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Thoracic epidural in the management of chest trauma

A study of 161 cases

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Abstract. During a 6-year period, 188 patients with chest wall trauma were admitted to the Royal Adelaide Hospital Intensive Care Unit. One hundred and sixty one patients were treated with thoracic epidural analgesia using bupivacaine 0.5% with adrenaline 1/200,000. One hundred and forty seven (91%) were treated conservatively; previously 100% of patients had been treated with mechanical ventilation. Two patients died from severe respiratory failure. Serious side effects associated with epidural analgesia included two cardiac arrests and one epidural infection. Conservative management of chest wall trauma relies largely upon the effectiveness of the pain relief. If complete plain relief is provided then the conservative approach is more likely to be successful. While epidural analgesia can provide complete relief from pain it is not without hazard.

Key words: Thoracic epidural analgesia – Thoracic trauma – Spontaneous breathing

Pain is often the major symptom associated with chest wall trauma. If it is severe it may restrict the patient's ability to cough, producing sputum retention, atelectasis, pneumonia and ultimately respiratory failure, requiring mechanical ventilation and positive end expiratory pressure for further management. If complete pain relief is provided, respiratory secretions are often able to be cleared, and the patient can usually be managed without the use of mechanical ventilation.

Opiate and antipyretic analgesics may give only partial pain relief, whereas local anaesthetic agents can provide complete relief from pain. To assess whether the local anaesthetic agent bupivacaine would reduce the need for artificial ventilation in patients with chest wall trauma, during a six year period thoracic epidural analgesia using 0.5% bupivacaine and 1/200,000 adrenaline was considered for pain relief in all patients admitted to the Royal Adelaide Hospital Intensive Care Unit with thoracic trauma.

Patients and methods

Thoracic epidural analgesia was considered for pain relief for all patients admitted to the intensive care unit with chest wall trauma from 1975 to 1981. Patients were excluded if they had spinal trauma, preexisting chronic neurological disease, skin infection overlying the area required for insertion of the epidural catheter, or were unconscious, uncooperative or unwilling to undergo a spinal anaesthetic procedure. Patients with a past history of cerebrovascular or myocardial ischaemia were included as were patients with flail chest segments, and pulmonary or cardiac contusion. Patients who initially underwent surgery for orthopaedic or abdominal injuries and were ventilated postoperatively were considered for extubation and epidural analgesia if they had an arterial $pO_2 > 50$ mm Hg, with an inspired oxygen concentration of 50%, and a vital capacity of >10 ml/kg. Associated injuries of pneumothorax or haemothorax were treated with underwater seal drains when necessary. The study was prospective and ethical approval was obtained.

The extent of the patients chest pain was assessed from the history. The diagnosis of flail chest was based upon the clinical presence of a paradoxical movement in a segment of chest wall. The number of fractured ribs was assessed from the chest X-ray and cardiac trauma was assessed by ECG and serum CPK-MB isoenzyme levels.

Epidural analgesia for thoracic pain relief and coughing and breathing exercises 30 min after bupivacaine administration was part of a conservative approach to the patients respiratory management. Supplemental oxygen administered by face mask to provide an arterial $pO_2 > 50$ mm Hg, 1 l of intravenous fluid daily in addition to blood and fluid to replace abnormal losses, and occasionally nasotracheal suction, was also used.

Analgesia was planned to provide a sensory block of the dermatome area of pain up to but no higher than the level of T4. Epidural cannulation was performed using the lateral approach, as previously described [1]. The catheter was inserted at an intervertebral level approximately half way between the upper and lower border of the area planned for analgesia. Five ml of bupivacaine 0.5% with 1/200,000 adrenaline were administered initially as a test dose. With the patient supine the blood pressure and pulse were measured at five min intervals for the next 30 min. Pain relief was assessed by the ability of the patient to cough and by measuring the vital capacity, using a Wright's respirometer, before and 30 min after the administration of bupivacaine. If further pain relief was required to enable the patient to cough effectively, then the next dose was increased by 1 ml, if the fall in systolic blood pressure produced by the first dose was not greater than 30 mm Hg or the systolic blood pressure did not fall below 80 mm Hg. Thereafter, to determine the optimal dose, the bupivacaine was increased or decreased by 1 ml amounts, with pain relief being titrated against the hypotensive effect of the drug. The second top up dose was given no sooner than 2 h after the first, thereafter it was given hourly as required.

Arterial gas analysis and supine CXR's were performed daily and when clinically deemed necessary. If the patient was unable to maintain an arterial blood gas > 50 mm Hg while on supplemental oxygen or if there was an increase in the respiratory rate > 40/min and an inability to cough despite adequate analgesia, the patient was considered for intubation and ventilation for further respiratory management.

Results

During the period of study 188 patients were admitted to the intensive care unit with chest wall trauma. Twenty-seven patients did not undergo thoracic epidural cannulation. Twenty-two patients were unconscious or uncooperative, four patients had spinal trauma and one patient was not extubated following surgery and required mechanical ventilation for further management. No patients had preexisting neurological disease or infection overlying the area of insertion.

One hundred and sixty one patients underwent thoracic epidural cannulation. There was 123 male and 38 female patients. Their ages ranged from 15 – 84 years (46.1 ± 16.8 (mean ± SD)). One hundred and forty seven patients (91%) were managed successfully with epidural alone, 21 of whom had flail chest segments. Eight patients underwent mechanical ventilation for a period of less than 24 h before epidural analgesia was used. Fourteen patients (9%) who failed to be managed with epidural analgesia required mechanical ventilation for further management, five had flail chest segments. The extent of the thoracic trauma (Table 1) and the associated injuries and disease (Table 2) in all patients who underwent thoracic cannulation are shown. In both tables the patients are separated into two groups (Spontaneous ventilation and Failed spontaneous ventilation).

Table 1. Extent of thoracic trauma

	Spontaneous ventilation	Failed spontaneous ventilation
	147 patients	14 patients
Rib fractures		
0 – 3	41 (28%)	–
4 – 7	81 (55%)	10 (71%)
8 – 12	25 (17%)	4 (29%)
Flail segment	21 (14%)	5 (36%)
Pneumothorax/subcut emphysema	58 (39%)	8 (57%)
Haemothorax	31 (21%)	7 (50%)
Pulmonary contusion	12 (8%)	4 (29%)
Cardiac contusion	7 (5%)	–
Ruptured aorta	1 (0.7%)	–

Table 2. Associated injuries and disease

	Spontaneous ventilation	Failed spontaneous ventilation
	147 patients	14 patients
Abdominal trauma		
Liver	5 (3%)	–
Bowel	8 (5%)	2 (14%)
Spleen	13 (9%)	1 (7%)
Head Trauma		
Fractured skull	4 (3%)	–
Concussion	25 (17%)	3 (21%)
Orthopaedic fractures		
Longbone	44 (30%)	6 (42%)
Pelvis	10 (7%)	1 (7%)
Preexisting disease		
Ischaemic heart disease	18 (12%)	3 (21%)
COPD	15 (10%)	12 (86%)

Two patients died. Both developed severe respiratory failure due to non cardiogenic pulmonary oedema and were treated with mechanical ventilation and positive end expiratory pressure after conservative therapy using epidural analgesia had failed. The first patient was an 84-year-old man with a past history of chronic obstructive pulmonary disease (COPD), who had four broken ribs following a motor vehicle accident. He managed for 3 days with epidural analgesia; however, on the 4th day he developed rapid atrial fibrillation with a ventricular rate of 185 and severe congestive cardiac failure, requiring intubation and mechanical ventilation. The ECG and serum biochemistry revealed no evidence of recent myocardial infarction. He was treated with intravenous digoxin 1 mg which slowed his pulse rate to 110 although his respiratory failure continued to worsen. Nine days after intubation the patient died from severe respiratory failure. The second patient was a 54-year-old man with a past history of heavy alcohol intake who had seven broken ribs following a motor vehicle accident. Two days after his admission, while his pain had been successfully managed with epidural analgesia, he became severely agitated and uncooperative. Sputum retention and non cardiogenic pulmonary oedema developed necessitating intubation and mechanical ventilation. His respiratory failure worsened and he died due to severe respiratory failure 12 days after his admission.

In 161 patients the duration of epidural cannulation ranged from 1 to 16 days (5.07 ± 3.22 days), the bupivacaine dose ranged from 2 to 10 ml (5.54 ± 1.7 ml), and the daily dose of bupivacaine ranged from 9 – 200 ml (63.4 ± 47.0 ml). The period between the 'top ups' varied from 1 to 12 h and depended upon pain, physiotherapy and sleep requirements of the patient. The vital capacity more than doubled after the first dose of bupivacaine was administered (Before bupivacaine 494 ± 199 cc. After bupivacaine 1130 ± 330 cc). The number of ribs broken ranged from 0 to 12 (4.96 ± 2.3) (Table 3).

The complications are summarized in Table 4. Two patients had a cardiac arrest, one 10 min after being given 10 ml of 0.5% bupivacaine inadvertently, the other patient developed hypovolaemia due to blood loss from a ruptured spleen and had a cardiac arrest 5 min after the administration of 5 ml of 0.5% bupivacaine. Both were resuscitated rapidly and after 18 h and 24 h respectively both had their epidural analgesia recommenced. One patient developed an epidural abscess. The organism was Staphylococcus aureus and had been transmitted from the external nares of one of the clinicians performing the procedure. The case has been previously reported [2]. The patient clinically presented with rigors and a swinging fever two days following the insertion of the catheter. The band of analgesia produced by the epidural block also failed to wear off. Urinary retention was treated with catheterization, and the episodes of hypotension were treated in the acute stage by standard therapy followed by reduction of the next dose of bupivacaine [1].

Table 3. Summary of epidural analgesia in 161 patients

Epidural catheter duration	5.07 ± 3.22 days
Average dose of bupivacaine	5.54 ± 1.7 ml
Average daily dose of bupivacaine	63.4 ± 47.0 ml
Number of ribs broken	4.96 ± 2.3
Vital capacity	
before analgesia	494 ± 199 cc
after analgesia	1130 ± 330 cc

Table 4. Major complications associated with epidural blockade in 161 patients

Cardiac arrest	2 (1%)
Epidural abscess	1 (0.6%)
Hypotension (systolic BP < 80 mm Hg)	27 (17%)
Urinary retention	21 (13%)
Dural puncture	6 (4%)

Discussion

Recent studies have shown a decreased mortality in patients with chest wall trauma treated using a conservative approach when compared to patients treated using routine mechanical ventilation [3, 4]. However, for the conservative approach to be successful, pain relief often needs to be complete and local anaesthetic techniques have often been used to achieve this [5, 6, 7, 8]. While intercostal [9] or paravertebral [10] techniques may provide satisfactory pain relief, the need for multiple injections is a distinct disadvantage. The spinal technique of epidural cannulation and 'top up' [11] or infusion [12] of the analgesic agent, resolves the problem of access, although the need for a trained specialist to perform the procedure and the hazards of infection and autonomic blockade with hypotension and motor blockade with a decrease in maximum ventilatory capacity [13, 14] are added problems. Hypotension may be dealt with by close titration of the dose, although in this study two cardiac arrests occurred using this method. In these two cases, however, hypovolaemia and excessive administration of bupivacaine were the likely precipitating causes, and confirms the necessity for care and close consideration of the cardiovascular status in all patients treated by this method [15]. The initial dose of bupivacaine in 161 patients resulted in serious hypotensive episodes in 17%, a figure similar to other reports [16], and all of whom were subsequently able to be managed with a lower dose of bupivacaine. To counter the problem of tachyphylaxis, bupivacaine was administered hourly as required, necessitating up to 200 ml (1000 mg) being given to one patient in 24 h. This practice led to no clinical episodes of neurological toxicity and successfully controlled tachyphylaxis.

Because of the difference in number of patients treated by spontaneous and mechanical ventilation, statistical analysis could not be performed. However, from an examination of Tables 1 and 2 it would seem that orthopaedic and abdominal injuries did not influence the course of the illness in these patients, whereas it was likely that the patients would require mechanical ventilation if the chest trauma was severe, since 36% of ventilated patients had flail segments, all had more than 4 ribs broken, and 59% had subcutaneous emphysema or pneumothorax. Nevertheless, of the 147 patients managed with epidural analgesia, 72% had more than 4 ribs broken, 14% had flail segments, and 39% had subcutaneous emphysema or pneumothorax, indicating that chest wall trauma alone was not the only factor determining patient management. However, patients who had pulmonary disease did have a greater requirement for mechanical ventilation, as 29% had pulmonary contusion and 86% had COPD, compared to 8% and 10% of the group who were managed without mechanical ventilation who had pulmonary contusion and COPD, respectively. The large increase in vital capacity from 494 ± 199 cc to 1130 ± 330 cc with the first dose of bupivacaine has not been described before and may have been observed in this study due to the lower initial vital capacity in these patients, in comparison to other reports [17, 18].

While a conservative approach should be used in the first instance to manage patients with chest wall trauma [19], mechanical ventilation has an important role to play in managing patients who are unconscious or uncooperative, are in severe respiratory failure, or have sputum retention and worsening respiratory failure despite adequate analgesia [4]. In comparison to our previous incidence of 100% of patients with chest wall trauma treated with mechanical ventilation [20], this study revealed an incidence of 9%. Pain relief with the epidural analgesia was dramatic and not associated with sedation, providing an alert and cooperative patient who was able to comply with physiotherapy demands. Nonetheless the technique is not simple and the complications of cardiac arrest and epidural abscess are severe, indicating that the procedure should only be considered in patients with chest wall trauma who are unable to cough effectively with antipyretic and opiate analgesia. Furthermore the management of these patients should only be undertaken in an intensive care unit [21, 22, 23].

References

1. Worthley LIG (1982) Epidural Analgesia. Sem Resp Med 3:291
2. North JB, Brophy BP (1979) Epidural Abscess: a hazard of spinal epidural anaesthesia. Aust N Z Surg 49:484
3. Trinkle JK, Richardson JD, Franz JL, Grover FL, Arom KV, Holmstrom FMG (1975) Management of flail chest without mechanical ventilation. Ann Thorac Surg 19:355
4. Shackford SR, Virgilio RW, Peters RM (1981) Selective use of ventilator therapy in flail chest injury. J Thorac Cardiovas Surg 81:194
5. Trahan M (1961) Continuous epidural anaesthesia in multiple fractures of the ribs. Can Anaesth Soc J 8:512
6. Gibbons J, James O, Quail A (1973) Relief of pain in chest injury. Br J Anaesth 45:1136
7. Dittmann M, Keller R, Wolff G (1978) A rationale for epidural analgesia in the treatment of multiple ribfractures. Intensive Care Med 4:193
8. Dittmann M, Steenblock U, Kranzlin M, Wolff G (1982) Epidural analgesia or mechanical ventilation for multiple rib fractures? Intensive Care Med 8:89
9. Moore DC (1975) Intercostal nerve block for postoperative somatic pain following surgery of thorax and upper abdomen. Br J Anaesth 47:284
10. Guis JA (1940) Paravertebral procaine block in the treatment of postoperative atelectasis: a preliminary report. Surgery 8:832
11. Dawkins CJM (1956) Relief of postoperative pain by continuous epidural drip. Proceedings of the 4th Congress Scandinavian Society of Anaesthesiologists, Helsinki, p 77
12. Griffiths DPG, Diamond AW, Cameron JD (1975) Postoperative extradural analgesia following thoracic surgery: a feasibility study. Br J Anaesth 47:48
13. Freund FG, Bonica JJ, Ward RJ, Akamatsu TJ, Kennedy WF (1967) Ventilatory reserve and level of motor block during high spinal and epidural anaesthesia. Anesthesiology 28:834
14. Takasaki M, Takahashi T (1980) Respiratory function during cervical and thoracic extradural analgesia in patients with normal lungs. Br J Anaesth 52:1271
15. Bonica JJ, Kennedy WF, Akamatsu TJ, Gerbershagen MU (1972) Circulatory effects of peridural block. III: Effects of acute blood loss. Anesthesiology 36:219
16. Lund PC (1962) Peridural Anesthesia: A review of 10,000 administrations. Acta Anaesth Scand 6:143
17. Spence AA, Smith G (1971) Postoperative analgesia and lung function: a comparison of morphine with extradural block. Br J Anaesth 43:144
18. Pflug AE, Murphy TM, Butler SH, Tucker GT (1974) The effects of postoperative peridural analgesia on pulmonary therapy and pulmonary complications. Anesthesiology 41:8
19. Carpintero JL, Diez AR, Elvira MJR, Benitez JA, Rielo AP (1980) Methods of management of flail chest. Intensive Care Med 6:217
20. McCleave DJ, Gilligan JE, Worthley LIG (1977) The role and function of an Australian intensive care unit. Crit Care Med 5:245
21. Simpson BR, Parkhouse J, Marshall R, Lambrechts W (1961) Extradural analgesia and the prevention of postoperative respiratory complications. Br J Anaesth 33:628
22. Editorial. Pain relief after thoractomy (1976) Lancet 1:576
23. Richardson JD, Adams L, Flint LM (1982) Selective management of flail chest and pulmonary contusion. Ann Surg 196:481

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