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Comparative Study of Analgesia Produced by Thoracic Epidural and Intravenous Opioid in Cases of Multiple Rib Fracture

Authors
Dr Pankaj Kumar Omar[1], Dr Shipra Surin[2], Dr Anikta Borkar[3]
[1]M.D. Chief Consultant Critical Care
[2,3]Junior Resident Officer
Corresponding Author
Dr Pankaj Kumar Omar
Email: *pankajomar@rediffmail.com*

Introduction

Thoracic trauma is a significant cause of morbidity and mortality in our society. It ranks second only to head injury as a cause of traumatic death in USA. One of every four death resulting from trauma is attributable to a thoracic etiology. [1]

Multiple rib fracture causes severe pain and is the most common of all chest injuries and is indentified in 10% of patients after trauma.[3A] The overall incidence may be higher as not all rib fractures are seen on chest x-ray or otherwise detected.

Rib fracture is a marker of severe bodily and solid organ injury. Rib fractures are associated with concomitant thoracic, head, extimity, abdominal and blunt cardiac injury[2-5] Patients are at increased risk of multiple complications and have poor prognosis. Multiple rib fractures cause severe pain which may be more debilitating and harmful than the injury itself.[1] Multiple rib fractures contribute significantly to the morbidity and mortality of the injured patients with the elderly [1] and patients with poor respiratory reserves being most vulnerable.

Pain limits one's ability to cough and breathe deeply resulting in sputum retention, atlectesis and a reduction in functional residual capacity. Which in turn results in decrease lung compliance, ventilation perfusion mismatched, hypoxemia and respiratory distress.

Although, many studies have characterized the inflammatory mediators associated with traumatic injury[8-10] little is known about the effects of the route of analgesia administration on pain relief, pulmonary function, and systemic inflammatory mediators in patients with significant thoracic injury. Randomized controlled studies of patients undergoing elective thoracotomy have proven that epidural anaesthesia and postoperative continuous epidural analgesia decreases the stress response associated with surgical trauma compared with parental analgesia.[8]

The purpose of this study was to investigate the effect of analgesia delivery after severe chest injury on pain relief, pulmonary function average length of stay in hospital, ICU and on ventilator.

Bulgur et all showed a difference in mortality of 10% Vs 22% in young (18-64 years) Vs old (>65

years) patients with rib fractures There were also differences in ventilator days (3.1 Vs 4.3 days). Intensive care units days (4 Vs 6.1 days) and hospital length of stay (10.7 Vs 15.4 days) among young vs old patients.

Patients with multiple fractures have chances of multiple complications. Out of these complications thoracic complications of rib fractures are common which includes pneumonia, pulmonary fusion, aspiration, ARDS, pulmonary embodism and atelactasis or lobar collapse[2,5]

National trauma data bank (NTDB) from 1994 - 2003 identified a mortality rate of 10% and a complication rate of 13%, of which 48% were pulmonary complications.[3]

If 2 or more connected ribs are fractured in more than one place, flail chest occurs. In flail chest, part of the chest wall is able to move independently because of negative intrapleural pressure generated on inspiration, which causes the isolated segment of the chest wall to collapse inwards compromising ventilation.

Analgesia is the primary intervention in these patients.[12,13] Multiple analgesic modalities are used in patients with rib fractures such as systemic opioid,[13-15], intra plural blocks (8D) inter-costal,[13,16,17] para-vertebral blocks[13,18] and epidural analgesia.[19-22] The ideal method of pain management in rib fracture provides complete and prolonged analgesia, while promoting deep breathing, clearance of secretions and co-operation during chest physiotherapy.[13]

Systemic opioids are commonly used and are often the first line for relieving pain resulting from multiple rib fractures. they are used as intermittent on-demand injections,[23] continuous intravenous infusion,[12] or intravenous patient controlled analgesia (IVPCA).[13,14] mackersie et al.[12] demonstrated that fentanyl administered as a continuous intravenous infusion improves visual analog scores and vital capacity but also results in respiratory depression and hypoxemia. Opioids also cause sedation, respiratory depression and cough suppression. Various researchers have also found systemic opioids to be inadequate in controlling pain caused by multiple rib fractures, necessitating a regional analgesic technique for optimal pain control. considering this variable efficacy and potential for side effects associated with the use of opioids in patients with multiple rib fractures, it may be preferable to resort to a regional analgesic technique from the very outset , whenever feasible.

Epidural analgesia is particularly effective method of pain control as it provides an excellent level of pain relief with minimum sedation. It has also been shown to improve pulmonary function and reduce morbidity associated with multiple rib fractures. It involves the administration of local anaesthetics, opioids or both, via an epidural catheter.PCA is a useful alternative to epidural analgesia and allows parental administration of opiod analgesia. It is potentially safe and has significant benefits over conventional methods like intra-muscular injections. It allows the titration of doses to reduce the potential risk of respiratory depression. It allows the patient to control the amount of analgesia required at any one time for example before respiratory physiotherapy.

Intercostal nerve block is another method of providing pain relief but its drawback is in repetition of procedure every twelve hours. In a study carried out by Wisner, epidural, intra venous and intra costal blocks were compared as a method of relieving analgesia after thoracic trauma. The epidural route was found to be the most effective method to reduce pulmonary complications and reduced mortality was also found within the patient sample. Similar results were also reported by Mackersic et al.

A multi modal approach is the most effective way of controlling pain.

Material and Methods

This study was conducted with the approval of the institutional ethical committee and informed written consent. Study was carried out from February 2017 till January 2018 in a private super-specialty hospital. All patients in age group

of 18-67 years were included who has 3 or more than three rib fractures uni or bilateral.

Exclusion criteria included contraindication to epidural catheter placement, morbid obesity ,evidence of spinal cord injury above T10, Glasgow coma score <15, adrenal insufficiency, use of steroid within 6 months before injury, allergy to local anaesthetics or opioids. All study subjects were enrolled within 24 hours of admission after informed consent, and were randomized to receive opioid delivered by a self administered patient controlled analgesia (PCA) or thoracic epidural catheter.

Patients demographic profile, hospital – LOS, ICU-LOS and Ventilatory days were recorded, pain score on 10 point verbal scale was recorded. Respiratory parameters and complications were recorded.

All patients in PCA group were assessed by pain physicians. Patients randomized to PCA group received a loading dose of intravenous morphine 0.1mg/kg before establishment of PCA. The infusion rate was titrated by a member of pain management team to maximize pain relief before handling over the control of the system to the patient. PCA regime used morphine (1mg/ml) in bolus of two mg with a lock out duration of 10 minutes. There was no background infusion. Additional doses were given if required by a member of pain team.

Thoracic epidural catheter was placed by a pain physician who is also an anaesthesiologist (tuohycatheter, B.brown) in the epidural space between T5 and T7. A 3ml test dose of lidocane 1% with epinephrine 1:200000 was then administered through the epidural catheter to exclude sub arachnoids or intra venous location of the catheter. Sensory testing of appropriate dermatomes was performed after 15 minutes after administering this dose to confirm epidural placement of the catheter. After a successful test dose, the catheter was further dosed with an injection of fentanyl 50mcg. Within one hour of the placement of catheter a continuous infusion of 20-25mcg fentanyl in bupivacaine 0.125% was initiated using an infusion pump. Pain physician adjusted the dose to optimize pain relief and minimize side effects.

Results

Thirty patients were included in the study and were randomly divide in two groups. The groups did not differ demographically or in initial pain score.(Table 1)

Table 1

Age distribution		
AGE	GR A	GR B
18-28	5	4
28-38	6	7
38-48	2	3
48-58	1	1
58-65	1	0

Initial physiological parameters were as per the table 2,3,4 and 5.

Table 2

OXYGEN SATURATION		
SAO2	GR A	GR B
<80	1	1
80-85	1	1
86-90	3	2
91-95	9	8
96-100	1	3

Table 3

RESPIRATORT RATE		
RR	GR A	GR B
13-16	0	1
17-20	3	2
21-24	4	3
25-28	2	2
29-32	4	5
>32	2	2

Table 4

HR		
HR	GRA	GRB
41-60	1	2
61-80	1	2
81-100	4	2
101-120	5	4
121-140	2	4
>140	2	1

Table 5

MAP		
MAP	GR A	GR B
50-60	2	1
61-70	2	2
71-80	5	6
81-90	2	3
91-100	2	1
101-110	1	1
111-120	1	1

The tidal volume measurement showed an increase in tidal volume in thoracic epidural group as compared to PCA group. Although, the tidal volume for the PCA group on day 1 was increased more rapidly than the thoracic epidural group (0.376 – 0.424 vs 0.383- 0.376 ml), the difference did not reach significance. However, throughout the study period tidal volume for the thoracic epidural group continuously increased to reach a significance from 0.383 on day 1 to 0.424, 0.440, 0.475 ml over the next 3 days as compared to PCA group from 0.376ml base line to 0.424, 0.430, 0.412 ml over the next 3 days. Tidal volume was significantly greater in thoracic epidural group than in the PCA group (0.475ml vs 0.410 ml) p<0.001. (Table 6)

Table 6

Tidal volume before and after ana analgesia				
	initial		after anal on day 3	
sr no	t epi	pca	t epi	pca
1	0.4	0.35	0.52	0.48
2	0.38	0.35	0.55	0.46
3	0.41	0.35	0.54	0.45
4	0.39	0.37	0.56	0.43
5	0.4	0.39	0.46	0.5
6	0.42	0.38	0.49	0.45
7	0.41	0.4	0.5	0.46
8	0.39	0.41	0.52	0.47
9	0.38	0.37	0.54	0.52
10	0.36	0.39	0.54	0.44
11	0.35	0.41	0.56	0.45
12	0.38	0.42	0.53	0.43
13	0.35	0.36	0.52	0.45
14	0.32	0.32	0.52	0.46
15	0.41	0.37	0.54	0.44

During the first 24 hrs of study, the epidural group had a significant reduction in pain score P<0.001 on coughing as compared to intravenous opioid group. (7.4± 1.88 to 2.2 ± 0.944) with 95% CI 6.45 – 8.35 vs 1.72 – 2.67. while in PCA pain score became 7.2± 2.07 to 4.26 ± 0.88 with 95% CI 6.15 - 8.25 to 3.81 – 4.71. when pain score was compared between thoracic epidural group and PCA , it was 2.2 ± 0.94 vs 4.26 ± 0.88 with 95% CI 1.72-2.61 vs 3.81-4.71 with t= 6.2, df 28, p <0.001, which was highly significant. (Table 7)

Table 7

pain score before and after analgesia				
	thoracic epi	PCA	thoracic epi	PCA
1	10	3	3	4
2	9	5	3	5
3	8	9	2	6
4	5	9	1	4
5	6	7	2	5
6	9	8	1	4
7	8	6	2	3
8	4	5	1	5
9	7	9	2	4
10	9	10	4	3
11	10	5	3	3
12	6	8	2	4
13	5	9	1	2
14	8	6	1	3
15	7	9	1	4

pain score before analgesia	PAIN SCORE AFTER ANALGESIA	PAIN SCORE ON COUGH
8/.98	2.1/0.75	3.09/0.89
7.8/1.2	3.28/1.00	4.92/0.97

In thoracic epidural group patients los in ICU was less as compared to PCA group (12± 2 vs 14.73± 2.3) with t= 3.31, df 28 p<0.01.[29-32].

Similarly there was shorter stay in hospital in cases of thoracic epidural group as compared to PCA group (18.33± 3.69 vs 4.2± 2.51) with t=4.91 df 28 p<0.001.

Table 8

MEAN ICU & WARD STAY		
	WARD	ICU
GRA	5.8/1.99	1.56/0.92
GRB	7.68/3.73	1.93/1.36

Duration of analgesia required in either of the routes were same and no significant difference was found (8± 1.08 vs 8.2± 0.77) t=0.56 df 28 p>0.05. Table 9

Table 9

days of analgesia		
sr no	t-epi	opioid
1	5	8
2	5	9
3	6	8
4	5	7
5	4	8
6	5	9
7	3	8
8	5	9
9	6	8
10	5	9
11	7	8
12	5	7
13	4	7
14	4	9
15	3	9
mean	8	8.2
SD	1.082326	0.774597

Less umber of patient in thoracic epidural group needed ventilator support (6.66%) as compared to PCA group (20%) which was significantly lower. Moreover the ventilated days were also lesser in thoracic epidural group. [29-31]Patient in PCA group experienced more incidence of pneumonia (6.66% vs 13.3%) 1,5,8x. atelactasis (13.3% vs 25%) sepsis (6.66% vs 13.3%) and death (13.3% vs 25%). Table 10

mortality and morbidity		
	t-epi n=15	opioid n=15
pneumonia	1(6.66%)	2(13.33%)
atelactasis	2(13.33%)	4(26.44%)
sepsis	1(6.66%)	2(13.33%)
hypotension	2(13.33%)	0(0.00%)
intubation	1(6.66%)	3(20%)
death	1(6.66%)	3(20%)

However as against thoracic epidural group no patient experienced hypotension in PCA group. 13.33% patients had hypotension in the thoracic epidural group. Table 11

Table 11

mortality by no of rib fractured		
no of ribs fractured	t-epi	opioid
1--3	0	0
4--6	0	1(6.66%)
7--12	1(6.66%)	2(13.33%)

Epidural catheter group had catheter in place for an average of 6.92 ± 0.91 days. None of the patients had catheter side inflammation or infection, epidural hematoma or abscess.

Discussion

Thoracic trauma continues to be associated with significant morbidity and mortality as many as 25% trauma related deaths being attributable to thoracic region[33]. Rib fractures have been associated with increased morbidity and mortality in trauma patients.[34] Pain resulting from Rib fracture may contribute to voluntary splinting and muscle spasm therey impairing ventilator functions, causing atilectesis and other pulmonary complications. 7.11x. Deterioration of pulmonary function can lead to hypoxemia, increase in shunt fraction, pneumonia and eventually respiratory failure and mechanical ventilation.[35]

It is well stabilized that thoracic epidural specially with local anaesthetic agents is superior to PCA in providing post-thoracostomy pain relief.[36,37]. Patients receiving epidural anaesthetic in addition to significantly improved pain management were noted to have smaller decline in FVC, FEV1, and peak expiratory flow rate.[35]

Current study shows that patients receiving epidural anaesthetic had significantly greater tidal volume after 24 hours and spent less time on mechanical ventilation. Our study confirms results from other studies in which patients who received epidural anaesthetic had significantly less pain than those who received intravenous opioids[38-40].

Moon et al in there prospective study demonstrated superior analgesia and pulmonary function as well reduced level of circulating inflammatory mediators associated with lung injury in patients treated with thoracic epidural group vs PCA.

In another study Wu et al also reported lower pain scores in patients treated with epidural vs iv opioids.[41]

Winsor, in his retrospective study on 307 patients >60 years of age, found that epidural anaesthetic was an independent predictor of reduced mortality and less incidents of pulmonary complications.[42]

Respiratory functions improve significantly in our study in the form of tidal volume in thoracic epidural group as compared to intravenous opioids. On day three of epidural analgesia group patients had significant increase in their tidal volume ($p<0.001$).

Epidural therapy with local anaesthetic seems superior when compared with opioids alone.[47] In addition thoracic epidural group utilizing a combination of local anaesthetic plus opioid may have advantage over local anaesthetic or opioid when used alone.[48-50]

Pneumonia after rib fracture was seen less frequently in thoracic epidural group as it allowed improved lung mechanism.[52,53]

We also found similar results in our study. Epidural anaesthetic is now not without complications, morbidity associated with epidural anaesthetic includes accidental dural puncture with associated headache (1%), neurologic injury (<0.1%), epidural hymatoma 1 in 150000, epidural abscess, sympathetic block resulting in hypotension, accidental intra thecal injection (total spinal) and intravenous injection leading to local anaesthetic toxicity. [37,43]

Although these complications occur rarely, they must be calculated in the overall risk-benefit assessment of epidural anaesthetic in the setting of rib fracture.

Flagel et al 7d retrospectively reviewed rib fracture in 6475 patients and showed an increase in mortality rate with each additional rib fracture independent of patient's age. At our center we also found increased mortality rates with increased number of fractured ribs.

Despite small sample size still it can be postulated that thoracic epidural group had superior outcomes in the key clinical parameters i.e. pain relief, duration of mechanical ventilation, pulmonary complications, improvement in tidal volume and LOS- ICU and hospital.

Conclusion

This study demonstrated that despite more rib fracture, greater injury severity and physiologic acquity among patients receiving epidural analgesia, the use of this therapy may result in shorter duration of mechanical ventilation, greater increase in tidal volume as well as a lower incidence of pneumonia and non-pulmonary complications. Large well designed multi-institutional prospective randomized trials are needed to further delineate the benefits of epidural anaesthetic vs iv analgesics in patients treated for rib fracture.

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