Effectiveness of an autologous transfusion system following cemented and non-cemented revisions of total hip arthroplasty

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Abstract

Purpose The goal of this study was to analyse the efficacy of blood autotransfusion using a continuous autologous transfusion system in revisions of total hip arthroplasty (THA). We looked at whether administration of allogeneic blood units was reduced in these cases and if there is a difference between cemented and non-cemented revisions.

Methods Between January 2011 and December 2011, patients being treated with revision THA were included ($n=411$). The following parameters were analysed: patient age, gender, weight (kg), height (cm), body mass index (BMI, kg/m^2), surgical diagnosis, treatment and American Society of Anesthesiologists (ASA) classification score. The difference between pre- and post-operative haemoglobin (Hb, g/dl), amount of peri-operative blood loss (ml), amount of retransfused washed shed blood and amount of allogeneic and/or autologous transfusion (ml) were recorded.

Results In both the cemented and non-cemented revision THA groups, there was no significant difference between pre- and post-operative Hb with or without using an autotransfusion system. In 92 of 186 cemented cases using an autologous transfusion system (49.5 %) and 38 of 117 non-cemented cases using an autologous transfusion system (32.5 %), allogeneic blood transfusion (ABT) was required. Cemented procedures using an autologous transfusion system got significantly more ABTs than non-cemented procedures using an autologous transfusion system ($p=0.0042$, odds ratio=2.035).

Conclusions Use of an autologous transfusion system did not reduce the amount of ABT in revision THA in the patient cohort reported here. In our opinion, general blood management is required before and during surgery to reduce administration of ABT.

Keywords Autologous transfusion system · Revision · THA · Cemented · Non-cemented · ABT administration

Introduction

With an observed increasing number of total hip replacements and longer life expectancy of patients an increasing number of revision procedures is expected. Despite the excellent results following total hip and total knee arthroplasty (THA, TKA), Bierbaum et al. showed that almost half of the patients required blood transfusion with 57 % following THA and 39 % following TKA [1]. A revision procedure makes the surgery more complex due to the anatomical changes in soft tissue, bone and different types of implanted prostheses. Revision of THA is associated with significant blood loss and subsequent peri-operative blood transfusion [2–4].

Revision procedures are in some cases unpredictable and could lead to significantly more blood loss than primary procedures. Through autologous blood transfusion systems, allogeneic blood exposure is expected to decrease along with the well-known complications of transfusion reactions through storage-induced mechanisms, allergic reactions, errors in application and administration, immunosuppression and viral contamination (cytomegalovirus, human immunodeficiency virus, hepatitis B/C) [5–9]. In addition, there are economic considerations and limited supply of allogeneic blood transfusions (ABT). Despite general complications in the application of blood transfusions, there is a non-negligible

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risk of periprosthetic infection, which is to be avoided particularly in these complex revision surgeries [1].

To reduce exposure to ABT peri-operative blood management is in general discussed [10–13]. Some authors recommended pre-operative blood donation [14], correction of pre-operative anaemia [15], autologous donation and retransfusion systems [10, 16–23], supplementation of erythropoietin or iron [24, 25], pharmacologic agents like tranexamic acid [26, 27], plasmapheresis, normovolaemic haemodilution [28–31] and post-operative red blood cell salvage [32].

Although the use of retransfusion systems in orthopaedic surgery seems to have increased [15, 33–35] in recent years, it remains unclear whether there is a benefit in obviating the need for ABT [36] especially in revision procedures.

The authors performed a retrospective study to analyse the efficacy of autotransfusion using a continuous autologous transfusion system (CATS, Fresenius AG, Bad Homburg, Germany) in cemented and non-cemented revision cases of THA. The hypothesis of the study was that using continuous autologous transfusion in revision of THA would result in reduced ABT administration.

Materials and methods

Patient population

All patients who underwent an aseptic revision THA between January 2011 and December 2011 were consecutively reviewed retrospectively. All procedures were performed at the authors' institution and data were collected using the electronic database. Surgical treatment depended on intra-operative findings, ranging from exchange of only individual up to complete exchange of components.

The following parameters were analysed: patient age, gender, weight (kg), height (cm), body mass index (BMI, kg/m²), surgical diagnosis and American Society of Anesthesiologists (ASA) classification score. The difference between pre- and post-operative haemoglobin (Hb, g/dl) ($x = \text{pre-operative Hb value} - \text{post-operative Hb value}$), amount of peri-operative blood loss (ml), amount of retransfused washed shed blood (WSB) and amount of allogeneic and/or autologous transfusion (ml) were measured. Several parameters were used to calculate the blood loss: The total blood volume, total Hb count and decrease in Hb count were taken into account:

$((\text{Decrease in Hb} \times \text{total blood volume}) / \text{total Hb count}).$

The final formula to calculate the blood loss was:

$\text{Blood loss(l)} = \text{decrease in Hb count(g)} / \text{initial Hb value(g/l)}.$

During this time period, a total of 411 patients, treated with cemented (245 patients, 59.6 %) or non-cemented revision THA (166 patients, 40.4 %), met the inclusion criteria. All drains were opened immediately after surgery and were removed 48 hours after surgery.

Continuous autologous transfusion system

The autotransfusion system used in the authors' hospital is the CATS device (Fresenius AG, Bad Homburg, Germany). Preparation of the shed blood includes the following three steps: (1) separation of corpuscular particles, (2) washing of concentrated erythrocytes with heparinised saline solution and (3) separation of erythrocytes and consumed washing solution. The autotransfused unit contains about 150 ml prepared red cells and 30 g of Hb. The shed blood is collected intraoperatively and up to six hours post-operatively. The administration of ABT depended on clinical symptoms of anaemia like hypotension, low urinary output, lethargy, tachycardia, shortness of breath and/or low oxygen levels in pulse oximetry or arterial blood gas.

Outcome measures

To determine the effect of autotransfusion on additional post-operative ABT, we subdivided the cemented and non-cemented cases into two groups:

1. Patients undergoing CATS
2. Patients not undergoing CATS

Both groups were compared in terms of difference between pre- and post-operative Hb, total blood loss and amount of allogeneic blood units transfused.

Statistical analysis

All data were processed using GraphPad Prism (Prism 5 for Mac OS X, Version 5.0d, La Jolla, CA, USA). All variables were expressed in terms of mean and standard deviation (SD) of the mean. The Shapiro-Wilk normality test was performed to ascertain whether the data were normally distributed. Student's *t* test was performed when the data demonstrated a normal Gaussian distribution; otherwise the Mann-Whitney test was employed for non-parametric data. Two-by-two tables were used to calculate the odds ratio. To evaluate significant differences for BMI, ASA score and age groups, analysis of variance (ANOVA) was performed. Statistical significance for these analyses was set at a *p* value less than 0.05.

Results

The mean age in the cemented group was 70.7 ± 9.3 years and the mean BMI was 27.8 ± 4.9 , while the mean age in the non-

cemented group was 61.1 ± 11.7 years and the mean BMI was 28.1 ± 5.1 . Patients with cemented exchange were statistically significantly older than patients without ($p < 0.0001$). The BMI was not statistically different between the two groups ($p = 0.321$) (Fig. 1).

The mean ASA score for the cemented group when using CATS was 2.46 ± 0.54 and without using CATS 2.42 ± 0.53 . The difference between the two groups was not statistically significant ($p = 0.674$). The ASA score for non-cemented revisions when using CATS was 2.14 ± 0.49 and without using CATS 2.52 ± 0.47 . Also the difference between the two groups was not statistically significant ($p = 0.152$).

The mean operating time for cemented revisions was 2.5 ± 0.8 hours and for non-cemented revisions 2.1 ± 0.7 hours ($p < 0.0001$). The hospital stay for the surgical procedure for the cemented group was 12.9 ± 2.1 days and for the non-cemented group 12.8 ± 2.1 days without statistical significance ($p = 0.279$).

The mean difference between measured Hb before and after surgery in the cemented group was 3.5 ± 1.3 g/dl and in the non-cemented group 3.4 ± 1.4 g/dl (Fig. 2). The differences were not statistically significant ($p = 0.88$). The mean intra-operative blood loss in the cemented group was $1,824 \pm 526.8$ ml and in the non-cemented group $1,791 \pm 542.8$ ml ($p = 0.33$).

In the cemented group CATS was used in 186 cases (75.9 %). A mean of 302.2 ± 175.2 ml were retransfused. In the non-cemented group CATS was used in 119 cases (70.5 %) and 339.5 ± 165.5 ml were retransfused. The difference of retransfused blood between the two groups was statistically significant ($p = 0.0093$). In the cemented group the mean difference in Hb was 3.4 ± 1.2 g/dl using CATS. Without using CATS in 59 cases the difference was 3.6 ± 1.4 g/dl ($p = 0.676$) (Fig. 3).

In the non-cemented group the mean difference between the pre- and post-operative Hb using CATS was 3.4 ± 1.3 g/dl and without CATS in 49 cases 3.5 ± 1.5 g/dl ($p = 0.199$) (Fig. 4).

In 38 of 117 non-cemented cases using CATS ABT was required (32.5 %). In 17 of 49 non-cemented cases without CATS ABT was performed (34.7 %). There was no statistically significant difference between the two groups ($p =$

Fig. 1 Mean BMI and age of patients in the cemented and non-cemented revision THA groups

Fig. 2 Difference between Hb before and after revision THA

0.856). In 92 of 186 cemented cases using CATS ABT was required (49.5 %). In 24 of 59 cemented cases without CATS ABT was performed (40.7 %). There was no statistically significant difference between the two groups ($p = 0.295$).

Cemented procedures using CATS required significantly more ABTs than non-cemented procedures using CATS ($p = 0.0042$, odds ratio = 2.035, Fig. 5). Comparing the procedures without CATS no statistically significant difference could be seen between cemented and non-cemented exchanges concerning ABT administration ($p = 0.555$).

Discussion

During orthopaedic surgeries substantial peri- and post-operative blood loss is common. The risk for blood loss increases with the severity level of the procedure, especially

Fig. 3 Pre- and post-operative differences in Hb in the cemented group

Fig. 4 Pre- and post-operative differences in Hb in the non-cemented group

in revision cases. Blood substitution after surgery is a common course of action [19].

CATS would be an option to reduce post-operative blood loss and application of ABT with its known complications [20–22]. However, the efficacy of CATS is still controversial. We consecutively reviewed all revision surgeries of THA performed at our institution in the year 2011.

In general, our results could not reveal a significant benefit for patients using CATS by a significantly decreased post-operative blood donation. Cip et al. [36] performed a prospective randomised controlled study with 151 patients treated with TKA and did not find a reduction of the rate of post-operative ABTs for patients receiving WSB. Amin and colleagues presented similar results in their analysis of TKA patients [37]. Recently, Schneider and colleagues could not find a significant benefit for patients with CATS following primary THA and TKA [38].

In contrast, there are also other studies describing the use of CATS as an option for reducing blood loss and post-operative ABT [21, 32, 39–42]. del Trujillo et al. described in a prospective study a benefit in primary THA analysing 108 patients with no difference between cemented and non-cemented techniques [39]. Moonen et al. [40] found lower ABT

administration using CATS for THA and TKA; however, the results are contrary to the results presented by Amin et al. [37] using the same device.

Law and Wiedel recommend the use of CATS in all cases in which blood transfusions are expected [43]. Garvin et al. could show that the need for ABT using two different systems for CATS was reduced in cases of hip revision by 31 % [44]. Zarin et al. found decreased perioperative blood loss using CATS for patients with revision of femoral and acetabular components or only the acetabular component [23]. Recently, Greenky et al. performed a retrospective analysis of 298 patients and recommended using CATS for aseptic revisions of THA only in cases with advanced age, higher BMI, revision of both components (femoral and acetabular) and revision surgeries with trochanteric osteotomy. In their findings ABT in cases using CATS was higher [45]. Bridgens et al. found in their retrospective case-matched study in revision hip surgery significantly lower ABT in cases using CATS [3].

Because of different autologous blood transfusion systems, different study designs and in some cases combining THA and TKA cases, the comparison between the different results is not always reliable. Martin and von Strempel pointed out that vacuum activity of the retransfusion system causes additional blood loss, which could in general be a possible reason for the non-benefit using such CATS [46].

In general, a possible sealing effect in cemented procedures is expected that could result in less bleeding post-operatively. Accordingly, our cemented revision cases got significantly less blood retransfused than non-cemented revision cases. Considering all of our cases using CATS, cemented revisions got significantly more ABT administered than non-cemented. This could be related to the greater age of the patients accompanied by a larger number of co-morbidities and the time needed for surgery.

Fig. 5 ABT administration in cemented and non-cemented procedures using CATS

We agree with Cip et al. and suggest that blood management in general is needed to reduce use of ABT [18, 47], for example, collecting blood eight weeks before surgery and administration of iron and erythropoietin if needed. Jakovina Blazekovic et al. showed that pre-operative autologous blood donation in non-anaemic patients is not justified and is not economically feasible [48]. In our institute, patients get intra-operative tranexamic acid to reduce blood loss. After surgery, standardised Hb controls are needed and if clinically conspicuous with short-term intervals.

Our study has some limitations. The study is retrospective in nature and surgeries were performed by a number of different surgeons. The authors did not analyse the exchange of individual components for each group of surgeries. Lack of a well-defined threshold value at which to administer ABT for the study cohort was also a limitation. Additionally, the study included only data gathered during the hospital stay and not subsequent outpatient data. Complications or the need for transfusion post-discharge were not included in this study, which could also influence the ultimate outcome.

In conclusion, the use of an autotransfusion system did not reduce the amount of allogeneic transfusion in revision THA in the patient cohort reported here. However, it is not known whether patients who did receive autotransfusion via CATS would have required a greater amount of allogeneic blood to be transfused without an autotransfusion system.

Conflict of interest The authors declare that they have no conflict of interest.

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