ORIGINAL RESEARCH

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The Role of Local Anesthesia Methods on the Development of Wound Infection at Upper Extremity Lacerations

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Abstract

Objective: This study was designed to identify whether the application method of a local anesthetic agent before suturing affects the development of wound infection.

Materials and Methods: Adult patients with upper extremity lacerations were randomized into two groups if they required wound repair with simple sutures. Direct infiltration of a local anesthetic was performed in patients in Group 1, whereas parallel margin infiltration was performed in patients in Group 2. After 1 week, patients were evaluated clinically by different physicians who were blinded to the patients' wound infection.

Results: A total of 164 patients were enrolled in the study, but 144 were available for data analysis. 4 patients [1 patient was in group 1 (1/73, 1.4%), 3 patients were in group 2 (3/71, 4.2%)] were found to have an infection during the follow-up visit.

Conclusion: The application method of the local anesthetic agent before suturing does not affect the development of wound infection. There were no statistically significant differences related to the development of infection between the two methods.

Keywords: Local anesthesia, wound infection, suturation, laceration

Introduction

In our country, there are over 100 million visits to emergency departments (EDs) annually, and most of these are for traumas [1]. Lacerations and open wounds are the third most common cause of ED admissions in the United States, with an average of 6 million visits annually. Most of these injuries, which are on head or extremities, caused by blunt traumas. The rest are caused by sharp objects in the form of metal, glass, and wood [2,3]. Traumatic lacerations typically occur at the face, hairy skin, and hands, and generally, in young adult males. Wounds seen in children differ from adults. Lacerations in pediatric patients are usually linear lesions found at the head. Additionally, blunt traumas and dirty wounds are less common in pediatric patients [4].

The purpose of laceration management is to prevent wound infections and to provide functional and esthetically satisfactory wound healing. Risk factors of wound infections are separated into the following groups:

1) Factors related to the wound: mechanism of injury, type, and degree of contamination, time from injury to treatment, presence of the foreign body, deep lesions causing soft tissue trauma, and lacerations caused by ice or glass;

2) Factors related to the patient: diabetes mellitus, obesity, peripheral arterial diseases, malnutrition, chronic renal disease, immunosuppressor use, predisposition to keloid formation, and connective tissue disorders [5]. The effects of time on wound suturation, choice of suturing material, and use of irrigants and cleaning solutions are still unclear. The standard

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management of wounds includes wound cleaning, irrigation and appropriate dressing [6]. Although controversial, routine prophylactic antibiotic use is not recommended [7].

Although there are different methods, such as tissue adhesives, skin staples, and secondary healing for laceration repair, most lacerations require primary suturing, which is still the most commonly used method to cover was designed [4]. The duration of wound healing after primary suturing changes from patient to patient. According to previous reports, the possible factors affecting wound healing time are age, sex, presence of immunosuppression, sight of the foreign body, antibiotic use, and location and depth of the wound [4,8].

Many *in vivo* and *in vitro* studies have shown that local anesthetics can also prevent surgical site infections. Noda et al. [9] showed in a recent study that local anesthetics had bactericidal activity at standard clinical concentrations. Aydin et al. [10] investigated the antimicrobial activity of local anesthetics ropivacaine, bupivacaine, lidocaine, and prilocaine on various pathogens and showed that lidocaine and prilocaine had stronger antimicrobial effects than the other two local anesthetics. However, as we know, no study has investigated whether different methods of applying local anesthetics have an effect on the development of infection at the surgical site [9-11]. This study was designed to determine the effect of a local anesthetic application method on the development of wound infection.

Materials and Methods

This is a single-center, prospective, 1:1 randomized clinical trial with parallel groups. The study was approved by the institutional Marmara University Faculty of Medicine Clinical Research Ethics Committee (decision number: 09.2017.419, date: 02.06.2017). An informed written consent form was obtained from all participants. Our ED is a large medical center with approximately 350,000 visits per year. The sample of this study was enrolled from 03.06.2017 to 10.09.2018.

Patients who presented to the ED with upper extremity lacerations and met the following criteria were included in the study:

1) >18 years old

2) No allergic reaction to local anesthetics

3) No tendon or nerve laceration requiring intervention by hand surgeons

4) No antibiotic use for the last week

5) Non-human or animal bite wounds

6) No diabetes mellitus or other immunosuppressed situations

Patients who did not meet the above criteria were not included in the study. If there was a participant who did not come to follow-up or revoked his consent for participation in the study, he was excluded. Because the proportion of patients with devitalized tissue was low, subgroup analysis could not be performed because statistically significant results could not be obtained.

Study Protocol

This study was conducted by a single researcher. Patients who administered on researchers duty hours and met the inclusion criteria for upper extremity laceration were examined by ED physicians and were decided for primary suturing in the study. Every patient was evaluated for a foreign body using X-ray. The patients' wounds were recorded as either contaminated or non-contaminated. Every wound was cleansed with 200 cc normal saline, and materials such as soil and clotted blood were removed from the wound as much as possible. Devitalized tissues were debrided, and foreign bodies were removed if necessary. Topical anesthesia was not administered to the patients. After randomization, a local infiltration method was applied to the patients whose groups were determined. Prilocaine was used as the local anesthetic in all patients.

For Group 1 (direct infiltration into the wound), the injector was inserted into the superficial fascia (subcutaneous fat) from the open wound to the dermis, and a small bolus anesthetic solution was injected. The needle was removed, and another bolus was injected into an area immediately adjacent to the edge of the anesthesia of the previous injection. This procedure was repeated until all edges and corners of the wound were anesthetized.

For Group 2 (parallel margin infiltration), the injector, starting from the end of the laceration, was inserted into the intact skin of the wound and pushed forward parallel to the junction of the dermis and superficial fascia. After aspiration, the needle was pulled from the tissue plane to the entrance site, and slow anesthesia injections were performed. The needle was then re-inserted at the end of the first port at which the anesthetic effect had begun, and the procedure was repeated. This re-intervention and injections were continued on all sides of the wound until complete pain control was achieved.

After the administration of local anesthesia, simple interrupted sutures were applied to each patient. The suture material was non-absorbable polypropylene. After suturation, topical antibiotic containing mupirocin was applied to the wound, and the wound was closed with a sterile gauze bandage. Each patient was told that the wound should remain closed for at least 48 hours, and after that, it should remain dry. They were told that they had to dress wound 3 times a day with the same topical antibiotic containing mupirocin until they came to

control. No oral or parenteral antibiotics were prescribed to the patients. Tetanus prophylaxis was performed if necessary. Each patient was given a detailed form to follow up on wound care and was called for follow-up after 7 days. Each patient confirmed that they followed the wound care instructions during follow-up, and those who did not comply were excluded from the study. Regarding signs of infection, check-in patients were evaluated by emergency specialists who were blinded to the groups of patients.

Outcome Measures

The primary outcome of the study was the presence of infection in patients coming for control and the outcome measure was the difference in the rates of infection. The presence of any of the following criteria, which were created by Dire et al. [12] and used in another study, was considered sufficient for evidence of infection: fever and heat increase, erythema, edema, induration, sensitivity at the wound site, discharge, adenopathy, or development of lymphangitis. As secondary outcome measures, the presence of contamination, laceration length, depth, number, location, gender, age, and non-follow-up rates were compared between the assigned groups.

Statistical Analysis

In this study, we collected all cases that administered on researchers duty hours. Randomization was performed by a non-researcher lecturer who was interested in statistics and planning clinical trials via Research Randomizer software (http://www.researchrandomizer.org) and used 1:1 allocation. A randomization order list was prepared, and a consecutive plan was created with each number in an envelope. The group to which each patient would be assigned the next envelope extraction was determined during the patient's examination. Patient data were collected by ED physicians.

The suitability of continuous variables for normal distribution was evaluated using the Shapiro-Wilk test. Accordingly, in our study, since there were no continuous variables that fit the normal distribution, all were reported as median and interquartile range (IQR). Categorical variables were expressed by frequency and number. Mann-Whitney U test was used to compare continuous variables between different groups. The chi-square test was used to compare categorical variables between different groups. In addition to the analysis in which patients who were dropped from follow-up for the primary outcome were excluded, a secondary analysis (intent-to-treat) was also performed in which these patients were evaluated in the randomized group, and all those who were lost were considered infected. The Medcalc v19 statistical package program (Medcalc bvba, Belgium) was used for statistical analysis, and the Jamovi v0.9 package was used for graphics.

Results

A total of 164 patients were included and randomized in the study. After randomization, the study included 81 patients in Group 1 and 83 patients in Group 2. In Group 1, 8 subjects did not come to control on the specified date, 1 subject in Group 2 revoked consent during the transaction; and 11 subjects in Group 2 did not come to control on the specified date. All of these subjects could not be included in the primary analysis. After excluding subjects, there were 144 patients, 73 patients in Group 1 and 71 in Group 2, for primary analysis and 163 patients, 81 patients in Group 1 and 82 in Group 2, for secondary analysis (intent-to-treat analysis) in the study. Detailed information can be found in the patient flow chart (Figure 1).

Demographical Characteristics

A total of 163 patients were included in the study [median age: 35.0 years (IQR: 26.0-48.0)]. The median age was 35.0 years (IQR: 23.0-47.0) for 81 subjects in Group 1 and 35.0 years (IQR: 28.0-50.0) for 82 subjects in Group 2. There were no statistically significant differences between the median ages of the groups (p=0.4609). The number of male patients was 132 (81.0%) in total, 63 (77.8%) in Group 1, and 69 (84.1%) in Group 2. There were no statistically significant differences between the groups in terms of gender distribution (p=0.3017). The main characteristics of the enrolled patients were itemized in Table 1.

Wound Characteristics

The median number of lacerations requiring suturing in the upper extremities among the 163 patients included in the study was 1 (IQR: 1-1). The median number of lacerations in Groups 1 and 2 was 1 (IQR: 1-1). There was no statistically significant difference between the groups in the number of laceration (p=0.6365). Twenty-two of the 163 patients (13.5%) had lacerations requiring multiple sutures. Multiple lacerations occurred in 10 patients (12.3%) in Group 1 and 12 patients (14.6%) in Group 2. No statistically significant intergroup difference was observed regarding the rates of multiple laceration rates (p=0.6699).

The total number of patients who had only skin laceration and no subcutaneous tissue damage was 91 (55.8%). Forty four patients (54.3%) in Group 1 and 47 patients (57.3%) patients in Group 2 had only skin lacerations. There were no statistically significant differences between the groups in terms of superficial and deep laceration rates when grouped by laceration depth (p=0.7010).

The median length of lacerations in the 163 patients included in the study was 2.80 cm (IQR: 2.00-3.40). The median length of the lacerations of the patients in Group 1 was 3.00 cm (IQR: 2.00-4.05), and the median length of the lacerations of

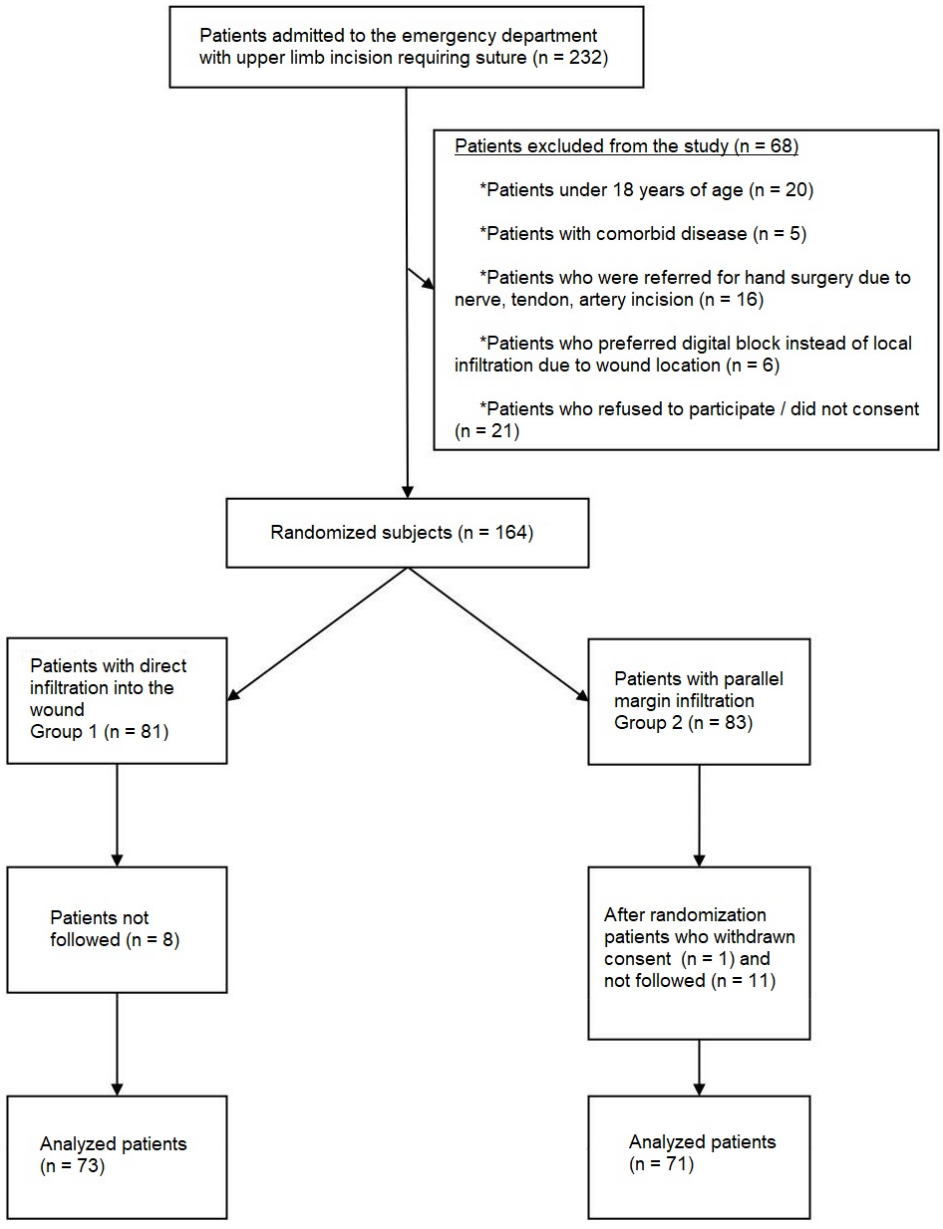

Figure 1. Patient flow chart

the patients in Group 2 was 2.50 cm (IQR: 2.00-3.20). There were no significant differences between the groups in terms of laceration length (p=0.1429).

Incisions were made in the finger in 83 (50.9%) of 163 patients, in the hand in 44 (27.0%), in the wrist in 15 (9.2%), in the forearm in 20 (12.3%), and in the arm in 1 (0.6%). The distribution of lacerations according to anatomical locations is presented in Table 1. There was no statistically significant difference between the groups in terms of the region in which accuracy was found (p=0.6894).

According to wound evaluation at admission, the wounds of 31 patients (19.0%) were contaminated. Fifteen (18.5%) of the patients in Group 1 and 16 (19.5%) of the patients in Group 2 had contaminated wounds. No statistically significant differences were found between the groups in terms of contamination rates (p=0.8720).

Outcomes

Nineteen (11.7%) of the 163 patients included in the study did not attend the control examination. In Group 1, the number of patients who did not come to control was 8 (9.9%), whereas, in Group 2, 11 patients (13.4%) were not present. There were no statistically significant differences between the groups in terms of non-control patients (p=0.4829).

Infection findings were detected in 4 (2.8%) of 144 patients who visited the control center and underwent primary analysis. Infection findings were detected in 1 patient (1.4%) in Group 1

Table 1. The main characteristics of the enrolled patients

Variable		Total (n=163)	Group 1 (n=81)	Group 2 (n=82)	p
Age (years)		35.0 (26.0-48.0)	35.0 (23.0-47.0)	35.0 (28.0-50.0)	0.4609*
Male gender, n (%)		132 (81.0)	63 (77.8)	69 (84.1)	0.3017**
Number of lacerations		1 (1-1)	1 (1-1)	1 (1-1)	0.6365**
Rate of patients with multiple wounds, n (%)		22 (13.5)	10 (12.3)	12 (14.6)	0.6699**
Rate of patients with only skin laceration, n (%)		91 (55.8)	44 (54.3)	47 (57.3)	0.7010**
Length of (cm)		2.80 (2.00-3.40)	3.00 (2.00-4.05)	2.50 (2.00-3.20)	0.1429*
Location of wound	Finger, n (%)	83 (50.9)	39 (47.0)	44 (53.0)	0.6894**
	Hand, n (%)	44 (27.0)	23 (52.3)	21 (47.7)	
	Wrist, n (%)	15 (9.2)	7 (46.7)	8 (53.3)	
	Forearm, n (%)	20 (12.3)	12 (60.0)	8 (40.0)	
	Arm, n (%)	1 (0.6)	0 (0.0)	1 (100.0)	
Contaminated wounds, n (%)		31 (19.0)	15 (18.5)	16 (19.5)	0.8720**
Uncontrolled patients, n (%)		19 (11.7)	8 (9.9)	11 (13.4)	0.4829**
Primary Analysis		**Total (n=144)**	**Group 1 (n=73)**	**Group 2 (n=71)**	**p**
Presence of infection, n (%)		4 (2.8)	1 (1.4)	3 (4.2)	0.2989**
Secondary Analysis		**Total (n=163)**	**Group 1 (n=81)**	**Group 2 (n=82)**	**p**
Presence of infection, n (%) (intent-to-treat analysis)		23 (14.1)	9 (11.1)	14 (17.1)	0.2758**

Data are presented as median (IQR) or n (%), Medians and IQRs; IQR: Interquartile range,
*Mann-Whitney U test; **Chi-square test

and 3 patients (4.2%) in Group 2, but no statistically significant difference was found between the groups in terms of infection rate (p=0.2989).

Data of 19 patients who were randomized to the groups but did not come to the control group were evaluated for bias risk by secondary analysis. Accordingly, it was determined that the infection rates between the groups were not statistically significant (11.1%-17.1%, p=0.2758) even if all patients who did not come to the control were infected. The outcome characteristics of the study are summarized in Table 1.

Discussion

Traumatic extremity lacerations are among the most common admissions to the ED. Although there are different methods for incision repair, primary suturation remains the most commonly used method. Local anesthetics are usually used to reduce pain before the primary suturing [11,13]. The results of numerous previous *in vitro* and *in vivo* studies have also proven that local anesthetics play an important role in the potential prevention and treatment of surgical site infections. However, as we know, there has been no study on whether different methods of applying local anesthetics have an effect on the development of infection at the surgical site. Therefore, this study aimed to compare the two most commonly used local anesthetic administration methods, whether there was a difference between them in terms of infection development. As a result of the study, no significant difference was found between local anesthesia methods in terms of wound infection development.

Aydin et al. [10] investigated the antimicrobial activity of local anesthetics ropivacaine, bupivacaine, lidocaine, and prilocaine against various pathogens such as *Escherichia coli, Staphylococcus aureus, Pseudomonas aeruginosa,* and *Candida albicans*. Of the four drugs tested, lidocaine and prilocaine had the strongest antimicrobial activity; both inhibited the growth of all pathogens tested at anesthetic concentrations of 2%; prilocaine at a concentration of 1% inhibited the growth of *E. coli, S. aureus,* and *P. aeruginosa*, whereas 1% lidocaine inhibited only *P. aeruginosa*.

Although there are many studies about the development of infection after wound management and laceration repair in the ED, we have not encountered a previous study that compared two local anesthesia methods in terms of infection development [9,10,12,14,15]. Most of the studies are old, and due to the limited number of patients, strong results could not be obtained. To appropriately evaluate the development

of wound infection correctly, it would be appropriate to work in larger groups. The importance of our study, which has the largest working group among these studies, emerges at this point.

In many studies, the relationship between prophylactic antibiotic use and wound infection has been investigated, and no statistically significant difference was observed in the development of infection between patients receiving prophylactic antibiotics and placebo or prophylactic antibiotics. In the majority of studies, similar results were found for infection rates (2.8%). In general, the rate of wound infection was 1-5% in the literature [14,16]. In some studies, patients with diabetes mellitus were not excluded from the study, and these patients were among those who developed wound infection [14,16]. Although there are similar results, our study found a relatively lower infection rate compared with other studies [14]. This may have been due to the exclusion of patients with diabetes from our study. However, in one study, the infection rate was 9.9% in all patients, and the difference between the two groups receiving prophylaxis and the placebo group (infection rates: 5.5%, 4.5%, 12.1%, respectively) was statistically significant (p=0.0018). In this study, not only upper extremity incisions but also other body injuries were performed, and no topical antibiotics were administered to the patients. These may be some of the reasons for the higher rates of wound infection compared to our study [12].

In the study of Roodsari et al. [14] the median age was 28 years; 24.7 years in the study of Hood et al. [15]; 17.1-19.9 years of the range of 4 different groups in the study of Dire et al. [12]; and 40 years in the study of Berwald et al. [16] In the present study, only patients aged over 18 years were included, and the median age was 35.0 (IQR: 26.0-48.0) years. In the first three studies, the median age was found to be lower than that of our study because patients under 18 years were also included in these studies. According to the study design, age groups vary significantly, but patients with laceration are a relatively young population. In the abovementioned studies, male sex ratios were 64%, 46%, 70%, and 71%, respectively. In our study, we found that the male proportion was 81%. In all studies, it is seen that the male sex ratio is higher. The median wound lengths in the groups were 2-2.5 cm; 2.5-3.5 cm; 2.4-2.7 cm; and 1.5-2 cm, respectively. In our study, the median wound length was 2.80 cm (IQR: 2.00-3.40) and was consistent with other studies [12,14,16]. In the study of Hood et al. [15]. The incidence of superficial incisions was found to be 53% among all patients, and it was found to be 55% in our study. The results of both studies were consistent regarding the depth of the incision.

Study Limitations

Our study was conducted at a single center in a tertiary referral hospital. The analysis of the study was performed by a single researcher to avoid bias among the researchers. Different results may be obtained in a multicenter study with more than one physician and more patients. As for the design of the study, it is not possible for the physician conducting the study to be blind to the patients. This can create bias. During the follow-up period after wound repair, although some patients follow the instructions for wound care, not all patients can maintain the same hygiene and dryness of the wound site. The physicians who evaluated the patients when they came for control were residents and specialist physicians, and all their knowledge and skills were accepted at the same level. The criteria for determining the presence of infection were ascertained before the study began. However, there may be differences in infection decision-making because the physicians-evaluating patients are different people. This is another limitation of our study.

Conclusion

In this study, we sought to answer the question of whether local anesthetics are associated with the development of wound infection according to the method of administration. Although there have been many studies on wound care, we could not find any studies on this topic in the literature. In our study, we found no statistical differences related to the development of infection between the two different methods, and the total infection rates obtained as a result of our study were similar to those of previous studies.

Ethics

Ethics Committee Approval: The study was approved by the institutional Marmara University Faculty of Medicine Clinical Research Ethics Committee (protocol number: 09.2017.419, date: 02.06.2017).

Informed Consent: An informed written consent form was obtained from all participants.

Footnotes

Authorship Contributions

Surgical and Medical Practices: O.D., Concept: O.D., Design: O.D., Ö.O., A.D.A., Data Collection or Processing: S.Ö., E.A., Analysis or Interpretation: O.D., H.A., Literature Search: M.A., E.O.K, Writing: O.D.

Conflict of Interest: No conflict of interest was declared by the authors.

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