Early surgical site infection in adult appendicular skeleton trauma surgery: A multicenter prospective series


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KEYWORDS
Surgical site infection; Wound healing complication; Surgical adverse events; Infection control; Nosocomial infections

Summary
Introduction: Surgical site infections (SSI) studies rely on an imprecise and debatable definition. The term "wound healing problems" (WHP), not necessarily septic, is also frequently cited. This study had the objectives of determining the frequency of early SSIs in traumatology, these terms eventual correlation, and the factors influencing onset.

Patients and methods: A multicenter prospective observational study was conducted in 12 centers. The exclusion criteria were open lesions as well as multiple injuries and multiple fractures (more than two fractures treated surgically). All patients were followed for the first three post-operative months until there was clinical certainty of healing and absence of infection. The presence of any WHP or SSI required a minimum follow-up of 1 year. WHP and SSI risk factors were determined using logistical regression adjusted on the centers.
Introduction

Surgical site infections (SSIs) are among the most dreaded complications, most often requiring surgical revision, altering the clinical and radiological result and calling into question the liability of the operator [1]. The definition of SSI remains imprecise and debatable, based on the presence of pus, the isolation of the bacterium, obvious clinical signs, and the surgeon’s confirmation of this diagnosis [2]. The term ‘superficial infection’ is often found in the literature with a definition that is just as contestable: bacterial colonization only involving the cutaneous and subcutaneous level and sparing the surgical site protected by the fascia. The term ‘scar tissue problem’ (WHP), not necessarily septic, was proposed in the follow-up of arthroplasties and nothing stands in the way of applying it to traumatology [3]. WHPs can have variable clinical aspects: inflammatory contour, disunion, necrosis, or persistent discharge. The frequency of SSIs has most particularly been studied in elective arthroplastic surgery or globally without identifying the recent injury, and the relations between WHPs and SSIs have not been thoroughly explored despite the mandatory declaration of nosocomial infections in France [4–9].

This study had the objectives of determining the frequency of early SSIs in traumatology and their reciprocal relations, as well as establishing the predisposing factors; it is based on a clinical prospective series.

Material and methods

A multicenter prospective observational study was conducted in 12 adult traumatology centers (Grenoble Sud University Hospital, Lille University Hospital, Limoges University Hospital, Nancy University Hospital, Nancy Centre Émile-Gallé, Paris La Pitié University Hospital, Rennes University Hospital, Strasbourg Hautepierre University Hospital, Toulon Hospital Center, Toulouse Purpan and Rangueil University Hospitals, Toulouse Nouvelle Clinique de l’Union) under the auspices of the French Orthopaedic and Traumatology Society (SOFCOT) from 01/02 to 30/04/102. All open fractures, patients with multiple injuries or having stayed in the intensive care unit or with more than two fracture sites were excluded. The most representative fracture sites and surgical techniques were selected, creating three groups of lesions:

- osteosynthesis with superficial bone sites (called ‘near the skin’), located in the elbow, the patella, the ankle, and the tibial pilon;
- osteosynthesis on deep sites, for closed or open fractures of the femoral, tibial, humeral diaphysis and the diaphysis of the upper extremity of the humerus and femur;
- first-line arthroplasty of the hip and shoulder.

Based on a common observational data sheet, all patients were followed up for the first three postoperative months until there was clinical certainty of healing and absence of infection. Any WHP or SSI observed during this period led to a minimum follow-up lasting 1 year. Risk factors were sought based on logistic regressions adjusted on the centers. The relative risk associated with a variable X was measured using the odds ratio with 95% confidence intervals and significance was evaluated with a one-tailed test at the 5% level. Significance was set at $p \leq 0.05$ and a trend (or intermediate significance) was established when $p$ was between 0.05 and 0.1.

Results: Out of 1617 cases, 103 were complicated by a WHP and 22 by a SSI. The SSIs were mainly secondary to Staphylococcus infections. The factors predisposing the patients to WHP and SSI ($p \leq 0.05$) were age; the NNIS, ASA, and Parker scores; alcoholism; antiinflammatory use; and the locoregional aspect at the time of injury. The 522 subcutaneous osteosyntheses ”near the skin” resulted in 58 WHPs (11%) and 14 SSIs (2.7%); 13 of the 58 WHPs (22%) resulted in one SSI. Out of 707 deep osteosyntheses, 24 (3.4%) presented a WHP and seven (1%) a SSI; Four SSIs originated from a WHP. The 352 fractures of the trochanter were complicated by a WHP in 15 cases (5.5%) and a SSI in one case (0.4%) after interlocked nailing and two WHPs and two SSIs (2.5%) after screw and plate fixation. Of the 388 first-line arthroplasties, only the prostheses implanted for a proximal femur fracture presented complications: 21 WHPs (6%) and one SSI (0.02%). Of the 103 WHPs of the entire series, 18 became SSIs. In absence of WHP, the SSI rate was 0.2%, whereas the probability of a WHP evolving toward a SSI was 100 times higher. The only factor significantly associated with a SSI becoming a WHP was osteosynthesis material exposure.

Discussion: This prospective study can be criticized on several points: the deliberately limited inclusion criteria, the short follow-up, and the possible subjectivity of the data collection. The SSI rates reported are for the most part in agreement with the literature. This study is innovative in traumatology given the large number of patients and the notion of WHP that was preferred over superficial infection. It demonstrates the relations between WHP and SSI, in particular for osteosyntheses near the skin.

Level of evidence: Level III.

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Table 1 Distribution of WHPs and SSIs.

<table>
<thead>
<tr>
<th></th>
<th>Upper limb (n = 275)</th>
<th>Lower limb (n = 1342)</th>
<th>Total (n = 1617)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHP</td>
<td>12 (4.36%)</td>
<td>91 (6.8%)</td>
<td>103 (6.4%)</td>
</tr>
<tr>
<td>Direct SSI</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>WHP → SSI</td>
<td>5</td>
<td>14</td>
<td>19</td>
</tr>
<tr>
<td>Total SSI</td>
<td>6 (2.8%)</td>
<td>16 (1.2%)</td>
<td>22 (1.7%)</td>
</tr>
</tbody>
</table>

WHP: wound healing problem; SSI: surgical site infection

Table 2 Type of WHP and mean time to appearance.

<table>
<thead>
<tr>
<th>Clinical aspect</th>
<th>n</th>
<th>Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inflammatory scar</td>
<td>54</td>
<td>15</td>
</tr>
<tr>
<td>Serous discharge</td>
<td>42</td>
<td>10</td>
</tr>
<tr>
<td>Disunion</td>
<td>28</td>
<td>32</td>
</tr>
<tr>
<td>Necrosis</td>
<td>20</td>
<td>17</td>
</tr>
<tr>
<td>Purulent discharge</td>
<td>7</td>
<td>34</td>
</tr>
<tr>
<td>Disunion with hardware visible</td>
<td>5</td>
<td>32</td>
</tr>
</tbody>
</table>

WHP: wound healing problem.

Results

Overall series

The 1617 cases included 522 osteosyntheses that were superficial, "near the skin," 707 osteosyntheses located in a deep site, and 388 arthroplasties: 103 were complicated by a WHP and 22 by a SSI (Table 1). The 22 SSIs were secondary to methicillin-sensitive *Staphylococcus aureus* in eight cases, methicillin-resistant *Staphylococcus aureus* in five patients, coagulase-negative *Staphylococcus* in three cases, *Enterobacter cloacae* in one patient, and three multimicrobial infections, two of which with *Staphylococcus*. The WHPs showed a variable time to appearance (Table 2).

The statistically significant factors predisposing patients to WHP were age; NNIS, ASA, and Parker scores; alcoholism; taking an antiaggregant; and the locoregional aspect at the time of injury. An intermediate rate of significance was found between the presence of cognitive impairment and taking antiaggregants prior to injury.

The statistically significant factors predisposing patients to SSI (p < 0.05) were age; NNIS, ASA, and Parker scores; taking an antiaggregant; and the locoregional cutaneous aspect of the fracture site. Taking anticoagulants appeared as a predisposing factor with intermediate significance.

Analysis by fracture group

Osteosynthesis "near the skin"

Of the 522 osteosyntheses near the skin, 58 WHPs (11%) and 14 SSIs (2.7%) were observed. Thirteen of the 58 WHPs (22%) resulted in a SSI (Table 3). The statistically significant predisposing factors to WHP (p < 0.05) of the ankle fractures were age older than 40 years, diabetes, corticotherapy, alteration of the teguments, comminuted fracture, the significance of the initial displacement, and surgical time greater than 40 min or tourniquet time longer than 45 min.

The statistically significant predisposing factors to SSI (p < 0.05) were female gender, ASA score = 2, antiaggregant treatment, and comminution fracture. Arteritis of the lower limbs and absence of prophylactic antibiotics had an intermediary significance.

Deep fractures

Of the 707 deep osteosyntheses, 24 (3.4%) presented a WHP and seven (1%) a SSI (Table 4). Four SSIs originated from a WHP, two out of the 17 proximal femur WHPs and one of the three proximal humerus WHPs; only one humeral diaphysis WHP resulted in a SSI. The 352 trochanter fractures were repaired with interlocking nailing fixation (33 of which were long nails) in 273 cases and 79 with screw and plate fixation. The nailing procedures led to 15 WHPs and one SSI complication, for a respective frequency of 5.5 and 0.4%. Two WHPs and two SSIs (2.5% of the total) complicated the screw and plate fixations, resulting in two SSIs. The predisposing factors of WHPs (p < 0.05) after intramedullary nailing was prolonged hospital stay with a risk of WHP multiplied by 3.4.
Early surgical site infection in adult traumatology

Table 4  Distribution of WHPs and SSIs in the 707 deep osteosyntheses.

<table>
<thead>
<tr>
<th>Site</th>
<th>Number</th>
<th>Nailing</th>
<th>Plate</th>
<th>WHP (%)</th>
<th>SSI (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proximal humerus</td>
<td>117</td>
<td>66</td>
<td>51</td>
<td>3 (2.2)</td>
<td>1 (0.7)</td>
</tr>
<tr>
<td>Humerus diaphysis</td>
<td>42</td>
<td>31</td>
<td>11</td>
<td>1 (2.4)</td>
<td>2 (4.7)</td>
</tr>
<tr>
<td>Femoral cervical fracture</td>
<td>77</td>
<td>6</td>
<td>71</td>
<td>17 (4.8)</td>
<td>2 (0.5)</td>
</tr>
<tr>
<td>Trochanteric fracture</td>
<td>352</td>
<td>273</td>
<td>79</td>
<td>1 (2.4)</td>
<td>2 (4.7)</td>
</tr>
<tr>
<td>Femur diaphysis</td>
<td>84</td>
<td>50</td>
<td>34</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Tibia diaphysis</td>
<td>112</td>
<td>81</td>
<td>31</td>
<td>3 (3.6)</td>
<td>2 (2.4)</td>
</tr>
<tr>
<td>Total</td>
<td>707</td>
<td>501</td>
<td>206</td>
<td>24 (3.4)</td>
<td>7 (1)</td>
</tr>
</tbody>
</table>

WHP: wound healing problem; SSI: surgical site infection.

Table 5  Distribution of the WHP/SSI in 388 arthroplasties.

<table>
<thead>
<tr>
<th>Site</th>
<th>n</th>
<th>WHP</th>
<th>SSI</th>
<th>Progression IC→ISO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proximal humerus</td>
<td>41</td>
<td>0</td>
<td>0</td>
<td>—</td>
</tr>
<tr>
<td>Femoral cervical fracture</td>
<td>308</td>
<td>n = 21</td>
<td>n = 1</td>
<td>1</td>
</tr>
<tr>
<td>Trochanter</td>
<td>39</td>
<td>n = 3</td>
<td>0.3%</td>
<td>—</td>
</tr>
</tbody>
</table>

WHP: wound healing problem; SSI: surgical site infection.

and the presence of postoperative drainage. In the nailing and plate and screw fixation group, no predisposing factor for SSI was statistically identified.

Arthroplasties
First-line surgeries included 388 arthroplasties, 41 (12 shoulder hemiarthroplasties/29 reverse total shoulder arthroplasties) for the proximal humerus, 39 (12 hip hemiarthroplasties, HHA, and 27 total hip arthroplasties, THA) for the trochanter, and 308 (192 HHAs and 116 THAs) for the femoral neck. The femoral neck lesions were for the most part transcervical (75% of the cases) and displaced as defined by Garden grades III and IV (83% of the cases). None of the humeral arthroplasties showed a WHP or SSI complication. Of the 349 proximal femoral arthroplasties, 21 were found to have a WHP (6%) and one a SSI (0.02%) (Table 5). The univariate and multivariate analyses of the classical risk factors of infection (age, ASA score, Parker score, diabetes) were not conclusive in the group of proximal femoral fractures.

Cross-sectional analyses
SSI–WHP relation
Of the 103 WHPs observed for the overall group, 18 transformed into a SSI but with a variable frequency dependent on the injury groups, with the osteosyntheses near the skin the most exposed to evolving toward a deep infection: in this group, one WHP out of five became a SSI (Table 6). In absence of a WHP, the SSI rate was 0.2%, whereas the probability of a WHP evolving toward a SSI was 100 times greater. The type of WHP greatly influenced the outcome toward SSI. The five scarring disunions with exposure of the material all evolved toward a SSI, whereas 12 of the 28 disunion cases (43%), seven of the 20 necrosis cases (35%), 12 of the 54 inflammatory scar cases (22%), and only three of the 42 cases with serous discharge (7%) evolved toward a SSI. The only significantly associated factor for a WHP evolving to a SSI was the exposure of the osteosynthesis material because of skin rupture. Finally, WHP tended to evolve toward SSI when the patient was older than 40, treated with an antiaggregant,

Table 6  Distribution of the WHP/SSI in the three groups and their progression.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>WHP</th>
<th>SSI</th>
<th>Progression IC→ISO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Near the skin</td>
<td>522</td>
<td>n = 58</td>
<td>n = 14</td>
<td>13/58</td>
</tr>
<tr>
<td>Deep site</td>
<td>352</td>
<td>n = 24</td>
<td>n = 7</td>
<td>4/24</td>
</tr>
<tr>
<td>Arthroplasty</td>
<td>388</td>
<td>n = 21</td>
<td>n = 1</td>
<td>1/24</td>
</tr>
</tbody>
</table>

WHP: wound healing problem; SSI: surgical site infection.
Table 7 Comparison of WHPs/SSIs by epiphyseal site between arthroplasty and osteosynthesis.

<table>
<thead>
<tr>
<th>Site</th>
<th>Arthroplasty</th>
<th>Osteosynthesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proximal humerus</td>
<td>n = 41</td>
<td>n = 117</td>
</tr>
<tr>
<td>WHP/SSI = 0</td>
<td>4 WHP (3.4%)/1</td>
<td></td>
</tr>
<tr>
<td>SSI (0.8%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Femoral cervical</td>
<td>n = 308</td>
<td>n = 77</td>
</tr>
<tr>
<td>fractures</td>
<td>21 WHP (7%)</td>
<td>2 WHP (2.5%)</td>
</tr>
<tr>
<td>1 ISO (0.3%)</td>
<td>0 SSI</td>
<td></td>
</tr>
<tr>
<td>Trochanter fractures</td>
<td>n = 39</td>
<td>n = 552</td>
</tr>
<tr>
<td>3 WHP (7.5%)</td>
<td>18 WHP (5.1%)</td>
<td></td>
</tr>
<tr>
<td>0 SSI</td>
<td>3 SSI (0.8%)</td>
<td></td>
</tr>
</tbody>
</table>

WHP: wound healing problem; SSI: surgical site infection.

and when the fracture occurred on the lower limb with pre-existing cutaneous lesions.

Comparison of techniques on a single site

In the subgroup of trochanter fractures, WHP and SSI occurrence was compared between intramedullary nailing (n = 273) and screw and plate fixation (n = 79): 15 WHPs (5.5%) that did not result in SSI and one immediate SSI (0.4%) complicated the nailing results; two WHPs (2.5%) giving two SSIs complicated the screw and plate fixations.

For the arthroplasty or osteosynthesis procedures of proximal humerus and femoral neck fractures (Table 7), a single SSI was observed after a WHP in one case of proximal humerus osteosynthesis; a single SSI secondary to a WHP after arthroplasty for a femoral neck fracture was observed. Two of the three SSIs after osteosynthesis for trochanter fractures occurred after WHP.

Discussion

This prospective study has several limitations. The first is the deliberately limiting inclusion criteria; the most habitual fracture sites were chosen and the techniques that a priori offer the greatest safety in terms of infection. This explains the exclusion of open lesions, patients with several injuries, osteosyntheses in which the implant material is relatively frequent (e.g., wiring of the wrist or the humerus), and closed lesions treated with external fixation whose pins are often the seat of cutaneous intolerance [10–12]. Setting the follow-up limit at the 3rd month allowed us to confirm that cutaneous healing and surgical site sterility were acquired. To prevent any subjectivity and obtain diagnostic homogeneity, each case of WHP or SSI was systematically reassessed through observation and/or direct questioning by the examiner responsible for data collection (FB). This study is an innovation in traumatology because it is based on a high number of patients and on the notion of WHP, variable clinical aspects, and an uncertain outcome. This notion is essentially clinical, close to the reality of the traumatologist, and should replace the concept of superficial infection [1,3]. The depth of bacterial colonization can only be assessed by samples taken under the subcutaneous cellular tissue and the fascia. Moreover, the positive bacteriological result of a superficial scraping sample is no longer acceptable or at the very least highly debatable [13].

Approximately 5% of the traumatic lesions included in this prospective cohort were followed by a WHP and 1.5% by a SSI; these rates are close to those recently published for the most frequent fracture sites [14–17]. With the above-mentioned reservations, they are the only results evaluating postoperative infectious risk in limb traumatology in France. The factors predisposing to WHP or SSI underscored by this study are in agreement with the recent literature, in particular age [18], diabetes [19], alcoholism [20], and the anterior cutaneous aspect and/or this aspect related to the injury. Only the absence of smoking as a predisposing factor, whereas it is widely mentioned in the literature, appears surprising [21].

The osteosyntheses “near the skin” presented higher rates of WHP and SSI (11% and 2.7%, respectively). The frequency of SSIs after this type of osteosynthesis is explained by the occurrence of septic infection in more than one WHP out of five (22.4%). A high rate of WHP evolving to SSI was noted at the distal tibia (22% of the cases), the patella (17%), and the distal humerus (12%), in agreement with the published series [22–25]. Ankle fractures have among their predisposing factors for WHP or SSI comminution and displacement, which should modify the therapeutic strategies [26].

WHP complicates deep osteosyntheses in 4.8% of cases, as do SSIs in 0.8% of cases; 11% of WHPs evolve to SSI. The highest WHP rate was observed for the distal tibia (3.6%), in agreement with the literature [27]. Diaphyseal fractures of the humerus were complicated by SSI at an unusual rate, 4.7% [28–30]. After trochanter fracture, there were more WHPs after intramedullary nailing (5.5% versus 2.5% after plate fixation) and more SSIs after plate osteosynthesis (2.5% versus 0.4% after nailing). As in the comparative studies already published, it is difficult to draw a conclusion in favor of any particular technique in terms of the SSI risk [31].

Arthroplasties were complicated by a WHP in 5.4% of the cases, by a SSI in 0.2%. Shoulder arthroplasties were not complicated by WHP or SSI, in relative agreement with the literature [32,33]. After arthroplasties for proximal femur fracture, 6% WHP and 0.2% SSI were observed, which corresponds to the rates published in the literature [34,35]. For proximal femur arthroplasties, the factors favoring WHP and SSI were the Parker score, the time to surgery, the absence of local preparation, and a prolonged hospital stay.

Conclusion

This study met its first goal in setting a WHP and SSI rate in the early follow-up of the most habitual surgical interventions in traumatology. These rates for the most part agreed with the literature. This work is innovative in traumatology, in particular underscoring the notion of scar tissue problems. It emphasizes the relation between WHP and SSI and establishes risk factors related to the fracture or the patient. Some cannot be prevented, but several should lead to modification of the first-line surgical technique.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.
Early surgical site infection in adult traumatology

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