Are intracostal sutures better than pericostal sutures for closing a thoracotomy?

Ravindran Visagana, David J. McCormackb, Alex R. Shipolini and Omar A. Jarra**

a King’s College London School of Medicine, London, UK
b Department of Cardiothoracic Surgery, The London Chest Hospital, London, UK

* Corresponding author. Department of Cardiothoracic Surgery, The London Chest Hospital, Bonner Road, London E2 9JX, UK. Tel: +44-7855-773118; fax: +0207-886-7950; e-mail: omar.jarral01@imperial.ac.uk (O.A. Jarral).

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Abstract

A best evidence topic was written according to a structured protocol. The question addressed was to identify which thoracotomy closure method lends itself to the least postoperative pain. Altogether 109 papers were found using the reported search; of which, seven represented the best evidence to answer the clinical question. The authors, journal, date and country of publication, patient group studied, study type, relevant outcomes and results of these papers are tabulated. We conclude that the closure by intracostal sutures with intercostal nerve sparing offers a superior postoperative pain profile for thoracotomy patients when compared with conventional techniques. Up to 1-year follow-up has shown that this technique (avoiding strangulation of the intercostal nerve) leads to lower postoperative pain and analgesic use, better ambulation and a quicker return to daily activities. Three papers (including two randomized trials) found intracostal sutures with intercostal nerve sparing techniques to be superior to conventional methods such as pericostal suture closure. Rib approximation with intercostal nerve sparing was found to be superior to rib approximation without nerve sparing in one study. Two studies associated with the creation of an intercostal muscle flap prior to the insertion of a rib retractor to be associated with significantly reduced postoperative pain. One study described a novel ‘edge-closure’ technique, comparable to the closure with intracostal sutures without drilling, to be superior to conventional closure with pericostal sutures. Postoperative pain is a significant issue faced by thoracic surgeons both in-hospital and in the longer term where patients may complain of chronic thoracotomy pain. We would therefore recommend that some form of intercostal nerve protection be implemented during thoracotomy opening and closure.

Keywords: Thoracotomy closure • Rib approximation • Muscle flap • Pericostal suture • Intracostal suture

INTRODUCTION

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

CLINICAL SCENARIO

You have just embarked on a video-assisted thoracoscopic surgery lobectomy programme and are concerned that a reduction of rib spreading and intercostal nerve crushing reduces pain. Thus you come to a case involving thoracotomy for a difficult intrapericardial pneumonectomy. On closure you reflect that despite reducing rib spreading as much as possible, your retractor must have crushed the nerve under the fifth rib and the pericostal sutures must be crushing the intercostal nerve below the sixth rib. You wonder whether a nerve sparing approach has been proven to reduce post-thoracotomy pain.

THREE-PART QUESTION

In [patients undergoing thoracotomy] does [rib approximation or intracostal suture placement] as opposed to [pericostal sutures] improve [perioperative pain].

SEARCH STRATEGY

The search Medline from 1948 to November 2011 using the OvidSP interface: (Thoracotomy.mp OR exp Thoracotomy/) AND (pericostal.mp OR intracostal.mp OR muscle flap.mp).

SEARCH OUTCOME

A total of 109 papers were found using the above search. From these, seven papers were identified that provided the best evidence to answer the question. These are presented in Table 1.

RESULTS

Allama et al. [2] prospectively randomized 120 patients undergoing thoracotomy into two groups: one undergoing closure with an intercostal muscle flap and intracostal sutures and one undergoing closure with pericostal sutures. The postoperative pain score throughout the first week was significantly lower in the intercostal muscle flap/intracostal suture group, which also had significantly earlier ambulation, return to daily activities and...
### Table 1: Best evidence papers

| Author, date and country | Patient Group | Outcomes | Key results | Comment |
|--------------------------|---------------|----------|-------------|---------|
| **Prospective randomized controlled trial (level 2 evidence)** | 120 patients undergoing posterolateral thoracotomy for a variety of thoracic diseases were prospectively randomized into two equal groups undergoing thoracotomy closure with either intercostal muscle flap (IMF) and intracostal sutures (ICSs) or pericostal sutures (PCSs) | IMF and ICS vs. PCS Day 1: 5.17 ± 0.99 vs. 5.60 ± 1.15 (P = 0.029) Day 7: 1.15 ± 0.48 vs. 1.40 ± 0.56 (P = 0.012) 1 month: 1.10 ± 0.6 vs. 1.35 ± 0.51 (P = 0.01) | Pain profile and analgesic use significantly lower in the IMF/ICS group up to 3 months | Study limitations: Total of 21 patients who dropped out of study following randomization for a variety of reasons |
| | | | Limitation in the methodology in that the use of a numeric pain scale (0–10) is subjective |
| **Bayram et al. (2010), Eur J Cardiothorac Surg, Turkey [3]** | 60 patients undergoing full muscle-sparing thoracotomy were randomized into two equal groups: Group A: placement of intercostal sutures: two holes were drilled in the sixth rib and sutures were passed through these holes and circled through the upper edge of the fifth rib (i.e. with intercostal nerve compression) | Analgesic consumption from epidural (patient controlled), bupivicaine and fentanyl; cm³ Postoperative visual analogue score 0–10 (at rest) | Group A vs. B (overall P = 0.1456): 48 h 150.3 (122–191) vs. 82.2 (56–123) (overall P = 0.0123) 48 h 5.09 (5–7) vs. 3.46 (3–6) | Thoracotomy closure avoiding intercostal nerve compression provided a significant reduction in postoperative pain up to 48 h at rest and during coughing Limitations: This study considered purely acute postoperative pain (up to 48 h) and had no further follow-up Postoperative complications not reported |

Continued
| Author, date and country | Patient Group | Outcomes | Key results | Comment |
|--------------------------|--------------|----------|-------------|---------|
| Wu et al., (2010), Eur J Cardiothorac Surg, China [4] | Seventy-two patients undergoing pulmonary resection via non-muscle sparing thoracotomy were randomly assigned to thoracotomy closure with either an intercostal muscle flap together with intracostal sutures or closure with intracostal sutures only | Average numeric rating scale (aNRS) at rest (Median (IQR)) | Overall $P = 0.279$ | Combining intercostal muscle flap with intracostal suture did not achieve better post-thoracotomy pain control compared with intracostal suture alone based on numeric rating scale at rest and during coughing. However, patients with a muscle flap closure needed less oxycodone on days 4–7 postoperatively. |
| Sevastikas et al., (2010) [5] | Patients undergoing lung resection via non-muscle sparing thoracotomy were randomly assigned to thoracotomy closure with either an intercostal muscle flap or vascularized intercostal muscle flap | Average numeric rating scale (aNRS) at rest (Median (IQR)) | Overall $P = 0.90$ | Combining intercostal muscle flap with intracostal suture did not achieve better post-thoracotomy pain control compared with intracostal suture alone based on numeric rating scale at rest and during coughing. However, patients with a muscle flap closure needed less oxycodone on days 4–7 postoperatively. |
| | All patients were operated on by the same surgeon. The patients and data collectors were blinded to the group assignment | | | |
| | IMF and ICS vs. ICS alone | | | |
| | Day 1–7: 1.71 (0.86–3) vs. 2.5 (1.16–3.12) ($P = 0.279$) | | | |
| | Week 2–12: 0 (0–0.14) vs. 0.05 (0–0.14) ($P = 0.856$) | | | |
| | Mean aNRS: Day 1–7: 4.41 (3.81–5.14) vs. 4.79 (4.09–5.67) ($P = 0.282$) | | | |
| | Median (IQR) Week 2–12 0.43 (0–0.86) vs. 0.48 (0.06–1.20) ($P = 0.595$) | | | |
| | Postoperative visual analogue score 0–10 (during coughing) | (overall $P = 0.0310$) | | |
| | Postoperative visual analogue score 0–10 (during coughing) | 48th h 8.45 (8–9) vs. 6.46 (6–8) | | |
| | Observer verbal ranking scale (OVRS) | (overall $P = 0.009$) | | |
| | Observer verbal ranking scale (OVRS) | 48th h 1.54 (1–2) vs. 0.06 (0–1) | | |
| | Ramsay sedation score | (overall $P = 0.3177$) | | |
| | Ramsay sedation score | 48th h 2.90 (2–3)/3.00 (3–3) | | |
| | von Frey hair test (hyperalgesia) (mean scores in cm) | (overall $P = 0.7355$) | | |
| | von Frey hair test (hyperalgesia) (mean scores in cm) | Day 2 2.75 vs. 2.75 | | |
| | von Frey hair test (hyperalgesia) (mean scores in cm) | Day 30 2.25 vs. 2.16 | | |

**Note:** Postoperative visual analogue score 0–10 (during coughing), Observer verbal ranking scale (OVRS), Ramsay sedation score, von Frey hair test (hyperalgesia) (mean scores in cm).
Table 1: Continued

| Author, date and country | Study type (level of evidence) | Patient Group | Outcomes | Key results | Comment |
|--------------------------|-------------------------------|---------------|----------|-------------|---------|
| Cerfolio et al., (2008), Ann Thorac Surg, USA [5] | Prospective randomized controlled trial (level 2 evidence) | All patients had a patient-controlled functional epidural, which was removed 24 h postoperatively. Subsequently, patients were given oxycodone according to their reaction to pain | Doses of oxycodone demand (mg; Median (IQR)) | Day 1: 0 (0–5) vs. 0 (0–6.25) \( P = 0.072 \) | Significant patient drop out/meeting of exclusion criteria as 144 patients were originally eligible for the trial |
| | | Pain scores were recorded by a trained blinded nurse in-hospital and by telephone interview at fixed intervals until 12 weeks after surgery | Proportion not taking oxycodone on each day postoperatively (%) | Day 1: 71% vs. 57% | Analgesia consumption was not recorded beyond seven days |
| | | No statistical differences between patient groups in terms of age, sex, length and width of incision, duration of rib retraction, duration of chest tube draining or incidence of common complications including atelectasis and atrial arrhythmia | | Day 4: 91% vs. 68% \( P < 0.05 \) | |
| | | Groups had similar demographics, preoperative pulmonary function, type of procedures and histology of lung cancer | | Day 7: 97% vs. 81% \( P < 0.05 \) | |
| | | The procedures were all performed by one surgeon. Only the surgeon and part of the surgical team were aware of the assignment. Members of the pain service managing the epidural, nursing team and data collectors were all blinded | | | |
| | | | | Day 1: 2.60 vs. 2.52 | This follow on study from the paper presented in the row below. Harvesting an intercostal muscle flap and leaving it intact, so that it dangles under the chest retractor leads to further reduction of post-thoracotomy pain than if the flap is divided anteriorly and reflected posteriorly |
| | | | | Day 4: 1.04 vs. 1.49 \( P = 0.013 \) | Limitations: |
| | | | | Day 5: 1.70 vs. 2.05 | Fairly extensive exclusion criteria. Postoperative lung function was not measured |
| | | | | Day 1: 2.0 vs. 2.65 | |
| | | | | Day 5: 1.0 vs. 1.25 | |
| | | | | Day 1: 99 vs. 97 | |
| | | | | Day 5: 100 vs. 100 | |
| | | | | Day 1: 100 vs. 100 | |
| | | | | Day 2: 95 vs. 96 | |
| | | | | Day 3: 97 vs. 97 | |
| | | | | Day 4: 100 vs. 100 | |
| | | | | Day 7: 100 vs. 100 | |
| | | | | Day 1: 100 vs. 100 | |
### Table 1: Continued

| Author, date and country | Patient Group | Outcomes | Key results | Comment |
|--------------------------|---------------|----------|-------------|---------|
| Cerfolio et al., (2005), J Thorac Cardiovasc Surg, USA [6] | Prospective randomized controlled trial (level 2 evidence) | 114 patients requiring a pulmonary resection were randomized to either a standard posterolateral thoracotomy (with preservation of serratus anterior) (n = 58) or an identical procedure, except an intercostal muscle was harvested from the lower rib (to protect the intercostal nerve) before chest retraction (n = 56). After harvesting of the flap, it was transacted anteriorly and reflected posteriorly prior to insertion of the retractor | IMF opening vs. Standard opening (unstated P values are >0.05) | Harvesting of an intercostal muscle flap to protect the intercostal nerve before chest retraction decreased the pain of thoracotomy with a decreased analgesic use postoperatively. Patients had less pain at 1, 2, 3, 4, 8, and 12 weeks postoperatively and were less likely to be using narcotics. There was improved spirometric function and reduced complications including atrial arrhythmia. Limitations: 31 patients excluded from trial for a variety of reasons (given in paper) |
| | | Numeric pain score | Week 2: 2.1 vs. 2.7 | |
| | | | Week 12: 0.51 vs. 1.2 (P = 0.002) | |
| | | Prescription pain medication use. Number (%) | Week 2: 44 (96) vs. 48 (94) | |
| | | | Week 4: 22 (27) vs. 29 (40) (P = 0.001) | |
| | | | Week 12: 3 (2) vs. 7 (10) | |
| | | Receiving adjuvant treatment. Number (%) | Week 2: 0 vs. 0 | |
| | | | Week 12: 6 vs. 8 | |
| | | Return to baseline activities. Number (%) | Week 4: 12 (15) vs. 13 (17) | |
| | | | Week 12: 60 (89) vs. 51 (74) (P = 0.002) | |
| | | Satisfaction with procedure. Number (%) | Week 2: 80 (96) vs. 71 (98) | |
| | | | Week 12: 65 (97) vs. 73 (95) | |
| | | Mean numeric postoperative pain score during hospitalization | Day 1: 2.29 vs. 4.50 (P = 0.04) | |
| | | | Day 4: 2.37 vs. 2.56 | |
| | | Visual pain score during hospitalization | Day 1: 1.60 vs. 2.27 (P = 0.03) | |
| | | | Day 4: 1.51 vs. 1.76 | |
| | | Descriptor, patients with mild to no pain during hospitalization | Day 1: 86% (48) vs. 71% (41) | |
| | | | Day 4: 97% (41) vs. 95% (41) | |
### Table 1: Continued

| Author, date and country | Patient Group | Outcomes | Key results | Comment |
|--------------------------|---------------|----------|-------------|---------|
| A single surgeon performed operations. Other medical staff were blinded to the randomization process including those involved in the postoperative pain service | Decrease in spirometry during hospitalization | Day 1: 53% vs. 44% |  |  |
| | | Day 3: 11% vs. 23% \((P = 0.02)\) |  |  |
| | | Day 4: 16% vs. 35% |  |  |
| | Proportion of patients ambulatory during hospitalization | Day 1: 100% vs. 98% |  |  |
| | | Day 4: 100% vs. 100% |  |  |
| | Patients epidural during hospitalization | Day 1: 100% vs. 100% |  |  |
| | | Day 4: 0% vs. 0% |  |  |
| | Patients with chest tube(s) during hospitalization | Day 1: 100% (56) vs. 100% (58) |  |  |
| | | Day 4: 5.2% (8) vs. 7.3% (7) |  |  |
| | Patients using oral pain medications (%) during hospitalization | Day 1: 0% vs. 5% (3) |  |  |
| | | Day 4: 100% vs. 100% |  |  |
| | Inpatient complications | Pneumonia (1 vs. 3) |  |  |
| | Need for reintubation (0 vs. 1) |  |  |  |
| | Ileus (1 vs. 1) |  |  |  |
| | Diverticulitis (1 vs. 0) |  |  |  |
| | Atrial arrhythmia (4 vs. 13) \((P < 0.05)\) |  |  |  |
| | Urinary retention (1 vs. 0) |  |  |  |
| | Postoperative numeric pain score | Week 1: 2.63 vs. 4 \((P < 0.05)\) |  |  |
| | | Week 12: 1.2 vs. 2.68 \((P < 0.05)\) |  |  |
| | Verbal descriptor scale, patients reporting mild or no discomfort | Week 1: 91% (51) vs. 79% (42) \((P = 0.03)\) |  |  |
| | | Week 12: 78% vs. 72% |  |  |
| | Patients readmitted within 30 days of the operation | Week 1: 2% (1) vs. 2% (1) |  |  |
| | | Week 4: 10.4% (5) vs. 6.7% (3) |  |  |
| | | Week 12: n/a |  |  |

Continued
| Author, date and country | Patient Group | Outcomes | Key results | Comment |
|-------------------------|--------------|----------|-------------|---------|
| Sakakura et al., (2010), Ann Thorac Surg, Japan [7] | Patients using pain medication | Week 1: 95% (53) vs. 95% (54) | Pain score by the type of thoracotomy | The intercostal bundle sparing edge-closure technique significantly reduced postoperative pain following both posterolateral or anterolateral thoracotomy. In addition, the creation of an intercostal muscle flap before rib retraction also reduced pain scores |
| Retrospective analysis (level 3 evidence) | Patients receiving adjuvant treatment | Week 1: 0 vs. 0 | Pain scores for intercostal muscle flap compared with no intercostal muscle flap | Limitations: The retrospective nature of this study is a limiting factor. This makes it impossible to standardize the surgical techniques that were used Also there was an uneven distribution of patient groups with follow-up affected by loss to follow-up and missing data Postoperative length of stay and complications were not measured. Patients undergoing anterolateral thoracotomy usually had smaller surgical procedures making comparisons less valid |
| | Patients satisfied with procedure and care | Week 1: 95% (53) vs. 96% (55) | Pain scores of conventional vs. edge closure technique | Postoperative length of stay and complications were not measured. Patients undergoing anterolateral thoracotomy usually had smaller surgical procedures making comparisons less valid |
| | 184 patients undergoing posterolateral or anterolateral thoracotomy retrospectively reviewed. In addition, these patients either had (a) an intercostal muscle flap harvested before using retraction to prevent compression of the cranial intercostal nerve in posterolateral thoracotomy patients who needed buttressing of the bronchial stump (n = 72) (b) the thin space between the inferior edge of caudal rib and the neurovascular bundle was sutured to prevent strangulation of the intercostal nerve and vessels on the caudal side (edge closure technique) (n = 97) (c) conventional closure with pericostal sutures (n = 87) | All mean ± SD | IMF (n = 72) vs. no IMF (n = 112) | Pain scores of conventional vs. edge closure technique |
| | Postoperatively epidural anaesthesia (160 ml of 0.25% ropivacaine plus 1000–1400 g of fentanyl) was performed continuously (2–4 ml/h) until the third day after surgery. Patients regularly took loxoprofen sodium at a dose of 180 mg/day for ~1 month, starting the day after surgery. Oral opioids were not used | 1–2 weeks: 4.6 ± 1.5 vs. 3.7 ± 1.3 (P = 0.006) | Pain scores for intercostal muscle flap compared with no intercostal muscle flap | Pain scores of conventional vs. edge closure technique |
| | | 2 weeks–1 month | IMF (n = 72) vs. no IMF (n = 112) | Pain scores of conventional vs. edge closure technique |
| | | 3.8 ± 1.3 vs. 3.1 ± 1.4 (P = 0.021) | Pain scores of conventional vs. edge closure technique | Pain scores of conventional vs. edge closure technique |
| | | 9–12 months: 1.2 ± 1.3 vs. 1.1 ± 1.2 (P = 0.756) | Pain scores of conventional vs. edge closure technique | Pain scores of conventional vs. edge closure technique |

Continued
Table 1: Continued

| Author, date and country | Patient Group | Outcomes | Key results | Comment |
|-------------------------|---------------|----------|-------------|---------|
| Exclusion criteria included ipsilateral operations, combined resections of chest wall, pneumonectomy, chronic pain diseases such as rheumatism and those on regular steroid medication | Pain scores of posterolateral thoracotomy patients stratified by closure technique (CC or EC) | CC vs. EC | 1–2 weeks: 5.0 ± 0.9 vs. 4.3 ± 1.0 (P < 0.001) |  |
| | | | 2 weeks-1 month: 4.2 ± 0.9 vs. 3.5 ± 1.1 (P < 0.001) |  |
| | | | 9–12 months: 1.6 ± 1.4 vs. 1.2 ± 1.3 (P = 0.083) |  |
| There were no significant differences between patients in terms of age, sex, type of lung disease, length of surgery, intraoperative bleeding, skin incision length | Pain scores after anterolateral thoracotomy technique stratified by closure technique (CC or EC) | CC vs. EC | 1–2 weeks: 4.0 ± 1.2 vs. 3.1 ± 1.0 (P = 0.031) |  |
| | | | 2 weeks-1 month: 3.7 ± 1.1 vs. 2.6 ± 0.9 (P = 0.021) |  |
| | | | 9–12 months: 1.0 ± 1.1 vs. 0.8 ± 0.8 (P = 0.108) |  |
| Cerfolio et al., (2003), Ann Thorac Surg, USA [8] | 280 patients underwent muscle sparing thoracotomy for pulmonary resection by one surgeon over 17 months. The first 140 patients had thoracotomy closure with pericostal sutures and the next 140 patients had chest closed with intracostal sutures. The sixth intercostal nerve was subject to analgesia (marcaine with epinephrine) as well as the fourth, fifth, seventh and eighth nerves. Identical postoperative pain regimens were employed | Group PCS vs. Group ICS | 2 weeks: 5.5 ± 1.4 vs. 3.3 ± 1.9 (P = 0.004) | Intracostal sutures are less painful than pericostal sutures at various time points postoperatively up to 3 months |
| | | | 3 months: 1.6 ± 0.8 vs. 0.6 ± 0.7 (P < 0.0001) | Post-thoracotomy pain is significantly less likely to be described as burning or shooting when intracostal sutures are used |
| | | | PCS patients statistically more likely (P = 0.004) to report their pain as hot/burning, stabbing, or shooting | Limitations: |
| | | |  | Subjective nature of measuring pain, limited data during hospitalization (i.e. days 1–7) and lack of measurement of postoperative complications |

IMF: intercostal muscle flap; ICS: intracostal suture; PCS: pericostal suture; FEV1: forced expiratory volume in the first second; CC: conventional closure; EC: edge closure; N/A: not available/applicable.
lower doses of analgesics. Additionally, the intercostal muscle flap/intracostal suture group had significantly lower pain scores and use of postoperative analgesia at 1 week and at 1 month. At 3 months, the intercostal muscle flap/intracostal suture group had significantly lower analgesic use but there was no difference in the pain score. There were no significant differences between groups when comparing analgesic use and pain scores at 6 months.

Bayram et al. [3] prospectively randomized 60 patients undergoing thoracotomy into two groups: one undergoing closure with intercostal sutures compressing the intercostal nerve bundle and one with intercostal nerve dissection and preservation before intracostal sutures were applied. Closure with intracostal sutures without intercostal nerve compression was associated with significantly lower visual analogue scores at rest and while coughing. Observer verbal ranking scores within a 48-h postoperative period were also significantly lower in this group. There was no significant difference between the groups in terms of their Ramsey sedation score over 48 h, consumption of postoperative patient controlled epidural analgesia or von Frey hair test results (a method used to assess hyperalgesia) at 30-day follow-up.

Wu et al. [4] prospectively randomized 72 patients undergoing non-muscle sparing thoracotomy into two groups: one undergoing closure with muscle flap and intracostal sutures and the other undergoing closure with intracostal sutures. The authors found no statistical differences between pain scores at rest or during coughing postoperatively. However, the intake of oxycodone was significantly lower in the muscle flap group during postoperative days 4–7.

Cerfolio et al. [5] prospectively investigated 160 patients undergoing thoracotomy. The sample was randomized into two groups, one group with an intercostal muscle harvest that was left to dangle beneath the rib retractor and the other group where this intercostal muscle flap was divided anteriorly and reflected posteriorly prior to retraction. On postoperative days 1 and 2, the intact muscle flap group had significantly lower visual pain scores and at postoperative weeks 3, 4, 8 and 12, the intact muscle flap group had significantly lower mean numeric pain scores and had used fewer analgesics. At 12 weeks, patients in the intact muscle flap group were more likely to have returned to baseline activity.

Cerfolio et al. [6] prospectively randomized 114 patients undergoing a pulmonary resection to either a thoracotomy or a thoracoscopic approach without having an intercostal muscle from the lower rib (to protect the intercostal nerve) before chest retraction. After harvesting of the flap, it was transacted anteriorly and reflected posteriorly prior to the insertion of the retractor. In this group, the numeric pain scores were lower on postoperative days 1 and 2 and at weeks 1, 2, 3, 4, 8 and 12. In addition, this group had a smaller decrease in spirometric values, was less likely to be using analgesics, was more likely to have returned to normal activity and had a lower incidence of atrial arrhythmia.

Sakaura et al. [7] retrospectively reviewed 184 patients who underwent posterolateral (n = 141) or anterolateral thoracotomy (n = 43). In addition, these patients either had (i) an intercostal muscle flap harvested before using retraction to prevent compression of the cranial intercostal (n = 72), (ii) the thin space between the inferior edge of caudal rib and the neurovascular bundle was sutured during closure to prevent strangulation of the intercostal nerve and vessels on the caudal side (edge closure technique) (n = 97) or (iii) conventional closure with pericostal sutures (n = 87) which comprise the neurovascular bundle. Up to 2 months postoperatively, anterolateral thoracotomy patients had less pain compared with the posterolateral thoracotomy patient group. It was also found that intercostal bundle sparing edge-closure techniques reduce postoperative pain significantly (up to 12 months) when compared with the conventional closure. The use of an intercostal muscle flap prior to rib retraction showed less postoperative pain up to 1 month after the operation.

Cerfolio et al. [8] retrospectively reviewed 280 consecutive patients following thoracotomy: half had closure with pericostal sutures and a similar-sized consecutive group received an intracostal suture closure. Intracostal sutures resulted in significantly less postoperative pain during the full course of the study (3 months). Intracostal suture patients were also less likely to report any pain as being hot, burning or stabbing (a symptom of intercostal nerve compression).

**CLINICAL BOTTOM LINE**

Postoperative pain is a significant issue faced by thoracic surgeons. During in-hospital stay, there is of course concern that increased pain may lead to poorer outcomes due to complications such as sputum retention and in the longer term there is the risk of chronic thoracotomy pain. The seven studies examined in this article suggest that techniques offering some form of protection to the intercostal nerve (such as intracostal sutures or the use of an intercostal muscle flap) are associated with significantly reduced postoperative pain and analgesic consumption, even up to 12 months after surgery. Only two studies reported complication rates in detail, one of which showed a significantly reduced rate of atrial arrhythmia when an intercostal muscle flap was created prior to rib retraction.

**Conflict of interest:** none declared.

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