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Does exercising the quadriceps muscle of patients on extracorporeal membrane oxygenation (ECMO) with electrical stimulation affect the blood flow to their feet? A feasibility study

The majority of veno-venous extra corporeal membrane oxygenation (VV-ECMO) patients are unable to participate in awake rehabilitation, a proven treatment for minimising the negative sequalae of prolonged bedrest.[1] Neuromuscular electrical stimulation (NMES) is commonly used with ICU patients unable to participate in active rehabilitation. However, its utilisation in this population is unclear, with concerns raised for the potential of vascular "steal", whereby the dilation of blood vessels in the

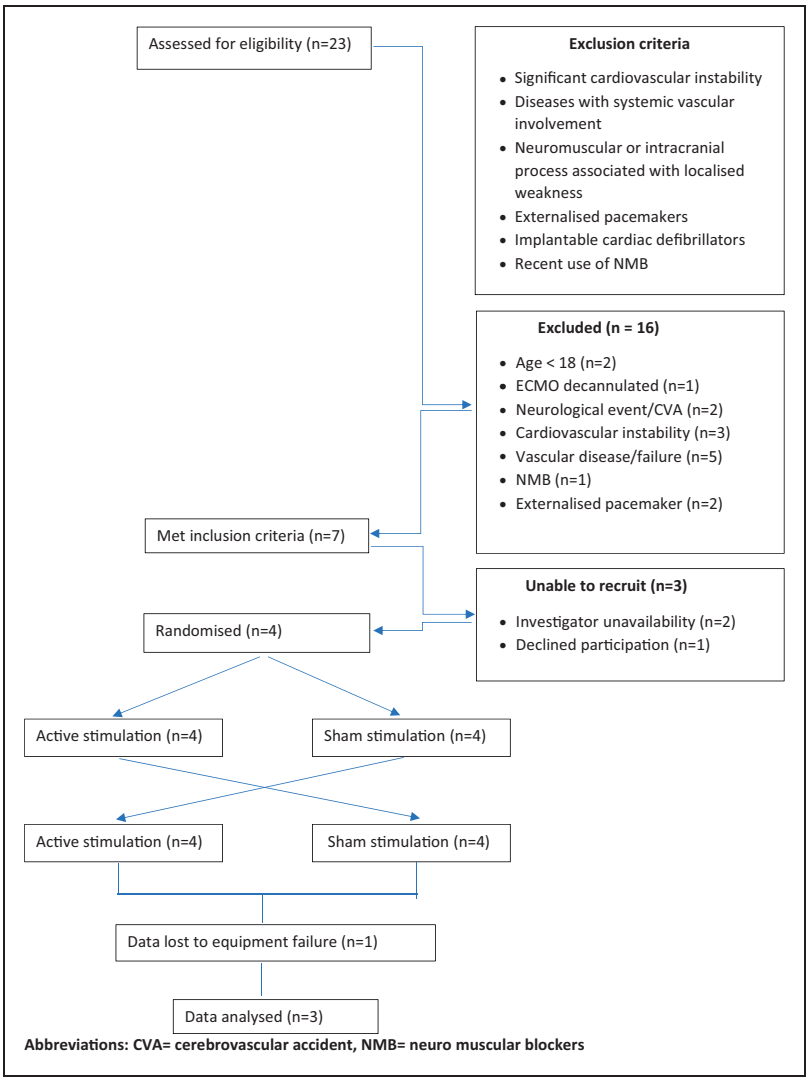

Figure 1. Exclusion criteria and derivation of the study sample for neuromuscular electrical stimulation in veno-venous extra corporeal membrane oxygenation (VV ECMO) patients.
Abbreviations: CVA = cerebrovascular accident, NMB = neuro muscular blockers.

Table 1. Absolute values and change (Δ) in laser speckled contrast imaging, non-imaging laser Doppler and transcutaneous oximetry during ACTIVE neuromuscular electrical stimulation.

Participant number and time points	LSCI (Δ)	NILD (Δ)	$P_{tc}O_2$ (Δ)
P1 Baseline	73.9	1.2	166
P1 15 minutes	71.2 (–2.7)	1.6 (+0.4)	167 (+1)
P1 30 minutes			
P1 5 minutes post			
P2 Baseline	61.4	–12.9	162
P2 15 minutes	64.2 (+2.8)	–3.8 (+9.1)	168 (+6)
P2 30 minutes	59.1 (–5.1)	–3.2 (+0.7)	168 (0)
P2 5 minutes post	51.2 (–7.9)	–10.6 (–7.5)	170 (+2)
P3 Baseline	135	60.7	168
P3 15 minutes	176.4 (+41.4)	67.5 (+6.8)	166 (–2)
P3 30 minutes	213.2 (+36.8)	56.1 (–11.4)	161(–5)
P3 5 minutes post	124.4 (–88.8)	83.6(+27.5)	160 (–1)

Data expressed as mean values; Blank space = no data available; LSCI = Laser speckled contrast imaging perfusion units; NILD= Non-imaging laser doppler perfusion units; P1 = participant one; P2 = participant two; P3 = participant three; $P_{tc}O_2$ = transcutaneous oximetry in mmHg.

thigh during exercise in poorly perfused limbs further reduces perfusion pressure to the distal vascular beds. A relationship between VV-ECMO and significant pedal vascular complications has previously been described.[2]

We examined the effects of NMES applied to the quadriceps muscle on the pedal perfusion of patients receiving VV-ECMO via bifemoral cannulation in a randomised crossover feasibility trial conducted in a single centre between January 2016 and December 2017. Institutional ethics committee approval and written next of kin informed consent was obtained prior to study commencement.

Adult patients admitted to ICU for VV-ECMO via bifemoral cannulation were screened for possible inclusion (Figure 1). Participants received, in a randomised order, both a 30-minute active and sham NMES session delivered to the quadriceps following previously published protocols.[3] Randomisation also determined the limb imaged, and the order of the initial application. Amplitude was adjusted in each active NMES session to an intensity sufficient to obtain a visible contraction of the quadriceps muscle and a palpable tensioning of the patellar ligament.[4]

Pedal perfusion was assessed via a combination of laser speckle contrast imaging (LSCI), non-imaging laser doppler (NILD) flowmetry, and transcutaneous oximetry ($P_{tc}O_2$).[5] Data interpretation was undertaken via a blinded assessor.

Three participants were included in the study. Absolute data values obtained during active NMES, and change between measurements, are shown in Table 1.

Participants 1 and 2 showed minimal change in pedal perfusion during NMES. Participant 3 demonstrated increased pedal perfusion during NMES on the LSCI data, which was maintained for the duration of the stimulation session (see supplementary video).

All participants demonstrated recruitable muscle with NMES and its application was well tolerated, with no alteration to ECMO flows, sedation requirements, or measured cardiovascular parameters. Increases in pedal blood flow appeared to be most marked when a very strong quadriceps contraction was obtained. However, small participant numbers mean that no definitive results can be drawn from our study. The practical difficulties of prolonged imaging on critically ill patients also contributed towards two sessions being prematurely terminated to allow for necessary medical interventions, resulting in limited data sets.

NMES appeared to offer a viable alternative to volitional exercise in this small cohort of bifemorally cannulated VV-ECMO patients. Strong or very strong muscle contractions could be obtained, during which pedal perfusion was maintained, or improved.

Declaration of conflicting interests

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