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Is cryoanalgesia effective for post-thoracotomy pain?

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Abstract

A best evidence topic was written according to a structured protocol. The question addressed was whether cryoanalgesia improves post-thoracotomy pain and recovery. Twelve articles were identified that provided the best evidence to answer the question. The authors, date, journal, study type, population, main outcome measures and results are tabulated. Reported measures were pain scores, additional opiate requirements, incidence of hypoesthesia and change in lung function. Half of the articles reviewed failed to demonstrate superiority of cryoanalgesia over other pain relief methods; however, additional opiate requirements were reduced in patients receiving cryoanalgesia. Change in lung function postoperatively was equivocal. Cryoanalgesia potentiated the incidence of postoperative neuropathic pain. Further analysis of the source of cryoanalgesia, duration, temperature obtained and extent of blockade revealed numerous discrepancies. Three studies utilized CO_2 as the source of cryoanalgesia and four used nitrous oxide, but at differing temperatures and duration. Five studies did not reveal the source of cyroanalgesia. The number of intercostal nerves anaesthetized in each study varied. Seven articles anaesthetized three intercostal nerves, three articles used five intercostal nerves, one article used four intercostal nerves and one used one intercostal nerve at the thoracotomy site. Thoracotomy closure and site of area of chest drain insertion may have a role in postoperative pain; but only one article explained method of closure, and two articles mentioned placement of chest drain through blocked dermatomes. No causal inferences can be made by the above results as they are not directly comparable due to confounding variables between studies. Currently, the evidence does not support the use of cryoanalgesia alone as an effective method for relieving post-thoracotomy pain.

Keywords: Cryoanalgesia • Thoracotomy • Pain

INTRODUCTION

A best evidence topic was constructed according to a structured protocol. This protocol is fully described in *ICVTS* [1].

CLINICAL SCENARIO

A 61-year old man underwent routine thoracotomy for a benign lung lesion. During closure of the thoracotomy incision, you contemplate whether performing an intercostal nerve block by cryoanalgesia would have an effect on his postoperative pain and recovery.

THREE-PART QUESTION

In (patients undergoing thoracotomy) is (cryoanalgesia) effective in (improving postoperative pain and recovery)?

SEARCH STRATEGY

Medline from 1948 to December 2012 using the PubMed interface 'thoracotomy' OR ('thoracotomy [MeSH Terms]) AND 'cryoanalgesia' OR ('cryoanalgesia' [MeSH Terms]). Related articles and references were screened for suitable articles.

SEARCH OUTCOME

Forty articles were found using the reported search strategy. From these, only randomized control studies and in the English language were selected. Twelve articles were identified that provided the best evidence to answer the question. These are presented in Table 1.

RESULTS

In the study by Momenzadeh *et al.* [2], 60 patients were randomized into two equal groups. Intensity of pain in the control group (pethidine) was higher compared with the study group (cryoanalgesia and pethidine) throughout the 7-day follow-up period. Cryoanalgesia was used at three intercostal nerves (one at the level of incision, one cranial and one caudal) for 90 s at −70°C using CO_2. On postoperative day 2, the frequencies of severe pain score were 33% in the control group and 0 in the study group, $P < 0.001$. 'No to mild' pain on the seventh day was 13.3 and

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Table 1: Best evidence papers

Author, date, journal and country Study type (level of evidence)	Study group	Outcomes	Key results	Comments
Momenzadeh *et al.* (2011), Act Med Iran [2] RCT (level Ib)	60 patients underwent posterolateral thoracotomy Study group (30) received cryoanalgesia and PRN pethidine Cryoanalgesia used at three intercostal nerves (one at the level of incision, one cranial and one caudal) for 90 s at −70°C using CO_2 Control group (30) received PRN pethidine	Pain measured using visual analogue scale (VAS) (0 [no pain to mild pain] – 10 [severe pain]) at different time intervals postoperatively Mean (±SD) pethidine (mg) requirement Side effects monitored in the study group	Day 2 postoperative, VAS score of 10: • 33% of the control group • 0% of the study group, $P < 0.001$ Day 7 postoperative VAS score of 0: • 13.3% control group • 83.3% study group, $P < 0.001$ Day 1 postoperative: • Control group, 151.6 ± 27 • Study group, 87 ± 48, $P < 0.001$ Pethidine required for: • 7 days in the control group • 4 days in the study group Hypoesthesia: • 90% at the end of first postoperative week • 76.7% at the end of first month • 16.6% at the end of third month Allodynia and dysesthesia: 10% at the end of first month	Cryoanalgesia is an advantageous technique to relieve post-thoracotomy pain and reduce opiate consumption
Mustola *et al.* (2011), Ann Thorac Surg [3] RCT (level Ib)	42 elective posterolateral thoracotomy patients Study group (21) received thoracic epidural and cryoanalgesia Cryoanalgesia used at three intercostal nerves (one at the level of incision, one cranial and one caudal) for 90 s at −70°C 10 cm from the nerve root Control group (21) received epidural only	Pain evaluated by verbal pain scale (0 [no pain] – 3 [severe]) or VAS at various time intervals postoperatively Neuropathic pain (allodynia, hyperalgesia, dysesthesia) Epidural infusion rate (ml/h) Number of boluses Oxycodone requirement (mg/3 days)	At 12 h postoperatively: • Study group (VAS at rest), 18.6 ± 17.8 • Control group, 6.4 ± 9.8, $P = 0.021$ 2 days: • Study group (VPS at rest), 0.70 ± 0.66 • Control group, 0.15 ± 0.37, $P = 0.017$ 8 weeks: • Study group (VPS on movement), 1.10 ± 1.04 • Control group, 0.48 ± 0.60, $P = 0.048$ 8 weeks postoperatively: Allodynia • Study group (11) • Control group (4), $P = 0.048$ Hypoesthesia • Study group (20) • Control group (10), $P = 0.0004$ • Study group, 4.7 ± 0.6 • Control group, 5.1 ± 0.5, not significant • Study group, 6.2 ± 4.9 • Control group, 5.8 ± 4.7, not significant • Study group, 23.1 ± 27.1 • Control group, 38.4 ± 66.9, not significant	Intercostal cryoanalgesia seems to increase the incidence of long-term pain post-thoracotomy

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Table 1: (*Continued*)

Author, date, journal and country Study type (level of evidence)	Study group	Outcomes	Key results	Comments
Ju *et al*. (2008), Eur J Pain [4] RCT (level Ib)	107 patients underwent posterolateral thoracotomy Study group (53) received intercostal nerve cryoanalgesia	The following criteria were evaluated at 1, 3, 6- and 12-month intervals: Incidence of chronic pain	No significant difference between the two groups	Cryoanalgesia may not be effective for post-thoracotomy pain due to a higher incidence of neuropathic pain
	Cryoanalgesia used at three intercostal nerves (one at the level of incision, one cranial and one caudal) for 90 s at −70°C using CO_2	Incidence of allodynia-like pain	Significant difference found at 6 and 12 months, respectively: • Study group, 7/43 (16.3%) • Control group, 1/48 (2.1%), $P = 0.044$	
	Control group (54) received epidural analgesia		• Study group, 6/39 (15.4%) • Control group, 0/38 (0%), $P = 0.025$	
		No pain or mild pain	Significant difference found at 6 months: • Study group, 31/43 (72.1%) • Control group, 45/48 (93.7%), $P = 0.013$	
		Moderate-to-severe pain	No significant difference between the two groups	
		Interference with daily life	Significant difference found at 3, 6 and 12 months, respectively: • Study group, 18/48 (37.5%) • Control group, 6/50 (12.0%) $P = 0.003$	
			• Study group, 15/43 (34.9%) • Control group, 5/48 (10.4%), $P = 0.005$	
			• Study group, 13/39 (33.3%) • Control group, 3/38 (7.9%), $P = 0.005$	
		Propofol and fentanyl dose	Significantly higher in the study group, $P < 0.05$	
Yang *et al*. (2004), Anaesthesia [5] RCT (level Ib)	80 patients scheduled for thoracotomy Study group (40) received cryoanalgesia and epidural analgesia	The following criteria were evaluated each day for 7 days postoperatively Pain at rest (VAS [median])	No significant difference between the two groups	Cryoanalgesia combined with thoracic epidural analgesia may result in less pain during movement, a lower daily requirement for rescue analgesia and allow early pulmonary function recovery
	Cryoanalgesia used at three intercostal nerves (one at the level of incision, one cranial and one caudal) and proximally as possible to the collateral branches for 90 s at −20°C using nitrous oxide	Pain on movement (VAS [median])	Significant difference found on day 7 only: • Study group, 1.9 • Control group, 3.3, $P = 0.036$	
		Rescue dose (median) of intravenous morphine	Significant difference found on days 6 and 7, respectively: • Study group, 3.9 • Control group, 7.0, $P = 0.044$	
	Control group (40) received epidural analgesia only		• Study group, 3.2 • Control group, 5.5, $P = 0.018$	
		Changes in FEV1 (%)	No significant difference between the two groups	

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Table 1: (*Continued*)

Author, date, journal and country Study type (level of evidence)	Study group	Outcomes	Key results	Comments
		Changes in FVC (%)	Significant difference found on day 7 only: • Study group, 52 • Control group, 46, $P = 0.024$	
		Incidence of pain and numbness reported 1, 3 and 6 months postoperatively	No significant difference between the two groups	
		Incidence of post-thoracotomy pain syndrome at rest at 1, 3 and 6 months	Significant difference found at 3 months only: • Study group, $n = 15$ • Control group, $n = 6$, $P = 0.042$	
Gwak *et al.* (2004), J Korean Med Sci [6] RCT (level Ib)	50 patients underwent posterolateral thoracotomy Study group (25) received IVCA and cryoanalgesia Cryoanalgesia used at three intercostal nerves (one at the level of incision, one cranial and one caudal) and to collateral branches for 90 s at −20°C using nitrous oxide Control group (25) received IVCA	The following criteria were evaluated each day for 7 days postoperatively: Pain at rest and on movement (VAS) Fentanyl (median [μg]) requirement FEV1 (mean [l]) and FVC (mean [l]) were evaluated preoperatively, 2 and 7 days postoperatively Incidence of pain and numbness at 1, 3 and 6 months postoperatively	 No significant difference between the two groups No significant difference between the two groups Significant difference found on day 7 only: FEV1 • Study group, 1.8 • Control group, 1.5, $P < 0.05$ FVC • Study group, 2.25 • Control group, 1.9, $P < 0.05$ No significant difference between the two groups	Cryoanalgesia combined with IVCA may improve respiratory function with no effect on postoperative pain
Moorjani *et al.* (2001), Eur J Cardiothorac Surg [7] RCT (level Ib)	200 patients underwent elective posterolateral thoracotomy Study group (100) received cryoanalgesia Cryoanalgesia used at three intercostal nerves (one at the level of incision, one cranial and one caudal) proximal to the origin of collateral branch for 60 s at −50°C using CO_2 Control group (100) received conventional analgesia	Pain (VAS) each day for 7 days postoperatively Additional opiate (mg) requirements FEV1 (% predicted) and FVC (% predicted)	Days 1–7, respectively; Study vs control group: • 3.8 vs 6.4 • 4.5 vs 7.4 • 3.1 vs 5.4 • 2.4 vs 3.6 • 0.2 vs 4.1 • 0.9 vs 2.1 • 0.1 vs 1.0, $P < 0.05$ Significantly lower use of opiates in the study compared with the control group, $P < 0.05$ No significant difference between the two groups	Cryoanalgesia may be able to reduce postoperative pain and reduce opiate requirements
Miguel *et al.* (1993), J Cardiothorac Vasc Anesth [8] RCT (level Ib)	45 patients underwent anterolateral and posterolateral thoracotomies Study group (14) received cryoanalgesia	Pain (VAS) each day for 5 days postoperatively Amount of breakthrough morphine	No significant difference in pain scores with cryoanalgesia compared with controls No significant difference between the groups	Cryoanalgesia post-thoracotomy does not have a superior analgesic effect compared with other modalities

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Table 1: (*Continued*)

Author, date, journal and country Study type (level of evidence)	Study group	Outcomes	Key results	Comments
	Cryoanalgesia used at three intercostal nerves (one at the level of incision, one cranial and one caudal) for 30 s at −56.7°C Control group I (10) received epidural morphine Control group II (11) received parenteral morphine Control group III (10) received intrapleural analgesia	Spirometry pre- and postoperatively	No significant difference between the groups	
Muller *et al.* (1989), Ann Thorac Surg [9] RCT (level Ib)	63 patients underwent posterolateral thoracotomy Study group (30) received cryoanalgesia Cryoanalgesia used at four intercostal nerves (one at the level of incision, one cranial and two caudal) with nitrous oxide until a ball of ice formed around the entire nerve Control group (33) received no treatment	Pain (0–4 [0 = none, 1 = light, 2 = moderate, 3 = strong, 4 = severe]) and, Mobility (1–5 [1 = none, 2 = with help, 3 = with strong effort, 4 = with light effort, 5 = with no effort]) scores each day for 7 days postoperatively Analgesic consumption of opiates and nonopiates Peak expiratory flow (% of preoperative value)	No significant difference between the groups No significant difference between the groups No significant difference between the groups No significant difference between the groups	Cryoanalgesia does not seem to provide any advantage to patient post-thoracotomy
Roberts *et al.* (1988), Scand J Thorac Cardiovasc Surg [10] RCT (level Ib)	144 patients underwent thoracotomy Study group (71) received cryoanalgesia Cryoanalgesia used at five intercostal nerves (one at the level of incision, two cranial and two caudal) for 30 s and repeated for a further 30 s at −60°C using nitrous oxide Chest drains were places at the anaesthetized area Control group (73) received bupivacaine-adrenaline intercostal blockade	Pain (VAS [median]) postoperatively Pain (VAS [median]) during physiotherapy Pethidine (mg [median]) administered after thoracotomy Patients (%) given oral analgesics administered after thoracotomy Pain related postoperative complications Patients (%) with stagnant bronchial secretions requiring bronchoscopy Patients (%) requiring local block(s)	Study vs control group: • 6–8 h, 1 vs 3 • 1 day, 4 vs 7 • 2 days, 2 vs 5 • 3 days, 2 vs 5, $P < 0.05$ Study vs control group: • 1 day, 6 vs 7 • 2 days, 6 vs 8 • 3 days, 4 vs 7, $P < 0.05$ Study vs control group: • Day 1, 145 vs 225, $P < 0.05$ • Day 2, 50 vs 200, $P < 0.01$ • Day 3, 0 vs 100, $P < 0.01$ Study vs control group: • 0–2 days, 65 vs 14 • 3–5 days, 31 vs 73, $P < 0.01$ Study vs control group: 1.4 vs 15, $P < 0.05$ 6 vs 16, $P < 0.05$	Cryoanalgesia appears to control post-thoracotomy pain in the short term only

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Table 1: (*Continued*)

Author, date, journal and country Study type (level of evidence)	Study group	Outcomes	Key results	Comments
		Patients (%) with late intercostal neuralgia	0 vs 3, not significant	
Roxburgh *et al.* (1987), Thorax [11] RCT (level Ib)	53 patients underwent thoracotomy Study group (23) received cryoanalgesia and lumbar epidural methadone Control group (30) lumbar epidural methadone only	Pain (linear analogue scale) each day post-thoracotomy until discharge and 6 weeks and 6 months after discharge	No significant difference between two groups	Cryoanalagesia does not result in lower pain scores
Rooney *et al.* (1986), Ann Thorac Surg [12] RCT (level Ib)	75 patients underwent thoracotomy Study group (25) received cryoanalgesia Cryoanalgesia used at five of six intercostal nerves centred on the nerve of incision site, including posterior rami and drain sites for 60 s at −60°C Control group I (25) received TNS Control group II (25) received no treatment	Preoperative and postoperative (Days 1 and 5) levels of FVC and FEV1 (l [mean])	FVC Study vs control group I: Preoperative 3.74 ± 0.71 vs 3.24 ± 0.64 Postoperative • Day 1, 1.27 ± 0.30 vs 1.65 ± 0.54, $P < 0.01$ • Day 5, 2.20 ± 0.61 vs 1.98 ± 0.49, not significant Study vs control group II: Preoperative 3.74 ± 0.71 vs 3.77 ± 0.83 Postoperative • Day 1, 1.27 ± 0.30 vs 1.42 ± 0.36, not significant • Day 5, 2.20 ± 0.61 vs 1.86 ± 0.33, $P < 0.001$ FEV1 Study vs control group I: Preoperative 2.78 ± 0.79 vs 2.48 ± 0.60 Postoperative • Day 1, 1.06 ± 0.20 vs 1.30 ± 0.46, $P < 0.01$ • Day 5, 1.89 ± 0.65 vs 1.54 ± 0.50, not significant Study vs control group II: Preoperative 2.78 ± 0.79 vs 2.86 ± 0.63 Postoperative • Day 1, 1.06 ± 0.20 vs 1.20 ± 0.31, not significant • Day 5, 1.89 ± 0.65 vs 1.60 ± 0.32, $P < 0.01$	Cryoanalgesia may improve pulmonary function post-thoracotomy however and this may be due to better pain management but no pain outcomes were recorded

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Table 1: (*Continued*)

Author, date, journal and country Study type (level of evidence)	Study group	Outcomes	Key results	Comments
Katz *et al*. (1980), Lancet [13]	24 patients underwent thoracotomy Study group (15) received cryoanalgesia	Pain (10-point score; 1–3, slight pain, 4–6 moderate pain and 7–10 severe pain)	Study vs control group: • Day 1, 2.8 vs 6.0, $P < 0.001$ • Day 3, 1.8 vs 2.3, $P < 0.05$ • Day 5, 0.92 vs 3.2, $P < 0.01$	Cryoanalgesia appears to control post-thoracotomy pain in the short term only
	Cryoanalgesia used at five intercostal nerves (one at the level of incision, two cranial and two caudal) for 30 s at −60°C followed by 5 s thaw and second freeze-thaw cycle	Narcotic usage	Study vs control group: 15 ± 2.3 vs 29 ± 4.5, $P < 0.01$	
		Postoperative pulmonary function	No significant difference between two groups	
	Control group (9) received either intercostal blocks or no nerve-blocks			

FEV1: forced expiratory volume in one second; FVC: forced vital capacity; IVCA: intravenous continuous analgesia; PRN: pro re nata.

83.3% in the control and study groups, respectively, $P < 0001$. Pain intensity was significantly higher in the control group compared with the cryoanalgesia group, $P < 0.001$. Mean ± SD administration of pethidine was significantly higher in the control group than the cryoanalgesia patients on postoperative day 1 (151.6 ± 27 vs 87 ± 48 mg; $P < 0.001$). Postoperative hypoesthesia occurred in the following pattern: 90% (first week), 76.7% (first month) and 16.6% (second month). Incidence of allodynia and dysesthesia diminished to 10% by the first month and 0 by the second month.

Mustola *et al*. [3] randomized 42 patients equally into cryoanalgesia and epidural (study) and epidural only (control) group. Cryoanalgesia was used at three intercostal nerves (one at the level of incision, one cranial and one caudal) for 90 s at −70°C, 10 cm from the nerve root. Thoracotomy was closed with intercostal sutures via 2 mm drilled holes to avoid intercostal nerve impingement. At postoperative week 8, 11 patients in the study group had neuropathic-type pain (mostly allodynia) compared with 4 patients in the control group, $P = 0.048$. Postoperatively, patients in the study group had significantly more pain than control patients at rest at 12 h ($P = 0.021$) and at 2 days ($P = 0.017$) and during normal daily activities at 8 weeks ($P = 0.041$). At postoperative month 6, there were no statistically significant differences between groups. Patients had more hypoesthesia at the operation site (20 of 20) in the study group compared with the control group (10 of 20) at 8 weeks, $P = 0.0004$. Hypoesthesia rates at 6 months were 8 of 20 in the study group and 6 of 20 in the control group, $P = 0.715$.

Ju *et al*. [4] recruited 107 patients who were randomized into those who received cryoanalgesia (study group) and epidural analgesia (control group). Cryoanalgesia was used at three intercostal nerves (one at the level of incision, one cranial and one caudal) for 90 s at −70°C using CO_2. Pain scores, intensity, allodynia-like pain, interference with daily life and propofol/fentanyl dosage were recorded at different intervals postoperatively. Incidence of allodynia-like pain was higher in the study group than the control group, at 6 (16.3 vs 2.1%, respectively, $P = 0.044$) and 12 months (15.4 vs 0%, respectively, $P = 0.025$). The percentage of patients with 'no or mild pain' was significantly higher in the control group compared with the study group, 93.7 vs 72.1%, respectively, $P = 0.013$. Patients in the study group reported a higher percentage in interference with daily life compared with the control group, $P < 0.005$. Propofol and fentanyl requirement postoperatively was higher in the study group, $P < 0.05$.

Yang *et al*. [5] randomly assigned 80 patients to receive cryoanalgesia and epidural analgesia (study) and epidural analgesia only (control). Cryoanalgesia was used at three intercostal nerves (one at the level of incision, one cranial and one caudal) and proximally as possible to the collateral branches for 90 s at −20°C using nitrous oxide. The only significant difference in pain scores was during movement on postoperative day 7. There was a lower pain score in the study group compared with the control group, $P = 0.036$. On days 6 and 7, the study group required lower IV morphine dose compared with the control group, $P < 0.05$. Incidence of post-thoracotomy pain syndrome was higher in the study group, $P < 0.05$.

Gwak *et al*. [6] randomized 50 patients to receive cryoanalgesia and intravenous continuous analgesia (IVCA) (study) or IVCA only (control). Cryoanalgesia was used at three intercostal nerves (one at the level of incision, one cranial and one caudal) and to collateral branches for 90 s at −20°C using nitrous oxide. No statistically significant difference was found between the two groups with respect to pain scores, and the groups were similar in terms of analgesic requirements. forced vital capacity (FVC) and forced expiratory volume in one second (FEV1) increased significantly in the study group on postoperative day 7, $P < 0.05$.

Moorjani *et al*. [7] randomized 200 patients of whom 100 received cryoanalgesia (study) and 100 received conventional analgesia (control). Cryoanalgesia was used at three intercostal nerves (one at the level of incision, one cranial and one caudal) proximal to the origin of collateral branch for 60 s at −50°C using CO_2. Postoperative pain score were significantly lower for patients

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in the study group, $P < 0.05$. Patients in the study group required significantly lower additional analgesia, $P < 0.05$. Patients in the study group achieved higher FEV1 and FVC score; however, this was not significant, $P > 0.05$.

Miguel *et al.* [8] randomized patients to receive cryoanalgesia (study), epidural morphine, parenteral morphine and intrapleural analgesia (Controls I–III, respectively). Cryoanalgesia was used at three intercostal nerves (one at the level of incision, one cranial and one caudal) for 30 s at −56.7°C. There was no significant difference in both groups for pain, analgesic requirements or spirometry.

Muller *et al.* [9] randomized 63 patients to receive cryoanalgesia (study) while the control group received no analgesia. Cryoanalgesia was used at four intercostal nerves (one at the level of incision, one cranial and two caudal) with nitrous oxide until a ball of ice formed around the entire nerve. There was no significant difference in either groups for pain, analgesic requirements or spirometry.

Roberts *et al.* [10] randomized 144 patients of whom the study group received cryoanalgesia and the control group received bupivacaine-adrenaline intercostal blockade. Cryoanalgesia used at five intercostal nerves (one at the level of incision, two cranial and two caudal) for 30 s and repeated for a further 30 s at −60°C using nitrous oxide. Chest drains were placed at the anaesthetized area. Postoperative pain scores and pain during physiotherapy were better in the study group compared with the control group, $P < 0.05$. Postoperative pethidine requirement was reduced in the study group compared with the control group, $P < 0.05$. Similarly, the percentage of patient given analgesics were significantly less in the study group vs the control group, $P < 0.01$.

Roxburgh *et al.* [11] studied 53 patients who were randomized to receive cryoanalgesia and lumbar epidural methadone and lumbar epidural methadone only. Cryoanalgesia was used at five of six intercostal nerves centred on the nerve of incision site, including posterior rami and drain sites for 60 s at −60°C. There was no significant difference with regard to pain score in either group.

Rooney *et al.* [12] randomized 75 patients of whom 25 received cryoanalgesia, 25 received transcutaneous electrical nerve stimulation (TNS) and 25 receive no treatment. Cryoanalgesia was used on the intercostal nerve at the thoracotomy site for 60 s at −60°C followed by 5 s thaw and second freeze–thaw cycle. Pain scores were not recorded. Spirometry results improved by the fifth postoperative day in patients receiving cryoanalgesia compared with patients receiving TNS, $P < 0.05$.

Katz *et al.* [13] studied 24 patients of whom 15 received cryoanalgesia and 9 received either intercostal nerve blocks or no nerve blocks. Cryoanalgesia was used at five intercostal nerves (one at the level of incision, two cranial and two caudal) for 30 s at −60°C followed by 5 s thaw and second freeze–thaw cycle. Pain scores as well as narcotic usage were significantly lower in the study group compared with the control group, $P < 0.05$. There was no significant difference in spirometry.

Of the 12 articles reviewed, 6 articles [3, 4, 6, 8, 9, 11] failed to demonstrate superiority of cryoanalgesia over other pain relief methods. All the articles [2–5] that evaluated neuropathic pain revealed that cryoanalgesia in fact increases the incidence of neuropathic pain postoperatively. Further analysis of the source of cryoanalgesia, duration, temperature obtained and extent of blockade revealed numerous discrepancies. Of those studies that used CO_2, two [2, 4] applied this for 90 s at −70°C and one [7] for 60 s at −50°C. Of those that used nitrous oxide, two [5, 6] applied this for 90 s at −20°C, one [10] for 30 s at −60°C for two cycles and one [9] until a ball of ice was formed. Five studies did not reveal the source of cyroanalgesia; two [11, 12] studies applied cryoanalgesia for 60 s at −60°C of which one [12] applied cryoanalgesia for two cycles; two studies applied cryoanalgesia for 30 s, of which one [13] applied this for two cycles at −60°C and one [8] at −56.7°C and one study [3] used cryoanalgesia for 60 s for −70°C. The number of intercostal nerves anaesthetized in each study varied. Seven articles [2–8] anaesthetized three intercostal nerves, three articles [10, 11, 13] used five intercostal nerves, one article [9] used four intercostal nerves and one [12] used one intercostal nerve at the thoracotomy site. No causal inferences can be made by the above results as they are not directly comparable due to confounding variables between studies. Thoracotomy closure and site of chest drain insertion may have a role in postoperative pain; only one [3] article explained method of closure, and two [11, 13] articles mentioned placement of chest drain through blocked dermatomes.

CLINICAL BOTTOM LINE

Post-thoracotomy pain is a compilation of several factors: incisional pain, pain secondary to interruption of muscular and ligamentous structures by the retractor and pain of pleural irritation usually secondary to chest tube. Cryoanalgesia in and of itself is unlikely to provide 100% pain relief; therefore, concomitant administration of epidural analgesia may be vital to cover other aspects of the post-thoracotomy pain syndrome.

Conflict of interest: none declared.

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