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The Prognostic Role of Biomarkers in Pulmonary Contusion

Akciğer Kontüzyonlarında Biyobelirteçlerin Prognostik Rolü

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ABSTRACT

Objective: Within the scope of this research, we aimed to elucidate the treatment and follow-up of pulmonary contusion patients by revealing the prognostic role of biomarkers. All parameters in total blood samples taken from the cases at the first admission were analyzed as biochemical biomarkers.
Method: A total of 482 patients aged 18 and over admitted to our institution due to thoracic traumas were examined. Among the cases admitted to the emergency department with injuries accompanied by blunt thoracic trauma, cases with radiologically proven pulmonary contusion were included in the study.
Results: WBCs, neutrophil, and lymphocyte count, neutrophil-lymphocyte ratio (NLR), ALT, AST, and LDH values were significantly higher in the group with pulmonary contusion ($p<0.05$). The lymphocyte levels were significantly lower in pulmonary contusion patients ($p<0.05$). The rate of complications, intensive care unit stay, requirement for mechanical ventilation, and mortality rate were significantly higher in the group with pulmonary contusion ($p>0.05$). The univariate analysis found that WBC, neutrophil and lymphocyte count, NLR, ALT, AST, and LDH parameters denoted a statistically significant difference between the two groups ($p>0.05$). WBC, neutrophil count, NLR, ALT, AST, and LDH values were significantly elevated in the group with lung contusion>50% ($p<0.05$).
Conclusion: In this study, WBC, neutrophil and lymphocyte count, NLR, ALT, AST, and LDH were predictive biomarkers. Additionally, age, motor vehicle accidents, falls, impact trauma mechanism, pneumothorax, injury site, and number of rib fractures were other contributing predictors that allow a wider range of clinical application and decision-making.

Keywords: Pulmonary Contusion, Biomarker, Prognosis.

ÖZET

Amaç: Bu araştırma kapsamında biyobelirteçlerin prognostik rolünü ortaya koyarak hastaların tedavi ve takibini aydınlatmayı amaçladık. Olgulardan ilk başvuruda alınan toplam kan örneğindeki tüm parametreler biyokimyasal biyobelirteçler olarak analiz edildi.
Yöntem: Kurumumuza göğüs travması nedeniyle başvuran 18 yaş ve üzeri toplam 482 hasta incelendi. Künt toraks travmasının eşlik ettiği yaralanmalarla acil servise başvuran olgulardan radyolojik olarak akciğer kontüzyonu kanıtlanmış olgular çalışmaya dahil edildi.
Bulgular: Akciğer kontüzyonu olan grupta BKH, nötrofil ve lenfosit sayısı, nötrofil-lenfosit oranı (NLO), ALT, AST ve LDH değerleri anlamlı derecede yüksekti ($p<0,05$). Akciğer kontüzyonu olan hastalarda lenfosit düzeyleri anlamlı derecede düşüktü ($p<0,05$). Pulmoner kontüzyonu olan grupta komplikasyon oranı, yoğun bakımda kalış süresi, mekanik ventilasyon gereksinimi ve mortalite oranı anlamlı olarak daha yüksekti ($p>0,05$). Tek değişkenli analizde WBC, nötrofil ve lenfosit sayısı, NLO, ALT, AST ve LDH parametrelerinin iki grup arasında istatistiksel olarak anlamlı farklılık gösterdiği bulundu ($p>0,05$). Akciğer kontüzyonu >%50 olan grupta BKH, nötrofil sayısı, NLO, ALT, AST ve LDH değerleri anlamlı derecede yüksekti ($p<0,05$).
Sonuç: Bu çalışmada BKH, nötrofil ve lenfosit sayısı, NLO, ALT, AST ve LDH öngörücü biyobelirteçlerdi. Ek olarak yaş, motorlu araç kazaları, düşmeler, darbe travma mekanizması, pnömotoraks, yaralanma bölgesi ve kaburga kırıklarının sayısı, daha geniş bir klinik uygulama ve karar verme aralığına izin veren katkıda bulunan diğer belirleyicilerdir.

Anahtar Kelimeler: Akciğer Kontüzyonu, Biyobelirteç, Prognoz.

INTRODUCTION

Pulmonary contusion is a common form of injury due to thoracic trauma. Pulmonary contusion is detected in 17 – 70% of major injuries. Although it can be seen with both blunt and penetrating injuries, it is more common, especially in in-vehicle traffic accidents, as a result of the chest hitting the steering wheel or door. It can also be seen with falls from a height, blast-style injuries, and high-velocity bullets (1). While pulmonary contusion occurs as isolated injuries in children, it is accompanied by other organ injuries in adults, and the mortality rate varies between 14 – 40% depending on the extent and severity of the contusion and other accompanying injuries. The thorax of children is extremely flexible because

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the ribs are elastic, the costal cartilages are not yet sufficiently ossified, and the ligaments are soft. Additionally, the mobility of mediastinal organs in children is greater than in adults. The flexibility allows them to be stretched excessively without breaking and causes energy to be directly transmitted to the underlying lung parenchyma. For this reason, children develop pulmonary contusions twice as often as adults in high-energy traumas (2).

Many changes occur in the lung parenchyma after contusion. Among these are hemorrhage, edema, and consolidation that cause deterioration of ventilation-perfusion ratio (VPR), hypoventilation, and decreased compliance resulting in hypoxia. Intra-alveolar hemorrhage (IAH) and interstitial edema are observed in localized areas in small-scale injuries. In more severe traumas, more widespread interstitial edema and hemorrhage occur in both alveolar and interstitial spaces. In adjacent lung areas that are not confused, increased mucus secretion, filling of the bronchial tree with blood and fluid, and surfactant concentration are observed (3).

Pulmonary contusion is the most common complication of blunt thoracic trauma (BTT). However, only approximately one-third of cases can be diagnosed in the acute phase. These types of injuries may result in the need for intensive care and mechanical ventilation (MV) as a result of hypoxia-hypoxemia. It is also an important risk factor for lung contusion, pneumonia, and acute respiratory complications. It is one of the main causes of Acute Respiratory Distress Syndrome (ARDS) in trauma patients. Additionally, approximately 25% of lung contusions are an independent risk factor for mortality in cases with thoracic trauma (4).

Pulmonary contusions are a type of injury that often accompanies blunt thoracic trauma. Non-surgical methods provide follow-up and treatment. Since it is a clinical condition that does not require surgical intervention, its existence is often ignored in practice. The requirement for mechanical ventilation increases in patients who do not receive a correct diagnosis and appropriate treatment, and it causes pulmonary complications that can reach ARDS (5).

Within the scope of this research, we aimed to elucidate the treatment and follow-up of patients by revealing the prognostic role of biomarkers based on our four-year experience. As biochemical parameters, all parameters in the complete diagnostic count studied from blood samples taken from the cases at the time of first admission were analyzed.

METHOD

A total of 482 patients aged 18 and over admitted to our institution between May 2019 and November 2023 due to thoracic traumas were examined. Among the cases admitted to the emergency department with injuries accompanied by blunt thoracic trauma, cases with radiologically proven pulmonary contusion were included in the study.

All procedures followed were in accordance with the cal standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008. Ethics committee approval has been granted from our institution with protocol number, 05.12.2023 /06 and informed consent has been obtained from all participants.

Cases with and without pulmonary contusions were compared in terms of age, gender, additional organ injuries, and tissue damage (such as rib fractures, lung contusion, hemothorax, abdominal organ injuries, head & neck injuries, pelvis and extremity injuries), severity contusion, intensity, type of treatment, trauma-related lung contusion from other clinics. The consultation rates, duration of hospital stay, complications, mechanical ventilation and intensive care unit (ICU) requirement, and mortality rates were investigated.

Statistical Analysis

Patient data collected within the scope of the study were analyzed with the IBM Statistical Package for the Social Sciences (SPSS) for Windows 28.0 (IBM Corp., Armonk, NY) package program. Frequency and percentage for categorical data and mean and standard deviation for continuous data were given as descriptive values. For comparisons between groups, the “Independent Sample T–test” was used for two groups, and the "Pearson Chi-Square Test" was used to compare categorical variables. The results were considered statistically significant when the p-value was less than 0.05.

RESULTS

A total of 482 patients with radiology-confirmed pulmonary contusion diagnoses were included in this study. The age of the patients in the group with pulmonary contusion was significantly ($p<0.05$) lower than those without pulmonary contusion. Gender distribution did not differ significantly ($p>0.05$) between the groups. The motor vehicle trauma rate in the group with lung contusion was significantly higher ($p<0.05$). The rate of non-vehicular traffic accidents in the group with pulmonary contusion was significantly higher ($p<0.05$). The rate of pneumothorax, hemothorax, clavicle, scapula, head, vertebra, pelvis, abdominal organ, and extremity injuries in the group with lung contusion was significantly higher ($p<0.05$) (Table 1).

Table 1. Comparison of Effective Factors in Pulmonary Contusion Prognosis

		Pulmonary Contusion (-)			**Pulmonary Contusion (+)**			**p-value**	
		Mean±SD/n-%		Median	Mean±SD/n-%		Median		
Age		53.9 ± 18.5		55.0	48.6 ± 18.8		48.0	***0.003***	m
Gender	Female	45	26.5%		65	20.8%		0.159	X^2
	Male	125	73.5%		247	79.2%			
Vehicle trauma	(-)	97	57.1%		133	42.6%		***0.002***	X^2
	(+)	73	42.9%		179	57.4%			
Vehicle trauma									
In-Vehicle Traffic Accident		53	31.2%		116	37.2%		0.187	X^2
Fall		72	42.4%		94	30.1%		***0.007***	X^2
Motorcycle accident		10	5.9%		30	9.6%		0.156	X^2
Non-Vehicular Traffic Accident		7	4.1%		28	9.0%		***0.050***	X^2
Work accident		9	5.3%		19	6.1%		0.721	X^2
Being trapped under rubble		3	1.8%		15	4.8%		0.092	X^2
Assault		7	4.1%		2	0.6%		***0.007***	X^2
Animal Butting		6	3.5%		3	1.0%		***0.047***	X^2
Tractor Accident		3	1.8%		5	1.6%		0.894	X^2
Type of Injury									
Pneumothorax		12	7.1%		129	41.3%		***0.000***	X^2
Hemothorax		10	5.9%		57	18.3%		***0.000***	X^2
Rib Fracture		151	88.8%		269	86.2%		0.414	X^2
Number of Rib Fractures		2.6 ± 1.6		3.0	4.8 ± 2.5		5.0	***0.000***	m
Clavicle		7	4.1%		58	18.6%		***0.000***	X^2
Sternum		24	14.1%		30	9.6%		0.134	X^2
Scapula		3	1.8%		78	25.0%		***0.000***	X^2
Head		20	11.8%		102	32.7%		***0.000***	X^2
Vertebra		16	9.4%		92	29.5%		***0.000***	X^2
Pelvis		10	5.9%		68	21.8%		***0.000***	X^2
Abdominal Organ		7	4.1%		53	17.0%		***0.000***	X^2
Extremity		19	11.2%		81	26.0%		***0.000***	X^2

^{m} Mann-Whitney-U test / X^2 Chi-square test

White blood cells (WBC), neutrophil, neutrophil-lymphocyte ratio (NLR), ALT (Alanine aminotransferase), AST (Aspartate aminotransferase), and LDH (Lactate dehydrogenase) values were significantly higher in the group with pulmonary contusion (p<0.05). The lymphocyte count was significantly lower in pulmonary contusion patients (p<0.05) (Table 2).

Table 2. Injuries in the Group With and Without Pulmonary Contusion

		Pulmonary Contusion (-)				Pulmonary Contusion (+)				p-value	
		Mean±SD/n-%			Median	Mean.±SD/n-%			Median		
WBC		8.8	±	3.5	8.2	17.5	±	6.4	16.3	***0.000***	m
Neutrophil		5.9	±	3.1	5.0	14.7	±	7.6	13.8	***0.000***	m
Neutrophil %		63.6	±	13.8	63.1	80.4	±	13.7	85.0	***0.000***	m
Lymphocyte		2.46	±	4.37	1.87	2.49	±	5.27	1.40	***0.000***	m
Lymphocyte %		25.4	±	11.5	25.0	11.4	±	9.5	8.0	***0.000***	m
NLR		3.8	±	5.5	2.5	12.2	±	10.0	10.4	***0.000***	m
ALT		42.9	±	179.5	21.0	91.5	±	125.6	48.0	***0.000***	m
AST		40.6	±	128.3	22.0	126.3	±	224.7	62.5	***0.000***	m
LDH		229.0	±	168.3	195.5	604.1	±	667.9	475.0	***0.000***	m
Complication	(-)	169		99.4%		250		80.1%		***0.000***	X²
	(+)	1		0.6%		62		19.9%			
Intensive Care Unit	(-)	149		87.6%		114		36.5%		***0.000***	X²
	(+)	21		12.4%		198		63.5%			
Hospitalization	(-)	4		2.4%		3		1.0%		0.222	X²
	(+)	166		97.6%		309		99.0%			
Duration of Hospitalization		4.0	±	3.6	3.0	9.0	±	6.5	7.0	***0.000***	m
Requirement for Mechanical Ventilation	(-)	161		94.7%		250		80.1%		***0.000***	X²
	(+)	9		5.3%		62		19.9%			
Duration in Mechanical Ventilation		1.00	±	0.00	1.00	1.23	±	1.11	1.00	0.503	m
Outcome	Discharged	167		98.2%		291		93.3%		***0.017***	X²
	Deceased	3		1.8%		21		6.7%			

m Mann-Whitney-U test / X² Chi-square test

The rate of complications, intensive care unit stay, requirement for mechanical ventilation, and mortality rate were significantly higher in the group with pulmonary contusion. Still, the hospitalization rate did not differ significantly (p>0.05).

The univariate analysis found that WBC, neutrophil and lymphocyte count, NLR, ALT, AST, and LDH parameters denoted a statistically significant difference between the two groups (p>0.05). Additionally, age, motor vehicle accidents, falls, impact trauma mechanism, pneumothorax, injury site (hemothorax, clavicle, scapula, head, vertebra, pelvis, abdominal organ), and number of rib fractures were also different (p<0.05) (Table 3).

The multivariate analysis revealed a significant and independent effect of pneumothorax, injury site, number of rib fractures, WBC, and lymphocyte count in distinguishing patients with and without pulmonary contusion (p<0.05) (Table 3).

The rate of pneumothorax, hemothorax, clavicle, scapula, head, vertebra, pelvis, abdominal organ, and extremity injuries in the group with lung contusion>50% was significantly higher than in the other group (p<0.05).

Complications, requirements for mechanical ventilation, duration of mechanical ventilation, length of hospital stay, intensive care unit admission, and mortality rate were also significantly higher (p<0.05).

WBC, neutrophil count, NLR, ALT, AST, and LDH values were significantly elevated in the group with lung contusion>50% (p<0.05) (Table 4).

Table 3. The Effective Factors in Pulmonary Contusion Prognosis Via Univariate And Multivariant Analysis

	Univariant Analysis			**Multivariant Analysis**		
	OR	95% CI	p-value	OR	95% CI	p-value
Age	0.985	0.975 - 0.995	***0.004***			
Vehicle trauma	1.788	1.226 - 2.609	***0.003***			
Mechanism of Trauma						
Non-Vehicular Traffic Accident	2.296	0.981 - 5.373	0.055			
Fall	0.587	0.398 - 0.866	***0.007***			
Assault	0.150	0.031 - 0.731	***0.019***			
Animal Butting	0.265	0.066 - 1.075	0.063			
Pneumothorax	9.281	4.950 - 17.403	***0.000***	4.986	1.904 - 13.053	***0.001***
Hemothorax	3.576	1.775 - 7.205	***0.000***			
Number of Rib Fractures	1.690	1.489 - 1.920	***0.000***	1.465	1.222 - 1.757	***0.000***
Clavicle	5.317	2.369 - 11.935	***0.000***			
Scapula	18.556	5.758 - 59.792	***0.000***			
Head	3.643	2.159 - 6.146	***0.000***			
Vertebra	4.025	2.278 - 7.113	***0.000***			
Pelvis	4.459	2.230 - 8.918	***0.000***			
Abdominal Organ	4.765	2.115 - 10.735	***0.000***			
Extremity	2.787	1.624 - 4.782	***0.000***			
WBC	1.542	1.423 - 1.670	***0.000***	1.444	1.310 - 1.593	***0.000***
Neutrophil	1.584	1.455 - 1.724	***0.000***			
Neutrophil %	1.088	1.070 - 1.107	***0.000***			
Lymphocyte	1.001	0.964 - 1.039	0.966			
Lymphocyte %	0.893	0.874 - 0.912	***0.000***	0.937	0.910 - 0.964	***0.000***
NLR	1.311	1.235 - 1.390	***0.000***			
ALT	1.007	1.003 - 1.010	***0.000***			
AST	1.014	1.009 - 1.020	***0.000***			
LDH	1.008	1.007 - 1.010	***0.000***			
Requirement for Mechanical Ventilation	4.436	2.145 - 9.175	***0.000***			

Logistic Regression (Forward LR)

DISCUSSION

Thoracic trauma usually results in injuries accompanied by high morbidity and mortality. It plays an important role in the causes of death in the first four decades. Chest trauma is seen in 70% of blunt traumas that occur as a result of motor vehicle accidents. When evaluating a patient with thoracic trauma, attention should be paid to the neck veins, the patient's appearance, chest wall movement, chest area palpation and percussion, and respiratory pattern (4,5). Effective treatment in critically ill patients depends on rapid diagnosis and application of aggressive treatment without delay. In the initial evaluation phase, knowing the mechanism of injury, radiological findings, the location of major injury, and vital signs should be evaluated together, and appropriate treatment should be selected (6). The most common finding in thoracic traumas is rib fractures. It is most commonly observed in 4th – 9th ribs after blunt thoracic trauma. Complications such as pneumothorax, hemothorax, and rib fracture may accompany lung contusion. Chest traumas are of great importance, as injuries to the esophagus, heart, diaphragm, and large vessels may occur in addition to the rib cage and lungs. In thoracic traumas with high mortality and morbidity, knowing the cause and mechanism of trauma during the diagnosis and treatment phase is important for the correct guidance. Lung contusion, which is quite common in blunt thoracic trauma, may accompany pneumothorax, hemothorax, and rib fractures (7). In our study, complications, requirements for mechanical ventilation, duration of mechanical ventilation, length of hospital stay, intensive care unit admission, and mortality rate were significantly higher, and WBC, neutrophil count, NLR, ALT, AST, and LDH values were significantly elevated in the group with lung contusion>50%.

Table 4. Injuries in the group with and without 50% pulmonary contusion

		Pulmonary Contusion <50%		Pulmonary Contusion >50%		p-value	
		Mean±SD/n-%	Median	Mean±SD/n-%	Median		
WBC		15.1 ± 5.2	14.3	20.0 ± 6.6	19.0	***0.000***	m
Neutrophil		13.0 ± 8.4	12.1	16.6 ± 6.0	15.9	***0.000***	m
Neutrophil %		78.4 ± 14.9	83.5	82.4 ± 12.1	85.7	***0.003***	m
lymphocyte		2.70 ± 6.30	1.34	2.25 ± 3.90	1.46	0.410	m
Lymphocyte %		12.2 ± 9.4	8.9	10.6 ± 9.6	7.3	***0.033***	m
NLR		11.2 ± 10.6	9.4	13.2 ± 9.1	11.3	***0.010***	m
ALT		65.7 ± 91.9	34.0	119.1 ± 149.1	68.0	***0.000***	m
AST		79.5 ± 99.7	46.0	176.3 ± 298.7	90.0	***0.000***	m
LDH		466.6 ± 301.3	390.0	750.7 ± 886.6	597.0	***0.000***	m
Complication	(-)	144 89.4%		106 70.2%		***0.000***	X²
	(+)	17 10.6%		45 29.8%			
Intensive Care Unit	(-)	88 54.7%		26 17.2%		***0.000***	X²
	(+)	73 45.3%		125 82.8%			
Hospitalization	(-)	2 1.2%		1 0.7%		1.000	X²
	(+)	159 98.8%		150 99.3%			
Duration of Hospitalization		7.0 ± 4.9	6.0	11.1 ± 7.4	9.0	***0.000***	m
Requirement for Mechanical Ventilation	(-)	148 91.9%		102 67.5%		***0.000***	X²
	(+)	13 8.1%		49 32.5%			
Duration in Mechanical Ventilation		2.08 ± 2.29	1.00	1.00 ± 0.00	1.00	***0.001***	m
Outcome	Discharged	158 98.1%		133 88.1%		***0.000***	X²
	Deceased	3 1.9%		18 11.9%			

m Mann-Whitney-U test / X² Chi-square test (Fischer test)

In previous literature, the predictive indicators and biomarkers were not investigated sufficiently. A majority of the published data were focused on the diagnosis, imaging, treatment, and surgery outcomes. Within the scope of this study, we tried to explore and emphasize the importance of biomarkers in the development of pulmonary contusion. Additionally, the clinical significance of several findings was elaborated (8– 10). In our study, the rate of complications, intensive care unit stay, requirement for mechanical ventilation, and mortality rate were significantly higher in the group with pulmonary contusion.

Li et al. reported that IL-17 could be used as a potential biomarker to predict the severity of pulmonary contusion. In their study, they tried to find the association between IL-17 and IL-22 in blunt-force thoracic trauma. Their research revealed that IL-17 was strongly associated with pulmonary contusion volume. Additionally, IL-17 was significantly associated with pro-inflammatory complications in pulmonary contusion patients and could be used as a biomarker for predicting in-patient outcomes of patients with pulmonary contusion (11). Hoth et al. elaborated that blunt chest injury resulting in pulmonary contusion primes innate immunity for an exaggerated TLR4 response. Once triggered, TLR4 signaling activates innate immune mechanisms, resulting in NFκB activation and expression of a number of proinflammatory mediators, including IL-1β, IL-6, and IL-8 (12). As biomarkers, we have investigated WBCs, neutrophil, NLR, ALT, AST, and LDH values and found that they were significantly higher in the group with pulmonary contusion, while the lymphocyte count was lower.

The scoring systems for evaluating injury severity in patients with pulmonary contusions include the chest abbreviated injury scale (AIS) and injury severity score (ISS). However, because these scoring systems are obtained through anatomical abnormalities, they have limitations in representing functional impairment or predicting prognosis (13–15). Quantifying pulmonary contusion volume using initial computerized tomography (CT) in patients with chest trauma allows early identification of patients at high risk of delayed respiratory complications, such as pneumonia. Moreover, it can improve the treatment effect in patients with chest trauma by preventing complications (16).

Pulmonary contusions are perceived as severe and fatal cases in thoracic trauma patients. The requirements for mechanical ventilation and intensive care unit admissions are extremely high. These individuals are at risk of developing respiratory complications, such as pneumonia and ARDS. Early identification of cases, concomitant risk factors, and probable complications are essential regarding these facts. In previous studies, the Glasgow Coma Scale (GCS), LDH levels, and the ratio of pulmonary contusion volume/total lung volume were utilized by clinicians (17).

Some physicians investigated the reliability of the Thoracic Trauma Severity Score (TTSS) and stated that it was useful to predict ARDS in chest traumas. This scoring system is mainly based on the PaO2 /FiO2 ratio. However, hypoxemia is not always observed during the initiation of ARDS. Some authors utilized the Yang Index and reported positive outcomes to evaluate pulmonary contusions. Last but not least, the Yang Index is linearly correlated with volume reconstruction. The number of fractured rib(s) and the Yang Index were two independent risk factors for respiratory failure. Other objective indicators that can be collected at admission, such as the severity of rib fracture and severe comorbid fracture(s) (spine, pelvis, and/or femur), can also be used in predicting pulmonary complications. This model can identify high-risk patients at an early stage (18). In our study, age, motor vehicle accidents, falls, impact trauma mechanism, pneumothorax, injury site, number of rib fractures, WBC, and lymphocyte count were significantly different in patients with pulmonary contusion.

CONCLUSION

A prognostic model or established biomarkers is an unmet need for patients with pulmonary contusion. Identification of high-risk patients and initiating treatment in the window of opportunity phase with supportive therapy. In this study, WBC, neutrophil and lymphocyte count, NLR, ALT, AST, and LDH were predictive biomarkers. Additionally, age, motor vehicle accidents, falls, impact trauma mechanism, pneumothorax, injury site, and number of rib fractures were other contributing predictors that allow a wider range of clinical application and decision-making.

DESCRIPTIONS

No financial support.

No conflict of interest.

Ethical Declaration: All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008. Ethics committee approval has been granted from our institution. Informed consent was obtained from all participants.

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