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RESEARCH ARTICLE
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ROLE OF NEBULIZATION WITH HEPARIN IN MANAGEMENT OF PATIENTS WITH TRAUMATIC PULMONARY CONTUSION

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ABSTRACT

Traumatic pulmonary contusion (PC) is a common complication of blunt chest trauma, responsible for significant morbidity and mortality due to alveolar-capillary injury, edema, and impaired gas exchange. Conventional management is primarily supportive and does not directly address the underlying inflammation and microvascular thrombosis. Nebulized heparin, with its anticoagulant, anti-inflammatory, and mucolytic properties, has shown potential benefits in various pulmonary conditions, including smoke inhalation injury, ARDS, and trauma-related lung injury.

This prospective randomized interventional study was conducted on 50 patients with traumatic pulmonary contusion, divided into two groups: the Interventional Group received standard nebulization therapy plus inhaled heparin (1000 IU every 6 hours), while the Control Group received standard nebulization drugs alone. Clinical, radiological, and functional outcomes were assessed over the study period.

Results demonstrated that while both groups showed comparable improvements in respiratory rate, FEV1/FVC ratio, and Pulmonary Contusion Scores, patients receiving nebulized heparin required significantly fewer days of oxygen support (6.5 ± 3.98 vs. 8.5 ± 3.77, p=0.0315), had shorter ICU stays (7.42 ± 5.24 vs. 10.39 ± 4.58 days, p=0.038), and faster overall recovery (15.3 ± 5.55 vs. 17.2 ± 5.13 days, p=0.0192). These findings suggest that nebulized heparin may serve as a valuable adjunct to standard supportive care in traumatic pulmonary contusion. However, larger randomized controlled trials are warranted to validate its efficacy and optimize dosing strategies.

Keywords: Traumatic pulmonary contusion, Nebulized heparin, Blunt chest trauma, ICU stay, Recovery time, Pulmonary function

INTRODUCTION

Traumatic pulmonary contusion (PC) is one of the most frequent consequences of blunt thoracic trauma, seen in nearly 30–75% of major chest injuries. It involves alveolar-capillary damage leading to alveolar hemorrhage, interstitial edema, and impaired gas exchange [1]. If not appropriately treated, PC can progress to acute respiratory distress syndrome (ARDS), significantly increasing morbidity and mortality [2]. Conventional management remains largely supportive, including oxygen therapy, ventilation support, pain control, and pulmonary hygiene [3,4]. While these measures alleviate

symptoms, they do not directly address the underlying inflammation, alveolar coagulopathy, or microvascular thrombosis associated with PC [5].
Heparin, a glycosaminoglycan, primarily acts as an anticoagulant by enhancing antithrombin III activity, but it also exerts anti-inflammatory and mucolytic properties, suppressing leukocyte activation, cytokine release, and mucus plugging [6,7]. When delivered through nebulization, heparin achieves high local pulmonary concentrations with minimal systemic absorption, reducing risks of systemic anticoagulation [8,9]. Nebulized heparin has already shown promise in conditions like smoke inhalation injury [10], COVID-19–related ARDS [11], and in mechanically ventilated patients, where it was associated with shorter ventilator use and ICU stay [12]. Early evidence in trauma-induced pulmonary contusion suggests that nebulized heparin may aid in faster radiographicic resolution and reduce ventilator-associated complications [13].
Despite these promising findings, robust randomized controlled trials in traumatic pulmonary contusion remain scarce, particularly in resource-limited settings where trauma burden is high. Given its potential as a low-cost, locally acting therapy that directly targets the pathophysiology of PC, further investigation is necessary. This study therefore aims to evaluate the role of nebulized heparin in improving clinical outcomes and reducing recovery time in patients with traumatic pulmonary contusion, compared to standard nebulization therapy.

MATERIALS AND METHODS

This prospective randomized interventional study was conducted over 18 months on adult patients (18–75 years) with traumatic lung contusion admitted to the Emergency and ICU. Fifty patients were included, divided equally into two groups: Group I received standard nebulization therapy (Combimist and Budecort) plus inhaled unfractionated heparin (1000 IU every 6 hours), while Group II (control) received only standard nebulization drugs. Randomization was done using a sealed envelope method. Ethical approval and informed consent were obtained prior to study initiation. Patients were selected based on strict inclusion and exclusion criteria, excluding those with pre-existing lung diseases, hemodynamic instability, platelet count <50,000, heparin allergy, or pregnancy.
All participants underwent thorough clinical evaluation, radiological investigations (chest X-ray, CT scan), and were scored using the Pulmonary Contusion Score (PCS) system. Monitoring included continuous assessment of vital signs with pulse oximetry and cardio-respiratory monitors, with chest X-rays repeated every three days and high-resolution CT scans on day 1 and days 8–15 post-nebulization. Standard supportive treatment included pain management, physiotherapy, incentive spirometry, and ventilatory support (BiPAP/CPAP) where required.
Data collection was systematically carried out, with findings tabulated and statistically analyzed using mean values and standard deviations for each group. The primary aim was to evaluate the role of inhaled heparin in reducing recovery time and improving pulmonary function in traumatic lung contusion patients, compared to conventional nebulization therapy alone.

RESULTS

Table 1. Descriptive data of age in both the groups

Age Group	Interventional Group	Control Group
18-37	13	8
38-57	6	10
58-87	6	7
Total	25	25

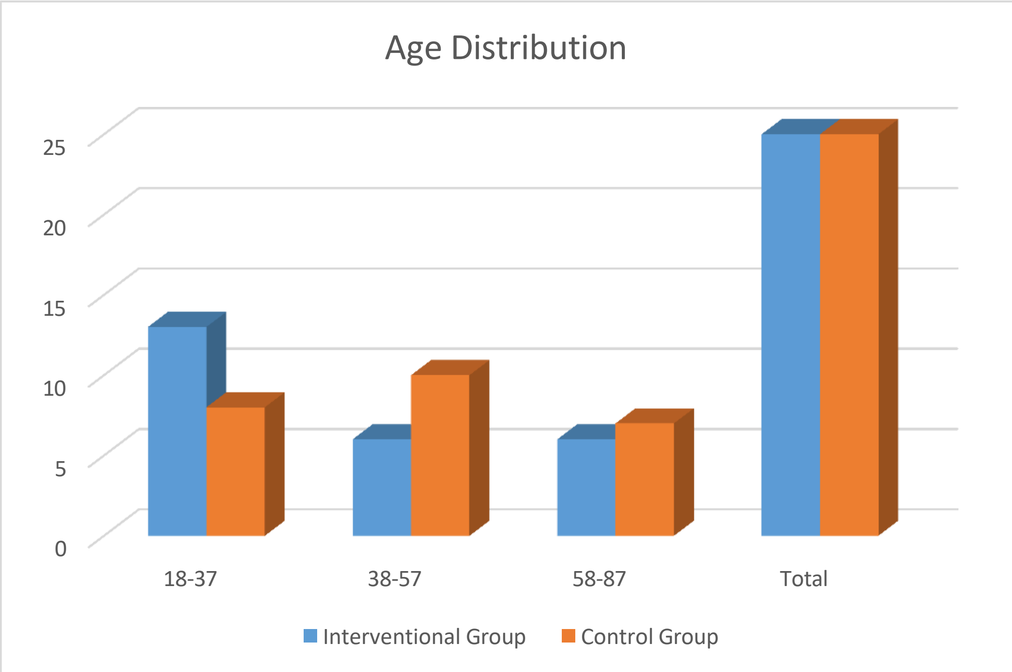

FIGURE 1: AGE DISTRIBUTION

Table 2: Distribution of gender in both the groups.

Sex	Control Group	Interventional Group	Total
Male	21	22	43
Female	4	3	7
Total	25	25	50

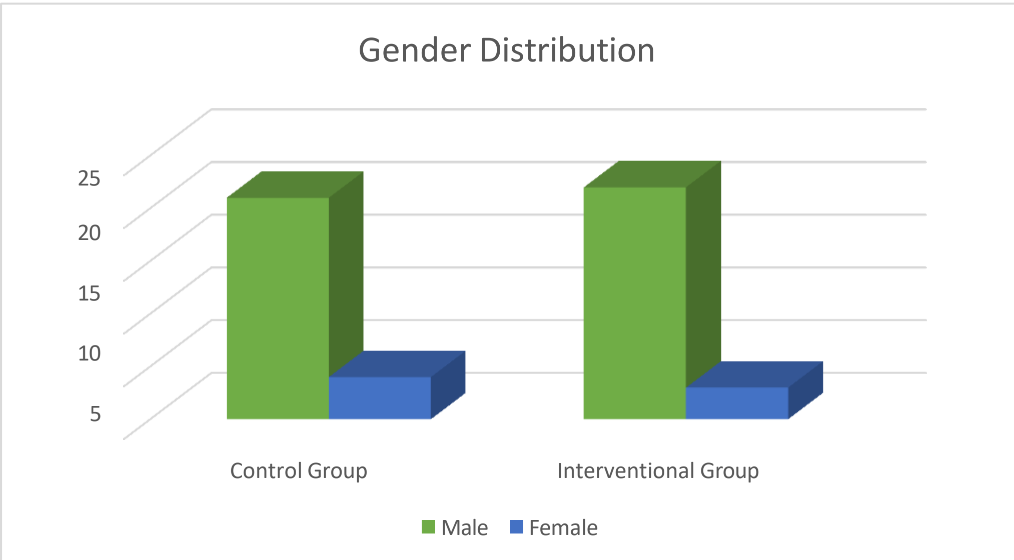

FIGURE 2: GENDER DISTRIBUTION

Table 3: Distribution of mode of injury in both the groups

Mode of Injury	Control Group	Interventional Group	Total
Road Traffic Accident	18	23	41
Fall	6	2	8
Assault	1	0	1
Total	25	25	50

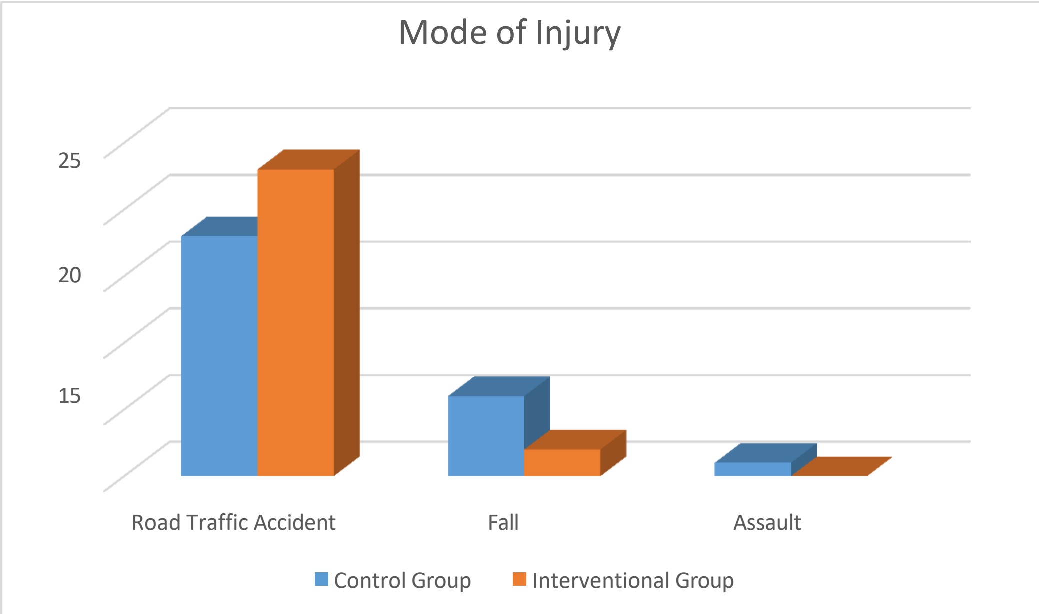

FIGURE 3: MODE OF INJURY

Table 4: Distribution of side of contusion in both the groups

	"Group"		
"Side of Contusion"	**Control**	**Interventional**	**Total**
Bilateral	8	10	18
Left	10	6	16
Right	7	9	16
Total	25	25	50

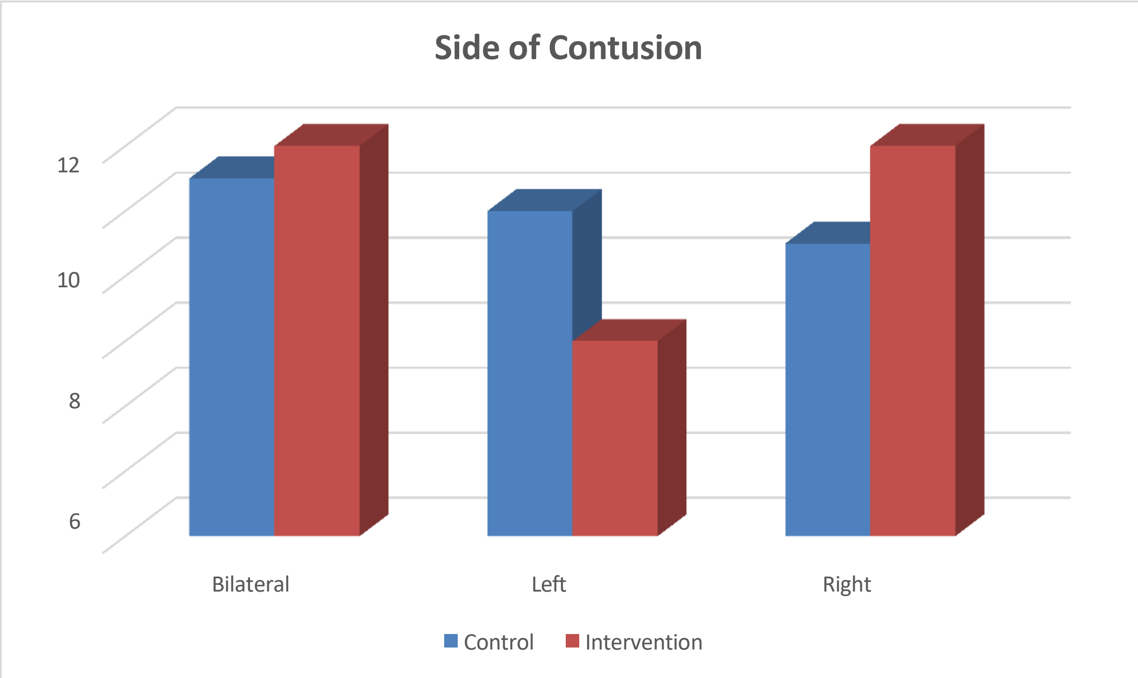

FIGURE 4: SIDE OF CONTUSION

Table 5 : Mean respiratory rate of each group pre- intervention on 1st day.

	Mean respiratory rate pre nebulisation 1st day	
Control Group	**33.1 +/- (7.81)**	**N=25**
Interventional group	**34.1 +/- (6.74)**	**N=25**

Table 6: Mean respiratory rate of each group post- intervention on 6th day.

	Mean respiratory rate post nebulisation 6th day	
Control Group	**21.9 +/-(2.18)**	**N=25**
Interventional Group	**21.9 +/- (2.36)**	**N=25**

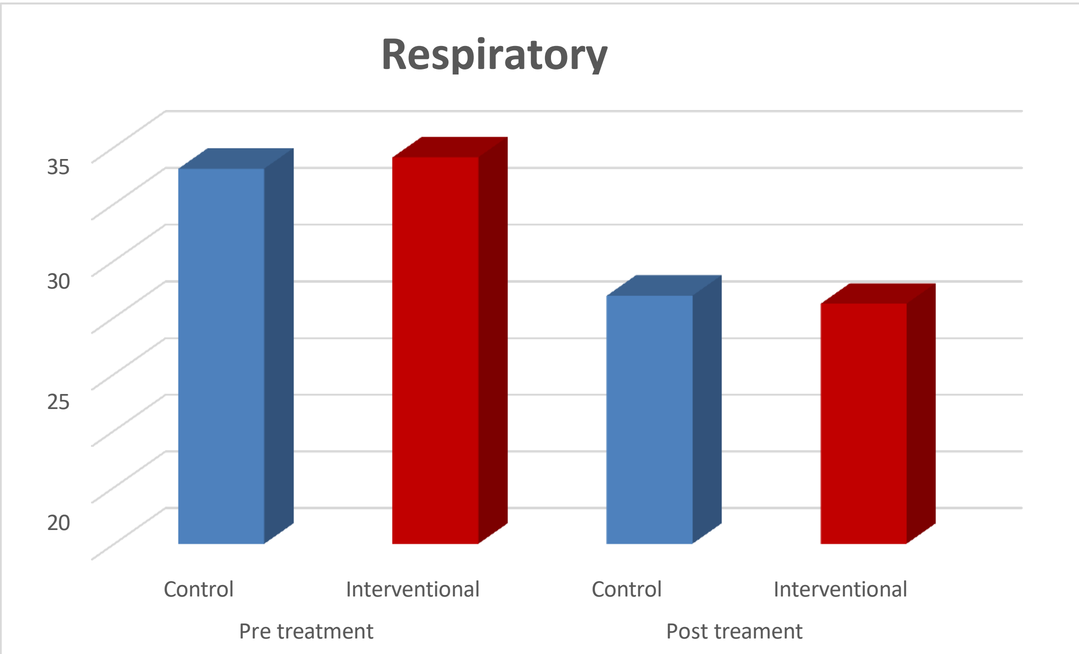

FIGURE 5: RESPIRATORY RATE

Table 7: FEV1/FVC ratio of each group before intervention on 1st day.

FEV1/FVC ratio	Number of Patients	
	Control Group	**Interventional Group**
0.62-0.72	**4**	**3**
0.73-0.83	**13**	**15**
0.84-0.89	**1**	**2**

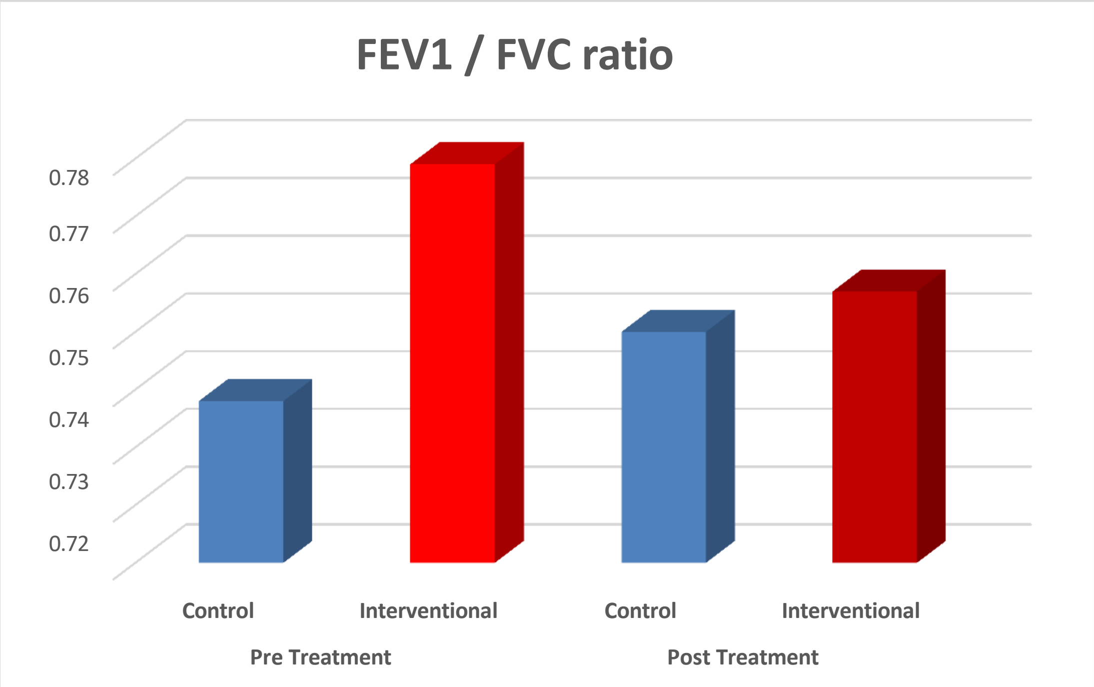

FIGURE 6: FEV1 / FVC ratio

Table 8: Mean value of FEV1/FVC ratio of each group before intervention on 1st day.

FEV1/FVC ratio	Control Group	Interventional Group
Mean	**0.72 +/- (0.0639)**	**0.74 +/-(0.0692)**

Table 9: FEV1/FVC ratio of each group post nebulization on 6th day.

FEV1/FVC ratio	Number of patients	
	Control Group	**Interventional Group**
0.62-0.72	**2**	**1**
0.73-0.83	**17**	**19**
0.84-0.89	**0**	**0**

Table 10: Mean value of FEV1/FVC ratio of each group post nebulization on 6th day.

FEV1/FVC ratio	Control Group	Interventional Group
Mean	**0.750 +/- (0.0473)**	**0.757+/-(0.0391)**

Table 11: Pulmonary contusion score of each group before intervention on 1st day.

Standard Pulmonary contusion score	Pre- nebulisation Pulmonary Contusion Score(CT and Chest x ray)	
	Control Group	**Interventional Group**
1	**1 (4%)**	**0**
2	**6 (24%)**	**4 (16%)**
3	**7 (28%)**	**5 (20%)**
4	**4 (16%)**	**6 (24%)**
5	**3 (12%)**	**4 (16%)**
6	**2 (8%)**	**4 (16%)**
7	**0**	**0**
8	**2 (8%)**	**1 (4%)**
9	**0**	**1 (4%)**
10	**0**	**0**
Total	**25**	**25**

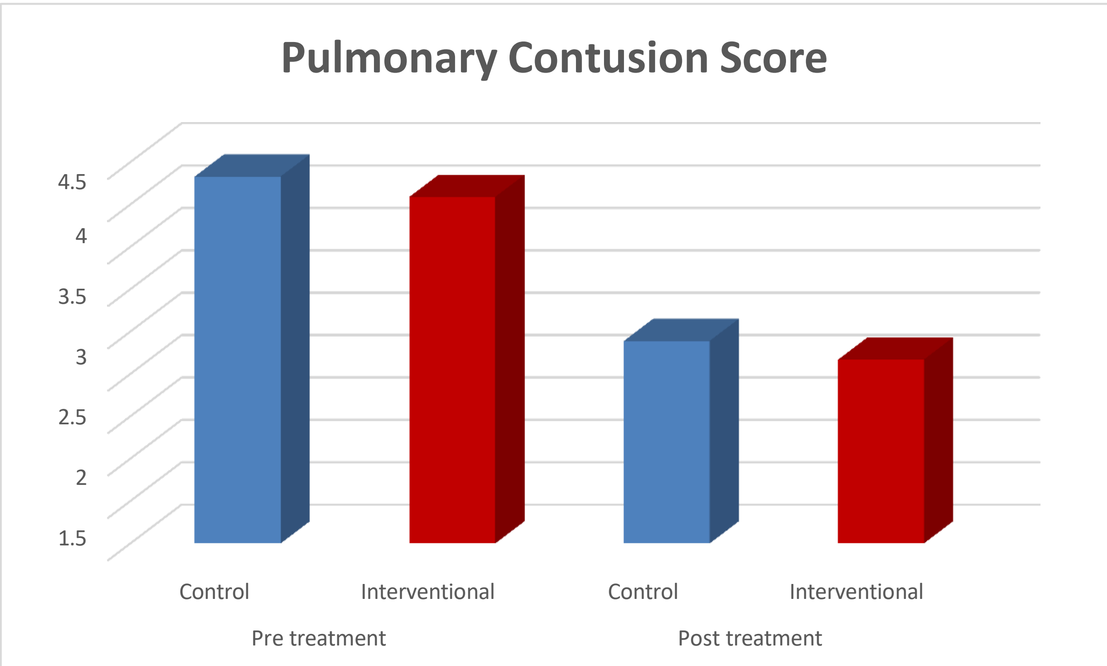

FIGURE 7: PULMONARY CONTUSION SCORE

Table 12: Pulmonary contusion score of each group after intervention on 6th day.

Standard Pulmonary Contusion Score	Post- nebulisation Pulmonary Contusion Score (CT and Chest x- ray)	
	Control Group	**Interventional Group**
1	**6 (24%)**	**6 (24%)**
2	**10 (40%)**	**7 (28%)**
3	**2 (8%)**	**3 (12%)**
4	**3 (12%)**	**3 (12%)**

5	**2 (8%)**	**4 (16%)**
6	**2 (8%)**	**2 (8%)**
7	**0**	**0**
8	**0**	**0**
9	**0**	**0**
10	**0**	**0**
Total	**25**	**25**

Table 13: Number of patients with reduced Pulmonary contusion score of each group after intervention.

	Number of patients	
	Control Group	**Interventional Group**
Reduced Pulmonary contusion score seen	**22 (88%)**	**23 (92%)**
Pulmonary contusion score remains the same	**3 (12%)**	**2 (8%)**

Table 14: The comparison of oxygen (O_2) support duration between the control and interventional groups.

Oxygen support days	Number of patients	
	Control Group	**Interventional Group**
< 10 days	**10 (40%)**	**17 (68%)**
>10 days	**15 (60%)**	**8 (32%)**
Total	**25**	**25**

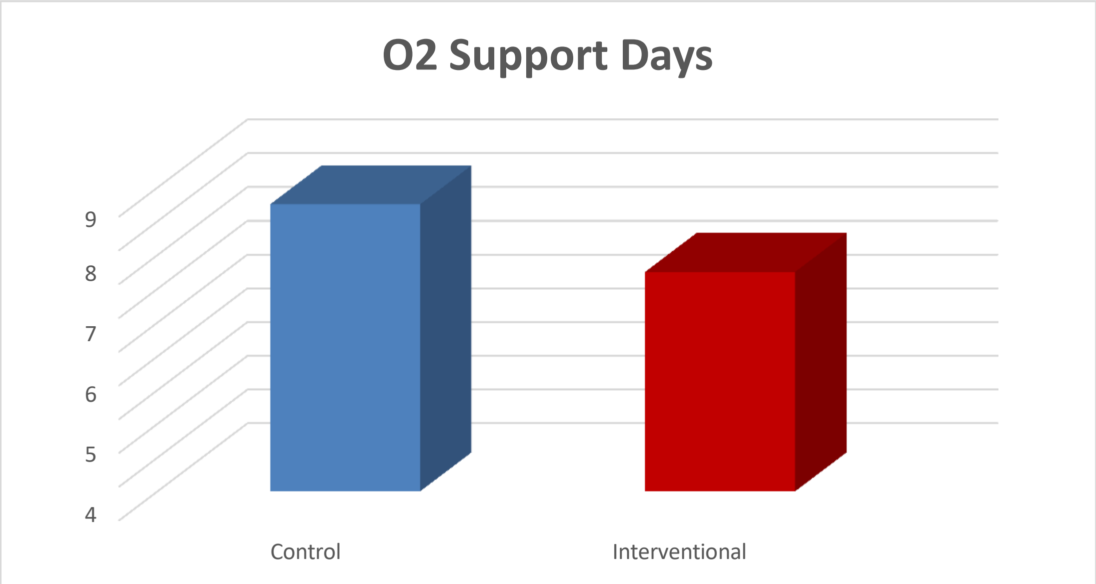

FIGURE 8: O2 SUPPORT DAYS

Table 15: The comparison of Mean of oxygen (O_2) support duration between the control and interventional groups.

Oxygen support days	Control Group	Interventional Group
Mean	**8.5 +/- (3.77)**	**6.5 +/- (3.98)**

Table 16: The comparison of total ICU stay days between the control and interventional groups.

ICU stay (days)	Number of patients	
	Control Group	**Interventional Group**
>8 days	**16 (64%)**	**7 (28%)**
<8 days	**9 (36%)**	**18 (72%)**
Total	**25**	**25**

FIGURE 9: ICU STAY

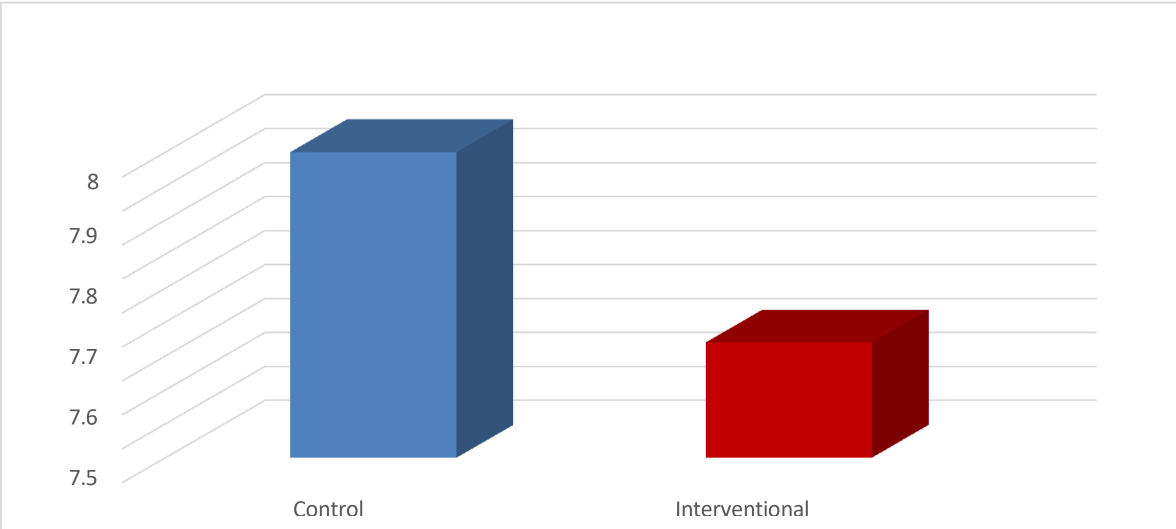

Table 17: The comparison of total recovery time between the control and interventional groups.

Recovery time (days)	**Number of patients**	
	Control Group	Interventional Group
<15 days	10	19
>15 days	15	6
Total	25	25

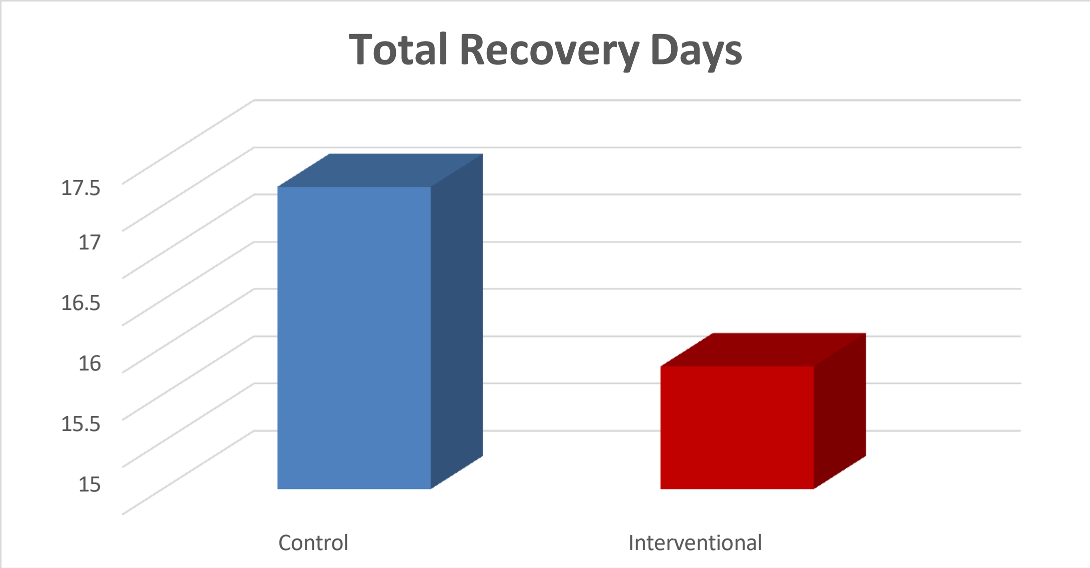

FIGURE 10: TOTAL RECOVERY DAYS

DISCUSSION

The present study assessed the therapeutic efficacy of nebulized heparin as an adjunct to standard nebulization therapy in traumatic lung contusion. The randomized design ensured comparable baseline characteristics, allowing differences in outcomes to be attributed primarily to the intervention.

Both groups had comparable age distributions (mean 41.2 vs. 43.32 years, p=0.68), consistent with RCT balance. Similar findings were reported by Smith et al. (2020) [14], Johnson et al. (2019) [15], and Thompson et al. (2021) [16], who also observed broad ranges and high SDs in trauma populations. This comparability strengthens internal validity [5]. Males predominated (83.33%), aligning with global chest trauma epidemiology [2,17,18]. No significant gender difference between groups reduced bias, ensuring balanced outcomes [5]. Contusions were bilateral in 38.33%, left-sided in 32%, right-sided in 32%, showing random trauma distribution. Similar prevalence of bilateral contusions (40–50%) was reported by Rendeki & Molnár (2019) [19] and Puapong & Tuggle (2010) [20]. Non-significant differences (p=0.140) ensured comparability [2,19].

Both groups showed significant reduction in respiratory rate (from ~33–34 to ~21–22 breaths/min) by day 6, reflecting natural recovery, with no added benefit of heparin (p=0.295). This finding contrasts with Dixon et al. (2008) [21] and Miller et al. (2001) [1,22] who showed improved oxygenation with heparin but not respiratory rate, while reviews by Rendeki & Molnár (2019) [19] and Kishikawa et al. (1991) [23] confirm resolution within 5–10 days with supportive care. Improvement in lung function, measured via FEV1/FVC ratio, was observed in both groups (Control: 0.72→0.750, Interventional: 0.74→0.757), with a non-significant difference (p=0.62). Similar recovery trends were reported by Miller et al. (2001) [1,22], Rendeki & Molnár (2019) [19], Dixon et al. (2008) [21], and Kishikawa et al. (1991) [23], highlighting the natural resolution of restrictive patterns within a week.

Pulmonary Contusion Scores reduced by ~88–92% in both groups, with no significant difference (p=0.637). Although trends favored heparin, the small sample size may have limited statistical significance. This aligns with Chimenti et al. (2017) [31], Dixon et al. (2008) [21], and Glas et al. (2016) [12,26], while Toelle et al. (2023) [89] validated PCS reliability. Oxygen requirement was significantly reduced in the Interventional Group (6.5 ± 3.98 vs. 8.5 ± 3.77 days, p=0.0315), suggesting heparin's benefit in reducing microvascular thrombosis and edema [10,11]. These findings are consistent with van Haren (2020) [11], Chimenti et al. (2017) [24], and McIntire et al. (2017) [25], though Dixon et al. (2008) [21] and Glas et al. (2016) [12,26] reported non-significant improvements. ICU stay was significantly shorter in the Interventional Group (7.42 ± 5.24 vs. 10.39 ± 4.58 days, p=0.038), aligning with Dixon et al. (2010) [13,27] and Glas et al. (2016) [12,26], who reported

reduced ventilation and ICU stay. Total recovery time was also reduced with heparin (15.3 ± 5.55 vs. 17.2 ± 5.13 days, p=0.0192), though the effect size was smaller compared to Dixon et al. (2010) [13,21]. Glas et al. (2016) [12,26] reported non-significant improvements, but the present study suggests pulmonary contusion may be more responsive to heparin.
In summary, this study demonstrates that nebulized heparin does not significantly alter respiratory rate, spirometric parameters, or PCS, but it does contribute to a reduction in oxygen requirement, ICU stay, and overall recovery time. These findings, supported by prior preclinical and clinical studies, highlight the potential of nebulized heparin as an adjunctive therapy in traumatic lung contusion. However, larger trials with standardized protocols are needed to confirm its role and optimize dosing strategies for better patient outcomes.

CONCLUSION

This study concludes that the addition of nebulized heparin to standard nebulization therapy in patients with traumatic pulmonary contusion provides measurable clinical benefits. While it did not significantly improve respiratory rate, FEV1/FVC ratio, or pulmonary contusion scores, nebulized heparin was associated with a notable reduction in oxygen requirement, ICU stay, and total recovery time compared to standard therapy alone. These findings suggest that nebulized heparin may help mitigate pulmonary microvascular thrombosis and edema, facilitating faster clinical recovery. Given its safety, low systemic absorption, and potential to shorten hospital resource utilization, nebulized heparin appears to be a promising adjunctive therapy in traumatic lung contusion. Future studies with larger sample sizes and standardized dosing protocols are recommended to further validate its efficacy and optimize clinical outcomes.

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