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Correlation between Preoperative Nutritional Prognostic Index and Split-Thickness Skin Graft Take in Severe Burn Patients

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ABSTRACT

Background: Morbidity and mortality due to severe burns remain high. Severe burns require split-thickness skin grafts (STSG), and research on the factors influencing take of STSG success is always developing. The relationship between the preoperative Prognostic Nutritional Index (PNI) and take of STSG success, as measured by graft take percentage, has not been studied in Indonesia, despite PNI being an easily accessible and cost-effective tool.
Methods: This case-control study involved 60 patients with severe burns at Burn Unit in I.G.N.G. Prof. Ngoerah General Hospital, Bali, Indonesia, from 2018 to 2024. Cases were patients with STSG take below 85%, and controls were patients with STSG take above 85%. Preoperative PNI and 14-day STSG-take rates were analyzed and correlated.
Results: Statistical analysis revealed a significant correlation between preoperative PNI and STSG take in severe burn patients, with a correlation coefficient of 0.628 ($p<0.01$). The optimal PNI cutoff value was 23.5058. Preoperative PNI was significantly associated with the STSG take success (OR = 3.696; $p < 0.001$).
Conclusion: Preoperative PNI predicts STSG take success in severe burn patients at Burn Unit in I.G.N.G. Prof. Ngoerah General Hospital.

Keywords: Burn injury, skin graft, prognosis

INTRODUCTION

Severe burns are traumatic injuries affecting 20% or more of the total body surface area (TBSA) in adults, leading to systemic complications and life-threatening conditions.[1] Skin, as the primary protective barrier, is essential for preventing infection and dehydration. However, extensive burns often require skin grafting for wound closure.[2] Skin grafting involves transplanting skin without its vascular supply, relying on the recipient site for survival. The two main types are split-thickness skin grafts (STSG) and full-thickness skin grafts (FTSG).[3] STSG is preferred for severe burns due to limited donor sites and the possibility of re-harvesting.[4] STSG is widely used globally, with the UK reporting 10,000 procedures annually, 75% in adults.[5] In Indonesia, it is the second most common burn treatment after debridement.[6]

The process to achieve STSG take follows phases of imbibition, inosculation, and revascularization.[7] Factors like nutrition and vascularization influence graft take. Severe burns increase metabolic demands, leading to malnutrition, which impairs healing and increases infection risk.[8] Prognostic Nutritional Index (PNI), calculated from serum albumin and lymphocyte levels, serves as a predictor of STSG take success.[9] Hypoalbuminemia disrupts healing, while lymphocyte count reflects immune status.[10] Studies show that PNI <40 increases postoperative complications, while PNI >34.98 correlates with higher STSG success.[11]

Despite its potential, limited research exists on PNI's role in STSG-take for severe burns, particularly in Indonesia. Given its accessibility and cost-effectiveness, this study aims to evaluate the correlation between preoperative PNI and STSG-take, providing valuable insights for improving burn patient outcomes.

MATERIALS & METHODS

This study employed a case-control design, involving 60 patients with severe burns (TBSA > 20%) who underwent STSG at Burn Unit in Prof. Dr. I.G.N.G. Ngoerah Public Hospital from 2018 to 2024. The inclusion criteria were patients aged 18 years or older, diagnosed with severe burns (TBSA >20%), and who underwent STSG. Exclusion criteria included chronic liver or kidney disease and recent anti-inflammatory drug use. Data were collected from medical records, including demographic information, burn characteristics, preoperative PNI, and STSG outcomes. PNI was calculated using the formula: PNI = 10 × albumin serum (g/dL) + 0.005 × lymphocyte count (/µL). The sample consisted of 60 patients, divided into cases and controls that summarized in Figure 1. Ethical approval was obtained from the Ethical Committee Board of Prof. Dr. I.G.N.G. Ngoerah Public Hospital/Faculty of Medicine Udayana University Number: 1861/UN14.2.2.VII.14/LT/2024 issued on 16th July 2024.

STATISTICAL ANALYSIS

Statistical analyses were performed using SPSS software. Descriptive statistics were calculated, and the correlation between PNI and STSG-take rates was assessed using Spearman's correlation coefficient. A p-value < 0.05 was considered statistically significant. In addition, Receiver Operating Characteristic (ROC) curve analysis and multivariate analysis using logistic regression were carried out which were tested by variables with a significance value of <0.25.

RESULT

Baseline Characteristics

The study included 60 patients, with 39 in the control group (take of STSG > 85%) and 21 in the case group (take of STSG ≤ 85%). The demographic data, including age, gender, burn area, length of stay, and burn causes, are detailed in Table 1. Statistical test results indicated that there were no significant differences in the variables between the control and case groups, except burn causes (p = 0.016), as summarized in Table 1.

Preoperative PNI and STSG Outcomes

A non-parametric Spearman correlation was performed due to non-normal data distribution. A strong positive correlation was found between preoperative PNI and STSG-take (r = 0.628, p < 0.01), indicating that higher PNI correlates with better graft take. These correlation results are presented in Table 2. Additionally, albumin levels showed a significant positive correlation with STSG take (r = 0.629, p < 0.01), while lymphocyte counts did not show a significant relationship (r = 0.108, p = 0.41). The details of these analyses are summarized in Table 3 and Table 4. The linear regression analysis revealed that the regression coefficient for PNI was B = 1.060, indicating that a one-unit increase in PNI corresponds to a 1.060% increase in

STSG take percentage ($p < 0.01$). PNI explained 29.7% of the variation in STSG-take level, as shown in Table 5. Furthermore, the ROC curve analysis indicated that the area under the ROC curve was 0.894 (95% CI: 0.809-0.979), demonstrating good predictive ability. The optimal cutoff for PNI was determined to be 23.5058, with sensitivity of 79.5% and specificity of 81%. Higher PNI (>23.5) significantly increased the likelihood of successful STSG take (OR = 3.696, $p < 0.001$). These findings are illustrated in Figure 2 and Table 6. In the multivariate analysis, age, burn area, and length of stay did not show significant statistical relationships with STSG take success ($p > 0.05$), indicating they are not confounding factors in this study. The results of this analysis are summarized in Table 7. This summary highlights the key findings and statistical analyses conducted in the research, emphasizing the significant relationship between preoperative PNI and the success of skin grafting in burn patients.

Table 1. Baseline characteristics of patients

Variable		Control Group (n=39)	Case Group (n=21)	Sig.
Gender				0,694[a]
Male	n (%)	24 (61,54)	14 (66,67)	
Female	n (%)	15 (38,46)	7 (33,33)	
Age	Years	35 (18-65)	40 (22-81)	0,145[b]
Burn area	%	28 (20-54)	32,5 (20-54,5)	0,171[b]
Length of stay	Days	16 (7-31)	20 (9-53)	0,155[b]
Burn causes				0,016[a*]
Flame	n (%)	24 (61,54)	14 (66,67)	
Flame + Inhalation trauma	n (%)	8 (20,51)	2 (9,52)	
Scald		3 (7,69)	0 (0)	
Hot oil	n (%)	1 (2,56)	1 (4,76)	
LVEI	n (%)	1 (2,56)	0 (0)	
HVEI	n (%)	2 (5,14)	4 (19,05)	

Notes: HVEI: High Voltage Electricity Injury; LVEI: Low Voltage Electricity Injury. Age, burn area, and length of stay are presented as median (min-max). [a]Chi-Square (x2) test. [b]Mann-Whitney test. *p<0.05.

Table 2. Spearman Correlation and Linear Regression Analysis on PNI and STSG Take Percentage

Category	n	Median PNI	Median % STSG	r[1] Value (r; p)	B[2] Value (B; p)
Control group	39	26,51 (21,01-38,91)	96 (88-99)	0,628; 0,00	1,060; 0,00
Case group	21	21,01 (16,61-28)	80 (63,5-85)		

Notes: The control group consists of individuals with an STSG take percentage >85%, while the case group includes those with an STSG percentage ≤85%. PNI: Prognostic Nutritional Index; STSG: Split Thickness Skin Graft. PNI data and STSG take percentage are presented as median (min-max). The correlation coefficient (r) ranges between -1 and 1. A positive value indicates a positive correlation, whereas a negative value indicates a negative correlation. *Sig with a 95% confidence interval (CI); p<0.05.

1. Correlation values are based on the Spearman analysis test, with p <0.05.
2. Regression coefficient values are based on linear regression analysis, with p <0.05.

Table 3. Spearman Correlation and Linear Regression Analysis on Lymphocytes and STSG Take Percentage

Category	n	Median Lymphocytes	Median % STSG	r[1] Value (r; p)	B[2] Value (B; p)
Control group	39	1,29 (0,4-3,7)	96 (88-99)	0,108; 0,41	0,412; 0,68
Case group	21	1,35 (0,3-2,7)	80 (63,5-85)		

Notes: The control group consists of individuals with an STSG take percentage >85%, while the case group includes those with an STSG percentage ≤85%. PNI: Prognostic Nutritional Index; STSG: Split Thickness Skin Graft. Albumin and STSG take percentage data are presented as median (min-max). The correlation coefficient (r) ranges between -1 and 1. A positive value indicates a positive correlation, whereas a negative value indicates a negative correlation. *Sig with a 95% confidence interval (CI); p<0.05.

1. Correlation values are based on the Spearman analysis test, with p <0.05.
2. Regression coefficient values are based on linear regression analysis, with p <0.05.

Table 4. Preoperative PNI Cut-off Values for STSG Take Percentage Based on the Youden Index

Cut-off Point	Youden Index
23,3534	0,583
23,4049	0,557
23,5058	0,605
23,6556	0,554
23,7096	0,528

Table 5. Cross-tabulation of PNI Groups and STSG Take

Variable	Control n = 21	Case n = 39	OR (KI 95%)	p-value
Preoperative PNI			3,696 (1,249-10,933)	
PNI (<23,5)	15 (71,4)	16 (41,0)		< 0,001
PNI (>23,5)	6 (28,6)	23 (59,0)		

Table 6. Multiple Linear Regression Analysis on STSG Take Percentage

Variable	B	Standard Error	t-value	p-value
(Constant)	71,334	12,635	5,646	0,000
Age	-0,083	0,079	-1,041	0,303
Burn area	-0,031	0,154	-0,201	0,841
Length of stay	-0,116	0,131	-0,887	0,379
PNI	1,034	0,264	3,486	0,001*

Figures

Figure 1. Research flow.

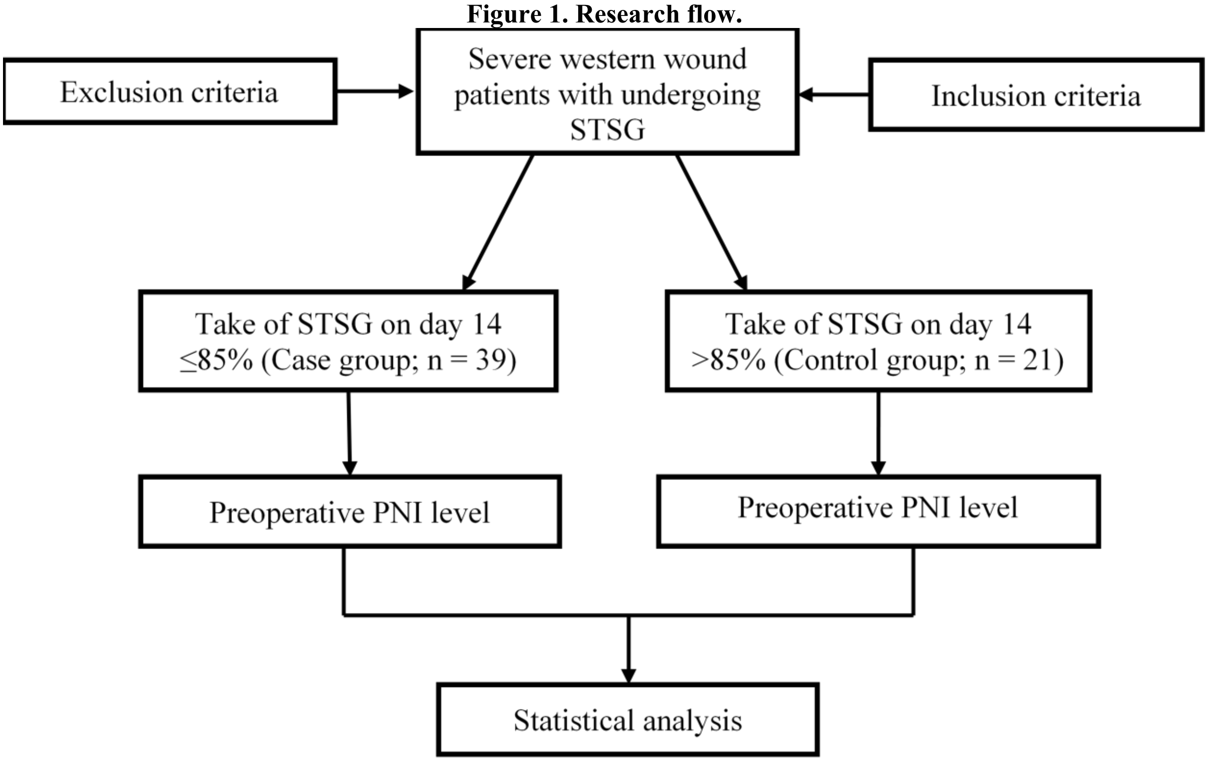
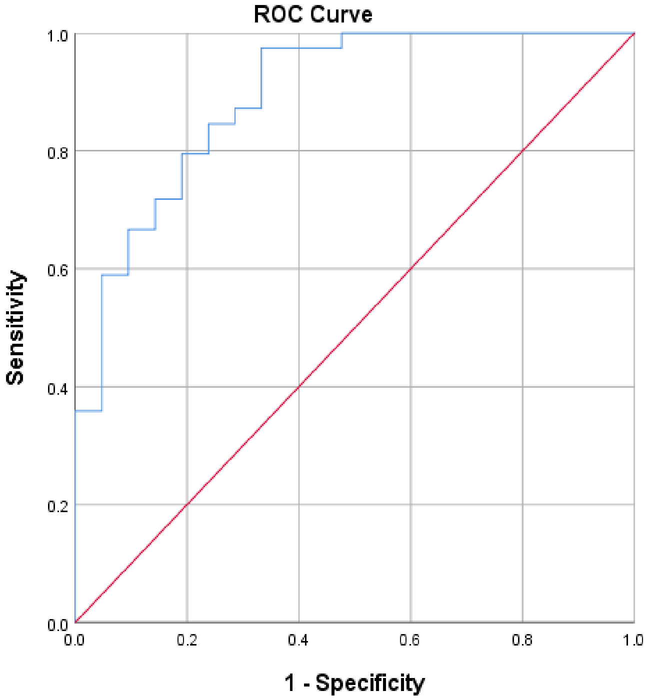


Figure 2. The ROC curve is used to evaluate the predictive ability of preoperative PNI on the percentage of STSG take success.



DISCUSSION

Sample Characteristics and Relationship with STSG Procedures

Among the 60 study subjects, the age range of patients upon hospital admission was 18 to 81 years, with the case group having ages between 22 and 81 years, and the control group ranging from 18 to 65 years. The majority of subjects were male, comprising 38 individuals (63.33%), while 22 were female (36.67%). Similar findings were reported by Wardhana *et al.* and Wang *et al.* who noted a comparable gender ratio, with more males than females among burn patients undergoing STSG.[12,13] Chi-square statistical analysis indicated no significant differences in gender and burn etiology between the two groups ($p > 0.05$).

Additionally, Mann-Whitney tests showed no significant differences in age, burn size, or length of stay between the groups ($p > 0.05$). The homogeneity of these characteristics suggests they do not confound the analysis of preoperative PNI and take of STSG success. The burn etiologies varied, with the most common being flame (n=37; 63%), flame and inhalation trauma (n=10; 17%), high voltage electrical injury (HVEI) (n=6; 10%), scald (n=3; 5%), hot oil (n=2; 3%), and low voltage electrical injury (LVEI) (n=1; 2%). A previous study similarly reported that the highest incidence of burns in surgical patients was due to flame, with 13 cases (31%).[12]

Correlation Between Preoperative PNI and Take of STSG Level

Previous studies have shown that the Prognostic Nutritional Index (PNI) is closely related to the prognosis of both cancer and burn injury patients.[11,14–16] In this study, a significant positive correlation was found between preoperative PNI values and take of STSG success rates, with a correlation coefficient of 0.628 ($p < 0.01$). This indicates that higher preoperative PNI values are associated with increased take of STSG success rates. Linear regression analysis further revealed that each unit increase in preoperative PNI correlates with a 1.060% increase in STSG-take success ($p < 0.01$). A PNI threshold of >23.5 emerged as a significant cut-off point, where the likelihood of STSG-take success increases substantially (OR = 3.969; 95% CI = 1.249-10.933). This finding reinforces the hypothesis that preoperative PNI is a significant predictor of higher STSG success rates. Previous research by Hu *et al.* also identified preoperative PNI as a protective factor for STSG success (OR = 0.646; 95% CI = 0.547-0.761; $p < 0.05$).[11]

PNI comprised of serum albumin and lymphocyte counts, providing a comprehensive overview of a patient's nutritional and immunological status. A low preoperative PNI indicates malnutrition, which impairs the body's ability to combat infections and triggers inflammatory responses. This malnutrition can significantly impair the healing process, making it critical to address nutritional deficiencies before surgical interventions. The success of skin grafting in burn injuries heavily relies on the nutrition provided by the wound tissue and the formation of new blood vessels. In patients with severe burns, increased vascular permeability leads to significant exudate loss from the wound and decreased organ function, which hinders albumin production or causes a drastic reduction in albumin levels.[17] Extensive burns also elevate metabolic rates, exacerbating malnutrition if nutritional intake is inadequate.[18]

A recent study by Vanaclocha *et al.* in 2024 explored the relationship between perioperative serum prealbumin levels and PNI calculations, finding that each 1 mg/dL increase in prealbumin was associated with a 3.77% decrease in the time to complete epithelialization ($p = 0.088$).[19] This highlights the importance of maintaining adequate nutritional levels, as prealbumin serves as a marker for short-term nutritional status. In our study, albumin was chosen for PNI calculation due to its longer half-life (approximately 20 days), making it a better indicator of long-term nutritional status compared to prealbumin, which has a shorter half-life (2-3 days).[20]

Low PNI levels affect every phase of STSG, including the imbibition phase, where malnutrition can disrupt plasma quality absorbed by the graft. Hypoalbuminemia can reduce oncotic pressure and hinder the distribution of proteins and growth factors necessary for early tissue regeneration.[21] Following this phase, skin graft relies on angiogenesis (revascularization phase), which depends on collagen presence. Hypoalbuminemia can inhibit collagen synthesis, while decreased lymphocyte counts can slow endothelial recruitment.[17]

Previous studies by Seo *et al.* also evaluated risk factors affecting one-year mortality after burn surgery in elderly patients, including PNI. Their findings indicated that PNI values on the first postoperative day were associated with one-year mortality risk (hazard ratio (HR) = 0.872; 95% CI = 0.812-0.936; $p < 0.001$). Patients with low PNI, defined as less than 25.5, had significantly lower one-year survival rates compared to those with PNI above 25.5 (32.1% vs. 75.9%, $p < 0.001$).[14]

The ROC curve analysis in this study discovered that a PNI cut-off value of 23.5 can accurately predict the take of STSG success. Patients with a PNI above 23.5 are more likely to achieve STSG take rates exceeding 85%, while those with a PNI below this threshold are likely to have lower take rates. An AUC of 0.894 indicates that preoperative PNI is a reliable indicator for predicting STSG-take success. In the previous study, the ROC curve demonstrated that PNI outperformed other markers, such as neutrophil-lymphocyte ratio, platelet-lymphocyte ratio, total lymphocyte count, and albumin levels in predicting outcomes for burn patients. The preoperative PNI cut-off in that study was found to be 34.98, with an AUC of 0.865 (95% CI: 0.801–0.928; $p < 0.001$).[11]

The significant differences in cut-off values are likely due to differences in the skin grafting techniques employed. The Meek procedure reduces the need for extensive donor skin by expanding a small amount of skin into a larger area for grafting.[22] Conversely, this study utilized a simple STSG technique, which involves harvesting skin of a specific thickness from a larger donor area and transferring it to the burn site, often requiring more donor area to cover the entire burn. Therefore, standard STSG techniques may be more dependent on the quality and quantity of available donor skin, as well as factors such as the nutritional status of the patient reflected in the PNI. In addition, the differences in cut-off values for burns compared to cancer may be due to the physiology of burn injuries, which can cause tissue damage, capillary leakage, edema, and severe hypovolemia, necessitating active fluid management. This impacts the PNI values, which tend to be lower in burn studies, as seen in this research.[23–25]

Relationship with Other Factors and Take of STSG Level

The findings of this study suggest that preoperative PNI values can be recommended as a parameter for predicting the take of STSG success in patients with severe burns. However, since PNI only explains a small portion of the outcome variation (moderate ability), it is essential to also consider other factors that may influence healing. Literature indicates that factors affecting the final success of STSG-take may include age, overall nutritional status, degree of immune system impairment, comorbidities, severity and/or depth of the burn, wound preparation, surgical technique, and postoperative wound care.[26,27]

After STSG is harvested, the graft no longer receives nutrition and oxygen from the blood supply. Additionally, skin graft failure is often caused by the formation of hematomas or blisters beneath the skin layer, which prevents efficient imbibition and revascularization of the graft. The size of the burn, particularly with TBSA >30%, is associated with higher mortality rates; however, its relationship with STSG success rates remains variable. Jackson *et al.* reported that patients with TBSA <30% had better STSG success rates (71% compared to 41% for TBSA >30%).[28] The findings of this study did not indicate burn size as a predictor of STSG success, consistent with other studies.[26,29]

Several previous studies have shown inconclusive results regarding the impact of age, length of stay, and infection rates on STSG-take success.[30–34] Significant physiological differences exist between elderly and younger burn patients, which can negatively affect the severity of burn morbidity. Geriatric patients are more vulnerable to severe burns due to skin atrophy, comorbidities, polypharmacy, visual and mobility impairments, and susceptibility to household accidents.[35–36] The success rate of STSG-take in patients under 55 years is significantly better than in those over 55 years due to slower microcirculation and inflammatory responses.[26] Younger patients generally have better metabolic rates, optimal immune responses, and better tissue regeneration capabilities. Longer lengths of stay are associated with higher burn severity, complications such as secondary infections, and ongoing nutritional deficiencies.

LIMITATIONS

This study focuses on the role of preoperative PNI as a predictor of STSG take success in severe burn patients. However, limitations include the lack of examination of other laboratory data that may influence STSG outcomes, such as hemoglobin levels and complete blood counts. Additionally, other variables, such as hydration status and comorbidities, were not included in the analysis. The study's single-center design also limits the ability to generalize the findings, suggesting the need for multicenter studies to validate the results.

CONCLUSION

Preoperative PNI is a strong predictor of STSG take success in severe burn patients, emphasizing the importance of preoperative nutritional assessment before surgery. Patients with higher PNI values are more likely to achieve successful graft integration, while those with lower PNI scores may require additional nutritional interventions. Implementing routine PNI screening can help identify at-risk patients and guide preoperative optimization strategies, ultimately improving patient outcomes. Future research should explore the role of targeted nutritional supplementation and the long-term functional benefits of improving preoperative PNI in severe burn cases.

Declaration by Authors

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