Exsanguinating tourniquet assessed

Consultant orthopaedic surgeon **MATTHEW S HENDERSON** FRCS (Trauma and Orthopaedics), MBChB, describes how the The S-MART™ sterile exsanguinating tourniquet from Summit Medical shows significant potential for improving efficiency in ankle surgery at Gloucester Royal Hospital.

The use of tourniquets for both upper and lower limb surgery has been common practice in amputations for many centuries.

However, although methods of exsanguination used today (such as limb elevation and the Esmarch bandage) appear to date back to the early 19th Century, it was not until around 1860 that the use of bloodless surgery was first applied, by Joseph Lister, in procedures other than amputations.

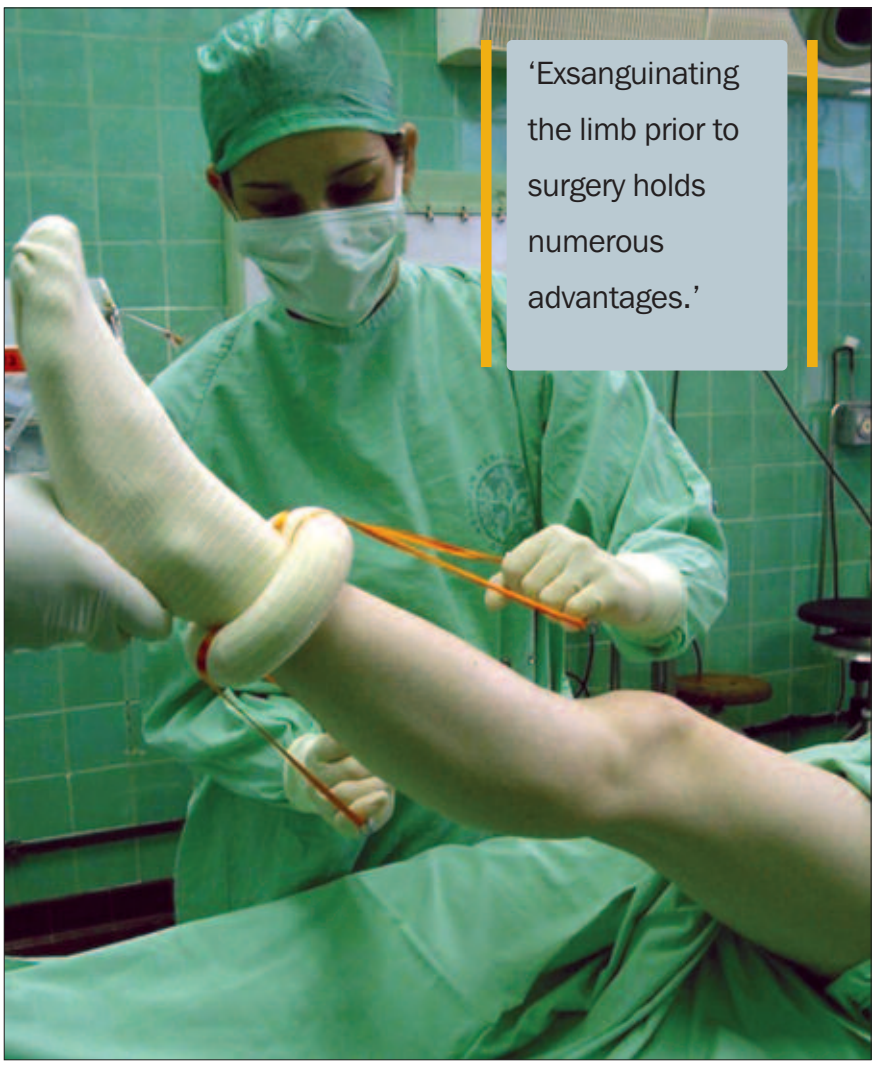
Exsanguinating the limb prior to surgery holds numerous advantages including establishing a clear operating field, reducing overall blood loss and reducing the risk of micro-emboli on tourniquet release.

The limb is usually exsanguinated through elevation, Esmarch bandage or Rhys-Davis techniques. The tourniquet is then applied to the limb to prevent the blood from returning to the exsanguinated limb during surgery. The tourniquet is usually a pneumatic cuff, which is placed on the upper arm or thigh and is inflated by a machine to a pre-determined pressure.

This pressure is typically 200-250 mmHg for upper limbs and 300-350 mmHg for lower limbs, although this may vary with limb size and the systolic pressure of the patient. The idea is to provide a clear bloodless field throughout the duration of surgery.

TOURNIQUET TECHNIQUES

Using the current methods employed at Gloucester Royal Hospital, the patients undergoing foot and ankle surgery receive a regional block at the knee with a pressure tourniquet placed on the upper thigh, at 350 mmHg, after exsanguination by elevation.



'Exsanguinating the limb prior to surgery holds numerous advantages.'

Applying S-MART.

The thigh is chosen as a placement site in order to keep the non-sterile pressure tourniquet well away from the surgical site, therefore reducing the risk of cross-infection. So while the patient feels no pain at the surgical site, he or she routinely requires further anaesthesia due to the discomfort experienced from the pressure tourniquet.

NEW APPROACH

We have recently employed the use of a new type of tourniquet called the S-MART™. This is a single use and sterile tourniquet that exsanguinates on application and occludes arterial flow at its placement site.

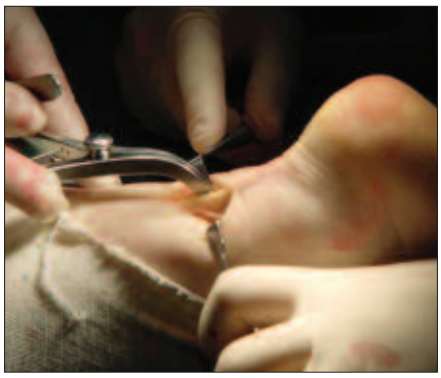
By using the sterile S-MART, a more distal placement site is possible (15 cm proximally to the lateral malleolus) without increasing the risk of infection. Not only does this reduce the volume of ischemic tissue but the tourniquet pressure is applied within the anaesthetised area. The theory is that the use of this method reduces the need for the subsequent general anaesthetic often required to alleviate pain created by the pressure tourniquet on the thigh.

The evaluation of S-MART was performed in order to assess the feasibility of a more detailed and statistically significant study aimed at assessing its use as an alternative method to the current utilisation of pressure tourniquets. The key variables identified for assessment from further evaluation are: patient wellbeing and recovery, use of appropriate anaesthesia and occurrences of complications. The information in this text summarises the evaluations that have taken place so far at Gloucester Royal Hospital and the conclusion as to the feasibility of a further and more detailed study.

EVALUATIONS

The initial evaluation of S-MART was carried out in March 2006 during a carpel tunnel release performed on a 43 year old woman under local anaesthetic. The new tourniquet was placed mid-forearm following the preparation of the limb, and knife to skin was within 20 seconds of it being applied. The ability to site the device after preparation is due to the device sterility. The resulting shorter than normal duration between placement and incision means we were able to achieve a reduction in the overall tourniquet time. In this case, the tourniquet time was only seven minutes.

There were two further cases on the day. Case 1 (34 year old man) was a ganglion removal from the wrist and case 2 (32 year old man) a knee arthroscopy and debridement. Both procedures were performed under general anaesthetic. As with the carpel tunnel release, an excellent



S-MART effectiveness demonstrated in ankle ligament surgery.

bloodless field was established using the new tourniquet and, in all cases, a satisfactory clinical outcome was achieved.

Due to the initial successes, we considered further procedures where the device could demonstrate clinical benefits. It was at this stage that the methods we currently employ for ankle surgery were highlighted and the potential use of the new tourniquet was centred around the possibility of reducing the need for additional anaesthetic by applying the device over the area covered by our regional anaesthesia.

So far to date we have completed two foot and ankle cases using the new tourniquet. Both local anaesthetic and regional block were employed and this allowed us to asses tolerance of the tourniquet and the ability of the device to reduce the need for GA.

The first case was the removal of a cyst from the toe of a 44 year old man under local anaesthetic. The S-MART was sited approximately 40 cm from the toes and by using the correct system delivered a pressure of 228 mmHg. This is considerably lower than the 350 mmHg routinely applied using a pneumatic tourniquet on the thigh.

The patient was prepped and draped and the new tourniquet was applied in the final moments before knife to skin, again allowing us to reduce tourniquet time. On this occasion the patient tolerated the tourniquet over a non-anaesthetised area for over 13 minutes and until the procedure was completed.

Family of S-MART devices.

The second case was an ankle arthroscopy and debridement on a 42 year old man. A clear bloodless field was achieved and, importantly, there was no requirement for additional anaesthetic during the surgery. The tourniquet time in this instance was 49 minutes, which was well tolerated as the device could be placed close to the surgical site over an anaesthetised area. This result would not have been achievable with a pressure cuff as the infection risk would have meant placing the pressure cuff on the thigh. The 49 minute duration with the cuff at 350 mmHg would certainly have resulted in severe patient discomfort and the subsequent need for general anaesthetic.

HOW THE DEVICE WORKS

The new tourniquet uses a simple yet innovative approach to limb exsanguination and arterial occlusion. The basis of the idea stems from the original Esmarch device invented by Johann T. Friederich von Esmarch in the 19th Century. The name Esmarch is today widely associated with the elasticated bandages used for limb exsanguination but the original Esmarch device was an altogether more innovative approach.

The Esmarch device was a rubber tube that was wound tightly around the limb and then moved proximally using a wooden roller. This process provided consistent pressure leading to good exsanguination but the device then also served as a tourniquet at the appropriate placement site. The new tourniquet uses a similar idea in order to encapsulate the exsanguination and tourniquet properties in a single device.

In the case of S-MART, the rubber tube is replaced by a silicone ring, the tensile properties of which vary by device type, depending on the force required to generate the appropriate internal pressures. The type of device chosen will therefore be dictated partly by the patient's systolic pressure. The device's pull straps facilitate placement and a stockinette unravels during application in order to provide a sterile barrier.

The dimensions of patients' limbs vary as does their systolic pressure. An understanding of both is required to ensure that the correct S-MART is chosen for surgery. So, the device is available in different sizes for upper and lower limbs. There are also two other sizes that may be appropriate for extreme limb dimensions – one is for small or paediatric limbs and the other is for oversized limbs.

So, before selecting the device, the limb circumference at the desired placement site must be measured along with the patient's systolic pressure. Using charts supplied by the manufacturer, the most appropriate device can be identified (Fig. 1). The device should be offered into the sterile field using a normal aseptic technique. There is a plastic card inside the device. This card is

also sterile and must be retained as it is used to protect the patient's skin on removal of the device post-operatively.

The sterile device is opened using normal aseptic technique. The patient's fingers or toes are placed into the device aperture and the straps pulled proximally along the limb. Exsanguination takes place during proximal movement of the device as does the application of the stockinette. The device must be stopped at the pre-identified placement site to ensure that the selected system is still operating within its dimensional capabilities. From here, the stockinette can be cut away, or a window opened through it at the surgical site. Pressure charts provided by the manufacturer allow the skin pressure to be recorded.

Device selection in our practice was largely dictated by the limb size and was usually independent of the patient's systolic pressure. The reason for this was because the tibialis posterior artery "hides" between the medial malleolus and the Achilles tendon. In order to ensure the most effective exsanguination and occlusion, the manufacturer recommends that the highest pressure system is always used under these circumstances (for us, this was usually the yellow system) and that it should be placed 15 cm above the lateral malleolus.

In order to remove S-MART, the retained card should be placed proximally, the device rolled over the corner of the card, and the ring cut gently with a scalpel.

Limb circumference	Patient blood pressure		
	<130 mmHg	<160 mmHg	<190 mmHg
S-MART SM pediatric arm and leg 14-28 cm	●		
S-MART 40 arm and ankle 24-40 cm	●	●	●
S-MART 60 leg 30-60 cm	●	●	●
S-MART XL leg 50-90 cm		◑	

Figure 1: Device selection chart.

CONCLUSIONS

In conclusion, my team at Gloucestershire Royal Hospital are currently investigating use of the S-MART in patients having foot and ankle surgery. We found the device to be better tolerated by patients undergoing shorter duration surgeries under local anaesthetic, and that the routine use of general anaesthetic, due to pressure cuff discomfort during ankle surgery, was avoidable.

The evaluations that have taken place so far lead us to believe that the device can provide clinical benefits to our patients, improve our processes in preparing the patients for surgery and reduce the cost of surgery by removing the routine use of general anaesthetic.

Further evaluations will take place in an attempt to quantify results and to demonstrate compliance to these hypotheses.

As such, the aims of further evaluations, in foot and ankle surgery, are likely to be as follows:

- To assess improvement to patient wellbeing.
- To reduce intra-operative tourniquet pain and reduce the need for additional general anaesthesia.
- To reduce average recovery time by reducing use of general anaesthesia.

We are confident that such aims are achievable by continuing to apply our new methods.