Prolonged operative time increases risk of blood loss and transfusion requirements in revision hip surgery

Abstract

Introduction

Revision Hip Surgery is well documented to have a high association with substantial blood loss and the associated need for a blood transfusion. This exposes the patient to increased risk of transfusion reaction and blood borne infection. There are many strategies to minimize allogeneic transfusion rates in revision surgery such as pre-operative autologous donation, peri-operative tranexamic acid, thrombin sealants, normovolaemic haemodilution, intra-operative blood salvage and the use of post-operative autologous drains.

Patients and Methods

We prospectively looked at 177 consecutive cases performed at one centre by a single surgical and anaesthetic team to identify which patient and operative factors were most significant in minimizing the requirement for an allogeneic blood transfusion.

Results

Our results identified the duration of surgery as being the only significant variable affecting the level of blood loss. We noted a 3% increase in the probability of massive blood loss (>2000mls) for every minute of increased surgical time in our series.

Conclusion

We conclude that measures to minimize the duration of surgery would be beneficial in reducing blood loss and the risks of requiring blood transfusions in revision hip surgery.

Keywords: blood-loss, hip, revision, arthroplasty, transfusion, complications

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Introduction

Revision hip surgery can be associated with massive volume blood loss. This is increasingly a concern for clinicians with respect to the availability and cost of blood products, and exposure to blood borne communicable diseases. During 2016 7933 hip revision procedures were performed across England and Wales in the NHS and independent sector (87% as a single stage) (1). Hip revision is undoubtedly a significant resource issue, with the consequent increase in the need for blood products.

It has been reported in Scotland that, between centres, there is a wide variation in the use of blood conservation techniques to deal with the increased potential requirement for blood products in revision hip surgery (2). These techniques include pre-operative autologous donation, normovolaemic haemodilution, intra-operative blood salvage, the use of post-operative cell salvage drains and the use of tranexamic acid (3,4). Surgical technique modification is also being advocated to minimize blood loss intra-operatively. This becomes more significant when considering European regulations, which have some restrictions on the use of pharmacological alternatives to allogeneic blood transfusion (5).

The aim of our study was to review a consecutive series of hip revision patients to determine which patient and operative factors influenced the peri-operative blood loss and the need for transfusion.

Patients and Methods

We prospectively looked at a consecutive series of 177 revision hip replacements ("revision" as defined by the NJR(1)) performed at our institution over a 5-year period, by a single surgeon and single anaesthetic team from a prospectively collected database. A number of descriptive patient and operative variables were prospectively recorded in an Excel database, specifically looking at blood loss and its associated variables as well as the influence of surgical experience.

An anaesthetist assessed all the patients the day before surgery, which is standard practice in the unit, ensuring they were optimized for surgery and anaesthesia. General and regional anaesthesia (mainly combined spinal-epidural (CSE) anaesthesia) were used in combination primarily, with intra-operative patient warming. The CSE consisted of spinal with Bupivacaine and diamorphine 0.4mg, with low dose epidural maintaining analgesia without anaesthesia of 0.075% Bupivacaine and Fentanlyl 2mcg/ml.

Normovolaemic haemodilution using regional anaesthesia techniques were used to minimize the effects of volume blood loss intra- and post- operatively, where possible. All patients had a pre-operative plan made in clinic prior to their surgery. A standard posterior approach was used with the patient in a lateral decubitus position and a single surgical assistant. The surgical approach was pragmatic, aiming to reconstruct the hip with an effective but short operation. This ensured efficient, safe surgery with a good clinical outcome, especially for the elderly patients. Tranexamic acid was not routinely used in patients in this study nor were surgical drains.

The descriptive patient variables recorded were the general demographics of the patients, date and nature of surgery, type of anaesthesia, operative duration (the combined anaesthetic and surgical time) and complications. More specifically the pre-operative haemoglobin, the estimated total blood loss (both intra- and post- operative), the fluid volume (crystalloid and colloid) and blood products replacement, as well as the post-operative haemoglobin were recorded. Blood loss was estimated by the surgical team as a result of swab weight and volume of blood in the suction. Transfusion requirement was individualised according to comorbidities, estimated blood loss and post operative haemoglobin.

Statistical analysis was performed using Stata 10.0 SE (Stata Corp. College Station, Texas, 2002).). Due to the non-normal distribution (based on Shapiro-Wilk testing) of most variables, binary logistic models were chosen to evaluate the effect of potential covariates on operative blood loss. The binary outcome variable was defined as the presence or absence of

massive haemorrhage, defined as ≥2000 mls blood loss, since this equated well with the conventional need for massive transfusion, defined as ≥6 units (Chi2 $p<0.0001$).

Results

Our single anaesthetic and surgical team carried out 177 cases of revision hip replacement were performed in 79 males and 98 females, with the median age being 75 years (range, 45-95 years). The anaesthetic was a combined general and epidural in 165 cases and a general in 12 cases. The median duration of surgery was 180 minutes (range, 60-360 minutes), with the median blood loss being 1050 mls (range, 200 - 4500 mls; Figure 1) and the median blood transfusion requirement being 4 units (range, 0-12 units). There was no mortality prior to discharge, and 4 cases required admission to HDU / ITU for post-operative monitoring. There was one dislocation in the early postoperative period, and one peri-prosthetic fracture following a fall.

The variables that were assessed with respect to blood loss were age, sex, type of anaesthesia, year of surgery (in relation to time since appointment of the surgeon), duration of surgery, pre-operative haemoglobin level and side of surgery. The only variable found to have a significant effect on blood loss in revision hip surgery was the duration of surgery (Odds Ratio 1.03, CI 1.02-1.05, $p<0.0001$). Blood loss with respect to duration of surgery is shown in Figure 2. The risk of massive transfusion was significantly affected by the duration of surgery as shown in Table 1. The interpretation of the odds ratio is that the probability of blood loss >2000mls and transfusion were increased by 3% for every minute of excess surgical time. There was also an observed effect of the year of surgery on blood loss, which we have thought to be linked to the effect on surgical duration. The median operating time after 2 years of Consultant practice decreased by 40 minutes, which then remained constant. This increased surgical time of 40 minutes increases the risk of massive blood loss and transfusion by a factor of three.

Discussion

It is well recognized that blood loss is greater during revision hip surgery than in primary hip arthroplasty, and is associated with an increased risk of complications, compromised outcome, prolonged in-patient stay and cost implications (6). It is recognised that those with a higher risk of intraoperative blood transfusion are patients with a low or raised body mass index, advancing age, low pre-operative haemoglobin, two component revision and those requiring a trochanteric osteotomy (6,7). There are problems and potential complications with blood transfusion such as administration errors, transfusion reactions, infection risk (both blood borne and peri-prosthesic infections) (8,9) as well as the increasing resource problems of cost and availability. In modern day arthroplasty surgery, where enhanced recovery programmes are being advocated, blood transfusions are likely to delay mobilisation and further complicate the implementation of such programmes. In addition there is significant mortality associated with revision hip surgery as demonstrated by Katz et al. (10) for 12,956 Medicare patients, showing 90-day mortality of 1.5% for experienced specialist surgeons and 3.1% for generalist surgeons, although the NJR does suggest modern practice is increasingly moving towards specialist surgeons performing hip revision surgery (1). This is possibly as a result of the ‘getting it right first time report’ (11). It is worth noting in our study that as the experience of the surgeon involved grew the operative time decreased. Carson et al. demonstrated the importance of haemoglobin levels and mortality in their randomized study of elderly hip fracture surgery patients (12). Patients who were transfused when their post-operative haemoglobin was < 10g/dl had a 60-day mortality of 4.8%, compared with patients who were transfused if they either had a haemoglobin <8g/dl or were symptomatic and had a 60-day mortality of 11.9%. Hogue et al. also demonstrated for elderly patients undergoing elective surgery that intra-operative or postoperative myocardial ischaemia was increased with a haematocrit of 28% or less (13). An anaesthetic study aiming to find the appropriate threshold for transfusion by Nielsen et al.. in revision hip surgery found an Hb of 8.9g/dl was associated with a quicker Timed-up and Go-test compared to a threshold of 7.3g/dl (14).

The importance of maintaining the haemoglobin levels and minimizing blood loss in elderly patients undergoing revision hip surgery is evident from these studies.
Previous studies have suggested a range of strategies to minimise the need for allogeneic blood transfusion. These include; pre-operative autologous donation, normovolaemic haemodilution, intra-operative blood salvage, the use of post-operative cell salvage drains and use of tranexamic acid (4).
For the purposes of our study, normovolaemic haemodilution was selected as one of the techniques of blood conservation. Goodnough et al., in a randomized trial, demonstrated normovolaemic haemodilution to have a similar success rates to preoperative blood donation with advantages of saving cost and time and reduced likelihood of clerical error or contamination (15).
Regional anaesthesia was selected as it lowers mean blood pressure and improves blood drainage from the operative site from venodilation. This improves surgical site conditions as well as reducing blood loss. This was borne out by Rashiq et al., who retrospectively reviewed 1875 arthroplasty cases, demonstrating that spinal anaesthesia strongly protects against the need for allogeneic blood transfusions in hip arthroplasty (16).
Intra-operative red blood cell salvage is a popular technique for minimizing blood loss. However Zarin et al. looked in a series of 222 patients that had undergone revision hip arthoplasty assessed the efficacy of intra-operative blood collection and reinfusion. They found the mean blood loss where both components were revised was 1955+/- 1085ml. The mean blood loss of isolated femoral component revision was 1487+/- 936ml and for isolated acetabular component revision was 1292+/-754, which are all higher than the median loss in our study. They concluded that intra-operative blood collection and re-infusion was effective at reducing net operative blood loss in patients that had both components revised and those that had an acetabular revision only, but not in those that had only the femoral component revised. This study however used a combination of blood conservation techniques including pre-operative autologous donation, intra-operative cell salvage and post-operative autologous re-infusion (18).
Conversely, Garvin et al. with a similar median blood loss to our study concluded intra-operative blood salvage and replacement reduced the need for allogeneic blood transfusions by 31% (19). However they used 2 different systems and their median blood loss for revision of both components was less than that of the blood loss for an isolated femoral component. Their results have been borne out by other studies such Bridgens et al.'s case matched series of 47 patients, concluding there were significant reductions in allogeneic blood transfusions (20). Phillips et al. also looked at cell salvage in conjunction with tranexamic acid in a case-control study with 80 matched patients and concluded this combination resulted in an apparent reduction in allogeneic blood transfusions (20,21). There have been some good results reported with thrombin fibrin sealants stating they reduce the requirements for blood products and peri-operative decreases in haemaglobin whilst there are also significant concerns by others over the safety of some antifibrinolytics as they may promote a hypercoagulable state, with concerns of renal impairment, cardiovascular and cerebrovascular events stating they should be used with caution (21,22). Kandemir et al.. advocate a high fresh frozen plasma to red blood cell suspension ratio may reduce the risk of complications (23).
A meta-analysis of the use of closed-suction drainage systems for hip and knee arthroplasty by Parker et al., showed there was a significantly greater need for blood transfusion with these systems (24). This again is borne out by Walmsley et al. in a RCT of the use of closed suction drains in primary hip arthroplasty(25). They demonstrated no advantage for use of drains and concluded there was high risk of transfusion with their use. This would be avoided by employing the described technique of normovolaemic haemodilution instead of the salvage reinfusion approach.
Pola et al. in a consecutive series of 85 primary total hip arthroplasties, showed that for age, gender, hypertension and body mass index there was no single factor that predicted the increased risk of perioperative blood transfusion (26). However these factors showed a synergistic effect in

that when two or more were present that there was a significantly increased risk of transfusion requirement.

Our study was prospectively conducted in a large homogeneous cohort of patients undergoing revision hip surgery in a single centre, where all data was recorded in an identical manner. The statistical analysis used is valid and the possibility of confounding effects was tested. Thus the findings above appear to be conclusive.

Conclusions

This combined approach to revision hip surgery by a single Consultant anaesthetist and single Consultant surgeon team, using the techniques of combined general and epidural anaesthesia, normovolaemic haemodilution and a pragmatic approach to surgery has shown to be safe, with a median blood loss of 1050mls.

Our study has shown the duration of the surgery to be the most significant factor in terms of blood loss in our series of revision hip replacements. For every minute of increased surgical time, the risk of excessive blood loss increases by 3%. The time saving of 40 minutes in the latter part of the series reduces the risk of massive blood loss and transfusion by a factor of 3. The effect of the year of surgery has been thought to be linked to the learning curve associated with starting as a Consultant, with the latter years being associated with more meticulous technique and shorter duration. It's worth noting in our study we quote the combined Anaesthetic and Surgical time. There was little variance in the anaesthetic time given it was a single team used in all cases. Limitations included that this is a single centre study with as single surgeon and anaesthetic team. The blood loss estimate used is not entirely accurate but is pragmatic and common place in clinical practice.

Extra attention needs to be paid to the surgical support team and other resources to minimise delays during surgery, especially during the early years, when experience is being developed. This may involve two Consultant operating, senior scrub staff and presence of Company representaives for unfamiliar prostheses. This study clearly shows the progression of a surgical and anaesthetic team, and how with time and experience the need for a blood transfusion and in particular a 'massive' transfusion is significantly reduced.

Resource allocation in terms of blood product supply also needs to be taken into consideration with the appointment of new revision hip surgical teams.

Figure Legend

Figure 1: Histogram of intra-operative blood loss
Figure 2: X-Y box plot of blood loss versus duration of surgery
Table I: Surgical duration and massive transfusion risk

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