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Tourniquet Injuries In Hand Surgery: Prevention And Management In University of Calabar Teaching Hospital

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***Abstract*—Background: Tourniquet is commonly used in hand surgery to provide bloodless field that will facilitate dissection although fraught with complications. Aims: This study is aimed at identifying complications associated with the use of tourniquet in our practice as well as their prevention and management. Materials and Methods: Our cohort included 152 patients who underwent one of the most common procedures in the unit for hand trauma or infection, tumours including ganglion, syndactyly, trigger finger and camptodactyly with an average follow up period of 8 months. Exclusion criteria included incomplete notes, no documented post operative follow- up, pre-existing soft tissue damage or neurological lesion affecting the limb concerned. 25 patients were excluded because of incomplete or missing notes, 4 no follow-up records and 2 pre-existing nerve or soft tissue injury in the affected hand. Medical notes relating to the cohort were documented, the type of procedures, tourniquet time, adequacy of the bloodless field using the quantity of the estimated blood loss and any intra-operative or post-operative complications were also ascertained.Results: 121 patients fulfilled the inclusion criteria and were reviewed for the purpose of the study with male to female ratio of 1:1.6, average age of 45years ranging from 8 months to 72 years. A total of 5 post operative complications were identified: 2 nerve injuries, (neuropraxia which resolved within 6months and post operative tourniquet pain in 3 patients). The use of tourniquet was discontinued in 3 patients due to venous tourniquet effect with inadequate bloodless field. The duration of tourniquet varies between 30 minutes and 108 minutes with an average interval of 86 per 10minutes. Conclusion: The use of tourniquet is often followed with complications for which the pathophysiology, their preventive measures and management should be known by limb surgeons if they should arise.**

***Index Terms*—About four key words or phrases in alphabetical order, separated by commas.**

I. INTRODUCTION

Tourniquets are commonly used in hand surgery to provide bloodless field and facilitate dissection although it is fraught with some complications. It is important to minimize the complications associated with the use of tourniquet as well as understanding the principles of its usage and careful patient evaluation. The use of appropriate cuff size, duration of its application , pressure of application, appropriate padding and the use of the breathing period are some the measures to reduce these injuries. The management of obvious tourniquet injuries promptly could also help to reduce the final morbidity and mortality. The movement from tourniquet designed from rubber band to Esmarch tourniquet to pneumatic and S-MART tourniquets was intended to reduce the tourniquet associated injuries. Advances in the understanding of cellular mechanisms and specific mediators involved in ischaemia reperfusion injury may provide therapeutic modalities to improve the safety and possibly the duration of surgery under tourniquet control [1]. It is also important for hand surgeons to be familiar with the potential complications of using tourniquet in extremity surgeries as well as having the knowledge of pathophysiology of tourniquet induced injuries. However, prevention of the complication and prompt treatment if they should arise is very imperative.

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II. MATERIALS AND METHOD

Our cohort included 152 patients undergoing one of the most common procedures in our unit for hand trauma or infection, tumours including ganglion, syndactyly, trigger finger and camptodactyly with an average follow up period of 8 months. Exclusion criteria included incomplete notes, no documented post operative follow- up, pre-existing soft tissue damage or neurological lesion affecting the limb concerned .Twenty-five patients were excluded because of incomplete or missing notes, 4 no follow-up records and 2 pre-existing nerve or soft tissue injury in the affected hand .We reviewed all medical notes relating to the cohort and documented the type of procedures, tourniquet time, adequacy of the bloodless field using the quantity of the estimated blood loss and any intra-operative or post operative complications.

III. RESULT

121 patients fulfilled the inclusion criteria and were reviewed for the purpose of the study with male to female ratio of 1:1.6 and an average age of 45years, ranging from 8 months to 72 years. A total of 5 post operative complications were identified: 2 nerve injuries, that is, neuropraxia which resolved within 6months and post operative tourniquet pain in 3 patients. The use of tourniquet was discontinued in 3 patients due to venous tourniquet effect with inadequate

bloodless field. The duration of tourniquet varies between 30 minutes and 108minutes with an average interval of 86 ± 10mins.

IV. DISCUSSION

Tourniquet application dates back to antiquity. It is commonly used by limb surgeons. As a hand surgeon, tourniquet is one item among our armamentarium. It is associated with some potential complications despite its frequent usage. Attempts have been made to reduce the complications but it is still present .The advantages of tourniquet include the provision of a bloodless field which facilitate dissection and thereby reduce operation time and blood loss at surgery is minimized.

The term tourniquet was coined by Louis petit which was derived from the French word "tourner" meaning 'to turn' in 1718. Von Esmarch advanced the design in the late 19th century, adding a concentric flat rubber bandage wraps before Harvey Cushing introduced the first pneumatic tourniquet in 1904. Its use has become almost routine since, as the use of a bloodless field has become an integral part of limb surgery. Modern pneumatic tourniquets are designed to minimize the incidence of potential complications but their use is still associated with potentially serious morbidity [3, 4] and mortality [5]. However, in resource poor hospitals the use of rubber bandage and Esmarch tourniquets is still invoked.

Before the tourniquet application, the limb is exsanguinated by elevation and /or using Esmarch bandage or tourniquet exsanguinators to empty the blood vessels from the distal end to the proximal end before its application. The advantages include establishing a clear operating field, reducing overall blood loss and reducing the risk of microemboli at the time of release. This exsanguination of blood from the peripheral circulation into the central circulation [7], increases cardiac output. The optimal timing and angle of elevation for maximal exsanguinations of arm has been shown to be 5 minutes at 90o [8].

The use of optimal pressure could prevent extremity injury. The pressure to which the cuff should be inflated is dependent on a number of variables, including the patient's age, blood pressure and the shape of and size of the extremity in question, as well as the dimensions of the cuff. Lower tourniquet pressures to achieve haemostasis may be tolerated in younger patients due to youthful vessel compliance [9]. There are a number of methods described to determine the optimal inflation pressure for extremity surgery. One method is to add 50-75mmHg above arm systolic blood pressure for surgery on the upper limb [10]. Alternative includes adding 50-75mmHg to the pressure required to obliterate the peripheral pulse on Doppler probe [11]. The optimal pressure used was 100mmHg above systolic blood pressure for over 90 minutes in the hand surgery. Shaw et al [12] recommended that the lowest tourniquet pressure that maintains a bloodless field should be used [13].

Velband or soft band should be applied as it is found to be safe and cost effective skin protection beneath the tourniquet [14]. This has prevented skin burns. Excessive tourniquet time or poorly placed tourniquets may cause cutaneous abrasion, blisters and even pressure necrosis. Skin burns have also been reported in alcohol based skin preparation [15]. Adequate padding is therefore recommended.

The safe duration and pressure for tourniquet use remains a controversy. Horlocker et al [16] have found a strong correlation of nerve injury with prolonged total tourniquet time with an approximate three-fold increase in the risk of neurological compliance for each 30 minutes increase in tourniquet inflation. In our study , we found 2(0.012%) with radial nerve injury following the use of rubber band produced from motor cycle tube but none from the Esmarch tourniquet patients in the cohort. This was due to the excessive uncontrollable pressure used with tube tourniquet. The incidence of tourniquet related nerve injury varies in literature but it appears uncommon ranging from 1:750-1:11000 in the upper limb surgery [14]. The radial nerve is more prone to injury [14, 17], in the upper extremity.

Another precaution is to use broad tourniquet cuff of about 6-14cm for better transmission of tissue pressure. Mechanical pressure seems more important in the causation of the injury than distal ischaemia [18]. Compression of the nerve causes micro-vascular congestion and oedema, causing inadequate tissue perfusion and axonal degeneration [19]. High tourniquet pressures and faulty pressure gauges are implicated in many reports; example Esmarch tourniquet generates pressure in excess of 1000mmHg immediately under the tourniquet [20]. Excessive continuous compression times cause a higher likelihood of neuropathy and delayed recovery of function [21].

The muscle destruction in tourniquet application is time dependent. A time dependent hypoxia and acidosis in venous blood taken distal to the cuff has been demonstrated in humans [22]. Application of the inflated tourniquet cuff causes interruption of blood supply leading to tissue hypoxia, hyperkalaemia and acidosis. High energy phosphate depletion results in loss of membrane potential of the ischaemic myocytes due to failure of the sodium pump with leakage of potassium into the interstitium. There is elevation of serum creatine phosphokinase concentration locally and distally if the ischaemia exceeds 1.5hours [23], and intracellular adenosine triphosphate [ATP] is depleted after 3hours of ischaemia, metabolic recovery of muscles is impaired [24]. One way of preventing muscle ischaemia is the so- called 'breathing period" whereby the tourniquet is released during surgery for a period of time then re-applied for a second or third period of ischaemia time. The unfortunate thing is that the subsequent ischaemia time is not known but some authors believed that it ranges from three to twenty minutes [18, 25].

Tourniquet release prior to wound closure is associated with significantly greater blood loss and demands in blood transfusion suggesting release after wound closure would offer better control [26].

Following tourniquet application, the leakage of potassium, the major intracellular cation leads to hyperkalaemia in the early reperfusion period and has been implicated in sudden death [27, 28]. Methods to minimize this risk include ensuring the availability of agents to reduce acidosis and hyperkalaemia respectively, and a high index of suspicion for

such problems.

Reperfusion syndrome is a complication of tourniquet use. The re-establishment of blood flow following a period of ischaemia is essential to restore energy and remove toxic metabolites but reperfusion can induce a paradoxical extension of ischaemic damage [29]. An important component in the pathogenesis of reperfusion syndrome is the upregulation of surface adhesion molecules on the vascular endothelium and their subsequent interaction with the activated neutrophils [30, 31]. Transendothelial migration of neutrophils, with release of reactive oxygen species and cytokines causes further damage to the injured tissue. There are two main effects: the local effects that cause an exacerbation of the regional ischaemia, and the systemic effects that cause secondary organ failure remote from the ischaemic site. This could be modulated by infusion of fluid to flush and dilute these toxic metabolites during and immediately after surgery.

V. CONCLUSION

Tourniquet is commonly used in hand surgery to provide a bloodless field and to ease dissection of the tiny structures therein. Tourniquet has some complications for which the pathophysiology, their preventive measures and management should be known by limb surgeons if they should arise. A thorough patient evaluation and careful precautionary measures in tourniquet application should be undertaken to avert these complications.

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