

## Review Article

# Modern Anesthesia Techniques for Total Joint Arthroplasty: From Blood Preservation to Modern Pain Control

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## Special Issue on

## Modern Anesthesia Techniques for Total Joint Arthroplasty: from Blood Preservation to Modern Pain Control

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## Abstract

Total Joint Arthroplasty (TJA) increased by over 150% during the last ten years. Patient's satisfaction and comfort are essential for improving general health, quality of life and functional outcome after this surgery. The degree of this satisfaction is closely correlated with postoperative pain control and blood preservation techniques. Today, modern analgesia is based on the concept of multimodal analgesia: it is an association of drugs and other analgesic techniques used in combination to increase efficiency and/or reduce side effects of the treatment. Multiple protocols have shown clinical benefits, but without the same efficacy. Loco-regional anesthesia has a clear role in multimodal analgesia, so, the different techniques are still under study and the efficiency of local anesthetic administration remains to be determined. Secondly, previously undiagnosed anaemia is common in elective orthopaedic surgical patients and is associated with increased likelihood of blood transfusion and increased perioperative morbidity and mortality. In this way, perioperative blood management protocols are necessary for early detection and management of anemia to improve patient outcomes. The goal of this review is to describe and define the profitability of the various modalities for pain control and blood preservation in total hip and knee arthroplasty.

## ABBREVIATIONS

**TJA:** Total Joint Arthroplasty; **THA:** Total Hip Arthroplasty; **TKA:** Total Knee Arthroplasty; **MIS:** Minimally Invasive Surgery; **VAS:** Visual Analogue Scale; **SFAR:** French Society of Anaesthesiology and Intensive Care Medicine; **NATA:** Network for Advancement of Transfusion Alternative; **EPO:** Erythropoietin; **Hb:** Haemoglobin; **TS:** Transferrin Saturation.

## INTRODUCTION

Over the past 10 years, the number of patients receiving a primary arthroplasty surgery has increased by almost 150% (1). A reduction of hospital length of stay has been observed following the development of the so-called Minimally Invasive Surgery (MIS), also associated with an increased number of readmissions.

The modern anesthesia approach for total joint arthroplasty

included a multimodal analgesic protocol and new techniques for blood preservation.

First of all, in July 2000, the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) introduced a new standard for pain management, declaring the pain level to be the "fifth vital sign" (2). The Commission stated that acute and chronic pain are major causes of patient displeasure in the United States health-care system, leading to slower recovery times, creating a burden for patients and their families, and increasing costs (2). This statement is particularly true after total joint arthroplasty (3). Patients have high expectations regarding the outcomes of total hip arthroplasty (THA): over 75% expect to be completely pain free when only 40% expect to be unlimited in their usual activities (3). Furthermore the post-operative pain and the length of recovery are two of the most important patients concerns after total hip arthroplasty (4). Previous studies have shown

that postoperative pain is correlated with the quality of patients long term recovery (5). To limit the surgical trauma and improve patient's recovery after arthroplasty, minimally-invasive approaches have been introduced during the last decade to become a standard of care in THA (6). The most important factor related to the development of MIS is the development of improved peri-operative pain management protocols (7). Reduction in post-operative pain and hospital length of stay, earlier hospital discharge directly to home and improved patient's satisfaction have been observed (5–8). Following this trend, multimodal analgesics protocols including initially peripheral nerve blocks and more recently intra-articular anesthetic injections have been more widely used (5–8).

Secondly, previously undiagnosed anemia is common in elective orthopaedic surgical patients and is associated with increased likelihood of blood transfusion and increased perioperative morbidity and mortality. In this way, perioperative protocols are necessary for early detection and management of anemia in order to improve patient outcomes.

## MODERN ANESTHESIA TECHNIQUES FOR TOTAL JOINT ARTHROPLASTY: PAIN CONTROL

In a recent study evaluating pain during the postoperative days after different surgical techniques, prosthetic replacement surgery appears to be one of the most painful surgeries. Visual analogue (pain) scale (VAS) greater than 5-6 during the first postoperative day (9) have been reported. The authors concluded that hence the need for an adequate perioperative support in concerns on analgesia.

Several recommendations have been published (10-12) and serve as guidelines for the management of perioperative pain in orthopedic surgery. This analgesia is based on the concept of multimodal analgesia described by Kehlet in 1993 (13). The principle is to use combined agents or analgesic to optimize the balance between efficiency and side effects. In postoperative pain management, sensitization plays also an important role. This central hyperalgesic component contributes to increase pain intensity, especially under dynamic conditions. It maintains and sustains independently of peripheral nociceptive stimuli and generates post-surgical chronic pain. This central component can be treated or prevented with anti- hyperalgesic drugs without anti-nociceptive effects. These drugs are synergistic with conventional analgesics.

### A - Systemic analgesia

**Non-opioid analgesia:** The combination of several non-opioid drugs allows additive or synergistic analgesia and therefore reduced the need for opioids and consecutively their secondary and side effects (14).

Thus it is recommended to use acetaminophen and non-steroidal anti-inflammatory drugs, in the absence of contraindication and nefopam in combination with opioids (14). But a recent study reports that nefopam provides no additional analgesic effect in a multimodal analgesia (15). Rebound effects of nefopam and ketamine could be the cause. Otherwise the eviction of nefopam could reduce some postoperative side effects like acute retention of urine.

**Ketamine.** At low doses, ketamine, a non-competitive antagonist (on Non-Methyl-D-Aspartate NMDA), is able to limit the awareness of the central nervous system in painful animals, in healthy volunteers exposed to various models of pain and in postoperative patients. In fact, a study reported a significant decrease of the post-operative pain level and better functional recovery in patients undergoing TKA after low dose of ketamine intravenously (16). It also allows a reduction in morphine consumption after THA (17). Ketamine is more effective with a preoperative bolus (0.1 to 0.5 mg/kg) followed by a continuous infusion during 48 hours (2 µg/kg/min or above 5 to 12 mg/h). Ketamine decrease the post-operative pain in limiting both postoperative hyperalgesia after the surgical trauma and intraoperative use of high doses of opioids. This limits the use of analgesics, reduces morphine tolerance and improves the overall quality of analgesia in postoperative period (18).

Before surgery, *gabapentin* not only reduces morphine consumption but also the postoperative pain at rest and in dynamic conditions (19–21). It also improves functional recovery after orthopaedic surgery (22), and prevents pruritus induced by intrathecal morphine in patients undergoing lower extremity surgery under spinal anaesthesia (23). It is mainly due to a presynaptic blockage of calcium channel voltages dependent resulting in an anti-hyperalgesic effect. However, recent studies have shown that the effectiveness of gabapentin given preoperatively in THA (24) or in TKA (25) may not be as high as initially described. Currently international recommendations concerning postoperative analgesia propose to use gabapentin premedication without exceeding one daily dose of 800mg to avoid side effects like sedation or dizziness.

**Intravenous lidocaine.** It has been shown that the use of low doses of intravenous lidocaine before and after THA did not improve postoperative analgesia (26). Lidocaine is probably recommended for analgesia in abdominal surgery but not in orthopedic surgery.

### Opioid analgesia

Prosthetic joint replacement surgery is considered like a moderate to severe painful surgery and the use of opioids called « strong » (level III of WHO) is recommended, including the use of controlled analgesia with an opioid pump device. The oral treatment can be provided by morphine sulphate. In elderly patients however, the goal is to limit the use of opioid to avoid central and peripheral side effects.

### B - Intrathecal and epidural analgesia

Epidural analgesia provides the same analgesia than peripheral nerve blocks but a better analgesia at rest and especially during mobilization than analgesia with drugs alone (12). However, epidural analgesia is not without risks or side effects and the risk / benefit ratio is clearly in favour of peripheral blocks for the management of post arthroplasty analgesia. The central blocks can induce arterial hypotension, acute retention of urine, infectious complications and headaches. They have a small benefit in terms of morbidity and mortality and a low profitability on convalescence: therefore epidural analgesia is not indicated after lower limb arthroplasty (27). However indications should be discussed in each case.

Spinal anaesthesia may be used for arthroplasty surgery of the lower limb as well as to start postoperative analgesia. Indeed the use of adjuvants, such as clonidine, or liposoluble opioids can potentiate the action of local anaesthetics. The postoperative analgesic effect does not exceed 12 to 14h and the use of high doses quickly exposes to many side effects (sedation, pruritus, nausea and vomiting, acute urinary retention, hypotension). Despite a low cost, the profitability of spinal anaesthesia in terms of postoperative analgesia seems minimal because of many side effects and a short analgesia

## C - Peripheral analgesia

### Blocks and perineural catheters devices:

**Indications and feasibility:** It is recommended to use peripheral blocks for post operative analgesia of arthroplasty surgery compared with epidural analgesia (12). The benefit of analgesia with peripheral blocks is also true with intravenous patient-controlled analgesia with morphine pump. Indeed perineural blocks minimize the sympathetic response to surgery, reduced postoperative pain especially during mobilization, improve analgesia during the postoperative period and increase patient's satisfaction.

Today, it is not mandatory to use ultrasound for a peripheral nerve block (single injection or catheterization). Up to now the superiority of ultrasound compared with neurostimulation on the success of locoregional anaesthesia has not been demonstrated. There is however several advantages for ultrasound: a direct visualization of the needle and of the surrounding tissue and the dissemination of local anaesthetic. Ultrasound help to decrease time required to perform the nerve blocks, the number of needle's redirection, the number of vascular punctures and decrease the setting time of nerve blocks (28–31). Ultrasound also allows a better understanding of the anatomical variations. There is also a decrease of complications due to systemic toxicity of local anaesthetic (32). It also improves patient's satisfaction by reducing the discomfort of the nerve research by neurostimulation (33) and by decreasing pain in trauma patient (28,31). The impact on the risk of postoperative neuropathy is less clear, but a trend in favour of ultrasonographic techniques has been outlined (34). Thus the cost of an ultrasound remains the main limitation compared to standards neurostimulation techniques. However, a study published in 2004 reported the same cost for an infraclavicular block under ultrasound and neurostimulation (the introduction of a catheter costs only 13.90 dollars more with ultrasound) (35). Another study published in 2012 compared the cost- effectiveness of the analgesia produced by an ultrasound-guided popliteal sciatic catheter inserted with the same block by neurostimulation approach. The use of ultrasound is associated with a higher probability of success and reduced the costs about 84.7% (36).

**Hip arthroplasty:** For postoperative analgesia, a femoral nerve block with a single injection is recommended.

**Knee arthroplasty:** The debate is over: the French guidelines recommend the use of a femoral perineural catheter, probably associated with a single injection sciatic nerve block (37,38), while an European working group (PROSPECT Group) recommend neither a single injection nor a continuous infusion

femoral nerve block because of too much heterogeneity among studies (39).

If the implementation of a femoral nerve block, at least as a single injection, seems obvious to improve the management of acute and chronic pain after TKA, the effect of a sciatic block has not been demonstrated. Indeed, Wegener and al. (40) did not found any significant difference in terms of functional recovery, acute and chronic pain in patients who underwent TKA with a continuous femoral block alone, or combined with a single or continuous injection sciatic nerve block. Sinha and al. (41) found an improvement of postoperative acute pain in patients with a femoral catheter associated with a sciatic block or elective tibial block.

Thus, peripheral nerve blocks after arthroplasty surgery improve management of acute and chronic pain (42), reduces postoperative morphine consumption and improves patient's satisfaction (39). However, the locoregional anaesthesia leads to postoperative quadriceps paresis whatever the concentration and volume of the local anaesthetic (43). It may alter the initial functional recovery and increase the number of falls (44). Methods of local infiltration of the surgical site can also be proposed.

### Infiltration of local anaesthetic

In 2011, Kehlet performed a review of literature about analgesic infiltration after hip and knee arthroplasty (45). This approach was first described by Bianconi and al. in 2003 (46): patients undergoing THA or TKA with continuous infiltration of ropivacaine in scar had better pain control than those receiving only systemic analgesia. Kerr and Kohan, in a case study of 325 patients, reported an excellent pain control after systematic periarticular infiltration with a mixture of Ropivacaine associated with Ketorolac and adrenaline (47). Rostlund and Kehlet also described an excellent analgesia after infiltration of high doses of long acting local anaesthetic: there was no motor block, a low morbidity and a reduced length of hospital stay (48).

Despite positive results in many studies, the apparent simplicity and safety of the technique, Kehlet pointed out several methodological errors and a lack of comparison with other analgesic techniques such as peripheral nerve blocks (45). In conclusion, there is little evidence to support the use of analgesic infiltration after THA. On the contrary, after TKA the scientific data support the use of intraoperative infiltration of long acting local anaesthetic but not the use of a catheter for continuous infiltration of the scar. Few current data support the use of NSAIDs or adrenaline in mixtures of analgesic infiltration, although a recent study advocates the use of ketorolac (49).

A recent meta-analysis of Keijsers (50) concluded that infiltration of local anaesthetic improves postoperative analgesia and reduces morphine consumption on the first postoperative day after a TKA when compared to placebo. However, in a review of Fowler and Christellis (51), the authors report that the equivalence in terms of analgesia and functional outcome is not clear between infiltration and peripheral nerve blocks. This is confirmed by the study of Carli (52): a better management of pain and improved functional recovery initially and at 6 weeks with continuous perineural femoral techniques.

Also many studies describe earlier and more effective ambulation when infiltration is performed as compared to a continuous femoral block (53–55). A local analgesic infiltration reduces pain after TKA in the same manner as peripheral nerve block, but without motor block. Otherwise, a large recent study (56) identified several risk factors for inpatients falls in total knee arthroplasty patients. Contrary to common concerns, no association was found between peripheral nerve block and inpatients falls. However, volumes, and therefore doses of local anaesthetic are more important than with locoregional anaesthesia exposing to a potential systemic toxicity.

In addition, the duration and effectiveness of analgesia by infiltration remain insufficient compared with a continuous femoral nerve block. The latest studies report that the combination of a catheter on the adductor feeder (continuous block of the saphenous nerve) and a local periarticular infiltration provide equivalent analgesia to a continuous femoral nerve block (57). It is associated with earlier ambulation and a less functional impairment of quadriceps (58–60). In a recent study, an adductor canal block compared to a femoral nerve block, exhibited early relative sparing of quadriceps strength and was not inferior in both providing analgesia or opioid intake in patients undergoing total knee arthroplasty (61).

Moreover, it has also been proposed to use a liposomal bupivacaine to extend the analgesic effect of local anaesthetic. An animal study published in 2012 (62) reported a duration of sensory block of about 40 hours and a motor block about 36 hours after sciatic nerve block. Thus, the use of the liposomal bupivacaine would improve analgesia by extending the duration of sensory block. On the other hand, the duration of motor block is also increased and compromise the initial functional recovery. It would be interesting to use this liposomal bupivacaine by infiltration. However, its cost of around \$283 per vial is its main limitation.

## MODERN ANESTHESIA TECHNIQUES FOR TOTAL JOINT ARTHROPLASTY: BLOOD PRESERVATION

### 1 – Epidemiology of anemia in patients undergoing hip or knee arthroplasty

Anemia is defined biologically by the World Health Organization, as 13g/dl haemoglobin in males and 12g/dl in non-pregnancy females. According to Guralnik et al. (63), the prevalence of anemia in the general U.S. population over 65 years is about 10.6%. After age 50 years, anemia prevalence rates rose rapidly to a rate greater than 20% after 85 years. The most common causes of anemia are nutritional deficiencies (iron, folate, Vitamin B12), chronic renal failure and chronic inflammatory diseases.

Loss of haemoglobin occurred mostly in the early postoperative period (64). To avoid transfusion delays, haemoglobin levels should be monitored regularly until the third postoperative day after total arthroplasty.

Before arthroplastic surgery, the prevalence of anemia is between 15 and 39%. (Table 1)

According to Wells and al. (65), 8% of all blood transfusions occur during major orthopedic surgery (like Total Hip Arthroplasty

(THA), Total Knee Arthroplasty (TKA) and hip fracture) and thus represent the most common indication for transfusion in surgical patients. Indeed, in a systematic review of literature, Spahn et al. (66) observe: a mean volume of blood loss in knee and hip arthroplastic surgery of  $1004 \pm 302\text{ml}$ , a rate of transfused patients  $45 \pm 25\%$  and a number of red blood cells transfused of  $2.6 \pm 0.6$ . It was also demonstrated that the preoperative anemia increased the incidence of transfusion (67,68). Anemia and transfusion were both and independently associated with an increase of perioperative risk such as postoperative infections, increased length of stay, reducing functional recovery, increased occurrence of cardiovascular events, or increased costs (66,69–73). Furthermore preoperative anemia increases the postoperative mortality. According to Wu and al. (69), in the case of patients with preoperative non-cardiac surgery, an hematocrit  $\text{Ht} < 39\%$  is associated with increased mortality. According to Beattie and al. (71), it seems to be also associated with an increase of mortality at day 90. Therefore a perioperative blood saving strategy is essential to reduce transfusion requirements and to improve patient's outcomes. This management requires early detection, evaluation and preoperative management of anemia. In 2011, Goodnough developed the recommendations of the Network for Advancement of Transfusion Alternative (NATA) in preoperative major orthopedic surgery (74):

**Recommendation 1:** It is recommended that elective surgical patients have a haemoglobin level determination as close to 28 days before the scheduled surgical procedure as possible.

**Recommendation 2:** It is suggested that the patient's target hemoglobin before elective surgery be within the normal range ( $> 13\text{g/dl}$  for male,  $> 13\text{g/dl}$  for female).

**Recommendation 3:** It is recommended that laboratory testing be performed to further evaluate anemia for nutritional deficiencies, chronic renal insufficiency, and/or chronic inflammatory disease.

**Recommendation 4:** It is recommended that nutritional deficiencies be treated.

**Recommendation 5:** It is suggested that stimulation of erythropoiesis be used for anemic patients in whom nutritional deficiencies have been ruled out, corrected or both (Figure 1).

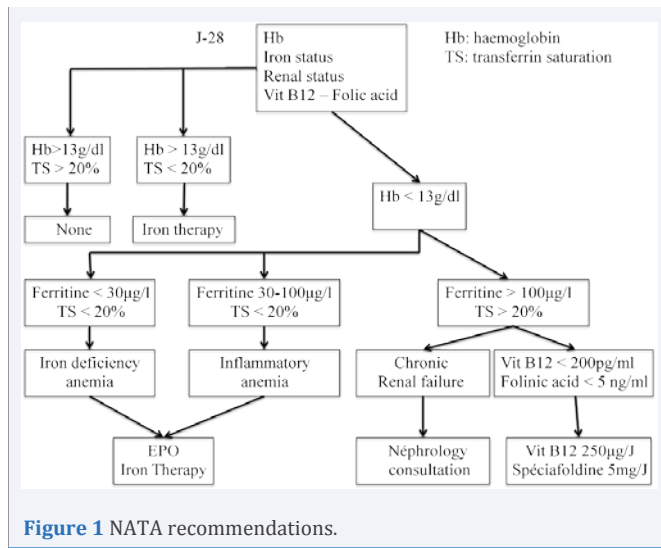
### 2 – Red blood cells transfusion triggers

In France, a professional agreement provides red blood cells transfusion with an intraoperative trigger at 7g/dl, a

**Table 1:** Epidemiology of anemia in patients undergoing hip or knee arthroplasty.

Studies	Type of surgery	Haemoglobin triggers	Prevalence
Myers and col. (99)	THA	Hb<12,5 (M), Hb<11,5 (F)	15%
Saleh and col. (67)	THA/TKA	Hb<13 (M), Hb<11,5 (F)	20%
Rosencher and col. (68)	THA	Hb<13	31%
Basora and col. (100)	THA/TKA	Hb<13	39%

Abbreviations: **Hb:** Haemoglobin (g/dl); **THA:** Total Hip Arthroplasty; **TKA:** Total Knee Arthroplasty.



postoperative trigger at 8 g/dl, this can be raised to 10 g/dl in patients with active coronary artery disease and/or active heart failure. However, in view of the literature, the value of this transfusion threshold remains controversial. Indeed, Foss and al. (75) compared two transfusion strategies in 120 patients undergoing a hip fracture surgery: a liberal strategy (transfusion threshold of 10 g/dl) and a restrictive strategy (threshold to 8 g/dl). The authors reported a higher rate of blood transfusion in the liberal group, the same postoperative rehabilitation in the two groups, but a significant decrease in the occurrence of cardiovascular events and mortality in the liberal group. Using the same method, Carson and al. reported on a larger group of patients, nor significant decrease in hospital morbidity and mortality, nor improved postoperative functional recovery in a liberal blood transfusion strategy after hip fracture.

### 3 – Erythropoietin (EPO)

The use of preoperative blood saving protocol including EPO significantly reduces the rate of postoperative blood transfusion during THA (76) or TKA (77). A study published in 2005 (78) shows that only two EPO injections are sufficient to reach an hemoglobin level more than 13.5 g/dl in the majority of patients waiting for a major prosthetic surgery.

EPO is indicated with an anemia between 10 and 13 g/dl. This treatment has some contre-indications: recent cardiovascular events (myocardial infarction, stroke, severe hypertension). Its efficiency is directly correlated with the dose (600 IU/kg/week), the time between the first injection and the day of surgery, and the body iron stores of the patient. Thus it is proposed to optimize the preoperative use of EPO with the hemoglobin of the patient (79); it would also be preferable to add systematically an iron supplementation (80,81).

A recent study shows that the transfusion rate in the EPO group was lower than the non-EPO group: 14 and 50%, respectively (p < 0.01)(76). In a prospective, randomized, controlled trial (between 2004 and 2008) including 683 patients undergoing hip and/or knee arthroplasty, with a preoperative hemoglobin level between 10 and 13 g/dl, EPO was found to significantly reduce the number of patients requiring the use

of erythrocyte transfusion, but not the amount of erythrocytes transfused. However, costs due to EPO were €7300 per avoided transfusion (82).

4 – Treatment of iron deficiency Two cohort studies report the effects of preoperative oral iron therapy before primary TKA (83) and intravenously during 4 days before a surgery for hip fracture (84): it shows a decrease in postoperative transfusion. In 2008 some recommendations are published on the role of iron therapy as an alternative to transfusion (85). The experts reported a low to moderate benefice on the rate of postoperative transfusion with an intravenous iron supplementation; they found only an income in orthopedic surgery. Thus, it is recommended to treat a preoperative iron deficiency, with or without anemia (74,86) and to perform a routine iron supplementation treatment with EPO. Indeed, the stimulation of erythropoiesis increases the need for iron, the iron fixed to the transferrin is very quickly exhausted and iron reserves (with ferritin) will be mobilized. However, iron is not delivered quickly enough because of an accelerated erythropoiesis (by EPO).

The oral iron therapy is the first used because of its low cost and user. However, there are many limitations to the oral pathway (limited tolerance and compliance to treatment, significant onset of action, drug interactions and many factors of malabsorption) which tend to prefer the intravenously pathway preoperatively. Indeed its efficiency is higher (87,88) and the time needed to correct anemia is shorter. It was also demonstrated a superior efficiency and easier administration procedures with ferric carboxymaltose compared to iron sucrose (89). However intravenous ferric carboxymaltose exposed to a rare but serious risk of anaphylaxis, which requires only a hospital use in France today.

The choice of an oral or intravenous iron therapy depends on the medical history and tolerance of the patient, but also on the delay between treatment and surgery. A recent study (90) also reported the existence of a new marker, the hepcidin, initially studied in ICU patients (91); it is a regulator of iron homeostasis. Indeed, hepcidin levels could predict no responsiveness to oral iron therapy in patients with iron deficiency anemia (when the rate of hepcidin is higher than 20 ng/ml).

### 5 – Intraoperative blood salvage system or autologous blood transfusion

Spahn et al. (66) identified 11 studies reporting the effects of a blood salvage system compared to a standard drain with no blood reinfusion during a prosthetic surgery. The majority of studies reported a decrease of transfusion rate, of length of stay and time to ambulation. However the cost of this blood salvage system must be weighed against its profitability and its place in the global blood saving strategy; a recent study confirms that autologous blood salvage devices are not effective in sparing erythrocyte transfusion in patients undergoing hip and/or knee arthroplasty (82). Furthermore, in a prospective, randomized, controlled trial including 1,759 patients with a preoperative hemoglobin level greater than 13 g/dl (and therefore ineligible for erythropoietin) undergoing hip and/or knee arthroplasty, autologous intra- and postoperative blood salvage devices were not effective as transfusion alternatives. The use of this device in these conditions increased costs (92).

No current study has helped to define the population at risk requiring this system. It seems lawful not to use it systematically and prefer it to a population at high risk of bleeding.

6 –Tranexamic acid Tranexamic acid is an analogue of lysine and has an antifibrinolytic effect. Its efficiency on the bleeding is already proven. Indeed, two systematic reviews of the literature reported a decrease in the rate of transfusion in orthopedic surgery (93) and a decrease of bleeding after hemorrhagic surgery (94).

Tranexamic acid was also studied in a multicenter study about trauma patients (95): it significantly decreased bleeding and mortality without increasing adverse vascular events. A recent study confirms that the use of tranexamic acid reduces bleeding and the costs after primary hip and knee arthroplasty (96). The use of tranexamic acid would use unnecessary a blood salvage system for autologous transfusion after primary TKA or THA (97).

However the protocol for use of the tranexamic acid is not yet formalized. We know that its efficiency on the bleeding is dose-dependent, especially when the doses are repeated (93). We also know the duration of postoperative fibrinolysis after THA and TKA: it is about 18 hours with a peak at the 6th hour after the end of surgery (98). Thus it seems rightful to propose a protocol including repeated injections of tranexamic acid at a dose of 15 mg/kg in the incision, then at the third hour, then every 4 hours during the first night; this protocol should be modified in case of renal failure or significant postoperative thrombotic risk (79).

Furthermore, tranexamic acid does not significantly increase mortality or the occurrence of cardiovascular events during the postoperative period (93–96).

## CONCLUSION

The control of postoperative pain control after joint replacement surgery is closely linked to the concept of multimodal analgesia. It combines first systemic drugs analgesia represented by paracetamol, NSAIDs, gabapentin and ketamine, associated or not with opioid analgesia, especially because of low costs. In addition locoregional analgesia should be explored .but the recommendations on the type of locoregional analgesia are still not very clear, especially for knee arthroplasty. However, the cost - effectiveness study of these techniques have shown that the use of ultrasonographic techniques and perineural analgesia is better. The most significant point is that the cost of the multimodal analgesia is minimal and largely compensated by the saving in terms of hospital length of stay.

In addition to more restrictive « transfusion triggers », presently available allogenic blood conservation strategies in surgery include preoperative increase in red blood cells mass, techniques or pharmaceutical agents that reduce blood loss, and perioperative blood salvage. The most important pharmacological techniques are: EPO before surgery with a number of injections related to baseline haemoglobin, and tranexamic acid during and after surgery. Cell saving is used only if the importance of bleeding is high enough like in revision arthroplasty. The choice of a technique should take into account the delay before surgery, the anticipated blood loss, the tolerance of blood loss without transfusion, and the efficacy of the blood conservation technique.

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