Severe Calcification of Femoral Arteries Causes Tourniquet Failure Accompanied by Massive Bleeding

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Tourniquet failure is attributed to inadequate tourniquet pressure, inadequate exsanguination, failure to compress medullary vessels within the bone, and incompressible calcified arteries. We herein report a case of massive bleeding using a properly functioning tourniquet in a patient who had bilateral calcified femoral arteries. When incompressible calcified arteries are present, the inflated tourniquet cuff fails to adequately compress the underlying artery, yet acts as an efficient venous tourniquet, which leads to an increase in bleeding. It is therefore critical to preoperatively confirm the effectiveness of the tourniquet in arterial occlusion in patients with severe arterial calcification. (J Am Podiatr Med Assoc 113(1), 2023)

Tourniquets are widely used to obtain a nearly bloodless surgical field, achieve improved operative visualization, and expedite surgery by occluding the arteries.[1] Tourniquet failure is attributed to inadequate tourniquet pressure, inadequate exsanguination, failure to compress medullary vessels within the bone (tourniquet ooze), and incompressible calcified arteries.[2-4] There is no consensus on whether using the tourniquet is effective and safe in patients with arterial calcification.[4] Several case reports have demonstrated that using the tourniquet in patients with arterial calcification paradoxically increases the amount of bleeding.[2-4] In contrast, previous reports found no significant difference in the occurrence of tourniquet failure and the amount of blood loss in total knee arthroplasty between the patients without and with arterial calcification confirmed by preoperative radiographic images.[4,5] However, we experienced a case of massive bleeding using a properly functioning tourniquet in a patient who had bilateral calcified femoral arteries.

Written informed consent for publication of the clinical details and clinical images was obtained from the patient. A 74-year-old man (height, 166 cm; weight, 58 kg) suffered from diabetic gangrene with infection in his legs and was scheduled for amputation of lower legs. Computed tomography revealed the presence of extensive calcification in bilateral femoral arteries. The perfusion of lower extremities was found to be maintained, because the blood flow at bilateral popliteal arteries was detected by color Doppler ultrasonography.

The patient received general anesthesia and was mechanically ventilated under tracheal intubation. Although surgery was commenced without using a tourniquet, bleeding occurred because of an accidental injury of the left anterior tibial artery. We therefore inflated the straight tourniquet cuff (cuff width, 107 mm) attached to the left thigh at 300 mm Hg after exsanguination by limb elevation without elastic bandage. Thereafter, massive bleeding associated with a rapid decrease in blood pressure was observed. The inflating pressure of the tourniquet was further increased to 330 mm Hg; however, massive bleeding continued. The tourniquet was functioning without any leak in circuit or obstruction of cuff inflation. Surgeons tried to achieve hemostasis by ligating vessels and using electrocoagulation. We regarded inflating the tourniquet as ineffective in achieving hemostasis and decided to deflate the tourniquet. After the tourniquet had been deflated, the amount of bleeding significantly decreased. The amount of bleeding was 3,364 mL over approximately 40 min of using the tourniquet and 1,020 mL over approximately 2 hours after its release. The patient received 20 U of red cell concentrate, 8 U of

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fresh frozen plasma and 10 U of platelet concentrate during surgery. As judged from preoperative computed tomography showing significant calcification of bilateral femoral arteries, it seemed difficult to compress the arteries using a tourniquet.

It has been demonstrated that calcified vessels are resistant to collapse with high tourniquet pressure, because of their rigid vessel wall.[2-5] Incompressible lower limb arteries have been found in 10 of 1,500 patients with arteriosclerosis.[2] Hoffman (A. F. Hoffman DPM, PhD, personal written communication, 2021) reported that over a 40-year period, approximately 5% of the diabetic patients older than 70 years that she evaluated at the Non-invasive Vascular Laboratory at the California College of Podiatric Medicine had both posterior tibial and anterior tibial arterial pressures exceeding 300 mm Hg. When incompressible calcified arteries are present, the inflated tourniquet cuff fails to adequately compress the underlying artery, yet acts as an efficient venous tourniquet.[2-4] Under these conditions, the amount of bleeding can be greater than that without the use of a tourniquet. To suppress the increased bleeding by venous tourniquet, the only way should be to remove the tourniquet completely. However, tourniquet failure does not consistently occur in patients with arterial calcification. In this way, it seems difficult to predict the occurrence of tourniquet failure by the presence of arterial calcification alone.

In addition, the use of tourniquet in lower extremities sometimes induces vascular complications, such as acute arterial occlusion, aneurysm formation, thrombosis and/or embolism from a ruptured atherosclerotic plaque, and vasospasm.[3,4,6,7] These complications are usually rare, but can be serious in patients having problems associated with the peripheral vascular system, including calcified arteries.[7]

To reduce tissue injuries associated with high tourniquet pressure, surgeons should measure limb occlusion pressure (LOP), defined as the minimum pressure that stops arterial blood flow distal to the cuff.[8,9] Limb occlusion pressure is originally determined by gradually increasing tourniquet pressure until distal arterial pulses cease, as detected using a Doppler stethoscope.[8] Later, an automated plethysmographic system was developed to find LOP, where a modified tourniquet controller is used to adjust cuff pressure while detecting a distal pulse using a pulse oximetry sensor temporarily clipped onto the second toe of the involved limb.[9] When the tourniquet is applied in patients with severe arterial calcification, it seems necessary to confirm whether the tourniquet can effectively occlude the underlying arteries before surgery, in a way similar to measurement of LOP. If the distal pulsation is detectable despite sufficient inflation of the tourniquet cuff, we should regard inflating the tourniquet cuff as ineffective in occluding arteries and therefore avoid using the tourniquet to achieve hemostasis during surgery. Thus, we can anticipate the risk of inadequate occlusion of arteries with the tourniquet preoperatively.

Conclusions

In conclusion, anesthesiologists and surgeons should take it into consideration that the presence of arterial calcification can cause tourniquet failure accompanied by massive bleeding. It is therefore critical to preoperatively confirm the effectiveness of the tourniquet in arterial occlusion in patients with severe arterial calcification.

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