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ORIGINAL ARTICLE

Skin preparation before hip replacement in emergency setting versus elective scheduled arthroplasty: Bacteriological comparative analysis

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Summary
Introduction: Hip arthroplasty needs to be performed in an emergency setting after intracapsular femur neck fracture, whereas pain makes preoperative skin preparation of the limb difficult and it may therefore be incomplete. To date no study has analyzed the patient's skin bacteriological status in these surgical conditions.
Hypothesis: The skin's bacterial flora is quantitatively and qualitatively different in the trauma context compared to an elective scheduled arthroplasty for chronic hip disease.
Materials and methods: Two groups of patients, undergoing hip arthroplasty and having the same preparation at the time of surgery but different skin preparation procedures the day before and the day of surgery, were prospectively compared: 30 patients operated on in an emergency setting for fracture (group A) had no skin preparation and 32 patients operated on in scheduled surgery (group B). Group A had no skin disinfection before going into surgery, whereas group B followed a predefined protocol the day before surgery. Skin samples were taken on gelose at three different stages of skin preparation at the time of surgery (before and after detersive cleaning, and at the end of the surgery) and on two sites (inguinal and greater trochanter). The bacteriological analysis took place after 48 hours of incubation.

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Results: Before detersive cleaning, group A had 3.6 times more bacteria than group B in the trochanter region and 2.7 times more in the inguinal area. After detersive cleaning, the contamination rate in the trochanter area was similar in both groups (group A: 10%; group B: 12.5%), but different in the inguinal region (group A: 33%; group B: 3%; $P = 0.002$). At the end of the surgery, no difference was identified. Coagulase-negative Staphylococcus and *Bacillus cereus* accounted for 44% and 37%, respectively, of the bacteria isolated. In addition, the frequency of pathogenic non-saprotrophic bacteria was higher in group A (38%) compared to group B (6%). At a mean follow-up of 9.7 months (range: 8—11 months), no infection of the surgical site was identified.
Conclusion: The dermal flora is more abundant and different when the patient is managed in an emergency context. Although effective in the trochanter area, cutaneous detersive cleaning in the operating room is insufficient in the inguinal area and the frequency of pathogenic bacteria warrants identical rigor in preoperative preparation in all situations.
Level of evidence: III. Prospective case—control study.

Introduction

Total or partial hip arthroplasty is a frequent emergency intervention after femur neck fracture in the elderly subject [1]. In this context, preoperative skin preparation of the fractured limb is made difficult by pain and may be incomplete because of required immobilization. In scheduled surgery for chronic hip disease, skin flora is often to blame in deep infections following arthroplasty [2,3]. In 2004, the consensus conference of the French Society for Hospital Hygiene (Société Française d'Hygiène Hospitalière) on behalf of the French Health Authority (Haute Autorité de santé) established guidelines for the skin preparation of patients undergoing surgery [4,5]. However, when a patient suffering from recent fracture and acute pain is managed in an emergency setting, these guidelines may be incompletely applied. In addition, the trauma context warranting emergency hip arthroplasty has been identified as a situation exposing the patient to a higher risk of surgical site infection (SSI) compared to the scheduled intervention [6,7]. Beyond certain identified preoperative risk factors such as age, diabetes, the American Society of Anesthesiologists (ASA) score, and obesity, the patient's bacteriological status at the time of surgery has not yet been taken into account [7—13].

We hypothesized that the skin flora of the surgical zone and its immediate surroundings was quantitatively greater and qualitatively different at the time of surgery in patients managed in the emergency context compared to patients undergoing scheduled surgery. The objective of this study was to compare the cutaneous bacterial flora of patients treated in an emergency situation (for fracture) and those undergoing scheduled surgery (for hip disease or non-infected revision hip arthroplasty) during hip arthroplasty.

Material and methods

Inclusion and exclusion criteria

From 1st February to 30th April 2012, the patients undergoing hip arthroplasty were prospectively included in a continuous and nonrandomized manner in two groups:

- group A: surgery performed in an emergency setting (less than12 hours after patient admission), following a recent fracture of the femoral neck or a femoral periprosthetic fracture;
- group B: scheduled surgery performed for chronic hip disease or revision arthroplasty because of mechanical failure. The patients in this group were hospitalized the day before the intervention, after a preoperative workup 3 weeks before (negative urinary workup, healthy oral-dental status, normal inflammatory workup).

We excluded any patient intolerant to polyvidone—iodine, presenting a diagnosed dermatological disorder, a documented active infection (osseous or extraosseous), asymptomatic bacteriuria, as well as those taking an antibiotic treatment for any reason at the time of surgery. In addition, patients treated for rheumatoid arthritis or early revisions of total hip arthroplasty (less than 6 months after insertion) were excluded.

The patients (or their relatives) gave their consent to participate in this study; the ethics committee was not specifically consulted since this study was observational with no change in the care protocols.

Patients

Age, the ASA score, the body mass index (BMI), and the duration of surgery were recorded as criteria for comparison of the two groups of patients. Their clinical follow-up was prospective with particular attention paid to detecting the onset of a SSI.

Preoperative skin preparation and sampling technique

Patients were prepared before entering the operating room as follows:

- group A: no particular skin preparation (no preoperative shower);

- group B: application of the preoperative protocol defined by the Committee for the control of nosocomial infections (Comité de Lutte contre les Infections Nosocomiales [CLIN]) including an antiseptic shower with polyvidone—iodine (Bétadine® scrub 4%) over the entire body the day before and the day of surgery [4].

However, the patients in the two groups were treated similarly in the operating room, with preoperative antibiotic treatment with first-generation cephalosporin when the patient was installed [14]. Under general or locoregional anesthesia, the patient was positioned in the lateral decubitus position and the entire lower limb to be operated was prepared as follows:

- detersive cleaning of the surgical area using polyvidone—iodine solution (Bétadine® scrub 4%);
- rinsing with sterile water;
- drying with sterile compresses;
- application of the first layer of an alcohol antiseptic dermal polyvidone—iodine solution (Bétadine® alcohol 5%) with a contact time lasting until the skin dried before application of a second layer;
- application by the surgeon in sterile scrubs of a second layer of the alcohol dermal antiseptic solution: polyvidone—iodine (Bétadine® alcohol 5%).

Evaluation method

The skin samples were taken by application of 25 cm^2 TSA Contact + LTH-RT geloses (heipha Dr. Müller GmbH, Eppelheim, Germany). Contact was maintained for 10 seconds on two different areas: the inguinal area (I) and the trochanter area (T). These samples were taken three different times for each patient:

- upon entering the operating room, with the patient installed in the lateral decubitus position (T1, I1);
- after the initial detersive cleaning with polyvidone—iodine, before the final disinfection, and when the sterile surgical drapes were installed (T2, I2);
- at the end of the intervention, once the skin had been closed and before having removed the sterile drapes [3]. For this reason, only the trochanter region corresponding to the surgical site was accessible (T3).

The gelose boxes were incubated for 48 hours at 37 °C before quantitative evaluation in colony-forming units (CFUs) and qualitative assessment of the different bacterial strains.

Statistical analysis

The statistical analysis was done with Statview 5.0 software (SAS Institute, Cary, NC, USA). The Chi^2 and Fischer tests were used to compare the categorical data. The distribution of the quantitative data was analyzed with the Agostino-Pearson test, using the Student *t* test and the Mann-Whitney U-test. The significance threshold was set at $P < 0.05$.

Results

Population studied

In the inclusion period, 86 patients underwent hip arthroplasty: 62 patients were included in this study following the predefined criteria (Fig. 1). Of the 30 patients in group A, 26 (87%) underwent an arthroplasty after displaced femoral neck fracture and four patients had their prosthesis revised because of a peri-prosthetic fracture around a loosened implant. Twenty-three intermediate prostheses and seven dual-mobility prostheses were placed. Of the 32 patients in group B, 17 underwent total arthroplasty for chronic hip disease and 15 patients (47%) underwent aseptic revision of a prior arthroplasty because of a mechanical failure. All the arthroplasties were performed via a posterolateral approach. At the minimum follow-up at 8 months (mean: 9.7 ± 1.06 [range: 8—11 months]), no SSI was recorded in either of the two groups during the prospective postoperative follow-up. Between the two groups, no significant difference was demonstrated for gender, ASA score, and surgical duration criteria. However, the group A patients were statistically older, more frequently diabetic, but had a lower BMI (Table 1).

Quantitative results

The two groups' quantitative data are reported in Table 2. In phase 1, before detersive cleaning, there were 3.6 times more bacterial colony-forming units on average in group A patients than in group B patients in the trochanter area and 2.7 times more in the inguinal area. Aftercleaning, there was no longer a significant difference between the two groups.

The analysis of the contaminated sample rates after the detersive cleaning phase (phases 2 and 3) (Fig. 2), proved, however, that the inguinal folds (I2) of group A patients were more frequently contaminated than those of group B patients ($n = 9$, 33% versus $n = 1$, 3%; $P = 0.002$). However, the difference was not significant in the trochanter area (T2) and at the end of surgery (T3).

Qualitative results

The microorganisms identified in the samples were classified into three groups: bacteria belonging to the commensal skin flora, bacteria from the digestive flora, and environmental saprophyte bacteria (Table 3). In group A in the trochanter area and before detersive cleaning, each of these three groups accounted for 81.5% (44/54), 11.1% (6/54), and 7.4% (4/54), respectively, of the bacteria identified; in group B, the distribution was 83.6% (46/54), 3.7% (2/54), and 12.7% (7/54), respectively ($P < 0.05$).

Before detersive cleaning and in the trochanter area (T1), coagulase-negative staphylococci, micrococci, and *Bacillus cereus* were the most frequently found bacteria: 93.3% (28/30), 43.3% (13/30), and 13.3% (4/30), respectively, in group A and 84.4% (27/32), 34.4% (11/32), and 12.5% (4/32)

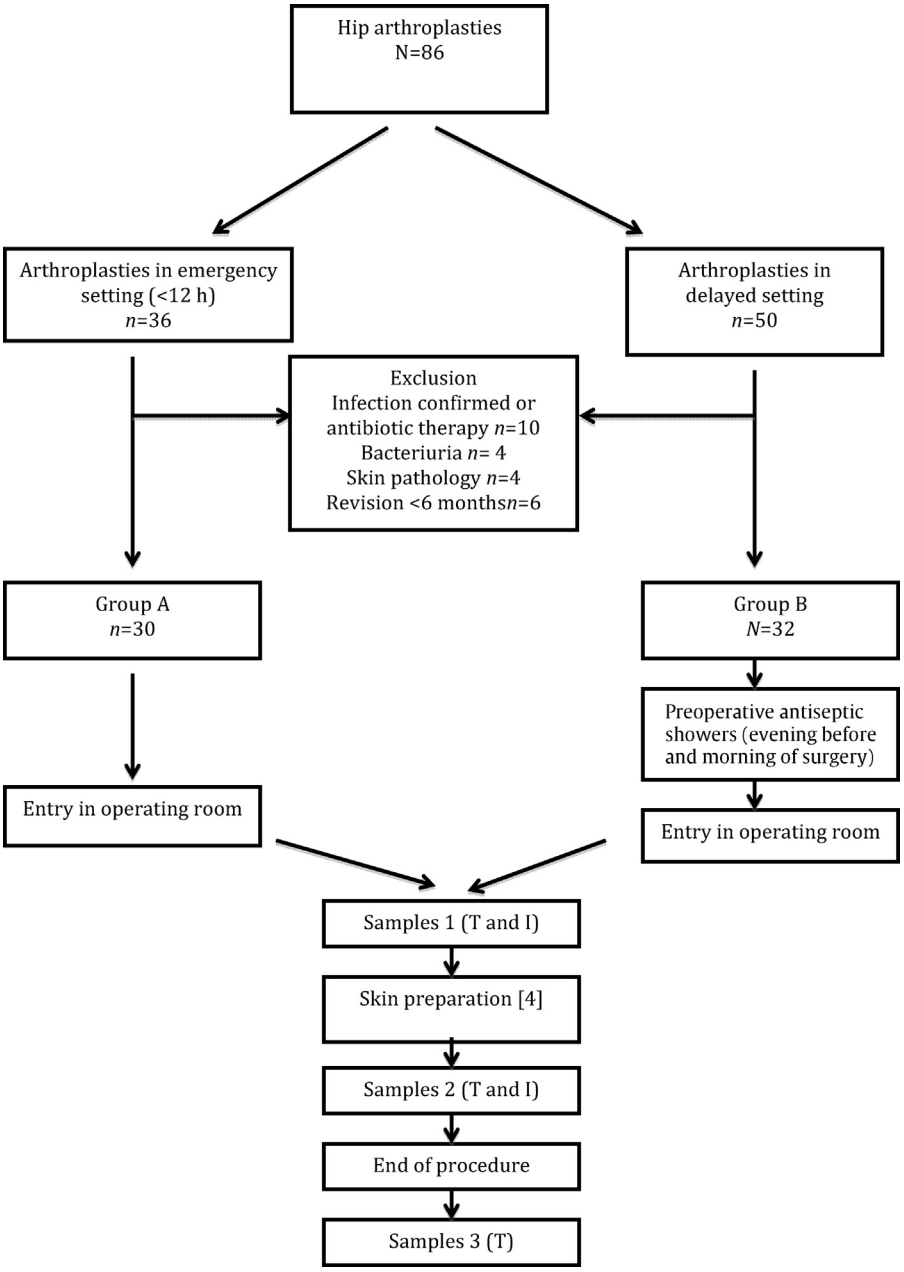

Figure 1 Flowchart and sample methodology. T: trochanter; I: inguinal.

in group B, with in addition 18.75% (6/32) of the samples positive for *Corynebacterium acnes* ($P > 0.05$).

After detersive cleaning in the trochanter area (T2), three samples in group A were positive for *B. cereus* with in addition three cases of coagulase-negative staphylococci at the end of surgery (T3). In group B, after detersive cleaning of the trochanter area (T2), all the samples were sterile except for two identifications of *Micrococcus* species and two *B. cereus*. At the end of the intervention (T3), an additional five cases of coagulase-negative staphylococci were identified.

Moreover, other than the above-cited bacteria, in the inguinal area in group A, two cases of *Escherichia coli*-positive samples and one *Proteus mirabilis*-positive sample (digestive bacteria) were found.

Discussion

Hip arthroplasty is frequently done in an emergency situation after fracture of the proximal femur in fragile elderly patients [1]. Pain often complicates preoperative skin preparation of the limb, which therefore may be incomplete, possibly increasing the risk of postoperative infectious complications [7—13]. This study confirmed our hypothesis: in these conditions, the initial bacterial skin flora is three times more abundant than in patients who were prepared for a scheduled intervention according to the current guidelines [4]. However, detersive cleaning in the operating room seems to be sufficiently effective to correct the excess bacteria in the trochanter area. The inguinal area remains significantly more contaminated.

Table 1 Patient data for group A (treated in an emergency setting) and B (scheduled surgery).

	Group A	Group B	*P*
n	30	32	
Mean age (years)	77,1 (45–94; ± 14.9)	68,4 (33–90; ± 14.5)	0.02*
Sex ratio (H/F)	0,87 (H = 14; F = 16)	0,88 (H = 15; F = 17)	0.56
Mean ASA score	2,3 (1–3; ± 0.66)	2,1 (1–3; ± 0.7)	0.08
BMI	22 (18–28; ± 3)	26 (17–34; ± 4.3)	0.0002*
Number of diabetic patients (%)	8 (26.7)	1 (3.2)	0.049*
Mean surgical time (min)	78 (30–150; ± 35)	105 (50–300; ± 51)	0.07

ASA score: American Society of Anesthesiologists; BMI: body mass index.
* Significant difference.

This study presents a certain number of limits. The first is the comparability of the two groups of patients studied. The patients managed in an emergency setting were logically older since they presented a fracture of the femoral neck. On the other hand, group A was characterized by a lower BMI and a higher prevalence of diabetes than the patients undergoing planned surgery. This totally involuntary selection bias due to the fortuitousness of the inclusion criteria could probably be corrected with a larger sample studied over a longer time. Although some of these criteria are recognized as being risk factors for surgical site infection, only diabetes could influence the cutaneous bacterial flora of the lower limb [7,10–13]. The second limit is related to the follow-up in this study, which was insufficient to clearly confirm the absence of infection at the surgical site. However, the objective was not to determine how the arthroplasties performed evolved, and this follow-up period was sufficient to eliminate superficial wound infection. Nonetheless, at the maximum follow-up and with revision being completely exhaustive, none of the patients in the two groups presented any signs of infection. Finally, we did not identify the patients from an elderly-care facility, with medical care or otherwise. This could induce a bias because institutionalized patients are carriers of a different quantity and quality of bacteria. However, this study was close to the management of the elderly person suffering from a fracture and we excluded early revisions within less than 6 months since these patients had been exposed to hospital bacteria.

After detersive cleaning, the inguinal area remained significantly more contaminated than the trochanter area in this study. Either improper preparation or a natural overabundance of bacteria in this region could be to blame [15], this inguinal site is close to the anterior surgical approaches to the hip, which, however, were not used for implantation for our patients [16]. Despite this observation, to date no study has demonstrated the type of surgical approach that could influence the onset of a SSI [10].

Table 2 Quantitative results in CFUs/100 cm^2.

	Group A Mean CFU (range; SD)	Group B Mean CFU (range; SD)	*P*
I1	900 (24–4000; ± 1045)	336 (4–2000; ± 630)	0.003*
T1	812 (32–4000; ± 1053)	228 (2–1516; ± 417)	0.007*
I2	74 (0–200; ± 313)	1,5 (0–44; ± 8)	0.1
T2	0.3 (0–4; ± 1)	0,5 (0–4; ± 1.3)	0.4
T3	0.8 (0–12; ± 2.5)	20 (0–400; ± 78)	0.09

CFU: colony-forming unit; T: trochanter; I: inguinal; 1: before detersive cleaning; 2: after detersive cleaning; 3: end of surgery.
* Significant difference.

Table 3 Qualitative results expressed as the number of positive samples to a given microorganism.

		Group A $n = 30$					Group B $n = 32$				
		T1	I1	T2	I2	T3	T1	I1	T2	I2	T3
Microorganisms from commensal skin flora	*Coagulase-negative Staphylococcus*	28	26	0	3	3	27	29	0	1	5
	Staphylococcus aureus	1	1	0	0	0	1	3	0	0	0
	Corynebacterium acnes	2	6	0	0	0	6	3	0	0	0
	Micrococcus species	13	7	0	0	0	11	3	2	0	2
	Streptococcus viridans	0	0	0	0	0	1	0	0	0	0
	Total	44	32	0	3	3	46	38	2	1	7
Microorganisms from digestive flora	*Klebsiella pneumoniae*	1	1	0	0	0	1	1	0	0	0
	Klebsiellaoxytoca	1	0	0	0	0	0	0	0	0	0
	EscherichiaColi	3	4	0	2	0	0	0	0	0	0
	Enterococcus faecalis	0	0	0	0	0	1	0	0	0	0
	Proteusmirabilis	0	2	0	1	0	0	0	0	0	0
	Morganella morganii	1	0	0	0	0	0	0	0	0	0
	yeast	0	0	0	0	0	0	1	0	0	0
	Total	6	7	0	3	0	2	2	0	0	0
Environmental microorganisms	*Bacillus cereus*	4	5	3	5	3	4	3	2	2	2
	Rhodococcus	0	0	0	0	0	1	1	0	0	0
	Pseudomonas oryzihabitans	0	0	0	0	0	1	0	0	0	0
	Total	4	5	3	5	3	7	4	2	2	0

T: trochanter; I: inguinal. 1: before detersive cleaning; 2: after detersive cleaning; 3: end of surgery.

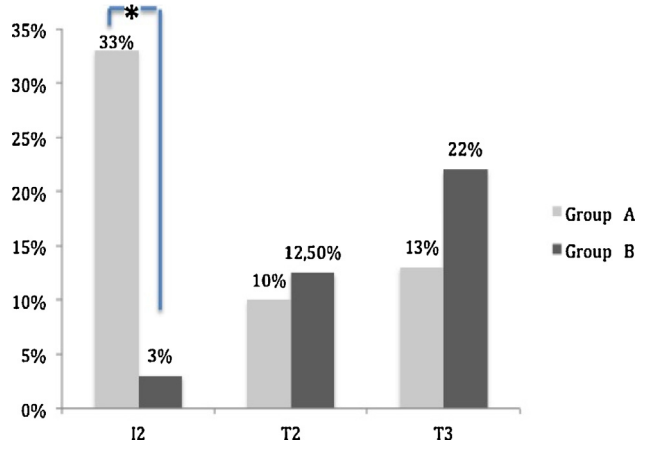

Figure 2 Comparison of the frequency of contaminated samples after detersive cleaning (phases 2 and 3) in the inguinal area (I) and the trochanter area (T). * significant difference ($P < 0.05$) group A (treated in an emergency setting) and B (scheduled surgery).

The cutaneous antiseptic solutions available for patient preparation have variable compositions whose efficacy is displayed as a percentage of microorganism reduction. Each treatment therefore increases the efficacy of the following application [17]. However, Ellenhorn et al. [18] found no difference in the onset of a SSI between scrubbing skin preparation in the operating room followed by polyvidone—iodine application compared to a single application of an antiseptic solution. In a meta-analysis, Webster and Osborne [19] identified seven studies including more than 10,000 patients comparing the efficacy of a preoperative preparation with an antiseptic cutaneous soap (chlorhexidine) and the absence of preparation or preparation with non-antiseptic soap. These authors were not able to clearly demonstrate the superiority of chlorhexidine use during preoperative showers in SSI prevention. However, none of these studies concerned patients prepared for arthroplasty of the lower limb, where the appearance of a SSI can appear long after surgery.

The trend toward a greater presence of digestive or environmental skin bacteria in unprepared patients in the present study remains worrisome. *B. cereus* is most

often telluric contamination and both the currently used polyvidone—iodine and chlorhexidine only reduce the quantity of bacteria by 1.5 logs, which is insufficient [20,21]. As a consequence, multiplying applications of antiseptic seems necessary to eradicate this type of bacteria as much as possible. In addition, the presence of *E. coli* and *P. mirabilis* in the inguinal zone is not surprising because of the orofecal origin of this type of bacteria and the proximity of the anal and urogenital site. Systemic antibiotic treatment is mandatory during hip arthroplasty and requires the administration of first-generation cephalosporin [14]. Although *B. cereus* is not sensitive to this range of antibiotics, *E. coli* and *P. mirabilis* have a 10—30% resistance prevalence. A risk of inefficacy of classical antibiotic treatment exists in case of contamination of the surgical site by these micro-organisms.

Conclusion

The skin flora is more abundant and potentially more pathogenic in patients managed in an emergency setting with no local preparation by successive showers with an antiseptic soap in contrast to patients undergoing a scheduled operation: the original hypothesis is verified by this study. Although effective in the trochanter area, a single skin cleaning in the operating room is insufficient in the inguinal area, as shown by the persistence of cutaneous digestive flora. It seems necessary to emphasize the application of skin preparation guidelines in all circumstances.

Disclosure of interest

Paul Bonnevialle declares no conflicts of interest related to this article, but declares being a consultant for Amplitude. Nicolas Bonnevialle, Laurent Geiss, Laurent Cavailé, Aissa Ibnoulkhatib, and Xavier Verdeil declare that they have no conflicts of interest concerning this article.

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