Patient blood management in elective orthopaedic surgery

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Chapter 5

Efficacy, safety and user-friendliness of two devices for postoperative autologous shed red blood cell re-infusion in elective orthopaedic surgery patients: a randomized pilot-study

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ABSTRACT

To determine the safety, efficacy and user-friendliness of two different postoperative autologous blood re-infusion systems an open, randomized, controlled study was performed.

Eligible consecutive primary and revision total hip and knee replacement patients were randomized for one of the two systems or for a control group in which shed blood was not re-infused. The nursing staff scored user friendliness. Patients were monitored after re-infusion. In all three patient groups a restrictive transfusion trigger was used.

Sixty-nine of 70 randomized patients were evaluated. Ease of use, efficacy and safety of both re-infusion systems were comparable. There was no difference in allogeneic blood use between the groups. Thirty per cent of the patients re-infused with autologous blood developed a mainly mild, febrile transfusion reaction. No other adverse reactions were seen. Signs of coagulopathy after re-infusion were not found. In multivariate analysis autologous re-infusion was an independent factor associated with a shorter hospital stay. Both postoperative autologous blood re-infusion systems were of equal efficacy and safety. The contribution of autologous wound blood re-infusion to reduce allogeneic transfusions must be investigated in a larger study.

After total knee or hip arthroplasty a total blood loss of 750 ml or more is common [14]. Postoperative re-infusion of autologous shed wound blood would be a possibility to save the use of allogeneic red blood cell (RBC) transfusions [12,16,17]. Preliminary studies also suggest a reduction in postoperative (wound) infections using autologous wound blood transfusions [8,12,18]. Several re-infusion devices (of which the collected blood is leukocyte reduced, washed or "unprocessed") are available, but limited comparison between systems is available [3,10,11]. For the design of a large randomized study, investigating the value of several blood management interventions in orthopaedic surgery, we wanted to make a valid decision between commercially available postoperative autologous blood re-infusion systems. In an open randomized, controlled study in primary and revision total hip replacement (THR) and total knee replacement (TKR) patients, two different postoperative re-infusion systems currently used in the Netherlands were compared with respect to efficacy, safety and user friendliness.

PATIENTS, MATERIALS AND METHODS

In 2003, patients of 18 years and older who were scheduled for a primary or revision THR or TKR at the Leiden University Medical Centre (LUMC) were included for this study. All patients were of American Society of Anaesthesiologists (ASA) 2 or 3 category. Exclusion criteria were: sickle cell anaemia, cancer, bacterially contaminated wounds and participation in other blood management studies. Patients were randomized to three groups: A, a control group with a standard closed suction wound drainage system not intended for re-infusion; B, a re-infusion system, using continuous suction at a vacuum pressure of 120 mm Hg and just prior to re-infusion a double shielded 40 micron filter (Pall Lipiguard VS filter) entrapping lipids larger than 10 micron and 2 log of leukocytes (DONOR™ system, Van Straten Medical, Nieuwegein, The Netherlands); C, a re-infusion system, which uses intermittent suction pressure by a manually expandable bag at a maximum pressure of 90 mm Hg and three filters: a 200 mm filter, a secondary 80 mm filter and prior to re-infusion a third 40 mm filter (Bellovac A.B.T.®, Astra Tech, Zoetermeer, The Netherlands). The companies of the drainage devices were allowed to train the nursing staff on theoretical aspects in two sessions and practical aspects at bedside in 4 sessions. Thereafter the companies were available for advice if needed.

The study was approved by the local Medical Ethical Committee and written informed consent was given by all patients. A randomisation list was generated by a statistical software package: preoperatively, the patient was randomly assigned to one of the three groups by opening a sealed envelope with the randomisation number. General anaesthesia or loco-regional anaesthesia was chosen based on each patients' requirements. An ischaemic tourniquet was applied to all TKR patients, whereas THR patients were operated

in the lateral position by a direct lateral approach to the hip. During the study a restrictive transfusion trigger according to the Dutch guidelines was used (CBO consensus guidelines, 2004). No intra-operative blood saving measurements were performed. A sterile disposable drainage system set was intra-operatively inserted, just before suturing the wound, to drain wound blood. One Redon catheter was placed intra-articular. Blood collection began after skin closure (THR) or 15 minutes after tourniquet deflation (TKR).

Outcome measures

Outcome measures were efficacy, safety and user-friendliness of the wound drainage devices. User-friendliness was scored by the nursing staff by the following questions, ranked on a scale from 1 to 5 (1= very difficult, 5=very easy): frequency of handling the same system (first time or more than once), extent of burden to the patient and the nurse, occurrence and chance of wrong use and user-friendliness in daily practice. Efficacy and safety were measured by blood loss, units of allogeneic RBCs transfused, amount of autologous blood re-infused, transfusion reactions, postoperative haemoglobin (Hb) level, delay in mobilisation beyond the routine schedule at day 3 and length of hospital stay (LOHS) (defined as the interval between the day of surgery until the day of discharge from the hospital). Infections were scored according to CDC-criteria [9], wound infections were scored according to Gaine et al (2000). Transfusion reactions were scored according to the Dutch hemovigilance criteria, including mild reactions such as a temperature rise ≥1°C. Criteria for discharge were according to the hospital protocol. A serious adverse event was defined as a transfusion reaction of the third or fourth degree (life threatening or death). Antibiotics and anticoagulant therapy were given according to the standard hospital protocols. Total amounts of shed blood were measured within and after 24 hours for group A, and within and after 6 hours for groups B and C, respectively, until the drain was removed.

Laboratory analysis

Venous blood samples were taken pre-operatively and on day 1 after surgery for Hb (g dL^{-1}), haematocrit (Hct), White Blood Cell (WBC) count (x10^9 L^{-1}), Thrombocyte (Tr) count (x10^9 L^{-1}) and LDH (U L^{-1}). Levels of interleukin (IL)-6, IL-10 and IL-12 cytokines were measured by ELISA with a detection range of 1 to 50.000 pg mL^{-1} (Sanquin diagnostics, Amsterdam, the Netherlands). Percentage antitrombin activity was measured by chromogenic assay (Coamatic Antithrombin, Chromogenix–Instrumentation Laboratory SpA, Milan, Italy) on an automated coagulation analyser (STA-R®, Diagnostica Stago, Asnières sur Seine, France), fibrinogen (g L^{-1}) was measured according to the Clauss method on an automated coagulation analyser (Electra 1800C, Medical Laboratory Automation, Inc., Pleasantville, NY), and D-dimers (ng mL^{-1}) were determined by an automated immuno-analyser (VIDAS®, bioMérieux, Breda, the Netherlands) with a maximal measurable value of 50.000 ng mL^{-1}. In case of re-infusion of autologous shed blood (group B and C patients), additional venous

blood samples were taken immediately after re-infusion was completed. At discharge, patients' Hb and Hct were measured.

Shed blood samples (up to a maximum of 150 ml) were taken immediately after start of drainage (T0), pre-filter (T1) and post-filter just before re-infusion (max. 6 hours after surgery) (T2). These samples were analysed for Hb, WBC count, Tr, Free Hb (mg dL^{-1}) and LDH. Plasma and serum were stored at -80°C for coagulation factor and cytokine measurements. In addition, samples were taken for bacterial culture.

Statistical analysis

The study size was not based on statistical power calculations, but on descriptive comparisons. To allow for detection of large differences between the systems, each randomisation group consisted of minimal 20 patients. Statistical analysis was performed in SPSS for Windows 11.0. Frequencies were described as mean and standard deviation (SD), or median and range in case of a nonparametric distribution. Analysis of laboratory parameters between patients and other numeric endpoints was performed with the ANOVA-test and analysis within the patients with a paired t-test. Differences between the groups in the number of RBC transfusions and the total number of units RBC transfusions given were analysed with the non-parametric Mann-Whitney test. Categorical endpoints were tested using the Chi-square test or Fisher's Exact test. LOHS was analysed as a continuous variable and dichotomized (< eight days and ≥ eight days). Age was analysed as a continuous variable and categorized into four groups (≤40, 41-65, 66-75, >75 years). End points were analysed univariate, and when relevant, to correct for confounding factors, multivariate analysis with backward conditional regression was performed. P values <0.05 were considered statistically significant.

RESULTS

Baseline characteristics are shown in Table 1. Of 70 patients included, one patient was not operated, leaving 69 evaluable patients. 42 (61%) patients had a primary THR, 20 (29%) a primary TKR, four (6%) a revision THR and three (4%) a revision TKR. THR patients were underrepresented and TKR over-represented in group A as compared to the wound blood re-infusion groups B and C (p=0.06). Diagnosis (osteo-arthritis and rheumatoid arthritis), co-morbidity (arterial disease, pulmonary disease, diabetes) and use of medication were comparable in the three groups.

Concerning intra-operative parameters (Table 2), groups were comparable for surgery duration and blood loss. Four patients received intra-operative blood transfusions (total of seven units RBC's) because of large blood loss of more than 1500 mL. No transfusion reactions were seen.

Table 1. Baseline characteristics

	ABC (n=69)	A[a] (n=22)	B[a] (n=23)	C[a] (n=24)
Baseline parameters				
Female (%)	62	68	61	58
Age (years) mean ± SD	60 ± 16.0	58 ± 14.3	66 ± 15.6	58 ± 17.2
Weight (kg) mean ± SD	79 ± 14.9	85 ± 21.9	77 ± 13.1	76 ± 17.1
Type of surgery				
THR primary/ revision (n)[b]	42/4	10/1	15/2	17/1
TKR primary/ revision (n)[b]	20/3	8/3	6/0	6/0
Pre-operative lab				
Hb (g dL^{-1}) mean ± SD	13.7 ± 1.61[c]	13.7 ± 1.61	13.7 ± 1.77[c]	13.7 ± 1.61
Hct (L L^{-1}) mean ± SD	0.40 ± 0.04[c]	0.40 ± 0.04	0.40 ± 0.04[c]	0.40 ± 0.04
WBC (x10^9 L^{-1}) mean ± SD	7.8 ± 2.4[c]	8.2 ± 3.3	8.4 ± 2.0[c]	7.0 ± 1.2
Tr (x10^9 L^{-1}) mean ± SD	274 ± 84[d]	291 ± 100[c]	281 ± 76[c]	252 ± 75

[a] A, control group; B, DONOR™ group; C, Bellovac A.B.T.® group
[b] difference in type of surgery (n) of re-infusion groups compared to control group: P=0.06
[c] one missing value
[d] two missing values

Questionnaires to score the user-friendliness of the drainage systems, were completed in 28 of 30 re-infused cases (response rate of 93%). Outcome of both devices was comparable with a learning effect after handling the same device for more than one time (Figure 1).

Of 47 patients randomized for the use of a shed blood re-infusion system, 30 (64%) were actually re-infused (mean 401 ± 170 mL): 11 of 12 (92%) of the TKR patients (mean 591 ± 322 mL) and 19 of 35 (54%) of THR patients (mean 290 ± 170 mL) (Table 2). Of 17 patients not re-infused, in 11 cases the collected volume was too low (<100 mL), four patients dropped out from the study due to venous access problems and in two cases accidentally a control drainage system was placed. No serious adverse events after re-infusion were observed. Six patients had mild reactions (transient fever and/or shivers) after re-infusion.

Of the total of 71 units RBCs transfused, 64 (90%) were given to 32 patients postoperatively from day +1 onwards post surgery. The main reason for postoperative transfusions was a low Hb value (in 92%). The mean Hb trigger for RBC transfusions was 8.4 g dL^{-1} (SD 1.45).

Table 2. Intra- and postoperative parameters

	n	ABC	n	A[a]	n	B[a]	n	C[a]
Intra operative parameters								
Duration of surgery (min) mean ± SD	69	146 ± 44	22	156 ± 48	23	137 ± 42	24	145 ± 44
THR	46	138 ± 40	11	143 ± 36	17	128 ± 37	18	145 ± 45
TKR	23	161 ± 49	11	169 ± 55	6	163 ± 47	6	146 ± 43
Blood loss (mL) median (range)	69	450 (0-2400)	22	313 (0-1625)	22	500 (0-2400)	23	485 (0-1700)
THR	44	600 (0-2400)	11	600 (250-1625)	16	563 (0-2400)	17	750 (200-1700)
TKR	23	0 (0-835)	11	0 (0-835)	6	0 (0-500)	6	0 (0-250)
Postoperative parameters								
LOHS (days) mean ± SD		8.2 ± 3.3		9.0 ± 2.8		7.8 ± 4.0		7.9 ± 3.1
THR		7.7 ± 3.6		8.9 ± 3.4		7.4 ± 4.3		7.4 ± 2.8
TKR		9.2 ± 2.7		9.1 ± 2.3		9.0 ± 2.4		9.5 ± 3.8
Total drain production (mL) median (range)								
THR		445 (45-1350)		538 (65-1245)		440 (100-1350)		430 (45-1230)
TKR		963 (350-1745)		885 (455-1710)		630 (350-1150)		1443 (960-1745)
Shed blood re-infusion (mL)[b]								
mean ± SD	30	64%			15	329 ± 274	15	472 ± 265
THR	19	54%			9	260.0 ± 192.0	10	317.5 ± 151.5
TKR	11	92%			6	433.3 ± 359.2	5	781.0 ± 126.3
Re-infusion reactions	30	6				4		2
Intra- and postoperative allogeneic RBC transfusions								
Number of units (% of patients)	32	(46%)	10	(45%)	13	(57%)	9	(38%)
THR	20	(43%)	4	(36%)	10	(59%)	6	(33%)
TKR	12	(52%)	6	(55%)	3	(50%)	3	(50%)
RBC/transfused patient ± SD		2.2 ± 0.8		1.9 ± 0.7		2.4 ± 1.0		2.3 ± 0.7
THR		2.3 ± 0.6		2.5 ± 0.6		2.2 ± 0.6		2.2 ± 0.4
TKR		2.2 ± 1.2		1.5 ± 0.5		3.0 ± 0.7		2.7± 1.2
Transfusion reactions	2		1	shivers	1	shivers		
Hb values (g dL^{-1}) day+1 mean ± SD		10.3 ± 1.45		10.5 ± 1.45		10.0 ± 1.45		10.3 ± 1.61
at discharge mean ± SD		10.8 ± 1.29		10.6 ± 1.13		10.6 ± 1.13		10.9 ± 1.45

[a] A, control group; B, DONOR™ group; C, Bellovac A.B.T.® group
[b] this concerns only groups B and C

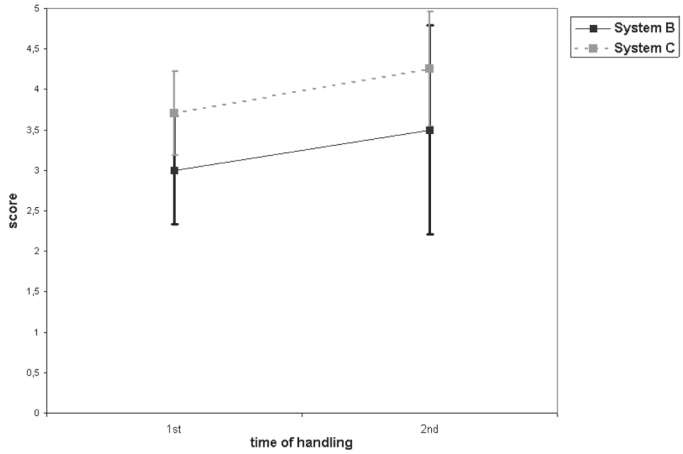

Figure 1. Scores of questionnaire: user-friendliness (n=28).

The figure shows the mean scores of system B (DONOR™) at first time of handling (n=10)and at second time of handling (n=4) and of system C (Bellovac A.B.T.®) at first time of handling (n=6) and at second (or more) time of handling (n=8). One nurse handled system C four times. Scores: 1=very difficult; 2= difficult; 3=neutral; 4=easy; 5=very easy.

Neither the percentage of patients transfused, nor the transfusion index [mean units of RBCs transfused per patient (1.0 ± 1.2 for both THR and TKR)] differed among the three groups. Six patients could not be mobilized on the third day after surgery: two control patients, three of group B and one patient of group C were delayed. Overall, the infection rate was 13 % (9/69) and was not different between groups: urinary tract infections (n=3), superficial wound infections (n=2), one deep wound infection resulting in prosthesis revision surgery, localized infections elsewhere (n=2) and bacteraemia (n=1).

Mean LOHS was slightly shorter in the THR re-infusion groups B and C and significantly less patients had a LOHS longer than 8 days as compared to the control group. In multivariate analysis, re-infusion group, age group, type of surgery and gender were entered, of which re-infusion group and age group remained independent variables to LOHS (p=0.02; corrected odds ratio=0.230 for re-infusion group and p=0.002; corrected odds ratio=2.775 for age group).

Laboratory analysis

Venous blood samples

Postoperative Hb values and Hb at discharge were similar in the groups (Table 2). In both re-infusion groups B and C, the D-dimer values on day 1 postoperatively were high (Table

3), resulting from high D-dimer values (>50.000 ng mL^{-1}) in the re-infused shed blood, and other coagulation values were comparable. In all groups, analysis of paired samples within the whole study group showed a significant decrease of antithrombin levels at day +1 after surgery compared with the pre-operative samples [103.2 to 83.6 % ($p<0.001$)]. In the re-infused patients this decrease was present directly after re-infusion [101.0 to 81.6 % ($p<0.001$); n=22] and remained stable up to the first postoperative day. Fibrinogen levels in the re-infused patients were also significantly decreased just after re-infusion: from 4,62 to 3,35 g L^{-1} ($p<0.001$) (n=22) and increased between time of re-infusion and day+1 (n=23): from 3,37 to 4,70 g L^{-1} ($p<0.001$). Fibrinogen levels at day+1 of the re-infused patients and the control patients were not significantly different.

Table 3. Coagulation parameters of venous blood samples

Group	Moment of sampling	Antithrombin (%) Mean (SD)	D-dimers (ng mL^{-1}) Median (range)	Fibrinogen (g L^{-1}) Mean (SD)
A[a]	Day –1	104.2 (9.7)	645 (225-9578)	4.33 (1.1)
	Day +1	85.9 (11.2)	1719 (695-15736)	4.67 (1.1)
B[a]	Day –1	103.3 (14.0)	995 (225-6247)	4.69 (1.4)
	Directly after re-infusion	80.8 (10.1)	39101 (5750-50000)	3.57 (0.8)
	Day +1	82.8 (13.6)	6172 (691-19224)	5.15 (1.1)
C[a]	Day –1	102.7 (11.5)	528 (233-6251)	4.19 (0.9)
	Directly after re-infusion	80.3 (20.6)	42437 (15730-50000)	3.01 (1.1)
	Day +1	82.2 (11.6)	7113 (601-17894)	4.63 (0.8)

[a] A: control group, B: DONOR™ group, C: Bellovac-A.B.T.® group

IL-12 levels in venous blood were not different between re-infused and control patients (median 38 pg mL^{-1} (range 5-615) on day-1 and 27 pg mL^{-1} (range 5-559) on day +1). Pre-operative values correlated with postoperative values (Figure 2). Measurable pre-operative IL-6 values (i.e. >1 pg mL^{-1}), were present in 54% of patients (n=34) with a median of 188 pg mL^{-1} and a wide range of 5-8758. After re-infusion, the median value (n=24) increased to 648 pg mL^{-1} (range 89-3512) and dropped to 361 pg mL^{-1} (range 48-4419) on day+1 after surgery (n=51) without a difference between groups. IL-10 levels were below detection level in 92% pre-operatively, in 72% directly after re-infusion and in 79% on day +1. The detectable values ranged from 4 to 126 pg mL^{-1}.

Patients' LDH after re-infusion was slightly elevated (446 ± 85 U L^{-1}).

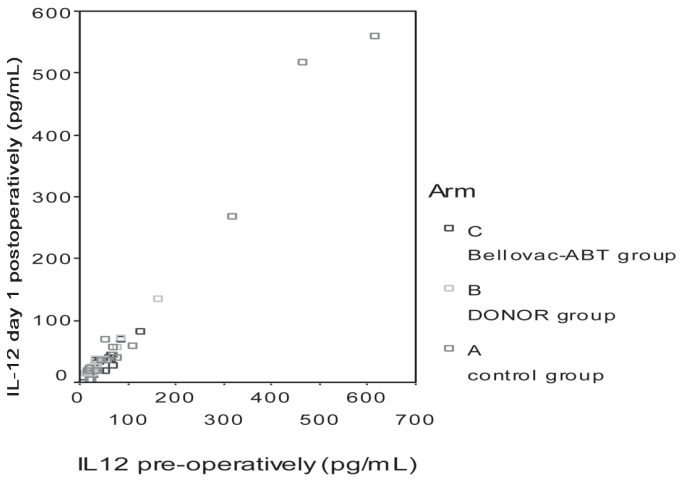

Figure 2. IL-12 levels of venous blood samples (pre- and postoperatively).

Shed blood samples

Whole-blood volume, Hb, Hct, platelets and haemolysis parameters of shed blood samples were comparable between both systems before (T1) and after filtering-just before re-infusion (T2) (Table 4), except for leukocyte count, as the Lipiguard filter used in drainage system B had a modest leucocyte depleting effect: from 5.6 x 10^9 L^{-1} (T1) to 1.9 x 10^9 L^{-1} (T2). IL-6 levels exceeded the maximal measurable value of 50.000 pg mL^{-1} in 4 of 37 (11%) wound blood samples at T0, in 20 of 33 (61%) at T1 (after 4-6 h of collecting) and in 21 of 35 (60%) prior to re-infusion at T2. IL-10 levels could not be detected in 6-14% at all time points. The range in the other samples was 4-157 pg mL^{-1}. Mean IL-12 levels (± SD) are shown in Table 4.

No bacterial contamination was found. There was no relation with transfusion reactions and cytokine levels in the re-infused shed blood. In one case, high haemolysis parameters were found in association with a febrile transfusion reaction (LDH and free Hb levels of 9890 U L^{-1} and 239 mmol L^{-1}, respectively). LDH of the patient directly after re-infusion was 610 U L^{-1}, but decreased to a nearly normal value on the next day (454 U L^{-1}).

Table 4. Mean shed blood values (± SD) just before re-infusion (T2).

Groups B and C shed blood values	
Hb (g dL^{-1})	8.4 ± 1.61
Thrombocytes (x10^9 L^{-1})	40 ± 22
Free Hb (mg dL^{-1})	184 ± 111.2
LDH (U L^{-1})	2511 ± 1853
Antithrombin (%)	39 ± 12.0
IL-12 (pg mL^{-1})	48 ± 35.0

DISCUSSION

Both postoperative autologous blood re-infusion systems turned out to be user-friendly and feasible to use. For both drainage systems a learning effect was present. The use of drainage systems was more effective for TKR patients, who were re-infused in 92% of the cases, compared to 54% of THR patients. Clearly, in TKR patients more blood is drained post-operatively. The overall relatively low percentage of re-infusion (60% and 63% for systems B and C respectively) was partly due to the use of 150 mL shed blood for study analysis and could increase to 75%. Approximately 50-100 mL shed blood remained in the system even after full re-infusion. In this pilot study, no reduction of allogeneic RBC transfusions was found, as was reported by others in THR patients [13]. However, our study was not powered for this conclusion.

No serious adverse events were seen. In one case, a reaction occurred upon fairly haemolytic blood. In literature, transient fever reactions during auto-transfusion have been related with surgery using cement [19]. In our study, however, in only two of these six patients bone cement (Palacos, Biomet Merck Inc., Warsaw, IN, USA) was used. Although the percentage of (30%; 6 of 20) mild febrile transfusion reactions was higher than previously reported [2,6,7], this may be due to the inclusion of all mild febrile reactions (≥1°C rise in temperature). A slower pace of re-infusion might prevent such transfusion reactions. However, there was no relation with transfusion reactions and cytokine levels in the shed blood or in the patient immediately after re-infusion, despite the extreme high levels of IL-6 in the shed blood. Preoperatively, IL-6 was undetectable in 46% of patients, but increased in all cases post-surgery. IL-12 values were between 0-600 pg mL^{-1} and not affected by surgery, autologous re-infusion or allogeneic transfusions (Figure 2). Although previous reports found an increased level of IL-10 after surgery and allogeneic transfusions might lead to deviation towards a T helper 2 type cytokine pattern, associated with an immune-suppressed state and even with LOHS, in our small pilot study we could not confirm this.

Despite IL-10 was present in shed blood, this was not recovered in the circulation after re-infusion.

A mean rise in temperature of 0,5°C immediately after re-infusion was found. Fever upon re-infusion has been attributed to high pro-inflammatory cytokine levels in re-infused blood [2]. The control group showed a similar pattern of temperature rise at this interval after surgery. It has been suggested that this is rather a response to the surgical procedure itself [11].

There were no signs of triggering of diffuse intra-vascular coagulation after shed blood re-infusion. Antithrombin activity levels decreased after surgery by 20% and remained stable in the patient after re-infusion up to the first postoperative day. Postoperative fibrinogen levels at day +1 in the re-infused patients were not significantly different compared to the control group. In all patient groups, fibrinogen levels also decreased significantly after surgery, probably due to a dilution factor (fluid infusion) and consumption during surgery, and increased to a slightly higher level on day +1 due to an acute phase response. Fibrinogen levels were not measured in shed blood, because these values are extremely low [6,10]. D-dimer levels in shed blood were very high due to coagulation activation and fibrinolysis in the wound area, and were passively infused in the patient in case of re-infusion which resulted in significant elevated levels in the patient directly after re-infusion up to day 1. All these data suggest that re-infusion of shed blood does not induce coagulopathy.

Despite the fact that no difference in the allogeneic RBC transfusion rate was found, in the control group the LOHS was one day longer than in the re-infusion groups B and C. In multivariate analysis, re-infusion group remained an independent variable to LOHS. This finding, however, should be interpreted with caution, because our study was not powered for this conclusion. A reduction in LOHS was also seen by Newman et al (1997) and Shulman et al (2002) who both found a reduction of two days, but this was associated with a reduction in allogeneic RBC's. It has been postulated that the pro-inflammatory cytokines in shed blood activate natural killer (NK) cells [5]. Whether and how such a stimulation of NK cells might have an effect on LOHS is unknown. We observed no difference in postoperative infections, but our study was not powered for this purpose and served as a pilot study for a large randomized controlled trial (International Standard Randomized Controlled Trial Number 96327523).

To conclude, the use of a postoperative autologous shed-blood re-infusion system is user-friendly and easily implemented in a blood management protocol. Efficacy is greatest in TKR patients. Concerning safety, no serious adverse events were seen. Although there was no blood saving, LOHS was slightly shorter in the re-infusion groups compared to the control group. Larger sufficiently powered studies are necessary to evaluate presumed reduction in allogeneic transfusions, postoperative infections and LOHS by the use of re-infusion of shed wound blood. As no difference in user friendliness and efficacy between

the two autologous shed blood re-infusion systems was found, the choice for a particular device can be based on economical aspects.

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REFERENCES

1. CBO consensus guidelines «Richtlijn Bloedtransfusie» (2004).Inleiding anemie (Ch. 2) Table 2.1 De AZG-4-5-6-flexinorm, 109. Van Zuiden Communications BV. Alphen aan den Rijn.
2. Dalen T., Nilsson K.G. & Engström K.G. (2002). Fever and autologous blood retransfusion after total knee arthroplasty: a prospective study of 40 autotransfusion events in 21 patients. Acta Orthopaedica Scandinavica , 73, 321-325.
3. Dalen T., Bengtsson A., Brorsson B. & Engström K.G. (2003). Inflammatory mediators in autotransfusion drain blood after knee arthroplasty, with and without leukocyte reduction. Vox Sanguinis, 85, 31-39.
4. Gaine W.J., Ramamohan N.A., Hussein N.A., Hullin M.G. & McCreath S.W. (2000). Wound infection in hip and knee arthroplasty. Journal of Bone and Joint Surgery [British], 82, 561-565.
5. Gharehbaghian A., Haque K.M., Truman C., Evans R., Morse R., Newman J., Bannister G., Rogers C.& Bradley B.A. (2004). Effect of autologous salvaged blood on postoperative natural killer cell precursor frequency. Lancet, 363, 1025-1030.
6. Han C.D.& Shin D.E. (1997). Postoperative blood salvage and reinfusion after total joint arthroplasty. Journal of Arthroplasty,12, 511-516.
7. Healy W.L., Pfeifer B.A., Kurtz S.R., Johnson C., Johnson W., Johnston R., Sanders D., Karpman R., Hallack G.N. & Valeri C.R. (1994). Evaluation of autologous shed blood for autotransfusion after orthopaedic surgery. Clinical Orthopaedics and Related Research, 299, 53-59.
8. Heddle N.M., Brox W.T., Klama L.N., Dickson L.L. & Levine M.N. (1992). A randomized trial on the efficacy of an autologous blood drainage and transfusion device in patients undergoing elective knee arthroplasty. Transfusion, 32, 742-746.
9. Horan T.C., Gaynes R.P., Martone W.J., Jarvis W.R. & Emori T.G. (1992). CDC definitions of nosocomial surgical site infections, a modification of CDC definitions of surgical wound infections. Infection Control and Hospital Epidemiology, 13, 606-608.
10. Jensen C.M., Pilegaard R., Hviid K., Nielsen J.D. & Nielsen H.J. (1999). Quality of reinfused drainage blood after total knee arthroplasty. Journal of Arthroplasty,14, 312-318.
11. Munoz M., Cobos A., Campos A., Ariza D., Munoz-Moran E. & Gomez A. (2005). Impact of postoperative shed blood transfusion, with or without leukocytes, on acute phase response to surgery for total knee replacement. Acta Anaesthesiologica Scandinavica, 49, 1182-1190.
12. Newman J.H., Bowers M. & Murphy J.(1997). The clinical advantages of autologous transfusion. A randomized controlled study after knee replacement. Journal of Bone and Joint Surgery [British], 79, 630-632.
13. Rollo V.J., Hozack W.J., Rothman R.H., Chao W. & Eng K.O. (1995). Prospective randomized evaluation of blood salvage techniques for primary total hip arthroplasty. Journal of Arthroplasty, 10, 532-539.
14. Rosencher N., Kerkkamp H.E.M., Macheras G., Munuera L.M., Menichella G., Barton D.M., Cremers S. & Abraham I.L. (2003) OSTHEO Investigation. Orthopedic Surgery Transfusion Hemoglobin European Overview (OSTHEO) study: blood management in elective knee and hip arthroplasty in Europe. Transfusion, 43, 459-469.
15. Shulman G., Grecula M.J. & Hadjipavlou A.G.(2002). Intraoperative autotransfusion in hip arthroplasty. Clinical Orthopaedics, 396, 119-130.
16. Sinardi D., Marino A., Chillemi S., Irrera M., Labruto G. & Mondello E. (2005) Composition of the blood sampled from surgical drainage after joint arthroplasty: quality of return. Transfusion, 45, 202-206.
17. Strümper D., Weber E.W.G., Gielen-Wijffels S., Van Drumpt R., Bulstra S., Slappendel R., Durieux M.E. & Marcus M.A.E. (2004). Clinical efficacy of postoperative transfusion of filtered shed blood in hip and knee arthroplasty. Transfusion, 44, 1567-1571.
18. Thomas D., Wareham K., Cohen D. & Hutchings H. (2001). Autologous blood transfusion in total knee replacement surgery. British Journal of Anaesthesia, 86, 669-673.
19. Veikkolin T., Korkala O., Niskanen R. & Liesjarvi S. (1995). Autotransfusion of drained blood after total knee arthroplasty. Annales Chirurgiae et Gynaecologiae, 84, 281-284.