Benefits of Intermittent Pneumatic Compression

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Accelerating the wound healing process has been the objective of many medical devices and treatments and while many agents make therapeutic claims, few can be validated or even be explained by sound physiologic evidence. Compression treatment for soft tissue wounds has long been used in nearly all fields of medicine. While basic bandaging has been the standby to control bleeding, swelling and protection of soft tissue wounds, the use of intermittent pneumatic compression (IPC) is becoming more prevalent in equine and small animal medicine. Previous devices have been cumbersome, expensive and limited to the human medical environment, but IPC is a modality that can now be practically applied to animal patients. The application of IPC has been studied in both human medical and rehabilitation fields as well as in veterinary medicine and has been significantly effective at increasing blood flow, improving lymphatic propulsion, stimulating tissue proliferation and fracture healing.

Treatment and prevention of deep vein thrombosis with IPC has been thoroughly evaluated in humans. The benefits reported by Comerota et al.' were explained by increased venous velocity and stimulation of the endogenous fibrinolytic system. More specifically, significant increases in global fibrinolytic activities were demonstrated in the 180 minutes following IPC in normal and post-thrombotic human subjects. Other studies [2,3,4,5] show similar results. The fibrinolytic activities in these studies were all demonstrated through reduced endothelial cell production and pathway inhibition of tissue associated clotting factors. The effects were shown to be short-lived (150-180 minutes) but as effective as heparin treatment and other established drug protocols.

Blood flow was also reported in limbs receiving IPC. Both mechanical and biochemical mechanisms may be explained for subjects receiving IPC. An increase in arterial blood flow is achieved by raising interstitial pressure on the limb. Veins are collapsed momentarily allowing for improved venous ejection from the treated area. A hydrostatic pressure gradient is achieved post-compression before the veins are quickly refilled by arterial inflow [6'8]. Delis et al. noted a 2-3 fold increase in initial arterial flow velocity as well as the development of new collateral circulation after long term use of IPC. The same researcher suggests the value of IPC when performed with the objective of reducing tissue loss resulting from ischemia in both the skin and deeper tissues of the legs [9]. Arterial grafts were also more successful in patients that received IPC due to increased blood arterial and venous velocity and mean blood flow to the graft area 10.

Nitric oxide-mediated vasodilatation has been shown to be associated with IPC11 r. Enhanced blood flow as a result of IPC can be explained through the induction of nitric oxide (NO) production by endothelial cells in the area receiving IPC treatment and to the peripheral areas containing skeletal muscle [7]. Up regulation of eNOS mRNA, a potent vasodilator precursor drives the vasodilatation to the IPC treatment area as well as to the adjacent areas of treated limb. Elevated shear stress in the walls of the treated vasculature and increased flow velocity seems to be the physiologic mechanism for enhanced NO production 12, ". The ascending vasodilatation moves from the small capillaries to the larger arterioles over distances of several centimeters as endothelial cells propagate vasodilator signals. Countercurrent exchange of NO may also contribute to the ascending dilation of the treated arterial system. Diffusing NO levels could be the reason for vasodilatation in remote areas significantly distant to the treated limbs. Increased levels of NO are beneficial in not only increasing blood flow but also in inhibiting platelet aggregation and neutrophil adherence, two factors important to decreasing secondary hypoxic injury. NO is also a neurotransmitter that can have a feed back influence on vascular tone and thus blood flow[7].

Lymphatic drainage is another important factor in many types of injury. The accumulation of protein rich interstitial fluid can lead to the secondary accumulation of fibroblasts, collagen production and destruction of elastin fibers within the skin". IPC was shown to be effective in reducing lymphoedema during both the initial and decongestive phases of therapy'. The reduction of edema around injured tissues allows for better perfusion and oxygen delivery and IPC has been demonstrated to be significantly effective at lymphatic drainage [l3]. McGeown et al. has demonstrated in sheep that while lymphatic drainage is intrinsically aided by animal movement even though the lack of muscle for contraction in the distal legs is absent. Proximal drainage and the resulting pressure gradient by the lymphatics is probably more responsible for lymphatic flow from these distal areas. They also concluded that external intermittent compression was extremely effective at propelling lymphatic fluid""". Additionally, pressure was directly proportional to the amount of lymphatic flow even though low pressures (20mmHg) were still effective at increasing lymph flow.

Fracture healing is another regenerative application that was shown to be significantly improved as a result of IPC. Park et al. examined fracture healing in mice after a surgically induced femoral fracture [18]. They found that after two weeks post fracture the treatment group receiving IPC was significantly improved in respect to callus area, bone mineral content, torsional stiffness, torque to failure and angular displacement at maximum torque. They also noted the improvements in blood flow discussed earlier, but did not offer an explanation for the improved fracture healing. A fracture healing study in dogs demonstrated IPC benefits[19]. Their results were evident through histological examination but did not include biomechanical improvements. Bone mineral content was improved in the treatment group as well as fracture gap and neovascularity. They propose that increases in interstitial fluid flow and the transport of nutrients is responsible for the improved fracture healing. They also noted that NO is also known to be a potent stimulator of bone healing and the increases in venous pressure and endothelial shear stress could also stimulate bone healing.

Intermittent pneumatic compression has been repeatedly shown to improve various types of wound healing. IPC's potent biomechanical and biochemical effects make it a safe and easily used modality that has few if any negative side effects. As IPC becomes more commonplace in the veterinary medical field, certainly, more explanation will be provided for how this modality improves healing. The simplicity of IPC make it ideal for combining other rehabilitative treatments like cryotherapy and topically applied therapies. Future studies should focus on developing protocols that standardize the mode, duration and frequency of IPC in order to optimize IPC during acute and rehabilitative care of veterinary patients.