Is time to closure a factor in the occurrence of infection in traumatic wounds? A prospective cohort study in a Dutch level 1 trauma centre

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ABSTRACT

Background The dogma that traumatic wounds should not be sutured after 6 h is based on an animal experiment by P L Friedrich in 1898. There is no adequately powered prospective study on this cut-off of 6 h to confirm or disprove the dogma. The aim of this study was to provide evidence against the dogma that wounds should be sutured within 6 h after trauma.

Method 425 patients were included in a prospective cohort study. Patients' wounds were closed, independent of time after trauma. All patients were seen after 7—10 days for removal of stitches and wound control on infection.

Results Of the 425 patients, 17 were lost to follow-up. Of the remaining 408 patients, 45 had wounds older than 6 h after trauma. At follow-up 372 patients (91%) had no infection and 36 patients had redness of the suture sites or worse. 11 patients (2.7%) had general redness or pus. Of those with a wound older than 6 h, three of 45 (6.7%) wounds were infected, versus 30 of 363 (9.1%) in wounds younger than 6 h (p=0.59).

Conclusion In everyday practice wounds are sutured regardless of elapsed time. Here an attempt was made to present the evidence for this daily routine, contrary to Friedrich's Dogma.

INTRODUCTION

A dogma exists in surgery about closure of traumatic wounds. However, in daily practice a lot of factors determine the treatment of a wound, eg, location, infection, and time since trauma. In standard medical textbooks on emergency medicine[1 2] used by students all over the world, you can find statements saying that a traumatic wound should not be closed after 6 h. This timeframe is first mentioned in an article by Paul Leopold Friedrich in 1898 (figure 1).[3] In this guinea-pig experiment wounds were created in the triceps region and contaminated with mud and house dust. With an interval of 30 min the wounds were cleaned. In this experiment all guinea-pigs with wound cleaning up until 6 h survived and all guinea-pigs with wound cleaning after 8.5 h died. A review of the literature shows that after Friedrich very little research was done in this field: a database search was done on the MeSH terms: (wound healing[MeSH] OR 'wounds and injuries'[MeSH]) AND 'time factors'[MeSH Major Topic];'wound healing'[MeSH Major Topic] AND 'wound infection/surgery'[MeSH Major Topic] AND 'wounds and injuries/surgery'[MeSH Major Topic];'Time Factors'[MeSH Major Topic] AND surgery[MeSH];'Time delay'[TIAB] AND surgery[MeSH].

Only a few studies mention the relationship between time to closure and wound infection.[4–8] In fact, after the study by Friedrich it was 40 years before the first reference to the study was found. In treatment of wounded soldiers in the Second World War, Friedrich's study was used to determine that 6 h was a safe time interval for suturing.

The most relevant study was done by Berk *et al*[4] who studied wound closure in 1988 in Jamaica. They included 373 patients, of whom 204 were analysed. They found an infection rate of 7.9% in wounds closed before 19 h, compared to 22.6% in wounds closed after 19 h. Wounds in the face closed after 19 h healed without infection in 95.5% of cases. However, they used one set of instruments and one pair of sterile gloves for multiple patients.

The only other prospective study was done by Bongartz *et al*[5] in 1988, who included 42 patients with old wounds (average time to closure 23.8 h; range 12—72) and eight patients with butcher knife wounds. All wounds were mechanically and antiseptically cleaned and sutured. Only two wounds were infected at follow-up.

The primary aim of the present study was to investigate whether time to wound closure is a risk factor for infection in traumatic wounds. The study was approved by the medical Ethics Committee at Medisch Spectrum Twente at Enschede.

PATIENTS AND METHODS

From July 2005 until March 2007 all patients older than 18 years of age with a traumatic wound who came to the Emergency Room (ER) of Medisch Spectrum Twente at Enschede, a level 1 trauma centre in the Netherlands, were asked to participate in the study. An a priori power analysis[9 10] showed that with an infection rate of 2.5% in wounds inflicted within 6 h, a maximal acceptable rate of infection of 12.5% in older wounds, and one out of eight patients presenting with a wound older than 6 h, 405 patients were needed for the study. In total 425 consecutive patients were included. Treatment with antibiotics was an exclusion criterion. The maximal acceptable infection rate of 12.5% was based on consensus at Medisch Spectrum Twente at Enschede, where it was thought that a relatively large infection rate would be acceptable because it would be balanced by better wound outcome (eg, costs and cosmetic), and in case of infection this infection would be easy to treat by removing one or more sutures.

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Figure 1 Picture of Friedrich. http://www.deboor.de

All wounds were digitally photographed on arrival and a wound swab was taken for bacteriological testing before wound cleaning. Depending on the amount of contamination, wounds were disinfected and debrided before they were sutured, using non-resorbable material, independent of time since trauma. This was done by the surgical resident in the ER present at that moment. The attending resident used a purpose-designed scoring form to register age of the patient, the type of wound (crush or sharp), the location (head, torso, upper extremities, lower extremities), depth and length of the wound, time and date of trauma, time and date of suturing, and type of wound care.

The patients were seen for wound control and suture removal at the outpatient clinic after 7 days for head wounds, 10 days for wounds of the upper extremities or 12 days for wounds of the torso and lower extremities. This is in line with common practice in the Netherlands. The wound control was done by the surgical resident working at that moment in the clinic. At this point a second digital photograph was taken and the infection was scored (1: no infection, 2: redness at the suture points, 3: general redness and 4: pus). Two independent surgeons reviewed the digital photographs. When there was a difference in opinion between reviewing surgeons and surgical resident or between the two reviewing surgeons, the highest level of infection was chosen.

Statistical analysis

Baseline characteristics are reported as mean with SD or as numbers with corresponding percentages for categorical variables, stratified by wound age ≤6 h and >6 h and by infection or not.

First, to identify potential confounders in the relationship between wound age (≤6 h and >6 h) and risk of infection, Student t tests were performed, after verifying a normal distribution, to identify variables that were associated both with infection and wound age, Between-group comparisons of nominal or ordinal variables were performed using χ^2 tests. Additionally, a log-rank test, taking into account the time to closure, was used to assess the association with infection. The a priori list of potential predicting variables included: age (continuous or in quartiles with youngest as reference group), type of wound, location of the wound, depth and length of the wound, and type of wound care. Only those variables with a significance p≤0.15 in relation to infection were considered as candidate variables for multivariate logistic regression analyses. Initially, for the development of the model, all candidate variables were included. Subsequently, the variables with the highest p values were eliminated step by step, until the coefficient for wound age changed by 10% or more. Statistical analysis was performed using SPSS V 15.

RESULTS

Of the 425 patients included in the study, 17 were lost to follow-up. Of the remaining 408 patients, 45 had wounds older than 6 h after trauma. The time patients had to wait in the ER for treatment was included in the time before closure and was on average <1 h.

Because of the low incidence of infection in the cohort, every sign of redness at the wound area was defined as a sign of infection. Therefore, there were two groups: no infection at all versus any infection (even the smallest) (table 1). At follow-up, 372 patients (91%) had no infection and 36 patients had some level of infection. In 11 of these patients (30.6%) general redness or pus was observed. There was no correlation between infection after 7–12 days and bacterial growth at the moment of

Table 1 Patient and wound characteristics. Data are presented as mean (SD) or numbers (%)

	Infection (n=36)	No infection (n=372)	p Value
Age	47.9 (19.0)	39.1 (17.9)	0.004
Age in quartiles			
First quartile	3 (3.0)	98 (97.0)	0.007
Second quartile	9 (8.7)	94 (91.3)	
Third quartile	7 (7.0)	93 (93.0)	
Fourth quartile	17 (16.3)	87 (83.7)	
Time to closure			
≤6 h	33 (9.1)	330 (90.1)	0.59
>6 h	3 (6.7)	42 (93.3)	
Time to closure in min			
Mean (SD)	305 (952)	189 (234)	0.59
Median (IQR)	110 (90–180)	120 (70–180)	
Length wound in cm	4.6 (3.1)	3.4 (2.5)	0.004
Type of wound			
Cut	25 (8.5)	270 (91.5)	0.69
Crush	11 (9.7)	102 (90.3)	
Wound location			
Head	3 (3.2)	69 (95.8)	0.001
Torso	1 (20.0)	4 (80.0)	
Upper extremities	16 (6.4)	233 (93.6)	
Lower extremities	16 (19.5)	66 (80.5)	
Depth of the wound in anatomical layers			
Cutis	31 (9.9)	283 (90.1)	0.26
Subcutis	2 (3.3)	58 (96.7)	
Fascia	3 (8.8)	31 (91.2)	
Wound cleaning			
1 Disinfection	18 (7.8)	212 (92.2)	0.82
2 + Wound cleaning	12 (9.9)	109 (90.1)	
3 + Wound edge resection	2 (8.3)	22 (91.7)	
4 Complete debridement	4 (12.1)	29 (87.9)	

suturing. The cultures were all negative or showed at most 30 colony forming units of skin flora.

Univariate analyses

There was no significant relationship between wound age (older or younger than 6 h) and the presence of infection (p=0.59). Also a log-rank test taking into account the time to closure did not reveal a significant association with infection (p=0.59). Location of the wound was significantly related to a higher infection rate (p=0.001), with wounds of the torso and lower extremities having higher infection rates. Also, age of the patient as a continuous variable (p=0.004) or in quartiles (p=0.007), and length of the wound (p=0.004) were related to the probability of an infection.

Table 2 and figure 2 show patient and wound characteristics related to time to closure. Older wounds were significantly more often crush wounds.

Multivariate analyses

Multivariate logistic regression analysis did not show a significant relationship between wound age (≤6 or >6 h) and infection (p=0.889) (table 3). The only parameters that significantly predicted wound infection (defined as redness at the wound site or more) were location of the wound at the lower extremity compared to the head as reference, and age of the patient in the fourth quartile compared to the first quartile.

DISCUSSION

It has been shown in an adequately powered cohort study that there is no reason to maintain a time limit of 6 h in the suturing of traumatic wounds.

Two prospective studies from the literature[4 5] suggest a maximal closing time of 19 h. In the present study only five patients presented themselves at the ER after 19 h, so it is not possible to present a revised maximum time of closure. However, it is thought that this experience, where 99% of the wounds present themselves within 19 h after trauma, will be the general rule for most hospitals in the Western world.

Because wounds present themselves 24/7 it was not possible to have one doctor treat them all. However, the authors feel it is unlikely that this has introduced possible bias. No attempt was made to do extensive analysis on comorbidity, but it is thought that with the large size of the cohort and the relatively young population it would have had little effect on the outcome.

Separate from time to closure, there is another characteristic of wound healing that ‘everybody’ knows exists but that has never been researched. In the present study, it was proven that wounds of the lower limb have a significantly higher infection rate than wounds of the head. One of the hypotheses for this is that the difference in thickness of the skin leads to differences in neo-angiogenesis. This topic will be the subject of further investigation.

Another finding was that that there was no relationship between the bacterial load at closure and the risk of infection for each group. Therefore, the authors’ advice is not to do bacterial swaps when closing a traumatic wound, regardless of time until closure.

In conclusion, time since trauma should no longer be a factor in the decision to close a wound, especially if taking into consideration the costs that come with secondary wound healing (bandages, controls at the outpatient clinic) and the costs of scar tissue correction.

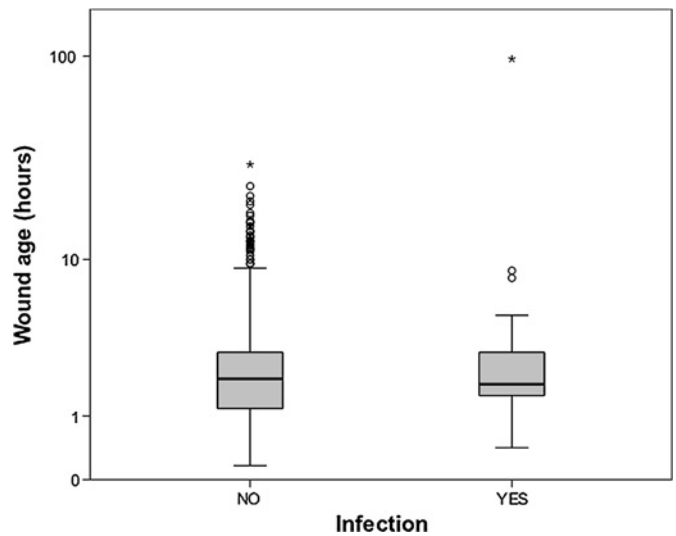

Figure 2 Wound age in hours on a 10-log scale.

Table 2 Characteristics related to time to closure. Data are presented as mean (SD) or numbers with percentages

	Time to closure ≤6 h	Time to closure >6 h	p Value
Age in years	40.0 (18.0)	37.6 (19.1)	0.40
Age in quartiles			
First quartile	86 (85.1)	15 (14.9)	0.36
Second quartile	91 (88.3)	12 (11.7)	
Third quartile	93 (93.0)	7 (7.0)	
Fourth quartile	93 (89.4)	11 (10.6)	
Length of wound in cm	3.6 (3.1)	3.5 (2.5)	0.71
Type of wound			
Cut	271 (91.9)	24 (8.1)	0.003
Crush	92 (81.4)	21 (18.6)	
Wound location			
Head	59 (81.9)	13 (18.1)	0.14
Torso	4 (80.0)	1 (20.0)	
Upper extremities	224 (90.0)	25 (10.0)	
Lower extremities	76 (92.7)	6 (7.3)	
Depth of the wound in anatomical layers			
Cutis	282 (89.8)	32 (10.2)	0.11
Subcutis	49 (81.7)	11 (18.3)	
Fascia	32 (94.1)	2 (5.9)	
Wound cleaning			
1 Disinfection	210 (91.3)	20 (8.7)	0.11
2 + Wound cleaning	103 (85.1)	18 (14.9)	
3 + Wound edge resection	21 (95.8)	1 (4.2)	
4 Complete debridement	27 (81.8)	6 (18.2)	

Table 3 Logistic regression (wound characteristics for the two groups of closure ≤6 h vs >6 h)

	OR (95% CI)	Significance
>6 h	1.096 (0.305 to 3.935)	0.889
Torso	7.738 (0.616 to 97.173)	0.113
Upper extremities	1.479 (0.412 to 5.309)	0.548
Lower extremities	**6.075 (1.647 to 22.407)**	**0.007**
Second quartile	3.621 (0.926 to 14.152)	0.064
Third quartile	2.766 (0.673 to 11.364)	0.158
Fourth quartile	**7.833 (2.151 to 28.529)**	**0.002**

Time to closure ≤6 h, wound location at the head, and the first percentile of age were the reference groups.

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Competing interests None.

Patient consent Obtained.

Ethics approval This study was conducted with the approval of the Ethics Committee at Medisch Spectrum Twente.

Contributors The trauma center euregio is a non-profit organisation with the objective, among others, to stimulate research in the field of trauma care.

Provenance and peer review Not commissioned; externally peer reviewed.

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Images in emergency medicine

Major tracheal disruption after emergency uncomplicated endotracheal intubation

A 36-year-old woman presented as an emergency with decompensated alcoholic liver disease and sepsis from spontaneous bacterial peritonitis. Emergency intubation was carried out without difficulty (size 8 endotracheal tube without stylet). Chest *x* ray revealed suboptimal tube placement, so 8 ml of air was aspirated from the balloon and the tube was pulled back to 22 cm from the incisors before reinflation. Several hours later the patient was noted to have increasing amounts of subcutaneous emphysema. There were no ventilatory difficulties. Chest CT (figure 1) revealed extensive pneumomediastinum with disruption of the posterolateral tracheal wall (white arrow) just above the tip of the endotracheal tube. Imaging was reviewed by both a thoracic surgeon and an interventional radiologist but the patient's underlying condition deteriorated rapidly and prevented transfer or intervention. She died shortly thereafter. This case highlights tracheal rupture as a rare but significant complication of emergency intubation.

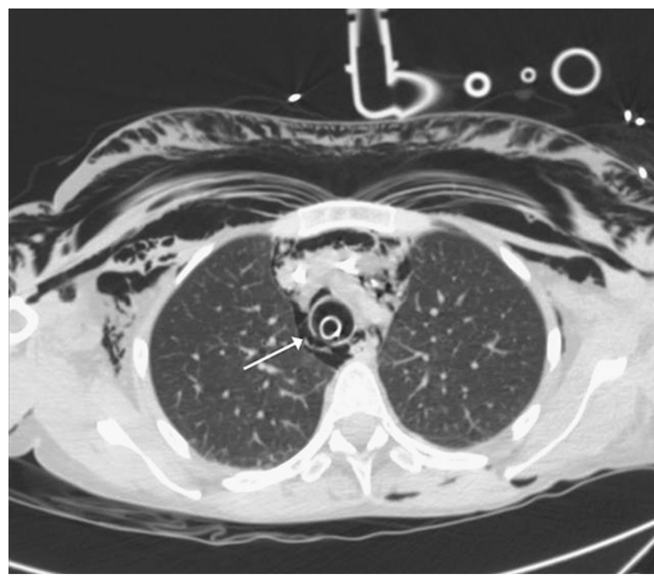

Figure 1 Thoracic CT scan demonstrating complete disruption of the potero-lateral tracheal wall (white arrow) with extensive pneumomediastinum and subcutaneous emphysema. The endotracheal tube can be seen in situ.

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Competing interests None.

Patient consent The patient is deceased so no written consent was obtained. Unfortunately, no relatives were able to be contacted to consent on the patient's behalf. The author is of the opinion that the images are of anonymous internal CT scan with no patient identifiable data.

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