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Original Article

Analysis of the factors affecting survival in digital replantation

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Abstract: Digital replantations were reported in literature commonly and have a high successful survival rate. However, in other cases, replantations were done hurriedly, and lives even endangered. How to improve the survival rate of replantation has become a rigorous problem faced by medical personnel. Our study was designed to investigate the influencing factors of survival in digital replantation. Consecutive patients with severed digital injury in our hospital between January 1, 2002, and December 31, 2013, were recruited for evaluating. The relationship of survival rate with baseline information, etiology of injury, ways of preservation, treatments and vascular crisis were evaluated using univariate and multivariate logistic regression analysis. 896 severed fingers were reviewed with the average age of 22.0±3.8 years and 851 (94.98%) fingers were succeeded with replantation. Univariate analysis demonstrated that many factors were correlated with success, such as ischemic time, the etiology of injury, age, plane of severed fingers, ways of preservation, artery reconstruction, platelet level, the incidence of vascular crisis (all $P<0.05$). Multivariate logistic regression analysis showed ischemic time, the etiology of injury, ways of preservation and the incidence of vascular crisis were the significant independent predictors for survival of replantation. Decreasing the ischemic time, preservation with freeze-dried, and prevention of vascular crisis were the key points of success of digital replantation. Given the importance of survival rates for the digital replantation, functional performance and economic status also should be monitored closely in clinical practice.

Keywords: Digital replantation, survival rate, factors

Introduction

Since chinese surgeons first reported to the world the successful replantation of severed limbs in 1963, the successful rate for replantation in China has been the highest in the world [1, 2]. During the past several years, most replantation patients have had good results. However, in other cases, replantations were done hurriedly, and lives even endangered [3]. How to improve the survival rate of replantation has become a luxury the problems faced by medical personnel. Consequently, we look back and summarize the experience from clinical practice.

Materials and methods

Consecutive patients with severed digital injury, who be performed microscopic replantation surgery, were recruited from Ganzhou People's hospital from January 1, 2002 to December 31, 2013. All patients have no passive or active smoking in perioperative, and the room temperature maintain 20°C~25°C, humidity maintain 50%~60% at ward. Anticoagulant, antispasmodic, anti-infective and analgesia were performed for 5~7 days in postoperative. Relative contraindications include patient's factors such as psychiatric illness and comorbidities deeming surgery unsafe, self-inflicted amputees, and patients unable to follow postoperative protocols and therapy.

Information of patients with severed digital injury was collected from medical records retrospectively. Following variables were recorded: (1) baseline information: age (I<15 years old, II 15-45 years old, III>45 years old), gender (I male, II female); (2) sort of severed fingers (I

Table 1. Risk factors of survival of severed fingers after replantation by univariate analysis

Variables	Survival (n=851)	No survival (n=45)	*P* values
Age (mean ± SD, years)	22.1±2.6	21.6±2.8	0.259
Age groups			0.011
<15 years	356 (41.8)	25 (55.6)	
15~45 years	397 (46.7)	11 (24.4)	
>45 years	98 (11.5)	9 (20.0)	
Gender (Male)	458 (53.8)	24 (53.3)	0.993
Ischemic time (mean ± SD, h)	8.1±2.3	9.9±3.5	<0.001
Dominant hand	622 (73.1)	32 (71.1)	0.627
Sequence of replantation			0.669
Anterograde	428 (50.3)	23 (51.1)	
Retrograde	423 (49.7)	22 (48.9)	
Sort of severed fingers			0.142
Thumb	212 (24.9)	11 (24.4)	
Forefinger	230 (27.0)	12 (26.7)	
Middle finger	264 (31.0)	13 (28.9)	
Ring finger	89 (10.5)	4 (8.9)	
Pinky	56 (6.6)	5 (11.1)	
Etiology of injury			0.012
Sharp cutting	344 (40.4)	12 (26.7)	
Blunt cutting	360 (42.3)	21 (46.6)	
Extrusion or avulsed	147 (17.3)	12 (26.7)	
Plane			0.044
Distal	423 (49.7)	25 (55.6)	
Non-distal	428 (50.3)	20 (44.4)	
Degree of break			0.625
Complete mutilation	516 (60.6)	29 (64.4)	
Incomplete mutilation	335 (39.4)	16 (35.6)	
Ways of arterial repairment			0.021
An artery anastomosis	387 (45.5)	22 (48.9)	
Two artery anastomosis	464 (54.5)	23 (51.1)	
Venous backflow			0.056
Anastomosis dorsal or finger pulp vein	219 (25.7)	13 (28.9)	
Small incision bleeding or medullary enlargement for venous drainage	306 (36.0)	14 (31.1)	
Anastomosis vein associated with small incision bleeding or medullary enlargement for venous drainage	326 (38.3)	18 (40.0)	
Ways of preservation			0.008
Freeze-dried	518 (60.9)	18 (40.0)	
Room temperature dry	257 (30.2)	16 (35.6)	
Soaking liquid	76 (8.9)	11 (24.4)	
Vascular crisis	61 (7.2)	28 (62.2)	<0.001
Platelet count ($\times 10^9$/L)	158±12.5	236±13.9	0.028
Hemoglobin count (g/L)	106±7.3	108±6.4	0.277

thumb, II forefinger, III middle finger, IV ring finger, V pinky), dominant hands (I yes, II no); (3) plane (I distal, II proximal) and degree of break (I complete mutilation, II incomplete mutilation); (4) etiologies of injury (I sharp cutting injury, II blunt cutting injury, III extrusion or avulsed injury); (5) amputation of severed fingers (I freeze-dried, II room temperature dry, III soaking liquid); (6) ischemic time of severed fingers; (7) count of platelet and hemoglobin; and (8) treatments: sequence of replantation (I anterograde, II retrograde), way of arterial repairment (I an artery anastomosis, II two artery anastomosis) and venous backflow (I anastomosis dorsal or finger pulp vein, II small incision bleeding or medullary enlargement for venous drainage, III anastomosis vein associated with small incision bleeding or medullary enlargement for venous drainage); (9) outcome: vascular crisis (I yes, II no) and survival or not.

Table 2. Risk factors of survival of severed fingers after replantation by multi-univariate Logistic regression analysis

Variables	Partial regression coefficients	Standard error	*P* values	OR Value	95% CI
Constant	0.338	0.325			
Ischemic time	1.321	0.416	0.000	11.354	3.277-15.450
Vascular crisis	1.260	0.038	0.005	2.033	1.340-3.226
Ways of preservation	2.012	0.506	0.013	1.119	1.319-4.008
Etiology of injury	1.131	0.302	0.021	4.821	1.228-5.623

This protocol was approved by the Institutional Review Board and written informed consent was obtained from each subject, either directly or from his/her guardians, before study.

Statistical analysis

All statistical analyses were performed using SPSS computerized statistics package (version 17.0), whether to survival of severed fingers as dependent variable, other variables as independent variables. Descriptive analyses were conducted for the demographic data. First, measurement data were using single factor analysis, normal distribution of amputation ischemic time were using independent sample t test, and platelet count and hemoglobin count in part by skewness of the distribution with a median of M (QU-QL) expression were using an independent samples nonparametric tests. Count data were using χ^2 test or calibrated χ^2 test of single factor analysis. Second, significant univariate factors were additional analyzed in two-category Logistic regression models. Their respective odds ratios (ORs) and 95% confidence intervals (CIs) were calculated. A value of $P<0.05$ was considered statistically significant.

Results

A total of 896 severed fingers were studied and 851 (94.98%) fingers were succeeded by performing microscopic replantation surgery. The mean age was 22.0±3.8 years, and 53.8% were men.

Univariate analyses showed that the ischemic time (t test) and platelet count (wilcoxon test) in patients with failure of finger replantation were significantly higher than the survival of patients, and hemoglobin count (wilcoxon test) was not significant difference in two group patients. Age, etiologies of injury, plane of the break, way of arterial repairment, amputation of severed fingers and vascular crisis occurred have significant difference in two group patients, while gender, venous backflow, sort of severed fingers, dominant hands and sequence of replantation have no significant difference on survival of severed fingers (**Table 1**).

Multivariate logistic regression analyses found that ischemic time, vascular crisis, amputation of severed fingers, etiologies of injury were independent predictors of survival of severed fingers. Ischemic time of severed fingers was the most important influencing factor, followed by the amputation and vascular crisis, finally for the cause of injury (**Table 2**).

Discussion

On the basis of a large hospital-based cohort, our study indicated that survival of severed fingers after replantation was 94.98% and related to the ischemic time, vascular crisis, and ways of amputation and etiology of injury.

In the literature, including a systematic review [4], many studies have reported the similar survival rate of 80~90% for distal or proximal digital replantations [1, 5, 6].

Dec W [7] reported a significant difference in survival between clean-cut amputations and the more crushed amputations types (crush-cut and crush-avulsion) in a meta-analysis, which were confirmed in our present study. Sebastin SJ [4] also found a similar difference in better survival rate for clean-cut amputations compared with the more crushed amputations types. However, there was no difference in survival between crush-cut and crush-avulsion amputation. This may be because of a selection bias in digital replantation in which the severely crushed digits were not replanted, and the so called crush-avulsion amputations were likely to have a narrower zone of injury.

In literature, there were opposite views about the association between survival and the repair of vein, especially for zone I replantations. Matsuda M et al [8] reported that venous anastomosis did not influence survival in zone I amputation. While, Lee BI et al [9] noted a higher survival rate in zone I replantations, when a vein repair was carried out, Sebastin SJ [4] found that the repair of a vein improved survival in both zone I and zone II replantations. Our study found no difference between survival and the repair of vein. It is likely that a venous anastomosis may not be necessary, but the artery must be done well in order to establish rich blood flow.

Our study also found that the ischemic time and vascular crisis were influencing the survival of replantation. Although the time limit for the warm ischemic is lack of sufficient research in literature [10], the temperature of external environment influence on the progress of amputated tissues is relatively clear.

Our study had several limitations. First, it was from our tertiary hospital that have experienced micro-surgeons doing digital replantations, not from multicenter, and, therefore, our patients may not represent the overall orient status. However, substantial training courses of microsurgery were provided for microsurgeons in China. We, therefore, speculate that our cohort has a good external validity and our total survival is similar to literature reported. Second, our study was not follow-up and has no sufficient data about functional outcomes and the relationship with economic analysis to provide evidence in guiding the currently practices. As a retrospective study, our data collection is not perfect. But, we will consider these two factors in the future prospective studies.

Conclusions

Our study indicated that survival of severed fingers after replantation was related to the ischemic time, vascular crisis, ways of amputation and etiology of injury. These factors are useful in clinical practice for digital replantations. Given the importance of survival rates for the replantation of amputated fingers, functional performance and economic status should be monitored closely in clinical practice.

Disclosure of conflict of interest

None.

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