

Richard Crevenna  
Christine Marosi  
Manuela Schmidinger  
Veronika Fialka-Moser

## Neuromuscular electrical stimulation for a patient with metastatic lung cancer—a case report

Received: 10 September 2005  
Accepted: 25 January 2006  
Published online: 8 March 2006  
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R. Crevenna (✉) · V. Fialka-Moser  
Department of Physical Medicine  
and Rehabilitation,  
Vienna Medical University,  
Währinger Gürtel 18-20,  
A-1090 Vienna, Austria  
e-mail: richard.crevenna@meduniwien.  
ac.at  
Tel.: +43-1-404004330  
Fax: +43-1-404005281

C. Marosi · M. Schmidinger  
Department of Oncology/  
Internal Medicine I,  
Vienna Medical University,  
Vienna, Austria

**Abstract** A 47-year-old female patient suffering from advanced lung cancer with metastatic bone and brain disease participated in a passive exercise program, consisting of neuromuscular electrical stimulation (NMES) five times a week, carried out for 4 weeks. After the training period, the results of the 6-min walk (420 m before and 603 m after the training period) have improved by 44%, which demonstrates the increase of physical performance (mobility, endurance capacity). The results of the “Timed up and go” indicate an improvement of mobility and functional health of skeletal muscles. Furthermore, the quality of life (QOL)-scales (assessed by using the SF-36 health survey) “Physical functioning”, “Role—physical”, “Mental health”, “Role—emotional”, “Vitality”, “Bodily pain”, and

“General health” showed improvements after the intervention period. Feasibility, safety, and beneficial effects of the NMES program were proven for the patient in this case study. These findings indicate that NMES, initiated and executed with appropriate care, may serve as a useful supportive means of palliative treatment in some patients with advanced cancer and metastatic disease, especially in cases of metastatic involvement of the brain and of the skeletal system with the risk of seizures and pathological fractures where volitional training is not allowed.

**Keywords** NMES · Palliative · Rehabilitation · Cancer · Metastatic bone disease · Metastatic brain disease

### Introduction

Despite advances in the adjuvant treatment of cancer, several patients show progressive cancer and develop metastases during the clinical course of their disease, which is generally an incurable condition. Fatigue and impairment of physical performance are common side effects of advanced metastatic tumors, leading to a significant loss in quality of life [1–10]. Low physical performance imposes limitations on basic activities of daily life [1–10]. For patients with incurable advanced malignancy, the prognosis and clinical course is profoundly influenced by the site of the primary tumor and

the availability of palliative treatment strategies [3, 8–10]. Nevertheless, patients suffering from advanced cancer with metastatic bone and/or brain disease, especially those with a longer survival time, urgently need treatment strategies that will increase their physical performance and quality of life for the rest of their lives [9].

Neuromuscular electrical stimulation (NMES) has proven beneficial effects on physical performance and quality of life of different patient groups, and is very useful especially in cardiac patients who are not allowed to perform active exercise due to the progression of their underlying disease [11, 12]. Currently, NMES is not

regarded as a quality-of-life intervention for cancer patients suffering from metastatic bone and/or brain disease. This case study was aimed to determine the feasibility and effects of a passive NMES exercise program for a patient suffering from advanced non-small-cell lung cancer with metastatic brain and bone disease.

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## Patient and methods

A 47-year-old female patient suffering from non-small-cell lung cancer that had been first diagnosed 18 months ago (first diagnosis in November 2003) reported at our Department of Physical Medicine and Rehabilitation (PMR) for consultation. Medical history revealed that she suffered from advanced metastatic lung cancer involving the lung, liver, brain and from extended metastatic bone disease. The underlying non-small-cell lung cancer had been treated with chemotherapy (which was started in January of 2004 by application of four cycles of Gemcitabine/Vinorelbine/Cisplatin, followed by one cycle of Mitomycin C/Ifosfamide in June of 2004, followed by three cycles of Taxotere 75 mg/m<sup>2</sup> in September of 2004), the metastatic brain disease with surgery (neurosurgical intervention in November 2003) and radiotherapy (whole-brain radiation therapy/30 Gy in December 2003, stereotactic brain radiation in December 2004). Furthermore (in February 2004), the clinical course was complicated by a 1-week hospitalization at the Department of Internal Medicine/Oncology due to deep venous thrombosis and pulmonary embolism, which has been treated by the application of subcutaneous low-molecular weight heparin (Fragmin/Dalteparin sodium injection), and symptomatically by application of Oxygen, and of Paracetamol. Two weeks after dismissal from the hospital, the patients's clinical state and circumstances allowed her to return to work.

Although the progressive disease and the necessary interventions led to poor physical performance and decreased quality of life during the last months, for this patient, returning to work was a priority, and she felt physically able to work as an environmental engineer three times a week for 2 h. Nevertheless, she kept in mind that it may take a while to adjust. Therefore, she presented at the Department of PMR (in April 2005), with the objective of improving her mobility and poor physical performance (muscle strength and endurance capacity), and was willing to perform an active exercise program. Due to their advanced disease involving the brain (with the risk of seizures due to hyperventilation during active aerobic exercise) and the bones (with the risk of pathological fractures due to bone stress during active strength exercises), it was decided that she start an individually tailored passive rehabilitation program with the intention to increase her mobility by strengthening of thigh and gluteal skeletal muscles through application of NMES. A cardiac examination (ECG during rest, and an echocardiogram)

showed no relevant pathological changes, and the patient's hemoglobin level was in the normal range. The patient's medical history revealed a deep venous thrombosis and consecutive pulmonary embolism 1 month ago, but there were no signs of further accompanying diseases and no psychiatric disorder. Written informed consent was obtained before this case observation.

A NMES protocol with the intention of increasing muscle strength and endurance capacity was administered on the gluteal and thigh muscles, using the Stimulette Cx device for electrical stimulation (Schuhfried, Vienna, Austria). The NMES protocol consisted of biphasic, symmetric pulses (pulse duration of  $\pm 400$   $\mu$ s at a frequency of 63.3 Hz, 3.5 s on, 4.5 s off). The described NMES protocol was applied at the Department of PMR through adhesive surface electrode patches (8 $\times$ 13 cm) attached to the skin of both gluteal muscles, and the knee extensors of both thighs during a time period of 4 weeks in 20 60-min sessions (every session consisted of one 30-min NMES treatment of gluteal muscles and one 30-min NMES application to the thigh muscles). Diet and drug therapy of the patient were not been changed during the whole intervention period.

In this patient, exercise testing (risk of seizures due to metastatic brain disease caused by hyperventilation) and isokinetic strength testing (risk of pathological fractures due to bone stress) were contraindicated for the assessment of endurance capacity and muscle strength. Therefore, a 6-min walk to assess the patient's mobility and endurance capacity was performed before and after the training (NMES) period [13]. To assess the patient's mobility and function of gluteal and thigh muscles, the timed up-and-go test was performed before and after the training period [14]. Furthermore, the patient filled the SF-36 health survey, which is a validated and generally accepted instrument for assessing health-related quality of life, before and after the training period [15]. After the training period, the patient answered questions that addressed her subjective attitudes regarding the NMES exercise intervention.

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## Results

Feasibility (safety, practicability): No adverse events were encountered during the entire training period, i.e., the safety and practicability of the program were proven beyond question. The patient was able to integrate the exercise program (five times a week) into her daily life. Her compliance with the training sessions was 100%.

The results of the 6-min walk (420 m before and 603 m after the training period) improved by 44% and demonstrate the increase of physical performance (mobility, endurance capacity). The results of the "Timed up and go" (6 s before and 5 s after the training period, improved by 20%) underline this fact and indicate an improvement of mobility and functional health of skeletal muscles. The results of the

**Table 1** Health-related quality of life (SF-36 health survey): for each of the eight scales of the SF-36 health survey, the responses to the 36 questions are summarized and converted to a 0-to-100 scale, with 100 indicating best function

	Before NMES	After 4 weeks of NMES	Reference values
Physical functioning	45	80	(87±17)
Role physical	50	100	(87±26)
Role emotional	33.3	100	(90±22)
Social functioning	100	87.5	(88±16)
Mental health	48	80	(75±18)
Bodily pain	22	100	(77±26)
Vitality	30	60	(62±16)
General health	35	65	(68±17)

The summarized scores for the eight scales, including reference values (means±SD) for a 41–50-year aged healthy German-speaking population

SF-36 health survey are given in Table 1, where the scores for the eight QOL-scales are summarized, including reference values. For each of the eight scales of the SF-36 health survey, the responses to the 36 questions are summarized and converted to a 0-to-100 scale, with 100 indicating best function. After the 4-week NMES training period, enormous improvements could be found for the QOL-scales “Physical functioning”, “Role—physical”, “Mental health”, “Role—emotional”, “Vitality”, “Bodily pain”, and “General health”, while “Social functioning” decreased. Time loss due to the fact that the patient had to perform the NMES program during a time period of 4 weeks every day as an outpatient at the Department of PMR caused the impaired “social functioning” in her own words.

Concerning her subjective attitudes regarding the NMES exercise intervention, the patient reported immense benefit. In her own words, she gained mobility, self-confidence, and independence.

## Discussion

As survival times increase even in cases of metastatic cancer, so have public attitudes and the willingness to discuss cancer and the needs of the patient. Increasingly, the thrust in cancer care is not simply on survival, but on cancer rehabilitation which aims to improve functional status and quality of life [3, 8–10]. Muscle waste and loss

of strength are severe problems of cancer patients. There are no satisfactory treatments for these disorders, yet.

The described female lung cancer patient suffered from marked muscle weakness, but due to her underlying metastatic involvement of brain and of the skeletal system and the risk of seizures and pathological fractures, she was not allowed to perform an active training program. Therefore, it was decided, with the intention to treat, that she start a passive training program by NMES, which has been shown to be an effective modality to increase muscle strength and endurance capacity in other patient groups that are not allowed to exercise due to the progression of their underlying disease [11, 12]. Most of the (scientific) evidence indicates that NMES can be an effective modality to increase quadriceps muscle strength [16]. NMES may even be more effective than volitional training for minimising the strength loss in the immobilization period, especially in cases where patients are wearing a cast and in specific situations where volitional training does not receive sufficient patient compliance, or where volitional training is not allowed/contraindicated as in the presented case [11, 12, 16].

For the presented cancer patient, the safety and practicability of the passive exercise program by NMES were proven. The improvement of performance status, walking distance, and quality of life could also be related to spontaneous recovery after traditional oncological treatment (chemotherapy, brain radiation). Nevertheless, the clinical course of the patient (last chemotherapy in October of 2004, last brain radiation in January 2005, consultation for NMES in April 2005), and the improvements, especially after the intervention period, indicate NMES to be an effective and well-tolerated modality to increase muscle strength, mobility and QOL, in this case. Furthermore, the patient reported immense benefit from NMES. In her own words, she gained self-confidence and independence, and was no longer a passive object of diagnostic and therapeutic measures but an active participant in the rehabilitation process, even under palliative conditions.

To our knowledge, this single-case study is the first report of successful NMES treatment in a patient suffering from advanced metastatic cancer. These findings indicate that NMES, initiated and executed with appropriate care, may serve as a useful supportive means of palliative treatment in some patients with advanced cancer and metastatic disease. Further research is urgently needed to determine the effects of NMES for patients suffering from advanced cancer.

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