Composite Sterile Aneroid Sphygmomanometer And Rubber Bandage Tourniquet: Indications, Techniques and Results

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Citation

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Abstract

Safety and ease of application are features of modern tourniquets such as the pneumatic tourniquet. The relatively high cost of purchase and maintenance has limited the availability of pneumatic tourniquets in most hospitals in developing countries where the rubber bandage tourniquet remains the only effective option available to orthopaedic surgeons. To improve on the safety profile of rubber tourniquets, we combined sterile rubber bandage and aneroid sphygmomanometer to provide a composite sterile tourniquet that could be applied and removed by the surgeon after scrubbing and draping the patient. Application of the tourniquet after preparation and draping of the patient's skin ensured that greater part of the tourniquet time was devoted to the actual procedure. This article presents the indications, techniques and results of using this composite sterile aneroid sphygmomanometer and rubber bandage tourniquet.

INTRODUCTION

Temporary cessation of circulation in a limb with the aid of a tourniquet helps to control bleeding and create bloodless field for easy and accurate surgical dissection. Tourniquet-induced bloodless field surgery is an integral part of most operations on the extremity. The pneumatic tourniquet has been established as a safe device.[1] Although the rubber bandage tourniquet is also in use, its safety is a major concern because of the difficulty in determining the pressure exerted on the tissue beneath it. Tourniquet safety is related to the pressure and duration of application which is directly proportional to the occurrence of complications. The pressure applied to the limb could easily exceed the safe limits because the rubber bandage is capable of generating pressures in excess of 1000mmHg beneath it[2] and put the limb at risk of complications. Indeed stretching the rubber bandage after each wrap increases the pressure underneath the bandage by three to four times the initial pressure.[3]

The relationship between high pressure and neurovascular deficit makes the use of the rubber bandage as tourniquet risky. The accurate and reproducible control of the circumferential compression pressure applied to a limb[4] and ease of inflation and deflation from a distance without encroaching on the sterile field are the main advantages the pneumatic tourniquet has over the rubber bandage tourniquet. But the need for regular maintenance and calibration are drawbacks to the use of pneumatic tourniquets in hospitals in developing countries where there is paucity of personnel. The rubber bandage tourniquet is a widely used alternative to the pneumatic tourniquet in such hospitals.

The cardinal disadvantages of the rubber bandage as tourniquet are the inability to ascertain the compressive force applied to the limb and the need to apply it before the commencement of draping. A new technique of application of the rubber bandage tourniquet that enabled the determination of the pressure applied on the tissues has been described.[5] However, this technique failed to address the inability to apply, remove and reapply the rubber bandage tourniquet without attendant risk of contaminating the operating field. A safe tourniquet's indispensability in orthopaedic practice is well established. It is also true that in those places where the pneumatic tourniquet is not readily available the need for safe and affordable tourniquets cannot be wished away. A modification of the technique referred to above was made to provide a sterile composite tourniquet which is safe and easy to apply. The modifications made to the technique[5] were sterilization of the rubber bandage, cotton wool and aneroid sphygmomanometer before application. In addition, during the application pressure was

exerted using the sphygmomanometer instead of using the bandage. The rationale for sterilizing the components of the tourniquet was to enable the application of the tourniquet by the scrubbed surgeon after the patient has been draped. Compressive exsanguination with the rubber bandage was not done in order to avoid the occasional complication of embolism associated with it.[6,7] I have used this composite tourniquet to carry out surgery on the upper and lower extremities and hereby present a report on the technique of application, its safety profile and effectiveness.

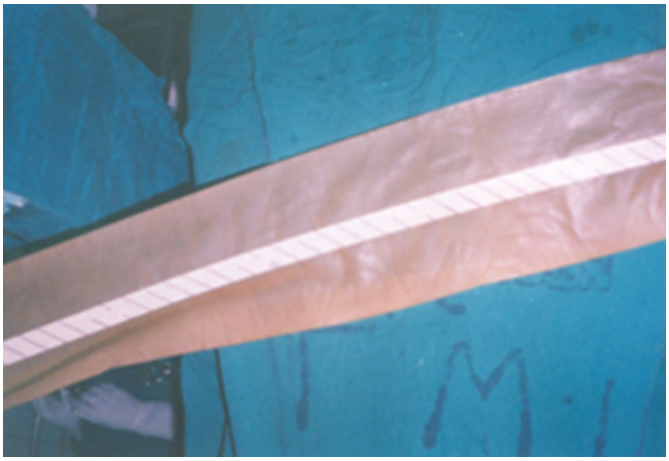
PATIENTS AND METHOD

This is a case series of one hundred and eighteen patients who had surgical operations on the upper or lower extremity using a new sterile composite tourniquet which was assembled from sterile rolls of cotton wool and rubber bandage and aneroid sphygmomanometer. Patients undergoing surgery on the extremities at the level of the knee or elbow and below made up the cohort. Sickle cell anaemia patients and patients with vascular insufficiency of any origin were excluded from the study. Also excluded were infants and those older than sixty-five years.

The procedures were done in the University of Benin Teaching Hospital, Benin City, Nigeria from November 2002 to June 2006. The demographic features of all the patients were recorded as well as their clinical features during the period of hospitalization and follow-up. A composite tourniquet designed to combine a sterile roll of cotton wool and rubber bandage with a sterile aneroid sphygmomanometer cuff and gauge was applied for every patient. The composite tourniquet enabled the determination of the pressure exerted on the tissue. The tourniquet was applied on already draped patients by the scrubbed surgeon. The device comprised of an autoclave sterilized soft rubber bandage of two metres in length, 15 centimetres in breadth (Figure 1) and an aneroid sphygmomanometer, with a cuff width of 15 centimetres and a hand-held gauge, which had been disinfected by soaking in 2% glutaradehyde solution for 30 minutes.

Figure 1

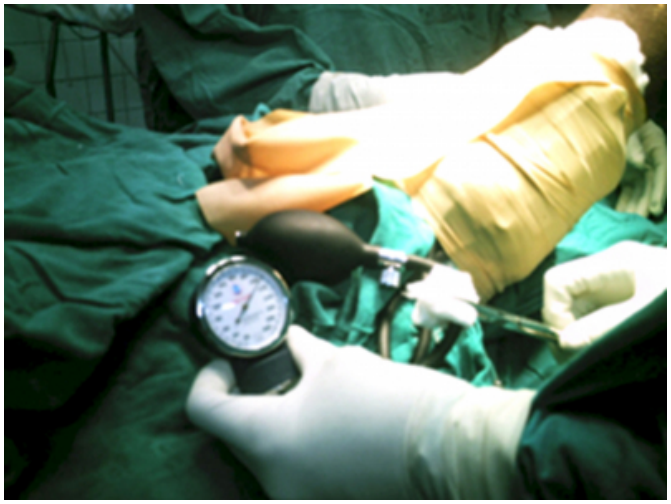
Figure 1: The sterile rubber bandage tourniquet with autoclave tape showing effective sterilization



Prior to the application, exsanguination of the limb was done by elevation of the limb for ten minutes at 60° to the horizontal. A protective 5mm thick layer of sterile cotton wool was applied on the limb and over it was applied the sterile aneroid sphygmomanometer cuff. The sterile rubber bandage was then applied snuggly over the cuff. The tightness of the rubber bandage was such that it did not cause a reduction in the volume of the dorsalis pedis or radial artery pulsation. The inflatable balloon of the aneroid sphygmomanometer was inflated until the gauge reached the maximum estimated pressure for the patient. The maximum tourniquet pressure for each patient was estimated prior to anaesthesia by adding 150mmhg to the highest systolic blood pressure reading in the last 24 hours prior to surgery for lower limbs and adding 100mmHg for upper limbs. The tubing of the aneroid sphygmomanometer was then clamped with artery forceps (Figure 2) and the device was concealed with a sterile drape.

Figure 2

Figure 2: Application of sterile composite tourniquet comprising of sterile rubber bandage and aneroid sphygmomanometer on an already draped patient.



The surgeon then wore a fresh pair of gloves. The time of application and removal of the device and the amount of haemorrhage in the course of surgery were noted. Also noted was the need to deflate the tourniquet before the completion of the procedure. The absence of arterial pulsation and superficial venous distension distal to the tourniquet were used as evidence of adequate arterial and collateral arterial occlusion. The maximum allowable tourniquet time was 150minutes. The patients were evaluated for the presence of paresis or paralysis, reactionary haemorrhage, haematoma, compartment syndrome, digital necrosis, wound infection and blistering of the skin at the site of application of the tourniquet within 24 hours and in five days after surgery and then monthly during follow-up for a period of twelve months. During the follow-up visits the presence of swelling, stiffness and pain in the hand or feet was taken as evidence of post-tourniquet syndrome if it persisted beyond twelve weeks after surgery.

RESULTS

Twenty-nine patients had operations on the elbow, forearm, or hand while eighty-nine patients had operations on the knee, leg, or foot. Thirty-seven of the patients were females while eighty-one were males. The patients' mean age was 28.24 14.12 years (range 2 to 64 years). The sex and age distribution of the patients are shown in Table 1.

Figure 3

Table 1: Age and Sex distribution of patients

Age range	Males	Females	Total	%
01-10	14	11	25	21.2
11-20	16	7	23	19.5
21-30	12	6	18	15.3
31-40	19	7	26	22.0
41-50	9	3	12	10.2
51-60	7	2	9	7.6
61-70	4	1	5	4.2
Total	81	37	118	100

The mean tourniquet time was 62.12 .06 minutes (Range 20 to 150 minutes). There was no case of ineffective tourniquet effect or loss of tourniquet pressure in the course of surgery in all the patients.

In 93 limbs the tourniquet was in place for 120minutes or less. Twenty-five patients had the tourniquet on for more than 120minutes but not exceeding the maximum time of 150minutes. In all those patients who had the tourniquet on for 120minutes and less, there was no complication attributable to the use of the composite tourniquet. No case of digital necrosis, nerve palsy, or blistering of the skin was recorded in any patient regardless of the duration of application. All but four operations were completed before removal of the tourniquet. Twelve of the patients who had the tourniquet in place for between 120 and 150 minutes had one or more complications (Table 2).

Figure 4

Table 2: Correlation between tourniquet time and complications

Variable	≤120minutes Tourniquet time	121-150 minutes tourniquet time	Total
Number of patients	93	25	118
Primary haemorrhage	0	4	4
Reactionary haemorrhage	0	12	12
Haematoma	0	3	3
Compartment Syndrome	0	1	1
Digital Necrosis	0	0	0
Blisters at site of application	0	0	0
Paresis	0	0	0
Paralysis	0	0	0
Wound infection	0	1	1
Post tourniquet syndrome	0	1	1

DISCUSSION

This study showed that the composite tourniquet which consisted of a roll of sterile cotton wool, a sterile rubber bandage and an aneroid sphygmomanometer was able to achieve effective and safe tourniquet effect with acceptable risk of complications. It has shown that it is possible to apply a rubber bandage tourniquet with objective assessment of the tourniquet pressure. This offers solution to the problem of indeterminable underlying pressure which is a reason for the poor safety margin of the rubber bandage tourniquet and it seems to have improved on the safety of the rubber bandage tourniquet. In addition, the sterility of the device enabled the surgeon who had scrubbed to apply the tourniquet on the already draped patient. This definitely afforded the surgeons more time for the operation under the effect of the tourniquet and may indeed be responsible for the low number of cases that were not completed before removal of the tourniquet. The wound infection rate of 0.85% is considered tolerable in an orthopaedic practice.

Abraham and Amirouche[3] had in a previous study established that the force exerted by the Esmarch bandage is thrice or four times the initial pressure applied. It remains a difficult task to determine the initial pressure which certainly would vary from one individual to the other. Excessive or insufficient pressure and application for too long are factors that may increase the risk of tourniquet related complications.[8] The rubber tourniquet in its unmodified form could be associated with excessive or inadequate pressure which could cause direct damage to nerves in particular. The use of the rubber bandage for bloodless field surgery had been condemned on account of the inability to determine the pressure beneath it.[9] However, the incorporation of sterile and pressure determinable components to the rubber bandage tourniquet had made it possible to apply the tourniquet with known tourniquet pressure. Indeed, the ability of the surgeon to apply and remove the tourniquet personally surpasses the erstwhile advantage of the pneumatic tourniquet over the rubber bandage tourniquet. Exsanguination was done by elevation because of the potential risk of thrombo-embolism associated with exsanguination by compression with a rubber. [6,7] In addition, exsanguination by elevation enhanced identification of small blood vessels for appropriate haemostatic measures in order to prevent reactionary haemorrhage. The 100% safety in those patients who had the tourniquet on for 120minutes supports the opinion that 2hrs is the ideal safety margin of a tourniquet.[10]This notwithstanding this study also found no serious or long term complications associated with tourniquet time of between 120-150 minutes. Premature removal of the tourniquet before completion of surgery was 3.38% as compared to 10.3% in a study done using non-sterile composite rubber bandage and aneroid sphygmomanometer tourniquet.[5]

This sterile composite tourniquet which was made from the rubber bandage and an aneroid sphygmomanometer is easy to apply and requires no extraordinary measures to assemble and is readily affordable. This tourniquet should find use in any setting including those where the pneumatic tourniquet is available because of its safety profile and the ability to apply it on the draped patient and the capacity of the surgeon to control its application and removal. One possible drawback is the risk of leaving the tourniquet on the patient's limb after surgery because of its portability. To prevent this it is advisable that such tourniquets should be clamped to the sterile drapes and the circulating and scrub nurses should be actively involved in recording the application and removal of the device.

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