Local anaesthesia and analgesia guidance for surgical treatment of cows with necrotic hoof

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Key words: local anaesthesia | analgesia | necrotic hoof lesions

Sole ulcers, white line lesions, digital dermatitis, sole bruising (haemorrhage) and foul-in-the-foot have been reported as the major lesions causing lameness throughout the world, including the UK (Barker et al, 2010). However, within the chronically lame cows, the necrotic claw lesions are over represented. Necrotic hoof lesions include toe necrosis, some vertical fissures, many axial wall fissures and white line lesions (wall ulcers). These complicated necrotic lesions are characterised by severe local pain, a foetid odour, dyskeratotic horn production and ulcerated corium, usually with stippled surface granulation tissue. These polymicrobial infections are consistently

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Box 1. Non-healing lesions claw lesions

In recent years there has been an increase in reports of apparently 'non-healing' claw lesions in cattle, predominantly located in the toe region. These lesions are often termed 'toe necrosis', which is defined as necrosis of the tip of the toe with involvement of the distal phalanxbone tissue caused by a bacterial infection (Egger-Danner et al., 2015). The main pathogen linked to these lesions are *Treponema* spp. (the cause also linked to digital dermatitis), which results in chronic corium inflammation and alterations to the bony tissue (Kofler, 2017).

Treatment of these lesions requires careful debridement of all infected corium as well as removal of any loose horn. The only way to humanely achieve this is thorough debridement with the use of local anaesthesia.

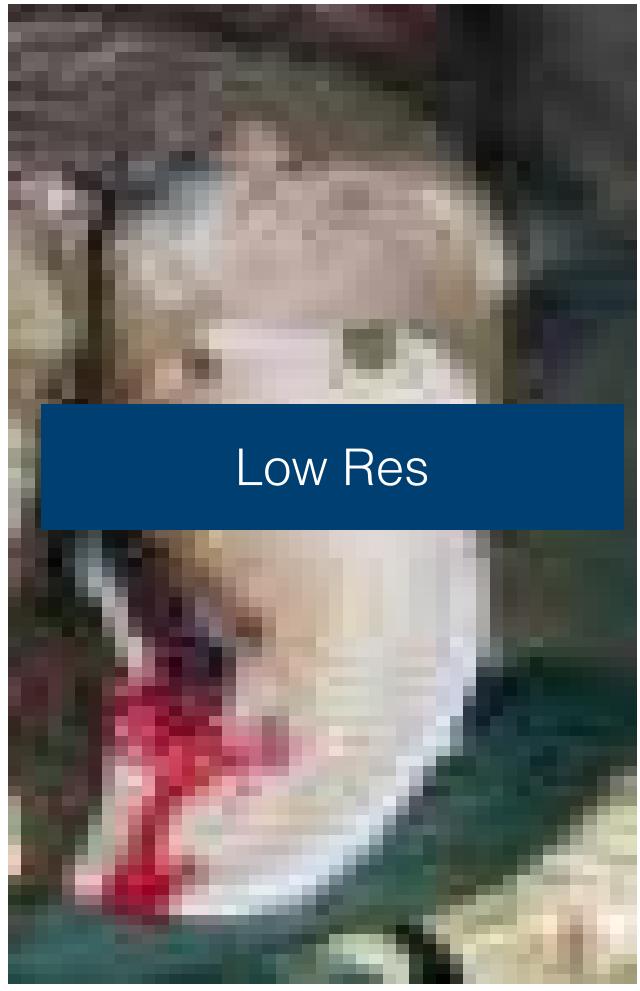

Figure 1. Axial wall fissure. *(AQ2 Please provide a high res version) (AQ3 Please cite in the text)*

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Figure 2. Vertical fissure. *(AQ4 Please provide a high res version) (AQ5 Please cite in the text)*

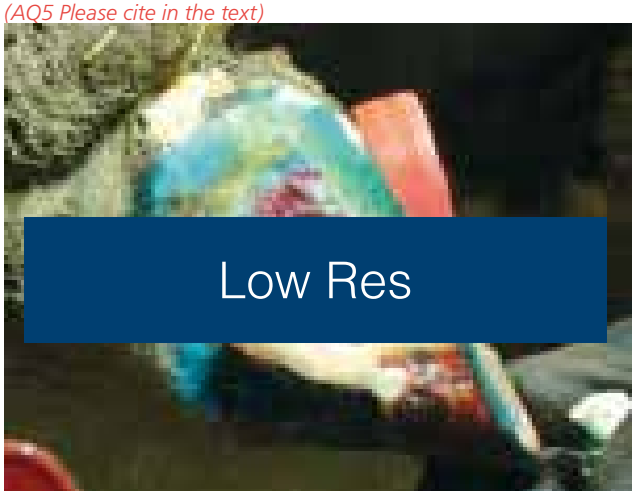

Figure 3. Infected white line lesion (wall ulcer). *(AQ6 Please provide a high res version) (AQ7 Please cite in the text)*

Figure 4. Toe necrosis. *(AQ8 Please provide a high res version) (AQ9 Please cite in the text)*

infected by treponemes. Originally termed 'non-healing lesions' (Evans et al, 2011), there is growing evidence that curative or palliative treatment may be a viable option, supported by case reports describing surgical debridement (Alcock, 2015; Kofler et al, 2017; Starke et al, 2017).

Box 2: Legislation and guidance relating to treatment and transport of lame cows

Veterinary Surgeons Act 1966

- Veterinary Surgery surgery is defined as the medical or surgical treatment of animals and the performance of surgical operations
  - Cutting into sensitive foot tissue such as the corium or laminae falls under this act
- This means that only a veterinarian (or a person under direct veterinary supervision) can trim foot lesions that may involve the corium or sensitive tissue of the foot, e.g. surgical debridement or claw amputations.

Welfare of Farmed Animals (England) Regulations 2000

- This legislation states that an owner must take all reasonable steps to ensure the welfare of animals under their care, including preventing any unnecessary pain or suffering
- It is also an offence to restrain an animal in such a way as to cause unnecessary pain or distress
- Extensive therapeutic trimming of claw lesions involving the sensitive tissues is painful for cattle. In addition to this, extended periods of restraint in a cattle crush can also be uncomfortable and highly stressful for a cow.

Defra Guidance on the Transport of Casualty Farm Animals (www.nifcc.co.uk/publications/44)

- An animal which cannot bear any weight on one or more legs should not be transported. When deciding whether or not a lame animal is fit to travel, consider the degree of lameness and the demeanour of the animal. The movement of the vehicle will require an animal which is standing to use all four legs to maintain balance and this is likely to inflict considerably more pain on the lame animal than simply standing in a pen on-farm.

a. [bullet point 2 for these please] The questions which a farmer should ask when making the decision whether to transport the animal should include:
b. Can the animal be loaded without using force?
c. Can the animal bear weight on all four legs and, if it is likely to stand during the
i. Journey, can it do so without pain or distress?
d. What is the duration of the journey?
e. What is the nature of the road over which the animal will be transported?
f. Is the animal's condition going to deteriorate significantly over the time it takes to reach the slaughterhouse?
g. Is there a slaughterhouse near enough which will accept the animal? (You should send the animal to the nearest available place of slaughter).
h. Is there a suitable vehicle and driver available?
i. Can the animal be looked after satisfactorily during the journey?
j. Can suitable padding or bedding be provided?

- When assessing a cow for suitability, it is important to observe the cow walking in a tight circles (each direction), should be able to steady herself when pushed firmly, should be able to walk up and down slopes, and if a block is fitted, it should be secure and free from rocking.

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This article reviews options for local anaesthesia and analgesia protocols which can be used for surgical treatment of cows with necrotic hoof lesions. Note, however, for many of these cows , humane euthanasia or perhaps slaughter, provided the animal is fit for transport, will be the best option for the cow and economic reasons. Fitness to transport must be assessed carefully in cows with foot lesions *(Box 1)*, as safeguarding welfare must be a primary concern. Complications, such as blocks falling off, occasionally arise during journeys or unloading. Effective treatment may be implemented to allow legal transportation.

Welfare concerns

Cows with necrotic claw lesions represent a major welfare concern for several reasons. First, they are usually chronically lame for weeks, often until slaughter. Even with treatment, the likelihood of returning to true soundness is limited due to the bony changes reported in some cases. Another welfare concern is the treatment of cases by farmers or hoof trimmers without necessary local anaesthesia. Having reviewed foot trimming records for many years, the authors note the majority of cows with necrotic claw lesions recorded at hoof trimming are being treated or managed by farmers and hoof trimmers, with very few referred to a veterinary surgeon for treatment. Generally veterinary intervention is a last resort, if used at all.

There are three common interventions used to treat necrotic claw lesions:

- Digit amputation — generally case selection is determined by the absence of tendon laxity, absence of ascending infection and cow factors such as robustness and economic value
- Partial toe amputation, using surgical wire or rotary cutting discs
- Deep surgical curettage of infected, necrotic corium, sometimes referred to as 'radical resection' or 'deep debridement'.

Despite the surgical debridement falling under the Veterinary Surgeons Act (1966) *(Box 2)*, many professional hoof trimmers and some farmers are compelled to attempt this procedure, in an effort to treat the lesion and improve cow welfare. Consequently, these cows do not receive either pre-operative analgesia followed by regional intravenous anaesthesia (RIVA). As cows are inevitably in pain during this procedure, the paring out of the lesion may be incomplete compared with surgical debridement by a veterinary surgeon. The main motivations for farmers not using a veterinary surgeon has not been studied, but they may relate to perceived cost, lack of awareness of the benefit of treatment options, or a perception by the farmer that the veterinary profession lacks the necessary skills or equipment to do the job. Many cows end up without effective treatment, and they then suffer from a chronically painful, yet treatable condition, for months or years.

Figure 5. Extensive surgical debridement of toe necrosis (dorso-ventral view showing debrided corium over the tip of PIII). (AQ10 Please provide a high res version) (AQ11 Please cite in the text)

Box 3. Case selection for cows undergoing major digit surgery

- The cow is in good body condition, it is cost effective to treat her and there is a high chance of success (her welfare will improve)
- The cow is at a stage in the management cycle appropriate for surgery and recovery, i.e. not in transition period or freshly calved
- The partner claw within the lame foot is sound
- The cow is sound on other limbs, which have no lesions causing lameness
- Flexor tendon laxity is not present
- The appropriate surgical method is chosen according to severity of disease and extent of pathology. This can be challenging to determine with certainty without diagnostic imaging and investigation.
- Management on farm is of a standard to achieve the necessary aftercare (skills, time, commitment and facilities)

(AQ12 Please cite in the text)

Arguably the veterinary profession has a role to proactively raise awareness amongst farmers about the effective treatment options, which are feasible, effective and not prohibitively costly compared with the repeated treatments by hoof trimmers.

Digit amputation through the proximal phalanx (PI) is preferable to low amputation through the middle phalanx (PII), as the nutrient foramen in PII is often severed in the low amputation, creating a sequestrum (Pedersen, 2012). Survival rates with high amputation are good, with Pederson (2012) reporting 55% survival at 1 year post surgery in hindlimbs, and 84% survival in forelimbs. In mainland Europe, partial toe amputation is often preferred due to the lower risk of complications compared with digit amputation (Kofler, 2017). In recent years, deep surgical curettage has been proposed as the preferred method as it can restore normal, healthy claw horn growth, preserves PII (AQ13 What is PIII?) and results in a functioning digit, although the procedure may take longer to perform than partial toe amputation with a rotary blade.

Pre-operative analgesia

The recognition and management of pain in cattle is still an undervalued element of treatment, particularly for lameness. The fact that cows are already chronically painful at the time of presentation to the veterinary surgeon means that 'wind-up' has already

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Table 1. Analgesics licensed for used in dairy cattle in the UK. Half-life data were derived from the European Medicine Agency or the Summary of Product Characteristics

Active analgesic	Product	License claim in relation to lameness	Half-life	Withdrawal
Ketoprofen	Ketofen 10%, Dinalgen	Reducing pain associated with lameness	30 mins	Meat — 1 day IV, 4 days IM Milk — 0 days
Tolfenamic acid	Tolfine	Acute mastitis and respiratory disease	8–15 hours	Meat — 3 day IV, 7 days SC Milk — 24 hours
Meloxicam	Metacam, Loxicom	Not a licensed claim	17–26 hours	Meat- —15 days Milk — 5 days
Carprofen	Rimadyl, Caprieve	Not a licensed claim	44.5–64.6 hours	Meat — 21 days Milk — 0 days
Flunixin Meglumine	Finadyne, Allevinix	Not a licensed claim	3–8 hours	Meat — 5–10 days IV (depending on product), 31 days IM Milk — 24 hours IV, 36 hours IM

SC=subcutaneous, IM=intramuscular IV=intravenous

begun. 'Wind-up' is the process of central amplification of pain perception which results in increased sensitivity and levels of pain (Hudson et al, 2008) presenting as allodynia (pain response to non-noxious stimuli) and hyperalgesia (increased sensitivity to pain). To prevent further wind-up, intravenous non-steroidal anti-inflammatory drugs (NSAIDs) should be administered before surgery begins. In addition to this, the anti-inflammatory effects of NSAIDs may be beneficial for treatment of claw horn disruption lesions (sole haemorrhage, sole ulcers and white line disease) which become complicated with soft tissue swelling within the hoof capsule (a closed space). It may also minimise periosteal inflammation and new bone formation on the plantart/palmar aspect of the flexor tuberosity of the distal phalanx (Newsome et al, 2016). There are five analgesics licensed for use in dairy cattle (*Table 1*).

Pre- and post-operative analgesia

While long-term dosing of cattle post-operatively with analgesics such as ketoprofen is unusual for economic reasons, it is normal to give several repeat doses to animals undergoing painful surgery such as amputation and surgical debridement. For hospitalised cattle undergoing surgery, a steady-state meloxicam regimen has been used for periods extending many weeks without ill effects. This involves giving an initial intravenous (IV) treatment according to normal dose rate, followed by half-dose sub-cutaneous injections at 24-hour intervals (personal communication, Arne Vanhoudt). It is advisable to monitor kidney function with extended therapy. Steady-state regimens for other analgesics may be more complicated due to different half-lives (*Table 1*), and pharmaceutical companies should be consulted before embarking on these. Off-label treatment regimens like this attract the minimum statutory milk and meat withdrawal periods but should be considered on welfare grounds and could be economically feasible, particularly for cows treated at dry off.

Local and regional anaesthesia

A number of different techniques have been described for provision of local anaesthesia to the lower limb and claws in cattle, including retrograde intravenous anaesthesia (RIVA, also known as intravenous regional anaesthesia or IVRA), a four-point nerve block or ring block, and application of local anaesthetic into the palmer/plantar pastern region. For all methods, the skin over the injection sites should be cleaned, ideally with disinfectant, and wiped with alcohol (e.g. with an alcohol impregnated teat wipe) to reduce the chance of introducing bacterial pathogens which might result in cellulitis or phlebitis.

Local anaesthetics work by blocking sodium channels in nerve cells, thereby stopping transduction and transmission of pain signals to the central nervous system. Their duration of action depends on the contact time with nerve cells, but generally will have a duration of less than 90 minutes. As most cows do not tolerate being restrained in the handling facilities for more than 25–30 minutes, this duration is ample for most procedures.

(AQ14 sub sub head RIVA?)

RIVA is the simplest of the local anaesthetic techniques. It involves the application of a tourniquet to the distal limb to limit venous blood flow and then infusion of local anaesthetic into a major vein. Some analgesia is achieved with the ischaemic effect of the tourniquet (Nuss, 2016), but note that ischaemia can itself be painful without local anaesthetic. It works through the retrograde diffusion of the local anaesthetic along and then out of the veins running adjacent to nerves within neurovascular bundles. It relies on the interlinked venous network which has numerous shunts in the distal limb, which allows widespread perfusion and complete anaesthesia of the distal limb. Occasionally this perfusion is incomplete so it is important to check pain sensation around the coronary band to judge anaesthesia and supplement local anaes-

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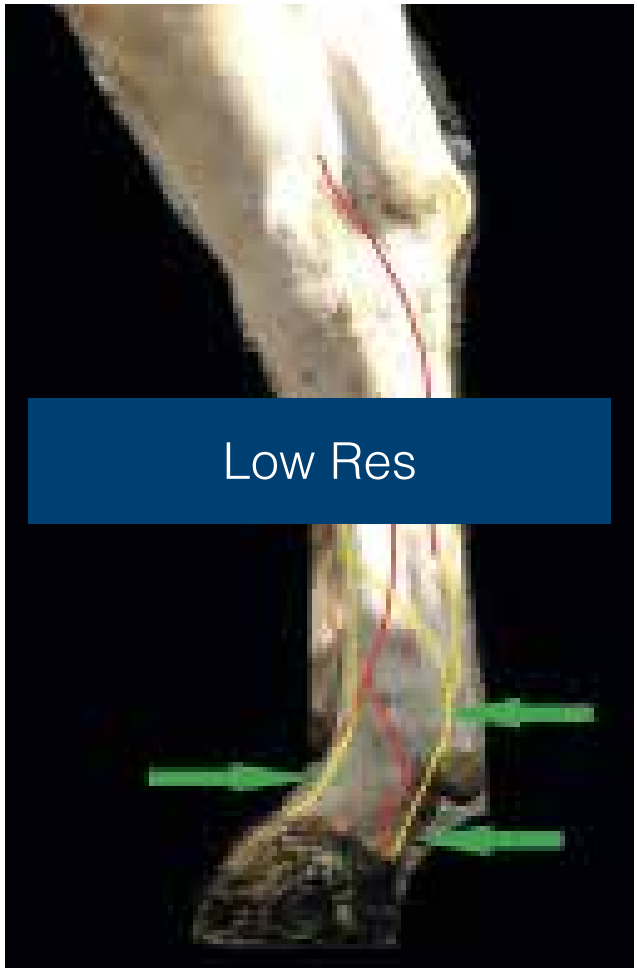

Figure 6. image of the lateral hindleg, depicting the approximate locations of the hindlimb veins (red) and nerves (yellow). The green arrows indicate the location for the low four-point block. The blue bar indicates the location for a high ring block. The lower forelimb and foot is innervated on the dorsal aspect by nerves originating from the radial and ulnar nerves, and on the palmer aspect from nerves originating from the median, palmer and ulnar nerves. The lower hindlimb and foot is innervated on the dorsal aspect by nerves originating from the peroneal nerve, and on the plantar aspect from the nerves originating from the tibial nerve. An understanding of this anatomy aids understanding of the three methods of anaesthesia. (AQ15 Please provide a high res version) (AQ16 Please cite in the text)

thesia as necessary.

There are multiple locations described for both the application of the tourniquet and the selection of an appropriate superficial vein for injection. In both the fore- and hindlimbs, a tourniquet can be applied to the mid-metacarpal or metatarsal area. This is quick, simple and effective for raising a vein and achieving reliable venous occlusion. In hindlimbs it is possible to apply the tourniquet above the hock which provides a large vein for injection which, is less likely to be affected by swelling from the distal limb, may achieve a more reliable local anaesthesia of the whole distal limb, but is generally less accessible in most handling systems, and it requires extra padding to be placed in the depression between the gastrocnemius tendon and distal tibia to achieve venous occlusion.

Correct tourniquet application should lead to raising of the superficial veins, which are generally visible in thin haired cattle. Cleaning within disinfectant and alcohol further assist in visualising veins, but some practitioners choose to clip hair to aid visualisation and cleaning. In the forelimb, the radial vein or the medial palmer digital vein are used. In the hindlimb, the medial or lateral digital veins on either side of the metatarsal region, or the common digital vein which is on the dorsal aspect of the limb are used (Clarke et al, 2014).

Once a vein is identified then around 20–30 ml of local anaesthesia can be injected into a vein. This can be done using a butterfly catheter to allow for movement of the limb, as cattle often react on insertion of the needle and injection of local, which may lead to rupture of the vessel being used. In well-restrained animals or with practice, a standard 16–18 gauge needle can be used. On injection a degree of massage will assist the retrograde perfusion of local anaesthetic. The anaesthesia can require 10 minutes to take effect and so this procedure should be started immediately after intravenous NSAID administration. While the anaesthesia is taking effect the foot can be prepared and a block secured to the sound claw (if appropriate). Some practitioners advocate exsanguination of the lower limb prior to injection of the local anaesthetic, but the authors have not found this to be necessary. The tourniquet can be left on the limb for up to 1 hour, and also provides haemostasis during debridement of the claw (Apley, 2015). Old flutter valves or bicycle inner tubes make very good tourniquets due to their elastic properties, with additional use of the leg strap as a tourniquet. String can be used if other alternatives are not available.

The presence of cellulitis in the limb can make RIVA challenging to carry out. Other potential complications of a RIVA are development thrombosis and thromboembolism of the vein used (Nuss, 2016) as well as bacteraemia following injection. The risk of these complications can be reduced through the use of nerve blocks, with variations of the four-point block and ring block being described. If, following application of RIVA, full anaesthesia of

Box 4. locations for the low four-point nerve block

1. Injection into the dorsal aspect of the pastern, in the groove between the proximal phalanges, just distal to the fetlock. Place 5 ml of local anaesthetic deep, and 5 ml superficially in this location. This corresponds to the dorsal common digital nerve III.
2. Injection into the plantar aspect of the pastern, in the groove between the proximal phalanges, just distal to the dewclaws. Place 5 ml of local anaesthetic deep, and 5ml superficially in this location. This corresponds to the plantar common digital nerve III.

3 + 4. Injections on both the medial and lateral aspect of the fetlock, approximately 2 cm dorsal to the dewclaw. This corresponds to the axial and abaxial plantar digital nerve digital nerve II and III and the axial and abaxial dorsal digital nerve II and III.

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the foot has not been achieved, an additional injection of 10–20 ml of local anaesthetic into the palmer/plantar aspect of the pastern, in the space between the proximal phalanges, just distal to the fetlock, can also be used to provide additional analgesia.

(AQ17 sub sub head four-point nerve block and ring block?)

The four-point nerve block (AQ18 Cite Box 4 here?) anaesthetises the lower limb from the pastern distally. This process is slightly different from that described in horses, as palpation of the nerves is relatively difficult in the cow due to the tense, thick skin and fibrous subcutaneous tissue (Clarke et al, 2014). Instead, 5–10 ml of local anaesthetic is injected at four different anatomical locations using a 20 G, 1.5 inch needle. The sites are described in *Box 4* (Edmondson, 2016).

The final commonly used method for providing anaesthesia to the foot is with a ring block. In essence, this is a simpler version of the four-point block, and is achieved by injecting local anaesthetic at multiple locations around the mid-metacarpus or metacarpus region. However, this technique does require good massage of the local anaesthetic and requires multiple injection sites unlike RIVA (Edmondson, 2008). This same ring block method can also be employed higher up the leg in the proximal metacarpus/tarsus region. This is particularly helpful when there is swelling of the distal limb, or following a failed RIVA when a vein has been blown. This proximal position also avoids injection into digital sheaths, so removing any potential complications of a tendinitis.

(AQ19 New sub sub head?)

Commercially available licenced local anaesthetics contain procaine or lignocaine. In the UK procaine products come with epinephrine and are off-label for intravenous use. In some countries procaine is available without epinephrine and the Veterinary Medicines Directorate (VMD) can advise on accessing and using these. Epinephrine will cause some vasoconstriction although the adverse effects of vasoconstriction on the rate and extent of desensitisation is probably not noticeable in practice. The pros and cons of peripheral vasoconstriction and haemostasis for surgical procedures, and subsequent wound healing, warrants investigation. Lignocaine is licensed for intravenous use but the European Medicines Agency's Committee for Medicinal Products for Veterinary Use (CVMP) has placed a 15 day milk withdrawal period on it in dairy cattle (Hendrickx, 2015). Therefore, many practitioners opt for procaine with epinephrine for intravenous use which attracts a statutory minimum 7-day milk and 21-day meat withhold period for off-label use under the cascade. If procaine with epinephrine is used for four-point blocks or ring blocks then there is no milk withdrawal. Lignocaine is a pharmacologically more desirable drug due to its quicker onset of action, increased potency and wider diffusion throughout tissues when compared with procaine (Edmondson, 2016). It also has a longer duration of action of around 90 minutes compared with procaine which is only up to 60 minutes, however this is a minor factor due to the maximum time a tourniquet can be safely applied being only 60 minutes.

Consideration must also be given to the volume of local anaesthetic used. The toxic dose rate for lignocaine is 10 mg/kg, and although it is unlikely this limit would be reached in an adult dairy cow, it is possible to reach this limit in immature animals that require multiple location injections.

KEY POINTS

- (AQ20 Please provide 5-6 key points - these are full sentences summarising the main points made throughout th article) ?????????????????? ?????????? ?????????????
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Conclusions

Use of appropriate local anaesthesia and analgesia to allow thorough therapeutic trimming of cattle is a vitally important tool in the armoury of the farm animal veterinary surgeon. Once clinicians become confident in their usage, this routine procedure can be utilised for treatment of a wide variety of claw lesions, making the experience pain free for the animal, and (nearly) stress free for the veterinary surgeon. This push towards increasing cow comfort both during and after foot trimming can only be beneficial in terms of cattle welfare and return to maximal productivity, therefore should be strongly advocated in all suitable situations. LS

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[Note to self - style references]

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