Thoracoscopic cryoanalgesia: A new strategy for postoperative pain control in minimally invasive pectus excavatum repair

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ABSTRACT

Objective. Recent publications report early discharge and low opioid requirements after minimally invasive pectus excavatum repair treated with bilateral intercostal nerve cryoablation. Our aim is to report our initial experience with this technique.

Materials and methods. Retrospective analysis of medical records of patients undergoing bilateral thoracoscopic cryoanalgesia during minimally invasive pectus excavatum repair within our institution from September 2018 to March 2019.

Technique. A cryoprobe was applied at -70 ºC for 2 minutes each from the 3rd to the 7th intercostal nerves bilaterally under thoracoscopic control. Postoperative pain was assessed using a visual analogue scale (VAS).

Results. Twenty-one patients were included. Ninety percent were male, the mean age being 15.2 ± 4.29 years, and the mean weight being 53.6 ± 15.33 kg. The average Haller index was 5.1 ± 2.97, and the mean repair index was 37.6 ± 13.77%. The mean number of implants introduced was 2.55 ± 0.74. The mean duration of cryoanalgesia was 39.9 ± 21.1. No patients received epidural anesthesia. Mean postoperative stay was 1.64 ± 0.73 days. Seventy-one percent of the patients required 1 dose of opioids at the most for postoperative pain control. According to the VAS, the average pain score on postoperative days 1, 3, 7, and 21 was 2.55, 2.01, 0.5, and 0.06, respectively.

Conclusions. Bilateral thoracoscopic cryoanalgesia during minimally invasive pectus excavatum repair leads to early discharge and good postoperative pain control in all cases. Cryoanalgesia has become our treatment of choice for pain control in the thoracoscopic repair of pectus excavatum.

KEY WORDS: Cryoanalgesia; Nerve cryoablation; Pectus excavatum; Minimally invasive pectus excavatum repair; Postoperative pain; Intercostal nerve.

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CRIOANALGESIA TORACOSCÓPICA: NUEVA ESTRATEGIA PARA EL CONTROL DEL DOLOR POSTOPERATORIO EN CIRUGÍA DEL *PECTUS EXCAVATUM*

RESUMEN

Introducción. Publicaciones recientes reportaron el alta temprana y bajos requerimientos de opioides para el control del dolor postoperatorio en la reparación mínimamente invasiva del *pectus excavatum* tras crioablación bilateral de nervios intercostales. Nuestro objetivo es describir nuestra experiencia inicial con esta técnica.

Material y métodos. Análisis retrospectivo de historias clínicas de pacientes sometidos a crioanalgesia toracoscópica bilateral durante la reparación mínimamente invasiva del *pectus excavatum* en nuestra institución desde septiembre de 2018 a marzo de 2019.

Técnica. Se aplicó una criosonda a -70°C bajo visión toracoscópica durante 2 minutos del 3er al 7º espacio intercostal, de manera bilateral. El dolor postoperatorio fue evaluado con una Escala Visual Analógica.

Resultados. Se incluyeron 21 pacientes, de los cuales el 90% era de sexo masculino con una edad media de 15,2 ± 4,29 años y un peso de 53,6 ± 15,33 kg. El índice de Haller promedio fue de 5,1 ± 2,97 y el índice de corrección de 37,6 ± 13,77%. El número promedio de implantes fue de 2,55 ± 0,74. La duración media de la crioanalgesia fue de 39,9 ± 21,1 minutos. Ninguno recibió anestesia peridural. El tiempo de internación postquirúrgico fue de 1,64 ± 0,73. La necesidad de rescate con opiáceos fue menor a 1 dosis en el 71,3%. La puntuación de dolor en los días postoperatorios 1, 3, 7 y 21 fue, en promedio, de 2,55; 2,01; 0,5 y 0,06, respectivamente.

Conclusiones. El empleo de la crioanalgesia toracoscópica bilateral permitió el alta hospitalaria temprana y buen control del dolor postoperatorio en todos los casos, convirtiéndose en el método analgésico de elección en nuestra práctica clínica.

PALABRAS CLAVE: Crioanalgesia; Crioablación nerviosa; *Pectus excavatum*; Reparación mínimamente invasiva del *pectus excavatum*; Dolor postoperatorio; Nervio intercostal.

INTRODUCTION

Pectus excavatum (PE) surgical repair has evolved over time. The minimally invasive repair of sunken chest deformities described by Nuss was a revolution since it was first

introduced in 1997[1]. Over time, technique modifications, such as the use of lighter and more resistant implants[2], or new sternal traction techniques reducing the risk of cardiac lacerations during bar passage through the anterior mediastinum, have been reported[3].

Postoperative pain, as well as complications stemming from the use of high doses of opioids, have become key factors in the increase in hospital stay following PE repair[4], and they represent a challenge our specialty should respond to. Currently, thoracic epidural analgesia is the most common strategy in the management of postoperative pain[5]. However, this is not a risk-free technique, since it can cause limb paralysis, respiratory depression, nausea, vomits, digestive intolerance, intestinal ileum and urinary retention, and long-term catheterization[6].

At the beginning of the current century, a new technique – cryoanalgesia – became popular as a pain control strategy in thoracotomies and other procedures requiring a thoracic approach[7]. It is based on the axonotmesis of the intercostal nerve[8], which produces a long-term anesthesia, with a subsequent nerve recovery and, therefore, of sensitivity and proprioception over the following 6 weeks.

The first series of patients[9] undergoing bilateral thoracoscopic cryoanalgesia in minimally invasive PE repair have been reported recently, with favorable results as compared to traditional pain management strategies.

Our objective is to describe our initial experience with this technique and discuss what we learnt in the process.

MATERIALS AND METHODS

Type of study and selection of patients

Retrospective analysis of the clinical records of all patients undergoing minimally invasive pectus excavatum repair between September 2018 and April 2019. The following variables were analyzed: demographic characteristics (age, sex, and weight), sunken chest severity, number of implants per patient, cryoanalgesia time, postoperative complications, hospital stay, and postoperative pain record. Informed consent was requested in all cases.

Technique

Prophylactic neuroprotection

In order to prevent neurapraxia or allodynia, prophylaxis is carried out using neuroleptic and neuroprotective drugs pre- and post-operatively. The drug administration regime is detailed below:

- Pre-surgical preparation: 1 week prior to the procedure. Selection of one drug or the other:
  - Gabapentin: Start with 100 mg every 8 hours for 3 days. Then, increase the dose up to 200 mg every 8 hours unless adverse effects such as somnolence are observed.
  - Pregabalin: Start with 50 mg every 8 hours for 3 days. Then, increase the dose up to 75 mg every 8 hours unless adverse effects are observed.
- Postsurgical prophylaxis during hospital stay:
  - Intravenous paracetamol every 8 hours and ibuprofen every 8 hours (alternate).
  - Intravenous tramadol.
  - Gabapentin or pregabalin: maintain the same dose.
- Outpatient postsurgical prophylaxis:
  - 400 mg ibuprofen every 6 hours.
  - Gabapentin or pregabalin for 1 week.
  - 50 mg diclofenac.

Cryoanalgesia technique

The procedure is carried out before implant placement. An external cryogenics system (Cryosurgery System CE-4G. Frigitronics®, Connecticut, USA) is used. It is connected to a sterilized cryoprobe whose tip is cooled down to -70ºC with liquid nitrogen. A selective orobronchial intubation is performed, and the right lung is collapsed first.

Then, when proceeding on the left side, the right lung is grasped and the left one is collapsed until completing the cryoanalgesia. A bilateral incision is carried out in the skin at the level of the sites through which the implants will be introduced. The subcutaneous pockets are dissected, and a 5 mm port is placed at the level of the intersection of the right eighth intercostal space and the anterior axillary line. This allows a 5 mm scope to be introduced for thoracoscopic control purposes and carbon dioxide insufflation with a 6 mm of mercury pressure. The cryoprobe is introduced at the level of the right fifth intercostal space through the incision previously carried out. The probe is protected, except for its distal end, so as not to cause any damage in the skin when it cools down (Fig. 1). Once inside the thoracic cavity, the probe is set at -70ºC and is applied on the lower costal edge at the level of five intercostal spaces (from the 3rd to the 7th space at the level of the posterior thoracic groove) for 2 minutes (Fig. 2). Once the right cryoablation has been completed, the tip of the probe is defrosted. The procedure is repeated on the left side.

Postoperative care

Postoperatively, the patient stays at the intensive care unit for 24-48 hours. Non-steroid anti-inflammatory drugs – and opioids, if need be – are administered for analgesic purposes. After discharge, non-steroid anti-inflammatory drugs and prophylaxis neuroprotection are prescribed for one week. In case of uncontrolled pain, tramadol is prescribed.

Postoperative pain record

At discharge, a computer record is created by completing an online survey with a pain score ranging from 0 to 10 according to a Visual Analogue Scale (VAS). This record

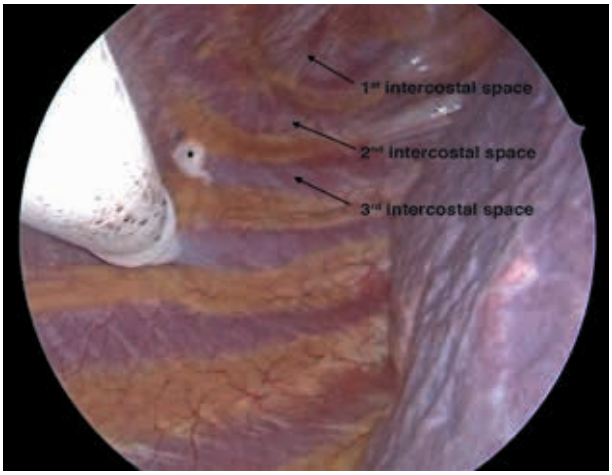

Figure 1. Direct thoracoscopic vision in the right hemithorax. Cryoprobe applying cold at -70ºC in the lower costal edge for two minutes. The first three intercostal spaces are identified with black arrows, while the fovea resulting from the application of the cryoprobe in the third intercostal space is identified with an asterisk.

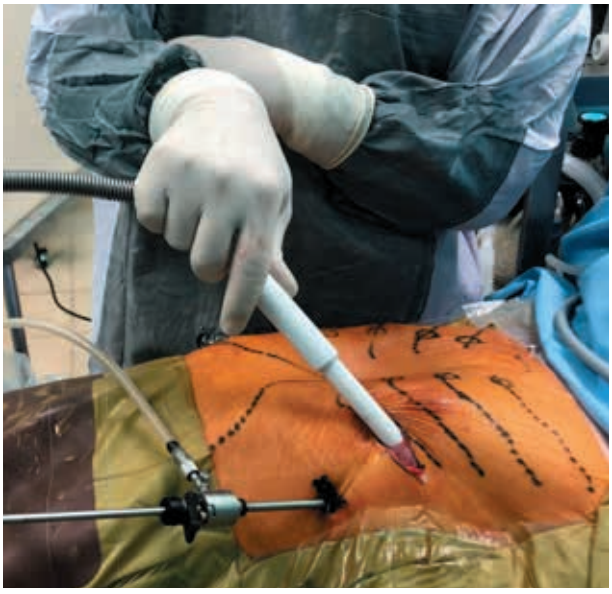

Figure 2. Left hemithorax cryoanalgesia. The cryoprobe is introduced into the fourth intercostal space, outside of the mid clavicular line. At the level of the eighth intercostal space and the anterior left axillar line, a 5mm port for direct thoracoscopic vision, with a 6mmHg controlled pneumothorax, is seen.

is created by the patient via a mobile app daily – if more than one daily datum is introduced, all data are averaged out. In addition, a weekly outpatient follow-up is carried out over the first month post surgery, and a monthly one is performed until month four. Then, controls take place at months 6, 12, and 24.

RESULTS

Bilateral thoracoscopic cryoanalgesia was performed in 21 patients diagnosed with pectus excavatum, 19 of whom male. Table 1 features the demographic data of the study population as well as PE severity degrees and the number of bars implanted per patient.

Mean cryoanalgesia duration was 39.9 ± 21.1 minutes, with a range of 29 to 105 minutes. From the seventh patient on, selective intubation was systematically carried out. Mean cryoanalgesia duration in the first 7 patients was 56.3 minutes, as compared to 33.7 minutes for the other patients.

Mean postoperative hospital stay was 1.64 ± 0.73 days. 38% of patients were discharged on the first day, 52% on the second day, and 10% on the third day.

Table 2 features the results of the analysis of the Visual Analogue Scale scores provided by the patients for postoperative pain assessment.

Regarding the need for opioids during hospital stay, 71.3% of patients required one dose at the most. Table 3 features the results in detail. No intraoperative complications were noted. One patient did present with a postoperative complication – pain expressed as a "puncture" sensation for three weeks.

Table 1. Demographic and chest deformity characteristics.

	Mean (standard deviation)
Age (years)	15.2 ± 4.29
Weight (kg)	53.6 ± 15.33
Haller index	5.1 ± 2.97
Repair index	37.6 ± 13.77
Number of implants per patient	2.55 ± 0.74

DISCUSSION

Cryoanalgesia has been used for centuries as an analgesic and anti-inflammatory therapy[10,11]. The direct application of cold on the peripheral nerve produces axonotmesis[13], a transitory axonal disruption, including its myelin layer, with no lesion in the endoneurium, perineurium, or epineurium. In the case of thoracoscopic cryoanalgesia in PE repair, with a cryolesion of approximately 2.4 cm in size, nerve regeneration is completed within 4-6 weeks[14].

Our series, one of the longest published up until now, includes 21 cases of bilateral thoracoscopic cryoanalgesia for the management of postoperative pain in PE repair over eight months. Our results in terms of postoperative hospital stay (1.64 ± 0.73 days) and need for opioids (1 dose at the most during hospital stay in more than 70% of

Table 2. Analysis of postoperative pain Visual Analogue Scale (VAS) according to patient records.

Postoperative day	*VAS mean and standard deviation*
1	2.5 ± 1.84
3	2.1 ± 1.99
5	1.8 ± 1.79
7	0.5 ± 0.88
21	0 ± 0.27

Table 3. Number of patients according to the number of opioid doses required during postoperative stay.

Opioid doses required	*Number of patients*
0	8 (33%)
1	9 (38%)
2	2 (10%)
3	3 (14%)
4	1 (5%)

cases) are very favorable. Similarly, the results achieved through the analysis of the VAS scale are consistent with these findings, with a mean of 2 on the third postoperative day, and of 0.5 after one week.

Recently, other research groups reported the use of cryoanalgesia in minimally invasive PE repair[15-17]. The work by Graves et al[16], who carried out a randomized study comparing cryoanalgesia with thoracic epidural anesthesia, proves all the more interesting as it demonstrates that the first is better in terms of hospital stay and need for opioids, consistent with our results.

Although bilateral cryoanalgesia via a single incision in the right hemithorax[18] by passing the cryoanalgesia probe through the retrosternal space has been reported, we prefer to perform the procedure using independent incisions in each hemithorax, since we use a rigid cryoprobe.

Regarding cryoanalgesia's operating times, with the cryotherapy device used in these patients, a minimum of 20 minutes is required (2 minutes for each of the 10 intercostal spaces), plus some extra time for scope port placement on the left side. In the last cases, approximately 30 minutes in average were devoted to cryoanalgesia. We believe this is an acceptable operating time extension in light of the reduction of the variables previously analyzed – hospital stay and need for opioids.

At the beginning of the experience, an important lesson was learnt – the importance of one-lung ventilation in order to create an adequate field for cryoanalgesic purposes without damaging the surrounding tissues. On the left side, selective ventilation is key to create a nice field; a lateral inclination of the stretcher can also prove useful to overturn the heart to the right side. This improvement is demonstrated by the fact that mean cryoanalgesic times are significantly lower in selective intubation patients than in non-selective intubation patients, but it could also be explained by the fact that we are more familiar with the first procedure throughout our experience.

Finally, although our study is a retrospective one and, as such, it provides with a lower level of evidence than prospective studies, when other pain management strategies are used in minimally invasive PE repair, mean hospital stay ranges between 5 and 7 days, and opioids are necessary for one or two weeks. As a result of all this, bilateral thoracoscopic cryoanalgesia has become our strategy of choice for postoperative pain management in PE repair.

CONCLUSIONS

In patients undergoing a minimally invasive repair of sunken chest with retrosternal implants, cryoanalgesia is a safe and effective procedure which allows for an early discharge and a very low need for opioids in all cases.

This technique has become our strategy of choice for the postoperative control of patients undergoing thoracoscopic thoracoplasty for the treatment of sunken chest deformities.

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