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Case Series: Herein, we present a case series of three complex patients illustrating the successful use of a new single-use disposable neuromuscular electrical stimulation (NMES) device (geko™, Firstkind Ltd, UK). Cases include the management of recalcitrant ulcers, non-reconstructable critical limb ischemia, and an infected arterial bypass graft.

Conclusion: Neuromuscular electrical stimulation (NMES) can potentially enhance peripheral circulation in vascular patients. Difficult or recalcitrant vascular cases may benefit from it as an adjunct to best medical care. NMES has few side effects, and may be especially useful where polypharmacy is an issue. The incidence of a skin reaction may necessitate device discontinuation.

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Keywords: Neuromuscular electrical stimulation, NMES, EMS, Vascular disease

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INTRODUCTION

Neuromuscular electrical stimulation (NMES) can be used to enhance circulation, and may be a useful adjunct in the management of vascular disorders [1]. Artificial augmentation of blood flow, using intermittent pneumatic compression, has been shown to prevent in-patient venous thromboembolic events, aid vascular ulcer healing, increase walking distances in arteriopathies, and reduce limb swelling [2–5]. NMES can be used to enhance circulation, and may be a useful medical adjunct in both the in-patient and out-patient setting. We present a case series illustrating the use of an NMES device in complex patients.

CASE SERIES

Case 1: A 90-year-old female presented to outpatient clinic with a large ulcer in her right ankle gaiter area. She had a longstanding diagnosis of mixed peripheral venous and arterial disease, with recurrent hard to heal ulcers. The current wound had previously been treated with vacuum therapy, compression bandaging and honey dressings for six months. She had required repeated admissions to hospital for intravenous antibiotics for infection of this recalcitrant ulcer. Compression bandaging was poorly tolerated at home and had to be discontinued due to clinical progression of peripheral arterial disease. An NMES device was applied unilaterally

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to the right leg, and operated for 24 hours a day for 14 days. At the end of this period, ulcer characteristics were much more favorable, with active granulation tissue and a significant improvement in depth of ulcer. Wound size decreased in surface area from 64.6–18.9 cm² (Figure 1). Allergic reaction (simple rash) to device adhesive caused discontinuation of device use, but with simple dressings for a further four weeks the wound healed completely. The rash resolved spontaneously.

Case 2: A 64-year-old diabetic male with critical limb ischemia of his right leg (ABPI 0.45) was given NMES therapy for eight weeks. He was a unilateral above-knee amputee with a history of endocarditis, aortic and pulmonary valve repair, malaria and hepatitis. He had undergone multiple right lower limb angioplasties and a failed axillo-femoral bypass. Further reconstruction was deemed technically inappropriate. His regular medications included gliclazide, metformin, beta blockers, and regular high dose analgesia. He was trained in how to fit the device and wore it for 6–10 hours per day for six weeks.

Patient progress was followed using calculated leg volumes (perometer, from knee crease to sole of foot), the intermittent claudication questionnaire (ICQ), and patient reported quality of life questionnaires.

At six weeks leg swelling was reduced (3602–3480 mL), patient reported quality of life had improved (Visual Analogue Score, a subjective measure of health, increased from 75–90, and depression score, CES-D, decreased from 24–18), but ICQ showed a slight worsening of symptoms (78.5–81.6). The patient expressed pleasure in wearing the device, and reported increased motivation to leave the house in his wheelchair. No side effects were reported.

Case 3: A 78-year-old male with a history of peripheral vascular disease presented to the emergency department with wet gangrene of his right forefoot secondary to critical ischemia, complicated by systemic sepsis. He had a background of insulin-dependent diabetes, ischemic heart disease, atrial fibrillation, hypertension, and rheumatoid arthritis. The patient was resuscitated, admitted and right femoral to posterior tibial bypass was performed with PTFE graft and vein cuff. An angioplasty with drug eluting stent of the right posterior tibial artery was performed. Fasciotomies, were performed, as were amputations of the first, second, and third toes of the forefoot. An intravenous heparin infusion was administered overnight and warfarin commenced. His admission was complicated by severe respiratory tract infection requiring non-invasive ventilatory support, and difficult glycemic control. An episode of cholecystitis was treated by the general surgical team and the patient underwent a laparoscopic cholecystectomy. Postoperative limb swelling was problematic, forefoot wound healing and mobility were poor, and the arterial graft became infected. A multidisciplinary team decision was made to treat this conservatively with antibiotics. A negative pressure dressing (VAC pump, KCI) was applied to the

Figure 1: Photographs of leg ulcer; before and after two weeks NMES therapy.

Figure 2: Application of the NMES device to a patient by his wife.

forefoot wound. NMES devices were applied bilaterally and activated continuously for two weeks. Each device battery lasts for approximately 24 hours, and his wife was trained in how to remove the device and re-fit a new one (Figure 2).

Swelling reduced in both legs, maximal diameter right calf 41–33 cm, left calf 37–34 cm but returned to the initial postoperative values when NMES was discontinued. No device side effects were reported. His right forefoot amputation wound and a left heel pressure sore healed completely over six weeks. After a period of physiotherapy the patient was discharged with a walking aid. Graft patency was confirmed by ultrasound at discharge.

The NMES Device

All cases reported here were treated with the gekoTM device (Firstkind Ltd, UK), applied transcutaneously over the common peroneal nerve at the knee (Figures 3 and 4). It is portable and disposable, with a self-adhesive strip on

Figure 3: NMES device.

Figure 4: NMES device applied correctly to the leg.

the underside. Activation of the device causes excitation of the motor nerve supplying the muscles of the anterior and lateral compartments of the leg, and causes the foot to dorsiflex in a twitching motion, frequency 1 Hz. Pulse width can be adjusted for strength of desired effect. Treatment protocols are flexible according to indication, but we have found that longer periods of stimulation may predispose to contact allergy. Topical emollients are recommended for use on the application site after removal of the device. Correct application of the device requires training, and this normally takes an average of 10–15 minutes. Once trained the patient or their family can apply the device themselves each day.

DISCUSSION

The management of complex patients requires knowledge of many different treatment modalities, with tailoring to the individual patient to achieve optimum results. With this case series we have illustrated the utility of NMES as an adjunct to standard care, in different cohorts of patients. It has been shown to potentially aid healing of treatment-resistant ulcers, help reduce limb swelling, and increase quality of life in complex arteriopathies. By causing contraction of the leg muscles, increasing venous return, and removing dependent fluid from the limb, the potential clinical applications of this device are huge. In contrast to pharmaceutical

and surgical interventions, this medical device is easy to apply and has few side effects. There are no reported drug interactions, which is important in vascular patients where polypharmacy is common. The efficacy of the device has not yet been evaluated in large scale clinical trials, but they are awaited eagerly.

CONCLUSION

Neuromuscular electrical stimulation (NMES) can potentially enhance peripheral circulation in vascular patients. Difficult or recalcitrant cases may benefit from NMES as an adjunct to best medical care. NMES has few side effects, but skin rash may necessitate device discontinuation.

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Author Contributions

Katherine J. Williams – Conception and design, Acquisition of data, Analysis and interpretation of data, Drafting the article, Critical revision of the article, Final approval of the version to be published

Alun H. Davies – Conception and design, Critical revision of the article, Final approval of the version to be published

Guarantor

The corresponding author is the guarantor of submission.

Conflict of Interest

Authors declare no conflict of interest.

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