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RESEARCH ARTICLE

IMPROVEMENT IN PRESSURE ULCER SURGICAL RATE CLOSURE USING BACTERIAL TYPE AND QUANTITY MEASUREMENT

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ABSTRACT

Background: Pressure ulcer is a chronic wound that has a high prevalence. Despite all the efforts, pressure ulcers closure of tentimes fail. A tool is required to establish the right moment for wound closure. The presence of bacteria is one of the big factors that interfere with the wound healing process.The type and number of certain bacterial load also determine the success of wound closure.
Objectives: We propose a solution by using the bacterial type and number measurement to determine wound closure success in pressure ulcers.
Methods: This was a hospital-based nested case-control study at Hasan Sadikin General Hospital, Bandung. Data were collected from April 2012 to February 2014. The relationship between variables was analyzed with bivariate analysis, while its strength was assessed by the contingency coefficient.
Results: Twenty-four patients who underwent wound closure were enrolled as respondents. The relationship of bacterial types with the success rate of pressure ulcer closure did not show significant differences (P-value = 0.921). The bacteria quantity in the group that succeeded and failed also did not show a significant difference (P-value = 0.995). However, the combination of type and number of bacteria were significantly different between the successful and unsuccessful group (P-value = 0.034; C = 0.653).
Conclusion: The success rate of pressure ulcer closure determined by both the number and type of bacteria, not separately. Thus, it is important that surgeons perform both tests on preoperative pressure ulcer patients due to their proven benefits in predicting the success rate of surgical closure.

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INTRODUCTION

Chronic wounds are huge health problems which spend a lot of expenses on long-term management. More than 90% of chronic wounds are included in three main categories: venous ulcer, diabetic ulcer and pressure ulcer (Mustoe *et al.,* 2006). Pressure ulcer is a major health problem with a high prevalence, especially among patients with immobilization. Elderly patients contribute more than 65% of the incidence of pressure ulcers and increase the risk of death five times in pressure ulcer patients in hospital care (Thoroddsen, 1999). Pressure ulcers are usually accompanied with severe complications, such as cellulitis, non-healing wounds, sepsis, and even death. These can be prevented if handled properly (Bauer *et al.,* 2007). The proper management of pressure ulcers includes nutritional improvement, mobilization, wound bed preparation, which is the act of cleaning the wound repeatedly to get a healthy wound before the surgical closure (Bauer *et al.,* 2007). Surgery is one of the important ways in managing pressure ulcers, this includes debridement of necrotic tissue, the use of negative pressure in wound preparation and finally wound closure using skin grafting or flaps (Fereira *et al.,* 2006). Although this action is routinely done, failure rates remain high. A study conducted at the University of Maryland Hospital in Baltimore on 40 pressure ulcer patients who underwent surgical procedures, in elderly patients with nontraumatic paraplegia there were 12% having ulcers again before the patient was discharged, 40% experienced recurrence and 69% of patients had ulcers on the other locations, whereas in young patients with traumatic paraplegia 79% experienced recurrence and 79% experienced ulcers elsewhere. Only 21% of elderly patients with traumatic paraplegia and 31% of nontraumatic paraplegia remain cured (Thomas, 2001; Disa *et al.,* 1992). A diagnostic tool is required to determine the right moment to perform wound closure so

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that the incidence of failure can be reduced or prevented. One factor that interferes wound healing process is bacterial contamination. The success of a wound to granulate spontaneously depends on the number of bacteria present in the wound (Krizek and Robson, 1975). In addition, the concentration and quantity of bacteria taken from the wound surface tissue sample (after exudate is removed), can be used to predict the success rate of wound closure (Scheneider *et al.,* 1983). In cases of chronic wounds that are refractory or difficult to predict whether or not a surgical closure is feasible, these bacterial examinations are quite relevant. When compared with the operating costs incurred and the trauma experienced by the patient during the operation, these examination procedures actually benefit them. This study aims to explore the relationship between the type and number of bacteria to the success rate of pressure ulcer surgical closure.

MATERIALS AND METHODS

This was a hospital-based nested case-control study at Hasan Sadikin General Hospital, Bandung, Indonesia. Data were collected from April 2012 to February 2014.

Inclusion criteria:

- Patients with pressure ulcer grade III or IV in the sacral area as big as 5-15 cm diameter.
- Age range 14 to 70 years old.
- Pre-operation hemoglobin >10 g/dl and leukocyte < 10,000 cell/mm^3
- Good wound bed preparation (healthy granulation tissue without pus and necrotic)

Exclusion criteria:

- Patients who have diabetes mellitus or other comorbid diseases.
- Patients with bad arterial perfusion including blood viscosity disorder, red blood cell deformities, and other artery diseases.
- Immunocompromised condition (history of radiation or cytotoxic drugs usage).
- Malnutrition (pre-operation albumin value < 2.5 gr/dl).
- History of corticosteroid use more than 1 week.

Drop out criteria:

- Patients who are unwilling to take surgery after informed consent about possible risks and complications.
- Patients who do not finish the complete follow-up procedure for any possible reasons.

Tissue biopsy was taken from the granulation tissue of the ulcers with a size of 0.5 x 1 x 1 cm^3 by aseptic biopsy directly before surgical closure procedure. The samples were sent to the clinical pathology department which will conduct culture, identification of types of bacteria, and count the number of bacteria. The type of bacteria was said to be pathogenic if there was growth of *Staphylocccus aureus, Pseudomonas aeruginosa, Klebsiella pneumoniae, Streptococcus pneumoniae, Sterptococcus pyogenes, Meningococcus spp, Mycobacterium spp, Clostridium spp, Shigella flexneri, Chlamidia trachomatis* and *Salmonella spp* found in the tissue. Bacterial load was classified as the following score:

0: no bacterial growth
I: bacterial growth with low virulence (non-pathogenic) $<10^5$ CFU/gram tissue
II: bacterial growth with low virulence (non-pathogenic) $\geq 10^5$ CFU/gram tissue
III: bacterial growth with high virulence (pathogenic) $<10^5$ CFU/gram tissue
IV: bacterial growth with high virulence (pathogenic) $\geq 10^5$ CFU/gram tissue

Wound closure was performed in a tertiary fashion. The wound was considered ready for closure if it had healthy granulation and no necrotic tissue. Surgical and mechanical debridement techniques were done for wound bed preparation. Surgeries were done within one week range from the last debridement by the first author, who has 20 years of average clinical experience, using fasciocutaneous flap without any tension. Antibiotic tulle, natrium chloride, and gauze were used as the dressing with daily changing. Oral broad-spectrum antibiotics were given according to the bacterial sensitivity test result. All patients have the same post-surgical handling which in same prone position with 2-hourly repositioning on a standard mattress. Then the patients were assessed every week until the 3rd week. Patients were not put in supine position until all follow-up assessment has finished. Wound closure was considered successful if it was neither accompanied by the presence of pus nor wound dehiscence. All data were analyzed using SPSS ver. 20.0 (IBM Corp., Armonk, NY, USA). The relationship between variables was analyzed with bivariate analysis, while its strength was assessed by the contingency coefficient. A P-value of < 0.05 was regarded as statistically significant.

RESULTS

Twenty-six patients were included in the study. A total of two subjects dropped out because they refused further medical treatment. The final number of patients that included in this study was 24 in total. The surgical closure was successful in 14 patients and failed in the remaining 10. The characteristics of patients are summarized in Table 1.

Table 1. General characteristics of study subjects

Characteristics	Wound closure	
	Successful	Unsuccessful
Gender		
Male	9	7
Female	5	3
Underlying disease		
Trauma	8	6
Malignancy	3	1
Infection	2	1
Cerebrovascular disease	1	2
Age		
Mean age ± SD	37,86± 14,7	42,40± 18,3
Total	**14**	**10**

Table 2 shows the type of bacteria that were found. If there were any single pathogenic bacteria type even in the combination group, it was considered as pathogenic. There were only 1 out of 14 (7.1%) successful wound closure group that has pathogenic bacteria and there were 3 out of 4 (75%) in the unsuccessful wound closure group. The number of bacteria that exceed 10^5 CFU/gram only found in 2 patients, with an equal percentage between both groups.

Table 2. The clinical pathology test results in the successful and unsuccessful group

Culture result		Wound closure	
		Successful	Unsuccessful
No growth		6	6
Bacterial growth		8	4
1 type of bacteria		7	3
2 types of bacteria		1	1
Bacterial type		**Successful**	**Unsuccessful**
Single: *A.baumanii*		3	0
S. aureus		0	1
E. coli		2	1
K. pneumoniae		0	1
S. epidermidis		2	0
Combination:		0	1
A. Baumanii and*S. Aureus*		1	0
*P. aeruginosa*and*E. Coli*			
Bacterialnumber		**Successful**	**Unsuccessful**
*A. baumanii*5714	CFU/gram	√	
>100.000	CFU/gram	√	
2000	CFU/gram	√	
*S. epidermidis*500	CFU/gram	√	
7777	CFU/gram	√	
*E. coli*88.000	CFU/gram	√	
6774	CFU/gram	√	
>100.000	CFU/gram		√
*S. aureus*3166	CFU/gram		√
750	CFU/gram		√
*P. aeruginosa*500	CFU/gram	√	
*K. pneumoniae*666	CFU/gram		√

However, there was no significant difference between bacterial type or number and the success of wound closure (P-value were 0.921 and 0. 995). When classification was based on bacterial load (combination of both bacterial type and number), the surgical closure success showed a significant difference (P-value = 0.034) with high closeness relationship (C-value = 0.653).

Table 3. The relationship between type, number, and bacterial load with the success of pressure ulcer surgical closure

Culture result	Wound closure		P-value	C-Value
	Successful	Unsuccessful		
Bacterial type			0,921*	
No growth	6	6		
Nonpathogenic bacteria	7	1		
Pathogenic bacteria	1	3		
Bacterial number			0,995*	
No growth	6	6		
$< 10^5$ CFU/gram tissue	3	7		
$\geq 10^5$ CFU/gram tissue	1	1		
Bacterial load score			0,034**	0,653
0	6	6		
I	6	0		
II	1	1		
III	1	3		
IV	0	0		

*Kolmogorof-Smirnov test, **chisquare test
P-value: level of significance
C-value: contingency coefficient (Cmax : 0,707)

DISCUSSION

Most of the wounds that do not heal within 3 months are called chronic wounds (Gurtner 2007). No response to the normal regulation of the wound healing process is a predictive factor for wounds to be categorized as chronic wounds (Efron *et al.,* 2008). Pressure ulcers are defined as soft tissue injury due to persistent pressure on the bony prominence. A pressure that more than 32 mmHg in soft tissue results in ischemia and can become necrosis and ulceration if this continue, even in tissues that rich in vascularization (Bauer *et al.,* 2007; Bauer *et al.,* 2008; Grey *et al.,* 2006). Ninety-nine percent located below the umbilicus level, namely the sacral area (36-60%), heel (30%), and followed with ischium and trochanter as big as 6% (Giuglea *et al.,* 2010). From the total of 24 patients included in this study, trauma was found as the dominant cause of immobilization and pressure ulcer seems to happen more common in men. Fasciocutaneous flap was chosen because it provides the advantage of adequate oxygen supply, good wound closure, minimal potential for functional deformity and the donor site can be closed primary. In addition, this type of flap does not preclude the use of other types of flap in the reconstruction of recurrent ulcers, it provides simple techniques, flexible design, and proven to reduced hospitalization time (Bauer *et al.,* 2007; Shehab, 2003). From a microbiological perspective, good wound healing depends on the host's ability to maintain the control over microorganisms that colonize the wound tissue. Infection depends not only on the type and virulence of bacteria but also on quantitative aspect. If the number of bacteria in a wound is more than 10^5 bacteria/gram of tissue, this can be called an invasive infection, and this can increase the failure of surgical wound closure (Bowler, 2003). The most common bacterial colonies in pressure ulcers are the normal skin flora (*Staphylococcus sp.*, *Streptococcus sp.*, and *Corynebacterium sp.*) and gastrointestinal bacteria like *Proteus sp., Escherichia coli* and *Pseudomonas sp.* (Bauer *et al.,* 2007). An open wound can be contaminated by bacteria from the skin around the wound after 48 hours (Mustoe *et al.,* 2006). This was shown by the presence of 12 study subjects who had bacterial growth in the pressure ulcer tissue sample (table 1). The best strategy in overcoming the bacterial defense mechanism is to get rid of biofilms by debridement (Gurtner *et al.,* 2007). The absence of bacteria in microbiological examination of pressure ulcer tissue from some of the research samples showed a good wound bed preparation before surgical closure. This study showed that the examination of the type or number of bacteria separately had no significant difference to the success of pressure ulcer surgical closure (P-value > 0.05). However, when categorized on bacterial load by combining of both factors, a significant difference was found between the successful and unsuccessful closure group (P-value < 0, 05).

Conclusion

In summary, the pressure ulcer surgical closure improvement can be improved using the measurement of bacterial pathogenic type and quantity. The successful rate of pressure ulcer closure determined by both the number and type of bacteria, not separately. Thus, it is important that surgeons perform both tests on preoperative pressure ulcer patients due to their proven benefits in predicting the success rate of surgical closure.

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