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Functional Pathology and Management

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Foreword

Teach us to live that we may dread
Unnecessary time in bed
Get people up and we may save
Our patients from an early grave.

A most revealing paraphrase by Asher* of a verse by Bishop Thomas Ken more than adequately summarizes the plight of the immobilized patient, who often lies dormant and depressed for years on end. In this volume, Dr. Steinberg has offered the reader a unique opportunity to share his many years of experience in caring for the immobilized patient. His careful attempt to explore the pathophysiologic effects of immobilization on a number of organ systems, combined with a host of practical aspects with regard to patient care, is unique and refreshing. This text should command the respect of any physician faced with the vicissitudes and frustrations of caring for the immobilized. The final chapter detailing "The Psychological Aspects of Immobilization," by Hammer and Kenan, offers the reader considerable insight into the essentials and value of occupational and physical therapy. It should prove most valuable to physicians as well

*Asher, R. A. J. Dangers of going to bed. *Br. Med. J.* **2**:907, 1947.

as social workers, paramedical personnel, and the many physical therapists who come into daily contact with the nonambulatory patient.

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Preface

It may be a paradox that the importance of disability and immobilization has been enhanced by the very progress of medical science. The advances in diagnostic and therapeutic skills let many patients survive diseases and trauma which would have doomed them in decades past. The price of survival, however, may be a permanent or temporary disability which may include long periods of immobilization. The morbidity of a long-term illness or injury is often, in part, caused by the immobilization that circumstances have imposed upon the patient. It is important, therefore, to realize that immobilization carries a morbidity of its own which can be modified and ameliorated by appropriate management. The original charge to me was to prepare a text on "The Management of the Immobilized Patient." It soon became apparent that it is not possible to deal with therapy and management without discussing the pathophysiologic effects of immobilization. As a result, the scope of the book was broadened and the title was changed to *The Immobilized Patient*.

The book does not purport to cover every aspect of immobilization. I have concentrated my attention on those organ systems which are most affected and in which the effects of immobilization contribute most to the patient's morbidity. These will be the areas of greatest importance to the clinician, who carries the final responsibility for the immobilized patient's welfare.

I would like to express my appreciation to Dr. Louis V. Avioli for his valuable help and advice; to Dr. Randy L. Hammer and Miss Emily H. Kenan for writing the chapter on the psychological aspects of immobilization; to my secretary, Mrs. Mary Pelchman, for her help in preparing the manuscript through many drafts; and to my wife, Lisl R. Steinberg, for her patience and encouragement.

Franz U. Steinberg

St. Louis

Contents

CHAPTER 1

General Aspects of Immobilization

Man's body is organized for motion. The instrument of mobility, skeletal muscle, makes up 40 percent of the body mass. Its structure and metabolic capability permit an efficient and almost instantaneous shift from complete rest to a high level of activity. As a muscle becomes active, its blood flow may rise 15 to 20 times over the resting value, and the number of open capillaries may increase 50 times. The metabolic rate of the working muscle may be 50 to 100 times above that of a muscle at rest.

The working muscle needs to be supplied with nutrients and oxygen. Metabolic waste and carbon dioxide need to be removed. The burden of this task falls upon the circulation and respiration. These organ systems are well suited to adapt to the demands of increased muscular activity. During moderate exercise the cardiac output may increase threefold; the heart rate may double. The left ventricular work may rise to 3.5 times more than resting value and the oxygen uptake per minute 6 times that seen at rest. The minute volume of respiration may increase from 5 to 7 liters to more than 50 liters. In heavy exercise, the tidal volume may be as high as 50 percent of the vital capacity.[1]

The capacity of circulation and respiration to adapt to the demands of muscular activity and of stress in general falls within the general concept of "physical fitness." This potential is furthered by physical training and is sharply reduced by immobilization. Training not only strengthens muscles; it also enhances the functional capabilities of the cardiovascular and respiratory systems. Fitness cannot be maintained without the stimulus of muscular activity. During immobilization physical fitness declines rapidly. The resting heart rate is increased. The cardiac output and the left ventricular work no longer rise sufficiently during even mild activity, and the immobile upright position is poorly tolerated. This will be discussed in more detail in Chapter 2.

Immobilization slows the response of the nervous system. A patient who is confined to bed for a long period of time becomes dull and his intellectual capabilities diminish. Depending upon his premorbid personality, the patient may become depressed, anxious, lethargic, dependent, and disassociated from family and society (see Chapter 7 for details).

The ability to perform precisely coordinated movements is also adversely affected by prolonged inactivity. The pyramidal and extrapyramidal systems make it possible to gear the force of muscular contractions to the task at hand. The activation of some muscles and the inhibition of others is the key to the precise coordination of skilled motor activity. Sensory feedback from muscles, tendons, and joints allows for the instantaneous correction of errors. This remarkable coordination of muscular activity is achieved without volitional input. Our will only directs the motor system to perform a specific task, to walk through the room, to pick up a book, etc. The needed coordination that makes some muscles contract and others relax and that gauges the force of muscular contractions is an automatic function that takes place at a subcortical level. When an individual has been immobilized for some time, the nervous system loses its capacity to coordinate movements quickly and efficiently. A patient arising from bed for the first time after a long period of confinement will stagger about. His legs do not obey his commands. The muscles, of course, are weak from long disuse but the ability to perform skilled movements has also diminished; it will take several days until this function has been regained.

The gastrointestinal tract is also affected by prolonged immobilization. The appetite is diminished. This may be advantageous since the reduced energy output requires a lower caloric intake. Unfortunately, the appetite for protein-rich foods is often selectively depressed, and this adds to the considerable net protein loss engendered by long recumbency. The constipation associated with inactivity is well known and may be difficult to manage. In elderly patients with a depressed sensorium, immobilization may lead to a fecal impaction. Often this is not suspected because the patient may have frequent liquid stools around the impaction. Since constipation further contributes to the loss of appetite, and the diminished intake of food and liquids aggravates the constipation, a vicious cycle develops.

Bladder evacuation may be inhibited by bed rest; the bladder may become distended, and overflow incontinence may be the result. A man with a hypertrophy of the prostate may develop a complete retention once confined to bed. Browse has pointed out that in the recumbent position urine may stagnate in the renal pelves.[2] In the erect body position, the hilus is almost the lowest point of the renal pelvis and only a few calices are situated below the hilar level. In the recumbent position the hilus is uppermost and all calices are positioned below. Gravity cannot aid in the expulsion of urine from the renal pelvis and the urine may remain stagnant. Calculi may form because the osteoporosis of immobilization causes an excessive excretion of calcium salts which may precipitate in a concentrated urine.

Immobilization, therefore, not only weakens muscles; it reduces the plasticity of many organ systems, their ability to adjust to changing environmental circumstances and demands. The immobilized patient no longer can adequately respond to stress. His margins of safety are sharply reduced.

The risks engendered by prolonged inactivity have been known for a long time, but systematic investigations are of relatively recent vintage. The first study of this type was published by Deitrick, Whedon, and Shorr in 1948.[3] This classic study will be cited repeatedly in subsequent sections of this volume, but the most important findings will be presented in this introductory chapter. Four healthy men were placed on 6 to 8 weeks of strict bed rest. Their movements were further restricted by the application of plaster casts. Their metabolic and circulatory functions were thoroughly investigated. Nitrogen excretion began to increase on the fifth or sixth day of immobilization. The total nitrogen loss for the four subjects averaged 53.6 g. The creatine tolerance was reduced, commensurate with the degree of muscular atrophy. One subject, who had the greatest nitrogen loss, showed a significant lowering of the 17-ketosteroid excretion. The basal metabolic rate declined at an average of 6.9 percent. The changes in body weight were small; as muscle protein was lost, fat and carbohydrate storage increased. The excretion of calcium, phosphorus, sulfate, sodium and potassium increased, with total calcium loss ranging from 9 to 24 g and phosphorus excretion paralleling that of calcium. The excess sulfate excretion correlated with the loss of nitrogen since both were due to the catabolism of muscle protein. The resting heart rate rose steadily. In the later periods of immobilization the individuals had lost much of their ability to maintain an erect posture without becoming hypotensive.

The recovery was slow. Calcium, nitrogen, and phosphorus were retained to make up for the losses during immobilization, but it took more than six weeks to establish a normal equilibrium.

In 1965, N. L. Browse published a monograph, *The Physiology and Pathology of Bed Rest.*[2] This monograph explores in detail the physiologic effects of assuming a supine position in general and of prolonged bed rest in particular. The material is based on the author's own observations and on a review of the literature. The perusal of this monograph makes it clear that there is no bodily function that is not affected by prolonged bed rest.

A number of thorough investigations on the physiologic effects of immobilization have been published by the staff of the Texas Institute for Rehabilitation and Research. A summary of their findings was published in 1965.[4] The advent of space flights has evoked a great deal of interest in the problems of immobilization because the state of weightlessness produces very similar changes in body organ function. Furthermore, astronauts spend a considerable time in the cramped quarters of their space capsule and are, in fact, immobilized by their environment.

THERAPEUTIC IMPLICATIONS OF BED REST

Browse points out that up to the middle of the 19th century, sick people took to their beds only when they were so ill that they could no longer stay up, and this they did most reluctantly. In 1863, John Hilton published a book entitled *Rest and Pain: The Influence of Mechanical and Physiological Rest in the Treatment of Accidents and Surgical Diseases and the Diagnostic Value of Pain*. In this book Hilton propounded the healing powers of rest. He explained that just as a surgeon would heal a broken bone by immobilizing it, other diseased organs could be successfully treated when the body as a whole was put to rest. Therefore bed rest for the treatment of all kinds of ailments became fashionable, and, as happens so often, rest was prescribed indiscriminately without much consideration of its possible deleterious effects.

There are, of course, conditions for which bed rest is beneficial. The patient with an acute infection, such as influenza, will do best to spend a few days in bed. Often weakness will force the patient to bed as it is. An acute myocardial infarction is treated with strict bed rest, at least for the first few days. In fact, it has been shown that the work of the heart is at its lowest when the patient is in a sitting position. The recumbent position does not rest the heart. Many years ago S. Levine suggested armchair management of patients with acute myocardial infarctions.[5] Although this suggestion has not been routinely accepted by many cardiologists, the duration of bed confinement has been sharply reduced. As little as 15 or 20 years ago, a patient with a myocardial infarction was kept in bed for 3 weeks and remained in the hospital for 6 weeks. Now the average accepted period of hospitalization for uncomplicated myocardial infarctions and other cardiac disorders is 3 weeks; patients are permitted out of bed and allowed to be active after a few days. The only apparent exception is cardiomyopathy, in which prolonged rest appears to be beneficial.

Acute hepatitis is usually treated with bed rest. This form of treatment had its origin during World War II when it was shown that soldiers had a quicker recovery and fewer relapses when kept in bed. There is some doubt that this observation carries over to civilian medicine, and over the years the prescription of strict bed rest has been modified.

Some rheumatologists have recommended that patients with acute rheumatoid arthritis be treated with strict bed rest in a sanatorium fashion.[6] This has not been universally accepted, and its value has not been demonstrated.

The well-established use of bed rest in the treatment of pulmonary tuberculosis has also been radically modified. In the 1943 edition of Cecil's *Textbook of Medicine,* it is noted that: "The chief principle (of treatment) is rest, which may vary from strict rest in bed to a combination of rest periods and regulated exercise. The effect of rest is both local and general. Diminution of the respiratory rate and amplitude implies lessened motion of the lung which is known to favor healing of tuberculous lesions."[7] Strümpell, in his *Textbook of Internal Medicine* (1929 edition), recommends that tuberculous patients should spend the greater part of the day in the open air on comfortable lounge chairs. "Thereby any unnecessary exertion, any stress on the respiratory system and any irritation on the respiratory passages is avoided. The dissipation of body heat, facilitated by the open air, stimulates the metabolism. Moderate activity in the open air will not be harmful to many patients and is perhaps beneficial. However, even with a minimal temperature elevation absolute bed rest is mandatory."[8] It is interesting that these authors were not only content to prescribe what was the accepted form of therapy of the time, but also searched for physiologic underpinnings to support the rest treatment of tuberculosis.

The rest cure of tuberculosis created a virtual industry. Especially in the mountainous regions of central Europe, numerous sanatoria for patients with tuberculosis were established, and often the patients stayed there for months or years, subjected to a rigid routine of open-air cures and regulated activity. Thomas Mann, in his novel *The Magic Mountain,* has described how life in such an isolated and somewhat artificial community leads to demoralization and personality disintegration. With the advent of chemotherapy, the rest-cure treatment of pulmonary tuberculosis has all but disappeared. Patients can now be treated while ambulatory with relatively little disruption of their personal lives.

Another revolution has occurred in the management of postoperative patients. After almost any type of operation patients remained in bed for many days or weeks. The postoperative morbidity, constipation, urinary retention, and weakness were often due to the prolonged immobilization, rather than to the operation. In 1944, Powers published the results of a controlled study in which he demonstrated that early ambulation greatly reduced the postoperative morbidity.[9] This concept was quickly accepted. Early ambulation not only has made for a more rapid recovery, but by reducing the number of hospital days it has cut the cost of care. After an uncomplicated herniorrhaphy a patient will now be discharged in 3 to 5 days. Before Powers' report patients remained in the hospital for 2 weeks.

In the following chapters, the effects of immobilization on circulation and respiration, bone, muscle, joints, and skin and on the emotional and intellectual capabilities will be explored in detail. These effects, as will be demonstrated, can be profound. When immobilization is forced upon an individual by nature of disease or injury, its potential deleterious effects must be recognized and corrective measures taken whenever possible. As a form of therapy bed rest may be beneficial or harmful. It can be used to the patient's advantage or it can be abused. As for all potent remedies, the degree and duration of bed confinement must be carefully prescribed, keeping in mind its harmful aspects. R. A. J. Asher, in a discussion on "Dangers of Going to Bed," aptly paraphrased a verse by Bishop Thomas Ken[10]:

> Teach us to live that we may dread
> Unnecessary time in bed.
> Get people up and we may save
> Our patients from an early grave.

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CHAPTER 2

The Effects of Immobilization on Circulation and Respiration

Any individual who has spent several days in bed has experienced the deconditioning effect caused by prolonged bed rest. When first resuming an upright position, the heart pounds, the head feels drained of blood, the skin becomes moist with sweat, and fainting is not uncommon. The patient feels weak with a diminished tolerance to exertion. One of the major advances in medical care during World War II was the institution of early ambulation after illness and surgical operations. The period of bed rest after repairs of hernias, for instance, was reduced from 2 weeks to a few days. Early ambulation drastically reduced the morbidity of surgical procedures which, as it turned out, had been due to immobilization as much as to the procedures themselves.

Deitrick, Whedon, and Shorr were among the first to study the effect of immobilization on various physiologic functions of normal men.[1] Four healthy men were immobilized for 6 to 7 weeks by bed rest, enforced by the application of a body plaster cast. Within a week of the institution of immobilization, the subjects developed an increasing tendency to fainting when tilted to an erect position. This tendency became more pronounced as the period of immobilization advanced. Fainting was closely correlated with the decrease of the pulse pressure. It occurred when the pulse pressure reached the critically low level of 10 to 12 mm Hg.

An extensive study of the effects of prolonged bed rest on cardiovascular and pulmonary functions was conducted by Saltin and co-workers[2] in 1968. Their observations were made on five healthy young men who were subjected to 20 days of complete bed rest followed by a period of intensive physical training. We owe much of our knowledge on the debilitating effect of immobilization to Saltin's thorough investigation.

CARDIOVASCULAR FUNCTION AT REST

Resting Heart Rate. Deitrick *et al.*[1] reported an increase of the resting heart rate during immobilization averaging 3.8 beats/min. During the first 3 weeks of recovery, there was a further increase which averaged 4.7 beats/min. Thereafter, the heart rate decreased to the control level. Saltin and co-workers[2] computed the basal heart rate during 20 days of bed rest from 7 to 8 hr of continuous tape recordings. The resting heart rate increased during the period of immobilization by 0.4 beats/min/day.

Resting Blood Pressure. Both Deitrick[1] and Saltin[2] reported that prolonged bed rest did not alter the arterial blood pressure. Sokoll *et al.*,[3] however, found a significant fall in the resting systolic pressure after 3 weeks of bed rest. There was no change in the diastolic pressure.

Heart Volume. Twenty days of bed rest reduced the heart volume by 11 percent as measured by radiographic techniques. Physical training for 13 to 15 days after the period of bed rest restored the heart volume to its original value.[2]