

Pain was assessed using a numerical pain scale, at rest with shallow breathing and with expiration pre-radiofrequency and post-radiofrequency. Pain intensity was also indirectly measured by daily opioid consumption. All patients were conscious when pain was assessed.

To measure pre- and post-radiofrequency opioid consumption, the amount of morphine in milligrams (mg) administered intravenously in 24 hours required by each patient was documented. In the cases in which morphine was not used, other analgesic drugs were converted to mg of morphine, seeking the equivalence of other opioids to morphine to be able to unify and compare the daily consumption of morphine pre-treatment and post-treatment.

RESULTS

During this period, 12 patients with blunt chest trauma and multiple rib fractures were treated with this ablation technique. Five female and seven male patients, ranging in age from 28 to 76 with an average of 57.5 years, with the following trauma kinematics, were included: six automobile accidents,

two motorcycle accidents and four falls (2 from their own height, and one each from 10 and 25 m), with a range of fractured ribs from three to 10 and an average of six ribs. Trauma intensity was graded using the combined trauma score scale and the Trauma Injury Severity Index (TRISS) of the American Association for the Surgery of Trauma with a range of 1.1 to 49.7, a mean of 11.71 and a standard deviation of 13.12 points. Patients with blunt trauma were graded as severe (8.3%) using these scales from 1 to 12.

Figure 2: *Multiple rib fractures due to blunt trauma, third to tenth ribs, right hemithorax. CT scan with bone reconstruction.*

All 12 patients had a mean number of fractured ribs of 5.75 with a standard deviation of 2.18. Pain was measured at rest with shallow breathing and on exhalation *(Figure 2)*.

Pain at rest with shallow breathing before radiofrequency had a mean of 7.6 points on the numerical scale with a standard deviation of 2.18 points. After intercostal nerve ablation the mean was 2.08 with a standard deviation of 1.73 on the numerical pain scale. Pain on exhalation was measured before radiofrequency with a mean of 9.75 and a standard deviation of 0.62 and after radiofrequency with a mean of 2.75 and a standard deviation of 1.36 using this same scale.

The dose in mg per day of morphine equivalent opioids administered intravenously before radiofrequency had a mean of 26.67 mg in 24 hours with a standard deviation of 10.5 mg and after radiofrequency was 7.79 mg in 24 hours with a standard deviation of 0.28 *(Table 1)*.

Pain decreased by 70% post-radiofrequency at rest, and at expiration was also reduced by 70%, and opioid consumption in mg per 24 hours was reduced by 70.8%.

The complications observed with the radiofrequency technique were mild and consisted mainly of transient allodynia in

Table 1: Post-ablation pain assessment and morphine consumption (N = 12).

Parameter	Female Mean ± SD	Male Mean ± SD	Total Mean ± SD
Number of fractured ribs	5.4 ± 2.70	6.00 ± 1.91	5.75 ± 2.18
Pain (VAS) resting w/shallow breathing Pre ablation DRSPA	7.2 ± 2.39	7.71 ± 2.36	7.50 ± 2.28
Pain (VAS) rest w/shallow breathing Post ablation DRSPOA	2.6 ± 1.52	1.71 ± 1.89	2.08 ± 1.73
Pain (VAS) normal expiratory Pre ablation DEPA	10.0 ± 0.00	9.57 ± 0.79	9.75 ± 0.62
Pain (VAS) normal expiratory Post ablation DEPOA	3.0 ± 1.22	2.57 ± 1.51	2.75 ± 1.36
Dose/day mg opioid morphine equivalent Pre ablation DO = M	25.8 ± 13.40	27.29 ± 12.85	26.67 ± 12.49
Min-max	10-40	10-50	10-50
Opioid dose (mg) morphine equivalent Post ablation DO = M Post ablation	7.8 ± 6.11	7.79 ± 10.30	7.79 ± 8.45
Min-max	0-16.5	0-28	0-28

41.2% of the patients that was controlled with gabapentin-like drugs every eight hours for two weeks. There were no serious complications or mortality in this series. In some cases, fixation of the fractured ribs was combined with trans operative intercostal thermal ablation when the patient presented with an unstable thorax or rib displacement.

Complications attributed to this technique were minor, mainly due to mild and transient allodynia in 41.2% of the cases controlled with low dose gabapentin-like drugs for two weeks. There were no cases of post-ablation pneumothorax or mortality in this series.

DISCUSSION

Currently, pain is considered the fifth vital sign and pain relief is now seen as a fundamental right of the patient at the international level, and it has been decreed by the World Health Organization (WHO) as one of the human rights. Currently, it is a serious breach of professional ethics not to treat or undertreat the patient's pain.

Pain management in the trauma patient is a challenge. Initial assessment and treatment of life-threatening or limb-threatening injuries takes priority and initiation of analgesia is often postponed until the patient is stable. The first-line treatment for the trauma patient is low-dose opioids administered intravenously. They act rapidly, are effective and are indicated in severe pain. However, there are multiple reasons why the trauma patient receives insufficient analgesia: physicians are reluctant to administer opioids systemically due to fear of aggravating hemodynamic instability or respiratory depression with airway loss. In addition, in patients with head injury, there is concern about masking the clinical picture or producing delirium, particularly in elderly patients, which may confound the clinical picture of head injury. Frequent patient assessments are usually needed without sedation and it is not possible to estimate whether the patient is really deteriorating.[16,17]

Another reason why patients do not receive adequate analgesia is because it is difficult to measure pain in trauma because patients are often intubated and mechanically ventilated, and communication cannot be established.[18]

Based on the above, multimodal analgesia and in particular regional analgesia, such as radiofrequency ablation, significantly reduce opioid requirements, shortening the stay in the intensive care unit and emergency rooms, recovery, reducing the adverse effects of these drugs such as nausea, vomiting, headache, respiratory depression, delirium, vasodilatation with hypotension, constipation, pruritus, and immunosuppression all of which requires more staff for surveillance and monitoring.

In this case series it was evident how radiofrequency of the intercostal nerves significantly reduced morphine consumption in mg per 24 hours (70.8%) by producing high quality analgesia that is specific to the chest wall, and therefore, without systemic effects.

In our patients, pain managed with intercostal nerve ablation by radiofrequency decreased from severe pain (from 7-10 points) with a mean of 7.5 points with superficial ventilation measured with a numerical pain scale, to a pain of 2-4 with a mean of 2, being a mild pain and attributed to the fact that there are also other causes of pain in thoracic trauma independent of rib fractures. This represented an approximate relief of 70% in most cases since it was possible to manage pain without opiates and with other types of analgesics, which was of great help for the intensive care unit since the patients could be extubated earlier due to a much better respiratory mechanics, achieving a deeper inspiration and expiration and consequently, a better management of airway secretions with less possibilities of complications like pulmonary atelectasis and pneumonia.

The results observed in our study agree with the world literature in observing a significant reduction in daily morphine consumption.[15,19]

CONCLUSION

Trauma is a worldwide public health problem and one of the main causes of mortality in all age groups. The pain produced particularly by blunt trauma of the thorax is severe, usually requires opiates, and it is not uncommon to be undertreated for several reasons.

Thermal ablation of the intercostal nerves by radiofrequency in blunt chest trauma with multiple rib fractures and unstable thorax is a useful and safe procedure for the treatment of these patients. In this case series it was evident how radiofrequency of the intercostal nerves significantly decreased morphine consumption in mg per 24 hours (70.8%) by producing high quality analgesia specific to the chest wall and therefore without side effects.

This technique significantly reduces pain and allows better ventilation with less consumption of other analgesics.

Thermal ablation of the intercostal nerves may emerge as a new gold standard for pain control in severe chest trauma. Larger studies with higher number of patients are required to further validate these initial conclusions.

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Ethical considerations and responsibility: Data privacy. In accordance with the protocols established at the authors' work site, the authors declare that they have followed the protocols

on patient data privacy while preserving their anonymity. The informed consent of the patient referred to in the article is in the possession of the author.

Funding: No financial support was received for this study.

Disclosure: The authors declare that they do not have any conflict of interests in the conduction of this work.

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