One of the most common causes of an ICU admission is a severe episode of acute respiratory failure due either to an exacerbation of chronic pulmonary disease or its ex-novo development after a surgical procedure, trauma or medical complications. These patients usually report, at admission to the ICU, a sedentary life before the acute episode, because the evolution of the disease is characterized by a progressive decline not only in respiratory function (e.g. FEV1), but also in the functional status, due to the effects of lack of exercise, drug administration, malnutrition and, later on, gas exchange abnormalities. Together with specific vital organ support, such as mechanical ventilation, patients admitted to an ICU may require other complex and integrated interventions in order to maintain the spared function and to prevent further damage. These interventions include nutritional and psychological support, counselling, nursing, prevention (e.g. to preserve skin integrity) and in particular a complete physiotherapeutic program, that may range from simple help to maintain a correct posture to complete recovery of walking autonomy.

Key words: Intensive care units - Muscle, skeletal - Critical care - Physical therapy - Exercise.

There is general agreement that the term “rehabilitation” is reserved to a multidisciplinary intervention and that the management of each patient should be individualized. A recent official European definition of Rehabilitation was given by the European Respiratory Society Task Force Position Paper 1 “Pulmonary rehabilitation is a process which systematically uses scientifically based diagnostic management and evaluation options to achieve the optimal daily functioning and health-related quality of life of individual patients suffering from impairment and disability due to chronic respiratory disease, as measured by clinically and/or physiologically relevant outcome measures”. The American Thoracic Society 2 adopted the following definition “a multidisciplinary program of care for patients with chronic respiratory impairment that is individually tailored and designed to optimize physical and social performance and autonomy”. These “broad” definitions, while giving a panoramic view of what should be achieved do not enter into the specific details of how. Thus pulmonary rehabilitation may vary, according to different environments, from simple passive mobilization of a patient to more complex interventions, such as weaning from mechanical ventilation. One thing that is...
clear, however, from these official statements is that the common idea that there is no hope for improvement in patients with chronic diseases, especially if recovering from an episode of acute respiratory failure, is no longer acceptable, either clinically or scientifically.

The general aims of an ICU respiratory rehabilitation program is to apply advanced, cost-effectiveness therapeutic modalities to spare and eventually to improve the remaining function, decrease the patient's dependency (i.e. on the ventilator), and prevent the need of new hospitalization, — in brief, to improve the patient's measured quality of life.

The earlier the rehabilitation program of a ventilated patient is started, the greater its effect is, since later consequences, such as the limited mobility, or even worse, total dependency on a ventilator, may make the high costs spent taking care of the patient futile. As illustrated in Figure 1, the physiological changes caused by inactivity involve skeletal muscle, cardiovascular and respiratory functions, body and blood composition, and central nervous and endocrine systems. During a period of inactivity muscle mass declines and the potential efficiency of a muscle to perform aerobic exercise declines. Skeletal muscles are composed of two major types of fiber: Type I fibers are mainly involved in aerobic activity, while type II fibers have a lower capacity for this activity. Deconditioning causes a distinct transformation of subtypes of type II fibers: type IIa fibers convert to type IIb fibers, the former having a higher aerobic capacity. Moreover, during immobility, the number and density of mitochondria decrease. The cardiovascular response to exercise is also dramatically altered after a period of
bed rest, since there is a decrease in cardiac output and stroke volume during maximal exercise and an increase in heart rate during submaximal exercise. Indeed of particular importance in bed-ridden patients, the ability of the system to adjust to changing posture, such as moving from the supine to the sitting position, is impaired. In postoperative patients, if early rehabilitation (i.e. the application of positive end-expiratory pressure) is not started, the decrease in functional residual capacity and lung compliance may lead to atelectasis, retained secretions and in some cases to pneumonia, which if occurring in ventilated patients may dramatically increase the probability of death.

Immobility also leads to clinically significant bone demineralization, together with protein wastage and a decrease in total body water and sodium. There is generally a loss of body weight and an increase in the percentage of body fat. Deterioration of central nervous system function results in a decreased capacity to maintain the standing position and to walk; the performance of tests of intellectual function may also be impaired, and disorientation may occur.

The first goals of rehabilitation in these patients are therefore targeted to all the procedures aimed at obtaining early mobilization. Maintenance of correct posture and passive mobilization of legs and arms are the preliminary steps, followed by active sitting in bed and thereafter sitting in a chair. It is also clear that physical therapy per se may not be enough to obtain satisfactory outcomes of our ICU patients, so comprehensive interventions are mandatory in these first steps of treatment. Correction of electrolyte disturbances, nutritional and psychological support and a balanced use of cardiovascular drugs may also help to improve the clinical picture.

Skeletal muscle strength and endurance performances are impaired not only as a consequence of bed rest but also because of a direct effect of hypercapnia, hypoxia, malnutrition, treatment with corticosteroids or other agents, and hemodynamic instability. The possible need for heavy sedation of curarization during the first few days of ventilation may also lead to generalized myopathy. Training is nevertheless an important aspect in these patients, since one of the rehabilitative end points in ICU is defined as a return of a muscle strength that allows basic daily life-activities (e.g. washing, combing hair, cooking) and the ability to walk 20-50 meters independently. The patients may undergo sessions aimed at passively and actively training the lower and upper extremities, such as lifting light weights or pushing against a resistance. Any patient able to walk at one point in time can start directly with progressive walking retraining, aided by a rolling platform walker or by the therapist, if needed. When a patient cannot be weaned from the ventilator, a portable resistor can be used to decrease the work of breathing during walking. As soon as possible, it is useful to monitor patient’s outcome using dyspnea scales (VAS, Borg scale, etc.) and exercise tolerance tests (6 minute walked distance). Patients, who successfully regain complete autonomy and, therefore, are discharged from the ICU to a medical ward should not be “abandoned” but should be included in training programs with cyclette, treadmill, and ergometry for the upper extremities. The usefulness of gradual retraining has recently been assessed in COPD patients recovering from an acute episode of hypercapnic respiratory failure, most of whom were admitted to the Respiratory Intensive Care Unit while still ventilated.

Two aspects of training are basic: threshold and specificity. If the training threshold is too low, there will not be changes in the muscle; if it is too high, there will be fiber damage and muscle degenerative changes. Specificity of training means that training produces an increase in VO\textsubscript{max} only in the specific muscles in use.

As for the other skeletal muscles, also the ventilatory pump may be profoundly altered by the effects of bed-rest and of the disease itself and any comorbid conditions. Indeed the “abuse” of controlled mechanical ventilation in the ICU may lead to the development of selective diaphragmatic
atrophy after only 48 hours, as shown in a laboratory study performed on rats.\textsuperscript{16} The weakness of the respiratory muscle and in particular an imbalance between the load the respiratory system has to face and its capacity is, together with the cardiovascular impairment, the major determinant of weaning failure in ventilated patients. The rationale of respiratory muscle training in the ICU is nevertheless controversial. Patients affected by COPD for example are not likely to benefit much from this specific treatment. Chronic airflow obstruction is always present, at least in the end-stage of the disease, leading to acute respiratory failure by pulmonary hyperinflation.\textsuperscript{17} It has been shown that the impaired inotropic effect of the diaphragm in these patients is due to the altered geometric shape of the diaphragm dome rather than to muscle atrophy. As a matter of fact, Similowski et al.\textsuperscript{18} demonstrated how the diaphragm of patients with COPD was as good as that of normal subjects in generating pressure in response to bilateral phrenic nerve stimulation, at the same lung volumes. Their conclusions were quite strongly against the use of inspiratory muscle training since they stated that “the absence of central inhibition and the absence of evidence of chronic fatigue cast doubts on the need to treat such patients with interventions intended to improve the contractility of the diaphragm”. More recently Levine et al.\textsuperscript{19} added support to this statement when they showed, after having obtained diaphragmatic biopsy specimens from 6 patients with severe COPD, that the disease increases the slow-twitch characteristics of the muscle fibers as an adaptive mechanism which increases resistance to fatigue. Does this mean that respiratory muscle training in the ICU should be definitively abandoned? We do not think so. We must say that the above mentioned studies were performed in patients with severe, but probably (although this was not clearly stated in either paper) normocapnic COPD, likely to have a different histological picture from critically ill patients. The load, frequency and intensity of training should be scientifically specified since, if it is true that during the training exercises, the pressure generated per breath should be at least 30% of the maximal generated in order to achieve significant improvement, it should also be kept in mind that high resistances may induce structural changes in the diaphragm. It has been shown in animal trained for 4 days (2 hr/day) that this protocol induces diaphragm membrane damage, sarcomere disruption and damage predominantly to type I fibers.\textsuperscript{20} Muscle training does not, however, necessarily mean performing loading breathing, since in ICU patients, potentialization of the expiratory muscles may be nonspecifically obtained with cough exercises, which reinforcing the abdominal muscles, may also improve clearance of the airways. Despite COPD patients being by far the most likely to experience weaning problems, inspiratory muscle training may also have a rationale in other kinds of pathologies.\textsuperscript{21} An interesting potential role of inspiratory muscle training may be its use in preventing steroid-induced myopathy. In fact, Weiner et al.\textsuperscript{22} showed, in a randomized-controlled trial, that the inotropic and endurance capacity of inspiratory muscles were spared from the damage due to 2 weeks’ administration of this drug only in the group of patients undergoing specific training.

**Riassunto**

Riabilitazione motoria nel paziente in Terapia Intensiva

L’Insufficienza Respiratoria Acuta (IRA), sia essa secondaria ad una riacutizzazione di una patologia respiratoria cronica o ad interventi chirurgici, traumi o complicazioni di patologie sistemiche, è una delle cause più comuni di ricovero in Terapia Intensiva. Questi pazienti molto spesso hanno alle loro spalle una vita molto sedentaria dovuta all’evoluzione della patologia e caratterizzata non solo da un progressivo declino della funzionalità respiratoria (es. FEV\textsubscript{1}), ma anche da un decadimento dello stato funzionale generale, dovuto alla mancanza di esercizio fisico, alla somministrazione di farmaci (es. steroidi), ad uno stato di malnutrizione e, successivamente, a variazioni nello scambio dei gas. Oltre al supporto degli organi vitali (es. ventilazione meccanica) il paziente in TI richiede altri
interventi, complessi ed integrati, che mirano a mantenere la funzionalità residua e prevenire ulteriori peggioramenti. Questi interventi includono il mantenimento dello stato nutrizionale e psicologico, il nursing, la prevenzione (es. lesioni da decubito) e la stesura di un programma di riabilitazione completo, che può variare da una semplice impostazione di posture corrette al raggiungimento di un’autonomia motora.

Parole chiave: Terapia intensiva - Muscoli, scheletrici - Esercizio - Terapia fisica.

References