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The role of intercostal cryoanalgesia in post-thoracotomy analgesia

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Abstract

OBJECTIVES: Patients undergoing thoracotomy were studied to compare the effects of cryoanalgesia, combined with intravenous patient-controlled analgesia (IVPCA), against IVPCA alone during the four days following surgery.

METHODS: Fifty patients were randomized into two groups: an IVPCA group ($n = 25$) and an IVPCA-cryo group ($n = 25$). Subjective pain intensity was assessed on a verbal analogue scale at rest and during coughing. The intensity and the incidence of post-thoracotomy pain, numbness, epigastric distension and/or back pain, the analgesic requirements, as well as the blood gas values and respiratory function tests were evaluated up to the second postoperative (postop) month. Haemodynamic data and episodes of nausea and/or vomiting were recorded over the four postop days.

RESULTS: In the cryo group there was a statistically significant improvement in postop pain scores ($P = 10^{-4}$), reduction in consumption of morphine ($P = 10^{-4}$) and other analgesics ($P = 10^{-4}$), optimization (less acidosis) of the pH values of blood gases ($P < 0.015$ over 72 hours postop and $P < 0.03$ on the first and second postop months), increase in systolic blood pressure ($P < 0.05$ over 96 hours postop), reduction in heart rate ($P < 0.05$ over 96 hours postop), increase in values of FEV_1 ($P < 0.02$) and FVC ($P < 0.05$) at the first and second postop months, reduction in the incidence of nausea ($0.05 < P < 0.1$ over 18 hours postop), numbness, epigastric distension and back pain ($P < 0.05$ at days 5, 6, 7, 14, 30 and 60 following surgery).

CONCLUSIONS: We suggest that cryoanalgesia be considered as a simple, safe, inexpensive, long-term form of post-thoracotomy pain relief. Cryoanalgesia effectively restores FEV_1 values at the second postop month.

Keywords: Post-thoracotomy pain • Cryonalgesia • Pulmonary function tests

INTRODUCTION

Post-thoracotomy pain is usually severe, due to extensive intraoperative nerve injury and continuous chest wall movements during respiration and coughing. Postoperative pain after thoracotomy represents a major morbidity issue because it cannot be eliminated with a simple technique that is effective, cheap, applicable to all patients and free from complications [1]. As a result, post-thoracotomy pain is currently being addressed in a multifactorial manner with combinations of different analgesic medications and, frequently, with various routes of administration, as well as with the use of locoregional analgesia techniques, which require practice, special skills, tight titration of dosing regimes and close postoperative patient monitoring. Apart from the analgesia technique chosen for each patient, opioids are indispensable—with their consequent risks—given that it is not always possible to maintain effective postoperative analgesia without affecting the adequacy of respiratory function and the mental status of the patient [1].

Cryoanalgesia was proposed in 1975 as an alternative to the use of topical analgesic agents to ensure prolonged intercostal blockage for up to two months [2, 3]. The method was famous for about 20 years, followed by a period of decline because of the spread of thoracic epidural analgesia, mainly in western Europe and the USA [4]. However, in our country thoracic epidural analgesia is not a widespread, routine technique for dealing with post-thoracotomy pain, because it is not always applicable due to anatomical issues. Additionally, the relative risk of epidural haematoma formation has significantly increased because of the widespread use of antithrombotic agents. Finally, thoracic epidural analgesia effectiveness is limited to the first three postoperative days, after which the thoracic surgery patient is exposed to post-thoracotomy pain [1].

Besides being affected by the popularity of thoracic epidural analgesia, cryoanalgesia was abandoned because it was questioned either as an ineffective analgesia technique or as harmful, due to the risk of development of subsequent chronic neuralgia from permanent intercostal nerve injury [4]. Various differences

and ambiguities have been reported in the medical literature concerning the applied protocols, which include varied numbers or durations of cryoanalgesia sessions, at one or more intercostal levels, with significant variation in applied cooling temperatures and not always with specific definition of the anatomical region of nerve blockage [4]. As a result, serious conflicts ensued between supporters and critics of cryoanalgesia.

The present study was designed for patients undergoing thoracotomy, taking into consideration the above mentioned factors concerning the technique applied. A strict protocol of intraoperative intercostal cryoanalgesia was applied, with special emphasis on patient safety, in order to evaluate the efficacy of cryoanalgesia in dealing with early and late postoperative pain, the potential reduction of analgesic requirements by the patients, the early and late postoperative respiratory function and the overall patient outcome.

MATERIALS AND METHODS

A double-blind randomized study was performed, involving lung cancer patients undergoing thoracotomy and pulmonary resection (lobectomy, bilobectomy, pneumonectomy) by the same surgical team and using the same surgical technique. This study was approved by the Scientific and Ethical Committee of the 'Sotiria' General Hospital for Chest Diseases. The senior surgeon was responsible for the acquisition of informed consent. Exclusion criteria were American Society of Anaesthesiologists (ASA) score ≥4, patients >75 years of age, patients with body mass index (BMI) >35, patients with history of other malignancy, patients suffering from sleep apnoea and those who refused to give informed consent ($n = 11$). No patient presented with post-obstructive segmental or lobar atelectasis. Taking into consideration the size of the study group used in the landmark study of Mainwand *et al*. and the respective results reported concerning postoperative analgesia, a power analysis was performed, resulting in a study group population of not more than 20 patients [3]. After informed consent, patients were randomly assigned to one of two groups, using the method of closed envelopes. Patients in Group A (the study group; $n = 25$) received intraoperative intercostal cryoanalgesia. Group B patients (the control Group; $n = 25$) did not receive intraoperative cryoanalgesia.

General anaesthesia was provided throughout by the same team of anaesthesiologists, using a specific technique: propofol and remifentanil for induction to general anaesthesia, a non-depolarizing neuromuscular blocker, single lung ventilation with the use of a double lumen endobronchial tube or endobronchial blocker, remifentanil for intraoperative analgesia and sevoflurane (without N_2O) for maintenance of the anaesthesia. In order to achieve postoperative analgesia, morphine 0.3 mg/kg, tenoxicam 16 mg and paracetamol 2 g were administered intravenously approximately 30 min before the end of the surgical procedure.

The procedure was performed through a posterolateral thoracotomy via the upper rim of the 5th rib. Pericostal sutures were applied around both ribs. Group A patients were submitted to one session of cryoanalgesia (−40°C) for 60 s, under direct vision —up to 10 cm from intercostal nerve outgrowth and definitely before its bifurcation—at the thoracotomy level, as well as one level above and two levels below. Cryoanalgesia sessions were performed by the same surgeon using a Spembly 142 Cryo Unit (Spembly Medical, Andover, UK).

Immediately after the patient recovered consciousness, time to extubation was recorded and the intensity of postoperative pain was evaluated using the 1-unit verbal analogue scale. When pain was ≥3 at rest or ≥5 on the verbal analogue scale during coughing, additional intravenous morphine (2.5 mg) was administered at 10 min intervals until pain was restored to these levels. Subsequently the patient was connected to a Rythmic^{TM} pump (Micrel Medical Devices, Gerakas, Greece) for patient-controlled intravenous analgesia (PCA), containing a 2 mg/ml morphine solution with 1 mg dosage and 10 min lockout. Postoperative monitoring and data recording were performed by a blinded researcher at designated postop time points:

Hours 0, 6, 12, 18, 24 (1 day), 36, 48 (2 days), 60, 72 (3 days), 84 and 96 (4 days)
Days 5, 6, 7 (1 week)
Week 2
Months 1 and 2.

During night hours, only patients who were awake were evaluated.

Continuous variables are presented as mean ± standard deviation. Categorical variables are presented as frequency. For categorical variable comparisons Chi-squared or Fisher's exact test were employed. Longitudinal comparison of intragroup continuous variables was performed with one-way analysis of variance (one-way ANOVA) and, whenever a statistical significant difference was observed, the Bonferroni *post-hoc* method was employed for individual comparisons between subgroups. Mean value comparison of normally distributed continuous variables was performed with the use of unpaired Student's *t*-test. A *P*-value <0.05 was defined as statistically significant for all analyses performed. All analyses were performed with SPSS, version 17.0 (SPSS Inc, Chicago, IL, USA).

RESULTS

There were no statistically significant intergroup differences in respect of patients' demographics or type of surgical procedure performed (Table 1). Time from the end of the surgical procedure to extubation was significantly increased in Group A patients, compared with Group B patients (11.9 ± 5.4 min, 5.4 ± 3.1 min, respectively, $P < 0.0001$). Group A patients had reduced levels of pain during quiet breathing (Table 2), as much as during coughing, at all time points evaluated during the early (hours 0–96) and late (days 5–60) postoperative periods. Tables 3 and 4 demonstrate the significantly decreased consumption by Group A patients of morphine delivered through PCA pump during the early postoperative period, as well as of oral analgesics received during the late postoperative period.

No significant differences were recorded between the two patient groups in terms of mean values of pulse oxymetry, arterial oxygen partial pressure-to-inspired oxygen concentration ratio (PaO_2/FiO_2), arterial carbon dioxide partial pressure and breathing frequency. Table 5 demonstrates increased arterial pH, measured from arterial blood gases, in Group A patients, compared with Group B patients, during the first three postop days, as well as at days 6, 30 and 60 of the late postoperative period.

Group A patients demonstrated increased systolic arterial pressure at nine out of eleven measurement points during the immediate postoperative period, combined with decreased heart rate (Table 6). Diastolic arterial pressure was increased in Group A patients at hour 36 and during all the measurements

Table 1: Demographic data and surgical procedures

	Study group	Control group	*P*-value
Sex (m/f)	21/4	21/4	0.6 (SNS)[a]
ASA (1/2/3)	8/13/4	8/16/1	0.3 (SNS)[a]
Age	64.4 ± 7.1	64.8 ± 8.6	0.9 (SNS)[a]
Weight (kg)	80.6 ± 15.4	77.5 ± 11.9	0.4 (SNS)[a]
Height (m)	1.73 ± 0.07	1.70 ± 0.07	0.5 (SNS)[a]
Right upper lobectomy	8	3	
Right upper and middle bilobectomy	0	1	
Right lower lobectomy	5	4	
Left upper lobectomy	4	6	0.5 (SNS)[b]
Left lower lobectomy	4	5	
Right pneumonectomy	2	1	
Left pneumonectomy	2	5	

M: males; f: females; ASA: physical status classification according to the American Society of Anesthesiologists; SNS: statistical non-significant.
[a]Students *t*-test.
[b]Pearson Chi-square test.

Table 2: Comparative timed distribution of mean values (± standard deviation) of postoperative pain at rest

Time point	Study group	*n*	Control group	*n*	*P*-value
Hours					
6	0.9 ± 0.7 (2,0)	25	3.00 ± 1.00 (5,2)	25	$<10^{-4}$
12[a]	0.8 ± 0.55 (2,0)	18	2.4 ± 0.5 (3,2)	15	$<10^{-4}$
18	0.8 ± 0.5 (2,0)	25	2.5 ± 0.9 (5,2)	25	$<10^{-4}$
24	0.6 ± 0.6 (2,0)	25	2.45 ± 1.2 (6,1)	25	$<10^{-4}$
36[a]	0.4 ± 0.5 (1,0)	10	2.6 ± 1.1 (4,1)	7	0.002
48	0.5 ± 0.5 (1,0)	25	2.1 ± 0.95 (5,1)	25	$<10^{-4}$
60[a]	0.1 ± 0.35 (1,0)	8	1.6 ± 0.5 (2,1)	9	$<10^{-4}$
72	0.4 ± 0.5 (1,0)	25	1.6 ± 0.8 (4,1)	25	$<10^{-4}$
84[a]	0.1 ± 0.3 (1,0)	9	1.3 ± 0.7 (2,0)	10	$<10^{-4}$
96	0.25 ± 0.4 (1,0)	25	1.4 ± 0.7 (3,0)	25	$<10^{-4}$
Days					
5	0.2 ± 0.4 (1,0)	25	1.4 ± 0.7 (3,0)	25	$<10^{-4}$
6	0.2 ± 0.4 (1,0)	25	1.3 ± 0.6 (3,0)	25	$<10^{-4}$
7	0.1 ± 0.3 (1,0)	25	1.2 ± 0.6 (3,0)	25	$<10^{-4}$
14	0.04 ± 0.2 (1,0)	25	1.2 ± 1.0 (3,0)	25	$<10^{-4}$
30	0.0 ± 0.0 (0,0)	25	1.0 ± 1.1 (3,0)	25	$<10^{-4}$
60	0.0 ± 0.0 (0,0)	25	0.25 ± 0.45 (1,0)	25	0.01

[a]Only awake patients were evaluated for pain during night hours, (–,–): maximum and minimum values of the verbal analogue scale of pain at rest recorded.

performed on the third postop day. It must be mentioned that measurements performed at hours 12, 36, 60 and 84 following the end of the surgical procedure did not include all patients but only those who were awake, given that those time points corresponded to night hours. Nausea was more frequent in Group B patients (20%) compared with Group A patients (0%), between hours 12 and 18 postop; however, vomiting was equally present in both groups. No patient demonstrated nausea

Table 3: Comparative timed distribution of mean values (± standard deviation) of morphine dosage administered (mg) during the immediate postoperative period (up to 96 hours)

Time point (h)	Study group	Control group	*P*-value
0	0.0 ± 0.0	1.25 ± 2.6	0.03
0–6	2.55 ± 1.55	12.0 ± 2.9	$<10^{-4}$
6–12	2.25 ± 1.3	11.1 ± 3.5	$<10^{-4}$
12–18	1.9 ± 1.2	11.4 ± 3.5	$<10^{-4}$
18–24	1.75 ± 1.0	10.7 ± 2.5	$<10^{-4}$
24–36	1.55 ± 0.9	10.1 ± 2.6	$<10^{-4}$
36–48	1.6 ± 1.05	10.3 ± 3.1	$<10^{-4}$
48–60	1.25 ± 0.8	9.1 ± 2.0	$<10^{-4}$
60–72	0.65 ± 0.7	9.5 ± 2.3	$<10^{-4}$
72–84	0.15 ± 0.3	9.0 ± 1.9	$<10^{-4}$
84–96	0.05 ± 0.2	8.1 ± 1.5	$<10^{-4}$

Table 4: Comparative timed distribution of analgesic regimens administered per patient during the late postoperative period (days 5–60)

Day	Study group					Control group					*P*-value
	0	TR	CD	PC	CL	0	TR	CD	PC	CL	
5	7	2	13	16	0	0	3	25	25	24	$<10^{-4}$
6	9	0	12	16	0	0	6	23	23	21	$<10^{-4}$
7	14	0	6	11	0	0	6	19	19	20	$<10^{-4}$
14	17	0	1	7	0	0	8	14	25	2	$<10^{-4}$
30	25	0	0	0	0	0	1	8	16	0	$<10^{-4}$
60	25	0	0	0	0	7	3	15	15	0	$<10^{-4}$

Oral analgesics administered and total 24 h dosage: 0 = none; TR = tramadol 200 mg; CD = codeine 90 mg; PC = paracetamol 1.5 g; CL = celecoxib 400 mg.

or vomiting after hours 24 and 18, respectively. Chest wall dysesthesia was assessed at 17 time points, from hour 0 up until two months postoperatively (Table 7). Group B patients demonstrated significantly increased chest wall dysesthesia during 13 of the 17 assessments (no differences were recorded between the two groups at hour 0 and at three out of four night assessments). Group B patients demonstrated significantly increased frequency of epigastric distension and back pain, compared with Group A ($P < 0.0001$) at all assessments performed, from day 5 up until two months after the surgical procedure.

Table 8 demonstrates increased spirometric values of FEV_1 and FVC of Group A patients on postop days 30 and 60, compared with Group B patients. Apart from paired comparisons between the two groups, analysis of variance (ANOVA) was performed at all time points between mean values recorded in each group separately and Bonferroni *P*-values were calculated for all comparisons. ANOVA *P*-values were <0.0001 at all comparisons but, from the paired intragroup comparisons, it was demonstrated that only Group A patients had their FEV_1 increased during the postoperative period to the point that, on day 60 (2.05 ± 0.5 l), there was no significant difference ($P = 0.11$) from the preoperative value (2.35 ± 0.9 l).

Table 5: Comparative timed distribution of mean values (± standard deviation) of arterial blood pH

Time point	Study group	*n*	Control group	*n*	*P*-value
Hour					
6	7.37 ± 0.04	25	7.33 ± 0.04	25	0.003
12[a]	7.40 ± 0.03	18	7.37 ± 0.05	15	0.03
18	7.42 ± 0.03	25	7.39 ± 0.03	25	0.001
24	7.43 ± 0.02	25	7.41 ± 0.03	25	0.01
36[a]	7.44 ± 0.03	10	7.40 ± 0.03	7	$<10^{-4}$
48	7.45 ± 0.03	25	7.41 ± 0.03	25	$<10^{-4}$
60[a]	7.45 ± 0.02	8	7.43 ± 0.03	9	0.005
72	7.45 ± 0.02	25	7.43 ± 0.04	25	0.016
84[a]	7.45 ± 0.02	9	7.43 ± 0.04	10	0.1 (SNS)
96	7.45 ± 0.03	25	7.45 ± 0.03	25	0.4 (SNS)
Day					
5	7.45 ± 0.02	25	7.44 ± 0.03	25	0.17 (SNS)
6	7.46 ± 0.03	25	7.44 ± 0.03	25	0.016
7	7.45 ± 0.03	25	7.45 ± 0.03	25	0.93 (SNS)
14	7.44 ± 0.02	25	7.44 ± 0.04	25	0.82 (SNS)
30	7.37 ± 0.04	25	7.33 ± 0.04	25	0.003
60	7.40 ± 0.03	25	7.37 ± 0.05	25	0.03

SNS: statistically non-significant.
[a]Blood samples were taken only from waking patients during night hours.

Table 6: Comparative timed distribution of mean values (± standard deviation) of heart rate

Postoperative hour	Study group	Control group	*P*-value
0	80.7 ± 10.9	87.2 ± 10.8	0.04
6	81.2 ± 14.3	88.1 ± 13.4	0.04
12	85.4 ± 14.6	93.1 ± 12.9	0.10 (SNS)
18	84.2 ± 10.9	91.7 ± 13.4	0.04
24	81.5 ± 7.1	89.8 ± 11.5	0.004
36	84.9 ± 10.4	96.3 ± 11.8	0.08 (MSD)
48	83.2 ± 7.6	89.8 ± 12.3	0.03
60	83.6 ± 7.7	94.2 ± 7.6	0.03
72	83.4 ± 8.7	89.9 ± 11.2	0.03
84	82.8 ± 3.9	91.4 ± 7.8	0.04
96	81.7 ± 6.7	88.7 ± 13.1	0.02

MSD: marginally significant difference between patient groups ($0.1 < P < 0.05$); SNS: statistically non-significant.

DISCUSSION

We studied 50 patients who underwent thoracotomy with or without intercostal cryoanalgesia, in order to evaluate pain relief, respiratory function and complications during the postoperative period. Patient selection and technique of cryoanalgesia was randomized in such a way as to achieve controlled reproducibility and maximum safety. Specifically, one session of cryoanalgesia was applied, that was of minimal duration and minimally aggressive in terms of temperature, based on proposals in the literature [4].

Our results indicate that cryoanalgesia reduces postoperative pain, as well as analgesics consumption. Similar results have been reported in 8 of the 12 studies in the literature that evaluate the efficacy of cryoanalgesia after thoracotomy in patients receiving systemic opioids [2, 5–11]. It must be mentioned that from the remaining four studies [12–15], one reported reduced

Table 7: Comparative timed distribution of patients with episodes of dysesthesia

Time point	Study group			Control group			*P*-value
	None	Few	Moderate	None	Few	Moderate	
Hour							
0	11	10	4	4	18	3	0.28 (SNS)
6	13	8	4	6	18	1	0.015
12[a]	10	6	2	6	8	1	0.19 (SNS)
18	14	7	4	7	17	1	0.02
24	14	8	3	5	19	1	0.004
36[a]	4	4	2	2	4	1	0.3 (SNS)
48	16	8	1	4	20	1	0.004
60[a]	5	2	1	1	7	1	0.02
72	17	7	1	1	24	0	10-4
84[a]	5	4	0	2	7	1	0.1 (SNS)
96	17	8	0	3	22	0	10^{-4}
Day							
5	15	10	0	8	17	0	0.04
6	15	10	0	8	17	0	0.05
7	17	8	0	8	17	0	0.01
14	18	7	0	9	16	0	0.01
30	19	6	0	7	17	1	0.003
60	19	6	0	9	15	1	0.02

SNS: statistically non-significant.
[a]Only waking patients were evaluated during night hours.

Table 8: Comparative timed distribution of mean values (± standard deviation) of forced expiratory volume in 1s (FEV_1) and of forced expiratory vital capacity (FVC)

Time	Study group FEV_1 (l)[b]	Control group FEV_1 (l)[c]	*P*-value[a]
A Preop	2.37 ± 0.87	2.28 ± 0.68	0.71 (SNS)
B Day 14	1.67 ± 0.47	1.50 ± 0.43	0.18 (SNS)
C Day 30	1.89 ± 0.54	1.60 ± 0.46	0.015
D Day 60	2.04 ± 0.56	1.70 ± 0.43	0.002
	FVC (L)[d]	FVC (L)[e]	
A Preop	3.29 ± 0.95	3.01 ± 0.82	0.27 (SNS)
B Day 14	2.19 ± 0.55	2.05 ± 0.54	0.24 (SNS)
C Day 30	2.42 ± 0.64	2.20 ± 0.59	0.045
D Day 60	2.61 ± 0.68	2.37 ± 0.58	0.015

SNS: statistically non-significant.
Bonferroni *P*-values
[a]Student's *t*-test.
[b]A vs B $< 10^{-4}$, A vs C 0.01, A vs D 0.11(SNS), B vs C 1.0 (SNS), B vs D 0.18 (SNS), C vs D 1.0 (SNS)
[c]A vs B $< 10^{-4}$, A vs C $< 10^{-4}$, A vs D 0.001, B vs C 1.0 (SNS), B vs D 1.0 (SNS), C vs D 1.0 (SNS)
[d]A vs B $< 10^{-4}$, A vs C $< 10^{-4}$, A vs D 0.01, B vs C 1.0 (SNS), B vs D 0.14 (SNS), C vs D 1.0 (SNS)
[e]A vs B $< 10^{-4}$, A vs C $< 10^{-4}$, A vs D 0.004, B vs C 1.0 (SNS), B vs D 0.5 (SNS), C vs D 1.0 (SNS)

opioid consumption without reduction of postoperative pain [13] whereas, in the other three studies [12, 14, 15], no significant difference was reported between cryoanalgesia and the control group.

In this study, patients of both groups were administered similar intravenous dosages of morphine, tenoxicam and paracetamol 30 min before the end of the surgical procedure, in order to maintain acceptable pain relief during the initial postoperative hours. However, given the additive analgesic effect of cryoanalgesia, patients in this group required reduced loading dosage of intravenous analgesics. This is further confirmed by the fact that, due to relative overdosing in the cryoanalgesia group, patients required almost twice the time from the end of the surgical procedure to tracheal extubation, compared with the control group.

Arterial blood gas analysis revealed that patients receiving cryoanalgesia had reduced acidotic pH levels (increased pH values), without influencing partial pressure of O_2 to administered O_2 percentage (PO_2/FiO_2) and partial pressure of CO_2 (PCO_2) in all arterial blood gases analyses performed during the first three postop days, as well as in three out of six analyses performed during the late postoperative period (days 6, 30 and 60). In the majority of evaluations of haemodynamic parameters, increased systolic blood pressure and reduced heart rate were noted in the study group (Group A). The combination of more acidotic pH and relative tachycardia observed in patients in this group who did not receive cryoanalgesia could be attributed to sympathetic stimulation due to increased postoperative pain, whereas reduced blood pressure may be the result of increased postoperative morphine administration [16].

During the first four postoperative days, 11 evaluations of nausea and vomiting were performed. Cryoanalgesia group patients had decreased nausea during the first 24 postop hours, probably due to decreased morphine consumption, given the action of morphine at the *medulla oblongata* chemoreceptors and the increased sense of nausea during the postop period [17].

Cryoanal has been implicated for dysesthesias, local swelling, epigastric distension, back pain and unpleasant feelings of stiffness—all part of the syndrome of postoperative neuralgia—which appear approximately six weeks after the operation [5, 14, 18] and last 2–4 weeks [5, 18]. However, the results of the current study do not confirm these findings. The aforementioned symptoms were actively looked for during every evaluation of our patient population—from the immediate postoperative period to the 60th day after surgery—and it was noted that, although they were expected to be found in the study group, they were far more frequent in the control group. Similar results have been reported from one study [7]. It must be mentioned that the observed symptomatology of neuralgia had a premature beginning, which correlates better with acute post-thoracotomy pain. This study, nevertheless, has the limitation that patients were not evaluated further after the completion of two months following the surgical procedure.

A very important finding of this study is the restoration of the postoperative forced expiratory volume in 1s (FEV_1) to almost the preoperative values in the study group of patients; a factor that was evaluated two months after surgery. Similar results have been reported from two earlier studies [15, 19], whereas two other studies [4, 8] have shown marginal restoration of respiratory parameters in post-thoracotomy patients who received cryoanalgesia. None of the studies that evaluated thoracotomy patients with spirometry during the late postoperative period reported that cryoanalgesia adversely affects respiratory function [5, 7–10, 14, 19].

Within the narrow frame of a surgical clinic and its various medical and nursing staff, biases could have influenced the results of Table 2. However, the use of the VAS will have minimised any such bias.

Post-thoracotomy analgesia remains a multifactorial, ambiguous and intractable issue. Intraoperative intercostal cryoanalgesia seems to be an auxiliary, cost-effective and efficient method, capable of controlling post-thoracotomy pain and restoring respiratory function in the majority of cases. Furthermore, cryoanalgesia reduces the frequency of unpleasant postoperative events such as nausea and dysesthesia.

Conflict of interest: none declared.

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