Tourniquet and the Obese Patient

White Paper

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By

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Abstract

More than a third of patients undergoing TKA have a BMI greater than 30 (obese) with many of these patients having a BMI that is greater than 40 (morbidly obese). Operating on these patients present the surgeon and the OR team with special problems all around, not the least of which is achieving and maintaining a blood-free surgical field. The problems include the need for larger and wider specialty (curved) cuffs thereby dangerously decreasing the distance from the distal edge of the tourniquet to the incision; tourniquets tend to slide distally when inflated due to the taper of the thigh; occlusion of arterial flow in the obese patient requires higher pressures, thereby causing more tissue compression (crush injury) and skin damage (1). Additionally, the obese patient is more vulnerable to infection if non-sterile tourniquets are used; the ability to expel the blood from the operated limb prior to tourniquet inflation is difficult in the obese patient, time consuming and tedious and often suboptimal, leaving substantial volume of blood in the vessels. This blood clots over the course of the tourniquet “up” period and when the tourniquet is deflated these clots travel to the pulmonary circulation (PE). The blood left behind also obstruct the surgical field visibility and the imperfect field requires additional OR time for hemostasis (2). Nevertheless, tourniquets are used in obese patients and the overall long term outcome of TKA in obese patients is as positive as in the normal BMI patients.

The HemaClear is a novel exsanguination tourniquet consisting of a rolling ring with an elastic stockinet and handles which can be applied quickly to the obese limb (picture). The HC90 is suitable for up to 90 cm of circumference which is suitable for most (but not all) obese patients. The HC provides a superior exsanguination, is a sterile, single patient use device and remains stable on the thigh (3). It applies safe levels of pressure to the limb and in more than 80,000 cases (all, not only obese) it has been used, proved to have an impeccable safety track record (no paralysis/paresis, no skin damage). The HC90 is a valuable addition to the tools designed to give the obese patient the same standard of care as the lean TKA recipient.
Adverse Effects of Pneumatic Tourniquet in Obese Patients.

Achieving blood-free surgical field in the obese patient undergoing TKA is a challenge. It requires experience and skill and some special tools, such as extra padding and special size and shape tourniquet. The obese thigh is typically very wide, acutely tapered, and relatively soft. The skin is loose and the distance to the groin is small relative to the circumference. These geometrical become obvious when Figure 1 is considered. The forces applied by the tourniquet on the tapered limb have, in addition to the desired radial component, an axial vector (arrow) that tends to slide the tourniquet distally towards the surgical incision site. The loose skin makes this sliding even easier with a tendency to pull some skin folds along (4).

In addition to the geometrical mechanics, the wider thigh requires a wider cuff thereby leaving less “real estate” for the surgical incision. The migration of the tourniquet occasionally brings it to an undesired proximity to the sterile field (5). The use of sterile tourniquets is therefore recommended in all obese patients. The rheology of the obese tissues is another factor that must be considered, namely the compressibility of the adipose tissue is such that higher pressures are needed in order to transmit the pressure from the skin surface beneath the tourniquet to the vicinity of the blood vessel. The higher pressures, particularly with a flat profile cuff, create higher shear forces at the proximal and distal edges of the tourniquet thereby increasing the risk of neural or vascular damage.

The obese patient often has delicate skin and poor peripheral circulation. It is essential to minimize tourniquet time and to apply tourniquets in a very even way. Attempts to squeeze skin folds and fat beneath a tourniquet that is not long enough can be detrimental. Case reports on pneumatic-tourniquet intduced rhabdomyolysis in obese patients are indicative of this higher vulnerability (6).

In addition to the challenges of tourniquet placement and maintenance of arterial occlusion, it is known that effectively expelling the blood from the limb (exsanguination) is quite difficult in the obese. Limb elevation is ineffective (7-Blond et al) and Esmarch bandage placement is tedious in the obese patient. The blood left behind inside the blood vessels tends to clot during the course of the procedure. Once the tourniquet is released, many of these clots travel with the blood flow to the lungs (Micro Pulmonary Emboli) while those who stay behind can form seeds for further thrombus formation and post op DVT.
The HemaClear Solution

Recently, OHK Medical Devices (Haifa, Israel) brought to the orthopedic market a novel exsanguination tourniquet for limb blood-free surgery. The largest size of the series is the HC90, which was specifically designed for use on the obese patient. The HC technology consists of a highly calibrated elastic silicone ring with a latex-free stockinet wrapped around it. The HC90 also has 4 straps that when pulled along the axis of the limb cause the rolling of the ring along the limb. The construction of the HC90 is such that when it is placed on the distal-most part of the leg the annulus is thick and the hole in its middle is small to fit the narrower aspect of the leg. As the ring rolls up, the thick stockinet material is spread behind so that the annulus becomes narrower while the middle hole gets wider. The result is a uniformly applied pressure along the limb despite the widely changing circumference. The device is secured in place by wrapping the straps just distally to the ring so that it cannot roll back down despite motion of the knee and the underlying thigh tissues. At the end of surgery the HC ring is cut away by cutting the elastic ring. If there is a desire to minimize the drop of blood pressure after the release of the occlusion (due to the opening of the empty vascular bed in the leg) it is possible to leave the stockinet for a few additional minutes before cutting it away with scissors.

The HemaClear is applied quickly and easily on the prepped leg. It is applied immediately prior to the beginning of surgery thereby minimizing tourniquet time. The level of exsanguination is outstanding with a very dry field, despite the obesity (pictures).

The HC90 is sterile single-patient device and as such is suitable for use in the obese patient with its higher vulnerability to infection. The high exsanguination level also prevents leaving blood behind in the blood vessels, thereby reducing the likelihood of clotting and PE formation. The effect of the ring on the skin and the underlying tissues is
gentle (arrow in pictures) and no undesired effects (tourniquet paralysis, tourniquet “burn”, tourniquet pain) have been reported in its frequent use in Europe and other countries.

Conclusions

The problems with pneumatic tourniquets in the obese patients drove some researchers to the conclusion that it is better to operate on these patients under non blood-free conditions. However, the majority of major joint surgeons continue to use exsanguination and tourniquet technique while struggling with the difficulties.

The data from large scale studies compiled by the CDC indicate that the overall satisfaction of obese patients with the outcome of TKA is as high as in non-obese patients(8). As such, it seems logical to conclude that they deserve the same level of quality care, including the details of the intra-operative process. The HC90, which was specifically designed to meet the needs of the very obese patient, is a useful addition to the care of these patients.

References:


### Classification of Weight by Body Mass Index*

<table>
<thead>
<tr>
<th>BMI</th>
<th>Class</th>
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<tbody>
<tr>
<td>Underweight</td>
<td>&lt;18.5</td>
</tr>
<tr>
<td>Normal</td>
<td>18.5 to 24.9</td>
</tr>
<tr>
<td>Overweight</td>
<td>25 to 29.9</td>
</tr>
<tr>
<td>Obesity</td>
<td>30 to 34.9 I</td>
</tr>
<tr>
<td></td>
<td>35 to 39.9 II</td>
</tr>
<tr>
<td>Extreme Obesity</td>
<td>&gt;40 III</td>
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</tbody>
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*BMI is calculated by dividing weight (in kg) by height (in m²).*