Pain Control after Thoracotomy*

An Extrapleural Tunnel to Provide a Continuous Bupivacaine Infusion for Intercostal Nerve Blockade

Aljafri A. Majid, F.R.C.S.Ed.(C.T.); and Hazian Hamzah, M.D.‡

This study was undertaken to determine whether an infusion of local anesthetic (LA) delivered through an extrapleural tunnel could provide satisfactory control of pain in the postthoracotomy period. Twelve patients undergoing thoracotomy were studied. A T-shaped tunnel was created by elevating the parietal pleura at the posteromedial end of the thoracotomy wound. An irrigation catheter was then inserted and an infusion of bupivacaine commenced, initially at 5 mg/kg/24 h and subsequently at 3 mg/kg/24 h.

Intercostal nerve blockade by local anesthetic (LA) agents is not associated with drowsiness or respiratory depression and has been shown to give relief of pain after thoracotomy. However, the duration of pain relief it provides is limited, even when long-acting LAs are used. Thus, unless supplementary doses can be administered, opiates will again be required once the effects of the LA have worn off. Delivery of supplementary LA has been achieved either by repeated injections to multiple intercostal nerves or through multiple catheters to several intercostal nerves. These methods are not entirely satisfactory and there is a need for a simpler method of delivery of LA to the intercostal nerves. Recently, Pain was well controlled in eight patients and satisfactory in four patients. The latter required one dose of opiate analgesia each in the 48-h postoperative period. We conclude that an infusion of bupivacaine into the extrapleural space is an effective means of control of pain after thoracotomy. (Chest 1992; 101:981-84)

LA = local anesthetic

vertebral bodies. This formed the short vertical limb of the T. The transverse limb of the T was then created by elevating the pleura by blunt digital dissection in a direction parallel to the vertebral bodies for a distance of some two intercostal spaces above and a similar distance below the level of the thoracotomy wound.

A perforated polyvinyl chloride catheter, 8 Fr, 50 cm long with 14 cm of perforations (Redon, Unoplast, Denmark) was inserted into the transverse limb of the T and brought out through the intercostal space at the lowermost end of the tunnel using a double-angled catheter introducer (Fig 2). The double angle on the catheter introducer facilitated the passage of the catheter introducer through the chest wall without damaging the pleura. The catheter introducer was manufactured with one angle on it. A second bend was quite readily made as in Figure 2 as the metal introducer is quite pliable. The vertical limb of the T was sealed off from the pleural cavity with an absorbable suture. The catheter was then connected to a catheter (Argyle 18 Angiocath) and then to an infusion pump (IVAC, Ivac Corporation, San Diego, Calif) containing 0.25 percent bupivacaine and infused at a rate of 5 mg/kg/24 h (3 to 5 ml/h). The

For editorial comment see page 892

Sabanathan et al described a means of delivering LA to the intercostal nerves by means of an extrapleural tunnel. We have also developed a similar technique and this article describes our experience in 12 patients.

METHODS

Patients

Twelve consecutive consenting patients undergoing thoracotomy for various closed heart or thoracic procedures were studied. The study was approved by the Ethics Subcommittee of the University Hospital. All patients received an opiate premedication and a general anesthetic consisting of intraoperative Fentanyl and nitrous oxide. After the intrathoracic procedure had been performed and with the chest still open, a T-shaped tunnel was created (Fig 1). The parietal pleura at the medial end of the thoracotomy wound was elevated for a distance of about 2.5 cm in a direction toward the

*From the Department of Surgery, Faculty of Medicine, University of Malaya, Kuala Lumpur, Malaysia.
†Cardiothoracic Surgeon.
‡Medical Officer.

Reprint requests: Dr. Majid, Department of Surgery, University of Malaya Faculty of Medicine, Kuala Lumpur, Malaysia 59100

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**Figure 1. Diagram of the extrapleural tunnel at a left thoracotomy.** The pleura overlying the catheter has been diagrammatically cut away in two places to reveal the catheter lying outside the parietal pleura. The suture depicts the closure of the vertical limb of the T-shaped tunnel from the medial end of the thoracotomy wound.
infusion was begun in the operating room prior to closure of the thoracotomy wound. Intercostal drains were inserted and the chest was closed. The infusion was maintained at a rate of 5 mg/kg/24 h (3 to 5 ml/h) for the first 24 h and then reduced to 3 mg/kg/24 h (2 to 4 ml/h) for the second 24 h.

Patients were extubated and returned to the cardiac intensive care ward where they were monitored for 48 h. The degree of pain relief obtained was closely monitored using three methods: (1) objective visual assessment; (2) subjective assessment with a four-point verbal response scale; and (3) demand for analgesics. A facial pain scale was used for objective monitoring and the observations were made hourly by trained intensive care nurses under supervision of a physician not directly involved in this project. The pain scale was modified to include a score of zero if the patients were sleeping. If they were awake, a subjective assessment of pain was also made on a four-point verbal rating scale by asking them if they had any pain (no pain = 0). If they did have pain, its degree of severity was noted: mild = 1; moderate = 2; or severe = 3. They were also asked if they required more analgesics. Morphine 10 mg was administered intramuscularly on request and no attempt was made to withhold analgesics while the catheter was in place. Morphine was administered intramuscularly rather than intravenously to enable the analgesia to be administered by the nurses; nurses in our hospital are not permitted to give intravenous morphine. Acetaminophen (paracetamol) 500 mg to 1 g was administered to the patients if requested after 48 h.

Postoperatively, chest physiotherapy was administered twice daily starting on the evening of the operative day and all patients were encouraged to cough. Blood pressure was monitored with an indwelling catheter into the radial artery and the electrocardiogram was continuously monitored for arrhythmias. Arterial blood gas analyses were performed regularly in the first 24 h after operation. The intercostal drains and infusion catheter (Redivac) were removed after 48 h. Serial chest roentgenograms were performed (Fig 3) on the evening of operation, on the first and second postoperative days, and after the intercostal drain and infusion catheter had been removed.

RESULTS

Twelve patients whose ages ranged from 19 to 66 years were studied. The types of surgery included pulmonary lobectomy (five patients), ligation of patent ductus arteriosus (five patients), lung biopsy (one patient), and mediastinal tumor resection (one patient) approached by a posterolateral thoracotomy incision on the appropriate side. With respect to the objective visual assessment, the median pain score for the 12 patients was 3 or less for every hour in the first 24 h. In eight patients in the 48 h immediately after operation, pain control was satisfactory with pain scores of less than 4 in these patients throughout the 48-h period. These eight patients also complained of no more than mild pain (pain score = 1) on questioning. They were able to cooperate with the physiotherapists and were noted to be able to cough well. Four patients were noted to have a pain score of more than 4 and also complained of pain on coughing (pain score = 2 or 3) when questioned. They required one supplemental dose each of intramuscularly administered opiate analgesics which was noted to be sufficient to control their discomfort. These four doses were required in the first 24 h period. Two of these patients were known to have had tears in their pleurae at the time the extrapleural tunnel was created. No hypoxia, acidosis, or hypercarbia was noted on blood gas analysis. No patients had atelectasis detected either clinically or on the chest roentgenograms. There were no hypotensive episodes and none of the other known toxic side effects of bupivacaine such as neurologic complications or arrhythmias were seen. No wound infections or empyemas were encountered.

DISCUSSION

We are encouraged by the results of this technique. Most patients had satisfactory pain relief, did not require opiate supplements, and were also able to tolerate physiotherapy in the early postoperative period. In addition, clinical examination, blood gas analyses, and chest roentgenography indicated satisfactory respiratory function in the postoperative period. At the doses used, toxic effects were absent. Creation of the tunnels and insertion of the catheters were easily performed in most cases and did not add much time to the operation. In addition, delivery to the relevant intercostal nerves could be made for an extended duration in the postoperative period. In
some patients, however, the tunnel could not be properly constructed because the pleura was thin and easily torn and the tears not readily repaired. We think these tears led to delivery of inadequate amounts of LA to the intercostal nerves such that opiates were required in at least two patients. Although cardiotoxicity was not observed, the possibility must be considered, particularly in patients with cardiac disease. Similarly, although no infections were seen, it is probably wise to limit the duration the catheter is left in situ.

In our study, we aimed to provide LA to the intercostal nerves continuously over a 48-h period. By using a perforated infusion catheter, we hoped to provide more even distribution of LA to the intercostal nerves than would be possible with a catheter that had only an end hole. With regard to the dose of LA, we used a dose of 5 mg/kg/24 h, which is close to the upper limit of the recommended dosage in this initial study. The rate of infusion of LA was reduced after the first 24 h to avoid any possible toxic effects from accumulation of bupivacaine. Our choice of dose of LA was influenced by previous work on the use of infusions of LA in the postthoracotomy period where rather high infusion rates of LA were used. Given the overall low pain scores obtained in this study, lower infusion rates may be possible. We have not expressed our results of the objective visual assessment in the form of mean pain scores as others have done since the pain scale is nonlinear and use of a mean is probably not appropriate.

The results of the previous studies using infusions of LA in the postthoracotomy period are reviewed herein for comparison. These authors have tended to report only the need for further analgesics as their end point of measurement of pain control. Sabanathan et al infused 0.5 percent bupivacaine through an extrapleural tunnel in the initial hours after operation. The total dose of 300 mg was infused intraoperatively and in the initial 5 h after the operation. The effectiveness of pain control was measured by recording the demand for supplementary analgesics. They achieved a remarkably high degree of pain relief; 92.6 percent required no additional analgesics in the first 24 h. Although the catheter was kept in situ for five days whether further local anesthetic was infused after the initial dose is not mentioned. Bryant et al used a multiple catheter technique in a series of 40 patients to infuse a rather high dose of lidocaine (2 ml of 2 percent lidocaine injected every 2 h, ie, 480 mg/24 h). Twenty-one patients had excellent relief (no narcotics), and 17 patients had a good result (one to three injections of opiate). It was completely ineffective in two patients. Olivet et al also used a multiple catheter technique and injected 80 mg every 6 h (320 mg/24 h) in 21 patients. They found their technique gave generally good and occasionally dramatic relief of pain and generally decreased the need for narcotics. Thus it would appear that while pain control is possible with infusion of LAs, the dosages that have been used in the past are rather high. Further work in this area to compare the effectiveness of different types and dosages of local anesthetics is required.

While the major site of neural blockade is likely to be the intercostal nerves within the tunnel, blockade of other intercostal nerves could also have occurred. Injections into the intercostal spaces have been shown to result in extravasation with spread to the paravertebral space as well as to other intercostal nerves.

Thus, spread of LAs to other intercostal nerves by direct extrapleural extravasation or via the paravertebral spaces could also have occurred with our technique. If this is so, blockade of other intercostal nerves by increasing the number of dermatomes anesthetized could also have contributed to the pain relief and tolerance of physiotherapy. Although spillage into the pleural space may have resulted in an interpleural collection of LA, it is not likely to have been important herein, mainly because the LA is likely to have been removed rapidly by the intercostal drains.

The combination of an opiate premedication and a local anesthetic block has been shown by McQuay et al to be synergistic and not purely additive in the control of postoperative pain in orthopedic patients. Wall has hypothesized that opiate premedication decreases the barrage of stimulation associated with the surgical incision and postoperative LA continues to keep the barrage to a minimum. Whether this synergistic effect also occurs when LA is infused after a thoracotomy is an area for future investigation.

In conclusion, LA can be delivered to the intercostal nerves and satisfactory postoperative pain control can be achieved with the extrapleural tunnel technique.

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