Tourniquet Pain: Calf versus Ankle Tourniquet

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The tourniquet pain during 30 minutes after the application of calf tourniquet and ankle tourniquet were assessed and compared in 63 healthy volunteers, 32 males and 31 females whose ages ranged from 21-36 (average, 24) years. The visual analogue pain score assessed at 0, 1, 3, 5, 10, 20, 30 minutes of adequate tourniquet pressure application and after removal of the tourniquet at 0, 5 and 30 minutes were recorded. The results revealed significant less visual analogue pain scores with the ankle tourniquet group (range, 0-4.4 mmHg) than the calf tourniquet group (range, 0-6.7 mmHg) at all time-points of evaluations and the tourniquet pain was also diminished faster in the ankle tourniquet group after the tourniquet was removed. It was also found a significant higher minimal tourniquet pressure required for the vascular occlusion distal to the tourniquet sites detected by a pulse oximeter in the ankle tourniquet group (mean, 310.8 $\pm$ 40.8 mmHg) than the calf tourniquet group (mean, 272.5 $\pm$ 36.9 mmHg, p = 0.024). The present study supports the use of ankle tourniquet to minimize tourniquet pain for foot surgery.

Keywords: *Tourniquet, Pain, Hemostasis, Bloodless field*

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The pneumatic tourniquet is commonly used for extremity surgery. The application was first described in 1904 by Harvey Cushing[1]. The application of tourniquet is to reduce intra-operative blood loss and create the bloodless field for the precision and visualization during the operation[2]. Although the modern tourniquet equipment has been designed to minimize complications, the tourniquet use is also associated with tourniquet pain and discomfort. To minimize the pain problem, the lower but effective pressure and the application of distally placed tourniquet for extremity surgery have been described[3,4]. However, it remains a controversial issue between the benefit and risks of distally placed tourniquet for many years[1,3,5,6]. From our experiences of foot surgery in Siriraj Hospital, most operations can be operated under local anesthesia using pneumatic tourniquet that applied around the thigh or leg. However, it was found that the application of both sites produces some intolerable pain to the patients within a short period of the tourniquet application. This will require other anesthetic method to overcome the problem. Currently the use of ankle tourniquet has been described for forefoot and mid-foot surgery under local anesthesia. It was found that the patient can tolerate a longer duration with the application of ankle tourniquet with only local anesthesia may be adequate[7]. However, there is a limited of information concerning the tourniquet pain and tourniquet pressure required for the application of the ankle tourniquet in comparison to the calf tourniquet. The authors therefore conducted the present study to compare the tourniquet pain during its application and after removal and the pressure requires for the application between the calf and the ankle tourniquet.

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Material and Method

The present study was approved by the institution review board. The present study was carried out in healthy volunteers between ages 18-50 years old. All the volunteers gave informed consent prior to the present study. The exclusion criteria were as followings: underlying diseases that cause insensate foot such as diabetes, peripheral neuropathy, history of peripheral vascular or nerve injury, history of analgesic drugs usage in 1 week, abnormal physical finding of peripheral vascular or vascular status detected before the intervention.

Prior to the present study, the volunteers were informed about the method and risk in the

usage of pneumatic tourniquet in both anatomic locations. The present study was performed in the orthopeadic operating room. The subjects were divided into 2 groups. The first group was performed under the use of calf tourniquet, which applied the tourniquet at 5 centimeters below the fibular head. The second group was performed under the use of the ankle tourniquet, which applied the tourniquet just above both malleoli. After the first study, after 30 minutes of tourniquet removal, then both groups were switched to another studies using contralateral side. The minimal tourniquet pressure that can occlude the vascular flow determined by pulse oximeter at distal part of the extremity was used in both groups. The tourniquet was applied for 30 minutes and then the tourniquet was released. The tourniquet pain was evaluated using the visual analogue pain scores at 0, 1, 3, 5, 10, 15, 20, 25, 30 minutes after the occlusion pressure was applied and at 0, 5, 30 minutes after the releaseof the tourniquet.

The demographic data of all subjects in term of sex, age, weight, height, calf and ankle circumferences were recorded. The minimal tourniquet pressure of the application, the severity of tourniquet pain assessed by using visual analogue pain scores were also collected. The paired t-test for parametricand Mann-Whitney-U test for non-parametric tests were used for statistical evaluation respectively. The p-value below 0.05 was considered significant.

Results

There were 63 healthy volunteers (32 males and 31 females) enrolled in the present study. The mean age was 24 (range, 21-36) years old, mean height was 167.5 (range, 155-187) centimeters, mean weight was 61.8 (range, 45-88) kilograms. The details of demographic data is shown in Table 1. There was no significant difference in demographic data of both groups.

From the present study, results revealed significant higher minimal tourniquet pressure required for the ankle tourniquet 310.8 $\pm$ 40.8 mmHg compare with the calf tourniquet 272.5 $\pm$ 37 mmHg, respectively ($p = 0.024$). There was also a significant lower visual analogue pain scores at any time of evaluation, from 0 to 30 minutes of application, in the ankle tourniquet group as shown in Table 2. The tourniquet pain was also resolved faster in ankle tourniquet group.

Discussion

From the past there are several studies about the safety and efficacy of the pneumatic tourniquet in the different sites of both upper and lower extremities such as arm, forearm, thigh, calf and ankle tourniquets[2-7]. In the present study revealed a significant higher minimal tourniquet pressure required for the ankle tourniquet compared with the calf tourniquet and this result was different from the previous study of Finsen in 1997 that reported nearly equal minimal tourniquet pressure in both ankle and calf tourniquets (247 and 248 mmHg, respectively)[6]. The reasons for the difference of minimal tourniquet pressure of both sites of tourniquet application may due to the different in contour at the ankle and calf and the volume of the muscle mass at the area of tourniquet application. In the calf area, the contour was more cylindrical and more muscle mass thatenhances the effectiveness of tourniquet application and the effective distribution of the tissue pressure underneath of the tourniquet. This may result in lower minimal tourniquet pressure required to obliterate the vascular flow at the area of tourniquet application.

From the present study, there was significant lower visual analogue pain scores in the group of ankle tourniquet as shown in Table 2. The finding was different to that of Finsen report which demonstrated no different in pain score between the use of calf and ankle tourniquets[6]. However, in the present study the patients received some local anesthesia. Same as the report from Udomwanasin and Mahaisavariya in 1996[8]

Table 1. Demographic data

	Mean	SD	Range
Age (years)	24.0	3.0	21-36
Height (cm)	167.5	7.5	155-187
Weight (kg)	61.8	10.5	45-88
Calf circumference (cm)	32.8	3.0	27-41
Ankle circumference (cm)	21.0	1.5	18-24
Systolic BP (mmHg)	124.7	17.2	92-162
Diastolic BP (mmHg)	72.8	9.1	54-94

Table 2. The visual analogue pain scores (VAS)

VAS	Calf Tourniquet (mean ± SD)	Ankle Tourniquet (mean ± SD)	p-value
at 0 min	3.2 ± 1.9	1.9 ± 1.6	0.001
at 1 min	3.4 ± 1.8	2.1 ± 1.6	0.002
at 3 min	4.0 ± 1.6	2.5 ± 1.6	0.024
at 5 min	4.5 ± 1.6	2.9 ± 1.5	0.412
at 10 min	5.0 ± 1.6	3.3 ± 1.6	0.016
at 15 min	5.5 ± 1.6	3.7 ± 1.5	0.002
at 20 min	6.0 ± 1.8	4.2 ± 1.6	0.001
at 25 min	6.5 ± 2.3	4.4 ± 1.9	0.001
at 30 min	6.7 ± 1.8	4.4 ± 2.0	0.03
Post removal 0 min	0.8 ± 1.4	0.3 ± 0.6	0.002
Post removal 5 min	0.1 ± 0.4	0	0.000
Post removal 30 min	0.0 ± 0.3	0	0.000

and Yousifin 1993[9], revealed no difference in pain score while using the pneumatic tourniquet at the different sites (thigh compare with calf and arm compare with forearm, respectively). It is believed that at the ankle level there is very little muscle mass to be affected by the compressive effect and the ischemic process from tourniquet application. This may result in less pain symptom during the application since the very early stage of tourniquet application until the removal of tourniquet.

In term of safety to use the ankle tourniquet, Lichtenfeld studied in 1992 about 84 patients with the use of ankle tourniquet for 30-105 minutes period of operations[7]. There was no complication reported. Derner and Buckholz also retrospectively reviewed 3,047 patients with the using of ankle tourniquet at the mean pressure of 325 mmHg for 30-60 minutes, there were only 3 patients who had the post-tourniquet syndrome[10].

The present study positively supports the use of ankle tourniquet if less tourniquet pain during tourniquet application is needed. The tourniquet pain also diminished faster after removal of the tourniquet in the ankle tourniquet group. The strength of the present study is that it was performed in the healthy volunteers without the effect of analgesic agent. And the duration of 30 minutes of tourniquet application in the present study is long enough for most of the mid- and forefoot surgery under local anesthesia. However, the present study group is relatively young and may not represent all population especially in elderly and pediatric patients.

Conclusion

The use of ankle tourniquet need a higher minimal tourniquet pressure compared with the calf tourniquet. Its application has less tourniquet pain than calf tourniquet at all timefrom beginning to 30 minutes of tourniquet application. Its application also has faster pain recovery after removal.

Potential conflicts of interest

None.

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อาการปวดจากเครื่องรัดห้ามเลือดเปรียบเทียบการใช้ที่ตำแหน่งน่องและที่เหนือข้อเท้า

ชุมพล ปิยวัณโณ, บรรจง มไหสวริยะ

ผู้นิพนธ์ได้ทำการศึกษาในอาสาสมัครทั้งหมด 63 คน แบ่งเป็นเพศชาย 32 คน เพศหญิง 31 คน อายุระหว่าง 21-36ปี (เฉลี่ย 24 ปี) เพื่อเปรียบเทียบความรุนแรงของอาการปวดที่เกิดขึ้นในขณะใช้เครื่องรัดห้ามเลือดที่ตำแหน่งน่องและที่เหนือข้อเท้า โดยบันทึกข้อมูลอาการปวดด้วย visual analogue pain score ประเมินที่ เวลา 0, 1, 3, 5, 10, 20, 30 นาที ของการห้ามเลือด และหลังจากนำเครื่องรัดห้ามเลือดออกแล้วที่เวลา 0, 5 และ 30 นาที ผลการศึกษาพบอาการปวดที่เกิดขึ้นโดยใช้เครื่องรัดห้ามเลือดบริเวณเหนือข้อเท้ามีพิสัย 0-4.4 ซึ่งน้อยกว่าการใช้เครื่องรัดห้ามเลือดที่บริเวณน่องซึ่งมีพิสัย 0-6.7 อย่างมีนัยสำคัญทางสถิติ ในทุกช่วงเวลาที่ทำการประเมิน และตามลำดับอาการปวดที่เกิดขึ้นโดยใช้เครื่องรัดห้ามเลือดลดลงและหายไปรวดเร็วกว่าในกลุ่มที่ใช้เครื่องรัดห้ามเลือดบริเวณเหนือข้อเท้า นอกจากนี้ยังพบความดันเฉลี่ยที่ต้องใช้ห้ามเลือดที่ตำแหน่งเหนือข้อเท้าสูงกว่าการใช้ที่ตำแหน่งน่องอย่างมีนัยสำคัญ (ค่าเฉลี่ย 310.8 $\pm$ 40.8 มิลลิเมตรปรอทและ 272.5 $\pm$ 36.9 มิลลิเมตรปรอท ตามลำดับ, $p = 0.024$)