Autotransfusion—bacterial contamination during hip arthroplasty and efficacy of cefuroxime prophylaxis

A randomized controlled study of 40 patients

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40 patients undergoing primary hip arthroplasty, given autologous processed blood transfusion, were randomized to receive no antibiotic prophylaxis (group A, n 20) or cefuroxime (1.5 g single injection; group B, n 20). Bacterial contamination at various steps in the autotransfusion procedure was assessed in liquid and solid culture media. The operation field and the wound drainage blood were never contaminated in either of the groups but some of the suction tips were. Parts of the Vacufix® blood collection bags of group A contained bacteria, but none in group B. Processed red blood cell concentrates in both groups showed bacterial growth. Greater blood loss did not increase the contamination rate in general. Isolated bacteria included the species *Staphylococcus epidermidis*, coagulase-negative staphylococci and *Propionibacteria* in both groups, but with different cell counts. In addition, *Corynebacterium bovis et minutissimum and Moraxella* were identified in group A.

In conclusion, autologous blood transfusion was a safe procedure. If contamination occurred, the bacterial count was low, and the bacteria of low pathogenicity. Antibiotic prophylaxis with cefuroxime reduced this contamination of suction tips and collection bags and limited the transfer of autologous blood products.

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Submitted 96-08-26. Accepted 97-03-08

Autologous blood transfusion techniques are increasingly used for the replacement of the intra- and postoperative blood loss in hip arthroplasty instead of homologous blood transfusion (Paravicini 1986, Mehrkens et al. 1990, Elawad et al. 1991, Toy et al. 1992). One of the possible drawbacks of autologous blood transfusion is the risk of secondary contamination of the intra- and postoperatively salvaged blood (Blumenberg et al. 1987, Ezzedine et al. 1991, Lorentz et al. 1991, Bauermann et al. 1995). Several studies, however, have shown that postoperative infection rates were not increased after autologous blood transfusion (Schwieger et al. 1989, Ezzedine et al. 1991). Not even the salvage of blood contaminated with enteric content (Timberlake and McSwain 1988) or after bladder injury (Horst et al. 1992) under emergency conditions, resulted in an increased infection rate. Since little is known as to where and to what extent secondary contamination of the intra- and postoperative salvaged wound blood occurs, we studied bacterial contamination at different steps in the autologous blood transfusion procedure: the operation field, the suction tips, the collection bags and the processed red blood cell concentrate, which is retransfused to the patient.

Patients and methods

40 patients undergoing primary hip arthroplasty were enrolled in the study after approval by the Ethics Committee of the University. All patients gave informed consent. Patients were treated according to the autologous blood management protocol with 2 sessions of plasmapheresis 2 weeks up to 3 months before the operation and normovolemic hemodilution after induction of the regional (epidural/spinal) anesthesia. The withdrawal volume (15 mL/kg of body weight) was replaced by the polygeline solution Haemaccel® (Behring, Marburg, Germany). The in-

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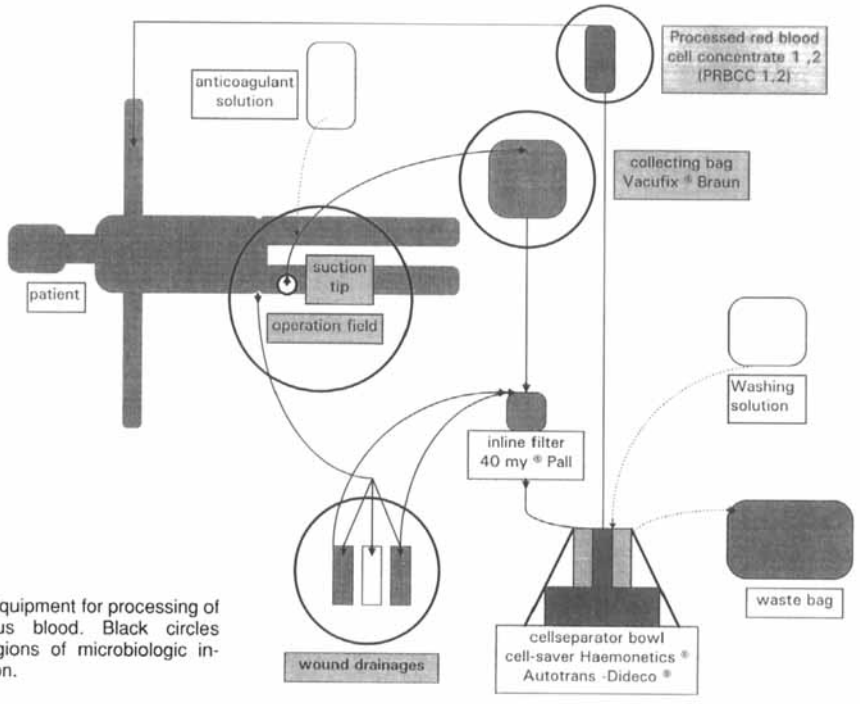

Figure. Equipment for processing of autologous blood. Black circles show regions of microbiologic investigation.

tra- and postoperative blood were salvaged in a modified collection reservoir, the collection bag Vacufix® (Braun, Melsungen, Germany), and processed in a Cell Saver III® (Hemonetics, München, Germany) or Autotrans® (Dideco, Puchheim, Germany). A small group of specially trained and experienced nurses carried out the autologous transfusion procedure. The postoperative portion of the wound blood was fed via a 40 µm in-line filter® (Pall Biomedizin, Dreieich, Germany) directly from the wound drainages (Drainobag 600®, Braun, Melsungen, Germany) into the bowl of the Cell Saver® or Autotrans®. The washing volume was 1000 mL of normal saline solution (Figure).

40 patients were randomly assigned to receive either no antibiotics (group A) or a single prophylactic dose of 1.5 g of cefuroxime (Zinacef®, Hoechst Frankfurt, Germany) (group B) after induction of anesthesia. The criteria for exclusion from the study were infections, antibiotic therapy up to 3 weeks before surgery, known allergy to cephalosporin drugs, history of arthritis, pregnancy and serum creatinine levels > 3 mg/mL.

Microbiology

Operation field. Intraoperatively, a swab specimen was taken from the operation field and transferred to a sterile transport medium (Port-A-Cul®, Becton und Dickinson, Heidelberg, Germany), cultured on sheep blood agar, Schaedler agar and MacConkey agar, and incubated as appropriate. Quantification of bacterial growth and species identification were performed by standard microbiologic techniques (Burkhardt 1992). If necessary, commercially available biochemical profile tests (Bio-Mérieux, Nürtingen, Germany) were used.

Suction tips. At the end of the operation, the tip of the suction line used intraoperatively for blood salvaging was clipped off directly into a sterile container. The segment was rolled over a sheep blood agar plate 4 times and then dropped into a tube of brain heart infusion broth. Plates and tubes were incubated for 48 hours.

Shed blood collection bag (Vacufix®). After disinfection with Kodan® (Schülke und Mayr, Norderstedt, Germany) solution, we punctured the collection bag aseptically. Samples for microbiological investigation were taken from the collection bag within 6 hours after opening the set (Figure). First, 1 mL of blood was mixed with 9 mL of melted liquid agar and poured into a sterile Petri dish (pour-plate technique). The plates were read after incubation at 35 °C for 48 hours and bacterial growth was quantified and species were identified. Secondly, 8 mL of blood were injected into an aerobic and anaerobic Bactec® (Becton and Dickinson, Heidelberg, Germany) blood culture bottle (broth culture enrichment). An aliquot was streaked onto blood agar plates on the seventh day of

Table 1. Contamination class

0	No growth on agar and in broth
1	Growth only in broth
2	Growth on agar with no more than 10 colonies
3	Growth on agar with 11–100 colonies
4	Growth on agar with more than 100 colonies

incubation or when bacterial growth was suspected.

Processed red blood cell concentrate (PRBCC). The blood from the collection bag was filled into the bowl of the cell-saving apparatus (Cell Saver III®, Haemonetics, München, Germany, or Autotrans®: Dideco, Puchheim, Germany). After washing with 1 liter of normal saline solution, the processed red blood cell concentrate was pumped into the retransfusion bag (processed red cell concentrate portion 1 = PRBCC 1). The second portion of PRBCC (2) was obtained postoperatively from wound blood that had been processed in the autotransfusion apparatus, as described above. In both cases, samples were withdrawn from the retransfusion bag (Figure) after disinfection of the site outlet, using a sterile three-way stopcock and sterile gloves. The samples were processed, using a pour-plate technique and broth culture enrichment, as described above.

Wound drainage blood. 12 hours after induction of anesthesia and hemodilution, we took blood samples from the drainages with a cannula under sterile conditions (Figure). The samples were processed, using a pour-plate technique and broth culture enrichment, as described above. Growth on the agar plate was expressed quantitatively as CFU/mL. Growth in the broth alone was given semiquantitatively as 0.1–1 CFU/mL.

Contamination was classified on a scale of 0–4. (Table 1). All bacteriological results were obtained blinded as to the patient's randomization status.

Statistics

Differences in the treatment groups were evaluated using the Student's two tailed t-test in case of Gaussian population, the nonparametric Mann-Whitney test in case of nonGaussian population. Comparison of two means between the treatment groups was performed by Fisher's exact test. Results were considered significant at p-values < 0.05.

Results

There were no significant differences concerning age (mean group A: 63, SD 10; group B: 64, SD 11), weight (mean group A: 76, SD 13; group B: 73, SD 14) and single risk factors between both study groups. In the antibiotic-treated group B, however, several risk factors were found in combinations that led to a significantly higher (p = 0.04) total anesthesiologic risk (group A: 2, SD 0.4; group B: 2,4, SD 0.7), rated according to the 5-point Scale of the American Society of Anesthesiologists.

Taken together, our data indicate that the operation site was sterile in all patients, irrespective of preceding antibiotic treatment (class 0). In contrast, suction tips were contaminated in one third of patients without antibiotic prophylaxis versus one sixth of patients with cefuroxime prophylaxis (p = 0.2). In all but one case, which yielded 6 CFU/mL (group A), the level of contamination was class 1 (1 CFU/mL), i.e., bacteria grew in the broth culture enrichment, but not in the simultaneously incubated pour-plates (Tables 2 and 3).

The next step in the autotransfusion procedure, the collection bags (Vacufix®), showed significant differences between the study groups. All 20 samples from group B (cefuroxime) were sterile, whereas 8 samples from group A (no antibiotics) showed bacterial growth of class 1 (p = 0.003) (Table 2).

This trend—lower contamination rates in the cefuroxime-treated group B, higher in group A without antibiotic prophylaxis—held true for both portions of the processed red cell blood cell concentrate. In contrast, the wound drainage blood was sterile in both groups. It is noteworthy that only 1 of the samples

Table 2. Number of contaminated samples as determined by broth culture enrichment

Study group	n	No. of patients with contaminated samples	No. of contaminated components	Source of samples: Operation field	Suction tip	Collection bag Vacufix®	PRBCC portion 1	PRBCC portion 2	Wound drainage blood
Group A, no antibiotic	20	13	25	0	6	8	8	3	0
Group B, cefuroxime	20	5	6 [a]	0	3	0 [b]	3	0	0

Group comparison B versus A, [a] p = 0.0004, [b] p = 0.003.

Table 3. Summary of species isolated from suction tips and autologous blood samples (collection bag, PRBCC, wound drainages) in contamination class 1 (growth solely in broth) and in contamination classes 2–4 (growth on agar)

	Suction tips								Blood products							
Group	no antibiotics				cefuroxime				no antibiotics				cefuroxime			
Contamination class	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Staphylococcus epidermidis		1			1				5	1		1	1			
Coagulase-negative staph.cc. [a]	5				2				2	2			1			
Propionibacterium acnes									5				1			
Corynebacterium bovis									1							
Corynebacterium minutissimum									1							
Moraxella species									1							
Total	5	1	0	0	3	0	0	0	15	3	0	1	3	0	0	0

[a] Other than *Staphylococcus epidermidis*
Figures indicate number of isolations.

was heavily contaminated: 1 sample (PRBCC 1, no antibiotics) grew 130 CFU/mL (class 4) of *Staphylococcus epidermidis* (Table 3). The corresponding PRBCC 2 sample contained 3 CFU/mL of the same microorganism. All other growth-positive samples showed only low numbers of bacteria (class 2, 2 CFU/mL). As expected, almost all identified species are part of the physiologic skin flora—e.g., coagulase-negative staphylococci. Only 1/31 samples yielded gram-negative organisms (*Moraxella species*).

Contamination never started in the operation field. In group A (no antibiotic), 6 contaminated suction tips were associated with 5 contaminated PRBCC. In all but 1, the bacterial load did not increase from the suction tip via Vacufix® to PRBCC 1, but in the latter it went up to class 4 (130 CFU/mL). In group B, 3 suction tips were contaminated, but subsequent bacterial growth on pour-plates was seen in only one PRBCC 1.

Intraoperative blood loss was higher in group A (min 700, max 1700, mean 1005, SD 256 mL) than in group B (min 500, max 1700, mean 840, SD 326 mL), but the difference was not significant ($p = 0.15$). Operation time differed ($p = 0.004$) between the two groups (group A: mean 121, SD 18 minutes, group B: 136, SD 14 minutes). The longer operation time in group B did not correlate with an increased blood loss.

We monitored the leucocyte and temperature charts of the patients as part of the screening for clinical signs of infection. The postoperative leucocyte count of the two treatment groups differed in that the patients in group A showed a higher leucocyte count on the 7th postoperative day as compared with the baseline value before operation. Comparison of the two study groups, however, showed no significant differences on all days pre- and postoperatively. Temperature charts, surprisingly, revealed a significantly higher body temperature in the no-antibiotic group on the 3rd and 7th postoperative days compared to the cefuroxime group. Neither leucocyte nor temperature differences were significantly correlated to a type or amount of bacterial contamination. None of the 40 patients showed signs of wound or pulmonary infections during the hospital stay. Urinary tract infections occurred in both groups (group A: 2 women, group B: 2 women, 2 men).

Discussion

Several reports show that bacterial contamination of autologous blood during collection, processing or retransfusion occurs with contamination rates varying widely between 5% (Lorentz et al. 1991) and 75% (Blumenberg et al. 1987, Decker and Heeg 1990, Ezzedine et al. 1991, Menges et al. 1995, Bauermann et al. 1996, Schürholz et al. 1996). In our study, blood samples of 13/20 patients in the group without antibiotic prophylaxis and of 5/20 patients in the cefuroxime group were contaminated at some step in the procedure. This seems a high rate; however, if only bacterial growth >1 CFU/mL was counted, the figures dropped to 3/20 and 0/20, respectively. The rationale for using the most sensitive detection method in our study—namely, broth culture enrichment—was to monitor the steps of the procedure from which this contamination originates closely and to assess the efficacy of antimicrobial prophylaxis.

No bacteria were cultured from the operation field in any of our patients, irrespective of antibiotic prophylaxis. This is in line with results by Williamson et al. (1989) who reported primarily sterile operation sites and by Lorentz et al. (1991) who found that only 1 of 33 operation site swabs was contaminated. In our study, the suction tips were the first step in the proce-

dure to be contaminated, and this contamination again was not related to antibiotic prophylaxis.

Our data compare well with data of Lorentz et al. (1991), who reported sterile collection bags during hip surgery receiving cefuroxime prophylaxis and by Ezzedine et al. (1991), who detected bacterial growth in 12% of PRBCC from patients undergoing cardiac surgery after antibiotic prophylaxis. The last step in the autotransfusion procedure comprised salvaged blood from closed wound drainages. Sørensen and Sørensen (1991) and Overgaard et al. (1993) reported moderate contamination rates of closed suction drainages of 56/489 and 13/81, respectively. In our study, however, blood from wound drainages was sterile in all patients even up to 12 hours after the operation.

An interesting finding in our study was the observation that the contamination of the suction tips of the double-lumen suction device seemed to be a predictor of subsequent contamination of processed red blood cell concentrates.

The increase in the bacterial load during various steps of the procedure proved to be rare, occurring in only one patient without antibiotic prophylaxis. Bacterial load increased from class 2 (6 CFU/mL) on the suction tip to class 4 (130 CFU/mL) in the PRBCC 1 but dropped to class 2 (only 3 CFU/mL) in the PRBCC 2. Two factors may have contributed to this reduction. First, the postoperative portion was obtained from the wound drainages that were sterile. Secondly, the postoperative portion passed neither the possibly contaminated suction line nor the collecting bag. This portion was fed directly into the centrifuge bowl after passing a 40 µm in-line filter (Geiger et al. 1995). By means of this technique, the potential multiplication of bacteria might have been interrupted. The contribution by the washing procedure itself to a reduction in the bacterial load is questionable (Boudreaux et al. 1983, Paravicini 1986, Wollinsky et al. 1991).

None of the patients showed any sign of postoperative infection. In the literature, autologous transfusion is not associated with an increased perioperative infection risk. Kang et al. (1991) detected *Staphylococcus epidermidis* in 30% of processed blood samples in liver transplant patients receiving antibiotic prophylaxis, yet all blood cultures before and after the transplantation were negative. He concluded that a low-grade occasional contamination of processed blood with coagulase-negative staphylococci was insignificant in patients who received antibiotic prophylaxis. Our data and data in the literature corroborate this conclusion. When the bacterial load was quantified in the studies, it was almost always shown to be as low as 1–2 CFU/ mL. In a report by Ezzedine et al. (1991) on cardiac surgery patients, 12% of samples were contaminated, 94% of which yielded less than 5 CFU/ mL bacteria, whereas three samples showed 20 CFU/ mL. In our study, only 5 of 200 samples, cultured from 40 patients, grew > 1 CFU/mL. All these samples were cultured from patients who had not received antibiotic prophylaxis and three of them were sequentially obtained from a single patient.

Overall, we never identified bacteria of high virulence—i.e., *Staphylococcus aureus* or *Pseudomonas aeruginosa*. The predominant species were *Staphylococcus epidermidis* and other coagulase-negative staphylococci derived from the physiological skin flora. A variety of other species, such as *Corynebacterium species, Moraxella species,* were detected only in the group without antibiotics. With the exception of *Propionibacterium acnes,* all bacteria cultured from patients in group B were coagulase-negative staphylococci. We believe that these bacteria were oxacillin-resistant (and hence cefuroxime-resistant) as also are about two thirds of strains investigated at our hospital (Oethinger et al. 1994). The results of the species identification compare well with a study on 220 units of autologous blood by Williamson et al. (1989). In that study 137/220 units were sterile, 75 units grew coagulase-negative staphylococci < 1 CFU/mL and 8 units 3–4 CFU/mL *Staphylococci* or *Corynebacteria.*

Antibiotic prophylaxis with cefuroxime had several advantages, as compared to no prophylaxis. First, cefuroxime lowered the total number of contaminated samples to an extent that was statistically significant. Secondly, it was associated with extremely low bacterial counts in all samples, i.e., 1 CFU/mL, as shown by quantitative culture techniques. Finally, it altered the spectrum of bacterial species cultured from the contaminated samples by narrowing it down to coagulase-negative staphylococci.

In conclusion, autologous blood transfusion in hip surgery, from a microbiologic point of view, is a safe procedure, if caution is paid to the suction tips as predictors of subsequent bacterial contamination. The bacterial load which occurs is usually tolerable for a patient with a normal immune response. Our data indicate that antibiotic prophylaxis with cefuroxime is beneficial, since it reduces the contamination rate, lowers the bacterial load and impedes transfer in the autotransfusion steps.

Acknowledgements

This study was supported by a grant from Hoechst AG, Stuttgart, Germany. We thank the reviewers and Prof. Marre, Department of Medical Microbiology and Hygiene at the University of Ulm, for valuable discussion of the paper.

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