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Chest Physiotherapy and Recruitment Maneuvers: Effects on Lung Mechanics and Pulmonary Complications among Mechanically Ventilated Patients with Acute Lung Injury

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Abstract: ***Background:*** *Acute lung injury Patients may require mechanical ventilation to survive, Chest physiotherapy and Recruitment maneuvers are two methods that improve respiratory efficiency, re-inflate collapsed regions , promote lung mechanics , reduce occurrence of pulmonary complications.*
Aim*: This study was carried out to investigate the effect of chest Physiotherapy and recruitment maneuvers on lung mechanics and pulmonary complications among mechanically ventilated patients with Acute Lung Injury*
Design*: Quasi-experimental research design.*
Hypothesis*: The mean arterial blood gases values, oxygen saturation readings, lung compliance, chest infection and length of ICU stay of the study group will be better than those of the control group .*
Setting*: The study was carried out in trauma intensive care units at Assiut university hospital.*
Subjects *convenience sample of 60 matched patients and randomly assigned into two equal groups diagnosed as having an acute lung injury, coma scale ≥ 13, on mechanical ventilation .*
Tool*: acute lung injury mechanically ventilated patient assessment sheet were utilized to collect data.* ***Methods****: Each patient of the study group subjects were exposed in addition to routine hospital care to two sessions/day of chest physiotherapy& recruitment maneuvers until disconnection from mechanical ventilator. However control group subjects were exposed to the routine hospital care only, both groups were monitored 3 times/day. The control group subjects were evaluated in the same way as the study group subjects.*
Results*: Finding of the present study revealed a significant statistical differences (P<0.001) between both groups in relation to improvement of oxygenation ,arterial blood gas ,length of ICU stay, mechanical ventilator parameters among study group compared to control group subjects ,thus research hypotheses cane be supported.*
Conclusion*: Combining Chest physiotherapy and Recruitment maneuvers are of great values for improvement of respiratory efficiency, lung mechanics and consequencely pulmonary complications. Replication of the study on larger probability sample is recommended. .*
Key wards*: Chest physiotherapy, Recruitment maneuver, pulmonary complications, lung mechanics, Mechanical ventilated patients, Acute lung injury.*

I. Introduction

Acute lung injury is a clinical entities of multi-factorial origin frequently seen in traumatically injured patients requiring intensive care & mechanical ventilation which is a supportive therapy used to assist patients who are unable to maintain adequate oxygenation or carbon dioxide elimination. The goal of mechanical ventilation is to improve ventilation, oxygenation, maintaining an optimal dynamic lung compliance by using ventilator management and respiratory care is considered to be most important when caring for these patients patient comfort while preventing complications.(**Carlson ,2011).**Acute Lung Injury (ALI) is defined as Bilateral pulmonary infiltrates on a chest radiograph consistent with the presence of pulmonary edema, no evidence of left atrial hypertension and if measured a Pulmonary Capillary Wedge Pressure of ≤ 18 mmHg .Oxygen criteria to include the ratio of arterial oxygen to the fraction of inspired oxygen (PaO_2/FiO_2) to be ≤ 300 mmHg. (**Boriosi et al, 2011).** ALI is caused by any stimulus of local or systemic inflammation, principally sepsis ,pneumonia ,major trauma ,pulmonary aspiration and near drowning , burns ,inhalation of noxious fumes ,fate embolism ,massive blood transfusion ,Amniotic fluid embolism ,air embolism , Eclampsia ,poisoning , radiation. (**Phua ,2009**)

The intensive care unit (ICU) is a unique environment, Approximately one third of all patients who enter the (ICU) require mechanical ventilation for management of hypoxemia and hypercapnea which the most common indications for admission to ICU. These patients have an increased risk of developing chest infection and atelectasis, besides an increased risk of sputum retentions leading to ventilation weaning more difficult and resulting in excess morbidity and mortality. (**Bakowitz et al. ,2012)**.Chest physiotherapy plays an important role in management of ventilated patients who are critically ill in intensive care unit (ICU) which is often necessary due to retained secretions following intubation and immobility and it used to minimize pulmonary secretion retention, maximize oxygenation, reexpand atelectatic lung segments , recruit collapsed distal lung units and to optimize the matching of ventilation and perfusion, improve changes in breath sounds , Improve vital signs , chest x ray , encourage early weaning , enhance patient' wellbeing , reduce ICU stay and decrease hospital cost .Chest physiotherapy usually consists of postural drainage, percussion, chest vibration, coughing and cough stimulation techniques, breathing exercises, suctioning, and patient mobilization which aids in the re-expansion of atelectatic lung and increases peak expiratory flow.(**Marchenkov et al ,2010)**

Recruitment maneuver is a the application of a sustained inflation pressure to the lungs for a specific duration to reinflating the collapsed lung segments in order to return the lung to normal volumes and distribution of air which induced lung volume loss and improving arterial oxygenation (**Lindgren et al ,2009)** .Recruitment maneuvers (RMs) is an important component of a lung protective ventilation strategy are often used to treat patients with acute lung injury (ALI) to increase intrathoracic pressure , re-inflate collapsed regions of the lungs by briefly raising transpulmonary pressure to levels higher than achieved during tidal ventilation to promote alveolar recruitment, leading to increased end-expiratory lung volume which improve gas exchange (**Trembley & Slutsky ,2006 & Kacmarek ,2007)**

The intensive care unit nurse who is primarily responsible for the patient's care she should be present at the bedside to assist with monitoring of the patient during the peri- Recruitment maneuver period she must evaluate hemodynamic status , Perform a baseline ventilator systems check , arterial blood gas (ABG) , note the baseline heart rate, rhythm, blood pressure and SpO_2 , Initiate alarm silence; use the alarm countdown clock display to time the 40 sec . Reinstitute mod of ventilation and previous settings , Repeat ventilator systems check with arterial blood gas and Vt measurement between 15-30 min after the initial Recruitment Maneuver , documented parameters in nurse sheet as ventilation mode , level of PEEP and FiO_2 used .Also chart the Outcome, Events, and Duration (in seconds) under the Recruitment Maneuver parameter row, identifying any change (or lack of change) in blood pressure, heart rate, presence of arrhythmias, and SpO_2 during the procedure or immediately afterwards. Any and all complications (and their treatment) are to be documented. (**Silva et al S 2013**).

The critical care nurse play vital role in maintaining patient normal respiration such as positioning to allow maximum chest expansion, enhance breathing and expectoration, allowing full lung expansion, preventing complications of prolonged immobilization and also responsible for assessing life threatening conditions, instituting appropriate intervention and evaluation the outcomes of theses interventions, assessment and early recognition and management of complications while fostering healing and recovery **(Marini et al ,2011**).

Aim of the study

This study was carried out to investigate the effect of chest Physiotherapy and recruitment maneuvers on lung mechanics and pulmonary complications among mechanically ventilated patients with Acute Lung Injury.

Patients and method

Research design:

Quasi-experimental research design were utilized in this study

Hypotheses: To fulfill the aim of the study the following research hypothesis were formulated:-

Hypothesis (1) the post means oxygen saturation reading of study group patients will be better than that of the control group.

Hypothesis (2) the mean values of lung compliance of the study group will be better than that of the control group.

Hypothesis (3) the mean arterial blood gases values of the study group will be better than those of the control group.

Hypothesis (4) the frequency of chest infection will be lesser among study group subjects compared to those of control group

Hypothesis (5) the length of ICU stay of study group will be shorter than that of the control group.

Setting: The study was conducted in trauma intensive care units of Assiut university hospitals.

Patients:-A convenience sample of 60 male & female adult patients who were admitted to trauma intensive care unit. They were matched & randomly assigned into two equal groups 30 patient each considering the following

Inclusion criteria :- mechanically ventilated Patients ,diagnosed as acute lung injury, hemodynamically stable with mean arterial pressure of more than 60mm , hemoglobin of not less than 8 gm/dl ,Lung injury score of 0.1 - 2.5.

Those whom pose the following
exclusion criteria were not included in the study as severe head injury, increase intracranial pressure and those who are potentially liable to develop pathologically raised intracranial pressure , having acute pulmonary edema, terminal diseases , inoperable cancers , age of more than 60 years , cardiac abnormality or disease ,Pregnancy , autoimmune diseases.
The potentially selected patients were matches according to the following

Matching criteria:- age range from 1 -3 years , sex , lung injury scale scores of 0.1 - 2.5 , Glasgow coma scale score of ≥13 ,Diagnosis ,comorbidity diseases (e.g. diabetes mellitus) in to 2 equal groups of 30 patients each ,then they were randomly assigned in to study &control group.

Content validity: -
The tools were tested for content related validity by jury of 7 specialists in the field of critical care nursing and critical care medicine from Assiut & Cairo University, and the necessary modifications were done.

A pilot study:-
- A pilot study was carried out on 6 patients to test the clarity and applicability of the tools and time needed to collect the data. The tools were applicable and there was not any modification.
- According to the results of the pilot study subjects included in to the study.
- The Reliability was done on tools by Cronback's Alpha it was (0.95)

Protection of human rights :
An official Permission was taken by the researcher from the head of trauma intensive care unit at Assiut university hospitals after explanation the aim and nature of the study, confidentiality and anonymity of the subjects were ascertained, Subjects were assured that can they withdraw from the study at any time without any rational at any time, Informed consent was obtained from each patient or from the responsible person for the unconscious patients.

Study Tool:-
Tool were utilized to collect data is:-

Acute lung injury mechanically ventilated patient assessment sheet:-
Assessment sheet were developed by the researcher after extensive literature of review. It composed of 7 main areas as (Socio-demographic data, clinical data, assessment of respiratory system, ventilator parameters, arterial blood gases in addition to chest x-ray and selected laboratory data. And assessment of acute lung injury score **It includes 34 items:-**

Items from 1-2 covering:-socio- demographic data (age ,sex).
Items from 3-8 covering:- clinical data (history of current disease, past medical diseases, date of admission, medical diagnosis, number of days on mechanical ventilator, length of ICU stay).
Items from 9-17 covering: ventilator profile (mode of ventilation ,tidal volume (vt) ,respiratory rate (f) ,mean airway pressure ,fraction of inspired oxygen (fio_2) ,positive end expiratory pressure (PEEP) ,peak inspiratory pressure (PIP) ,plateau pressure (PpL) , static lung compliance (Cstat).

Items from 18-21 covering:- respiratory system assessment in terms of the following (breath sounds, secretions, color and viscosity)
Items from 22-26 covering:- blood gases measurements(arterial oxygen tension (Pao_2), arterial carbon dioxide tension ($Paco_2$), oxygen saturation (Sao_2), pH and HCo_3 .
Items from 27-31 covering:-laboratory investigation:- (blood picture , liver function tests ,renal function tests).
Items 32 covering:- assessment of chest X-ray to detect site and type of lesion
Items 33 covering:- assessment of baseline galscow coma scale
Items 34 covering :-Assessment of lung injury score on admission and discharge.

Procedure:
Preparatory phase:-
1. Construction for data collection tools after extensive literature of review.
2. An official Permission was granted by the researcher from the head of trauma intensive care unit at Assiut university hospitals after explanation the aim and nature of the study.
3. An approval was obtained from the local ethical committee and the study was followed the common ethical principles in clinical research.
4. The tools used in this study were developed by the researcher based on reviewing the relevant literature.

Implementation and evaluation phases:-

The implementation phase was conducted over a period of nineteen months starting from (May 2012 to December 2013) because of the rate of attrition. Glasgow coma scale and acute lung injury score were utilized to select patient of GCS≥13, $Pao_2/fio_2 \leq 300$ then during this phase 30 legible patients who are welling to participate in the study were selected to constitute the control group, then their matches (30 patients) who are welling to participate in the study also were recruited to constitute the study group subjects .Both of two groups were received the routine hospital management and been assessed utilizing the three study tools as a baseline assessment, each of the study groups subjects were exposed to the following interventions:-

Each patient of the study group subjects were exposed in addition to routine hospital care to two sessions/day of chest physiotherapy & recruitment maneuvers until disconnection from mechanical ventilator & according to physician prescription and his condition on daily bases. However control group subjects were exposed to routine hospital care only, both groups was monitored 3 times/day. The control group subjects were evaluated in the same way as the study group subjects as follows evaluation of arterial blood gases values ,parameters of mechanical ventilator ,pulse oximetry and lung mechanics evaluated immediately before the application of chest physiotherapy .Then the recruitment maneuvers were applied by the researcher twice daily at which the researcher increased positive airway pressure to 30 or 40 cm H_2o for 30 to 40 seconds at the end of the 30 second period ,PEEP was gradually reduced in 3- to 5- cm H_2o increments back to the baseline PEEP over a period of 2 minutes. and the immediate post evaluation was conducted half an hour& 12 hour utilizing to the same parameters ,then these process was repeated according to patient's condition and physician description.

- Monitoring of variables was performed at baseline data, 30 minutes & 12 hours after CPT&RM as study group in order to compare to control group.
- Routine chest physiotherapy was done to control group by nurses as prescribed patient were positioned right side ,left side and back according to ICU schedule of turning.

Calculation : lung injury score developed by(**Maskara 2000**) were used to obtain baseline values for the presence and extent of a pulmonary damage and also used to monitor lungs improvement by the end of the study for both groups It can be used both at the onset of a lung disorder and during the course of the illness to monitor changing lung involvement. The score was calculated based on the results of logistic regression analysis. score = suma valores parameters maximum summation of parameters =16, minimum summation of parameters =0 , score 0: no lung injury , score 0.1 - 2.5: mild-to-moderate lung injury , score > 2.5: severe lung injury (ARDS)

Parameter	Finding	Value
Rx. Torax	no alveolar consolidation	0
	1 quadrant	1
	2 quadrant	2
	3 quadrant	3
	4 quadrant	4
Hypoxemia PaO2/FIO2	> 300	0
	225 – 299	1
	175 – 224	2
	100 – 174	3
	< 100	4
PEEP	<= 5 cm H2O	0
	6 - 8 cm H2O	1
	9 - 11 cm H2O	2
	12 - 14 cm H2O	3
	>= 15 cm H2O	4
Compliance	>= 80 mL/cm H2O	0
	60 - 79 mL/cm H2O	1
	40 - 59 mL/cm H2O	2
	20 - 39 mL/cm H2O	3
	<= 19 mL/cm H2O	4

**** Description of the chest physiotherapy procedure:-**

Study group:-

- Each patient was placed in baseline supine position with head of bed elevated 30 degree for 10 minute before commencement of study.
- The measurements of hemodynamic parameters were done before starting and after 30 min & after 12 hours of chest physiotherapy and recruitment maneuver
- Patient was turned to the postural drainage position for 15 minute according to affected segment on chest x-ray.
- Each postural drainage position was maintained for 5 minute and with 10 minutes of mechanical percussion and vibration followed by suction.
- Postural drainage positions were modified according to the patient's condition and tolerance warrant
- To prevent irritation caused by clapping the bare chest with mechanical precursor. A gown was used over the chest and avoiding places of electrode places .
- Percussion and vibration were applied over the lung .commonly accepted anatomical landmarks for percussion and vibration includes 10^{th} thoracic vertebra posteriorly and the xiphiod a anteriorly with normal respiration
- Percussion and vibration was avoided over the kidney, spinal column, breasts, floating rib, scapula and sternum.
- Suction was done with a sterile technique .patient were pre-oxygenated with 100% before suction and manually ventilated with a self inflated bag in between suction catheter passes .the amount of secretions were collected and a sputum trap amount was recorded.
- A suction procured was accomplished before getting in postural drainage and following percussion and vibration the suction time less than 10 seconds to prevent desaturation.
- During turning the patient any tubes and connections attached to the patient was observed as ECG monitor ,endotracheal tube ,feeding tube ,patient cuitical to ventilator ,chest tube , urinary catheter ,arterial line ,peripheral line and central venous pressure line to avoid pulling ,stretching or kilning these tube were avoided .
- By the end of the session leaving the patient to the routine nursing interventions.
- Chest physiotherapy procured was given 1 hour before feeding.
- The aerosolized treatment or bronchodilator prescribed by physical were given 15-30 minutes before chest physiotherapy .

Control group:-

The control group subjects were receiving the routine hospital care and evaluated in the same way as the study group subjects. the researcher observed the control group and the routine care the nurse give it to them.

II. Result

Table (1):-Shows that the highest percentage in both group in age ranged from (31< 40 years),were male, reported no past history, diagnosed as root traffic accident , had bilateral lung lesion and had mild degree of lung injury .No significant statistical difference was put in to evidence between the two groups in relation to socio demographic & clinical data .

Table (2) Demonstrates Arterial blood gas parameters of control group subjects showed higher pH values, $Paco_2$, with lower oxygen saturation, Pao_2 during the three assessments , PH showed slight tendency to be higher among control group compared to study group despite didn't reach a statically significant difference. However ABG values of study group subjects were nearly improved than the baseline readings & as compared to the control group subjects who showed respiratory alkalosis with lower oxygen saturation and increase $Paco_2$ in the after 12 hours assessment .A significant statistical difference (p=0.05to 0.01) found between the two groups. Thus hypothesis (3) can be supported.

Table (3) Clarifies that mechanical ventilator parameter's values show a significant statistical difference (p=0.05 to 0.01) founded between the two groups in relation to mean (Respiratory rate, plateau pressure, Tv & lung compliance) of study group subjects which improved than the base line readings & as compared to the control group subjects who showed (lower Tv, lung compliance)and increased in respiratory rate, plateau pressure, peak pressure & mean airway pressure, in the after 30 minute &12 hours assessment . However no significant difference was founded between both groups in relation to base line assessment data. Mean values of Pressure support & fio_2 show slight tendency to be higher among control group compared to study group & there were a statically significant difference (p=0.05 to 0.01). Concerning to PEEP level, showed nearly normal between the two groups. Thus hypothesis (2) can be supported.

Table (4) Delineate nearly half of study group subject expectorated larger amount of secretion compared to moderate amount among control group subject with statically significant difference between the both groups (p=0.05 to 0.01). In relation to color ,viscosity ,breath sound ,highest percentage of control group had green, viscid &wheezy chest as compared to the study group subject significant difference between the both groups (p=0.05 to 0.01). Thus hypothesis (4) can be supported.

Table (5):- Show that the majority of study group subject (73.3 %) had complete resolution on discharge in study group compared to (33.3%) in the control group respectively, a statistical significant difference between the both groups (p=0.05 to 0.01). Thus hypothesis (4) can be supported

Figure (1) Represents that a significant statistical difference (p=0.05 to 0.01) founded between the two groups in relation to mean of (Pao_2/fio_2 ratio) on discharge as compared to control group subject. However no significant difference was founded between both groups in relation to base line assessment data. Thus hypothesis (4 ,5) can be supported.

Table (6) Refers that patients in the control group had higher duration connected to mechanical ventilators with Mean ± SD of (20.0±6.1) days, longer ICU stay (25.5±8.5) days as compared to study group who show a statistically significant difference (p=0.05 to 0.01) duration connected to mechanical ventilators with Mean ± SD of (14.0±5.9) days, longer ICU stay(15.8±5.5) day . Thus hypothesis (5) can be supported.

Table (7): hieghlites that study group showed highly significantly decreases (p 0.05 -0.01) regard to the mean values of WBC& increase level of platelets &hemoglobin concentration .however the control group show increase mean values of WBC & decrease level of platelets & hemoglobin concentration .In relation to Hematocrit**,** red blood cells no statistical difference was founded by the end of the study between 2 groups. Thus hypothesis (4 ,5) can be supported.

Table (8) In relation to occurrence of complications (fever, hypotension, Progressive respiratory failure (ARDs) highest percentage was in control group subject (50%) had an elevation of body temperature (23.3%) had hypotension as compared to the study group who showed a statistically significant difference (p=0.05 to 0.01).Regarding to the frequency of mortality, approximately similar in both groups and the difference between the two groups were not statistically significant. Thus hypothesis (5) can be supported.

Table (1):- Percentage distribution of study and control group as regards socio-demographic characteristics & clinical data (n=60).

Variables	G1 "study group "n=30		G2 "control group " n=30		P value
	N	%	N	%	
Age" years"					
20< 30 years	7	23.3%	7	23.3%	
31< 40 years	14	46.6%s	14	46.6%s	
41 < 50 years	5	16.6%	5	16.6%	0.88
51 < 60 years	4	13.3%	4	13.3%	
Mean ± SD	40.60±11.2		40.16±11.4		
Sex					
Male	21	70.0%	21	70.0%	0.37
Female	9	30.0%	9	30.0%	
past medical history :-					
Cardiac disorder	0	0.0%	1	3.3%	
Renal disease	5	16.6%	5	16.6%	0.15
Diabetes mellitus	6	20%	6	20%	
Hepatic disorder	1	3.3%	0	0.0%	
No past history	18	60.0%	18	60.0%	
Diagnosis :-					
Brain edema	1	3.3%	3	10.0%	
Root traffic accident	13	43.4%	13	43.4%	0.27
Multiple fracture	11	36.6%	9	30.0%	
Stap wound	5	16.6%	4	13.3%	
Near drawing	0	0.0%	1	3.3%	
Site of Lung lesion according to chest x-ray on admission					
Right	8	26.7%	7	23.0%	0.17
Left	3	10.0%	3	10.0%	
Bilateral	19	63.3%	20	66.7%	
lung injury score on admission					
Mild (0.1)	20	66.7%	22	73.3%	0.08
Moderate(≤2.5)	10	33.3%	8	20.0%	

Chi- square test & Independent samples t-test P >0.05 non significant *P<0.05 significant **P<0.01 moderate significant ***P<0.001 highly significant

Hypothesis (1 , 2) the excepted mean arterial blood gases values of the study group will be better than those of the control group.

(2) The post mean oxygen saturation reading of patients on study group will be better than that of the control group. covered in table (2)

Table (2):- Comparison between the studied groups in relation to arterial blood gases& oxygen saturation mean values all through the assessment in both groups (n=60).

Arterial blood gases	(base line) before intervention		After 30 min of intervention		After 12 h of intervention	
	study group	control group	study group	control group	study group	control group
pH	7.29± 0.15	7.37± 0.11	7.37±.02	7.43±0.082	7.36±5.20	7.52±1.30
p value	0.37		0.16		0.001***	
PaO_2	74.6± 20.74	82.75± 33.17	161.5±1.2	112.4±4.5	152.2±2.2	95.74±3.2
p value	0.33		0.001***		0.001***	
$PaCO_2$	44.20±18.75	50.11±19.05	36.8±2.05	42.8±5.5	37.46±7.07	48.99±4.83
p value	0.33		0.001***		0.001***	
HcO_3	22.93±8.45	23.13±7.70	24.7±.77	26.2±2.7	22.7±1.14	23.3±2.28
p value	0.91		0.02*		0.98	
SaO_2	91.35±8.19	90.58±8.75	98.51±.66	93.43±3.7	98.73±2.27	94.83±2.27
p value	0.93		0.001***		0.001***	
SpO_2	93.58±1.7	92.35±1.19	97.65±2.09	96.47±1.8	99.79±2.10	95.31±3.6
p value	0.065		0.001***		0.003***	

Chi-square test P >0.05 non significant *P<0.05 significant **P<0.01 moderate significant ***P<0.001 highly significant used to compare between base line data &12hour after applying PT&RM each group **ABG** :arterial blood gas. **Pao2** :partial pressure of arterial oxygen **paco2**:-partial pressure of arterial carbon dioxide **Sao2** :arterial oxygen saturation

Hypothesis (3) the mean values of lung compliance of study group will be better than that of the control group. Covered in table ( )

Table(3):-Comparison between the studied groups in relation to Mechanical ventilator parameters mean values all through the assessment in both groups (n=60).

Arterial blood gases	(base line) before intervention		After 30 min of intervention		After 12 h of intervention	
	study group	control group	study group	control group	study group	control group
pH	7.29± 0.15	7.37± 0.11	7.37±.02	7.43±0.082	7.36±5.20	7.52±1.30
p value	0.37		0.16		0.001***	
PaO_2	74.6± 20.74	82.75± 33.17	161.5±1.2	112.4±4.5	152.2±2.2	95.74±3.2
p value	0.33		0.001***		0.001***	
$PaCO_2$	44.20±18.75	50.11±19.05	36.8±2.05	42.8±5.5	37.46±7.07	48.99±4.83
p value	0.33		0.001***		0.001***	
HcO_3	22.93±8.45	23.13±7.70	24.7±.77	26.2±2.7	22.7±1.14	23.3±2.28
p value	0.91		0.02*		0.98	
SaO_2	91.35±8.19	90.58±8.75	98.51±.66	93.43±3.7	98.73±2.27	94.83±2.27
p value	0.93		0.001***		0.001***	
SpO_2	93.58±1.7	92.35±1.19	97.65±2.09	96.47±1.8	99.79±2.10	95.31±3.6
p value	0.065		0.001***		0.003***	

Chi-square test P >0.05 non significant *P<0.05 significant **P<0.01 moderate significant ***P<0.001 highly significant **MV** :- Mechanical ventilation **Vt** :-Tidal volume **PEEP**:-Positive end expiratory pressure **MAP** = mean airway pressure **PS** = pressure support **PIP** = peak inspiratory pressure **RR** :- Respiratory rate **FIO_2**:-Fraction of inspired oxygen

Table(3):-Comparison between the studied groups in relation to Mechanical ventilator parameters mean values all through the assessment in both groups (n=60).....cot

Ventilatory parameters	(base line) before intervention		After 30 min of intervention		After 12 h of intervention	
	study group	control group	study group	control group	study group	control group
Pressure support (PS)	13.84±2.4	14.95±2.6	13.75±2.3	14.90±2.3	10.77±2.5	14.93±2.4
p value	0.84		0.26		0.001***	
(MAP) pressure	12.54±2.4	12.16±1.7	12.34±2.8	13.42±1.4	11.57±2.8	19.60±1.19
p value	0.32		0.24		0. 001***	
Lung compliance	41.76±11.1	39.29±9.42	41.09±11.9	39.26±8.62	46.23±15.3	40.25±29.1
p value	0.6		0.06		0.001***	
Fio_2	73.66±12.75	74.50±17.25	44.93±9.41	45.98±9.25	32.01±6.42	42.53±8.02
p value	0.82		0.82		0.001***	

Chi-square test P >0.05 non significant *P<0.05 significant **P<0.01 moderate significant ***P<0.001 highly significant **MV** :- Mechanical ventilation **Vt** :-Tidal volume **PEEP**:-Positive end expiratory pressure **MAP** = mean airway pressure **PS** = pressure support **PIP** = peak inspiratory pressure **RR** :- Respiratory rate **FIO_2**:-Fraction of inspired oxygen .

Hypothesis (4) The frequency of chest infection will be less among study group subjects compared to those of control group covered in table (4,)

Table (4):-Comparison between the studied groups in relation to characteristics of secretions amount, color, viscosity and breath sounds all through the assessment in both groups (n=60).

Variables	G1 "study group "n=30		G2"control group " n=30		P value
	N	%	N	%	
Amount of secretions :-					
Small	6	20.0%	4	13.3%	
Moderate	9	30.0%	16	53.3%	0.001* **
Large	15	50.0%	10	33.3%	
Color of secretions :-					
Clear	12	40.0%	4	13.3%	
Yellow	11	36.7%	5	16.7%	0.001 ***
Green	4	13.3%	11	36.7%	
Bloody	3	10.0%	10	33.3%	
Viscosity of secretions					
Loose	16	53.3%	10	33.3%	0.001 ***
Viscid	14	46.6%	20	66.7%	
Breath sounds					
Normal	16	53.3%	7	23.3%	
Crackles	4	13.3%	5	16.7%	
Wheezing	4	13.3%	9	30.0%	0.001 ***
Creption	3	10.0%	6	20.0%	
Ranchi	3	10.0%	3	10.0%	

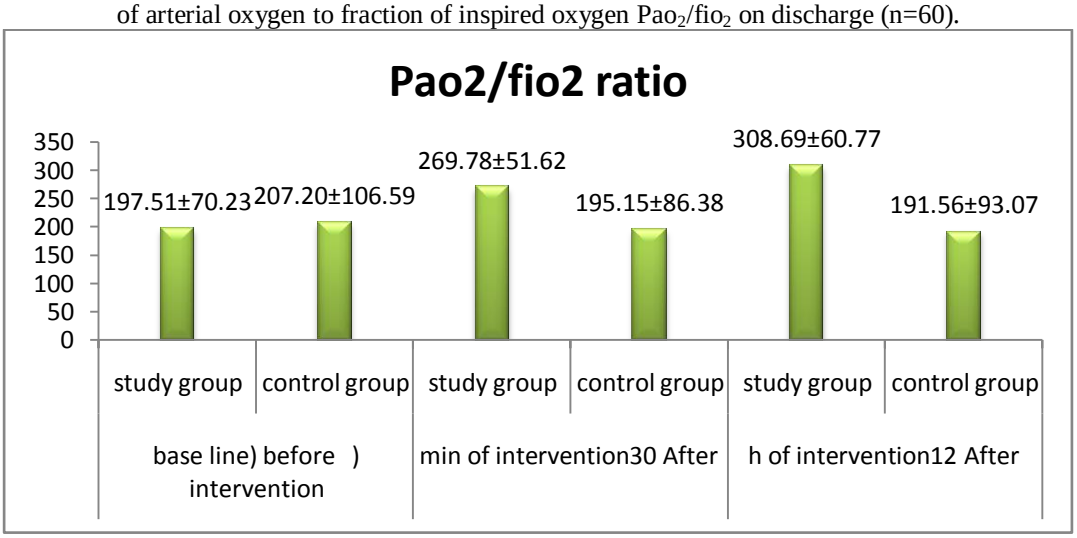
Independent samples t-test P >0.05 non significant *P<0.05 significant **P<0.01 moderate significant ***P<0.001 highly significant

Table (5):-Comparison between the studied groups in relation to chest x-ray findings on discharge (n=60).

Variables		G1 "study group "n=30		G2 "control group " n=30		P value
		N	%	N	%	
Sites of lung lesion according to chest x-ray on discharge	No affected lesion	22	73.3%	10	33.3%	
	Right lesion	4	13.3%	8	26.7%	
	left lesion	3	10.0%	8	26.7%1313.3%	0.001**
	Bilateral lesion	1	3.3%	4		*

Chi-square test P >0.05 non significant *P<0.05 significant **P<0.01 moderate significant ***P<0.001 highly significant **Pao2/fio2** the ratio of partial pressure of arterial oxygen to fraction of inspired oxygen

Figure (2) Comparison between the studied groups in relation to the ratio of partial pressure of arterial oxygen to fraction of inspired oxygen Pao_2/fio_2 on discharge (n=60).



Hypothesis (5) the mean length of ICU stay of study group will be shorter than that of the control group. Covered in table (6).

Table (6):- Comparison between the studied groups in relation to duration of ventilator dependency &length of ICU stay in study and control group (n=60).

Variables	G1 "study group "n=30	G2 "control group " n=30	P value
Mean ± SD	14.0±5.9	20.0±6.1	0.001***
Mean ± SD	15.8±5.5	25.5±8.5	0.001***

Chi-square test - Independent samples t-test P >0.05 non significant *P<0.05 significant **P<0.01 moderate significant ***P<0.001 highly significant

Table (7):- Comparison between the studied groups in relation to blood picture lab mean values by the end of the study (n=60).-

CBC	G1"studygroup "n=30	G2"control group " n=30	P value
1- WBC	7.11±0.91	13.26 ±1.41	0.001***
2- Red blood cells	3.41±0.85	3.27±0.67	0.481
3- Hemoglobin	10.28±1.43	9.32±0.99	0.03*
4- Hematocrit	33.72±3.66	32.95±5.36	0.423
5- Platelets	218.6±46.7	176.7±55.5	0.001***

Chi-square test P >0.05 non significant *P<0.05 significant **P<0.01 moderate significant ***P<0.001 highly significant **CBC** : complete blood picture **WBC**: White blood cells

Table (8):- Comparison between the studied groups in relation to occurrence of complications in study and control group by the end of the study (n=60)

Complications		G1 "study group "n=30		G2 "control group " n=30		P value
		N	%	N	%	
Frequency of mortality	Death Live	4 26	13.3% 86.7%	3 27	10.0% 90.0%	0.73
Frequency of fever	Yes No	8 22	20.0% 73.3%	15 15	50.0% 50.0%	0.001***
Progressive respiratory failure (ARDs)	Yes No	4 26	13.3% 86.7%	15 15	50.0% 50.0%	0.001***
Hypotension	Yes No	4 26	13.3 86.7%	7 23	23.3% 76.7%	0.35

Independent samples t-test P >0.05 non significant *P<0.05 significant **P<0.01 moderate significant ***P<0.001 highly significant

III. Discussion

The aim of this study was to investigate the effect of chest Physiotherapy and recruitment maneuvers on lung mechanics and pulmonary complication among mechanically ventilated Patients with Acute lung Injury. the present study presented that highest percentage of the two groups were males, had Mild degree of lung injury, did not report any past history and most of them diagnosed as Root traffic accident& multiple fractures There was no statistical differences between the both group .

Joseph 2005 who emphasized that the nurse should be aware of the patient diagnosis as well as the lung lobes or segments involved , any structural deformities of the chest wall to help to identify the areas needing drainage and to assess the effectiveness of treatment . **Graham and Bradley 2012** mentioned that Chest physiotherapy should be directed at a specific lobe or segment and should be continued until auscultation reveals signs of improvement and reduction of adventitial breath sounds.

The present study demonstrate that there were a marked improvement in arterial blood gas exchange reflected by a highly significant statistical difference was found between the both groups with (p = 0.001) after 30 min & 12h after CPT &RM in mean PH,pao_2, $sa0_2$ & lower $paco_2$ of study group compared to changes in theses parameters detected in control group. This improvement in ABG parameters when compared to base line values due to effect of postural drainage , mechanical percussion which lead to redistribution of blood flow ,improve ventilation to alveolar units, reducing hypoxic vasoconstriction, better secretion removal as well as increase functional residual capacity .

marini et al ,2009 mentioned that monitoring of ABG provides a comprehensive picture of oxygenation ,ventilation and acid base balance .it is used to initiate therapy and to monitor the effectiveness of therapy. **Brower et al, 2013** mentioned that arterial blood gas (ABG) analysis is the gold standard for determining arterial carbon dioxide and oxygen levels**.** the role of critical nurse are accurate and frequent

physical assessment for mechanically ventilated patient arterial blood gas analysis .**Hong & Choi ,2014** founded that a significant decrease in $PaCO_2$ value displayed at the 30 minutes post- intervention (p=0.009) and lung compliance displayed a significant difference over time (p<0.001). when applied two different chest physiotherapy (CPT) techniques to their patients

.**Potter &Perry ,2011**mentioned that when the patient inhales and cough the volume of air moving in his lungs increased ,the alveoli open, promoting good oxygen, carbon dioxide exchange resulting improvement in pao_2 and sao_2 , fluid electrolytes& acid base balance with the body maintains health and function in all body system .**Hess & Bigatello ,2008** reported that Recruitment maneuver(RM) is an intentional transient increase in intrapulmonary pressure to promote reopening of unstable or collapsed alveoli& thereby improve gas exchange .

As regards to ventilator setting data there were a highly significance increase (P<0.001) after 30 minute & 12 hours after CPT &RM founded in the mean value of tidal volume , respiratory rate , Lung compliance and Mean airway pressure in study group compared to control group. But In relation to Plateau pressure, pressure support, show there were a significance decrease (P<0.05) in study group versus in control group. on the other hand no significant changes in variables before CPT &RM . improvement of mechanical ventilator parameters and lung mechanics could be explained by decreasing resistance& obstruction caused by secretions and bulges that increases airway pressure &decrease compliance ,CPT&RM helped to clears the accumulation of secretions &improve lung mechanics. **AARC ,2010** mentioned that care of the mechanically ventilated patient is at the core of a nurse's clinical practice in the intensive care unit (ICU).

Philip ,2012 mentioned that the main role of critical care nurse when cared mechanically ventilated patient are to optimize oxygenation ,maintain tissue perfusion ,provide adequate nutrition ,provide emotional support to patient &family, assess respiratory status every 1 to 2 hours and document rate ,rhythm ,breathing pattern .,assess breath sounds at least every 4 hours for abnormal findings as crackles ,monitor ABGs for any significant changes . **marini et al, 2009** emphasized that caring of mechanically ventilated patient requires the nurse to be vigilant and aware of potential complications so the Critical care nurse must asses ventilator parameters setting at least every 2 hours ,FIO2 should be analyzed periodically to ensure correct amount is being maintained ,peak inspiratory pressure ,lung compliance and plateau pressure , Respiratory rate, tidal volume, minute volume and airway pressures .oxygen saturation level, level of consciousness ,breath sounds ,tolerance to ventilator , vital signs , and evaluate the adequacy of gas exchange

Fabiana & Rosmari ,2012 founded that there were statistical significant difference (p<0.0001) between study & control group in mean values of respiratory rate, tidal volume after the applying of twice dialy recruitment maneuver.

As regard to **Plateau pressure** show there were a significance decrease after 30 & 12h after CPT and RM (P<0.05) in study group versus in control group. **Morgan et al ,2006** mentioned that plateau pressure is the pressure applied to the small airways and alveoli. It is important, as excessive stretch of alveoli has been implicated. In relation to **peak pressure** .There were a highly significance decrease in study group after 30 & 12h after CPT and RM (P<0.001) which reflect secretions accumulation in control group . The peak pressure is the pressure measured by the ventilator in the major airways, and it strongly reflects airways resistance. **Ranieri ,2012** reported that Peak airway pressure is measured at the airway opening It represents the total pressure needed to push a volume of gas into the lung and is composed of pressures resulting from inspiratory flow resistance (resistive pressure), the elastic recoil of the lung and chest wall (elastic pressure), and the alveolar pressure present at the beginning of the breath

Mackenzie ,2011 concluded that measurement of total lung compliance was clinically useful in quantization of the effect of secretion clearance following chest physiotherapy in mechanically ventilated patient in intensive carte units **. Amato et al ,2008** reported that alveolar recruitment and maintaining lung volume is necessary in order to prevent lung injury & Mean airway pressure is a key component of oxygenation index **.Minhee et al ,201** found that lung compliance increased significantly immediately and 30-min after the intervention in the manual percussion and palm-cup percussion groups, while no significant changes were found over time in the comparative group

Concerning Fraction of inspired oxygen (**fio_2**).The results of the current study reflects that high percentage of oxygen were utilized among whole study sample on institutions of mechanical ventilation . While after 30 min of CPT & RM the mean values of **fio2** reflects that highly statistical significant decreased in study group compared to control group with (p =0.001). **Smeltzer and Bar ,2009** reported that fraction of inspired oxygen and concentration of oxygen delivered are dependent on patient need which evaluated by arterial blood gas. As explained by **Bonnie et al ,2007** successful weaning from the mechanical ventilation is supplemented by intensive pulmonary care ,the fio2 then is gradually reduce until the pao2 is in the 70 to 100 mm hg range, while the patient is in the breathing room air

Brower ,2013 are in line with the current study he founded that highly statistical significant difference in study group compared to control group with (P < 0.01). after 10 minutes and two hours after a recruitment

maneuver & concluded that Recruitment maneuvers improved oxygen saturation and fiO_2 from baseline measurements .**Jay Johannigman, 2009** founded that oxygenation improved and lung compliance improved At 30 minutes post CPT & RM, ($p < 0.05$). There were no hemodynamic or barotraumatic complications. Plateau pressure was reduced from a mean of 32 cm H_2O to 28cm H_2O Thirty minutes after application of an RM.

Effects of chest physiotherapy on various respiratory parameters of the patients under intubation and mechanical ventilation have been well documented by **Paratz et al ,2012** which have shown to significantly increase lung compliance (CL) and $PaO_2 : fio_2$, and decrease PCO_2 of treatment group in a study to determine the effect of manual hyperinflation on hemodynamics, gas exchange and respiratory mechanics in ventilated patients

In the present study the assessment of respiratory system showed that there was a highly significance decrease (p=0.001)of dyspnea, and crackles on study group versus control group after 30 min & 12h after CPT &RM.

The current study revealed that highest number of patient who receive regular CPT & RM gave large **amount of secretions** while patients who receive routine nursing care gave moderate amount of secretions & there were highly statistical significance difference between both groups.(p=0.001). This difference is due to effect of chest physiotherapy which mobilize the respiratory secretions from central to peripheral airway & increases the amount of trachobroncial mucus cleared from the respiratory tract.

Choi & Jones ,2009 mentioned that most hospitals in developed countries, chest physiotherapy is seen as an integral part of the management of patients in ICUs. Patients who are intubated and ventilated have increased sputum production because the patient usually sits in upright position ,secretions are likely to accumulated in the lower parts of the lungs .Therefore secretion removal is a major aim of physiotherapy treatment in patients who are Intubated and ventilated . **park et al ,2009** mentioned that Chest physiotherapy are used to mobilize and remove secretions in airways in order to improve lung function , facilitate gas exchange , adjust ventilation-perfusion adequacy of respiratory support, prevent and treat pulmonary complications, provide good maintenance of airways and to facilitate weaning from mechanical ventilation and oxygen therapy .**Mc Carren &Alison et al, 2012** concluded that Chest physiotherapy techniques for mechanically ventilated patients improve lung volume, promote ventilation, and mobilize secretions**.**

In relation to **color & viscosity** of secretions the finding indicated a statistical significant difference .(p=0.001) was founded between study & control group. **Jaber et al., 2010** reported that lung secretions should be assessed for color, consistency and volume , Auscultation of breath sounds across the lung **Pryor ,2006** mentioned that Percussions , Vibrations and Postural drainage are techniques increase clearance of airway secretions by the transmission of an energy wave to the chest wall help to increase the velocity of the air expired from the small airway ,thus freeing the mucus , loosen bronchial secretions and mucus plugs that adhere to the bronchioles and bronchi and to propel sputum in the direction of gravity drainage**.**

The current study revealed that the majority of study group had normal **breath sound** comparing with control group & The result revealed that a statistical highly significant difference was found between both groups. .(p=0.001). The results was supported by **Chamberlain ,2010** who mentioned that abnormal breath sounds might indicate presence of chest infection need more assessment and intervention. **Marik ,2005** reported that crackles sound reflects underling inflammations and congestion ,which is related to the presences of secretions or fluids which need continuous assessment according to the patient need to reduce the risk of accumulation of secretions **Graham & Bradley, 2012** concluded that chest physiotherapy should be directed at a specific lobe or segment and should be continued until auscultation reveals signs of improvement such as increased air entry and reduction of adventitial breath sounds

Urden, 2009 mentioned that Positioning the intensive care ventilated patient improve patient comfort , gas exchange , oxygen transport, reducing the work of breathing and reducing myocardial workload .**Ciesta,2008** performed two studies into the efficiency of chest physiotherapy and found that chest physiotherapy is useful in preventing pulmonary complications and described the aim of chest physiotherapy being to 'minimize pulmonary secretion retention, to maximize oxygenation and to re-expand atelectatic lung segments and concluded that chest physiotherapy is clearly effective in Intubated patients with acute lobar collapse.

Pryor & Webber,2012 mentioned that CPT is based on the theory that percussion to various areas of the chest and back transmits shock waves through the chest wall, thus loosening secretions in the airways. Typical treatment sessions last 20-30 minutes and may be required up to three times daily.

Concerning to the ratio of partial pressure of arterial oxygen to fraction of inspired oxygen **Pao2/fio2**Which demonstrate oxygenation status . it was increased in study compared to control group after 30 min & 12h of CPT & RM. The difference between two groups were statistically significant (p=0.001). The

results of this study supported by the findings of previous researcher **.Eddy Fan et al ,2008, Carol & Hodgson , 2011**) whom found a significant increase in pao_2/fio_2 after chest physiotherapy & performing recruitment maneuvers .**Brower et al ,2010** mentioned that lung recruitment maneuvers facilitating lung resolution ,re-inflating collapsed lung regions , preventing collapse during the subsequent mechanical ventilation. The aim of this is to improve oxygenation , lung health, reduce injurious cytokine production, shorten time to recovery and improve patient survival.This is are in agreement also with **Meade ,2008** who found a statistically significant improvement in PaO_2/FiO_2 ratio of study group on all three days with the package of ventilation (P =0.001). when investigate the effects of RM on PaO_2/FiO_2 at days one, three, and seven of the study by comparing the package of ventilation to the control group. **Oczenski ,2004** also founded that recruitment manoeuvre significantly increased $P < 0.001$) in the PaO_2/FiO_2 (139 ± 46 in control group versus 246 ± 111, in study group)

Juan & Boriosi, 2011 are in line with the current study they founded that the ratio of partial pressure of arterial oxygen over fraction of inspired oxygen increased 53% immediately after the recruitment maneuver. The median PaO_2/FIO_2 ratio increased from 111 pre-recruitment maneuver to 170 immediately & after 12 hours post-recruitment maneuver ($p < .01$). in a study to determine efficacy and safety of lung recruitment with acute lung injury. **Ibanez et al,2010** reported that the oxygenation index significantly increased when patients were positioned in side lying with the affected lung uppermost when studied 10 patients receiving mechanical ventilation with acute respiratory failure. **Villagra et al ,2010** reported Recruitment is a dynamic process that refers to the opening of previously collapsed lung units forced by application of a sustained inflation pressure to the lungs for a specific duration in order to return the lung to normal volumes and a good distribution of air and that most of the beneficial effect on oxygenation ,improving arterial oxygenation.

It was observed in the control group which had increase body temperature, white blood count , length of ICU hospital stay show significant increase in control group compared to study group .**Regarding to the frquency of mortality** during the period of mechanical ventilation ,it was similar in both groups (10.0% in control group versus 13.3 % for study group and the difference between the two groups were not statistically significant.

Fever was identified in 50% in the control group compared to 20.0% in the study group the difference between the two groups were statistically significant($p=0.001$). Theses are in line with **Laupland et al ,2008** who reported that fever complicates up to 70 percent of all ICU admissions and is often due to an infection or another serious condition **Lindgren & Ames, 2005** added that other methods that are commonly used to detect response to infection are measurement of white blood cell count, C-reactive protein (CRP) level **.Tablan et al ,2003 and Dodek et al ,2004** emphasized that elevation of the head of the bed and effective chest physiotherapy are strategies for minimizing the duration of ICU stay such strategies with application of standard nursing care prevent development of nosocomial infection**.** the nurse requires to be vigilant and aware of potential complications when Caring of mechanically ventilated patient requires .

Potter &Perry ,2011 reported that assessing signs &symptoms of infections are presence of fever ,reviewing laboratory data such as increase WBCs, positive blood or sputum cultures which assist in making the correct nursing diagnoses .**De Jong e et al ,2008** reported that Sputum specimens are often part of the respiratory assessment. Because healthy patients do not produce sputum ,obtaining a specimen requires the patient to cough to bring up sputum from the lungs. **Keller& Brimacombe ,2007** Maintenance of airway secretion clearance, or airway hygiene, is important for the preservation of airway patency and the prevention of respiratory tract infection.

Chest x-ray findings on discharge. As regards chest x-ray findings , (73.3 % had complete resolution) compared to (33.3%) in the control group respectively, p values 0.001. As regards sputum cultures findings , (60.0 % had negative respiratory secretion culture) compared to (46.7%) in the control group respectively, p values 0.01). **Duggan et al ,2010** emphasized that retained airway secretions occlude the airways of intubated and mechanically ventilated patients and the Persistent presence of sputum in the airways provide an ideal environment for colonizing organisms **Sheree comer , 2008** mentioned that chest x-ray is used to evaluate lung fields and it done routinely for all patients who admitted to acute care facilities In order to determine lung &heart abnormalities , Cultures identify causative organisms when bacterial infection is present and to identify proper antimicrobial agent.

The current study revealed that Control group patients had a longer period of ventilator dependency& in **staying in ICU** than the study group patients and difference was statistically significant ($p=0.001$) .Although the patients had similar diagnoses and physical features. The results show that physiotherapy has a great impact on ventilator dependency and length of stay in the ICU. **Antonio et al ,2012** concluded that Chest physiotherapy effectiveness is reducing mechanical ventilation support need, number of hospitalization days, incidence pulmonary infection rate and mortality in intensive care patients .The similarity was founded with **Renu et al ,2013** who founded that There were significant improvements in terms of rate of recovery in study group compared to the control group (P = 0.000). The similarity also founded with **Mehtap et al ,2009** in a

study to assess the effect of physiotherapy on ventilator dependency and lengths of intensive care unit (ICU) stay he found Control group patients had a longer period of ventilator dependency than the study group patients and difference was statistically significant (p=0.001) and concluded that positioning, manual hyperinflation, manual techniques, chest physiotherapy, bed exercises and mobilization have a significant effect on the length of stay in the ICU.

.**Castro et al ,2013** founded that patients admitted in study group presented a lower length of stay in mechanical ventilation ($p < 0.0001$), ICU stay ($p = 0.0003$), respiratory infections ($p = 0.0043$) than patients admitted control group . in study to determine effectiveness of Chest physiotherapy to reduce hospitalization and mechanical ventilation length of stay, pulmonary infection rate and mortality in ICU patients

IV. Conclusion

Based on the findings of the present study, it can be concluded that:-Applying regular chest physiotherapy complained with recruitment maneuver for mechanically ventilated patients in the intensive care unit contributes decisively to the early recovery of the patient, reducing mechanical ventilation support need, improvise oxygenation ,number of hospitalization days, incidence of respiratory infection, reduce pulmonary complications .

In the light of the study findings the following recommendations are suggested:

- Equip the trauma intensive care unit with simple illustrated booklet covering chest physiotherapy procuder
- Replication of this study on a larger probability sample from the different geographical location at the Arab republic of Egypt for generalization
- Chest physiotherapy must be applied as a routine care for patients of acute lung injury & respiratory disease patient's admitted to ICU.
- Further study is required regarding the effect of mechanical vibrator and precursor for cases of chest disease especially those who are mechanically ventilated.

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