

Comparing the Effectiveness of Bupivacaine Administration through Chest Tube and Intercostal Blockage in Patients with Rib Fractures

Abstract:

Background: There are several methods to control pain, especially in traumatic patients with rib fractures. Intrapleural analgesia (IPA) and intercostal block methods are recommended in patients with rib fractures to control pain. Here, we aimed to evaluate and compare the effects of IPA and intercostal block on patients' clinical conditions. **Materials and Methods:** This is a randomized clinical trial that was performed in 2020–2021 on thirty traumatic patients with rib fractures. We collected the results of arterial blood gas in all patients before interventions including HCO₃, pH, pO₂, and pCO₂ and also evaluated pain of patients. The first group underwent intercostal blockade with standard method with bupivacaine, and for the second group of patients, a chest tube was implanted. Patients were monitored for up to 12 h for pain intensity and need for analgesics. **Results:** The mean levels of HCO₃ decreased in both groups after the interventions, and this decrease was more significant in patients in the intercostal blockade group ($P < 0.05$). The mean levels of pO₂ increased in both groups after interventions, especially in patients in the intercostal blockade group ($P < 0.05$). The mean pCO₂ levels also decreased in both groups ($P < 0.05$). The mean pain intensity in both groups decreased significantly after the intervention ($P < 0.05$) and also the mean pain intensity in the intercostal blocking group decreased significantly more than the group treated with chest tube ($P < 0.05$). **Conclusion:** Intercostal blockade through bupivacaine is more effective than chest tube administration of bupivacaine in patients with rib fractures.

Keywords: Bupivacaine, pain, rib fractures, wounds and injuries

Introduction

Traumatic events can be defined as experiences that put either a person or someone close to them at risk of serious harm or death. Trauma is the leading cause of death, hospitalization, and disability in all age groups.^[1,2] Accidents are the most common cause of chest trauma. Based on epidemiologic data, 80% of deaths in people aged 15–24 years occur due to accidents, more than half of which are due to motor vehicles.^[3] Acceptance of accidents as a preventable problem leads to the development of prevention policies and strategies and ultimately reduces the number of deaths due to it.^[4] With simple interventions by physicians and emergency personnel, 85% of dangerous chest injuries can be overcome, so accurate and timely recognition of chest injuries is extremely important.^[5-7] Trauma is a major mental health problem in most developing societies, and trauma causes

more deaths in people under 30 than in other diseases.^[8]

Chest trauma alone accounts for 25% of deaths due to trauma. Most deaths from chest trauma occur after reaching the emergency room. Despite these facts, <15% of chest injuries require emergency surgery.^[9,10] In other injuries, only supportive measures and initial treatment seem to be sufficient. Today, approximately 6,000 out of 100,000 cases of disability per year are due to chest trauma, and the key to diagnosing chest injuries is having a strong mindset about the possibility of chest trauma in injured patients, based on a specific history of the patient.^[11] The severity and type of trauma-causing mechanism can be determined and a large percentage of injuries can be detected by simple paraclinical methods, especially plain chest radiography.^[12]

A chest tube is a hollow, flexible tube placed into the chest. It acts as a drain. Chest tubes drain blood, fluid, or air from

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Mohammad Nasr-Esfahani, Mohsen Kolahdouzan¹, Pezhman Pourazari¹, Emad Yazdani

Departments of Emergency Medicine and ¹Surgery, School of Medicine, Isfahan University of Medical Sciences, Isfahan, Iran

Address for correspondence:

*Dr. Emad Yazdani,
Department of Emergency Medicine, School of Medicine, Isfahan University of Medical Sciences, Isfahan, Iran.
E-mail: yazdani.emad@gmail.com*

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around lungs, heart, or esophagus. The tube around lung is placed between ribs and into the pleural space.^[13] Pain is a preventable complication of trauma but is usually not sufficient to treat it. Pain can indirectly lead to an increase in morbidity and mortality, as well as an increase in costs and a decrease in quality of life. Pain relief is considered a challenge in trauma that requires analgesic techniques with minimal side effects and the highest level of safety for the patient.^[14]

There are several methods to control pain, especially in traumatic patients with rib fractures, some of which include intravenous analgesia, subcutaneous analgesia, chest tube analgesia, and intercostal blockade. The technique of intrapleural analgesia (IPA) has been studied and reported in several publications in the past decade.^[15] IPA has been successfully used for pain relief after cholecystectomy, renal surgery, breast surgery, and thoracotomy. Little has been reported about side effects and complications. Insertion of analgesics through chest tube is accounted as an effective and beneficial method, especially in traumatic patients.^[16]

The intercostal block method is usually recommended in patients with rib fractures to control pain. Using pain management techniques such as intravenous injections of drugs such as fentanyl in patients with rib fractures can reduce the need for intercostal block.^[17] Pain control in these patients is usually not necessary, but pain control in these patients prevents secondary complications such as atelectasis and pneumonia in patients with rib fractures. Intercostal nerve blocks are simple to perform and useful for pain management either as the primary intervention or as adjuncts. They are useful for pain in the chest wall and upper abdomen.^[18]

To date, very few studies have compared the efficacy of IPA and intercostal block in pain relief in traumatic patients, and to the best of our knowledge, few studies have evaluated their effects on blood gas and further analgesic requirements.^[18] As a result, regarding the importance of trauma and traumatic events and also considering the value of pain relief in traumatic patients, we aimed to evaluate and compare the effects of IPA and intercostal block on improvement of arterial blood gas (ABG) indices, pain, and need for intravenous analgesia in trauma patients with rib fractures.

Materials and Methods

This is a randomized clinical trial that was performed in 2020–2021 in Kashani and Al-Zahra Hospitals affiliated to Isfahan University of Medical Sciences. The current study was conducted on all traumatic patients with rib fractures referred to our medical centers. The study protocol was approved by the Research Committee of Isfahan University of Medical Sciences, and the Ethics Committee has confirmed it (Ethics code: IR.MUI.MED.

REC.1398.585, Iranian Registry of Clinical Trials [IRCT] code: IRCT20120716010297N6).

The inclusion criteria were admission in our medical centers due to trauma, presence of rib fractures in chest radiography, undergoing chest tube insertion, disturbed ABG parameters, and signing the written informed consent to participate in this study. The exclusion criteria were intubation of the patient, allergies to bupivacaine, unstable vital signs and medical condition, addiction, and blood pressure lower than 90/60 mmHg or higher than 180/110 mmHg.

A total number of thirty patients with rib fractures due to trauma entered the study based on inclusion and exclusion criteria. All patients were randomized into two main groups using random allocation software. Demographic data of all patients including age, sex, and previous medical history were collected. Heart rate and American Society of Anesthesiologists classifications were noted for all patients. We also collected the results of ABG in all patients before interventions including HCO₃, pH, pO₂, and pCO₂. We also evaluated pain of patients using the Visual Analog Scale (VAS) scoring the pain from 0 (least pain) to 10 (worst pain). Measurements were performed before interventions, immediately after interventions, and 12 h after interventions. Pain measurement was conducted before and 60 min after the interventions.

The first group underwent chest tube insertion associated with intercostal blockade with standard method using bupivacaine 0.5% at the rate of 0.1 ml/kg/min weight. The chest tubes were inserted due to pneumothorax. For the second group of patients, a chest tube was implanted and 0.5% bupivacaine was injected into the pleural space through the chest tube at a rate of 20 ml/min. The amount of drug was injected for all patients as a single dose (20 ml from the 0.5% bupivacaine). Patients were monitored for up to 12 h for pain intensity and need for analgesics.

Furthermore, patients who had VAS more than 3 after the intervention were asked for intravenous analgesia (fentanyl), and the dose of the drug was recorded in the checklist for each patient.

The data of this study were entered into SPSS Statistical Software version 24 to show quantitative data of mean and standard deviation and qualitative data of frequency or percentage. Independent *t*-test and Chi-square test were used to compare quantitative data between the two groups and qualitative data. Repeated measures ANOVA test was used to evaluate changes in quantitative data at different times. *P* < 0.05 was considered as a significant level.

Results

A total of thirty patients with trauma and rib fractures were included in the study. Patients participating in the present study were divided into two groups of intercostal

blockade and chest tube with 15 patients in each group for interventions. The mean age of patients participating in the present study was 41.57 ± 12.6 . Furthermore, according to the results of Table 1, 73% of the participants were men and 27% of the participants were women [Table 1].

Table 2 also compares the frequency distribution of demographic variables in patients participating in the study. Based on the results of Table 2, no significant differences were observed between the mean age of patients in the two groups ($P > 0.05$) and also no significant differences in the distribution of gender frequency in the two groups ($P > 0.05$).

Table 3 compares the findings of ABG (HCO_3 , pCO_2 , pO_2 , and pH) in patients before the intervention and 12 h after the intervention in the two groups. Based on the results obtained in Table 3, mean levels of HCO_3 decreased in both groups after the interventions, and this decrease was more significant in patients in the intercostal blockade group ($P < 0.05$). However, no significant difference was observed between the mean pH in the two groups ($P > 0.05$), but the mean levels of pO_2 increased in both groups after interventions, especially in patients in the intercostal blockade group ($P < 0.05$). The mean pCO_2 levels also decreased in both groups ($P < 0.05$), but there were no significant differences between the two groups ($P > 0.05$). These data are summarized in Table 3.

Table 4 shows the determination and comparison of mean pain intensity in the two study groups before and after the intervention. As the results of the study show, the mean pain intensity in both groups decreased significantly after the intervention ($P < 0.05$) and also the mean pain intensity in the intercostal blocking group decreased significantly more than the group treated with chest tube ($P < 0.05$).

Table 1: Demographic characteristics of patients participating in the present study

Variable	Mean±SD
Age	41.57±12.6
Gender, n (%)	
Female	8 (29.6)
Male	22 (73.4)

SD: Standard deviation

Table 2: Mean age and frequency distribution of gender in the studied groups

Variable	Intercostal blockade	Chest tube	P
Age*	10.89±43.65	9.36±40.7	0.26
Gender, n (%)**			
Female	3 (20)	5 (33.3)	0.55
Male	12 (80)	10 (66.7)	

*Mann-Whitney test was used to compare the mean age of the two groups, **Chi-square test was used to compare the frequency distribution of gender in the two groups. Values of $P < 0.05$ indicate the significance of the test

Table 5 indicates the determination and comparison of the mean dose of injected opioid in the two study groups before and after the intervention. The results of Table 5 show that the mean dose of administered opioid after the intervention was significantly reduced in the intercostal blockade group ($P < 0.05$).

Discussion

In the present study, we evaluated thirty patients with trauma and rib fractures and administered bupivacaine 0.5% through chest tube or intercostal blockade technique. Our data indicated that the mean levels of HCO_3 and pCO_2 decreased in both groups after the interventions and the HCO_3 decrease was more significant in patients in the intercostal blockade group. Furthermore, we observed increased mean levels of pO_2 in both groups after interventions, especially in patients in the intercostal blockade group. Evaluation of pain in patients showed that the mean pain intensity in both groups decreased significantly after the interventions and also the mean pain intensity in the intercostal blocking group decreased significantly more than the group treated with chest tube and the mean dose of administered opioid after the intervention was significantly reduced in the intercostal blockade group.

These data show the efficacy and beneficial effects of both methods in patients with rib fractures. Based on our results, administration of bupivacaine 0.5% was associated with significant improvements in blood gas indices and also pain reduction in all patients. It was also shown that using intercostal blockade technique led to better clinical and laboratory results compared to the chest tube administration of bupivacaine. The blood gas indexes improved more in patients treated with intercostal blockade, and they received lower amounts of opioids. Various studies have evaluated the efficacy of pain reduction in clinical and laboratory outcomes of traumatic patients. There have been several administration methods in these studies including intercostal blockade, chest tube administration, and also epidural analgesia.

A recent study was conducted by Sheets *et al.* in 2020 in the United States on 116 patients with rib fractures. They investigated the effects of intercostal nerve block with bupivacaine versus epidural analgesia. It was indicated that patients receiving intercostal nerve blocks with bupivacaine were less likely to require intubation and had shorter hospital length of stay and intensive care unit (ICU) length of stay. Evaluations of pain and blood gas indexes also showed significant improvements in patients receiving intercostal blockade.^[19] Agamohammi *et al.* also investigated the beneficial effects of bupivacaine administration for pain control in patients with multiple rib fractures. It was indicated that injection of bupivacaine through epidural method or intercostal technique is associated with ABG improvements and significant pain

Table 3: Determination and comparison of arterial blood gas findings (HCO₃, pCO₂, pO₂, and pH) in patients before the intervention and 12 h after the interventions in the two groups

Variable	Measuring times	Intercostal blockade	Chest tube	P*	P**
HCO ₃	Before interventions	25.6±5.6	25.1±2.3	0.001	0.02
	1 h after interventions	23.3±7.4	24.7±4.2		
	12 h after interventions	23.11±6.9	24.8±7.3		
pH	Before interventions	7.4±0.33	7.44±0.13	0.85	0.69
	1 h after interventions	7.34±0.53	7.33±0.21		
	12 h after interventions	7.43±0.41	7.39±0.37		
pO ₂	Before interventions	28.54±12.6	28.12±5.9	0.001	0.001
	1 h after interventions	32.1±13.5	29.59±9.7		
	12 h after interventions	35.56±15.5	32.39±10.7		
pCO ₂	Before interventions	58.56±16.6	57.31±18.9	0.001	0.35
	1 h after interventions	46.59±15.7	50.14±14.71		
	12 h after interventions	38.22±18.1	43.7±17.64		

*Intragroup comparison, **Intergroup comparison. Values of $P < 0.05$ indicate the significance of the test. Repeated analysis of variance was used to compare the means of variables at different times

Table 4: Mean pain intensity in the two study groups before and after the intervention

Group	Pain intensity		P*
	Before interventions	After interventions	
Intercostal blocking	9.5±1.2	1.68±0.02	0.001
Chest tube	9.63±1.3	6.29±2.9	0.03
P**	0.98	0.001	-

*Wilcoxon test was used to compare the mean pain intensity before and after the intervention, **Mann–Whitney test was used to compare the mean pain intensity in the two groups. Values of $P < 0.05$ indicate the significance of the test

Table 5: Mean opioid dose in the two study groups before and after the interventions

Group	Opioid dose		P*
	Before interventions	After interventions	
Intercostal blocking	4.6±1.06	1.65±0.48	0.001
Chest tube	5.93±1.32	4.2±1.1	0.8
P**	0.4	0.001	-

*Wilcoxon test was used to compare the mean dose of administered opioids before and after the intervention, **Mann–Whitney test was used to compare the mean dose of administered drugs between the two groups. Values of $P < 0.05$ indicate the significance of the test

reductions. Patients that receive intercostal blockade have also lower opioid requirements.^[20] Our data are also in line with these findings, emphasizing the beneficial effects of intercostal blockade on ABG improvements and pain reduction.

Hashemzadeh *et al.* also compared sixty adults with rib fractures and compared the pain reduction and ABG results between patients receiving epidural bupivacaine and patients treated with intercostal blockade. They showed significant improvements in all patients regarding

pain intensity and ABG indexes and also declared more improvements in intercostal blockade technique.^[21] The same results were reported by Hofer *et al.* in 2015.^[22] Our results supported the previous findings showing that patients that receive intercostal blockade through bupivacaine have lower pain intensity and significant improvements in ABG indexes.

A study was performed by Demmy *et al.* in 2009 evaluating the effects of bupivacaine administration through chest tube. It was declared that this method is effective and associated with significant improvements in pain reduction and also improvements in ABG indexes.^[23] Recently, Caso *et al.* also showed that bupivacaine administration through chest tube could alter the clinical condition of patients, but it was also stated that further investigations on improving novel results are required.^[24] Our results are also in line with these findings, but very few studies have compared the two intercostal blockade and chest tube administration of bupivacaine.

Another study by May *et al.* showed that pain reduction techniques are pivotal in ameliorating patients' clinical conditions, especially in patients with rib fractures. As mentioned, such patients face difficulties in respiration mostly due to pain that, in turn, leads to disturbed ABG indexes. As a result, administration of bupivacaine has significant importance.^[25] Our results are also consistent with these findings. An important point of our study was that we compared intercostal blockade and chest tube administration of bupivacaine in individuals and showed significantly better results for intercostal blockade. To the best of our knowledge, this is the first randomized clinical trial that compares these two techniques in English literature.

The limitations of our study include restricted study population and also not evaluating further patients' outcomes including hospitalization duration or length

of stay in ICU. We believe that further studies on larger populations are required.

Conclusion

Taken together, we showed that intercostal blockade through bupivacaine is more effective than chest tube administration of bupivacaine in patients with rib fractures. These two methods reduced the pain of patients, their need for opioid injections, and their ABG indexes, but the improvements were more significant in patients undergoing intercostal blockade. These findings were in line with most previous studies, but further evaluations on larger populations seem critical.

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Conflicts of interest

There are no conflicts of interest.

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