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Tourniquet Use in Lower Limb Trauma and Fracture Surgery: Custom or Evidence Based Practice?

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The concept of using a tourniquet in lower limb trauma surgery to control bleeding and improve the surgical field of view dates back to the second century where narrow bands of cloth were used as constricting devices and applied to limbs undergoing amputation.[1] Almost twenty centuries on, tourniquets remain in widespread use for lower limb trauma and fracture fixation surgery, and are believed to limit intraoperative blood loss, improve the surgical field of view and reduce surgical time.[2]

We recently surveyed 77 surgeons at the Orthopaedic Trauma Society (OTS) 2020 conference to try to capture current lower limb trauma practice within the UK. A face-to-face survey was performed and responses were captured in paper format. 78% preferred to use a tourniquet for lower limb fracture surgery. The most popular reasons for tourniquet use were to reduce blood loss (65%) and improve visualisation of structures (32%). Other studies which surveyed orthopaedic surgeons on tourniquet practices have found similar results and determined thigh tourniquets are typically inflated to pressures of 251 – 350 mmHg.[3-5]

It is possible that the practice of using a tourniquet in lower limb surgery is so embedded within Orthopaedic culture and subconscious that we barely give it a second thought, distracted by the multitude of other seemingly more pressing issues such as templating, planning incisions, choosing implants and then executing the surgery. In the words of Mark Twain:

"The less there is to justify a traditional custom, the harder it is to get rid of it"

Our survey did demonstrate some variation in tourniquet use according to the type of fracture and fixation (Figure 1), with surgeons preferring not to use a tourniquet for distal femoral fracture fixation and intramedullary fixation of tibial fractures. Concerns about the effects of a tourniquet on the muscles when reducing and fixing a distal femoral fracture and concerns about thermal necrosis when reaming for an intramedullary tibial fixation are often cited as reasons to avoid a tourniquet in these cases.[6]

Although popular, a tourniquet applied for as little as 30 minutes can have significant physical and physiological effects on the patient. Most of the evidence examining the benefits and harms of using a tourniquet in the lower limb has focussed on their application in knee replacement surgery, with data suggesting an increased risk of pain, skin injuries, venous thromboembolism (VTE), neurovascular injuries and infection. They have also demonstrated reduced functional outcome and increased length of stay.[7-9] However, the additional potential benefit of using a tourniquet on the quality of cementation and long-term implant survival in knee replacement surgery are not obviously relevant to trauma surgery.[2,10] A tourniquet may in fact be more harmful in trauma surgery where induced tissue ischaemia and hypoxia may exacerbate the existing soft tissue injury potentially increasing the risk of wound and bone healing complications. Furthermore, deflation of the tourniquet at the end of the procedure provokes a reperfusion injury and this may worsen postoperative oedema and contribute to the development of compartment syndrome.[11-13] Tourniquet use is also believed to cause systemic effects such as tachycardia, hypertension, hypercapnia and changes in body temperature.[12] Intracranial pressures may also rise as a result of greater cerebral blood flow and cerebral microemboli have been detected even in the absence of a patent foramen ovale.[12,14]

So what is the evidence relating to tourniquet use in lower limb trauma surgery? A systematic review and meta-analysis of four randomised controlled trials (RCT) was published by researchers in Denmark last year and investigated post-operative pain, complications, duration of surgery and length of hospital stay following tourniquet use in lower limb fracture fixation surgery.[15] It included three RCTs[16-18] in patients undergoing ankle fracture fixation and one RCT[19] in patients undergoing plating of tibial

fractures; these trials were performed in Europe and Asia respectively. Pooled analyses of two RCTs totalling 170 patients who underwent open reduction internal fixation for either ankle or tibial fracture demonstrated that tourniquet use was associated with a higher mean level of post-operative pain at 24 hours. The mean difference in pain (based on a 10 point visual analogue scale) was 0.8 (95% CI 0.38 – 1.23; $p < 0.005$). Although this difference is statistically significant it is below published reports for a minimum clinically important difference (MCID) of 1.0.[20] However, the confidence intervals for the estimate do include a difference above the MCID threshold, therefore further trial data in the future would help to improve this estimate. In other clinical settings early rises in postoperative pain increase the risk of persistent chronic pain, therefore it is possible that any difference in acute pain as a result of using a tourniquet is relevant in the longer term.[21,22]

Three RCTs[16,18,19] and 224 patients who underwent ankle and tibial fracture fixation were included in the analysis for post-operative complications which included infections, deep vein thrombosis and non-union. Although no statistically significant differences were found, there was a suggestion of an increased risk of complications in patients who had surgery with a tourniquet (risk ratio 1.49, 95% CI 0.80 – 2.77; $p = 0.21$). Two RCTs[16,17] have found a greater risk of further surgery when a tourniquet is used. Three of 66 (4.55%) and one of 67 (1.47%) patients underwent a debridement procedure for infection following surgery with versus without tourniquet. It is important to remember that these complications described are generally rare events (approx. 1-2%) and therefore only trials with very large numbers would be sufficient to detect differences between groups.[23]

Tissue hypoxia may explain the higher incidence of wound complications and infections in patients having surgery with a tourniquet. In a different RCT which measured tissue oxygenation following total knee replacement greater wound hypoxia was demonstrated in patients who had surgery with a tourniquet and this persisted up to seven days ($p<0.017$). Furthermore, only 3 of 20 wound flaps in the tourniquet group compared to 14 of 20 wound flaps in the non-tourniquet group returned to pre-operative oxygenation levels within one week of the surgery ($p=0.000567$).[24] The effects of tourniquet induced wound hypoxia on injured soft tissues following trauma may be even more clinically significant than on healthy soft tissue in patients undergoing elective procedures.

The authors of the systematic review also investigated differences in length of hospital stay (two RCTs)[16,17] and duration of surgery (three RCTs)[16,17,19] in their systematic review, however they did not pool this data. The mean length of hospital stay in two trials was 12±5.1 and 12.4±9 days in the tourniquet group and 9±4 and 8.6±4.4 days in the group without a tourniquet ($p < 0.05$). Two RCTs[17,19] found a significantly shorter average procedure duration when a tourniquet was used compared to without a tourniquet (41±9 and 49.5±9.2 minutes versus 55.2±11 and 53±12 minutes). However, another RCT[16] found no significant difference between patient groups; 55.7±19.1 versus 52.1±25.5 minutes (tourniquet versus no tourniquet).

Although not reported in the systematic review, two of the included RCTs[16,17] compared ankle range of motion and reported no differences between patient groups. Maffulli et al.[17] demonstrated a quicker return to full-time employment amongst patients who had surgery without a tourniquet (55±9 days versus 62±13 days, $p<0.05$). Furthermore, patients who had surgery without a tourniquet in the study by Konrad et al. experienced less ankle swelling at day 5 and week 6 post-operatively ($p<0.01$).[16]

Three of the included RCTs[16,19,25] investigated blood loss between patient groups. Konrad et al.[16] and Salam et al.[25] reported no differences in total blood loss, however, Saied et al. [19] found higher volumes of surgical drain contents in the first 24 hours post-operatively in the group of patients who underwent surgery with a tourniquet (21.20±7.44 ml versus 23.47±6.44 ml; $p=0.03$). These results are not surprising given trauma surgery of the spine, shoulder and hip where tourniquet use is not

possible still proceed safely without concerns about the surgical field of view or excessive intraoperative blood loss. It is also possible that bleeding points are more readily identified intraoperatively when a tourniquet is not used and therefore blood loss reduced. Modern techniques such as tranexamic acid, electrocautery and controlled hypotensive anaesthesia may also have a greater impact on surgical blood loss than any effect from a a tourniquet.[26-29] None of the RCTs investigated differences in surgical field of view however some surgeons may consider intraoperative blood loss a surrogate marker for this..[2]

The included studies have focused on two sub populations of patients, limiting the external validity for all the relevant types of lower limb fracture fixation. Furthermore, the review authors have highlighted a high risk of bias amongst study design flaws and insufficient power amongst the included and pooled studies to robustly recommend a change in practice amongst surgeons. There are also limitations to the review itself including a limited search strategy and use of a fixed-effect model for the meta-analysis.[30]

More recently, a randomised controlled trial of 188 patients was conducted at University Hospital of North Midlands in the UK, examining the effects of using a tourniquet in ankle fracture fixation.[31] Although well-designed the study sought to primarily investigate differences in length of hospital. After adjusting for variables including Weber classification and time to surgery, a very small difference was found between groups, however this result was not statistically significant. Although, this study was powered to detect a difference between groups of at least one and half days, the mean length of stay in the tourniquet and non-tourniquet groups was 1.74 and 1.62 days, respectively (95% CI 0.85 – 1.35; p = 0.55). The authors also investigated differences in the duration of surgery and adverse events between groups. In the adjusted analysis, there was a small difference in mean procedure duration of 3.03 minutes (95% CI -4.96 – 11.02), favouring the tourniquet group however this finding was not statistically significant (p = 0.455). Similarly, no significant differences in adverse events were found however this only included 188 patients.

We have tried to identify any relevant new or ongoing trials or research by searching https://www.isrctn.com/ and https://clinicaltrials.gov/, but found no relevant studies after a search completed 23rd September 2020.

The existing evidence on tourniquet use in lower limb fracture fixation surgery, is limited in quantity and quality, but does suggest that using a tourniquet may cause patients harm with limited benefit. Despite this tourniquets continue to be routinely used. Our survey at the OTS conference established that most surgeons would be willing to engage in further research including a multi-centre trial to help improve the existing evidence base. Given the paucity of the current evidence, is it time to reconsider the time-honoured surgical practice of using a tourniquet for trauma surgery?

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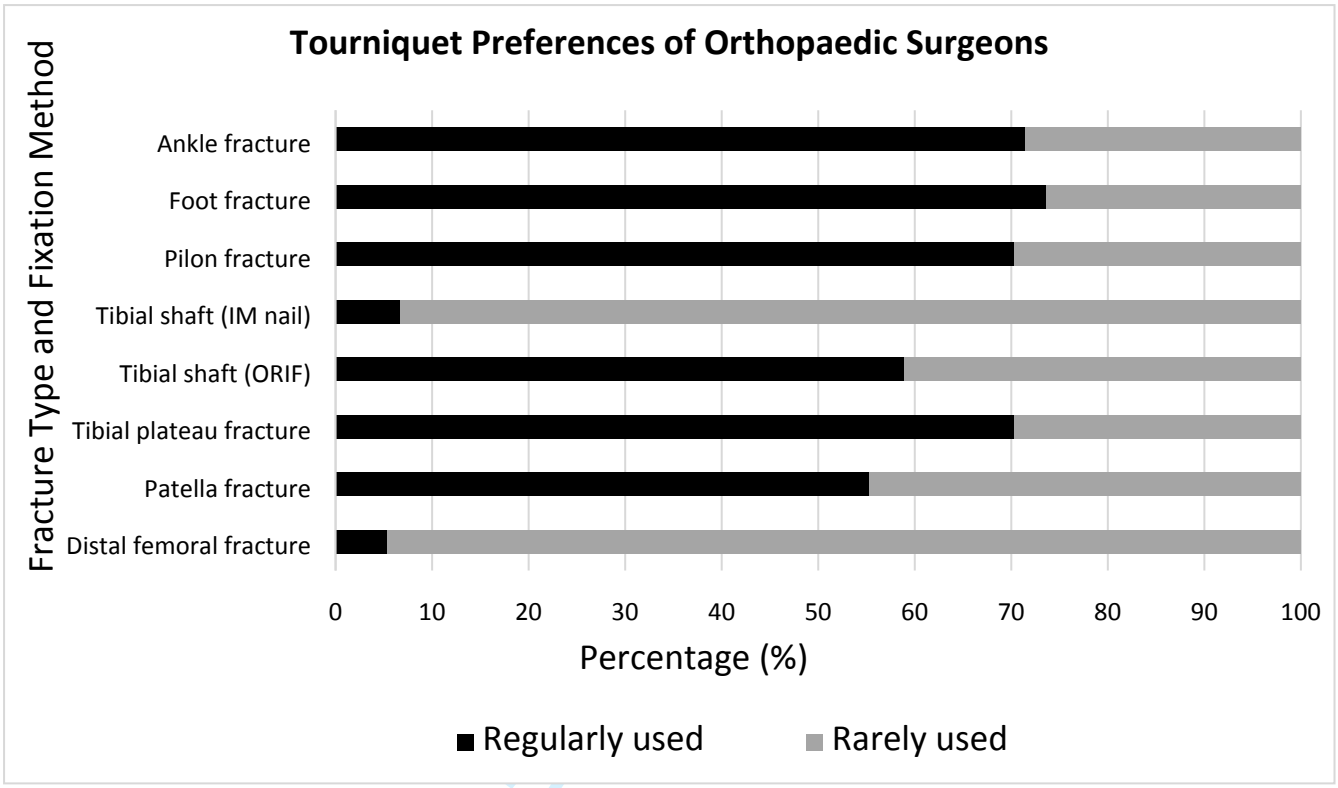

Figure 1: Frequency of tourniquet use by Orthopaedic surgeons for various lower limb fracture fixation procedures