Effect of Analgesia on the Changes in Respiratory Parameters in Blunt Chest Injury with Multiple Rib Fractures

Eyo Effiong Ekpe, Catherine Eyo

Department of Surgery, Cardiothoracic Surgery Unit, University of Uyo Teaching Hospital, †Department of Anaesthesia, University of Uyo Teaching Hospital, Uyo, Akwa Ibom State, Nigeria

Abstract

Background: Blunt chest injury with multiple rib fractures can result in such complications as pneumonia, atelectasis, bronchiectasis, empyema thoracis, acute respiratory distress syndrome, and prolonged Intensive Care Unit and hospital stay, with its concomitant mortality. These may be prevented or reduced by good analgesic therapy which is the subject of this study. Methods: This was a prospective study of effects of analgesia on changes in pulmonary functions of patients with traumatic multiple rib fractures resulting from blunt chest injury. Results: There were 64 adult patients who were studied with multiple rib fractures caused by blunt chest trauma. Of these patients, 54 (84.4%) were male and 10 (15.6%) were female. Motorcycle (popularly known as “okada”) and tricycle (popularly known as keke napep) accidents significantly accounted for the majority of the multiple rib fractures, that is, in 50 (78.1%) of the patients. Before analgesic administration, no patient had a normal respiratory rate, but at 1 h following the administration of analgesics, 21 (32.8%) of patients recorded normal respiratory rates and there was a significant reduction in the number (10.9% vs. 39.1%) of patients with respiratory rates >30 breaths/min. Before commencement of analgesia, no patient recorded up to 99% of oxygen saturation (SpO2) as measured by pulse oximeter, while 43.8% recorded SpO2 of 96%. This improved after 1 h of administration of analgesics to SpO2 of 100% in 18.8% of patients and 99% in 31.3% of patients and none recording SpO2 of < 97% (P = 0.006). Before analgesia, no patient was able to achieve peak expiratory flow rate (PEFR) value >100% of predicted while only 9 (14.1%) patients were able to achieve a PEFR value in the range of 91%–100% of predicted value. One hour after analgesia, a total of 6 (9.4%) patients were able to achieve PEFR values >100% predicted, while 35 (54.7%) patients achieved PEFR values in the range of 91%–100% predicted. Conclusion: Adequate analgesia is capable of reversing the negative effects of chest pain of traumatic multiple rib fractures on pulmonary function parameters through improvement in respiratory mechanics.

Keywords: Analgesia, blunt chest injury, respiratory parameters

Résumé

Contexte: La blessure de poitrine émoussée avec des fractures de côté multiples peut aboutir à de telles complications que la pneumonie, atelectasis, bronchiectasis, empyema thoracis, le syndrome de détresse respiratoire aigu et le Service de soins intensifs prolongé et le séjour à l’hôpital, avec sa mortalité concomitante. Ceux-ci peuvent être empêchés ou réduits par la bonne thérapie analgésique qui est l’objet de cette étude. Méthodes: C’était une étude de prospective des effets d’analgésie sur des changements des fonctions pulmonaires de patients avec des fractures de côté multiples traumatisantes résultant de la blessure de poitrine émoussée. Résultats: Il y avait 64 patients adultes qui ont été étudiés avec des fractures de côté multiples causées par le trauma de poitrine émoussé. De ces patients, 54 (84.4 %) étaient masculins et 10 (15.6 %) étaient féminins. Moto (populairement connu comme “okada”) et tricycle (populairement connu comme keke napep) accidents signifiants? Cantly a représenté la majorité des fractures de côté multiples, en somme, dans 50 (78.1 %) des patients. Avant l’administration analgésique, aucun patient n’avait un taux (tarif) respiratoire normal, mais à 1 h après l’administration d’analgésique, 21 (32.8 %) de patients a enregistré des taux (tarifs) respiratoires normaux et il y avait un signi? Réduction de pente(jargon) du nombre (numéro) (10.9 % contre 39.1 %) de patients avec taux (tarifs) respiratoires > 30 souffles/minute. Avant le...
Introduction

Blunt chest injury associated with multiple rib fractures is common.[1] This is associated with chest pain which can be difficult to manage and can lead to decreased pulmonary function, increased hospital stay, and increased health-care expenditures,[2] impairment of pulmonary mechanics, retention of trachea-bronchial secretions, atelectasis, and respiratory failure.[3,4] Good analgesia may help improve the patient’s respiratory mechanics, avoid intubation of the trachea for ventilatory support, and may therefore dramatically alter the course of recovery.[1]

Analgesia could be provided using systemic opioids, transcutaneous electrical nerve stimulation, or nonsteroidal anti-inflammatory drugs. Alternatively, regional analgesic techniques such as intercostal nerve block (ICNB), epidural analgesia, intrathecal opioids, intrapleural analgesia, and thoracic paravertebral block have been used effectively. Although invasive, in general, regional blocks tend to be more effective than systemic opioids and produce less systemic side effects.[4] Several other modalities such as administration of analgesics, rib belts, and subpleural block with 0.5% bupivacaine have been reported.[3] Immediate pain relief after ICNB and improvement in pulmonary mechanics have been demonstrated in several reports.[3] Surgical stabilization of rib fractures in the form of open reduction and internal fixation is an alternative treatment for pain management of multiple rib fractures.[3]

This study is aimed at prospectively evaluating the effects of systemic and regional analgesia in improvement of pulmonary function.

Methods

Ethical approval to embark on this study was sought and obtained from the Hospital Research Ethical Committee, and informed consent was duly obtained from the patients. The study was prospective and conducted from November 2013 to October 2014.

On presentation, the successive patients were clinically evaluated and resuscitated. At this point, patients with clinically discovered exclusion criteria were excluded from the study while those without were further evaluated with urgent chest radiogram for radiological identification of rib fracture(s) and calculation of abbreviated thoracic trauma severity score for each recruited patient.

Successive patients who met the inclusion criteria were randomized into the study. These were all adult blunt chest trauma patients with unilateral multiple rib fractures, all adult blunt chest trauma patients with unilateral multiple rib fractures with no associated major intrathoracic or extrathoracic injuries such as head injury, abdominal injury, or skeletal injury; however, those excluded were patients under 16 years of age, refusal to give consent, history of sensitivity to either bupivacaine or tramadol, or contraindication to adrenaline, associated major injury needing surgical operation or affecting consciousness level, preexisting pulmonary disease, and bilateral rib fractures. Other exclusion criteria included pleural injury, lung contusion and bilateral rib fractures, patients who had hemotherax or patients with greater than minor (15%) traumatic pneumothorax which on its own can adversely affect pulmonary function, patients with only one rib fracture, and patients with segmental rib fractures (flail chest). Baseline respiratory rate (with normal taken as 12–20 breaths/min), peripheral arterial oxygen saturation (SpO2) (finger pulse oximetry), and lung function test were taken and recorded in the respective patient’s pro forma. Then, the patients were admitted for observation and treated for their chest pain using 0.5% bupivacaine injection (premixed with 1:2,000,000 adrenaline injection) as 2 ml per fractured rib and one rib above and below for intercostal nerve block in 30 patients and 8-h intramuscular injection of 100 mg injection of tramadol in 34 patients over a 24-h assessment period.

All the patients were reassessed at 1 h and 24 h after commencement of analgesic and their respiratory rate, peripheral arterial oxygen saturation (SpO2) (finger pulse oximetry), and lung function test were repeated at each reassessment. All patients’ data including biodata, clinical data, analgesic treatment received, and outcome measure were collated from the pro forma and were analyzed using STATA version 10 (StataCorp www.stata.com).

After 24 hours assessment period, appropriate analgesic and other indicated treated were continued for all the 64 patients.

Results

There were 64 adult patients who were studied with multiple rib fractures caused by blunt chest trauma. Of these patients,
54 (84.4%) were male and 10 (15.6%) were female, with up to 92.2% of the victims being below 60 years old while elderly people accounted for only 7.8%. However, among the female adult victims with multiple rib fractures, the age distribution was even from young adult to elderly age group [Table 1 and Figure 1]. Table 1 shows the occupations of the victims of traumatic multiple rib fractures in this study; commercial motorcyclists (including tricycles popularly called keke napep), all males, accounted for 62.5% of all patients in the study. There were also five commercial drivers (7.8%) in the study, all males. This was statistically significant as commercial transportation is regarded as a males’ job ($P < 0.0001$). The other occupations in the study included civil service, schooling, trading, and technical work, which were few and not seem to be causatively related to blunt chest trauma.

Table 2 shows the characteristics of blunt chest injuries encountered in the study. Motorcycle (popularly known as “okada”) and tricycle (popularly known as keke napep) accidents accounted for the majority of the multiple rib fractures in 50 (78.1%, $P < 0.05$) of the patients. The other causes of multiple rib fractures encountered in the study were from motor traffic accident in 9 (14.1%), fall from height in 2 (3.1%), and one case each of fall into gutter, fall in bathtub, and hit by a falling tree branch.

Chest radiographs were routinely used in the 64 patients in the study to confirm the diagnosis of multiple rib fractures, ascertain the fractured ribs for the purpose of inclusion into or exclusion from the study [Figure 2]. Chest radiographs also helped in calculation of the abbreviated thoracic trauma severity score and guided intercostal nerve blocks in the patients who received that modality of treatment.

Table 3 shows the respiratory rates of the patients counted and recorded before administration of analgesic, 1 h and 24 h after commencement of analgesia. Before administration of analgesic, no patient had a normal respiratory rate which in this study was taken as 12–20 breaths/min. However, at 1 h following the administration of analgesics, there was a significant difference in respiratory rates among the patients. Twenty-one (32.8%) of patients recorded a normal respiratory rate. Again at the same 1 h reassessment period, there was a significant reduction in the number (10.9% vs. 39.1%)

![Figure 1: Sex distribution of the patients with blunt chest injury and multiple rib fractures](image-url)
of patients with a respiratory rate >30 breaths/min. At the 1 h posttherapy assessment, the reduction in the number of patients recording the worse class of respiratory rates (26–30 breaths/min) also reduced (15.6% vs. 37.5%). In 21 (32%) of the 64 patients, the respiratory rate became normal after single dose of analgesic. There was reduction of the worst respiratory rate from 25 (39.1%) of the 64 patients to 7 (10.9%) after first dose of analgesic. At 24 h following commencement of analgesic, the assessment of respiratory rates shows continuous improvement among all the patients with 28 (44.4%) patients maintaining normal respiratory rates.

Before commencement of analgesics, none of the 64 patients recorded up to 99% of SpO$_2$ as measured by pulse oximeter, while about 43.8% recorded SpO$_2$ of 96%. However, after 1 h of administration of analgesic, 18.8% and 31.3% of the patients recorded SpO$_2$ of 100% and 99% after a single dose of analgesic, respectively, while none recorded SpO$_2$ of <97%. This was statistically significant ($P=0.006$). At 24 h into commencement of analgesics, the assessment of respiratory rates shows continuous improvement among all the patients with 28 (44.4%) patients maintaining normal respiratory rates.

Table 5 shows the changes in peak expiratory flow rate (PEFR) before administration of analgesics, and at 1 h and 24th h following commencement of analgesia. Before analgesia, no patient was able to achieve a PEFR value >100% of the predicted while only 9 (14.1%) patients were able to achieve a PEFR value in the range of 91%–100% of the predicted value. Another 27 (42.2%) patients achieved PEFR value in the range of 81%–90% predicted, 23 (35.5%) patients achieved PEFR value in the range of 71%–80% predicted, while in the remaining 5 (7.8%) patients, preanalgesic PEFR values fell in the 61%–70% predicted range. The mean PEFR value before analgesia was 81.5% of predicted. At the 1st h postanalgesic assessment, a total of 6 (9.4%) patients were able to achieve PEFR values >100% predicted, while 35 (54.7%) patients achieved PEFR values of 91%–100% predicted, 19 (29.7%) patients achieved PEFR value of 81%–90% predicted, and the remaining 4 (6.3%) patients achieved PEFR value of 71%–80% predicted. There was no patient with a low PEFR value.
of <70% predicted. The mean PEFR value of 64 patients 1 h after commencement of analgesia was 94.7% of predicted, giving \( P = 0.003 \). At 24 h, reassessment showed a better improvement over the 1\text{st} h performance in PEFR values. For instance, 36 (56.3\%) patients had PEFR value >100\% predicted, another 17 (26.6\%) patients had PEFR value of 91\%–100\% predicted, and the remaining 11 (17.2\%) patients had PEFR value of 81\%–90\% predicted, with a mean of 99\% predicted PEFR value. When the average of PEFR value of the 64 patients at 24\text{th} h reassessment and preanalgesic PEFR mean (99.0\% predicted vs. 81.3\% predicted) are compared, the improvement was statistically significant (\( P < 0.00001 \)).

Analysis of the 64 adult patients with multiple rib fractures according to the abbreviated thorax trauma severity scores (ATTSSs) showed that the mean ATTSS was low. The abbreviated scoring system only considers unilateral rib fractures because of the exclusion of patients with bilateral involvement, hemothorax, pneumothorax, lung contusion, flail chest, etc., as shown in exclusion criteria in the study. There were no complications of rib fractures in the study either within the 24 h of study or during subsequent follow-up management. There were also no complications related to the chest pain treatment modalities. The ICNBs were devoid of intercostal neurovascular bundle or lung parenchymal injury. Only two patients demanded for rescue analgesia, and there was no mortality in the study.

**DISCUSSION**

The present study involves 64 adults who presented to our accident/emergency department between November 2013 and October 2014 with multiple rib fractures following blunt chest trauma. There were 205 cases of chest trauma out of a total of 2118 trauma cases received and treated during the 1 year period. Therefore, with chest trauma, it accounted for 9.7\% of all injuries. Comparison showed this figure to be slightly lower than other studies with thoracic traumas comprising 10\%–15\% of all traumas and being the direct causes of death in 25\% of all fatalities due to trauma.\[3\] However, only 64 of the 205 patients with chest trauma met the inclusion criteria for the study which included adult blunt chest trauma patients with unilateral multiple rib fractures with no associated major intrathoracic or extrathoracic injuries such as hemothorax, significant pneumothorax, lung contusion, segmental rib fractures (flail chest), head injury, abdominal injury, or skeletal injury, which on its own can adversely affect pulmonary function. This study has shown that chest trauma constitutes 9.7\% of traumas in the center, with 82 cases of rib fractures constituting 40\% of chest trauma. Another related study has reported rib fractures as the most common pathology associated with chest trauma.\[7\] However, 64 patients studied constituted only 31\% of chest injury since some cases of rib fractures were excluded from the study. There were more men than women (84.4\% vs. 15.6\%) giving a male: female ratio of 6.4:1. This is because 70.3\% of the patients were engaged in commercial transportation (commercial motorcyclists and commercial drivers) which is predominantly a male dominated occupation. Similar male preponderance has been found in other studies of motor vehicle accidents.\[5,6\] Other series analyzing chest trauma and rib fractures have noted that males predominate partly because of workplace injuries and involvement in crimes and assaults.\[5,9\] It can therefore be said that commercial transportation particularly with the use of motorcycles is an important risk factor for chest trauma in particular and all types of trauma in general. In this study, this was statistically significant when compared with all other occupations put together (\( P < 0.0001 \)). This is more so where and when motorcycles are used as a mean of commercial transportation in the city centers with high volumes of traffic.

As part of the strategy to curb the prevalence of motorcycles and motor vehicles accidents, outright legislation against and restriction on use of motorcycles in the city centers which have been operational in some states in Nigeria would help tremendously. Furthermore, training and retraining of all motorcyclists on safe riding should be implemented. For the same reasons alluded to the above, young adults and middle age men formed the majority (92.2\%) of patients with multiple rib fractures as a result of blunt chest trauma in this study (mean age = 41.1 years) against the 7.8\% elderly people. In the Sirmali et al.'s study, the mean age of the patients was 43 years.\[9\] The other mechanisms of chest trauma and multiple rib fractures were few and included fall from height, fall in bathtub, assault, and trip and fall. Women also bear the brunt of motorcycle when they are involved in motorcycle accidents as passengers.

Vital signs including respiratory rate and peripheral arterial SpO\textsubscript{2} measured with finger pulse oximetry and PEFR were tested in all patients. For instance, before analgesia, the mean of respiratory rate was 28.8/min with no patient having a normal respiratory rate. The reason for this is because rib fractures cause sharp and severe chest pain which is aggravated by deep breathing. Therefore, the patients try to get less pain by maintaining shallow respirations with near-motionless chest wall. Peripheral SpO\textsubscript{2} of the 64 patients also showed the same trend giving a mean of 96.7\% and no patient achieving >98\% oximetry before treatment. Osinowo et al. also found low peripheral SpO\textsubscript{2} in their 21 patients before ICNB which increased after ICNB.\[3\]

However, following commencement of analgesia, reassessment showed improvements in these vital signs in the study across the 24 h assessment period. The respiratory rate reduced toward normal with 21 patients having normal respiratory rates with overall average of 23.2/min at 1 h, and 28 patients achieved normal respiratory rate with overall mean of 22.8/min at 24 h. This corroborates the findings of other related studies.\[8\] Peripheral arterial saturation (SpO\textsubscript{2}) also improved in the study from the preanalgesic mean of 96.7\% to 98.4\% and 98.9\% at 1 h and 24 h reassessment, respectively. This difference was statistically significant (\( P = 0.006 \)).
Freixinet Gilart et al. noted that pain relief in multiple rib fractures patients is transcendental, as it allows for proper ventilation, effective cough, and adequate respiratory physiotherapy. They observed that intravenous use of nonsteroidal and nonopiate anti-inflammatory drugs is quite widespread, although their side effects are their main drawback. He therefore concluded that locoregional techniques which include ICNB and epidural analgesics are some available options.

The parameter of pulmonary function tests analyzed here was the PEFR. The mean PEFR of the 64 patients with blunt chest trauma and multiple unilateral rib fractures measured before analgesia and two times after analgesia showed improvement in respiratory function following administration of analgesic to control chest pain. Before analgesia, the mean PEFR of the 64 patients was 81.3% predicted value, which improved to 94.7% predicted at 1 h postanalgesic, and 99.0% predicted at 24 h of commencement of analgesia. The improvement was statistically significant at both periods with $P = 0.003$ and $0.00001$, respectively.

The ATSS for rib fractures used in this study was adapted from Pape et al. The mean ATSS in the group of patients was low (1.4) because of the stringent selection criteria in the study which excluded bilateral chest involvement, flail segment, lung contusion, hemothorax, and pneumothorax >15%. Other factors that contribute to ATSS include bilateral chest involvement, flail segment, lung contusion, and pleural involvement.

There was no mortality among the study population. Rescue analgesia demand was also very negligible, two patients. Overall, the clinical outcome of treatment was good based on normalization of $SpO_2$, normalization of abnormal respiratory rates, and normalization of PEFR of the patients following commencement of analgesia.

Blunt chest trauma has been studied extensively in other parts of Nigeria. The various studies in different parts of Nigeria have revealed the same socioeconomic characteristics of patients sustaining blunt chest trauma with rib fractures with predominance of male, young age group, and road traffic accident as the predominant cause. A particular study on blunt chest trauma in Enugu, Nigeria, specified that ICNB was the best pain control measure in patients sustaining rib fractures.

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