EFFECT OF IMMOBILIZATION ON THE SKELETON

ESSAY

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ORTHOPAEDIC SURGERY

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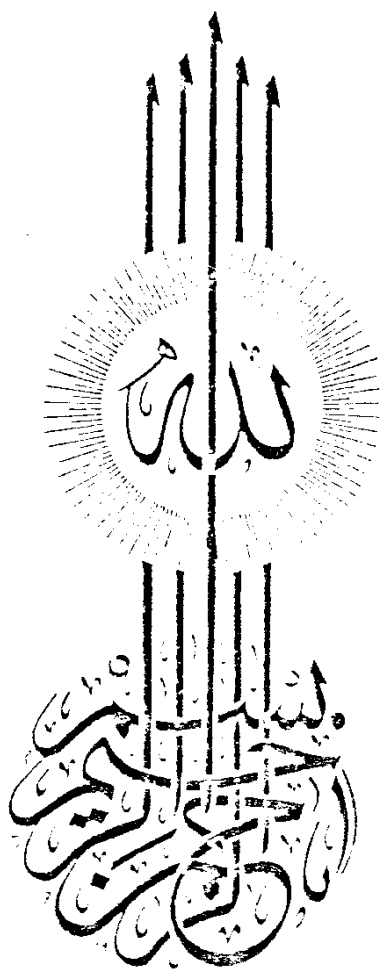

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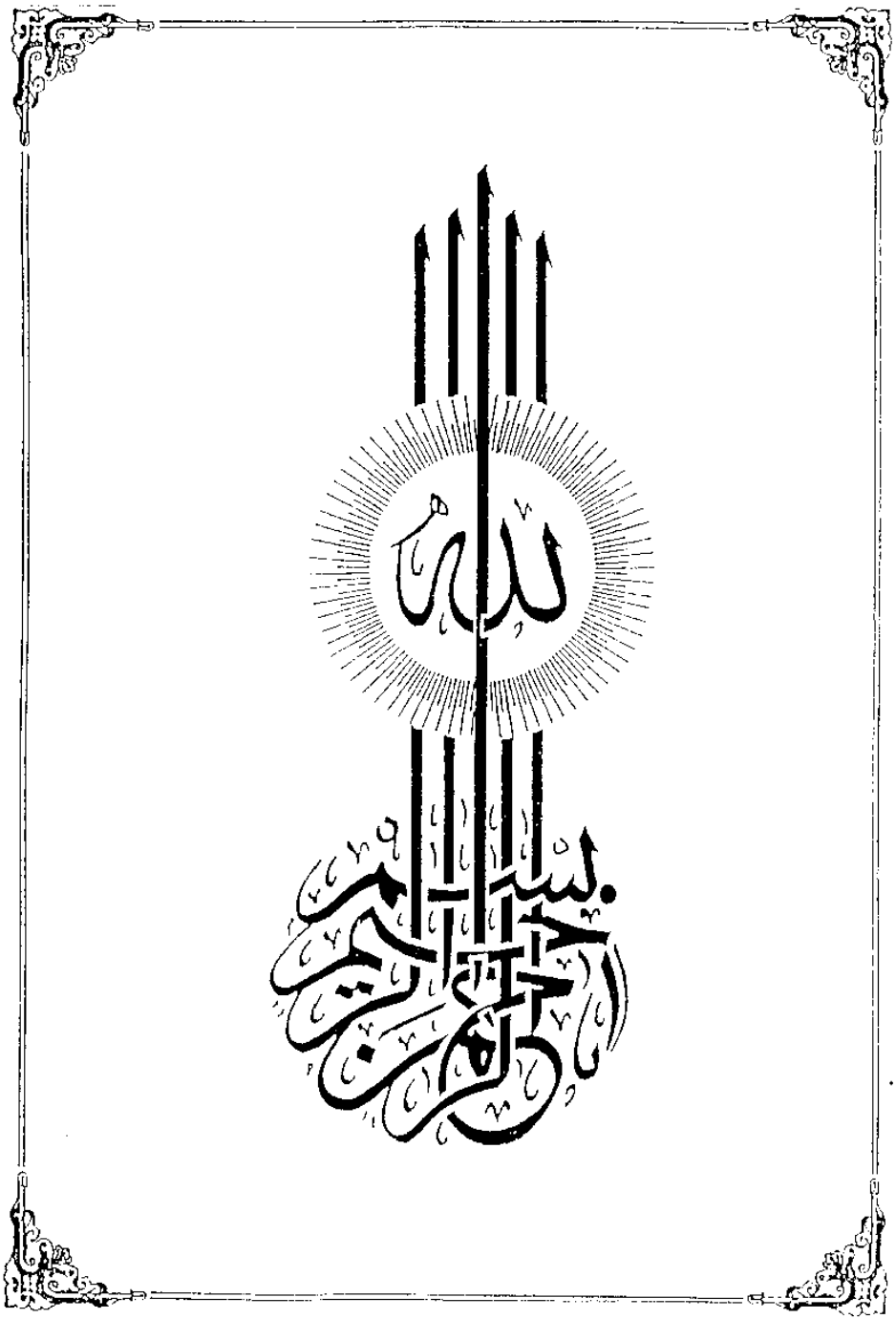

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ABBREVIATIONS

ABV : Absolute bone volume

ASIF: (Association for the study of Internal Fixation) is the English translation of AO (Arbeitsgemeinschaft fur osteosynthesefragen).

CT : Contraction time.

DVT : Deep vein thrombosis.

ECF : Extra-cellular fluid.

ECG : Electro-cardiogram.

EEG : Electro-myogram.

GAG : Glucosaminoglycans.

PNF : Proprioceptive neuromuscular facilitation.

PPS : Protein-polysaccharides.

PTH : Parathyroid hormone.

RT : Relaxation time .

SR : Sarcoplasmic reticulum.

TBV : Trabecular bone volume .

V_{max}: Maximum contraction velocity.

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INTRODUCTION

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A patient on prolonged bed rest can have many complications from inactivity e.g pressure sores, hypostatic pneumonia **(Larson and Gould, 1974a)**, renal calculi, soft tissue atrophy, hypercalcemia, and osteoporosis **(Pezeshki and Brooker, 1977)**.

Many years ago, fracture of the neck of the femur was often a terminal event in the lives of feeble and fragile individuals who died from cardiac, pulmonary or renal complications, aggravated by the recumbency and immobility that was attendant upon the conservative regime advised at that time. This state of affairs no longer prevails because it has long been recognized that the treatment of these fractures is essentially surgical, and that operative measures should not be withheld except under the most exceptional circumstances. Internal fixation of the fracture, or prosthetic replacement of the femoral head, carried out as soon as possible after injury is vitally important in order to permit early mobilization and thus avoid the dangers of prolonged recumbency and immobility in elderlly patients **(Devas, 1978)**.

It has long been recognized that stress deprivation from immobilization results in profound bone atrophy, and it is generally accepted that a minimum level of activity is necessary for homeostasis of bone **(Woo et al., 1981)**.

Immobilization of the whole body or a part of it for treatment of fractures, post-operative procedures, or resulting from conditions such as anterior poliomyelitis, rheumatoid arthritis and traumatic paraplegia, there is a general or local osteoporosis of bone **(Mercer, 1983).**

Immobilization removes a child from an opportunity for learning experience. In addition, immobilization results in an adjustment of the muscles of the limb or trunk to new fixed position, such adjustment is termed "myostatic" contracture. According to **Ferguson, 1981** a myostatic contracture in the muscles is the principle cause of joint stiffness.

One of the most common and dangerous of all complications of immobilization is the thromboembolic disease. The threat of thromboembolic disease increases with the age of patients, the severity of trauma, the degree and length of immobilization and the severity of the underlying systemic disease **(Evarts and Mayer, 1984).**

So, the rehabilitation should start as soon as the patient is admitted to hospital and must continue until he is satisfactorily resettled at home and in work. The rehabilitation aims to prevent the avoidable disabilities such as bed sores, venous thrombosis, urinary infection, renal stones, muscle wasting, joint stiffness and contractures by good nursing, physiotherapy and early mobilization whenever possible to restore the physical and

mental health (Mattingly, 1982).

In this essay we will try to review the current knowledge about the effects of immobilization (on the skeleton) which include causes of immobilization, the pathological effects, the methods of diagnosis of such effects, and how to avoid and treat these effects.

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PHYSIOLOGY AND BIOCHEMISTRY

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A. THE BONE

Biochemistry of bone :

The inorganic constituents of bone by dry weight comprise about 65 to 70 percent, and the organic constituents comprise about 30 to 35 percent, of which about 90 to 95 percent is the extra-cellular matrix consisting of the fibrous protein collagen. other organic constituents include small amounts of protein-polysaccharides (PPS) and lipids particularly phospholipids (**Turek, 1977a**).

Collagen : It forms a highly ordered system of collagen fibres with the typical axial periodicity of 640 to 700 Å and a unique protein composition of about one-third glycine residues, one-fifth imino acid residues, a large number of alanine residues,very few aromatic amino acids and completely lacking cysteine (**Turek, 1977a**).

Protein-polysaccharides : They are consisting of a polypeptide chain to which side-chains of highly sulphated polysaccharides are covalently bond (**Turek, 1977a**). The main polysaccharides in bone are chondroitin 4-sulphate and hyaluronic acid. They probably help to control the deposition of calcium salts (**Guyton, 1982b**).

Lipids : They comprise less than 0.1% of organic constituents. It was suggested that lipids participate in some unknown manner in the process of mineralization **(Turek 1977a).**

Inorganic constituents : The dry weight of bone is composed of 65 to 70 percent inorganic mineral, 95 percent of which is a calcium and phosphate **(Turek, 1977a).** The formula for the major crystalline salts, known as hydroxyapatites, is the following $Ca^{2+}_{10-x}(H_3O^+)_{2x}.(PO_4)_6(OH)_2$. The relative ratio of calcium to phosphorus can vary markedly under different nutritional conditions, the ca/P varying 1.3 to 2.0 **(Guyton, 1982b).** The minor mineral constituents of bone are magnesium, potassium and carbonate. Trace elements are zinc, manganese, fluoride and molybdenum **(Turek, 1977a).**

(a) Calcium : The total calcium content in the body is about 1 kg. Only about 1 g is found in plasma and ECF, whereas most of the remainder in the skeleton as calcium phosphates, carbonates and hydroxides. The normal daily requirement for a normal adult of 70 kg is 0.65 gram and 1.0 gram for growing children and pregnant woman **(Turek, 1977a).** The concentration of calcium in the plasma is approximately about 10mg/dl (5 mEq/L or 2.5 m mol/L) **(Ganong, 1983b).** The calcium in the plasma is present in three different forms : (a) approximately 41% of calcium is combined with plasma protein (non-diffusable fraction), (b) 4% of calcium is combined with other substances (citrate, phosphate) and

diffusible through the capillary membrane, and (c) 50% of the calcium in the plasma is both ionizable and diffusible (Guyton, 1982b).

(b) Phosphorus : The total phosphorus content of an average 70 kg man is about 1 percent of the total weight e.e about 700 g, 80-85% of this present as inorganic phosphorus in the bone (Rose, 1978). The total plasma phosphorus is about 12 mg/dL, with two thirds of this total in organic compounds and the remaining one third is inorganic (Ganong, 1983b). So, the normal level of serum phosphates as ionized inorganic phosphate is 3 to 4 mg/100 ml in the adult 5 to 6 mg/100 ml in the infant (Turek, 1977a).

The integrated calcitropic hormone system :

There are three principle hormones that regulate the plasma concentration of Ca^{2+} (Ganong, 1983b).

(1) Parathyroid hormone (PTH): It maintains calcium homeostasis as follows : (a) on the bone : it acts directly on the bone to increase bone resorption by promoting transfer the mineral from the bone to the ECF by proliferation and activation of the osteoclasts (Guyton, 1982b). (b) In the kidney : (i) it promotes resorption of calcium by the tubules from the glomerular filtrate (Turek, 1977a) , (ii) it also increases the formation of 1.25 dihydroxycholicalciferol , the physiologically active metabolite of vitamin D, and (iii) if inhibits the tubular reabsorption of phosphate, so it increases phosphate