Equine Veterinary Education

EQUINE VETERINARY EDUCATION
Equine vet. Educ. (2012) **24** (2) 81-89
doi: 10.1111/j.2042-3292.2011.00311.x

Original Article

Combined decongestive therapy including equine manual lymph drainage to assist management of chronic progressive lymphoedema in draught horses

***H. Powell*† *and V. K. Affolter**‡**

†Equine MLD, Worcestershire, UK; and ‡Department of Pathology, Microbiology, Immunology, School of Veterinary Medicine, UC Davis, California, USA.

Keywords: horse; chronic progressive lymphoedema; combined decongestive therapy (CDT); manual lymph drainage (MLD); equine CDT; equine MLD

Summary

Equine chronic progressive lymphoedema (CPL) is a disabling disorder of draught horse breeds. Combined decongestive therapy (CDT) is the treatment of choice for lymphoedema in man and has been adapted for use in horses. Equine CDT, which includes manual lymph drainage (MLD) and subsequent bandaging with short stretch bandages, was expected to improve the signs of CPL in draught horses because CPL resembles primary lymphoedema in man. Five affected horses - Gypsy cob (n = 1), Clydesdale (n = 1), Shires (n = 3) - were included. Lesions were documented pre- and post treatment. Percentage volume loss of the distal legs was calculated using the disc model. Initial plans for daily CDT had to be adapted; intermittent treatment of Chorioptes infections required alternating between CDT and MLD in 4/5 horses. Concurrent pyoderma (1/5 horses) was treated throughout the study. Development of unrelated lameness (hoof abscess) allowed limited CDT treatment only in one horse. Marked softening of previously firm tissue indicated the change from 'brawny' to pitting oedema in 2/5 horses. Fibrotic nodules and folds in the pasterns became markedly softened and smaller in 2/5 horses. Skin surface notably improved in all horses: hyperkeratosis decreased, erosions and ulcerations healed completely and crusts disappeared. After 2 weeks, a mean volume reduction of 11.25% was seen, ranging from 4.75–21.74% and quality of movement improved. This pilot study documents evidence that CDT assists management of CPL. Current CPL management is limited to palliative treatments of secondary infections. Whilst not a permanent treatment, CDT offers a promising tool to manage horses with CPL, improving their quality of life and potential usefulness. More extensive and prolonged studies with a larger number of horses are warranted to evaluate the full potential of CDT.

*Corresponding author email: vkaffolter@ucdavis.edu

Introduction

Equine chronic progressive lymphoedema (CPL) has been identified in several draught horse breeds with heavy feathering including Shires, Clydesdales and Belgian draught horses (De Cock *et al*. 2003). It has also recently been recognised in Gypsy cobs (V.K. Affolter and H. Powell, personal observations). Typically, lymphoedema first appears as a soft, pitting subcutaneous oedema, often not identified in the presence of heavy feathering. However, careful palpation allows detection of small fibrotic folds and oedema in horses as young as 2 years of age (De Cock *et al*. 2003; Ferraro 2003), sometimes mistaken for scar tissue due to mite infestation. Slowly progressive swelling of the distal extremities ultimately results in marked fibrosis and induration, firm large tissue folds and nodules (De Cock *et al*. 2003; Ferraro 2003). This reflects lesions seen with lymphoedema in man (Sisto and Khachemoune 2008). Development of fibrosis is not only disfiguring (De Cock *et al*. 2003; Ferraro 2003), it damages other tissues, affecting nerves, blood and lymphatic vessels, slowing delivery of oxygen to tissues and removal of metabolic waste products. Large fibrotic nodules and folds on the lower extremities are vulnerable to damage and can impair free movement of the joints leading to lameness.

As a result of lymphoedema and poor tissue perfusion, the integrity of the skin's barrier function is impaired. Decreased immunosurveillance predisposes to recurrent parasitic and bacterial infections, which reflects the situation in man with chronic lymphoedema (Devillers *et al*. 2007; Bernard 2008; Damstra *et al*. 2008; Ryan 2009). Recurrent infections can be addressed therapeutically, but folds and nodules do not regress with antibiotic and

antiparasitic treatments, and affected horses are often misdiagnosed with 'therapy-resistant' pastern dermatitis (Wallraf *et al*. 2004; Geburek *et al*. 2005a,b). This debilitating condition can lead to loss of use and premature death by euthanasia.

For decades, combined decongestive therapy (CDT) has been the preferred treatment for lymphoedema in man, as documented by the International Society of Lymphology (Anon 2009). It reduces oedema and promotes regaining and maintaining of normal or near normal limb size by preventing reaccumulation of fluid, breaking down fibrosis and preventing infection (Földi *et al*. 2006). As a result, patients experience relief of pain and discomfort. Movements are restored by weight reduction and enablement of joints, tendons, ligaments and muscles to function more effectively. If applied correctly, CDT is safe, effective, inexpensive and has very few contraindications.

Combined decongestive therapy is performed in 2 integrated phases (Anon 2009). The initial intensive phase involves daily manual lymph drainage (MLD), skin care, multi-layer compression bandaging and exercise. The second maintenance and optimisation phase starts immediately after the intensive phase and involves the use of specialised compression garments, continued skin care and exercise.

Combined decongestive therapy has been validated for use in horses with secondary lymphoedema following lymphangitis (Rötting 1999; Fedele and von Rautenfeld 2005, 2007). This pilot study documents positive effects of CDT in 5 horses affected with CPL.

Materials and methods

Horses

Five privately owned horses (one Gypsy cob, one Clydesdale, 3 Shires) were stabled in box stalls with free access to separate attached dry paddocks at the Centre for Equine Health, University California Davis. Detailed information about each horse is listed in **Table 1**. Due to time and financial constraints, treatment was limited to 2 legs per horse. Legs were clipped prior to taking pretreatment measurements. Numerous cutaneous fibrotic nodules gave the clipping an irregular appearance (*Horses 3, 4* and *5*).

Measurements

Measurements were taken at the start and end of the study. Initial volume and subsequent reduction were assessed with the disc model, which has been proven to give satisfactory results and is suitable for use with horses (Haase *et al*. 2009). The disc model uses sequential circumferential measurements to calculate cylindrical volume (Sander *et al*. 2002; Fedele and von Rautenfeld 2005, 2007; Tewari *et al*. 2008). Circumference measurements, starting from a set point from ground level and repeated every 4 cm, were taken between the fetlock and tarsal or carpal joint respectively. Due to large folds and nodules, pastern measurements were inconsistent and hence excluded. The volume (V) was calculated using the sequential circumference measurements (C):

$$V = \left(C1^2 + C2^2 + Cn^2\right) \times \pi^{-1}$$

In cases where no 'normal' unaffected legs are available for comparison, as was the case in this study, the following formula has been established for calculations of percentage loss, where V_F = final volume and V_I = initial volume (Kuhnke 1978):

$$\text{Reduction } \% = (V_F - V_I) \times V_I^{-1} \times 100$$

Lesion documentation

The lesions were photographically documented before initial treatments and after study completion. Skin scrapings documenting Chorioptes infestations were regularly performed during the study.

Combined decongestive therapy (CDT)

Combined decongestive therapy - *Phase I*: Treatments are repeated daily until changes in volume reduction measurements cease (Földi *et al*. 2006). Daily MLD and skin care are followed by specialised multi-layer compression bandaging and exercise. Manual lymph drainage - a manual therapy resembling massage - moves lymph 'transterritorially' from affected areas to ones where the system is functioning adequately and is always applied proximally, at the jugulo-subclavian area, before treating the affected region (Földi *et al*. 2006). Manual lymph drainage supports and stimulates the lymphatic system to remove accumulated proteins and water from the

TABLE 1: Case details of horses

Horse	Breed	Sex	Age (years)	Additional comments
1	Gypsy cob	Mare	5	-
2	Clydesdale	Mare	10	Club feet: right front deformed>left front; bilateral hind feet Poor maintenance of feet
3	Shire	Mare	17	Marked firm swelling ventral abdomen cranial to mammary gland, right side>left side
4	Shire	Mare	16	-
5	Shire	Mare	5	9 months pregnant

interstitium back to the blood stream (Wittlinger and Wittlinger 1998). Specific 'fibrosis' techniques are used to break down and disperse fibrotic and indurated tissue (Földi *et al*. 2006).

Equine MLD techniques have been adjusted to accommodate anatomical differences between man and horses (Fedele and von Rautenfeld 2005, 2007). Due to the anatomy of the equine distal limb, MLD also directly influences the regional deep lymphatic system.

Following MLD the skin is moisturised as required and multi-layer compression bandaging is applied in a distal to proximal direction using short stretch bandages, which overlay foam pads in man (Földi *et al*. 2006) and thick cotton wool padding in horses (Fedele and von Rautenfeld 2005, 2007) to distribute the pressure evenly. Short stretch bandages have a low working pressure when muscles are relaxed and a higher working pressure during exercise. This provides supportive pressure to the lymphatic vessels and prevents reaccumulation of lymph fluid. Exercise is then undertaken after bandaging to increase the flow of lymph.

Phase II: Skin care and exercise are continued. In human practice bandages are commonly replaced by specialised knitted cotton compression garments with distal to proximal graduated pressure, worn daily, for 12–24 h. Manual lymph drainage treatments are tapered off to a minimum of every 6 months or according to individual needs at which time garments are refitted. In severe cases, CDT treatment may be repeated (Földi *et al*. 2006). Elastic compression stockings, which support the flow of lymph, are available for horses[5].

Treatment programme

Daily treatments for 14 days were planned, based on previous documentation (Rötting 1999). The owners were advised to treat each horse for existing infections (mite infections or bacterial infections) prior to this study. Each horse received MLD performed by an Equine MLD practitioner (Heather Powell: http://www.equinemld.com; certified by the 'Europäisches Seminar für Equine Lymphdrainage' through the Medizinische Hochschule Hanover; http://www.ml-pferd.de). As described above, MLD was followed by multi-layer compression bandaging of both treated legs, using cotton wool padding[2] and short stretch bandages (Rosidal K)[3]. Each horse was then hand walked for 20–30 min.

Skin scrapings for chorioptic mange were repeated and if positive, anti-parasitic treatment with fipronil (Frontline)[4] was initiated. Superficial bacterial infections were treated with topical Cephapirin sodium (Cefa-Lak)[5]. Grooming tools were cleaned, washed in 10% hydrogen peroxide and rinsed after each use.

Follow-up maintenance

Due to constraints described previously, the inclusion of *Phase II* CDT was not planned for this study; however, to support the reduction of oedema, equine compression stockings[1] were given to owners of the horses that responded to *Phase I*.

Results

Lesions before treatment

The severity of skin lesions (listed in **Table 2**) varied from relatively mild to severe. Mild lesions were characterised by nonpitting oedema and small firm fibrotic folds in the palmar or plantar pastern. Distal limbs lacked visual and palpatory definition of normal anatomic structures such as bony protuberances, joints and tendons, but rather had a 'cone'-like appearance (**Fig 1**). Severely affected legs had marked fibrotic folds and nodules measuring up to 4.5 cm in diameter resulting in marked disfigurement of the distal limb (**Fig 2**). Fibrous folds and nodules were most prominent in the pastern and to a lesser degree on the palmar and plantar aspects of the cannon (**Fig 3**). Palpation of underlying structures was difficult and movement was restricted in the 2 most affected horses (*Horses 3* and *4*). Multiple erosions, small haemorrhages, ulcerations and miliary crusts became evident upon clipping (**Fig 4**). *Horse 2* presented with deep, firm, folds in the plantar

Fig 1:* Horse 1, *hind legs: Nonpitting oedema results in loss of definition of the distal limbs and extends to the mid cannon. There are small firm folds in the plantar pasterns.

Fig 2:* Horse 4, *hind legs: Severe disfigurement caused by many indurated nodules. Pastern folds are circumferential and many nodules are ulcerated.

Fig 3:* Horse 3, *front legs: Dermal folds and numerous nodules extend along the cannon up to the carpal joint, made more evident by irregular hair growth. Firm chronic oedema has obliterated the normal shape of the distal leg.

pastern, which completely obliterated the natural profile (**Fig 5**). The skin surface of the folds was eroded, severely erythematous, oozing and malodorous, indicating superficial intertriginous dermatitis. As infection was limited to the skin surface, CDT was initiated simultaneously to topical treatment of the bacterial infection. Cranial to the mammary gland, *Horse 3* had a marked linear, firm, nonpainful swelling on the ventral abdomen. The swelling was not warm and the udder was normal.

Adjustments to treatment plan

Upon the owner's request, the front legs were treated in *Horse 3*, as severe fibrotic nodules limited the horse's movement in the front. Both hind legs were chosen for treatment of the remaining horses. Frequency of CDT and MLD and individual responses of each horse to treatment are listed in **Table 2**.

Horse 2 responded well to topical Cephapirin sodium[5] and tolerated concurrent CDT well. The skin surface dried out and erosions cleared after 5 days. One week into the study CDT had to be discontinued when this horse developed an abscess in the right front hoof. Because of marked discomfort, bandaging and walking was stopped and appropriate treatment for the hoof abscess initiated. Treatment of the superficial skin infection and MLD were continued for the remainder of the study.

The warmth provided by the bandages may have encouraged a flare-up of latent mite infections in *Horses 3, 4* and *5*. The horses were pruritic, stomping and scratching their legs and mites were detected on skin scrapings. *Horses 3* and *4* received fipronil treatments every other day during the first week of the study and MLD was continued daily previous to the fipronil application. On the days of fipronil treatment the legs were not bandaged to avoid occlusion and additional irritation. Combined decongestive therapy was re-initiated the following day. The pregnant mare (*Horse 5*) was not treated with fipronil, but was brushed carefully, treated with MLD daily and simply not bandaged on some days.

Suitable cotton wool padding for compression bandaging could only be used once and the study had to be terminated 2 days early due to unforeseen problems with padding supplies.

Fig 4:* Horse 4, *hind legs: Multiple erosions, small haemorrhages ulcerations and miliary crusts extend over the entire length of the distal limbs. Marked folds and chronic oedema are present. Large firm nodules obscure the pasterns.

Fig 5:* Horse 2, hind legs: *plantar area of pastern: Deep, firm, folds completely obliterate the natural profile of the plantar area of pasterns. The skin surface is eroded, ulcerated and moist. Pitting oedema is noted extending up to the hock.

Clinical observations throughout treatment

Individual responses to treatment are listed in **Table 2**. Typically, oedema reduction was observed after the first CDT treatment. By the third CDT treatment, previously obscured underlying structures, such as tendons, were more distinct to palpation. This was particularly evident in *Horse 3*. Indurated, fibrotic nodules and deep folds in the distal leg became more defined as the marked oedema between nodules and folds reduced. The tissue between the nodules and folds was less firm to touch indicating the change of a 'brawny' oedema into a pitting oedema; in particular, in *Horses 1* and *5*. *Horse 1* regained a normal pastern shape, immediately observed by her owner at the end of the study. With continued treatment, many nodules and folds decreased in size and were softer to palpation, in particular in *Horses 3* and *4* (**Fig 6**), indicating a decrease in tissue fibrosis. Overall, the quality of the skin surface improved dramatically in all horses; hyperkeratosis decreased, erosions and ulcerations healed completely, and crusts were no longer present (**Fig 7**). With reduction of oedema, infected skin folds in the pasterns of *Horse 2* softened and reduced in size enabling better access for topical treatment. The improved skin condition, reduction of skin folds (**Fig 8**), as well as oedema reduction in the distal limb, was noted before CDT had to be stopped prematurely.

All horses were compliant to treatment and 4 horses (*1, 3, 4* and *5*) had excellent responses. The obvious oedema reduction as well as softening of the nodules and folds resulted in a better range of limb movement that was most obvious in *Horses 3* and *4*. The improved movement was immediately observed and spontaneously commented upon by their owners at the end of the study. The ventral abdominal swelling in *Horse 3* reduced in size and firmness. This reduction was interpreted as a possible systemic effect of MLD.

Measurements

Initial and post treatment measurements and volume reductions are listed in **Table 2**. There was an oedema volume reduction between 4.75 and 21.74%, with a mean of 11.25%. The lowest and highest reduction was observed in *Horses 3* and *1*, respectively.

Maintenance and follow-up

Although *Phase II* CDT was not included in this study, compression stockings[1] were given to owners of *Horses 1, 3, 4* and *5*. The owners were instructed in their use and advised to keep them on the horses for at least 12 h daily.

TABLE 2: Clinical observations pre- and post treatment

Horse	Clinical observations pretreatment	CDT	MLD	Δ%L	Δ%R	Clinical observations post treatment
1	Hind legs: Firm fibrotic plantar folds in pastern; multifocal erosions and crusts plantar cannon. Very sensitive to touch.	4	10	13.23	21.74	• Extremely sensitive about having lower hind legs touched • Mild sedation to perform CDT and MLD • Skin surface improved • Skin and subcutaneous tissue softer • Shape of fetlock and pastern better defined
2	Hind legs: pliable nonpitting oedema. Distal 3rd of cannon bone, fetlock and pastern enlarged, firm no definition. Deep infected folds in plantar pastern, smaller fold above ergot, fetlock.	4	7	NA	NA	• Quick response to CDT • Subsequent good response to topical therapy • CDT suspended after 5 treatments due to development of lameness on front leg, suggestive of hoof abscess. • Treatment of hoof abscess and MLD only • Returned home early • CPL at a relatively early stage. Fair response considering limited CDT treatment
3	Front legs: Many extremely firm cutaneous nodules completely covering legs distal to carpus. Difficult to palpate underlying structures. Large nodules (4.5 cm in diameter) in pastern areas, horizontal linear firm folds across dorsal pastern.	8	9	11.26	4.75	• Oedema between nodules reduced • Improved palpation of underlying structures • Firm nodules softened, palmar pastern nodules smaller • Tissues more pliable • Skin surface over nodules less hyperkeratotic • Freedom of movement visibly improved
4	Hind legs: Many extremely firm nodules on distal legs. Erosions, ulcerations and fibrous folds on plantar aspect of cannon bones. Horizontal firm folds across pastern and slightly overlapping hoof wall.	8	9	14.69	12.16	• Oedema reduced • Improved definition of leg shape and palpation of underlying structures • Softening of firm nodules • Erosion and ulcerations fully re-epithelised • Freedom of movement visibly improved
5	Hind legs: firm folds and nodules in pastern, firm swelling to approx. 8 cm proximal to fetlock. Above swelling softer.	8	9	6.14	6.05	• Oedema reduction at plantar aspect of distal legs • Tissue softening to 'pitting' oedema • Reduction in fetlock area • Fibrotic folds in plantar pastern region softened and reduced • Improved skin surface, healed erosions • Freedom of movement visibly improved

CDT: combined decongestive therapy; MLD: manual lymph drainage; Δ%L: percent volume reduction in the left leg; Δ%R: percent volume reduction in the right leg; NA: not applicable.

Some of the stockings were adapted by adding sturdy zippers and elastic inserts to accommodate the size of the legs of these draught horses. The owners of *Horses 3* and *4* reported that after returning home, both horses were trotting and galloping more freely during turnout time.

Follow-up after 6 months revealed that, due to various reasons, none of the owners issued with compression stockings had been continually able to use them. Owners reported that reduction in oedema and fibrotic nodules and improvement in movement appeared to have been largely maintained, indicating that changes produced during intensive treatment were not transient.

Discussion

This pilot study documents evidence that combined decongestive therapy (CDT) offers a helpful tool in assisting the clinical management of chronic progressive lymphoedema (CPL), which mostly affects heavy draught horses with pronounced feathering, including Belgian draught horses, Shires and Clydesdales (De Cock *et al*. 2003; Ferraro 2003).

Aetiology of equine CPL has not been identified, which reflects the situation with primary lymphoedema in man (Devillers *et al*. 2007; Ryan 2009). The exact incidence of CPL within a breed has not been determined. However, within affected breeds, it is difficult to identify completely unaffected horses amongst animals older than 10 years of age (De Cock *et al*. 2003; Ferraro 2003), suggesting a genetic background to this disorder. Elastin is crucial for effective function of lymphatic vessels and appropriate lymph drainage (Ryan 1989; Skobe and Detmar 2000). Altered elastin metabolism and elastin degradation are crucial contributors to equine CPL (De Cock *et al*. 2006a,b, 2009; van Brantegem *et al*. 2007a,b). Similar to *elephantiasis verrucosa nostra* in man (Devillers *et al*. 2007; Ryan 2009), skin barrier function in CPL is impaired. This sets the stage for recurrent bacterial and parasitic infections in affected horses, also referred to as therapy resistant pastern dermatitis (Geburek *et al*. 2005a,b; Kugler 2008).

Currently, options for CPL management are limited to palliative treatments of the secondary infections and maintenance of a clean skin surface. As shown in humans with lymphoedema (Sisto and Khachemoune 2008; Anon

Fig 6:* Horse 4, *pastern post treatment: The firm, fibrotic nodules and folds are notably reduced in size, resulting in better definition of the lower leg.

Fig 7:* Horse 4, *hind legs: There is notable decrease in surface hyperkeratosis. Erosions and ulcerations have healed. There is more definition to the hocks and cannons.

2009), avoidance of trauma and superficial skin infections is crucial in managing CPL. The moist, densely hyperkeratotic skin surface covered by heavy feathering sets the perfect stage for reinfestation with chorioptic mites and bacterial infections (Risberg *et al*. 2005; Rüfenacht *et al*. 2011). Careful grooming and drying of distal legs, avoiding friction, routine skin scrapings and early treatment of chorioptic mange are crucial, which often requires clipping of the feathers. Surgical debulking of fibrotic nodules followed by bandaging, as documented in a Belgian draught horse (Vlamink *et al*. 2008), can further damage the lymphatic system in the tissue. Debulking is therefore only performed in people who do not respond to CDT (Warren *et al*. 2007).

Combined decongestive therapy is the state of the art treatment for acute and chronic lymphoedema in humans (Cheville *et al*. 2003; Tiwari *et al*. 2003; Koul *et al*. 2007). For the best results, CDT should be initiated as early as possible with the aim of regressing the lymphoedema to a stage of latency, free of signs and symptoms. With marked fibrosis the condition requires extended treatment and results may not be as satisfactory, but CDT still produces observable improvement (Földi *et al*. 2006).

Although horses have a high susceptibility to lymphoedema in their lower extremities, usually referred to as 'filled legs' and 'stocking-up', the equine lymphatic system has not been subjected to extensive studies. Recent reports by the University of Hanover have documented the effectiveness of CDT for equine lymphangitis-induced lymphoedema (Rötting 1999). Horses are also more responsive to MLD than people (von Rautenfeld and Schacht 2006; Fedele and von Rautenfeld 2007). However, to the authors' knowledge, there are no reports documenting the effects of CDT and MLD in horses affected by CPL.

Despite several challenges encountered during this pilot study, all horses showed improvement of their skin condition as well as reduction of oedema and volume of their lower legs. As a result, the distal limbs regained better definition of their normal structures. The horses' movement improved due to softening of fibrotic nodules and folds. Based on reports in man (Lindemayr *et al*. 1980; Földi *et al*. 2006), these are considered positive effects of successful CDT. The intention to treat horses with CDT daily for 14 days was impeded by a number of factors, including the reduced number of times horses could be bandaged due to flare-up of mite infections, insufficient supplies of suitable padding material and limited time and personnel available for post treatment exercise. The pastern intertriginous pyoderma and, in particular, development of a hoof abscess further limited the results in *Horse* 2. Hence,

Fig 8:* Horse 2, *pastern: The folds have reduced in size and are less firm. The infection has cleared and skin surface markedly improved. There is more definition to the pastern and cannon.

treatments could not be pursued until maximum volume reduction had been reached.

The marked percentage volume reduction as seen in these horses is an important feature of assessing successful CDT treatment in man as well as in horses (Kasseroller 1998; Sander *et al*. 2002; Fedele and von Rautenfeld 2005; Tewari *et al*. 2008; Haase *et al*. 2009). Volume measurement by perometry (Haase *et al*. 2009), the most accurate volumetric assessment of the equine limb, was too expensive for this small pilot study. The disc model is considered adequate to use in horses and works well for the area of the equine cannon (Fedele and von Rautenfeld 2005). It is not as accurate in the area below the fetlock. Precise tape measuring was challenging as numerous nodules and folds result in an uneven skin surface. Moreover, areas with fibrotic nodules, most prominently seen in *Horses 3* and *4*, did not uniformly reduce in size. Therefore, volumetric measurements have to be interpreted in view of other changes, including better definition of the normal architecture of the distal legs as well as softening of fibrotic nodules and folds. The volume reduction was most noticeable in horses with prominent oedema, such as *Horses 1* and 2, despite receiving fewer CDT treatments. The least reduction was measured in *Horse 5* which also had the least oedema. Additional positive systemic effects of MLD, as earlier described by Fedele and von Rautenfeld (2005), was evidenced by the size reduction and softening of the ventral abdominal swelling in *Horse 3*.

Follow-up information indicates that results achieved by treatments applied during this pilot study were not limited to transient improvement of the horses' legs, but rather had long-term effects. Although maintenance management by using the stockings was inconsistent or lacking, owners reported that reduction of the oedema as well as fibrotic nodules and improvement in movement appeared to have been largely maintained.

In conclusion, this pilot study presents evidence that CDT offers a promising tool for the management of horses affected with CPL, a condition for which there is currently no cure. Until potential underlying genetic factors of CPL can be identified to further characterise the exact pathomechanisms of CPL (Momke and Distl 2007a,b; Young *et al*. 2007; Mittmann *et al*. 2009), CDT will help in keeping affected horses in better health and hence, prolong their lives. A more extensive study is warranted to evaluate the full potential of CDT. A fully comprehensive study will include a larger number of horses, rigorous pretreatment of mite and bacterial infections, extensive initial CDT treatment including a more extensive exercise programme until no further changes are observed, and adequate administration of *Phase II* CDT treatment.

Authors' declaration of interests

No conflicts of interest have been declared.

Acknowledgements

The authors are extremely grateful to everyone whose support made this pilot study possible, including the Centre for Equine Health at UC Davis, who generously offered stabling for the horses and partially funded the cotton wool and bandage supplies. Activa Healthcare Ltd generously supplied short stretch bandages and Simona-Strumpffabrik supplied the equine support stockings. We appreciate the help of our volunteer assistants who exercised the horses and, of course, are indebted to the owners who generously offered their horses for this pilot study.

Manufacturers' addresses

[1]Kerstin Gutberlet Strumpfproduktion u. Handel, Germany.
[2]CMC Consumer Medical Care GmbH Heidenheim, Germany.
[3]Lohmann & Rauscher International GmbH & Co KG, USA.
[4]Merial Limited, Duluth, Georgia, USA.
[5]Fort Dodge, Iowa, USA.

References

Anon (2009) The diagnosis and treatment of peripheral lymphedema. International Society of Lymphology. *Lymphol.* **42**, 51-60.

Bernard, P. (2008) Management of common bacterial infections of the skin. *Curr. Opin. Infect. Dis.* **21**, 122-128.

Cheville, A.L., McGarvey, C.L., Petrek, J.A., Russo, S.A., Taylor, M.E. and Thiadens, S.R. (2003) Lymphedema management. *Semin. Radiat. Oncol.* **13**, 290-301.

Damstra, R.J., van Steensel, M.A., Boomsma, J.H., Nelemans, P. and Veraart, J.C. (2008) Erysipelas as a sign of subclinical primary lymphoedema: a prospective quantitative scintigraphic study of 40 patients with unilateral erysipelas of the leg. *Br. J. Dermatol.* **158**, 1210-1215.

De Cock, H.E.V., Affolter, V.K., Wisner, E.R., Ferraro, G.L. and Maclachlan, N.J. (2003) Progressive swelling, hyperkeratosis, and fibrosis of distal limbs in Clydesdales, Shires, and Belgian draft horses, suggestive of primary lymphedema. *Lymphat. Res. Biol.* **1**, 191-199.

De Cock, H.E.V., Affolter, V.K., Farver, T.B., Van Brantegem, L., Scheuch, B. and Ferraro, G.L. (2006a) Measurement of skin desmosine as an indicator of altered cutaneous elastin in draft horses with chronic progressive lymphedema. *Lymphat. Res. Biol.* **4**, 67-72.

De Cock, H.E.V., Affolter, V.K., Wisner, E.R., Larson, R.F. and Ferraro, G.L. (2006b) Lymphoscintigraphy of draught horses with chronic progressive lymphoedema. *Equine vet. J.* **38**, 148-151.

De Cock, H.E.V., Van Brantegem, L., Affolter, V.K., Oosterlinck, M., Ferraro, G.L. and Ducatelle, R. (2009) Quantitative and qualitative evaluation of dermal elastin of draught horses with chronic progressive lymphoedema. *J. comp. Pathol.* **140**, 132-139.

Devillers, C., Vanhooteghem, O. and de la Brassinne, M. (2007) Lymphedema and cutaneous diseases. *Rev. Med. Suisse* **3**, 2802-2805.

Fedele, C. and von Rautenfeld, D.B. (2005) *Manuelle Lymhdrainage Beim Pferd*, Schlutersche, Hannover. p 180.

Fedele, C. and von Rautenfeld, D.B. (2007) Manual lymph drainage for equine lymphoedema-treatment and therapist training. *Equine vet. Educ.* **19**, 26-31.

Ferraro, G.L. (2003) Chronic progressive lymphedema in draft horses. *J. equine vet. Sci.* **23**, 189-190.

Földi, M., Földi, E., Kubrik, S. and Strössenreuther, R. (2006) *Földi's Texbook of Lymphology*, 2nd edn., Elsevier, New York. p 735.

Geburek, F., Deegen, E., Hewicker-Trautwein, M. and Ohnesorge, B. (2005a) The development of verrucous pastern dermatitis syndrome in heavy draught horses. Part I: review of the literature. *Dtsch. Tierarztl. Wochenschr.* **112**, 211-214.

Geburek, F., Deegen, E., Hewicker-Trautwein, M. and Ohnesorge, B. (2005b) Verrucous pastern dermatitis syndrome in heavy draught horses. Part II: clinical findings. *Dtsch. Tierarztl. Wochenschr.* **112**, 243-251.

Haase, F., Siewert, C., von Rautenfeld, D.B., Fischbach, J.U. and Seifert, H. (2009) Comparison of different methods to quantify the volume of horse limbs. *Berl. Munch. Tierarztl. Wochenschr.* **122**, 126-131.

Kasseroller, R.G. (1998) The Vodder School: the Vodder method. *Cancer* **83**, 2840-2842.

Koul, R., Dufan, T., Russell, C., Guenther, W., Nugent, Z., Sun, X. and Cooke, A.L. (2007) Efficacy of complete decongestive therapy and manual lymphatic drainage on treatment-related lymphedema in breast cancer. *Int. J. Radiat. Oncol. Biol. Phys.* **67**, 841-846.

Kugler, H. (2008) Scratches, grease heel, and grapes: or chronic pastern dermatitis then and now. *Vet. Herit.* **31**, 26-32.

Kuhnke, E. (1978) Statistical demonstration of the effectiveness of the Vodder-Asdonk method of manual drainage of lymph. *Experientia Suppl.* **33**, 33-46.

Lindemayr, H., Santler, R. and Jurecka, W. (1980) Compression therapy of lymphedema. *MMW Munch. Med. Wochenschr.* **122**, 825-828.

Mittmann, E.H., Momke, S. and Distl, O. (2009) Whole-genome scan identifies quantitative trait loci for chronic pastern dermatitis in German draft horses. *Mamm. Genome* **21**, 95-103.

Momke, S. and Distl, O. (2007a) Molecular characterization of the equine ATP2A2 gene. *Cytogenet. Genome Res.* **116**, 256-262.

Momke, S. and Distl, O. (2007b) Molecular genetic analysis of the ATP2A2 gene as candidate for chronic pastern dermatitis in German draft horses. *J. Hered.* **98**, 267-271.

Risberg, A.I., Webb, C.B., Cooley, A.J., Peek, S.F. and Darien, B.J. (2005) Leucocytoclastic vasculitis associated with Staphylococcus intermedius in the pastern of a horse. *Vet. Rec.* **156**, 740-743.

Rötting, A.K. (1999) Manuelle Lymphdrainage - Erprobung an den Extremitäten des Pferdes. *Thesis Anatomie der Medizinischen Hochshule Hannover and Klinik fur Pferde Chirurgie Freie Iniversität Berlin*. Berlin. p 135.

Rüfenacht, S., Roosje, P.J., Sager, H., Doherr, M.G., Straub, R., Goldinger-Muller, P. and Gerber, V. (2011) Combined moxidectin and environmental therapy do not eliminate Chorioptes bovis infestation in heavily feathered horses. *Vet. Dermatol.* **22**, 17-23. July 1, Epub ahead of print.

Ryan, T.J. (1989) Structure and function of lymphatics. *J. Invest. Dermatol.* **93**, 18s-24s.

Ryan, T.J. (2009) Elephantiasis, elastin, and chronic wound healing: 19th century and contemporary viewpoints relevant to hypotheses concerning lymphedema, leprosy, erysipelas, and psoriasis - review and reflections. *Lymphol.* **42**, 19-25.

Sander, A.P., Hajer, N.M., Hemenway, K. and Miller, A.C. (2002) Upper-extremity volume measurements in women with lymphedema: a comparison of measurements obtained via water displacement with geometrically determined volume. *Phys. Ther.* **82**, 1201-1212.

Sisto, K. and Khachemoune, E. (2008) Elephantiasis nostras verrucosa: a review. *Am. J. Clin. Dermatol.* **9**, 141-146.

Skobe, M. and Detmar, M. (2000) Structure, function, and molecular control of the skin lymphatic system. *J. Investig. Dermatol. Symp. Proc.* **5**, 14-19.

Tewari, N., Gill, P.G., Bochner, M.A. and Kollias, J. (2008) Comparison of volume displacement versus circumferential arm measurements for lymphoedema: implications for the SNAC trial. *ANZ J. Surg.* **78**, 889-893.

Tiwari, A., Cheng, K.S., Button, M., Myint, F. and Hamilton, G. (2003) Differential diagnosis, investigation, and current treatment of lower limb lymphedema. *Arch. Surg.* **138**, 152-161.

van Brantegem, L., De Cock, H.E.V., Affolter, V.K., Duchateau, L., Hoogewijs, M.K., Govaere, J., Ferraro, G.L. and Ducatelle, R. (2007a) Antibodies to elastin peptides in sera of Warmblood horses at different ages. *Equine vet. J.* **39**, 414-416.

van Brantegem, L., De Cock, H.E.V., Affolter, V.K., Duchateau, L., Hoogewijs, M.K., Govaere, J., Ferraro, G.L. and Ducatelle, R. (2007b) Antibodies to elastin peptides in sera of Belgian Draught horses with chronic progressive lymphoedema. *Equine vet. J.* **39**, 418-421.

Vlamink, L., DeCock, H.E.V., Hoesten, H. and Gasthuys, F. (2008) Epidermal shaving for hyperpapillomatopsis secondary to chronic progressive lymphoedema in Belgian draft horses. *Vet. Dermatol.* **19S**, 76.

von Rautenfeld, D.B. and Schacht, V. (2006) Fundamentals of comparative lymphology. In: *Földi's Textbook of Lymphology*, Eds: M. Földi, E. Földi and S. Kubik, Elsevier, New York. pp 164-178.

Wallraf, A., Hamann, H., Deegen, E., Ohnesorge, B. and Distl, O. (2004) Analysis of the prevalence of pastern dermatitis in German Coldblood horse breeds. *Berl. Munch. Tierarztl. Wochenschr.* **117**, 148-152.

Warren, A.G., Brorson, H., Borud, L.J. and Slavin, S.A. (2007) Lymphedema: a comprehensive review. *Ann. Plastic Surg.* **59**, 464-472.

Wittlinger, G. and Wittlinger, H. (1998) *Textbook of Dr Vodder's Manual Lymph Drainage: Basic Course*, Thieme, Stuttgart, New York. p 135.

Young, A.E., Bower, L.P., Affolter, V.K., DeCock, H.E.V., Ferraro, G.L. and Bannasch, D.L. (2007) Evaluation of FOXC2 as a candidate gene for chronic progressive lymphedema in draft horses. *Vet. J.* **174**, 397-399.