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ORIGINAL

IMPACT OF MULTIPLE SKIN EXPANSION ON FUNCTIONAL RECOVERY AND PATIENT SATISFACTION IN SCAR RECONSTRUCTION SURGERY FOLLOWING NECK BURN: IMPLICATIONS FOR PHYSICAL REHABILITATION AND SPORTS PERFORMANCE

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ABSTRACT

Objective: To explore the application of advanced data analysis techniques in evaluating the effectiveness of multiple skin expansion procedures on scar plastic surgery outcomes following neck burns, with a focus on functional recovery, patient satisfaction, and implications for physical rehabilitation and sports performance. **Methods:** This study utilized big data processing and machine learning techniques to analyze clinical data from severe burn patients. Data preprocessing was performed, followed by unsupervised algorithms such as hierarchical clustering and principal component analysis to identify patterns and subgroup classifications linked to clinical outcomes. Sixty patients with post-neck burn scars who underwent scar plastic surgery were included. Clinical parameters such as scar blood flow values and pruritus symptom scores were analyzed to evaluate the impact of skin expansion procedures. **Results:** In the early post-burn phase, patients often experienced local thickening, hardening, and extreme capillary congestion leading to pruritus. The results showed significant reductions in both scar blood flow values and pruritus symptom scores in all patients. However, patients in the observation group, who underwent multiple skin expansion procedures, exhibited greater improvements ($P < 0.05$). These findings align with prior research, confirming the effectiveness of the intervention and its potential benefits for enhanced recovery. **Conclusion:** The use of multiple skin expansion techniques in scar plastic surgery following neck burns significantly improves clinical outcomes, including reduced scar vascularity and pruritus severity, thereby promoting better functional recovery. These advancements have direct implications for physical rehabilitation, facilitating greater mobility and quality of life, and enabling patients to engage in physical activity and sports with improved confidence and comfort. Further research integrating machine learning-based prediction models can enhance personalized rehabilitation strategies for burn survivors.

KEYWORDS: Severe Burn; Septic Shock; Clinical Outcomes; Big Data; Data Mining

1. INTRODUCTION

Severe burns, particularly those involving the neck region, pose significant challenges to both physical recovery and psychological well-being. The resulting scars can lead to functional impairments, restricted range of motion, and aesthetic concerns, all of which impact a patient's quality of life and ability to engage in daily activities, including physical exercise and sports. Advances in surgical interventions, such as skin expansion techniques, have emerged as effective solutions for scar reconstruction, aiming to improve both functional outcomes and patient satisfaction. Neck scars, due to their proximity to vital anatomical structures, often result in local thickening, hardening, and pruritus during the early stages of recovery. These symptoms not only hinder mobility but also reduce the overall motivation to engage in rehabilitation or physical activities. As rehabilitation and physical performance are critical components of recovery for burn survivors, addressing these limitations through innovative surgical and therapeutic interventions is crucial. The integration of big data processing and machine learning in burn care has opened new avenues for analyzing clinical outcomes and optimizing treatment strategies. By identifying patterns in patient responses and clustering subgroups based on clinical outcomes, data-driven approaches can provide valuable insights into the effectiveness of treatments like multiple skin expansion. These insights can further inform personalized rehabilitation protocols that enhance physical recovery and long-term participation in physical activity and sports. This study focuses on evaluating the impact of multiple skin expansion techniques on the curative effect and patient satisfaction in scar plastic surgery after neck burns. By leveraging advanced data analysis techniques, the study aims to highlight the role of innovative surgical interventions in promoting functional recovery and facilitating sports and physical activity engagement in burn survivors. The findings underscore the importance of integrating technology and multidisciplinary approaches to optimize outcomes for patients recovering from severe burns (Jeon & Yoo, 2020;

Shah et al., 2021; Suharto et al., 2021). It is proposed to use tissue-engineered dermis to replace autologous dermis and scar epidermis to replace normal epidermis to reconstruct the skin structure for scar plastic surgery, so as to further explore the safety and effectiveness of tissue-engineered dermis combined with scar epidermis transplantation in the treatment of scars and explore new ideas for the treatment of large-area burn scars in clinic. Recently, tissue-engineered skins used in clinical factories are divided into two categories: acellular allogeneic dermal matrix (ADM) and implantable artificial dermis. ADM is a kind of tissue-engineered dermis, which is aseptic, non-toxic, non-irritating and non-immune rejection. At present, the commercialized products mainly include AlloDerm and acellular allogeneic dermis produced in China (Beijing Jieya Laifu Biotechnology Co., Ltd.). The main feature of implantable artificial leather is that it has a sponge like leather structure inside and covered with silica gel film outside. Representative products include integral (integral life science services, USA), pelnac, Gunze medical M materials center, Kyoto, Japan), etc. The implantable artificial dermis sold in China is pelnac.

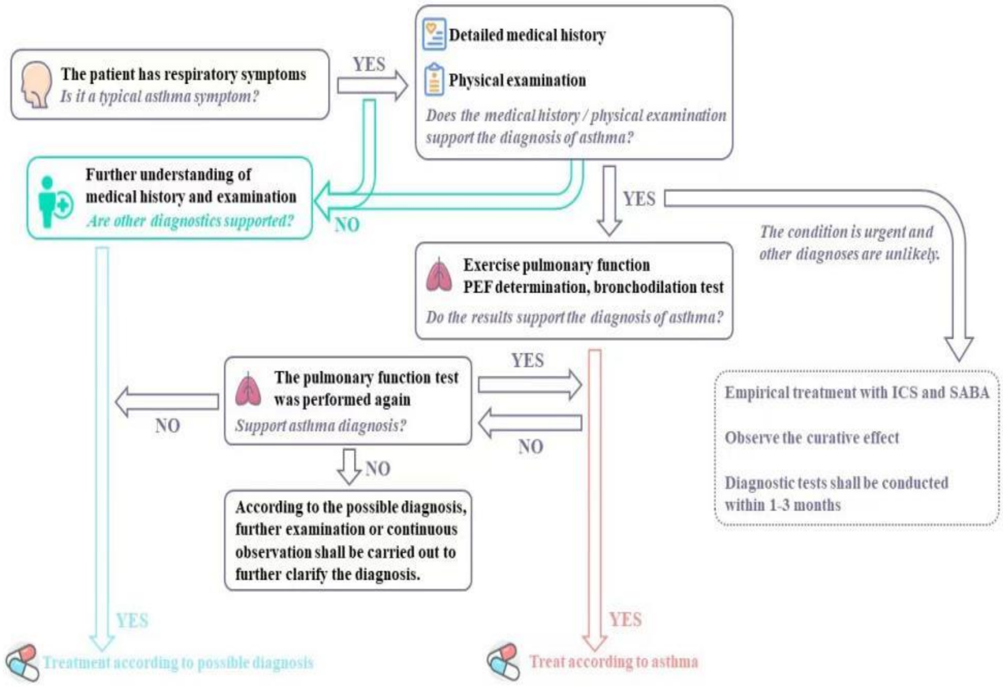

Figure 1: Flow chart of scar plastic surgery after burn

2. Literature Review

Scar is a normal and inevitable physiological reaction in the process of wound or wound healing after human trauma. It is also a natural product of the process of wound healing. It is an abnormal and imperfect tissue that loses the vitality of normal tissue. Kim and others found that the histological characteristics of pathological scar are mainly excessive proliferation of fibroblasts, excessive secretion and deposition of extracellular matrix, abnormal increase of capillaries and mutual influence(Kim, 2021). Gaddis, a. and others believe that once the scar is formed, it is difficult to return to normal skin (Gaddis et al., 2019). The treatment and repair of scar is a thorny problem in dermatology and plastic surgery. The pathogenesis of scar is complex, and there is no clear conclusion at present. In addition, although there are various methods to treat scar, its therapeutic effect is not very ideal. The mechanism and treatment of scar have been going on for a long time. For a long time, the research and literature report on scar have increased at a rate of 50% every year. Jafarpoor, H. and others found that the face is a special and complex tissue part of the human body. It is the aggregation of human facial features, has rich facial expression ability, is a direct display of human beauty, and plays a very important role in medical aesthetics (Jafarpoor et al., 2021). For thousands of years, people have been pursuing "beauty". Today, with the rapid development of high and new technology, people's pursuit of beauty is higher and higher, and more and more people tend to improve their appearance through cosmetic surgery. However, Yan and others believe that this face, which can best reflect the beauty of the human body, is the exposed part of the human body (Yan et al., 2021). In daily life, it is vulnerable to trauma, scald, burn and other injuries. These injuries and clinical operations such as surgery, infection and injection can cause scars. The functions and functions of facial features cannot be replaced by other human tissues. When they are damaged, they will inevitably cause patients' bad emotions. Facial injuries form scars during healing and repair. Research by Yeom, Y. R. and others shows that the psychological activities of patients with facial trauma are relatively complex, and there are also large psychological fluctuations in the process of treatment, which are affected by their own factors and external factors (Yeom & Park, 2020). Lee and others showed that the thought evolution process of facial burn patients was pain, tension, fear, anxiety, loneliness, pessimism, despair and so on (Lee & Heo, 2020). Azhari and others reported that the common psychological problems of burn scar patients are: 1. Fear, pain, tension, facial injury. Patients are worried about disfigurement and the prognosis of scar, which is easy to produce fear; 2. Depression, depression, anxiety, facial injury, appearance image damage, self-confidence reduction, lack of correct self-evaluation, it is easy to have low self-esteem, and then produce depression; 3. Avoidance Psychology: the patient's face becomes ugly due to facial injury, lacks self-confidence and is unwilling to contact with the outside world; 4. Pessimism and despair, patients lack correct evaluation of themselves, reduce their sense of self-worth, and produce pessimism. These negative psychological factors of patients with facial injury run through the whole treatment process. The interaction between physical factors and negative psychological factors will form a vicious circle (Azhari et al., 2020). Inangil and other believe that the treatment and nursing of patients with facial injury should include psychological nursing. The new medical model, social psychological biomedical model, emphasizes the role and influence of psychological factors on human health and diseases (Inangil & Inangil, 2020). Psychological nursing has become an important part of the new medical model. Park, G. H. and others found that studies at home and abroad have reported that anxiety and depression are the most common psychological problems of inpatients in general hospitals and the most popular mental diseases in the world (Park et al., 2020). Moderate anxiety mobilizes the normal psychological defense of the human body, which is conducive to overcoming difficulties, but long-term excessive anxiety will produce psychological pressure, which is not conducive to the recovery of the disease. Anxiety and depression are common negative psychological reactions associated with diseases, which affect the development and prognosis of the disease and the quality of life of patients. Patients with facial scar plastic surgery have negative emotions such as anxiety and depression, which directly affect the treatment and prognosis of scars. Therefore, corresponding psychological intervention is needed for patients. It is reported that comprehensive psychotherapy can significantly alleviate the depression of facial burn patients, and reduce the impact of depression on the physical state of patients through cognitive changes, so as to improve the treatment effect of patients, which is conducive to the treatment and rehabilitation of patients. Chung, J. W. and others also showed that psychological intervention nursing for young female patients with facial burns reduced their negative emotions and improved their quality of life. Therefore, in clinical work, medical staff should pay attention to the psychological status of anxiety and depression of patients with facial scar plastic surgery, and take corresponding intervention measures to enable patients to correctly understand the condition, obtain self-confidence and establish correct values, so as to improve their quality of life and promote the improvement of the condition (Chung et al., 2020).

3. Method

The statistical analysis and mathematical calculation of data were carried out by using software such as Ri386 3.1.2, Matlab 7.0 and SPSS 18.0. Use cluster analysis and hierarchical clustering based on principal component analysis to explore the data pattern, and screen the main variables by comparing the F value. The centroid calculation method is used to reduce the dimension of data, extract the change trend of data, and use the linear random effect model. Finally, the computer C language is used to make the prediction model of sepsis into computer software (Adewa & Agboola, 2020). There are some problems in the original data, such as missing value, illogical and inconsistent. If there are many missing values, delete this case. If there are few missing values and there are no continuous missing values, the data shall be filled, that is, the mean value of the previous and subsequent data shall be filled. Due to the different units and orders of magnitude of patients' clinical data, centralized and standardized processing is needed to eliminate the impact of dimension on the results. The data standardization refers to the data after centralization divided by the standard deviation of the data set, that is, each data in the data set minus the mean of the data set and then divided by the standard deviation of the data set. Therefore, centralize and standardize the data before data processing (Yoga & Gde, 2020). Hierarchical clustering algorithm is mainly divided into two parts: calculating the distance of data points and clustering connection. When calculating the distance, we use the standard Euclidean distance calculation method, as shown in equation 1

$$d_{i\,j} = \sqrt{\sum_{k=1}^{n}\left(x_{ki} - x_{kj}\right)}^{2} \qquad (1)$$

d_{ij} is the distance between data points I and J. After calculating the distance between all data points, cluster connection is carried out. At the beginning, each data point is regarded as a class, and there are as many classes as there are data points. Hierarchical clustering first divides the two nearest classes into one class, so that the number of classes is reduced by one class, and then classifies the two nearest classes into one class. In this way, it is carried out step by step until all points are classified into one class, and hierarchical clustering is completed. Principal component analysis (PCA) is an unsupervised multivariate analysis algorithm. It uses linear transformation to reduce the dimension of high-dimensional data and screen important variables. Its main purpose is to reduce the data dimension and facilitate analysis (Candel & Turliuc, 2019). Hierarchical clustering on principle components (HCPC) based on principal component analysis is a clustering method combining principal component analysis and hierarchical clustering. Due to the complexity of clinical data, the effect of simple direct clustering is not ideal. The center of mass is the center of mass of an object. Unlike the center of gravity, the center of mass does not have to be in a system with a gravitational field and is usually an imaginary point. The calculation formula of centroid in multidimensional space is, see formula 2:

$$X_m = \frac{\sum m_i x_i}{\sum m_i} \qquad (2)$$

X represents a specific coordinate axis; m_i and x_i respectively represent the mass and coordinates of point I in the coordinate system. Centroid is a physical concept. We apply its principle to the dimensionality reduction of clinical data. After preliminary test, centroid can better reflect the real information of the data itself. Because the clinical data obtained is a huge set of multivariate data.Standard deviation is the standard deviation of the main component, proportion of variance is the contribution rate of variance, and cumulative contribution is the cumulative contribution rate of variance. When using principal component analysis for dimensionality reduction, 30 principal components are required to make the cumulative contribution rate of variance reach 85% (the number of principal components when the cumulative contribution rate of variance reaches 85% is generally taken in principal component analysis), so the dimensionality reduction effect of direct use of principal component analysis is not good. The regression method of machine learning is used to analyze the data by decision tree. The data were matched with the outcome of whether the patient had septic shock, and decision tree analysis was performed (Candel & Turliuc, 2019). As shown in Figure 2, D dimer, RBC, Cl, HBDH, GGT, body temperature, CK and urine volume are the nodes of the decision tree. However, this result is relatively simple and does not fully accord with the clinical practice. Through the preliminary exploration and analysis of the data, it is found that the commonly used data analysis methods cannot effectively deal with the complex clinical data. Therefore, other algorithms need to be further explored.

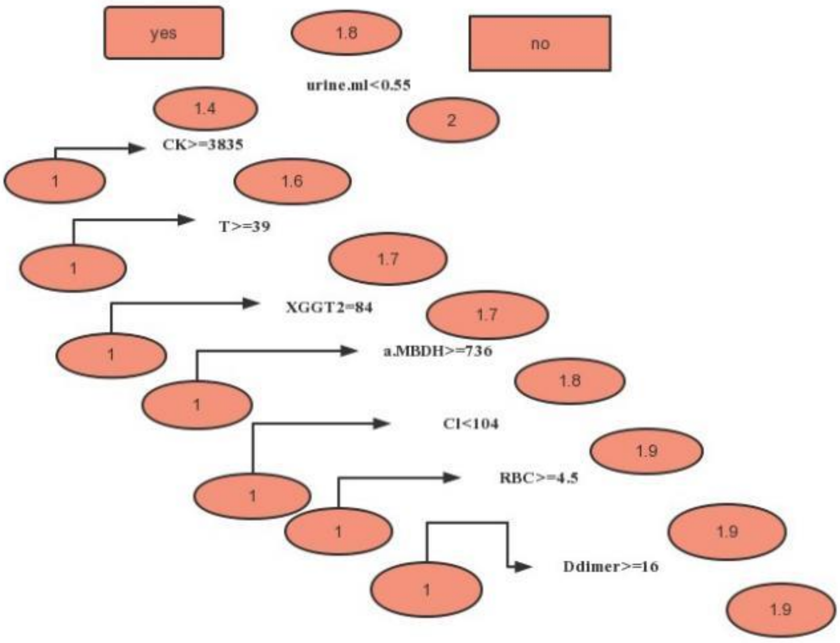

Figure 2: Schematic diagram of data decision tree analysis

Because there are many clinical data phase points, and there are more observations at each phase point, the data is a huge data cube. Traditional statistical analysis methods cannot effectively deal with this kind of data, and the effect of cluster analysis is not ideal. Therefore, the hierarchical clustering (HCPC) method based on principal component analysis is selected to analyze the data. The results are shown in Figure 3, 4 and 5 below. Figure 3 shows the clustering results of data by HCPC method. The horizontal axis is the clustering analysis result and the vertical axis is the scale of clustering analysis. Figures 4 and 5 show the classification of each data phase point on the principal component plane (Lestari et al., 2019).

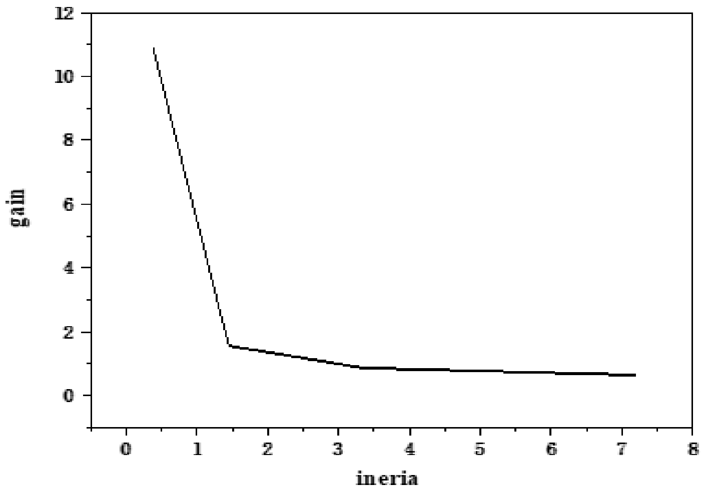

Figure 3: Tree view of HCPC results

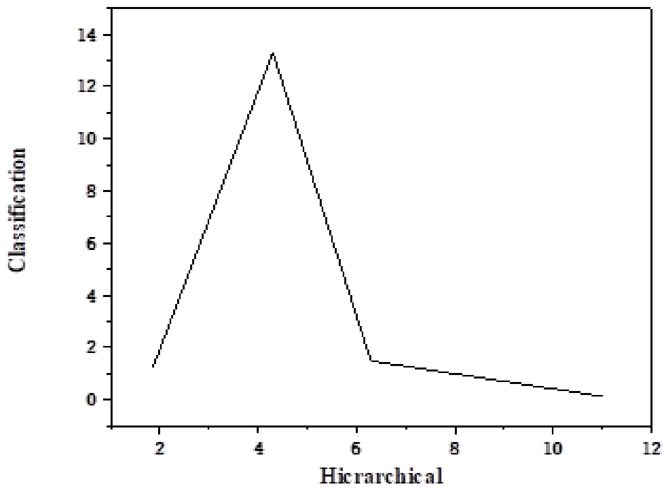

Figure 4: Three-dimensional tree view on two principal components of HCPC

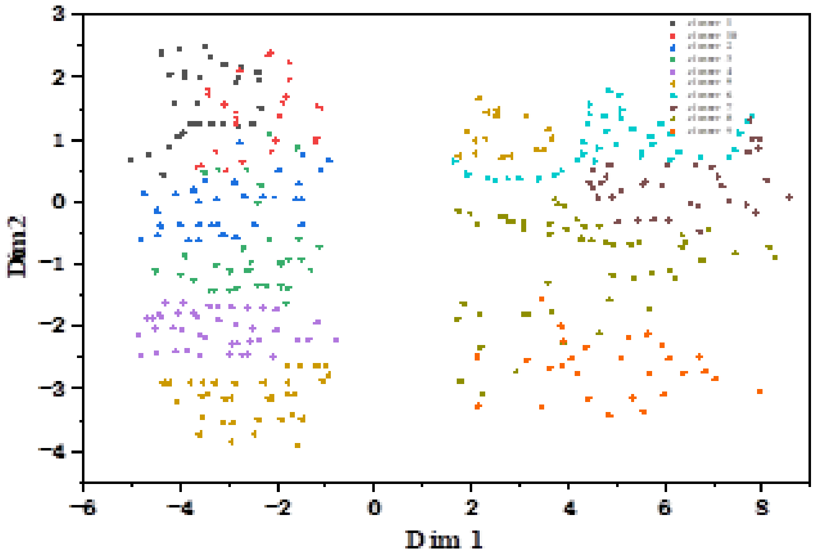

Figure 5: Classification diagram marked on HCPC principal component plane.

In the above figure, different colors represent different clustering subgroups, and different values represent the data points of patients every day. Using HCPC method to analyze the clinical data, the state of severe burn patients can be divided into 10 sub categories, and the pathophysiological status of patients is always changing in these 10 categories. In order to verify whether the selected 15 indicators can better replace the original 58 indicators, we used 58 indicators and simplified 15 indicators to HCPC the data respectively, and compared the differences in the classification of patients' clinical data. It is found that the subgroups classified by two different classification criteria are basically the same, and the data of patients at different time points are basically divided into the same subgroups, as shown in Table 1

Table 1: Classification Results of Patient Phase Points According to Different Indicators

	CLUSTER 1	CLUSTER 2	CLUSTER 3	CLUSTER 4	CLUSTER 5	CLUSTER 6	CLUSTER 7	CLUSTER 8	CLUSTER 9	CLUSTER 10
NUMBER OF PHASE POINTS CLASSIFIED BY 58 INDICATORS	9	68	238	385	254	194	250	355	354	148
NUMBER OF PHASE POINTS CLASSIFIED BY 15 INDICATORS	8	66	232	401	246	184	243	360	363	156

By comparing the classification results of patients' phase points by different indicators, it can be concluded that there is no significant difference in the classification results of patients' phase points by two different classification indicators ($P = 0.726$). As shown in Table 2.

Table 2: Comparison of Results of Classification of Patients by Different Indicators

PAIRWISE DIFFERENCE									
CLASSIFICATION OF 58 INDICATORS -	MEAN VALUE	STANDARD ERROR OF MEAN-	STANDARD OF MEAN	ERROR	95% OF DIFFERENCE	CONFIDENCE INTERVAL	T	DF	SIG. (BILATERAL)
CLASSIFICATION OF 15 INDICATORS	-1	8.6	2.75		-7.3	5.3	-.362	8	725

Through the correlation analysis between the classification and clinical outcomes of these 10 categories of patients, it is found that patients in different cluster groups are more inclined to different clinical outcomes, as shown in Table 3. Therefore, the most likely clinical outcome of patients can be predicted by determining the grouping of patients' real-time clinical status.

Table 3: Correlation Analysis Between Cluster Grouping and Clinical Outcome

	CLUSTER 1	CLUSTER 2	CLUSTER 3	CLUSTER 4	CLUSTER 5	CLUSTER 6	CLUSTER 7	CLUSTER8	CLUSTER 9	CLUSTER 10
DEATH			70%		82%					
SEPTIC SHOCK						78%	70%			
BECOME BETTER	90%	89%		60%				66%	71%	81%

The above method can better determine the real-time classification of patients according to the known classification conditions. The clinical outcome of patients was predicted by the relationship between classification and outcome. However, this method cannot well predict the occurrence of septic shock or MODS in advance, so as to carry out effective clinical intervention. Therefore, we continue to mine and analyze the data, hoping to establish a prediction model of septic shock.

The clinical indexes of 34 dead patients were processed by centroid algorithm, and 58 indexes of each patient every day were replaced by a centroid value, which simplified the clinical data of patients (Hadiwijaya & Febrianty, 2019). Due to the great difference in the course of the disease, the centroid values before and after septic shock were intercepted. As shown in Figure 6, the abscissa is the time axis and the ordinate is the centroid value. The number 6 in the abscissa represents the time of septic shock. It can be seen from the change trend of centroid value in the figure that the centroid value of patients with severe burn showed a continuous downward trend from about 4 days before septic shock.

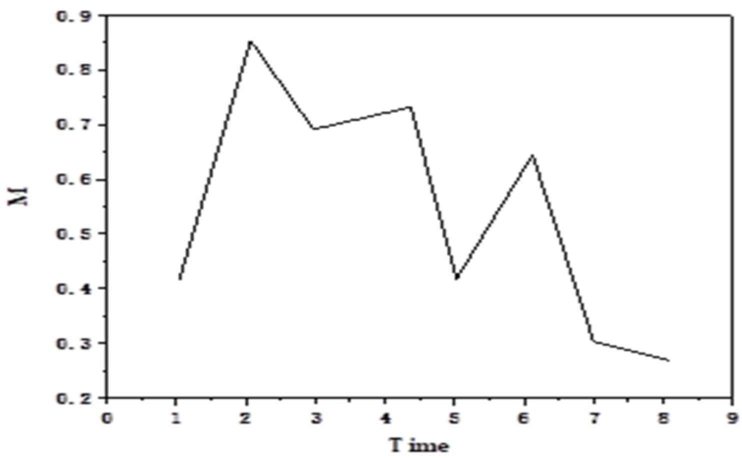

Figure 6: Centroid diagram of Dead Patients Before Septic Shock (Centroid Value Calculated by 58 Indexes)

Because of the characteristic changes of the change pattern of the center of mass before septic shock in severe burn patients. To do this, first extract the data change characteristics of phase points 3-6 in Figure 6. Here, according to the characteristics of clinical data, linear random effect model is selected to fit the data (Salim et al., 2019). As shown in Figure 6, the change trend of patient centroid value over time is similar to a straight line, but the slope and intercept are different. Therefore, the traditional linear regression model cannot be simply used to fit the data. As shown in Formula 3:

$$y_{ij} = \pi_{0i} + \pi_{li}x_{ij} + \varepsilon_{i_j}, \varepsilon_{ij} - N\left(0, \sigma_g^2\right) \quad (3)$$

x_{i_j} represents the j-th observation value of the object. However, the coefficients, intercept π_{0i} and slope π_{1i} here may be affected by some random factors, so we further try to establish the second layer model, such as formula 4-5:

$$\pi_{0i} = \beta_0 + \delta_{0i} \quad (4)$$

$$\pi_{1i} = \beta_1 + \delta_{1i} \quad (5)$$

Where β_0 and β_1 are fixed values, and $\delta_{0i}$and δ_{1i}obey the following distribution, as shown in formula 6:

$$\delta_i = \begin{pmatrix}\delta_{0i}\\ \delta_{1i}\end{pmatrix} - N(0,\Sigma) = N\left(0,\begin{pmatrix}\sigma_0^2 & \sigma_{01}\\ \sigma_{10} & \sigma_1^2\end{pmatrix}\right) \quad (6)$$

Substituting the π_{0i},π_{1i} of the second layer model into the first layer model, we can get equation 7:

$$\begin{aligned} y_{ij} &= (\beta_0 + \delta_{01}) + (\beta_1 + \delta_{1i})x_{i_j} + \varepsilon_{i_j} \\ &= \left(\beta_0 + \beta_1 x_{i_j}\right) + \left(\delta_{0i} + \delta_{1i}x_{i_j} + \varepsilon_{i_j}\right) \end{aligned} \quad (7)$$

In the formula, $(\beta_0 + \beta_1 x i_j)$ is the non randomized part of the model and $(\delta_{0i} + \delta_{1i}x_{ij} + \varepsilon_{ij})$ is its randomized part. $\beta_0,\beta_1,\sigma_0,\sigma_1$ and other parameters need to be estimated by constrained maximum likelihood method (REML). It can be concluded that the fitted centroid calculation model is as follows:

$$y_{ij} = \left(0.2527280 + N(0{,}6.450e-05)\right) + \left(-0.0251963 + N(0{,}1.273e-05)\right)x + \varepsilon_{i_j} \quad (8)$$

Where ε_{ij} is the random factor, y_{i_j} is the centroid value of the j-th phase point of the i-th patient, and X is the length of hospital stay. (0.2527280 + N (0,6.450e-05)) is the intercept part of the model, (-0.0251963 + N (0,1.273e-05)) is the slope of the model, and they are a group of arrays subject to normal distribution. Based on the time-varying model of centroid value before septic shock in severe burn patients, the effectiveness of the model was verified. When verifying the data, first calculate the centroid value of the patient changing with time every day. It can be seen from Figure 6 that the patient will have a characteristic downward trend at the four time points before septic shock (including septic shock). Therefore, taking every four adjacent days of patients as a verification cycle, linear fitting the characteristics of this cycle can obtain the fitting formula 9:

$$y_{i_j} = \pi_{0i} + \pi_{1i}x_{ij} \quad (9)$$

Then compare whether π_{0i} and π_{1i} obey the distribution of (0.2527280 + N (0,6.450e-05)) and (- 0.0251963 + N (0,1.273e-05)) respectively. If both take this distribution, the patient is considered to have a high probability of impending septic shock. As shown in Table 4: Y1 is the actual situation of the patient, Pred1 is the predicted situation of the patient, n is the absence of septic shock, and S is the occurrence of septic shock. The accuracy of this model in predicting the occurrence of septic shock in dead patients is 31 / (3 + 31) = 91.1%.

Table 4: Comparison between the predicted and actual results of sepsis in dead patients using the model

ACTUAL SITUATION OF DEAD PATIENTS(Y1)			
		N	S
PREDICTION OF DEAD PATIENTS (PRED1)	N	0	3
	S	0	31

Subsequently, this method was applied to 73 surviving patients, of which 21 actually developed septic shock. The results obtained are shown in table 10: Y2 is the actual situation of surviving patients, Pred2 is the predicted situation of patients, N is non septic shock and S is septic shock. Subsequently, this method was applied to 73 surviving patients, of which 21 actually developed septic shock. The results are shown in Table 5: Y2 is the actual situation of surviving patients, Pred2 is the predicted situation of patients, n is non septic shock, s is septic shock. The accuracy of this model in predicting septic shock in non-dead patients is: (37 + 16) / (73) = 72.6%.

Table 5: Comparison Between the Predicted and Actual Results of Sepsis Using the Model in Surviving Patients

ACTUAL SITUATION OF DEAD PATIENTS (Y2)			
		N	S
PREDICTION OF SURVIVAL PATIENTS(PRED2)	N	37	5
	S	15	16

By combining the results of all patients, we can get the prediction of the model on whether all patients have septic shock. In the table, y is the actual situation of all patients and Pred is the prediction of all patients. It can be obtained by calculating the data in Table 6, as shown in formula 10-12:

$$\text{Sensitivity} = 47/(47+15) = 75.8\% \quad (10)$$

$$\text{specificity} = 37/(37+8) = 67.3\% \quad (11)$$

$$\text{Overall diagnostic accuracy} = (37+47)/(37+8+15+47) = 78 \quad (12)$$

The sensitivity of the model reflects the ability of the model to predict whether septic shock occurs, and the specificity reflects the ability of the model to correctly judge the occurrence of non-septic shock, as shown in Table 6.

Table 6: Comparison of the Predicted and Actual Results of Sepsis in All Patients Using the Model (58 indicators)

ACTUAL SITUATION OF ALL PATIENTS(Y2)			
		N	S
PRE-CONDITION OF ALL PATIENTS(PRED)	N	37	8
	S	15	47

In order to test again whether the use of 15 indicators can better replace the original 58 indicators, the prediction model is established based on the screened 15 indicators and compared with the model established with 58 indicators (Canallatos et al., 2020). Using the same steps as before, through the change diagram of centroid before septic shock, it can be seen that the centroid calculated by using 15 indexes also has a similar change trend.

Then, the same linear random effect model is used to model, and a new prediction model can be obtained, as shown in equation 13:

$$y_{i_j} = \left(0.2016191 + N(0{,}4.126e - 05)\right) + \left(-0.0192177 + N(0{,}1.067e - 05)\right)x + \varepsilon_{ij} \quad (13)$$

Use the same method as before to verify and calculate the model, and also use MATLAB 7 0 software, as shown in Table 7.

Table 7: Comparison of the predicted and actual results of sepsis using the model in all patients (15 indicators)

ACTUAL SITUATION OF ALL PATIENTS (Y)			
		N	S
PRE-CONDITION OF ALL PATIENTS(PRED)	N	34	10
	S	18	45

It can be calculated from this. See formula 14-16:

$$\text{Sensitivity} = 45/(45 + 18) = 71.4\% \quad (14)$$

$$\text{specificity} = 34/(34 + 10) = 77.3\% \quad (15)$$

$$\text{Overall diagnostic accuracy} = \frac{(34+45)}{(34+10+18+45)} = 73.8\% \quad (16)$$

As shown in Table 7, the differences between different prediction models established by using different numbers of indicators are compared. Through comparison, it can be seen that although the sensitivity, specificity and overall diagnostic coincidence rate of the prediction model established with 58 indexes are slightly higher than those established with 15 indexes, the difference is not obvious. This further verifies that the 15 indicators we screened are highly representative.

4. Experiment and Discussion

60 patients with scar after neck burn in a hospital were selected for study.

Inclusion criteria: (1) Neck burn wound healing for 6 months to 2 years; (2) No drug dependence; (3) The functions of heart, liver, kidney and other important organs are normal; (4) The patient is conscious and can cooperate with the treatment; (5) Informed consent has been obtained from the patient.

Exclusion criteria: (1) Patients with coagulation dysfunction; (2) Patients with systemic or skin diseases that may affect the efficacy evaluation; (3) Women who are pregnant or breastfeeding.

The patients were randomly divided into two groups with 30 cases in each group. Control group: 16 males and 14 females; The age ranged from 24 to 53 years, with an average of 42.19 + 5.04 years; The scar area was 21 ~ 53cm^2, with an average of 33.08 + 7.91cm^2; The depth of burn was grade I in 18 cases and grade II in 12 cases. Observation group: 18 males and 12 females; The age ranged from 21 to 55 years, with an average of 42.63 + 5.11 years; The scar area was 20 ~ 57 cm^2, with an average of 33.61 + 7.82 cm^2; The depth of burn was grade I in 16 cases and grade II in 14 cases. There was no significant difference between the two groups (P > 0.05) (Choi et al., 2019).The clinical efficacy, scar blood flow, pruritus, EGF, TNF-a, patient satisfaction and complications were compared between the two groups.

(1) The curative effect was evaluated 6 months after operation, and the obvious effect was: The scar disappeared, and the score of "Vancouver Scar Scale" was 3 or below; effective: the scar was significantly reduced, and the score of Vancouver Scar Scale was 3 ~ 7; ineffective: the symptoms were not improved, and the score of Vancouver Scar Scale was 8 or above.

(2) Scar blood flow: The blood flow of scar was measured by laser speckle blood flow imaging before operation and 6 months after operation.

(3) Itching symptoms: The patients were evaluated with four item itch scale 8 before and 6 months after operation. The score range was 0 ~ 4 points. The higher the score, the more serious the scar itch.

(4) EGF、TNF-a: Fasting peripheral venous blood was collected before and 1 month after operation, and separated at the speed of 3000 R / min for 15 minutes. The serum was obtained and evaluated by enzyme-linked immunosorbent assay.

(5) Patient satisfaction: Six months after operation, according to the literature Likert scale, the satisfaction was scored as 3 ~ 5 points and 1 ~ 2 points as dissatisfaction. The satisfaction of the two groups was compared.

(6) Complications: The complications of the two groups during treatment were recorded (Inangil & Inangil, 2020). SPSS 24.0 software was used for statistical analysis. T-test was used for measurement data, and 2-test was used for counting data. P < 0.05 was statistically significant.

The total effective rate of the observation group was 93.33%, higher than 73.33% of the control group (P < 0.05). See Table 8:

Table 8: Comparison of Curative Effects Between the two Groups[n(%)]

GROUP	REMARKABLE EFFECT	EFFECTIVE	INVALID	TOTAL EFFECTIVE RATE
CONTROL GROUP (N = 30)	13(43.32)	9(30.00)	8(25.67)	22(72.33)
OBSERVATION GROUP (N = 30)	16(53.23)	12(40.00)	2(6.57)	28(83.33)
X^2				4.4
P				0.03

After operation, the scar blood flow value and pruritus symptom score in the two groups decreased significantly, but the decrease was greater in the observation group (P < 0.05), as shown in Table 9:

Table 9: Comparison of Blood Flow Value and Pruritus Symptoms Between the Two Groups

GROUP	SCAR BLOOD FLOW VALUE (PERFUSION UNIT)		PRURITUS LANGUAGE RATING SCALE (SCORE)	
	PREOPERATIVE	AFTER OPERATION	PREOPERATIVE	AFTER OPERATION
Control group (n = 30)	52.51±7.32	26.03±2.26*	3.35±1.68	2.38±0.91*
Observation group (n = 30)	51.40±6.55	16.31±1.52*	3.07±3.52	1.06±0.33*
t	0.303	18.186	0.30	5.41
p	0.762	0	0.86	0

Preoperative and postoperative comparison, 'p < 0.05

After operation, EGF increased significantly in the two groups, but increased more in the observation group. The level of TNF-a decreased significantly in both groups, but decreased more in the observation group (P < 0.05), as shown in table 10:

Table 10: Comparison of EGF and TNF-a Between the Two Groups

GROUP	EGF(NG/ML)		TNF-α (NG/ML)	
	PREOPERATIVE	AFTER OPERATION	PREOPERATIVE	AFTER OPERATION
CONTROL GROUP (N = 30)	12.51±2.38	15.83±4.26*	19.35±3.68	15.38±2.91*
OBSERVATION GROUP (N = 30)	12.40±2.55	18.31±4.52*	19.07±3.52	13.06±2.33*
T	0.173	-2.186	0.30	3.41
P	0.862	0.03	0.76	0

The total satisfaction rate in the observation group was 90.00% (27 / 30), which was higher than 66.67% (27 / 30) in the control group (P < 0.05). There were 3 cases (10.00%) of complications in the observation group, including 1 case of skin swelling, 1 case of pruritus and 1 case of distal flap necrosis; There was no significant difference between the two groups (P > 0.05). All patients were followed up for 6 months, of which 3 cases (10.00%) recurred in the control group and 1 case (3.33%) recurred in the observation group. There was no significant difference between the two groups (P > 0.05) (Lestari et al., 2019; Salim et al., 2019). Under normal circumstances, scar tissue is beneficial in the process of wound repair. Conventional skin flap grafting is a commonly used method for scar tissue repair, but this method has a high recurrence rate of skin contracture deformity, and may also cause postoperative neck bloat due to the large thickness of the flap. Multiple skin expansion technique can repair the scar by expanding the normal tissue around the scar tissue. Because the thickness, color, texture and function of normal tissue at the edge of neck scar are similar to those of scar tissue, it can effectively improve the appearance and function of scar tissue. Compared with conventional flap repair, multiple skin expansion has the following advantages: (1) Different dilators can be selected according to the size of scar to provide sufficient skin. Loose and tension-free skin can be used for repair, which is helpful to wound healing and reduce the recurrence of scar spasm symptoms; (2) The color and texture of the expanded flap are similar to the scar tissue, and the flatness of the recipient area can be improved after repair and plastic surgery; (3) Multiple skin expansion can enhance the blood supply of the flap, help to improve the survival rate of flap transplantation and accelerate the healing of the wound.In the early stage after burn, local thickening and hardening can occur, and capillaries are prone to extreme congestion and cause pruritus. This study shows that the scar blood flow value and pruritus symptom score in the two groups decreased significantly, but the decrease range in the observation group is greater (P < 0.05), which is consistent with the relevant research results. The reason may be that the blood supply of the flap used in the treatment of multiple skin expansion is similar to that of scar tissue, and multiple expansion can effectively reduce the tension of the flap, avoid excessive capillary congestion due to local tissue thickening after transplantation, and reduce the incidence of pruritus. EGF can stimulate the proliferation of a variety of cells in vivo, promote the division of skin cells, delay cell aging and improve the survival rate of skin flap after transplantation. TNF-a is mainly activated by macrophages to improve the killing ability of abnormal cells such as tumor cells. In this study, EGF increased significantly in the two groups after operation, but increased more in the observation group (شعابنة & زريفة, 2021). The level of TNF-a decreased significantly in both groups, but decreased more in the observation group (P < 0.05). It may be that the flap used in the multiple expansion technique is the normal tissue around the scar tissue, and its extracellular matrix framework is highly similar to the scar tissue. After transplantation, it can enter the dermis through the fibroblasts at the base and edge of the wound to accelerate the reconstruction of the vascular network. At the same time, the flap used in the multiple expansion technique has high histocompatibility with the recipient area, low antigenicity, and less inflammatory reaction caused by the transplantation process (Hadiwijaya & Febrianty, 2019).

5. Conclusion

This study demonstrates that multiple skin expansion techniques significantly enhance the curative outcomes and patient satisfaction in scar plastic surgery following neck burns. By effectively reducing scar vascularity and pruritus, these interventions promote better functional recovery and improve the aesthetic appearance of scars, addressing both physical and psychological aspects of rehabilitation. The results underscore the importance of innovative surgical approaches in facilitating mobility and restoring the range of motion, particularly in areas critical for physical activity and sports performance. By integrating advanced data analysis techniques, such as machine learning and big data processing, this study also highlights the potential for personalized treatment strategies that optimize recovery pathways for burn survivors. These findings pave the way for future research focusing on long-term impacts of skin expansion techniques on physical activity levels, sports participation, and quality of life in burn patients. Incorporating these insights into multidisciplinary rehabilitation programs can further enhance outcomes, empowering patients to regain confidence, functionality, and active engagement in their daily lives and physical pursuits.

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