Transcutaneous Electrostimulation of Respiration

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Abstract
The poor condition of cord-injured patients is often due to respiratory disturbances that develop in the acute post-injury period; indeed, respiratory failure is a common cause of death. Patients with cervical cord injuries cannot maintain adequate pulmonary ventilation because their respiratory musculature is impaired.
To provide ventilatory support for patients with cervical injury and thus facilitate their respiratory management, electrical stimulator of respiration have been designed by our clinic in collaboration with Institute of Electrical Engineering.
50 patients with injury of cervical spinal cord on the C5-7 levels had transcutaneous electrical stimulation of diaphragm. Plate electrodes applied to the skin effect this stimulation. Pulmonary function tests have shown that electrical stimulation improves respiratory parameters such as vital capacity and forced expiratory volume; large increases (two fold or more) were recorded in peak volume flow rates at vital capacities of 75, 50 and 25 percent, respectively.
Indication for transcutaneous electrical stimulation of diaphragm is respiratory insufficiency in patients with paresis or paralysis of intercostals muscles after C5-7 spine/spinal cord injuries in late phase.

1. Introduction
In order to provide ventilatory support for patients with cervical injury and thus facilitate their respiratory management, methods for artificial electrostimulation of the diaphragm and the phrenic nerve (s) (often referred to as diaphragm pacing) have been developed.
1.1. Previous Work
Three types of electrostimulation are used: direct, radiofrequency and transcutaneous electrostimulation (1, 2, 3).
Direct stimulation, delivered by wire electrodes implanted in the direct contact with a nerve or muscle, is used intraoperatively and in the postoperative period.
In radiofrequency stimulation, an extracorporeal radiofrequency transmitter induces electric pulses in a radioreceiver implanted into the patient’s body together with electrodes, such stimulation is used in patients with chronic respiratory problems.
Indications for direct stimulation are:
- trauma of the cervical spine with spinal cord damage and associated injuries to thoracic organs and ribs;
- high cervical cord injuries (at C4 or higher levels) with impairment at central respiration control by the medulla oblongata and spinal cord, but with partially preserved spontaneous respiration;
- thoracic spinal and cord injuries with associated lesions at the diaphragm;
- infraoperative instrumental, thermal or chemical lesions at the diaphragm or phrenic nerve;
- respiratory distress following surgery that involves serious trauma to pulmonary tissue and/or the chest such as prolonged or difficult resections, operations with extensive pneumonolysis, pleurectomy and single-stage bilateral interventions with performance of corrective thoracoplasty.

Direct stimulation of the phrenic nerve is indicate for patients with high (C1 – C4) cervical cord injuries an absent spontaneous respiration.
Indications for radiofrequency stimulation of the diaphragm through phrenic nerve are:
patients who have undergone transthoracic operations on the thoracic spine and spinal cord and also for those in the acute or early phase of cervical spine and spinal cord injury. But a prerequisite for effective radiofrequency stimulation when used on a long-term basis is preserved conduction in the phrenic nerve. Viability of this nerve can be evaluated by transcutaneous electrostimulation with recording of electromyographic tracing from the diaphragm via electrodes attached to the chest wall (1,2).

2. Summary and Conclusions

Effectiveness of transcutaneous electrostimulation of diaphragm in 50 patients with cervical spinal cord injuries on the C5-C7 levels in the late period of the trauma were investigated. Before and after electrostimulation pulmonary function tests such as vital capacity (VC), ml; forced expiratory volume (FEV), ml; (VC/FEV), %; peak flow rate (liters/sec), from rate (liters/sec) at 75%, at 50%, at 25% were investigated. Pulmonary function tests have shown that electrical stimulation improves respiratory parameters forced expiratory volume; large increases (two fold or more) were recorded in peak volume from rates at vital capacities of 75%, 50% and 25% respectively. The transcutaneous electrical stimulation of diaphragm in patients after C5-C7 spinal cord injuries in late phases are recommended.

References