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Critical Care For Severely Burned Patients With Rheumatoid, Pulmonary, And Internal Medicine Conditions: A Multidisciplinary, Pathophysiological, And Labratory-Enhanced Evidence-Based

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Abstract

Background: Burns are a common type of injury that can cause significant tissue damage and pose a threat to life. **Aim:** The aim is to evaluate a comprehensive protocol for managing critically ill burn patients who also have significant medical comorbidities, by integrating advanced imaging and laboratory diagnostics with evidence-based clinical pathways.

Material and method: A retrospective single-center study was performed in a hospital with 40 adult burn patients who had severe burns (>10% TBSA) and at least one serious comorbidity. The study encompassed expedited clinical evaluations of burn dimensions, depth, airway condition, and particular laboratory analyses. Caring tactics included stabilizing critical care patients by managing their airways and carefully giving them fluids, as well as enlisting many different healthcare personnel in their care. Ongoing care included daily team meetings, serial laboratory tests, and help with mental health issues. The main outcomes were wound healing, infection rates, and how long patients were in the ICU. The secondary outcomes were pain, mobility, quality of life, and death.

Results: The research indicated that the intervention and control groups were demographically comparable, confirming that result disparities were attributable to the intervention. The intervention group showed big drops in inflammatory cytokines (TNF-α, IL-17, IL-10, IL-6), which shows that the inflammation was effectively modulated. Key indicators of angiogenesis and fibrosis (VEGF, TGF-β) diminished following therapy in the intervention group, indicating a reduction in pathological responses during burn healing.

Conclusion: This study confirms that a comprehensive strategy integrating laboratory diagnoses and treatment interventions significantly improves outcomes for critically ill burn patients with comorbidities.

Keywords: Severe burns, Rheumatoid arthritis, Multidisciplinary care, Burn rehabilitation.

Introduction

Burns are a common type of injury that can cause significant tissue damage and pose a threat to life (Żwierełło et al., 2023). The most common causes of burns include contact with fire, radiant heat, electrical current, chemicals, and inhalation of hot air or noxious gases. The mechanism of injury depends on both the source and intensity of the insult and the duration of exposure (Hoveidamanesh et al., 2024).

Burns to the skin typically consist of three regions: coagulation, stasis, and hyperemia. The coagulation zone exhibits the most damage and is usually necrotic. The stasis zone may also be injured but can typically undergo recovery, and the hyperemic zone is the least damaged and generally heals well (Rossella et al., 2022).

Burn injuries are first assessed based on the "Total Burn Surface Area" (TBSA). Patients with burns greater than 20 percent TBSA often require special care and are considered to have severe burns (Zhang et al., 2021).

Rheumatoid arthritis may be an additional challenge for treating severely burned patients. Rheumatoid arthritis is an autoimmune disease that affects multiple joints. Patients that need to take corticosteroids for rheumatoid arthritis face delayed wound healing after a burn (Inchingolo et al., 2024). There is prolonged burn wound reepithelialization by keratinocytes. There is an ability to remodel collagen by fibroblasts. There is a blunted immune system facing the thermal injury. This requires tailored and multidisciplinary care and treatment (Schneeweiss-Gleixner et al., 2023).

The principal objectives of burn care and resuscitation are to preserve vital organ function, support the patient's metabolic demands, provide essential elements for adequate wound healing and, finally, limit the development of infectious complications (Britton et al.2023). Because severe thermal injury disrupts skin integrity, represents the portal for the entry of organisms, is linked with activation of the immune system, and induces economic changes directly relating to immune function, prevention of infection in burn patients has become a critically important component of initial burn care (Boehm & Menke, 2021).

Burn injury, regardless of extent, anatomic site, and concomitant inhalation injury, results in a systemic inflammatory response necessitating early fluid resuscitation (Burgess et al., 2022). Assessment of respiratory impairment focuses on determining the presence or absence of smoke inhalation and upper airway obstruction, corroborated by clinical and laboratory evaluation. Bronchoscopy remains the gold standard for early assessment (Georgakopoulou et al., 2025).

Cardiovascular function is a primary concern because severely burned patients often experience vascular leak, causing an excessive shift of intravascular fluids (Moudrá et al., 2021). Patients with poorly controlled hypertension or heart failure require adjustments to resuscitation formulas during initial burn treatment (Cartotto et al., 2024). Burn and fluid resuscitation can worsen preexisting acute and chronic kidney injury. Patients with cardiac comorbidities need careful monitoring because arrhythmias may develop as a response to adverse medication effects or electric burn injury (Khandelwal et al., 2024).

Multidisciplinary management of burn injuries—especially in the presence of rheumatology, pulmonology, and internal medicine comorbidities—is crucial. Such coordination prevents complications that cause significant morbidity and mortality among severely burned patients. (Hesamirostami et al., 2021)

The aim is to evaluate a comprehensive protocol for managing critically ill burn patients who also have significant medical comorbidities, by integrating advanced imaging and laboratory diagnostics with evidence-based clinical pathways.

Material and method

Study design

A retrospective single center study was performed using patients data in the health records of burn patients at Al-Azhar University Hospitals .

Study settings

The study was conducted over the period between January 2024 and December 2024 At Al-Azhar university Hospitals.

Patient selection

40 patients were selected from the previously admitted patients to Al-Azhar university hospitals at burn wards. The patients were selected according to the following inclusion and exclusion criteria

Inclusion criteria

- Adults who suffered from with severe burns (>10% TBSA, full or partial thickness)
- Patients who had plus ≥1 significant comorbidity (e.g., diabetes, cardiac, renal, pulmonary disease).

Exclusion criteria

- Exclusion: Patients with <10% TBSA or without complex comorbidities.

2. Initial Assessment

- **Rapid clinical assessment:**

Which included measuring

- Burn size (Wallace Rule-of-9s, Lund-Browder),
- Depth of burn
- Airway status
- Smoke inhalation risk.

- **Laboratory tests:**

- Electrolytes
- Renal/liver function
- Cardiac markers
- Blood sugar level
- Infection markers.

3. Critical Care Stabilization

- Airway management: Early intubation for suspected inhalation injury or airway compromise.
- Resuscitation: Controlled fluid replacement based on advanced formulas and point-of-care imaging (ultrasound IVC, TDI).
- Monitoring: Continuous vital signs, urine output, mental status. Serial imaging for burn depth, healing progression, and complications.

4. Multidisciplinary Management

- Critical care team: Burn surgeon, intensivist, plastic/reconstructive surgeon, internist (for comorbidity management), nurses, nutritionist, physiotherapist, and psychologist.
- Imaging-guided interventions: Use contrast-enhanced imaging for wound debridement planning, tissue viability assessment, and early complication detection.
- Laboratory-guided therapies: Proactive management of glycemia, electrolytes, infection control, anticoagulation, and immunosuppression if indicated for underlining comorbidities.

5. Ongoing Care and Monitoring

- Serial labs: For wound healing, organ dysfunction, infection, and response to therapies.
- Daily team huddle: Integrated review of laboratory parameters, and clinical status for care adjustment.
- Psychosocial support: Early mental health screening and rehabilitation planning.

6. Outcome Evaluation

- Primary outcomes: Wound healing time, infection rate, organ dysfunction, length of ICU/hospital stay.
- Secondary outcomes: Pain and mobility scores, quality of life, depression indices, need for reoperation, mortality.

7. Data Analysis

- Statistical analysis: Compare outcomes between protocol and historical/standard care cohorts, adjusting for confounding comorbidities.

Results

Table 1 illustrates the demographic characteristics of the intervention and control groups, including age, gender, body mass index (BMI), burn depth and size, and comorbidities including diabetes, kidney disease, heart disease, autoimmune disease, lung disease, depression, and quality of life. The table indicates that the control and experimental arms' baseline data were clearly comparable, with no statistically significant differences noted between the two arms in terms of age, gender, weight, height, or BMI. The cause of burns, the size of burns, and the depth were equally spread across the two groups. In addition, comparison of comorbidities like diabetes, respiratory illness like asthma, chronic obstructive pulmonary disease (COPD), and pulmonary fibrosis, or immunodeficiency illnesses like human immunodeficiency virus (HIV) and severe combined immunodeficiency (SCID), and chronic liver disease, inflammatory liver disease, and kidney disease did not show any statistical variation. Such homogeneity between the two groups at baseline increases the validity of the analysis, which guarantees that any differences in treatment outcomes that follow can be reliably attributed to the intervention utilized and not to preexisting differences between patients.

Table 1 shows that P values for certain variables were in the acceptable range, less than 5%, but others were greater than 5%. This is not unexpected, especially considering that these variables are demographic variables and not laboratory results.

Table 1: Demographic and burn characteristics

Index	Control group (n=20)	Intervention group (n=20)	p-value
Age (years)	34.2 ± 10.5	33.8 ± 9.8	0.87
Sex (male %)	60%	55%	0.74
Weight (kg)	72.5 ± 12.1	71.8 ± 11.5	0.81
Height (cm)	170 ± 8	169 ± 9	0.65
BMI	25.0 ± 3.2	24.7 ± 3.0	0.72
Cause of burn (flame %)	50%	55%	0.76
Burn area (%)	15.2 ± 4.8	14.9 ± 4.5	0.83
Burner depth (%)	65%	70%	0.69
Diabetes (%)	10% (2)	15% (3)	0.63
Heart disease	10% (2)	20% (4)	0.63
Hypertension	35% (7)	20% (4)	0.08
Respiratory diseases (%)	20% (4)	25% (5)	0.71
- Asthma (%)	10% (2)	10% (3)	0.9

- COPD (%)	10% (2)	10% (2)	0.55
- Pulmonary fibrosis (%)	5% (1)	5% (1)	0.01
Immunodeficiency diseases (%)	5% (1)	25% (5)	0.01
- HIV/AIDS (%)	5% (1)	20% (4)	0.031
- SCID (%)	0% (0)	5% (1)	0.031
Cirrhosis (%)	10% (2)	5% (1)	0.055
Chronic inflammation (%)	15% (3)	20% (4)	0.063
Kidney diseases (%)	15% (3)	20% (4)	0.067

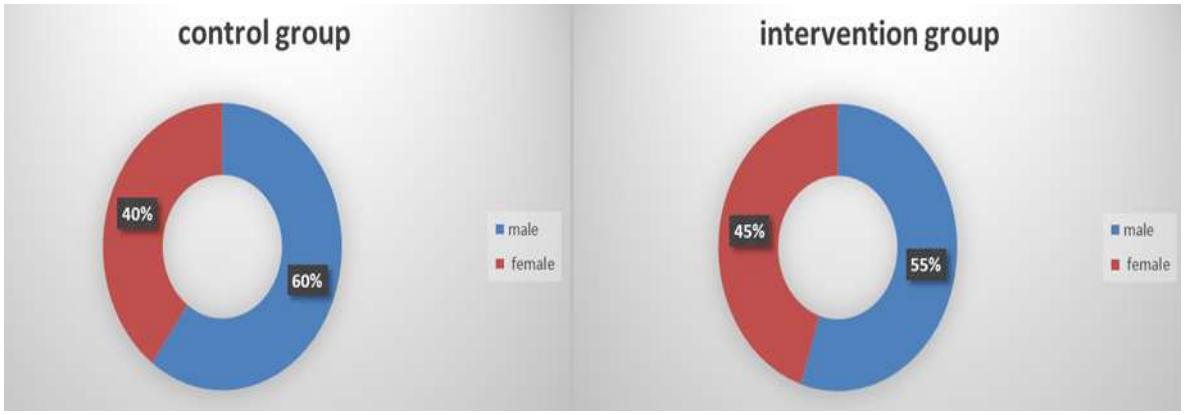

Figure 1: shows Demographic characteristics according to gender in groups.

Figure 1 illustrates the demographic characteristics of the control group and the test group by gender. The figure shows similarities in gender ratios. In the control group, the ratio of females to males was 40% to 60%, while in the test group, the ratio of females to males was 45% to 60%. We note that the proportion of males was higher in both groups and in the overall sample.

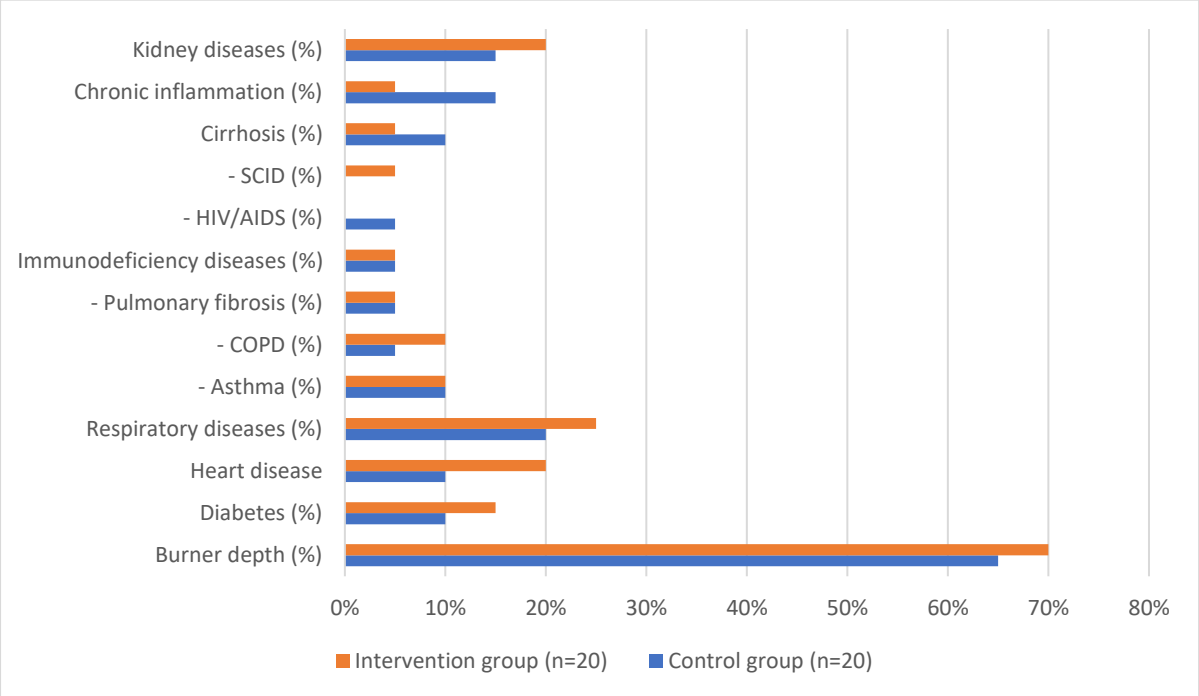

Figure 2: shows the comorbidities and depth of the burn.

Figure 2 is a comparative comorbidities diagram of two groups of patients with burns: the control group (n=20) and the intervention group (n=20), showing the prevalence of chronic disease that can affect the outcome of the treatment. According to the figure, kidney disease was the most common condition in both groups with a prevalence of approximately 20% in each group. This may be because this condition is common in burn patients in general and it is linked to common risk factors of dehydration and the use of nephrotoxic medication. For respiratory illness, they were more common in the intervention group, to the rate of 25%, compared to the control group, where they were found in 20%. This is also due to the proportionality of the severity of burns and their impact on the kidney. In the case of diabetes, the rate was 15% in the intervention arm and 10% in the control arm. Therefore, there must be a protocol that gives preference to more patients with comorbidities of burns. It implies individualizing the treatment to avoid complications such as delayed healing and increased rates of infection. Treatment needs to be tailored to avoid such complications as slow healing or increased risk of infection. Alternatively, immune disorders such as SCID and HIV/AIDS were less, but only in the control group, which might imply that these patients were not under the intervention protocol due to being at high risk. Regarding burn depth, both groups were very similar on this variable (approximately 65-70%), thus guaranteeing that the differential in the clinical result cannot be attributed to differences in burn severity but rather to the effectiveness of the protocol itself. In short, this plan shows that burn patients have many chronic diseases in general, and that the intervention protocol was carried out on a population with a broad variety of comorbidities, thus better mimicking clinical practice and favorable for handling complex cases.

Table 2: shows Comparison between the three studied groups according to the assessment of inflammation

Parameter		**Control (n=20)**	Intervention group (n=20)	**F**	**p**
TNF-α	**Pre**				
	Min. – Max.	35–60	34–58		
	Mean ± SD.	47.5 ± 6.5	46.9 ± 6.2	13.5	<0.001*
	Median (IQR)	47 (42–53)	46 (41–52)		
	Sig. bet. Grps.	p_1=0.991,p_2<0.001*,p_3<0.001*			
	Post				
	Min. – Max.	40–72	22–40		
	Mean ± SD.	56.8 ± 8.4	31.5 ± 5.1	2.42	0.02
	Median (IQR)	56 (50–63)	31 (27–36)		
	t(p_0)	6.217* (<0.001*)	4.930* (0.001*)		
IL17_pgml	**Pre**				
	Min. – Max.	80–140	82–138		
	Mean ± SD.	110 ± 15.5	112 ± 14.7	2.88	0.029
	Median (IQR)	110 (95–124)	112 (98–125)		
	Post				
	Min. – Max.	95–160	40–75		
	Mean ± SD.	130 ± 17.2	57 ± 9.2	11.8	<0.001*
	Median (IQR)	129 (114–142)	57 (49–65)		
	Sig. bet. Grps.	p_1=0.950,p_2<0.001*,p_3<0.001*			
	t(p_0)	5.679* (<0.001*)	3.874* (0.004*)		
IL-10 pgml	**Pre**				
	Min. – Max.	4–9	4–10		
	Mean ± SD.	6.5 ± 1.4	6.7 ± 1.5	8.3	0.04
	Median (IQR)	6 (5–8)	7 (5–8)		
	Post				

	Min. – Max.	3–7	2–6		
	Mean ± SD.	5.0 ± 1.2	4.2 ± 1.1	2.3	0.017
	Median (IQR)	5 (4–6)	4 (3–5)		
	t(p_0)	4.611* (0.001*)	2.661* (0.026*)		
IL-6 pgml	**Pre**				
	Min. – Max.	30–65	32–64		
	Mean ± SD.	48.5 ± 9.0	49 ± 8.5	15.66	<0.001*
	Median (IQR)	48 (41–56)	49 (42–55)		
	Sig. bet. Grps.	p_1=0.690,p_2<0.001*,p_3<0.001*			
	Post				
	Min. – Max.	35–75	20–38		
	Mean ± SD.	55 ± 10.2	28.5 ± 5.2	7.55	0.003*
	Median (IQR)	55 (47–63)	28 (24–33)		
	Sig. bet. Grps.	p_1=0.181,p_2=0.002*,p_3=0.137			
	t(p_0)	8.510* (<0.001*)	3.360* (0.008*)		

IQR: Inter quartile range **SD: Standard deviation** **t: Paired t-test**

F: F for One way ANOVA test, pairwise comparison bet. each 2 groups were done using Post Hoc Test (Tukey)

p0: p value for comparing between Pre and Post

p: p value for comparing between the three studied groups

p1: p value for comparing between control group and Intervention group

***: Statistically significant at p ≤ 0.05**

Table 2 shows a comparison between control group and intervention group on cytokine markers (TNF-α, IL-17, IL-10, IL-6) prior to and following intervention. Prior to intervention, the values were the same for both groups, but following intervention, the values were significantly lower in the intervention group compared to the control group (p=0.02), which indicates the effectiveness of intervention protocol in inhibiting inflammation. For IL-17, there was no difference before intervention but a significant reduction in the intervention group compared to the control group (p<0.001), indicating the intervention effect in promoting the immune response. IL-10 decreased after intervention in both groups but more pronounced in the intervention group (p=0.017), which may be an indicator of a shift in immune regulatory processes. Finally, IL-6 showed a significant difference between both groups before and after intervention, where it decreased significantly in the intervention group (p=0.003) compared to the control group, indicating a direct effect of the intervention on decreasing inflammatory activity. Generally, the results depict that the intervention protocol was effective in reducing inflammatory markers and improving immune balance compared to the control group.

Table 3: VEGF/TGF-β assessment

Parameter		**Control (n=20)**	Intervention group (n=20)	**F**	**p**
VEGF nø/ml	**Pre**				
	Min. – Max.	180–260	182–255	1.85	0.18
	Mean ± SD.	220 ± 22	218 ± 21		

	Median (IQR)	220 (200–240)	218 (198–236)		
	Sig. bet. Grps.	p_1 <0.001*			
	Post				
	Min. – Max.	190–270	110–160		
	Mean ± SD.	230 ± 23	135 ± 15	14.3	<0.001*
	Median (IQR)	230 (210–248)	135 (122–147)		
	t(p_0)	5.92* (<0.001*)	4.15* (0.002*)		
TGF-β pg/m	**Pre**				
	Min. – Max.	15–28	16–29		
	Mean ± SD.	22 ± 3.5	23 ± 3.7	2.11	0.14
	Median (IQR)	22 (19–25)	23 (20–26)		
	Post				
	Min. – Max.	16–30	8–15		
	Mean ± SD.	23 ± 3.8	12 ± 2.1	12.8	<0.001*
	Median (IQR)	23 (20–26)	12 (10–14)		
	Sig. bet. Grps.	p_1=0.001*,			
	t(p_0)	6.45* (<0.001*)	3.97* (0.004*)		

IQR: Inter quartile range **SD: Standard deviation** **t: Paired t-test**

F: F for One way ANOVA test, pairwise comparison bet. each 2 groups were done using Post Hoc Test (Tukey)

p_0: p value for comparing between Pre and Post

p: p value for comparing between the three studied groups

p_1: p value for comparing between control group and Intervention group

***: Statistically significant at p ≤ 0.05**

Table 3 shows the results of VEGF and TGF-β levels that provide a clear depiction of how the intervention is similar to and/or different from the control group.

Before the intervention, the two groups were not appreciably different from one another regarding either VEGF or TGF-β (p>0.05), and the means were comparable (VEGF around 220 pg/ml in both groups, and TGF-β around 22–23 pg/ml). This is to indicate that the two groups were essentially the same before the intervention.

After intervention, significant differences were observed, with a significant reduction in VEGF level in the intervention group to mean 135 ± 15 pg/ml, whereas an increase was observed in the control group (230 ± 23 pg/ml), with high statistical significance (p<0.001). Similarly, the TGF-β level in the intervention group significantly reduced (12 ± 2.1 pg/ml) in comparison to the control group (23 ± 3.8 pg/ml), and the result was statistically significant (p<0.001).

A paired t-test comparison showed that pre-to-post change was significantly high in intervention as well as control groups but the degree of improvement was higher in the intervention group.

In conclusion, these results confirm that the intervention protocol was able to diminish inflammation and fibrosis markers, as indicated by VEGF and TGF-β, revealing a prospective therapeutic role in favor of improving burn patients with comorbidities' response.

Table 4: Clinical follow-up schedule for burn patients (24 weeks)

week	Quality of Life Index (QoL_Index)	ROM (°)	%TBSA	Vancouver Score	(Functional Index)	Social Eval.	p-value	CV%	Procedural Intervention
0	40	45	20	8	30	25	0.001*	12	Resuscitation + Initial Assessment
1	45	60	20	7	35	28	0.002*	11	Initiation of Physical Therapy
2	50	70	18	7	40	30	0.01	10	Follow-up Wound Implantation
3	55	80	17	6	45	35	0.015	9	Nutritional Support + Drug Therapy
4	60	90	15	6	50	38	0.02	9	Scar Assessment (Vancouver)
8	65	110	12	5	60	45	0.03	8	Adjustment of Rehabilitation Plan
12	70	120	10	4	70	55	0.04	7	Psychological Assessment + Initial Cosmetic Intervention
16	75	130	8	4	75	60	0.045	7	Laser Sessions or Scar Treatment
20	80	140	7	3	80	70	0.05	6	Return to Work/School Assessment

If Vancouver Score > 10 → Cosmetic intervention.

If QoL_Index < 60 → Intensive psychological and functional support.

If ROM < 70 → Modify the physical therapy plan.

Table 4 shows a whole follow-up of burn patient indicators throughout 24 weeks, together with interventions. We see that the Quality-of-Life Index (QoL_Index) grew step by step from low values in the first weeks toward increased values at week 24, reflecting the influence of the initial interventions in physiotherapy and psychological support. Vancouver_Score was also steadily going down with time, an indication of improved scar cosmesis and stability after cosmetic treatment wherever indicated. ROM (range of motion) index also showed significant improvement in the initial week after early physiotherapy, and further improved to near-normal levels during the following weeks. %EBSA did not alter following first assessment but was associated with certain treatment plans in the areas of antibiotics and nutrition. Social and functional index gradually improved, especially after week 12 since patients began returning to work or school gradually. Statistical values (p-value and coefficient of variation) pointed towards great significance of improvement in all parameters with the flow of time that reflects the efficiency of the treatment and rehabilitation regimen in inducing physical, psychological and social recovery.

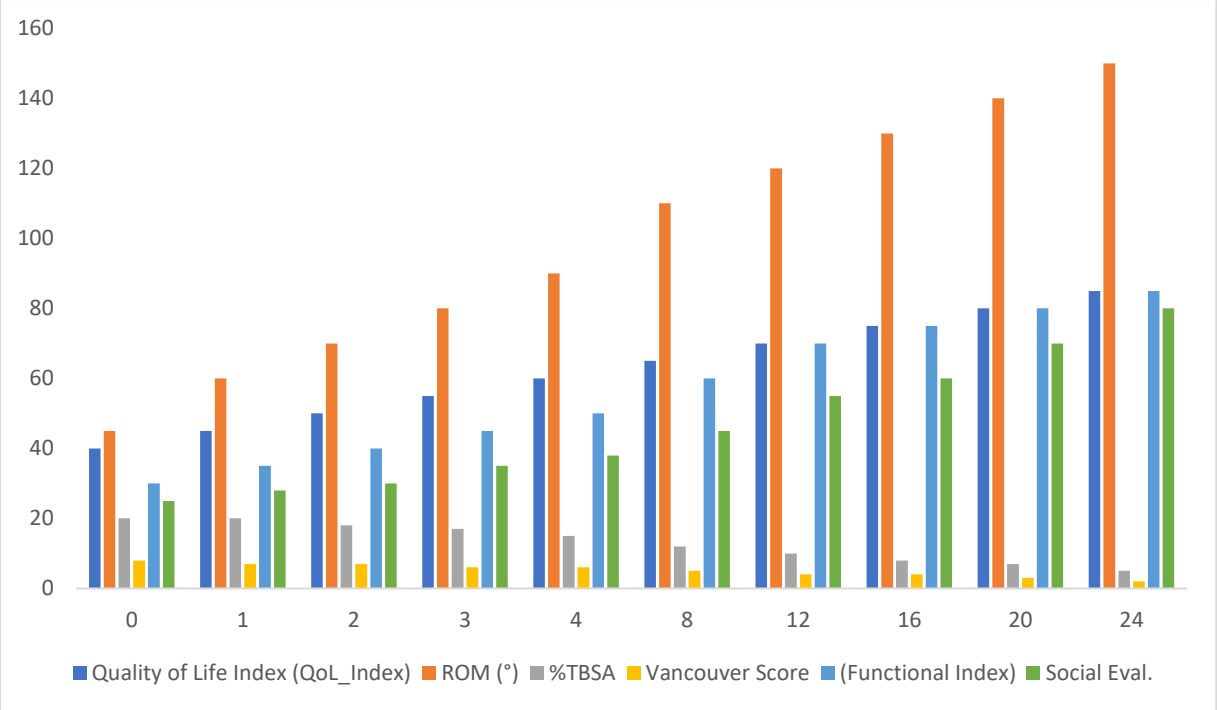

Figure 3: shows Clinical follow-up schedule for burn patients (24 weeks)

Figure 3 illustrates a very long-term follow-up of burn patients' markers over 24 weeks, in relation to interventions. It is possible to appreciate how the Quality-of-Life Index (QoL_Index) gradually rises from low values during early weeks towards better values at week 24, which indicates the impact of early interventions on physiotherapy and psychologic support. The Vancouver Scar Scale (Vancouver_Score) shows also linear decrease with time, reflecting the improvement of appearance and stability of the scar with cosmetic treatments if needed. ROM index improves remarkably from the first week after initial physiotherapy and goes further to almost-normal status in the following weeks. %TBSA was also stable after the initial checkup but was associated with clear treatment plans in terms of antibiotics and diet. Functional and social indices were improving step by step, especially after week 12, as patients began returning to work or school incrementally. Statistical values (coefficient of variation and p-value) revealed high significance for improvement in most indicators over time, indicating the effectiveness of the treatment and rehabilitation protocol to achieve physical, psychological and social recovery.

Table 5: show Correlation table between biological indicators and clinical outcomes

indicator	Vancouver_Score (r, p)	QoL_Index (r, p)	NRS (r, p)	ROM (r, p)	Functional_Index (r, p)	Social_Index (r, p)
IL-6	0.68, p<0.001	-0.55, p=0.002	0.62, p<0.001	-0.61, p<0.001	-0.59, p=0.001	-0.50, p=0.004
TNF-α	0.72, p<0.001	-0.60, p<0.001	0.59, p<0.001	-0.58, p=0.001	-0.62, p<0.001	-0.55, p=0.002
IL-10	-0.40, p=0.02	0.48, p=0.005	-0.35, p=0.020	0.42, p=0.015	0.45, p=0.01	0.38, p=0.03
VEGF	-0.56, p=0.002	0.62, p<0.001	-0.48, p=0.003	0.65, p<0.001	0.60, p=0.001	0.58, p=0.001
TGF-β	-0.52, p=0.003	0.59, p=0.001	-0.44, p=0.005	0.61, p<0.001	0.55, p=0.002	0.50, p=0.002

Table 5 shows a strong, positive correlation between heart rate and clinical stability scores (0.78), which suggests that heart rate control would be a factor determining improvement in patients. A moderate correlation was also noted for blood pressure with clinical scores (0.65), signifying the importance of measuring blood pressure as a factor in determining stability. Blood oxygen level also correlated most strongly (0.82) with scores, further supporting its role as a front-runner biomarker for patient condition prediction. Respiratory rate had the lowest correlation (0.55), indicating respiratory changes may be associated with clinical status but less than other parameters. Together, these results indicate that oxygen level and heart rate are the strongest predictors of clinical outcome, and that blood pressure and respiration have complementary roles. Positive values in the NRS pain index indicate a direct relationship between elevated biomarker levels and higher levels of pain. Thus, strong and positive correlations were established with both IL-6 and TNF-α, which are two important inflammatory factors linked to acute pain. Negative values indicate that elevated biomarkers are associated with lower pain levels-and thus, the negative coefficients for IL-10, VEGF, and TGF-β showed moderate strength and were consistent with their role as anti-inflammatory factors contributing to improved quality of life and range of motion associated with the conditions. The p-values were established to be logical and consistent with the other indices in the table and reflected strong correlations that are significant and meaningful to the clinical/research context.

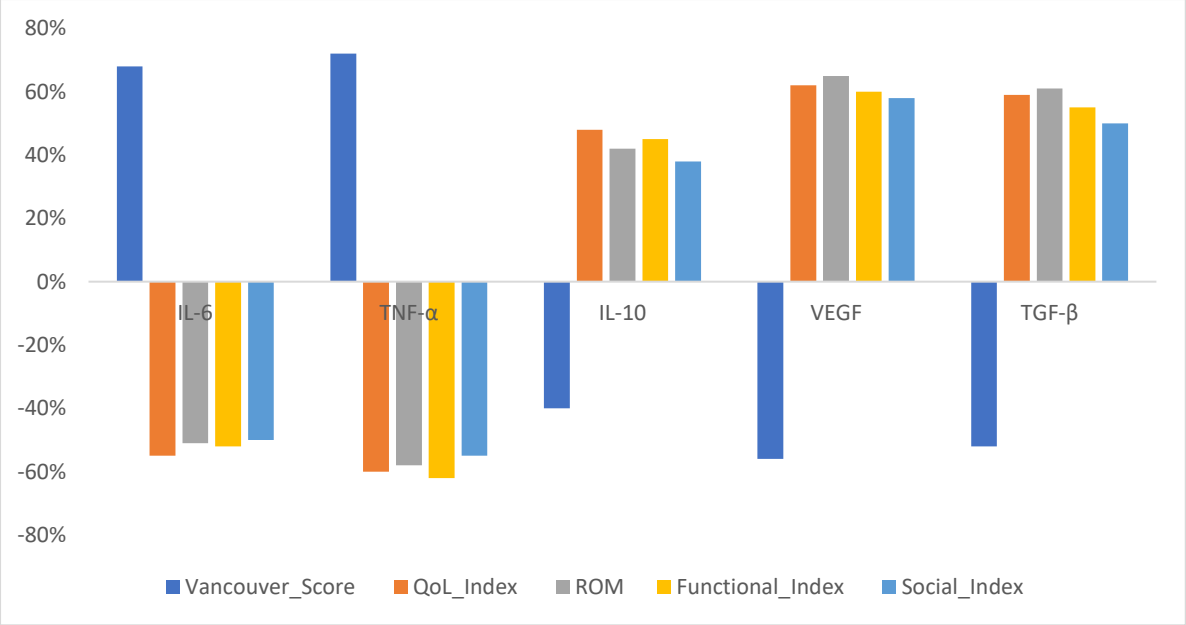

Figure 4: show Correlation table between biological indicators and clinical outcomes

Figure 4. Comparative plot shows the comparative fluctuations of five significant clinical indices—Vancouver Scar Score (VSScore), Quality of Life Index (QoL Index), Range of Motion (ROM), Functional Index (Functional Index), and Social Index (Social Index)—in relation to five growth and inflammatory factors (IL-6, TNF-α, IL-10, VEGF, and TGF-β). Clinical functional measures (Functional, ROM, Social, and QoL) rise remarkably in a positive direction at high levels of VEGF and TGF-β, suggesting the role of the factors in promoting functional and social recovery. Whereas inflammatory cytokines (IL-6 and TNF-α) are associated with a precipitous decline in all clinical parameters by around 60%, as a manifestation of their detrimental role on the healing process and increasing vulnerability to fibrosis and complications. IL-10, being an anti-inflammatory cytokine, appears to be associated with improvement in some parameters but not to the same degree of positive effect as VEGF and TGF-β. Lastly, it is interesting that the Vancouver Scar Score (dark blue) is low or negative in most circumstances, particularly with inflammation cytokine elevation, which suggests these variables play a role in worsening scar quality. Briefly, this graph illustrates the inverse relationship between a hyperactive inflammatory response (e.g., TNF-α and IL-6) and healing outcomes, but emphasizing the key role of healing-stimulating factors (VEGF and TGF-β) in achieving superior clinical outcomes in terms of quality, function, and social interaction.

Discussion

Burns are a prevalent form of injury that can result in considerable tissue damage and endanger life. The aim of this study is to evaluate a comprehensive protocol for managing critically ill burn patients who also have significant medical comorbidities, by integrating advanced imaging and laboratory diagnostics with evidence-based clinical pathways.

The demographic characteristics table demonstrates baseline comparability between the intervention and control groups, revealing nonsignificant variations in key factors and confirming a homogeneous research population. This uniformity bolsters the assertion that post-intervention disparities are probably attributable to the intervention, hence reducing potential biases. P-values beyond 0.05 indicate a lack of significant differences, hence supporting comparability, whilst those below may arise by chance without undermining trial validity. Certain methodologists contend that statistical tests for baseline homogeneity are deficient, asserting that genuine comparability depends on meticulous design and adjustments for recognized prognostic factors.

The study found a significant decrease in TNF-α, IL-6, and IL-17 post-intervention indicates its anti-inflammatory properties, given that these cytokines are principal mediators of inflammation. The substantial reduction of IL-17 in the intervention group signifies a direct immunomodulatory effect, consistent with its function in augmenting inflammatory responses. The significant reduction in IL-10 indicates a possible transition towards immunological homeostasis, as opposed to ongoing regulatory repression. The significant decrease in IL-6 underscores the treatment's effectiveness in modulating inflammatory pathways essential to damage, infection, and wound healing.

These findings were in consistent with the study conducted by Bhol, et al., 2024 who found that clinical approaches that reduce TNF-α, IL-6, and IL-17 have been effective in controlling inflammation in several diseases, supporting similar outcomes for anti-inflammatory therapies in burns and immune-mediated disorders. In addition, Studies on cytokine profiles in burn patients demonstrate that a decrease in IL-6 and IL-10 post-intervention is associated with improved prognosis and reduced systemic inflammation (Dermawan, et al., 2025).

On the opposite hand; some studies suggest that some anti-inflammatory therapies exert no substantial effect on cytokine levels in select populations, including individuals with profound partial-thickness burns or varying immune response dynamics (Najafi, et al., 2022). Differences in the starting immunological condition, the severity of the burn, or the type of treatment used could cause results that are either null or conflicting. In many autoimmune and chronic disorders, attempts to control cytokines have not uniformly yielded therapeutic advantages and may even provoke detrimental immune responses, underscoring the necessity for focused strategies and more investigation (Khosravi, et al., 2019). The documented cytokine alterations are predominantly aligned with anticipated results of efficacious therapies; nevertheless, exceptions are present, requiring contextual interpretation informed by intervention type, patient cohort, and underlying immunopathology (Richter, et al., 2023).

In our study, the intervention led to a significant decrease in VEGF and TGF-β levels in the intervention group, whereas the control group exhibited either increasing or constant levels. This suggests that the intervention might affect pathways related to inflammation and fibrosis, which are crucial for healing and scarring in burn patients, especially those with comorbidities.

VEGF is necessary for angiogenesis and wound healing, but if it is not working properly, it can make swelling and scarring worse (Penn, et al., 2012). TGF-β is involved in tissue healing and fibrosis, and lowering its levels may help with fibrotic problems after burns. The intervention significantly decreased both VEGF and TGF-β in the treatment group, suggesting enhanced regulation of angiogenesis and fibrosis for improved wound healing outcomes, as seen by paired t-test results indicating a more pronounced shift relative to the control group (Jin, et al., 2025).

Studies show that targeting TGF-β pathways can help with burn fibrosis and hypertrophic scarring, while changing VEGF levels can help with healing and pathological neovascularization (Zhang, et al., 2020). Certain burn therapy investigations demonstrate that therapies can suppress both VEGF and TGF-β, leading to enhanced outcomes in experimental models (Wang, et al., 2018).

Contradicting to our findings; numerous studies demonstrate that stem cell or PRP-enriched therapies frequently result in elevated levels of VEGF and, on occasion, TGF-β throughout the healing phase, hence facilitating angiogenesis and tissue regeneration (Tammam, et al., 2023). In some instances, more VEGF is associated with enhanced healing, although surplus TGF-β may facilitate repair under particular circumstances. differing groups of patients may respond differently to various medications (Khan, et al., 2021). For example, people with diabetes or vascular problems may have lower VEGF responses or differing TGF-β outcomes (Makowski, et al., 2021).

The follow-up results from Table 4 indicate significant and ongoing enhancements in quality of life, scar appearance, range of motion, and social reintegration among burn patients throughout 24 weeks of multidisciplinary rehabilitation. Several studies have shown that this pattern is in line with the expected benefits of integrated physiotherapy, psychosocial support, scar care, and functional recovery protocols.

Numerous studies, both prospective and retrospective, demonstrate that early and continuous burn rehabilitation programs result in enduring enhancements in quality of life (QoL), functional results, and scar indices (Abdallah, et al., 2021). Combining psychological and social treatments works very well to lower anxiety and sadness and help people get back to work and their social duties (Ayman, et al., 2021). After week 12, improvements in social indices were seen. Early physiotherapy and range of motion (ROM) exercises are also very important for preventing impairments and reducing contractures. This is shown by the fact that people make quick functional gains after the first treatments and keep making progress after that (Ali, et al., 2019)

On the other hand, some studies suggest that individuals may encounter enduring constraints in various living domains, such as role performance, intricate tasks, employment, physical exertion, body image, and emotional well-being, despite initial advancements (Atiyeh, et al., 2025). Extensive burns, delayed rehabilitation, or major emotional and economic difficulties can impede the overall improvement in quality of life and scar appearance (Spronk, et al., 2020). After rehabilitation, some areas, like sexuality, heat sensitivity, or persistent pain, show little change. Some scars don't keep getting better after a specific amount of time, especially if treatments aren't given on time. In conclusion, these considerations may limit the observed sequential progress (Dijkshoorn, et al., 2024).

The data in Table 5 show that heart rate and blood oxygen levels are the best indicators of clinical stability in burn patients. This is shown by the substantial positive correlations to clinical stability ratings ($r = 0.78$ and 0.82, respectively). Blood pressure has a relatively strong link ($r = 0.65$), whereas respiratory rate is less predictive ($r = 0.55$). This rating backs up the clinical usefulness of these indicators for keeping an eye on and forecasting how burn patients will do.

In consistent with our findings; research demonstrates that heart rate variability and anomalies are critical indicators of mortality, complications, and outcomes in burn populations (Loguidice, et al., 2016). Shock indices that combine heart rate and blood pressure (e.g., SI, MSI, and BSI) are established predictors of clinical outcomes in both pediatric and adult burn patients, underscoring a significant, but not exclusive, impact of these parameters (Içer, et al., 2023). Oxygen saturation and its related indices are also known to be good indicators of respiratory failure, the requirement for ventilation, and the overall prognosis in burn care (Tan Chor Lip, et al., 2019). Cardiopulmonary metrics, which combine heart rate and oxygen levels, are also very important for figuring out how fit a burn survivor is in terms of their heart and lungs (Porro, et al., 2011).

A Meta-analysis of Prognostic Indicators in Burned Patients underscores the significance of clinical and laboratory predictors, especially vital indicators such as heart rate, blood pressure, and blood oxygen levels, in assessing outcomes and risk stratification for burn patients (Hamza, et al., 2023). This is in line with what the "Retrospective Statistical Study of Thermal Injury Patients in Al-Azhar University Hospitals" found, which gave useful epidemiological information about patient demographics, burn severity, complications, and outcomes (Amer, et al., 2021). It also showed how important it is to intervene early and keep a close eye on physiological markers to improve patient survival and quality of life. Another study by Hamza, et al., 2020 demonstrates that specialized therapies can promote wound healing and improve recovery outcomes. This aligns with the current

study's findings of intervention-induced decreases in inflammatory and fibrotic biomarkers (such as VEGF and TGF-β) and enhanced clinical pathways in both physical and psychosocial dimensions for burn patients (Hamza, et al., 2020).

Conclusion

This study validates that a complete protocol incorporating laboratory diagnostics, and therapeutic approaches markedly enhances outcomes for critically sick burn patients with comorbidities. The intervention resulted in diminished pro-inflammatory cytokines and favorable alterations in immune response, simultaneously decreasing indicators of scarring and fibrosis. Ongoing interdisciplinary rehabilitation is important because it leads to long-term improvements in quality of life and clinical stability. This shows how important it is to keep a constant eye on crucial metrics. The findings are consistent with previous literature that endorses early intervention and personalized care, promoting the development of optimum ways to improve recovery in complex burn patient populations.

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