

A clinical study of the Safe use of Tourniquet – A prospective observational study

Ravikiran H G^{1,*}, Adarsh T², Gowrahar³, Ravi Shankar⁴, Tushar Pimpale⁵

^{1,2}Assistant Professor, ^{3,5}PG Student, ⁴Professor, Dept. of Orthopaedics, JSS Hospital, Mysuru

***Corresponding Author:**

Email: ravikiranhg@gmail.com

Abstract

Introduction: This study was undertaken to evaluate LOP (lowest occlusion pressure) is superior to the other ways of usage of Pneumatic Tourniquets in Orthopaedics surgery i.e. Fixed and Systolic BP variant.

Materials and Method: 120 cases of both upper and lower limbs operated from period September 2013 to October 2015 are randomly included in the study after full filling the inclusion and exclusion criteria and managed using Fixed, Systolic BP and LOP, each of the groups included 40 cases and results were analysed according to final outcome using Ishii et al. grading, VAS Score criteria.

Results: In our study 120 cases managed by LOP has a better result when compared to fixed variant and Systolic BP variant in terms of less pressure needed to keep tourniquet, good operative field, pain score (VAS) at tourniquet application region and skin injury (reddening). Bloodless field was excellent in 33 patients {14 (35%) in LOP, 9(22.5%) in Systemic and 10 (25%) in Fixed Tourniquet variant. Among 120 patients, 11 (27.5%), 35 (87.5%) and 40 (100%) patients had experienced Skin abrasions/ Flaring were observed in the patient who underwent LOP, systemic and Fixed Tourniquet respectively. But no complications like compartment syndrome, deep vein disorder, paresis, nerve injury has occurred before and after surgery.

Conclusion: LOP is superior to all other ways of Tourniquet in terms of less pressure needed for elevating tourniquet, Good operative (bloodless) field, no skin abrasions.

Keywords: Pneumatic tourniquet, LOP, fixed (Conventional), Systolic BP.

Introduction

Modern pneumatic tourniquet traces its roots to the time of Roman Empire (199 BCE-500 CE) when non-pneumatic bronze-and-leather devices were used to control bleeding from limb amputations during the wars when the goal was to save a life without regard for the limb.⁽¹⁾ The term tourniquet was coined by Jean Louis Petit derived from the French verb "Tourner" meaning turn, he described a new screw-like device that tightens a belt to stop arterial blood flow.⁽²⁾ With the advent of General Anaesthesia, Joseph Lister was first to use a tourniquet to create a bloodless surgical field in 1864.⁽³⁾ In 1904 Harvey Cushing introduced the 1st inflatable (Pneumatic) tourniquet, thereby permitting tourniquet pressure to be monitored and manually controlled which made operations on extremities easier.^(5,6)

The modern pneumatic tourniquet was invented by James A McEwan in early 1980's which consists of an inflatable cuff, compressed gas source, microprocessor-controlled pressure regulator that maintains cuff pressure within 1% of set pressure.⁽⁷⁾ In some procedures, Tourniquet is a luxury tool, whereas in other situations it is a necessity. However, the tourniquet is a potentially dangerous instrument that must be used with proper knowledge and care. A pneumatic tourniquet is safer than an Esmarch tourniquet or the Martin sheet rubber bandage. A pneumatic tourniquet and an accurate pressure gauge probably is the safest.⁽⁶⁾

The need for this study is to evaluate LOP (lowest occlusion pressure) is superior to the other ways of usage of Pneumatic Tourniquets in Orthopaedics surgery i.e. Fixed and Systolic BP variant.

Materials and Method

On approval from the JSS ethical committee for the protocol of the study, 120 patients were prospectively chosen who were undergoing limb surgeries under general anesthesia in Orthopaedics department in JSS Hospital Mysore. These patients were randomly categorized into 3 groups while applying the pneumatic tourniquet to the limb. Patients with Open Fractures, Sickle cell anaemia, Peripheral artery disease, Compartment syndrome, Malignant tumours and Severe crush injury were excluded from the study.

Patient on the operating table and before induction of the general anaesthesia, preoperative blood pressure was measured for all the patients. After the induction of the general anaesthesia, the pneumatic tourniquet was applied over a thin roll of the cotton padding and was fixed with a roller bandage. Now three different protocols were followed for the three groups of patients. **Group I** or for fixed (Conventional) variant irrespective of Blood Pressure tourniquet pressure was set to a pre-decided and fixed pressure of 250mm of hg for Upper limb and 350mm of hg for lower limb.

Group II or for the systolic variant of the pneumatic tourniquet, tourniquet pressure was set to pre-induction Systolic BP + 100mm of hg for Upper limb and 150mm of hg for Lower limb.

Group III or for LOP variant of pneumatic tourniquet, blood pressure was measured of that particular limb, pulselessness was identified and confirmed by hand Doppler and tourniquet pressure was set with LOP pressure +safety margin.

Results

In our study 120 patients were managed by LOP, systemic BP and fixed tourniquet systems (FT) under general anaesthesia. Of which 86 males (71.66%) and 34 females (28.33%) were randomly selected and studied.

Of the 120 patients, 40 patients were managed by LOP [Males: 28 (70%) and females 12 (30%)], with fixed 32(80%) males and 8(20%) females and systolic pressure variant with 40 patients [males: 26(65%) and females 14(35%)].

Bloodless field was excellent in 33 patients {[14 (35%) in LOP, 9(22.5%) in Systemic and 10 (25%) in FT]}.

Further, pain at tourniquet site (postoperative 1-hour interval) the patients who underwent LOP had at an average of 5.8 VAS scale, 7.02 VAS scale with patients who underwent with systemic variant and 7.6 VAS scale was observed for those who underwent Fixed Tourniquet.

Among 120 patients, 11 (27.5%), 35 (87.5%) and 40 (100%) patients had experienced Skin abrasions/ Flaring were observed in the patient who underwent LOP, systemic and Fixed Tourniquet respectively.

Table 1: Quality of bloodless field

	Fixed UL	Systolic UL	LOP UL	Fixed LL	Systolic LL	LOP LL
Excellent	6	6	8	4	3	6
Good	14	14	12	16	17	14
Fair	0	0	0	0	0	0
Poor	0	0	0	0	0	0

Table 2: Age distribution of patients

	<10	10-20	20-30	30-40	40-50	>50
Fixed UL	1.	1.	4.	3	6	5.
Systolic UL	0	2	2	4	7	5
Lop UL	1	1	7.	4	3	4
Fixed LL	1	3	2	6	2	6
Systolic LL	0	0	6	2	5	7
Lop LL	1.	4	1.	5	6	3.

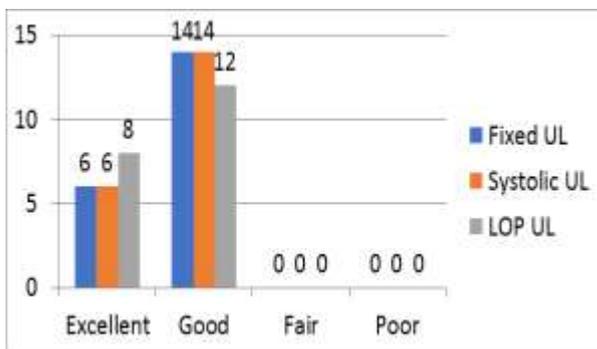


Fig. 1: Graph showing bloodless field in upper limb

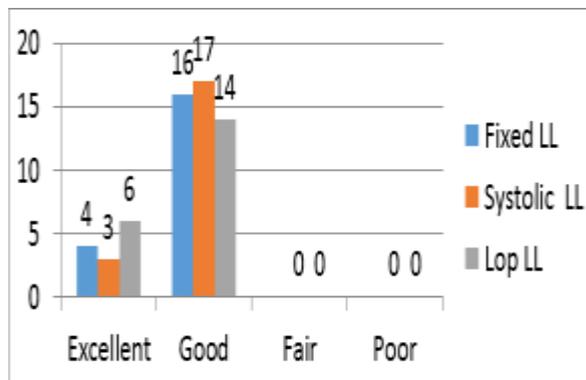


Fig. 2: Graph showing bloodless field in the lower limb



Fig. 3: Distal end radius fracture operated with buttress plate under LOP



Fig. 4: Bimalleolar fracture operated with fibula (plate and screw) medial malleoli CC screw under LOP

Discussion

A pneumatic tourniquet is commonly used in orthopaedic surgery to provide a clean, dry operative field, which improves visualization of anatomical structures and reduce operation time. Ideally, tourniquet should be applied for lowest pressure and shortest amount of time possible.

Omeroglu et al. reported a relationship between the use of pneumatic tourniquet and the intensity of post-operative pain in surgically treated ankle fractures.

Ochoa et al, Lundborg study suggest that localizes compression of nerve segment is a principal factor in the

pathogenesis of tourniquet paralysis.^(18,19) Tourniquet-induced pain is due to one of 3 reasons like nerve fibre related with pain transmitted along slow conducting unmyelinated C-fibres, during compression there is spontaneous firing activity in dorsal horn neurons around tourniquet application site and limb reperfusion pain when blood flow is restored and toxic metabolites removed.

The cause of blistering of skin is seepage of antiseptic solution into the padding beneath the cuff during skin preparation, resulting in a chemical burn. This is prevented by wrapping a plastic drape around the distal edge of cuff. Since the new way of tourniquet synchronized to lowest occlusion pressure of that particular limb, it needed less pressure than fixed (conventional) method and systolic blood pressure method. This can maintain Good to an Excellent bloodless operative field while minimizing potential complications. Thus, LOP way of tourniquet application appears to be reasonable and safe for use in orthopaedic surgery.

In a study of 164 patients who were undergoing Total Knee Arthroplasty, Charlotta Olivecrona et al⁽¹⁷⁾ has observed that the limb occlusion pressure method reduces the cuff pressure without reducing the quality of the bloodless field. However, there were no differences in outcomes between the groups (Conventional vs LOP) and patients with a cuff pressure of ≤ 225 mm Hg. This was concluded due to the fact that there were less postoperative tourniquet pain and no infections and a lower rate of wound complications in both control and experimental groups.

In our study as we have compared between three variants of pneumatic tourniquets, our results showed that LOP required less cuff pressure when compared to other variants and preoperatively the quality of bloodless field was excellent too good as commented by the operating surgeon. Postoperative complications like skin abrasions, tourniquet-induced pain were less when compared with other variants of pneumatic tourniquet.

Tejwani et al⁽¹⁶⁾ stated that a tourniquet pressure of more than 100mm of hg above the systolic blood pressure applied to the thigh in a normotensive, non-obese, patient, (cuff pressure of 250mm of hg) is sufficient compared to a commonly used fixed (conventional) 350mm of hg, to provide a sufficiently bloodless operative and minimize potential complications in surgery of foot and ankle.

In our study, we have taken pneumatic tourniquet pressure as, systolic BP+ 150mm of hg 1 for lower limbs and we have obtained good to excellent bloodless field, less pain over tourniquet region. These results were achieved with a less pressure when compared to the fixed (conventional) type of tourniquet.

Conclusion

This new tourniquet system synchronized with LOP is a reasonable device to maintain a bloodless surgical

field in orthopaedic limb surgery. It seemed to contribute to safety by lowering tissue pressure, preventing mid- and post-surgical complications. Systolic variant method and fixed variant method were next best method for use of tourniquet respectively. Although the incidence of complications in tourniquet usage is fortunately very rare, surgeons should choose a more practical tourniquet, such as the system used here.

References

- Noordin S, Mc Ewan JA, Eisen A, Masri BA. Surgical tourniquets in orthopaedics. *J Bone Joint Surg Am* 2009;91:295867.
- Klenerman L. The tourniquet in surgery. *J Bone Joint Surg Br.* 1962;44:937-43.
- Lister JB. Collected papers. Vol 1 Oxford: Clarendon Press; 1909. P 176.
- Von Esmerch F. First aid to the injured: Six ambulance lectures. HRH Princess Christian, translator. 6th ed. London: Smith, Elder and Co; 1898.
- Cushing H. Pneumatic tourniquets: with special references to their use in craniotomies. *Med. News.* 1904;84:557.
- Murphy CG, Winter DC, Bouchier-Hayes DJ. Tourniquet injuries: pathogenesis and modalities for attention. *Acta Orthop Belg.* 2005;71:635-45.
- Mc Ewan JA. Complications of and improvements in pneumatic tourniquets used in surgery. *Med Istrum.* 1982;15:253257.
- Crenshaw Jr AH & Witte DH Surgical technique and Approaches; Campbell's Operative Orthopaedics; 12th edition; (1). Mosby: Elsevier:2012.
- Mc Laren AC, Rorabeck CH. The pressure distribution under tourniquets. *J Bone Joint Surg Am.* 1985;67:433-8.
- Graham B, Breault MJ, Mc Ewan JA, Mc Graw RW. Perineural pressure under the pneumatic tourniquet in upper extremity. *J Hand Surg Br.* 1992;17:262-6.
- Graham B, Breault MJ, Mc Ewan JA, Mc Graw RW. Occlusion of arterial flow in the extremities at subsystolic pressure through the use of wide tourniquet cuff. *Clin Orthop Relat Res.* 1993;286:257-61.
- Pedowitz RA, Gershuni DH, Botte MJ, Kuiper S, Rydevik BL, Hargens AR. The use of lower tourniquet inflation pressure in extremity surgery facilitated.
- Warren PJ, Hardiman PJJ-P, Woolf VJ. Limb exsanguination. I. The arm: effect of angle of elevation and arterial compression. *Ann R Coll Surg Engl.* 1992;74:320-2. [PMC free article] [PubMed]
- Warren PJ, Hardiman PJJ-P, Woolf VJ. Limb exsanguination. II. The leg: Effect of angle of elevation. *Ann R Coll Surg Engl.* 1992;74:323-5. [PMC free article] [PubMed]
- Hampson NB, Piantadosi CA. Near infrared monitoring of human skeletal muscle oxygenation during forearm ischemia. *J Appl Physiol.* 1988;64:2449-57. [PubMed]
- Tejawani NC, Immerman I, Achan P, Egol KA, McLaurin T. Tourniquet cuff pressure: the gulf between science and practice. *J Trauma.* 2006;61:1415-1418. doi: 10.1097/01.ta.0000226159.84194.34.
- Charlotta Olivecrona, RN; Sari Ponzer, MD, PhD; Per Hamberg, MD, PhD; Richard Blomfeldt, MD, PhD. Lower Tourniquet Cuff Pressure Reduces Postoperative Wound Complications After Total Knee Arthroplasty. *J*

- Bone Joint Surg Am, 2012 Dec 19;94(24):2216-2221.
<http://dx.doi.org/10.2106/JBJS.K.01492>.
18. Ochoa J, Danta G, Flower TJ, Gilliatt RW. Nature of nerve lesions caused by a pneumatic tourniquet. *Nature*. 1971;233:265-6.
 19. Ochoa J, Flower TJ, Gilliatt RW. Anatomical changes in peripheral nerves compressed by pneumatic tourniquet. *J Anat*. 1972;113:433-55.