During the last ten years, greater attention has been given to the management of peri-operative blood loss after total knee arthroplasty (TKA), as it is a modifiable outcome that has a significant effect on the rate of complications, the recovery, and the economic burden. Blood loss after TKA has been greatly reduced during this time, thereby dramatically reducing the rates of allogeneic transfusion. This has significantly reduced the complications associated with transfusion, such as fluid overload, infection, and increased length of stay.

The greatest advent in lowering peri-operative blood loss after TKA has been the introduction of tranexamic acid, which reduces blood loss without increasing the risk of thromboembolic events.

This paper discusses the ways of reducing blood loss after TKA, for which a multimodal algorithm, with pre-, intra- and post-operative measures, has been adopted at our institution.

Increased attention has been given to the management of blood loss following total knee arthroplasty (TKA) during the last decade, due to the realisation that peri-operative blood loss can be a modifiable outcome that affects patient satisfaction and outcome. With less blood loss, the patient's post-operative mobilisation can be improved. Reduction in blood loss around the knee may also result in less swelling and haemarthrosis, thereby increasing range of movement and decreasing pain and stiffness. It has also become evident that transfusion, even with autologous blood, can result in complications such as fluid overload, wound problems, and infection. Finally, there is the potential for financial savings by lowering the rate of transfusion through blood conservation strategies.

Previously, it was accepted that TKA was an operation that typically resulted in significant post-operative blood loss, often requiring transfusion. This may be due to the bleeding surfaces of bone produced during the operation, the large joint cavity into which blood can accumulate, and the desire to move the knee immediately after surgery, compromising haemostasis. It has been estimated that approximately 20% to 50% of patients having a TKA require an allogeneic blood transfusion. Beside the costs associated with such a transfusion, allogeneic transfusion has risks and complications. An increased rate of infection, higher incidence of fluid overload, and an increased length of stay have been reported in patients who receive an allogeneic transfusion compared with those who do not. A higher rate of wound and lung infection in patients receiving a transfusion has also been reported. Thus, it would certainly be advantageous to the patient undergoing TKA to avoid the risks of transfusion.

In considering the approaches for reducing peri-operative blood loss in TKA, we have stratified an algorithm into pre-, intra- and post-operative strategies.

Pre-operative
Pre-operatively, the strategies for minimising the risk of requiring a transfusion historically were autologous blood donation, erythropoietin administration, and haemodilution. The rate of transfusion is lowered if one donates blood in the weeks leading up to surgery. However, not all banked blood is used, leading to the unnecessary storage and collection of blood, which is costly. Couvret et al. estimated that approximately 40% of pre-donated units of blood were wasted. Erythropoietin may be used to build up a patient's stores of haemoglobin. However, this method requires advance notice to coordinate the timing of injections, and can be difficult to implement, and is expensive.
Haemodilution may be used to reduce blood loss. This involves removing some of a patient’s blood immediately before surgery, supporting the blood pressure with the infusion of fluids (hence, haemodilution), and then returning the blood once blood loss is complete. This can be effective, but requires personnel to collect the blood, and provide storage facilities. Typically, this process would be carried out by an anaesthetist preceding the operation, with immediate post-operative transfusion of the removed blood.

**Intra-operative**

**Tranexamic acid (TXA).** The major advance in intra-operative strategies for reducing blood loss after TKA in the last ten years involves the administration of TXA. This is an anti-fibrinolytic agent that does not increase the proclivity for clot formation, but rather, prevents the breakdown of a clot. Many authors have shown the efficacy of TXA in reducing blood loss after TKA, significantly lowering the rate of transfusion, without an increase in the incidence of venous thromboembolism (VTE). A recent meta-analysis examined 19 studies with more than 1100 patients, and found that those who received TXA had a relative risk of 0.39 for requiring a transfusion compared with patients who did not receive TXA. TXA can be administered in various ways including intravenously (IV), topically, or orally. In orthopaedic surgery, IV and topical routes have been the most commonly used. For IV administration, the patient requires normal renal clearance and no history of cardiac surgery or of VTE.

In those in whom IV TXA is contra-indicated, topical TXA is thought to be safe because of limited systemic absorption. The dose of IV TXA that we use is 1 g before incision, and 1 g three hours later. This is based on the half-life of TXA, which is approximately two hours. We have used this this system since 2013. Since the recommended dose for orthopaedic surgery is 10 mg/kg to 15 mg/kg, this typical regime should be safe for all patients. TXA is routinely used in doses ten times greater in cardiac surgery than we use in orthopaedic surgery.

For topical usage, we currently use 3 g of undiluted liquid TXA, which has a volume of 30 cc. If it is felt that a greater volume is required, up to 30 cc of normal saline is used in a 1:1 dilution. We introduce this solution into the cavity of the joint before deflating the tourniquet. The fluid is left to bathe the bony surfaces and peri-articular tissue for five minutes and then removed with the sucker before routine further irrigation and closure.

Three studies have compared the efficacy of topical and IV TXA. Gomez-Barrena et al and Patel et al have shown that there was no difference in the reduction of the rate of transfusion with either topical or IV TXA. Seo et al found that topical TXA was slightly more efficacious, reducing blood loss by a mean of 426 ml versus 528 ml for IV. Some centres have advocated using both IV and topical TXA.

**Bipolar sealants.** It has been suggested that the use of a bipolar sealant might reduce blood loss during TKA. It is believed that this device promotes effective coagulation of the peri-articular soft tissues. It is a disposable device that requires its own energy generator. Some authors have reported reduced blood loss when compared with traditional electrocautery devices, and some have found no difference.

**The use of a tourniquet.** The avoidance of a tourniquet during TKA has been proposed as a method of conserving blood, as coagulation of bleeding tissue would occur as the operation proceeds. Furthermore, not using a tourniquet may help avoid the reflex hypaeremia that occurs after deflation, which may paradoxically increase blood loss. Authors have been divided on this issue and critics claim that the operation takes longer. Although it is likely that the blood loss will be similar whether or not a tourniquet is used, the timing of the blood loss may be moved from the intra- to the post-operative period.

**Fibrin sealants.** These are another intra-operative strategy for the conservation of blood, the idea being that fibrin, one of the constituents of a mature clot, can be applied preventatively to the surface of tissues that would bleed post-operatively. Reinhardt et al reported that the use of a fibrin sealant reduced the number of allogenic blood units transfused post-operatively. However, in this study, both groups of patients donated blood pre-operatively, which potentially affected the results. Thus, although the use of a fibrin sealant could be a worthwhile technique for the conservation of blood, TXA is more cost effective.

**Peri-articular injections.** Anderson et al reported that peri-articular analgesic injections containing epinephrine were effective not only in reducing pain post-operatively, but also in reducing blood loss. The output in the drain was a mean of 32% less in patients who received the peri-articular injection, the theory being that epinephrine constricts peri-articular blood vessels, thus reducing blood loss.

**Post-operatively.** The avoidance of a suction drain reduces the amount of blood lost. Although it is commonly believed that a suction drain, placed intra-articularly reduces the formation of a haemarthrosis and enhances rehabilitation, it is also clear that it increases blood loss. A prospective, randomised study by Li et al comparing 50 patients with drains, and 50 without a drain, demonstrated an additional mean of 318 ml of blood loss when a drain was used. The group of patients who did not receive a drain had a significantly lower need for blood transfusion. The lack of a drain might be expected to cause wound problems or difficulty in regaining movement, but this has not been demonstrated.

Compression and cryotherapy are commonly used, and are effective techniques for reducing blood loss after TKA. They have been shown to reduce post-operative blood loss slightly. Continuous passive movement (CPM) is
associated with a greater amount of blood loss, without any clinical benefit, and is therefore avoided.  

Algorithm. Our algorithm for reducing blood loss after TKA encompasses strategies at every point in the peri-operative process, in order to minimise the rate of transfusion. First, we identify those patients who are at greater risk of requiring a transfusion, namely those with a haemoglobin of < 11 g/dl. At that range, we recommend either pre-operative donation of one unit, or treatment with erythropoietin alfa. Intra-operatively, we use either IV or topical TXA in all patients. In general, we use a tourniquet which is inflated before the incision is made, and deflated before closure of the arthroscopy. We use standard electrocautery and advocate the use of a peri-articular cocktail of epinephrine for both analgesia and blood conservation. Post-operatively, we avoid the use of a drain, and use both compression and cryotherapy. CPM is avoided.

In conclusion, peri-operative blood loss after TKA has been greatly reduced during the last ten years, thereby reducing the rate of allogeneic transfusion dramatically. This has benefits for the reduction in complications associated with transfusion, such as fluid overload, infection, and increased length of stay. The greatest advent, however, has been the introduction of TXA, which reduces blood loss without increasing the risk of VTE. A multimodal algorithm for reducing blood loss after TKA including pre-, intra- and post-operative measures has been adopted at our institution.

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References