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Letter to the editor

Translational research and robotics

Early rehabilitation using gait exoskeletons is possible in the neurosurgical setting, even in patients with cognitive impairments

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Gait exoskeletons are developing in rehabilitation set-ups in order to allow patients with motor deficit to stand up and walk. In addition to increasing the patient’s mobility, it helps increasing axial tonus and decreasing spasticity, pains, digestive troubles [1], although there is no clear evidence yet that this technology provides a better long-term motor outcome. Until now, exoskeletons have only been used in rehabilitation departments, several months or years after the neurological deficit onset [2,3], and with cognitively intact patients. Patients using exoskeletons mainly present with medullary trauma [2,4,5], more rarely with cerebral strokes [3,6,7].

We propose that using a gait exoskeleton rapidly after the neurological deficit onset could benefit to the patients, for instance in neurosurgical or neurovascular wards or immediately after intensive care unit (ICU). This concerns patients with traumatic brain injury, subarachnoid hemorrhage, strokes, other causes of elevated intracranial pressure, for instance intracranial tumors, who often present some degree of motor deficit or generalized weakness. Mobilizing them requires the help of several carers and they are kept in bed or sitting until they are transferred to a rehabilitation ward. Using the exoskeleton gives the possibility to make them stand and walk earlier. We expect that this exercise, like any type of early mobilization, may help decrease the risk of comorbidity, such as pressure sores, thrombo-embolic events, infections, and globally stimulate the patients [1].

However, rehabilitation programs for these patients cannot be comparable to those proposed for chronic paraplegic patients [2], even if we consider using the same device. They present specific needs associated with ICU complications, like transitory tetraparesis [8], and regularly need medical material such as a gastrostomy, a urinary catheter, etc., whose compatibility with the exoskeleton is not clear. They often show a degree of cognitive and psychological impairment that may hinder the rehabilitation if the patient is opposing, anxious, or does not understand. We evaluated whether these obstacles could be overcome.

We report the use of the Wandercraft exoskeleton « Atalante », a commercialized self-balanced robotic exoskeleton, which is fixed around the legs and allows standing and walking induced by leaning forward (Fig.1a). Contraindications are a weight >90kg and inability to carry own weight, for instance in case of lower limbs fractures. The patient is a 58 year-old woman who presented with severe subarachnoid and intracerebral hemorrhage (WFNS5, initial Glasgow Coma Scale 3/15 with left mydriasis, Fisher4) due to a ruptured anterior communicating artery aneurysm (Fig.2) with acute hydrocephalus and myocarditis. She was hospitalized in ICU and was treated with external cerebrospinal fluid shunting and aneurysm embolization. She needed a tracheotomy for several weeks and a gastrostomy. She was discharged on the neurosurgical ward after 2 months. She had sat but never walked. She presented no focal motor deficit but a general weakness with a 4/5 motor testing. She showed severe cognitive troubles, with a Mini Mental State Examination of 15/30, a Montreal Cognitive Assessment of 14/30, and a Frontal Assessment Battery 13/18. Short-term memory was severely deteriorated, and she was disorientated but cooperant and had no language problem.

She was proposed a single session of exoskeleton on day 73, i.e. day 4 after being transferred on the ward, and approximately day 10 of being able to sit in an armchair with help (Fig.2).
She agreed to use the exoskeleton and was informed repeatedly that she could stop whenever she felt. She was still carrying a gastrostomy, urinary catheter and intravenous treatments. The session lasted for 15 minutes (Fig.1.b). The exoskeleton allowed her to stand up three times, with the help of one physiotherapist and keep firm to perform axial tonus training. Cardiovascular monitoring showed orthostatic hypotension with tachycardia and vertigo, which resolved when she sat back. She felt tired and did not wish to walk. The patient was exhausted but pleased to perform this session and volunteered to stand up several times. She reported being emotional about this event but was not afraid of the technology, feeling safe and painless. She was transferred to a rehabilitation setting on day 76, a very short period of time compared to similar patients. After six months, she could walk without help and still presented memory impairment.

This patient shows that using the exoskeleton was possible immediately after a long stay in ICU and allowed early standing, that was not possible in this setting without it. The presence of medical devices, including a gastrostomy, urinary catheter, IV catheter, and apparently tracheotomy, are not a limitation. The cognitive state is a major issue, since the session can only be performed if the patient is confident and understands the way the exoskeleton works. Because this technology is already used in clinical practice, the hospital ethical board stated that consent was not an issue and we made sure that the patient was willingly participating.

Some adaptations need to be taken into account, compared to patients with chronic lower limbs paralysis:

- The aim, structure and length of the session must be adapted to the patient’s possibilities. In our case, standing upright and being able to perform simple posture exercises were realistic objectives after a severe neurological condition. Walking would have been the next objective, once orthostatic hypotension had resolved.
- In the early stage, the patients may progress very rapidly, even without rehabilitation, and the exoskeleton may well become useless after a few sessions. The objective is to provide the patient the best care on a daily basis, in order to avoid medical complications and optimize his rehabilitation potential.
- Monitoring makes the procedure safer. Even if it is very unlikely that acute complications such as pulmonary embolism happen when the patient is getting up for the first time, it is useful to have access to the heart rate and blood pressure to secure the patient in case he feels dizzy.
- In patients with cognitive impairment, rehabilitation should always be performed with a dedicated physiotherapist, aware of the personal risks for the patient, and the learning phase may be longer.

Although the exoskeleton may contribute to lower limbs muscle training, it cannot replace physiotherapy. It allows mobilizing patients early on, so that they get used to standing upright and can start walking by themselves more quickly, especially for patients who stay in the neurosurgical ward for weeks, due to medical or administrative delay. Whether the use of a gait exoskeleton increases the chance of motor recuperation is a matter of debate. Electromechanically assisted gait training is not proved superior to conventional physiotherapy[9]. It has been shown that movements with exoskeletons, although passive,
induce parietal cortex activation in healthy volunteers, but the cortical effects of this type of rehabilitation in patients unable to walk must still be examined[10]. Globally, mobilization is a priority to optimize long-term outcome.

In total, exoskeletons can be used to mobilize patients early after a long neurosurgical ICU stay, even if they require medical devices and are cognitively impaired. This should be performed with a personalized planning and monitoring and could prevent complications in some patients, before they can be fully rehabilitated on dedicated wards.

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References:


**Legends:**

Figure 1: Pictures of (a) the Atalante (Wandercraft) robotic exoskeleton; (b) the patient sitting in the exoskeleton (c,d) standing for the first time 74 days after high-grade subarachnoid hemorrhage (e) performing upper members exercise with a physiotherapist.

Figure 2: Timeline of the patient’s medical history. Day 0: CT scan showing high-grade subarachnoid hemorrhage due to ruptured anterior communicating artery aneurysm with acute hydrocephalus and myocarditis. The patient stayed in neurosurgical ICU for 69 days, and was bedridden for 63 days. She sat for the first time on day 63 and stood up on day 73 in the exoskeleton. ACA: anterior communicating artery; ICU: intensive care unit.
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