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Wound pH and autograft taking in burn wounds: An experimental study

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Original Article

Wound pH and autograft taking in burn wounds: An experimental study

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INTRODUCTION

- Skin autograft is the most accepted technique in full-thickness burn injuries and is considered as the gold standard of treatment for large skin defects and deep burns.

- For a successful skin autograft transplantation, an appropriately excised and well-perfused wound bed is mandatory.

- the presence of pathogens such as Staphylococcus aureus or Pseudomonas aeruginosa in abundant numbers is associated with skin autograft failure.

- When the count of organism per gram of tissue is more than 105, the rate of autograft taking falls significantly.

INTRODUCTION

- Most surgeons decide on the appropriateness of the wound bed for autograft transplantation based on the clinical judgment.

- it seems that personal experience is not always reliable, especially in a patient with an extensive burn injury and limited donor sites when the skin autograft failure could be a catastrophic event.

INTRODUCTION

- Some solutions have been suggested to overcome this problem.
- Skin allograft is used by some surgeons to test the appropriateness of wound bed for autograft.
- However, skin allograft is a costly option with limited availability in most burn centers and must be reserved for critical patients.
- Moreover, the application of skin allograft as a test and waiting to see the result is a time-consuming procedure and increases hospitalization and the number of procedures on each patient.
- Some authors have suggested that wound culture examination should be performed on any wound, especially chronic ones and skin autograft should be considered only when the bacterial count of wound bed is less than a predefined number.
- Despite the fact, the result of wound culture would be available after 48–72 h and bacterial load of burn wound bed and the type of pathogens may change during this period.

INTRODUCTION

- Considering the limitations of previously suggested solutions, some investigators have tried to find a more rapid and less nexpensive way to evaluate the appropriateness of burn wound bed for skin autograft.
- There are some pieces of evidence that pH of the wound bed is associated with wound contamination and measurement of wound pH may be a simple, fast, and inexpensive way to assess the appropriateness of burn wound bed for skin autograft.
- It has been advocated that optimum pH for skin graft is 7.2–7.5.
- In a study by Schneider et al. as the pH increased gradually from 6.4 to 7.2, the take rate of skin graft increased from 20% to 90%.

INTRODUCTION

- The optimal pH for proliferation of fibroblasts and keratinocytes is 7.2–8.3.
- An acidic environment is more appropriate for wound healing, whereas nonhealing chronic wounds have an alkaline environment.
- Many factors,including infection, dressing material, and the level of tissue oxygenation, affect wound pH.
- The presence of micro-organisms and tissue necrosis causes an alkaline shift in the wound.
- Wound pH affects immune cells function, angiogenesis, collagen formation, and activity of matrix metalloproteinases.
- Moreover, most antibiotics have an optimum pH to exert their effects.

INTRODUCTION

- In many bacteria, including P. aeruginosa and Klebsiella pneumonia, biofilm production accelerates when the pH increases from 5.5 to 8.5.
- Some authors believe that the wound pH is related to the depth of burn wound and differs from 6.05 in superficial burns to 8.0 in full-thickness burns at the second dressing change. Therefore, they advocated that wound pH can be used for the early identification of nonhealing burn wounds.
- Healing wounds have a significantly lower pH (7.32) compared to nonhealed ones (7.73).

INTRODUCTION

- This study was designed to evaluate the association between wound pH, wound temperature, wound culture results, and the rate of autograft taking.

MATERIALS AND METHODS

- This prospective, cross-sectional study was performed in 2020, in Motahari Burns and Reconstructive Center, Tehran, Iran, by the convenient sampling method.
- This study was approved by the Institutional Ethics Committee, and informed consent was obtained from all the patients or their legal guardians.

MATERIALS AND METHODS

- The inclusion criteria were patients with thermal injury who were candidates for burn wound excision and skin grafting and the percent of burnt total body surface area (%TBSA) was <60.
- Demographic data (age and gender) and burn-related variables (burn size, burn mechanism, and time from burn accident up to surgery) alongside with the duration of hospitalization and final in-hospital patient outcomes were recorded.
- The anatomical site of burn wound was classified as head and neck, upper extremities, lower extremities, and trunk.
- The core temperature of patients was measured at the beginning of anesthesia induction immediately after the removal of dressing in the operating room.

MATERIALS AND METHODS

- Wound pH and local wound temperature were measured by portable pH meter (L2012, Labtron Co, IR Iran), and specimen for tissue culture was obtained from the burn wound.
- On the completion of wound excision, wound pH, local temperature, and tissue culture were repeated.
- All patients underwent skin autograft, and postoperative care was continued according to our standard institutional guidelines.
- As a part of the institutional practice, the first dressing change was performed on day 3 postoperative, and the take rate of the skin autograft was evaluated by an experienced burn surgeon .
- All patients were visited again on day 7 by the same surgeon to evaluate autograft taking.

MATERIALS AND METHODS

- Data were analyzed using the SPSS software version 16 (SPSS Inc. Chicago, Il, USA) by descriptive (mean, standard deviation, median, interquartile range [IQR], frequency, and percentage) and inferential (paired t-test, ANOVA, and Pearson correlation) analyses. All tests were two-tailed, and the statistical significance level was considered <0.05.

RESULTS

- Fifty consecutive cases of deep-burn injuries scheduled for burn wound excision and skin autograft were enrolled.
- Most (38, 76%) were male.
- The mean age of all patients was 29.9 ± 19.8 (median: 28.0, IQR: 12.7–40.0) years.
- The most common mechanism of burn injury was fire (27, 54%),followed by scalding (9, 18%) and contact (6, 12%).
- The mean %TBSA was 21.9 ± 15.2 (median: 19.0, IQR: 10.0–35.0).
- The average interval between burn accident and the final operation was 15.4 ± 15.7 (median: 9.5, IQR: 4.7–23.5)days.
- The mean hospital stay was 13.7 ± 10.8 (median: 13.0,IQR: 5.7–17.0) days.
- There was one (2%) in-hospital mortality.

RESULTS

- The mean core temperature of patients at the beginning of operation was 36.9°C ± 0.4°C.
- As Table 1 shows, the local temperature on the wound bed significantly increased at the end of operation while local wound pH significantly decreased.
- The take rate of skin autograft was 86.8% ± 11.1% on the 3rd day, which increased to 94.2% ± 12.3% on the 7^{th} day postoperatively.

RESULTS

- The wound culture had positive results in 22 patients (44%) before wound excision, but only in six patients, colony count was more than 105.
- Wound culture had positive results in 14 patients after wound excision, but in all of them, colony count was less than 10000 [Table 2].
- There was a significant reverse association between the take rate of the skin graft on day 3 and wound pH on the beginning of operation ($r = -0.34$, $P = 0.016$) [Figure 1] but not wound pH after excision ($r = -0.18$, $P = 0.19$).
- Furthermore, there was a statistically significant association between the core body temperature at the beginning of procedure and the rate of graft taking on days 3 ($r = 0.30$, $P = 0.035$) and 7 ($r = 0.42$, $P = 0.002$).
- However, there was no significant association between local wound temperature after dressing removal or at the end of wound excision and the take rate of skin autograft on day 3 or 7. Only, the skin take rate on day 7 was significantly associated with hospital stay ($r = -0.41$, $P = 0.003$).

RESULTS

- There was no statistically significant association between the results of wound culture before excision and wound pH or the rate of graft taking. However, a positive wound culture after burn wound excision, even when the colony count was <102, was significantly associated with the rate of autograft taking on days 3 and 7.
- There was no significant association between the anatomical site of burn injury or days from accident to wound excision with wound pH before and after excision, results of culture before and after excision and the rate of autograft taking.

RESULTS

Table 1: Comparison of wound bed temperature and pH before and after the operation

	Beginning of operation	End of operation	*P*
Wound bed temperature (°C)	33.7±2.7	34.6±2.1	<0.001
Wound pH	8.15±0.49	7.63±0.42	<0.001

RESULTS

Table 2: Results of wound culture before and after the operation

Result of wound culture	Frequency (%)	
	Before surgical wound excision	After surgical wound excision
Acinetobacter baumannii	7 (14)	2 (4)
Escherichia coli	1 (2)	0 (0)
Klebsiella pneumoniae	1 (2)	0 (0)
Pseudomonas aeruginosa	4 (8)	5 (10)
Staphylococcus aureus	8 (16)	6 (12)
Staphylococcus coagulase-negative	1 (2)	1 (2)
No growth	28 (56)	36 (72)
Total	50 (100)	50 (100)

RESULTS

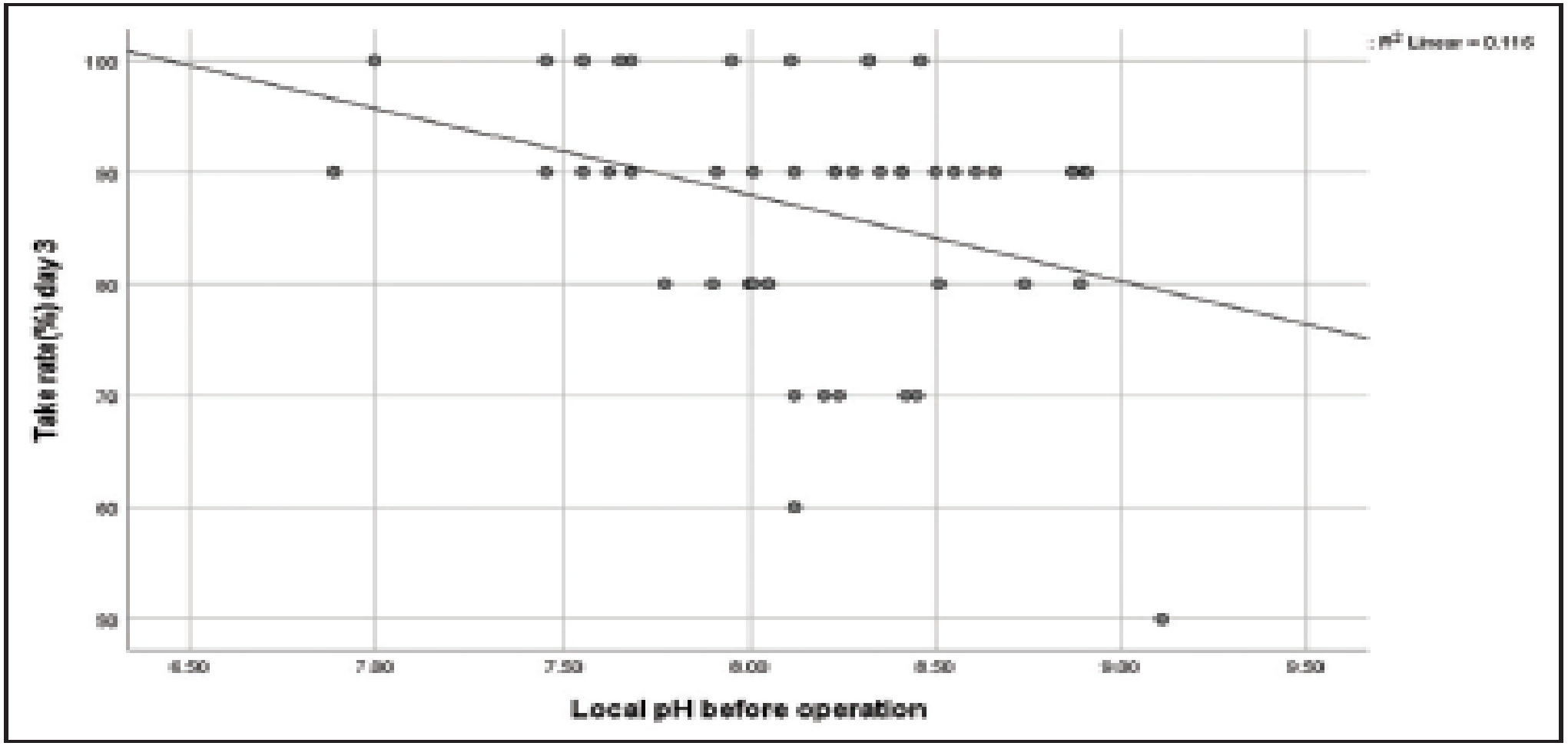

Figure 1: Correlation of local pH before the surgery and take rate on day 3

DISCUSSION

- This study was performed to evaluate the association between wound pH, wound temperature, and wound culture with the take rate of skin autograft.
- The results showed that there was a significant reverse association between the rate of graft taking on day 3 and wound pH on the beginning of operation but not wound pH after excision.
- Furthermore, there was a significant positive association between core body temperature at the beginning of procedure and the rate of graft taking on days 3 and 7.
- Wound temperature was not correlated with the take rate.

DISCUSSION

- The wound pH is important in many processes in wound including angiogenesis, bacterial toxicity, oxygen release, and even local pain.
- It seems that the pH is an important factor in wound management and has not been sufficiently underscored in burn wound management.
- The pH of the epithelial surface of the skin is about 4–6.
- While most pathogens prefer an alkaline pH, it provides a hostile environment for pathogens and works as an "acidic armor" on the surface of the skin. Just 10 μm deeper than the epithelial surface the pH of skin is about 7, and at the level of the stratum basale is 7.5–8.
- In the present study, the wound pH was alkaline (~8.15) immediately after removal of the dressing.

DISCUSSION

- All of these patients had deep partial or full-thickness burns with necrotic tissues and there was enough time for wound colonization before wound excision.
- Considering that the pH of a nonepithelialized wound is higher than epithelialized ones, our findings are consistent with previous studies.
- Some authors suggested that wound debridement leads to a pH shift toward alkaline, but in our study, after burn wound excision, the wound pH was reduced to 7.63.
- In wound excision procedure, all necrotic and nonviable tissues are eliminated and a pH value closer to the pH of blood (7.4) is expected.

DISCUSSION

- The wound pH before surgical excision was significantly related to the take rate of skin autograft. This finding has been reported in a previous investigation, but we were not able to define the appropriate cutoff point for skin grafting by the findings of the present study. More investigations with larger sample size are recommended.
- The pH of the wound after surgical excision is measured on a viable well-perfused tissue with the minimum of bacterial load and necrotic tissue. Therefore, the result is an indicator of pH in the interior deep tissues of the body as viable tissues are perfused by systemic blood circulation and any pH gradient is corrected promptly.
- Hence, the changes of wound pH on sequential sampling is probably a simple and readily accessible method to evaluate the healing process of the wound, and more investigations about the correlation between the changes in burn wound pH and healing process is suggested.

DISCUSSION

- While in other investigations, a bacterial count more than 105 colony-forming units (CFU)/g is considered deleterious for graft taking.In the present study, the presence of Acinetobacter baumannii, K. pneumoniae, P. aeruginosa, and S. aureus in quantities <102 after surgical wound excision was significantly related to the rate of autograft taking.
- Surgical burn wound excision can reduce bacterial count considerably, but it seems that the remaining of bacteria in wound bed even in amounts <100 CFU/g can be deleterious for successful skin grafting.
- Therefore, the experience of surgeon to detect proper depth of excision and applying aseptic techniques in surgical excision and autograft may be more important than bacterial count of burn wound before excision.

DISCUSSION

- This study had some limitations:
- First, the pH was only measured from one specimen which could lead to a random error.
- Although systematic error does not threaten the results, it is suggested to take at least three samples for each wound and consider the average value.
- This is also suggested for wound temperature.
- However, to the best of our knowledge,this is the first study in human burns in Asia.

CONCLUSIONS

- Evaluating wound pH immediately after dressing removal in the operation room may be a simple and easily available modality to assess the appropriateness of burn wound for skin grafting.
- More investigations to determine the appropriate cutoff point of pH for skin autograft are recommended.
- In burn surgery, complete wound excision by aseptic techniques might be more important than bacterial load before burn wound excision regarding the rate of autograft taking.

Thanks for your attention