

Effects of Tourniquet in Total Knee Arthroplasty

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Abstract

Tourniquet has long been used in TKA (Total Knee Arthroplasty) as the other orthopedic procedures for decreasing operation time and blood loss, providing better visualization of anatomic structures. While having much more advantages, these devices have a potential of serious complications, so they must be used with adequate knowledge and attention. Paralysis, compression neuropathy, compartment syndrome, prolonged period of rehabilitation, edema, pain, skin problems, nerve damage and systemic problems are the some complications seen. Selections of appropriate blood pressure, cuff selection, tourniquet timing are the essential points of tourniquet use. Through these increasing complication rates and improvements in the surgical and anesthesia methods contrary to old beliefs, surgery has been preferred without tourniquet in the patients who have no cardio-vascular problems and morbidity. In the patients who have any contraindicated situations as stated above, TKA must be performed with tourniquet, with proper control of the amount of pressure and the duration of application, the risk of complications decrease, in the other situations TKA can be performed without tourniquet with the aims for fast-recovery, post-surgical pain relief and better muscle activity. The objective of this paper is to describe current perspectives of tourniquet use in total knee arthroplasty.

Keywords

Tourniquet, Total Knee Arthroplasty

1. Introduction

Jean Lous Petit firstly introduced tourniquet to surgery in 1718 [1]. Intra and Post-operative mean blood loss

about 1000 - 1500 cc, transfusion requirement of much more patients, ABO incompatibility and infections due to immunosuppression have made mandatory these instruments in the extremity surgeries. Providing better visualization of anatomic structures, facilitation of sementing and other surgical procedures, decreasing the blood loss in the operation are the advantages of tourniquets [2] [3].

Total knee arthroplasty (TKA) is one of the major orthopedic operations and tourniquet has long been used for decreasing operation time, blood loss, inflammation and muscle-tissue damage in this procedure [2] [3]. While having much more advantages, these devices have a potential of serious complications in the patients of total knee arthroplasty, so they must be used with adequate knowledge and attention. Paralysis, compression neuropathy, compartment syndrome, prolonged period of rehabilitation, edema, pain, skin problems, nerve damage and systemic problems are the some complications seen in TKA as in the other major orthopedic procedures [4].

The objective of this paper is to describe current perspectives of tourniquet use in total knee arthroplasty.

2. Essential Points of Tourniquet Use

2.1. Selecting of Appropriate Blood Pressure

Most preferred pressure for upper extremity is 200 mmHg and 250 mmHg for lower extremity. Olivecrona *et al.* reported that the risk of perioperative complications increased when the mean cuff pressure was more than 293 mm Hg [5]. Previous studies have shown that with the higher amounts of tourniquet pressure and prolonged tourniquet time, the risk of postoperative complications such as DVT, wound complications, and deep infection increased [4] [6] [7]. When the appropriate blood pressure determining, arterial occlusion pressure is taken into account instead of systolic blood pressure. It is measured with stethoscope, doppler flowmetry and pulse oximeter, and is the lowest pressure that prevents the circulation. Optimal Tourniquet pressure must be in these intervals Arterial occlusion pressure + safety interval [8].

- AOB+ 40 mmHg (AOB < 130 mmHg).
- AOB+ 60 mmHg (AOB 131 - 190 mmHg).
- AOB+ 80 mmHg (AOB > 190 mmHg).

2.2. Cuff Selection

Appropriate tourniquet length must be half of the extremity diameter. It must be implemented most proximal circular area to the incision. Due to the effective bleeding control with lower pressure, the wider tourniquet must be used from extremity proximal to incision. 2 fingers can be able to enter both of the distal and proximal of the cuff. Cuff ends must overlap 7 - 15 centimeters not to be longer or shorter. When the diameters of the extremity proximal and distal diameters are equal cylindrical tourniquet; if the proximal diameter is thicker than distal cone, tourniquet must be chosen [9].

2.3. Tourniquet Timing

Tourniquet timing is an essential part of the major orthopedic operations and it is known to be performed short as much as possible, not excess for 120 minutes, if it is to be excess deflate and inflate again [6]. The prolonged duration of tourniquet used is thought to be the crucial factor for complications, which induced longer ischemic time for tissues. Harvey *et al.* [10] reported that prolonged tourniquet application is associated with more bleeding after deflation because of increased fibrinolytic activity. Sherman *et al.* [11] stated that there is a moderate risk of complications when tourniquet is performed between 40 and 60 minutes, there is a high risk when performed above 60 minutes in his study of 2640 arthroscopic procedures. Jorgensen [12] reported that performing the tourniquet application under the duration of 150 minutes, significantly reduces the risk of complications. Wound oozing and nerve injury are the significant complications reported with prolonged duration of tourniquet [13]-[15].

For the aim of reducing the prolonged tourniquet time some investigators advised tourniquet release before wound closure and declared that tourniquet release after wound closure could cause more excessive inflammation and muscle damage, minimizing blood loss and contribute to less discomfort postoperatively and earlier functional recovery [16]-[18]. Tourniquet release before wound closure for hemostasis reduced the risks of overall complications and major complications. Every prolonged application of 10 min of time was associated with an increased risk for complications [19]. Some studies stated that better subjective performance and earlier

functional recovery were observed at early postoperative follow-up with early tourniquet release [17] [20]. However, other investigators have reported conflicting results [21] [22]. Zeyu Huang [23] stated that tourniquet release after wound closure for hemostasis could significantly decrease the total measured blood loss in patients treated with TKA. Wei Zhang *et al.* [24] compared outcomes RCT studies of tourniquet release before wound closure for hemostasis with tourniquet release after wound closure and stated there were no significant differences in the hemoglobin drop, overt blood loss, rate of transfusion, and volume of transfusion between tourniquet release before wound closure for hemostasis and tourniquet release after wound closure in TKA. Widman *et al.* found no difference in the range of motion between the early and late release group at the first postoperative follow-up 2 - 3 months after TKA [25].

3. General Complications of Tourniquet

There are a number of complications, both local and systemic. However, rates of complications are rare. Some of them can be devastating, and may cause permanent loss of function, or damage to the limb. Complications are commonly due to mechanical compression of the structures due to ischemia, and reperfusion effects.

3.1. Local Complications

- Muscle-tissue ischemia.
- Paralysis, compression neuropathy.
- Compartment syndrome.
- Prolonged period of rehabilitation.
- Edema, pain.
- Skin problems.
- Nerve damage.

3.2. Systemic Complications

- Deep venous thrombosis, pulmonary embolism.
- Hyperkalemia, acidosis.
- Increasing in circulating blood volume.
- The possibility of cardiac decompensation.
- Central venous pressure—increase in systemic blood pressure.
- Tachycardia.
- Body temperature increasing.

3.3. Most Accused Reasons

- Long-term use.
- High pressure.
- Each patient in the same tourniquet.
- Inappropriate sleeve.
- Inability to protect skin.

4. Total Knee Arthroplasty without Tourniquet

Through these increasing complication rates and improvements in the surgical and anesthesia methods contrary to old beliefs, surgery has been preferred without tourniquet in the patients who have no cardio-vascular problems and morbidity. Thus fast-recovery and post-surgical pain relief is provided without tourniquet [17] [19]. Additionally due to the lack of local pressure or rhabdomyolysis; rapid return of knee flexion in the early post-operative period is provided [26]. H. M. Wakankar *et al.* [3] mentioned that patients without tourniquet have a faster recovery and better flexion gap in the early period (1 week); however, wound complications, deep vein thrombosis rates, pain control and range of motion in the 6 months of post-operative period is same between the tourniquet and non-tourniquet use. Nishikant Kumar *et al.* [27] evaluated pain in the patients with the comparison of non-tourniquet and tourniquet use in TKA with a prospective randomized control trial and declined non-tourniquet use in TKA provides less early postoperative pain and better recovery. Dennis *et al.* [28] stated that in

the patients who underwent TKA with tourniquet, quadriceps strength had diminished during the first 3 months after TKA. Hamstring strength did not differ between groups at any time point. David Liu *et al.* [29] evaluated effects of tourniquet use on Quadriceps Function and Pain in Total Knee Arthroplasty in a prospective randomized single-blinded study and found a significant difference in pain scores on 2 and 4 days. However there was no difference in Oxford knee scores, range of motion, or thigh and knee swelling up to 12 months of post-operative duration. Three patients in the tourniquet group required a blood transfusion whereas none in the non-tourniquet group did ($p = 0.05$). The tourniquet group showed significantly less muscle activity as measured by surface EMG than the non-tourniquet group; however, the energy output was similar between the two groups at 6 months of post-operative duration. Quadriceps functions returned to equivalent with the non-operative leg both of the tourniquet and no tourniquet group at post-operative 12 months.

Ta-Wei Tai [2] stated that the use of a tourniquet during TKA is effective for reducing blood loss and decreasing excessive postoperative inflammation and muscle damage. Patients have slightly less pain without tourniquet. They found no significant differences between tourniquet and non-tourniquet in terms of swelling, rehabilitation progress, or hospital stays.

Some agents have used for decreasing blood loss in the patients with no-usage of tourniquet lately.

Aprotin: It is serine protease analog that obtained from bovine lung and inhibits the final stage of fibrinolysis. However it has complications as allergy, thrombosis, nephrotoxicity and Spongiform encephalopathy.

Aminokaproik Acid: Acts for inhibition of plasminogen activation and decreases the risk of thrombus, thromboembolic complications and transfusion requirements.

Tranexamic Acid: It is a synthetic analogue of serin that inhibits fibrinolysis with inhibiting the lysine-attached regions of plasmin and plasminogen activator molecules. It has been used for cardiovascular surgery, urology, and gynecology for 20 years. Its effect starts after 10 - 15 minutes of infusion. The starting dose is 15 mg/kg and recommended two doses instead of single. It provides significant reduction in post-op bleeding, reduced risk of allogenic blood transfusion and tourniquet complications [1]. Peng-Fei Shen *et al.* [30] evaluated effectiveness and safety of tranexamic acid for TKA in a prospective randomized controlled trial found significant difference in post-operative 12-h drainage, post-operative 24-h D-dimer values, total drainage volume, hidden blood loss, total blood loss, and the rate of postoperative ecchymosis.

5. Conclusion

Tourniquet in TKA has much more advantages, however it is a potential of serious complications, so they must be used with adequate knowledge and attention. In the patients who have cardio-vascular problems, morbidity or any contraindicated situations, TDP must be performed with tourniquet. With proper control of the amount of pressure and the duration of application, the risk of complications decreases. In the patients have no problems as stated above, TDP can be performed without tourniquet with the aims for fast-recovery, post-surgical pain relief and better muscle activity. Some studies offer tourniquet release before wound closure for hemostasis or better post-operative functions however some studies state just the opposite so there is not enough evidence about the tourniquet release before or after wound closure.

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