Journal of Medicinal and Chemical Sciences 6 (2023) 304-312

Journal of Medicinal and Chemical Sciences

Journal homepage: http://www.jmchemsci.com/

Original Article

Wounding-To-Door Time Metrics Outcome of Traumatic Simple Wounds in Emergency Department

Roohie Farzaneh[1], Mohadese Arvan[2], Nazgol Khodaie[2], Sara Rahsepar[3], Arman Hakemi[4], Fatemeh Maleki[5], Mahdi Foroughian[1], Somayyeh Ahmadnezhad[6,*]

[1]*Department of Emergency Medicine, Faculty of Medicine, Mashhad University of Medical sciences, Mashhad, Iran*
[2]*Department of Emergency Medicine, Mazandaran University of Medical sciences, Sari, Iran*
[3]*Department of Emergency Medicine, Mashhad University of Medical sciences, Mashhad, Iran*
[4]*Department of Emergency Medicine, Faculty of Medicine, Shahroud University of Medical sciences, Shahroud, Iran*
[5]*Department of Emergency Medicine, Faculty of Medicine, Birjand University of Medical sciences, Birjand, Iran*
[6]*Department of Emergency Medicine, Faculty of Medicine, Mazandaran University of Medical sciences, Sari, Iran*

ARTICLE INFO

Article history

Receive: 2022-05-24
Received in revised: 2022-06-30
Accepted: 2022-08-07
Manuscript ID: JMCS-2207-1592
Checked for Plagiarism: **Yes**
Language Editor:
Dr. Fatimah Ramezani
Editor who approved publication:
Dr. Mohammad Mansoob Khan

DOI:10.26655/JMCHEMSCI.2023.2.11

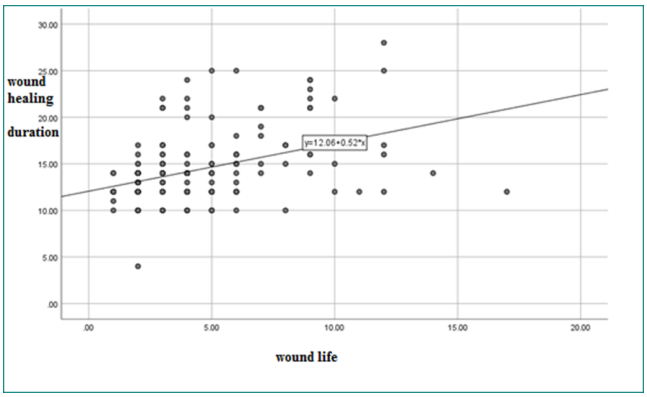
KEYWORDS

Wound Healing
Penetrating Wound
Trauma
Emergency Department

ABSTRACT

Objective: To examine the relationship between wounding-to-door time and wound healing duration in patients with simple traumatic wounds admitted to Shahid Rajaei Emergency Department (ED) in Tonekabon city during the COVID-19 pandemic.
Methods: This was a prospective longitudinal study on patients with simple traumatic wounds referred to ED of Shahid Rajaei Hospital in Tonekabon from April to the end of September 2021 were examined for demographics, trauma to hospital door, and body mass index. Patients were followed for wound healing for a month. Data was analyzed by considering the wound healing time as the primary outcome.
Results: There were 142 were males and 45 were females. The mean age of the subjects was 32.24±18.25. The mean wound-to-door time was 4.3±2.7 hours. The maximum and minimum wound-to-door time was 17 hours and 1 hour, respectively. The average wound healing duration was 14.3±3.6 days. A significant positive correlation was found between the wound healing duration and wound-to-door time (r= 0.435, P<0.001). When analyzing subgroups of patients based on the BMI, antibiotic use, smoking status, and some wound locations, there was no significant correlation between wound healing duration and wounding-to-door time (P>0.05).
Conclusion: This study revealed that delayed visit of ED for receiving proper wound care would be associated with increased wound healing duration; while this relationship is being modified by smoking status, using antibiotics, and the BMI.

GRAPHICAL ABSTRACT



* Corresponding author: Somayyeh Ahmadnezhad
✉ E-mail: Email: s.ahmadnezhad.sari@gmail.com

Introduction

Wounds are scratches, crevices, lacerations, or traumatic injuries to the skin which may remain intact but the bottom of the skin is usually red or bruised [1]. Injuries can be divided into closed and open, while cuts and lacerations on the skin are open and bruises are closed injuries [2]. Approximately 7 million traumatic wounds occur each year and 26 to 90 million wounds cause by surgical incisions. Open wounds and lacerations are the third most common problems in the ED accounting for approximately 8 million emergency department referrals in the United States each year [3]. Wound healing is a complex process that occurs in distinct, yet overlapping, highly coordinated stages, while hemostasis or coagulation is the first stage of the body's response to the skin laceration [3-4]. Wound healing is a dynamic and complex tissue response to injury and it is generally a regular phenomenon. This response requires interactions between different cell types, scleroprotein, growth factors, and proteases. Special cell types initially keep the injury site clean, and then gradually form a scaffold to fill the resulting defects. Factors such as soluble growth factors and extracellular matrix are the most important ones in the wound healing process. Besides, physical factors such as the generated forces by cell deformation are involved in this process [5-6]. Various factors can impact the wound healing process. These factors include the patients ʾold age, hypoxia, anemia, hypoperfusion, diabetes, uremia, obesity, malnutrition, chemotherapy and radiotherapy, inactivity, cardiovascular as well as metabolic diseases, and taking various drugs (corticosteroids, anticoagulants, anti-cancer, aspirin, colchicine, penicillamine, cyclosporine, and phenyl) [7-9]. Wounds made with a surgical razor heal faster than those with jagged edges and severe necrosis. Therefore, the lateral surfaces of the wound have an important effect on the nature and speed of wound healing. Poor blood supply due to various diseases can affect the speed of wound healing. For instance, atherosclerosis or vascular obstruction impairs wound healing. Since the wound healing process is perfectly dependent on blood circulation and blood cells, the lack of blood supply can disrupt this process [10]. Wound management is one of the most vital efforts in the ED [3]. When a patient refers to the ED, the size, precise location, depth, and shape of the wound and identification of a foreign body should be checked and recorded. Deep and wide wounds should be managed in the operating room with more complete facilities and under sufficient light. Wounds are usually managed with a moist dressing, wound dressing, and suturing, or covering [11]. The results of recent studies have shown that dressings should be designed to prevent crust formation on the wound to avoid cell migration. Dressing with an exudate absorbent coating or with a non-stick coating such as Vaseline gauze is helpful to prevent crust formation. Many physicians and researchers believe that the disinfectant solution is toxic to lymphocytes and fibroblasts which are essential cells for wound healing. The use of substances such as povidone-iodine or Betadine, acetic acid, and hydrogen peroxide is not suggested. The only commercial solution approved by the Food and Drug Administration is a saline buffer [5, 12]. Wound infection is one of the most important medical problems that delays wound healing. Wound infection loosens the abdominal sutures and hernia repair sutures. Wound opening and hernia recurrence are other complications of wound infection. Infection also affects the wound sight and causes the wound looks nasty or delays wound healing. Wounds that do not heal within 3 months are considered chronic. Skin wounds in damaged or non-vascular tissues are also chronic and are considered chronic ulcers [8, 13]. Knowing the potential barriers and risk factors for abnormal wound healing can help you properly prevent, diagnose, and treat large, problematic wounds [14]. Regarding the current situation and the lack of sufficient evidence for the relationship between wounding-to-door time and various factors, including wound healing duration, the present study investigated the relationship between wounding-to-door time and wound healing duration of simple wounds in patients referred to Shahid Rajaei ED in

Tonekabon city during COVID-19 pandemic in 2021.

Method

This was a prospective cohort study in which all patients who were referred to the ED of Shahid Rajaei Hospital in Tonekabon city from April to the end of September 2021 due to simple traumatic wounds were examined. Inclusion criteria included adult patients with trauma and complete patient records, and exclusion criteria included patients with a history of chronic diseases such as diabetes, taking immunosuppressive, hypertension, immunodeficiency, corticosteroids drugs, alcohol consumption, and a complex wound that requires hospitalization. The final statistical population of the study consisted of 187 patients. All stages of this study were conducted with the approval of the Research Council and the Ethics Committee of Mazandaran University of Medical Sciences (IR.MAZUMS.RIB.REC.1400.021).

The patients were interviewed, clinically examined, and their demographic and clinical variables (age, gender, education degree, smoking, scar site, obesity, and body mass index (BMI)) were recorded by using a checklist. According to the official WHO table, the subjects included in the study were classified based on their BMI.

The criterion of wounding-to-door time was the patient's report and based on the time of ulceration until arriving at ED. Patients' conditions were followed up daily and the complete wound healing and suture removal times were recorded. All examinations, treatments, and follow-ups were performed by one physician during the Covid-19 epidemic.

After data gathering and recording them in SPSS 22, a statistical method was selected based on the type of variables. Pearson and Spearman analysis methods were used to investigate the correlation coefficient between quantitative variables with normal and abnormal distributions, respectively. Quantitative data were expressed as mean and standard deviation as a percentage and the difference was higher than $P < 0.05$.

Results

A total of 187 patients, 142 males (75.94%) and 45 females (24.06%) were chosen as the statistical population of the study. The subjects' mean age was 32.24 ± 18.25 years old. The youngest subject was aged 18 and the oldest was 90. According to the chart below, approximately 76% of the participants were males. According to Table 1, approximately 60 subjects (32%) were smoker and most of the participants had high school degrees or lower (about 30%) and the highest percentages of participants' body mass index (BMI) were in normal weight (32.62%) and overweight (32.08%).

Regarding the studied subjects, 23% of them were classified as obese. Therefore, based on the criteria mentioned in Table 1, the highest percentage (13.4%) was classified in the first group (Obese class 1). According to the reported results, approximately 35% of the participants had wounds on their heads.

Wounding-to-door time in the subjects was 4.3 ± 2.7 hours on average, while the maximum and minimum wound lives were 17 and 1 hour, respectively. Regarding the wound healing duration, the total mean was 14.3 ±3.6 days, while it was 14 ±3.4 days in males, and 15.1. ± 4.1 days in females. It should be noted that this period has been reported on average 14.2 ±3.5 days in participants under 50 and 15.6 ±3.9 days in participants over 50 years old. In this study, a significant relationship was found between wound healing duration and wounding-to-door time ($P < 0.001$). Figure 1 displays a direct correlation between wounding-to-door time and wound healing duration.

The results of analyzing the relationship between wound healing duration and wounding-to-door time based on wound site are reported in the following table. Based on Table 2, there is a statistically significant relationship between wound healing duration and wounding-to-door time in the upper limb ($P = 0.014$) and hand ($P = 0.001$), and no significant relationship was found in the lower limb ($P = 0.113$), head ($P = 0.255$), and leg ($P = 0.335$). Likewise, a direct correlation was found between the wound healing duration

and wounding-to-door time in the upper limbs (Pearson = 0.435) and hands (Pearson = 0.510).

Table 1: Demographic Characteristics of Patients with Simple Traumatic Wounds

Variable		Frequency (percentage)
Age		18.25±32.24
Gender	Female	45(24.06)
	Male	142 (75.94)
Smoking	Yes	60 (32.09)
	No	127 (67.91)
Level of education	Illiterate	16 (8.51)
	Lower than high school	55 (29.41)
	High school degree	50 (26.73)
	College degree	19 (10.16)
	Bachelor	46 (24.59)
	Ma/Ms	1 (0.53)
BMI	Underweight	23 (12.29)
	Normal weight	61 (32.62)
	Overweight	60 (32.08)
	Obese	43 (22.99)
Obesity	Obese class 1	25 (13.4)
	Obese class 2	16 (8.6)
	Obese class 3	2 (1.1)
Wound site	Upper limb	21 (16.57)
	Lower limbs	34 (18.18)
	Head	65 (34.75)
	Hand	40 (21.39)
	Leg	17 (9.09)

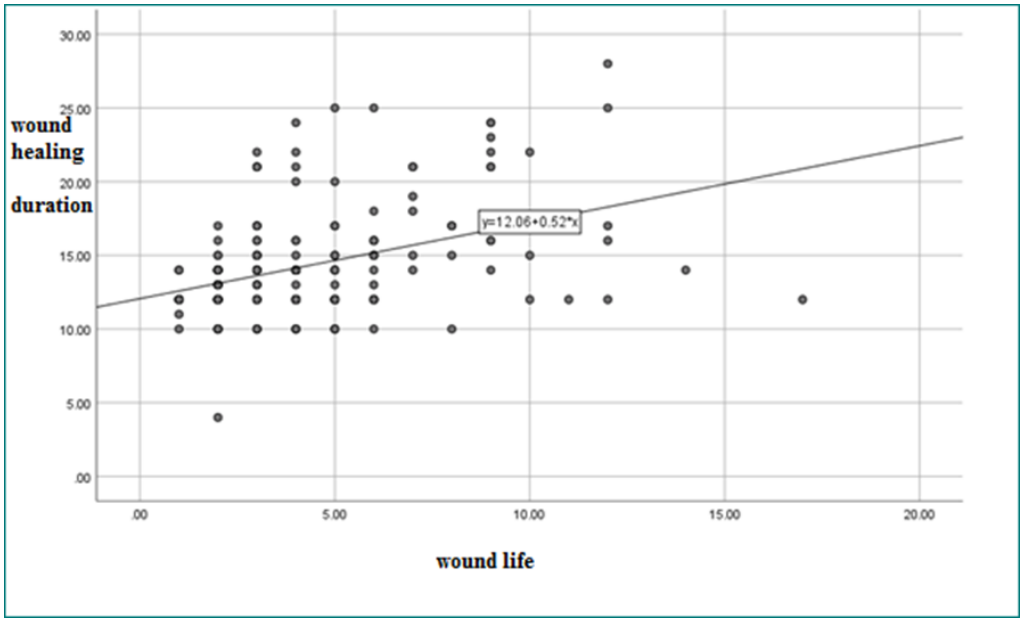


Figure 1: Correlation Diagram of Wound Healing Duration (days) and Wound Age (hours)

Table 2: Relationship between Wound Age and Wound Healing Duration based on the Studied Variables

		Number of observations	Pearson Correlation	P-value
Total		187	.435*	0.014
Wound location	Upper limb	31	0.277	0.113
	Lower limb	34	0.143	0.255
	Head	65	.510**	0.001
	Hand	40	0.249	0.335
	Leg	17	.393**	0.001
Gender	Male	142	.396**	0.007
	Female	45	.374**	0.001
Age	Younger than 50 years old	161	.512**	0.007
	Older than 50 years old	26	0.473	0.054
Education level	Illiterate	16	.480**	0.001
	Lower than high school degree	55	.311*	0.028
	High school degree	50	.520*	0.023
	College degree	19	.342*	0.02
	Bachelor degree	46	.393**	0.001
Taking antibiotics		183	0.602	0.398
Not taking antibiotics		4	0.306	0.058
Smoking		60	.440**	0.001
Non-smoking		127	0.167	0.448
BMI	Underweight	23	.357**	0.005
	Normal weight	61	.515**	0
	Overweight	60	0.271	0.079
	Obsess	43	-0.026	0.902
Obesity	Class I	25	0.434	0.093

Regarding the gender effect on wound healing duration and wounding-to-door time, a significant relationship was reported between wound healing duration and wounding-to-door time, and it was obtained at (P = 0.000) in males and (P = 0.007) in females with a direct correlation in males (Pearson = 0.393) and females (Pearson = 0.396). Besides, a significant relationship was found between wound healing duration and wounding-to-door time in the age group over 50 (P = 0.007) and under 50 (P = 0.000). Thus, there is a correlation between wound healing duration and wounding-to-door time in the age group over 50 (Pearson = 0.374) and under 50 (Pearson = 0.512).

According to the results of this study, there is a statistically significant relationship and a direct correlation between wound healing duration and wounding-to-door time regarding the participant's level of education (P <0.05), while the strongest significant relationship was reported in participants with high school and lower degrees (P = 0.000). Thus, the longer the wound lasts, the longer it takes to heal in this group of participants. Regarding two factors of smoking and taking antibiotics, there was a significant relationship between wound healing duration and wounding-to-door time (P = 0.000) and non-smoking (P = 0.000) with a correlation between wounding-to-door time with wound healing duration based on antibiotic use (Pearson = 0.393) and non-smoking (Pearson = 0.440). After examining the relationship between wound healing duration and wounding-to-door time regarding the patients' body mass index, a significant relationship was found between wound healing duration and wounding-to-door time regarding the normal weight (P = 0.005) and overweight (P = 0.000). According to Pearson's correlation coefficient, there is a direct correlation between wounding-to-door time and wound healing duration regarding participants

with normal weight (Pearson = 0.357) and overweight (Pearson = 0.515). In line with the performed analysis, the relationship between wound healing duration and wounding-to-door time based on obese class was also investigated and no significant relationship was found (P >0.05).

Discussion

The present study aimed to investigate the relationship between the wounding-to-door time of a simple traumatic wound and the duration of wound healing in patients referred to the ED of Shahid Rajjaei Hospital in Tonekabon City during the COVID-19 pandemic. The findings of this study indicated that the mean wound healing duration was shorter in male than in female patients. However, the results of a study by Marie Kjaer *et al*. (2018) revealed that wound healing duration was slower in males than in females [17], while the results of this study are in line with the results of the study conducted by Christopher G. *et al*. [18].

Another study by Hardman (2008) reported that the difference in gene expression between the wounds of old men and young men was regulated almost exclusively by estrogen. Estrogen affects wound healing by regulating a variety of genes associated with regeneration, matrix production, protease inhibition, epidermal function, and genes primarily associated with inflammation. Gilliver (2007) concluded that estrogen can increase age-related disorders in wound healing in males and females, while androgens negatively regulate skin wound healing [19, 20]. In our study, the mean duration of wound healing in participants aged over 50 was longer than in ones under 50 and this result was in line with the results of the study conducted by Christopher G. *et al.* [18].

The relationship between smoking and delayed wound healing in clinical practice is obvious, while no extensive controlled studies have been yet performed. The documented effects of the toxic components of cigarette smoke- particularly nicotine, carbon monoxide, and hydrogen cyanide- suggest potential mechanisms by which smoking may prevent rapid wound healing. According to the study conducted in our study, approximately 68% of the studied participants were non-smokers. Data analysis revealed a significant relationship between wound healing duration and wound age in non-smokers [21]. Lvarez-Jiménez *et al*. (2014) carried out a study in which the healing duration of burn wounds in smokers and non-smokers were compared and the obtained results were consistent with the results of our study [22].

According to the results of our study, the wound healing duration and wound age are interrelated with the level of education of the participants, while the most significant relationship was observed in participants with lower than high school degree. Thus in this group, the longer a wound lives, the longer it takes to heal. However, this relationship is almost weak in terms of correlation. It should be noted that participants of different ages participated in this study which may affect the obtained results.

Many complications may result from partial hypoperfusion and ischemia in the subcutaneous adipose tissue. This condition can also be caused by reduced delivery of antibiotics. In surgical wounds, the increased tension on the wound edges that is frequently seen in obese patients also contributes to wound dehiscence. Furthermore, the results of our study reveal that approximately 33% of the studied participants were categorized in the normal class in terms of BMI. According to the analysis on participants with normal BMI and overweight, the results are as follows: a significant relationship was found in both categories, but according to the Pearson coefficient reported in the tables, a more correlation was found between wound healing duration and wound age in the BMI category of the overweight. Therefore, in overweight patients, the longer the wound lasts, the longer it takes to heal. The adverse effects of adipokines on the systemic immune response appear to affect the wound healing process. Peripheral blood mononuclear cell dysfunction decreased lymphocyte proliferation, and altered peripheral cytokine levels have been reported in obesity. Hence, many obesity-related changes in peripheral immune system function improve with weight loss [23, 24].

In our study, the relationship between wound healing duration and wound age in the subjects was investigated. Hence, a significant relationship was observed between the wound healing duration and wound age (P <0.05). Minor scratches may not be uncomfortable; however, they usually heal within 3 to 7 days. The larger and deeper the scratches, the longer it takes to heal. It may take 7 to 10 days for a large, deep wound to heal [25]. In 1988, Berk *et al*. examined 372 patients with traumatic wounds at Jamaica Hospital. In this prospective observational study, wound healing wound edge detachment or wound infection were examined. Analysis of data based on wound site showed that wound healing duration in the head area was not related to wound age [26]. In our study, approximately 35% of the participants had wounds on their heads. There was a significant relationship between wound healing duration and wound age regarding the site of wounds in the upper limbs and hands. Therefore, no significant relationship was observed between wound age and wound healing duration on the head.

According to the results of previous studies, oral antibiotics of cephalexin reduce the rate of infection and increase wound healing. Various studies have also emphasized the importance of a moist wound environment in accelerating wound healing [27]. The results of a clinical trial conducted in 2017 showed that the use of oral antibiotics cephalexin and metronidazole in obese female patients has reduced the duration of wound healing. The results of our study revealed that the wounding-to-door time and wound healing duration can be modified based on the use of antibiotics. Other studies have indicated that taking antibiotics reduced wound healing duration and this result is consistent with the results of our studies [28].

Limitations

In this study, correlation statistics and covariates were used for data stratification to re-analyze the correlation and this limited our data interpretation to determine how those factors modifying correlations between the wound healing duration and wound to door of ED time affect the wound healing time. Thus, further studies are needed with logistic models.

Conclusion

Our study revealed that delayed visit of ED to receive proper wound care would be associated with increased wound healing duration; while this relationship is being modified by smoking status, using antibiotics, some wound locations, and the BMI.

Funding

This research did not receive any specific grant from fundig agencies in the public, commercial, or not-for-profit sectors.

Authors' contributions

All authors contributed to data analysis, drafting, and revising of the paper and agreed to be responsible for all the aspects of this work.

Conflict of Interest

There are no conflicts of interest in this study.

ORCID:

Roohie Farzaneh
https://www.orcid.org/0000-0002-0892-0155
Fatemeh Maleki
https://www.orcid.org/0000-0001-9760-2611
Mahdi Foroughian
https://www.orcid.org/0000-0002-3944-9361

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HOW TO CITE THIS ARTICLE

Roohie Farzaneh, Mohadese Arvan, Nazgol Khodaie, Sara Rahsepar, Arman Hakemi, Fatemeh Maleki, Mahdi Foroughian, Somayyeh Ahmadnezhad, Wounding-To-Door Time Metrics Outcome of Traumatic Simple Wounds in Emergency Department. *J. Med. Chem. Sci.*, 2023, 6(2) 304-312

https://doi.org/10.26655/JMCHEMSCI.2023.2.11

URL: http://www.jmchemsci.com/article_155937.html