Preventing deep tissue injury of the foot and ankle in the operating theatre

KEY WORDS
- Offloading
- Perioperative care
- Popliteal vein
- Pressure injury

Approximately 25% of heel and ankle pressure injuries begin in the operating theatre. These injuries can be prevented simply by offloading, but elevating the heel can cause other problems, mainly popliteal vein compression. Elevating the heel and allowing the knee to drop back unsupported, will result in popliteal vein compression in 64% of patients who are supine and anaesthetised. Popliteal vein compression increases the likelihood of deep vein thrombosis and can be overcome by flexing the knee around 5°. It must be done without putting pressure in the popliteal fossa.

DAVID HUBER
Chairman, Division of Vascular Surgery , Wollongong Hospital, Wollongong, NSW, Australia

Heel and ankle pressure injuries are a common but preventable complication of surgery (Whittington and Briones, 2004). Approximately 25% of pressure injuries begin in the operating theatre (Bliss and Simini, 1999), that is, the deep tissue injury is incurred at the time of surgery, with some authors quoting incidence rates of up to 66% for patients with a fractured hip (Versluysen, 1986).

The cost to the community is very high, and the cost to the American healthcare system for pressure injuries of the foot and ankle that develop in the operating theatre is around $US900 million (£592 million; Bliss and Simini, 1999; Whittington and Briones, 2004; Zulkowski et al, 2005; Vanderwee et al, 2007). In Australia the figure is approximately $AU84 million (£54.143 million; Australian Institute of Health and Welfare, 2008). In the UK, the cost of treating pressure ulcers totals up to £2.1 billion, which represents 4% of the total NHS expenditure (Bennett et al, 2004)

Twenty five percent of all pressure injuries occur on the heel and a further 8% occur on the lateral malleolus, making a total of 33% of all pressure injuries occurring on the foot (Whittington and Briones, 2004; Vanderwee et al, 2007).

OFFLOADING

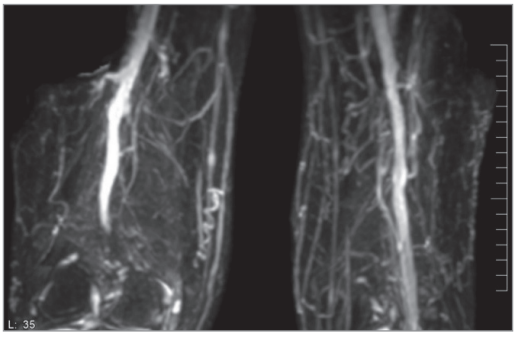
To prevent heel pressure injuries, the heel needs to be offloaded (Black, 2004; Huber et al, 2008; Donnelly et al, 2011). A distinction needs to be made between pressure redistribution and offloading. The National Pressure Ulcer Advisory Panel has suggested the term "pressure redistribution" where the body part cannot be weightless, but the surface area of contact is increased, thereby decreasing the pressure on a given area (pressure being force/area). Pressure redistribution includes shifting pressure from one area which is at risk to another region which is less at risk.

An example would be distributing the weight of the leg on the calf (which is at low risk of pressure ulcer) while offloading the heel (which is at high risk of pressure ulcer). In a recent study Donnelly et al (2011), showed the efficacy of offloading in patients with fractured hips. In the randomised and control study, there were 239 patients with 119 in the control arm (pressure redistributing surface alone) and 120 in the intervention arm (offloading boot combined with a pressure redistributing support surface). The incidence of heel pressure injury in the offloading group was 0%. The incidence in the nonintervention group was 29% (P=0.001).

POPLITEAL VEIN COMPRESSION

In 1992, Leon et al published a paper in which they described popliteal vein compression (although at the time, they referred to it as entrapment) in a normal group of 100 subjects, and found that 17 had complete obstruction and another 10 had severe obstruction of the popliteal vein. They conducted the study with the subjects sitting

Figure 1. MRI showing popliteal vein compression when the knee is flexed using and foam pad (left image). The image on the right shows the popliteal vein when the knee is flexed by supporting the calf with nothing behind in the popliteal fossa.



(hamstrings shortened) and awake (one would expect significant muscle tone as opposed to anaesthetised patients who will have minimal muscle tone). They went on to evaluate the significance of the popliteal vein compression and showed that when the diameter of the popliteal vein decreased by more than 50%, the venous outflow fraction (VOF) was either moderately or severely depressed and that the venous return was mainly via the superficial system. If the great saphenous vein was compressed (or had been harvested or removed) the VOF in all subjects with popliteal vein compression was either severely or very severely depressed. Flexing the knee slightly was enough to allow all those with popliteal vein compression to return to normal (Leon et al, 1992).

Most patients in the operating theatre are anaesthetised and supine (hamstrings lengthened). But elevating the heel to offload it will allow the knee to fall back unsupported. The author conducted a study of 90 legs in patients who were undergoing surgery and who were supine and anaesthetised (Huber and Huber, 2009). When the knee was allowed to drop back unsupported (i.e. heel offloaded), 43% of popliteal veins occluded and a further 21% were severely obstructed, for a total of 64%.

To prevent popliteal vein compression, the knee should be flexed approximately 5°. That is enough to unlock the knee and overcome the increased pressure in the popliteal compartment (Dijkstra et al, 2013). The hydrostatic pressure in the popliteal vein is low, especially when the patient is horizontal and that means that placing a foam pad or pillow behind the knee to flex it, will compress the vein and occlude it (*Figure 1*).

There are therefore two questions that need to be addressed. Firstly does popliteal vein compression affect the efficacy of intermittent calf compressors, and secondly, does popliteal vein compression increase the likelihood of perioperative DVT (*Figure 2*)?

"If one offloads the heel without taking care of the Achilles tendon, and without preventing hyperextension of the knee, the patient is at risk of pressure injury of the skin on the Achilles tendon"

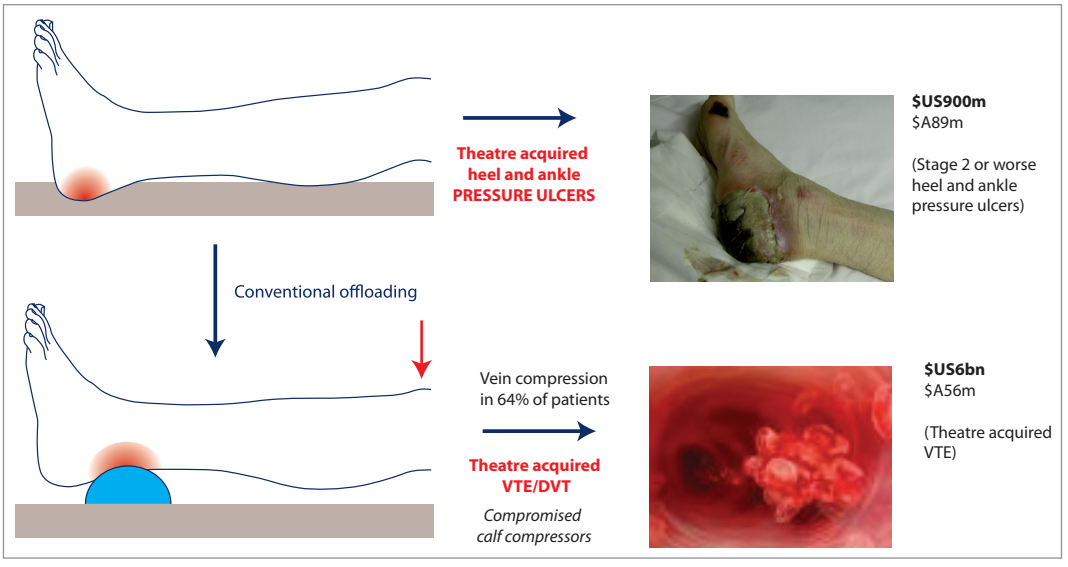


Figure 2. If one offloads the heel without taking care of the Achilles tendon, and without preventing hyperextension of the knee, the patient is at risk of pressure injury of the skin on the Achilles tendon, and is at risk of venous thromboembolism related to popliteal vein compression.

"The blood supply to the skin over the Achilles tendon is tenuous and makes the skin prone to breakdown."

INTERMITTENT CALF COMPRESSION

With respect to intermittent calf compressors, the author looked at flow velocities in the popliteal vein during inflation of intermittent calf compressors when the knee was flexed and then with the knee extended (Levine et al, 2011). Flow velocities increased significantly during extension and showed that the compression was functional. This shows that the efficacy of the calf compressors is affected by popliteal vein compression.

PERIOPERATIVE DEEP VENOUS THROMBOSIS (DVT)

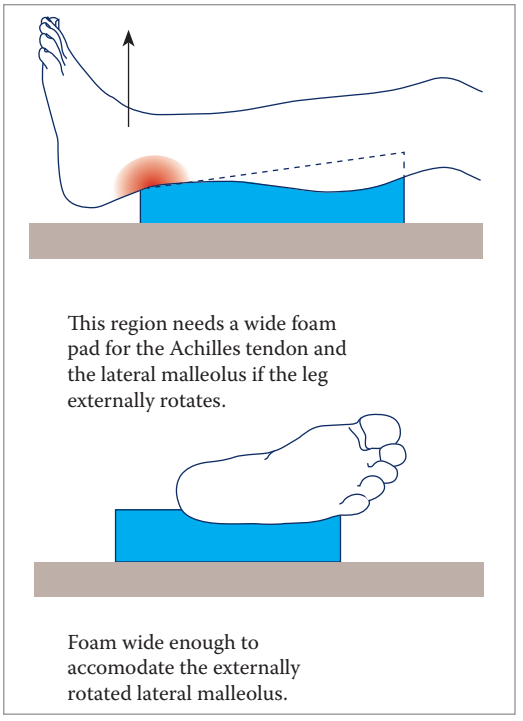
As far as perioperative DVTs are concerned, there are a number of studies which suggest that compression of the popliteal vein is associated with DVT (Gerkin et al, 1993; Kotval et al, 1995), but the most convincing is a pilot study in which the author looked at subjects who were sent to a vascular laboratory for a venous duplex to check for a DVT (Huber et al, 2012). The subjects were also checked to see whether they had popliteal vein compression when the knee was extended. In this study of 54 subjects, there was an increased relative risk of 2.9 (P<0.05) in subjects who have popliteal vein compression.

SKIN OVER THE ACHILLES TENDON AND LATERAL MALLEOLUS

With respect to the way one offloads the heel, placing a block under the Achilles tendon can cause problems. The blood supply to the skin over the Achilles tendon is tenuous (Haertsch, 1981) and makes the skin prone to breakdown.

Figure 3. Necrosis of the skin over the Achilles tendon.

Figure 4. The skin over the Achilles tendon needs protection with a pad, preferably wide enough to accommodate the lateral malleolus so that if the leg externally rotates, the skin over the lateral malleolus is protected.



If the Achilles tendon is used to elevate the heel (e.g. offloading with a Silastic block), then the skin over the Achilles tendon will be prone to pressure injuries. The calf should take most of the weight of the leg. The surface area is large so the pressure on any specific region is small. There are no bony prominences or tendon sheaths so the interface pressure is not amplified (Oomens et al, 2003).

Muscle is able to tolerate higher pressures for longer times before viability is at risk (Gefen, 2009). Putting weight on the calf will mean that the Achilles tendon takes very little weight and that can be controlled with a pad, preferably made of open cell foam.

The foam pad can be designed to be wide, so that in patients who externally rotate the leg, the lateral malleolus will be protected as well (*Figure 4*). It is very difficult to design a device which offloads the lateral malleolus if it is externally rotated without placing the Achilles tendon at risk.

"It is all very well to prevent heel pressure ulcers from developing in the operating theatres, but one must take care not to cause other problems."

CONCLUSION

So the conclusion is that if one offloads the heel in patients who are supine and anaesthetised, 64% will have significant popliteal vein compression (diameter reduction greater than 50%) and this will decrease the effectiveness of calf compressors and increase the likelihood of perioperative DVT.

In anaesthetised patients who are supine with the heel offloaded, the knee must be flexed between 5° and 10°. One could do this with a pillow, but the popliteal vein is a low-pressure structure. Simply placing the leg on a pillow will generate pressure, which will close the vein. This can be demonstrated by placing a subject in an MRI with one leg resting on a pillow and the other on a device to flex the knee without placing an object behind the popliteal fossa (*Figure 1*). The NHS is now placing a lot of importance on improving patient outcomes through the concept of "harm free care".

In a recent pilot programme, four aspects of patient care were targeted. These were pressure ulcers, falls, urinary catheter-associated infections and venous thromboembolism (QIPP Safe Care National Work Stream, 2012). It is all very well to prevent heel pressure ulcers from developing in the operating theatres, but one must take care not to cause other problems, such as DVT or necrosis of the skin covering the Achilles tendon (*Figure 3*).

Therefore, taking all the above into account, preventing heel and ankle pressure ulcers from developing in the operating theatre should include (European Pressure Ulcer Advisory Panel and National Pressure Ulcer Advisory Panel, 2009):

- Offloading the heel
- Flexing the knee to 5–10° (preventing popliteal vein compression)
- Distributing the weight of the leg along the calf with minimal pressure on the Achilles tendon (with relief pads)
- Preventing localised pressure on the lateral malleolus by anticipating external rotation and using appropriate relief pads
- The above measures should be done without pressure in the popliteal fossa. WUK

REFERENCES

Australian Institute of Health and Welfare (2008) *Health expenditure Australia 2006–07*. Health Expenditure Series, 42

Bennett G, Dealey C, Posnett J (2004) The cost of pressure ulcers in the UK. *Age Ageing* 33(3): 230–5

Black J (2004) Preventing heel pressure ulcers. *Nursing*, 34(11): 17

Bliss M, Simini B (1999) When are the seeds of postoperative pressure sores sown? *BMJ* 319: 863–4

Dijkstra ML, Khin NY, Thomas SD, Lane RJ (2013) Popliteal vein compression syndrome pathophysiology and correlation with popliteal compartment pressures. *Journal of Vascular Surgery: Venous and Lymphatic Disorders* 1(2): 181–6

Donnelly J, Winder J, Kernohan W, Stevenson M (2011) An RCT to determine the effect of a heel elevation device in pressure ulcer prevention post-hip fracture. *J Wound Care* 20(7): 309–18

European Pressure Ulcer Advisory Panel and National Pressure Ulcer Advisory Panel (2009) *Prevention and Treatment of Pressure Ulcers: Quick Reference Guide*. National Pressure Ulcer Advisory Panel, Washington DC

Gefen A (2009) Reswick and Rogers pressure-time curve for pressure ulcer risk. Part 2. *Nurs Stand* 23(46): 40–4

Gerkin TM, Beebe HG, Williams DM, Bloom JR, Wakefield TW (1993) Popliteal vein entrapment presenting as deep venous thrombosis and chronic venous insufficiency. *J Vasc Surg* 18(5): 760–6

Haertsch PA (1981) The blood supply to the skin of the leg. *Br J Plast Surg* 34(4): 470–7

Huber DE, Huber JP (2009) Popliteal vein compression under general anaesthetic. *Eur J Vasc Endovasc Surg* 37(4): 464–9

Huber D, Huber J, DeYoung E (2012) The association between popliteal vein compression and deep venous thrombosis: results of a pilot study. *Phlebology* Oct 3 [Epub ahead of print]

Huber J, Reddy R, Pitham T, Huber D (2008) Increasing heel perfusion by elevation. *Adv Skin Wound Care* 21(1): 37–41

Kotval PS, Shah PM, Babu SC et al (1995) Popliteal vein compression due to popliteal artery aneurysm: effects of aneurysm size. *J Ultrasound Med* 14(11): 805–11

Leon M, Labropoulos N, Hajj H et al (1992) Popliteal vein entrapment in the normal population. *Eur J Vasc Surg* 6(6): 623–7

Levine A, Huber J, Huber D (2011) Changes in popliteal vein diameter and flow velocity with knee flexion and hyperextension. *Phlebology* 26(7): 307–10

Oomens CW, Bressers OF, Bosboom EM et al (2003) Can loaded interface characteristics influence strain distributions in muscle adjacent to bony prominences? *Comput Methods Biomech Biomed Engin* 6(3): 171–80

QIPP Safe Care National Work Stream (2012) *'Harmfree' Care. A New Mindset in Patient Safety Improvement: Learning from the Safety Express Pilot*. Available at: www.harmfreecare.org/resources/harm-free-care-guide (accessed 22.05.2013)

Vanderwee K, Clark M, Dealey C et al (2007) Pressure ulcer prevalence in Europe: a pilot study. *J Eval Clin Pract* 13(2): 227–35

Versluysen M (1986) How elderly patients with femoral fractures develop pressure sores in hospital. *BMJ* 292: 1311–3

Whittington KT, Briones R (2004) National prevalence and incidence study: 6-year sequential acute care data. *Adv Wound Care* 17: 490–4

Zulkowski K, Langemo D, Posthauer ME, National Pressure Ulcer Advisory Panel (2005) Coming to consensus on deep tissue injury. *Adv Skin Wound Care* 18(1): 28–9