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**THE MINIMUM PHYSIOLOGICAL MOBILITY REQUIREMENT
FOR MAN SUPPORTED ON A SOFT SURFACE**

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Abstract. Conventional paraplegic nursing is based on 'skin care' only, i.e. 2 or 3 hourly turning on a soft bed. This gives the absolute minimum protection. Body weight acts through the skeleton, and is transferred to a natural hard surface, via weight bearing bony prominences, which protect vital tissues from ischaemia. This is not so on a soft surface where pressure causes ischaemia of muscle. There is evidence that 20 minutes ischaemia injures muscle. Injured muscle can repair itself. The majority of decubitus lesions therefore go undetected. There is proof that ischaemic muscle necrosis occurs well before skin necrosis. Therefore the prevention of decubiti on the European bed should be based on 'muscle care'. Normal sleeping subjects make on average, one gross postural change every 11.6 minutes. It is postulated that this is the minimum physiological mobility requirement for man supported on a soft surface. The physiological gross postural change was determined by observing man sleeping on the ground. Excluding the prone position, the fully lateral, with lower limbs flexed, or the supine, are the only stable sleeping postures. Considering these and many other factors, the optimum nursing condition was determined, i.e. kinetic nursing, which is by definition: the automatic and continuous turning of a patient equally from side to side, in a given posture, through a maximum excursion of 124° at a minimum rate of 124° in 4.5 minutes. The Roto Rest beds are a practical means of providing this.

Key words: Decubitus ulcers; Nursing; Paraplegia.

Introduction

Brown Secquard (1853), from paraplegic animal experiments, proved that decubiti could be prevented and cured by avoiding prolonged pressure; proving that these ulcers were not due to the neurological lesion *per se*. In 1940 Munro described the prevention of decubiti in paraplegia by systematic hourly turning of patients on a Sorbo mattress. By 1945 he had found that two-hourly turning was adequate in the acute paraplegic. In 1944, Stoke Mandeville Spinal Centre was established under the management of Guttmann (1945, 1953, 1956, 1973) who introduced the Lifting and Turning Team, and the Sorbo Pack Bed. While Guttmann turned some of his patients half hourly and stressed the importance of postural change for other reasons, two and three hourly turning remains the standard treatment of paraplegia. It is fair to state that Stoke Mandeville has influenced world nursing generally, which now accepts two or three hourly turning as the best method available to prevent sores. In 1948, Gardner introduced the Alternating Pressure Mattress to save the nurses' time normally spent in turning patients. Virtually all other nursing aids, e. g. the water bed, the low air loss bed,

etc. have been invented to prevent decubiti and save turning. In practice, therefore, frequency of postural change is determined solely by the minimum necessary frequency of turning to prevent visible decubiti, *i.e.* based on skin appearance. The nursing profession actually refers to the prevention of decubiti as 'skin care'. Secondly, weight distributing soft surfaces, to completely avoid pressure over the bony prominences or distribute pressure over the greatest possible area of the body are still favoured. This removes the natural necessary high intermittent pressure required to stimulate protective skin growth: resistant to abrasion and more resistant to exposure to urine and faeces.

Body Structure

Man is a terrestrial animal, with a rigid skeleton on which the viscera and other soft tissues are suspended. When man is supported on a natural hard surface, *i.e.* the ground, body weight is borne on superficial weight-bearing bony prominences. These are only covered by skin and superficial fascia. In this way the skeleton protects vital structures, and tissues such as muscle, from the effects of pressure, *i.e.* ischaemia. This is easy to accept when man stands, kneels or rests on his elbows.

Figure 1 shows the less obvious weight-bearing prominences, *e.g.* the spinous processes of the sacrum, the greater trochanter, iliac crest, etc. If the subject shown in Fig. 1 lies on a hard flat surface such as a sheet of glass, it can be seen that the weight-bearing bony prominences alone support body weight. Therefore the soft tissues, in the normally nourished or obese, are only incidental in the role of supporting body weight. If an emaciated subject becomes immobile on a natural hard surface, ischaemic necrosis is confined to skin and fascia directly overlying the bony prominences, ulcers are small, muscle and other vital structures are protected. The prevention of decubiti under these natural conditions could properly be described as 'skin care'. The frequency of turning for the prevention of decubiti would depend on the ischaemic survival time for skin and superficial fascia.

Incidentally, the natural stimulus to produce healthy protective skin is high intermittent pressure (Gray, 1969). These conditions are only fulfilled sleeping on a hard surface. In contrast to the thin subject, the panniculus adiposus of the obese individual, acts like a soft bed. The skeleton carrying body weight, sinks down through the fatty tissue, pressure builds up most on the tissue surrounding the bony prominences. Decubiti will be large and arise sooner because muscle may be rendered ischaemic.

Muscle Care

In relation to the aetiology of gangrenous decubiti, it is now certain that muscle damage and necrosis occur well before gangrene of the skin. Groath (1942), Guttman (1953), Husain (1953), Kosiak (1959) and Haimovici (1976). When man is supported on the man-made European domestic or hospital bed, or on any other weight-distributing soft surface, the protective function of the weight-bearing bony prominences is nullified. The soft tissues are compressed and distorted. Muscle is rendered ischaemic, particularly in proximity to the bony prominences where the greatest pressure gradient and tissue tension takes place. Unlike sores which arise lying on the ground, tissue destruction and ulcera-

tion on a soft bed may be massive from the outset. The prevention of gangrenous decubiti on the European bed should be described as 'muscle care'.

Seddon (1965) stated that provided muscle damage is limited, regeneration can occur. Therefore the majority of decubitus lesions; not showing visible evidence of their presence, go undetected. Kosiak (1959) found histological evidence of ischaemic injury in muscle following the application of only 60 mm Hg pressure for one hour. Lewis and Grant (1925) showed that ischaemia of twenty minutes will produce numbness and aching followed by tingling and cramps

FIG. 1

The skeleton carries body weight and transmits it to a natural surface via superficial weight bearing bony prominences.

when blood flow is restored. Proctor *et al.* (1977) state that a tourniquet should not be applied to a limb for longer than 20 min, and should be released for 5 min before next application. Therefore if we wish to avoid the possibility of decubitus ulceration, we must turn the patient at least every 20 min. This however still leaves the optimum turning frequency undetermined.

Minimum Physiological Mobility Requirement

Hartmann *et al.* (1971) state that sleep is a period of psychological and physical restoration. It is reasonable to assume that for the average 8-hour period of sleep, the body will reduce its activity to the minimum necessary to maintain the healthy state. From the findings of Johnson *et al.* (1930), Laird (1935), Kleitman (1963) and Oswald *et al.* (1963), the average interval between gross postural changes made during sleep by normal adult control subjects was calculated to be 11.6 min. I suggest therefore that one gross postural change every 11.6 min is the Minimum Physiological Mobility Requirement (MPMR) to maintain the healthy state for short periods of soft bed rest. We however, are dealing with patients immobilised for long periods, therefore the optimum frequency and type of postural change remains to be determined. The other complications of immobility must be considered.

Physiological Postural Change

In order to ascertain the degree and type of postural change necessary, man must be studied under normal, *i.e.* natural conditions sleeping on the ground (see Fig. 2). If we exclude the prone position as uncomfortable and dangerous

FIG. 2

Man, the terrestrial animal, sleeping under natural conditions: on the ground. Note the physiological stable posture.

for some patients, the sleeping body will only remain stable in the supine, and fully lateral position with lower limbs flexed. The ease of postural change and the maintenance of posture is determined by the anatomical relationships of the weight bearing bony prominences. Using these postures alone, complete relief of pressure can be achieved, together with the physiological function assistance of gravity *i.e.* lymphatic and venous return, drainage of all bronchii, greater lung ventilation, prevention of sediment in the kidney pelvis, ureter and bladder, assisted function of the alimentary tract, muscle relaxation, sleep promotion, stimulus of skin growth, ventilation, and drying, and many other effects.

Kinetic Nursing

Having determined the MPMR, and the physiological postural change for man supported on a natural surface, optimum conditions, *i.e.* kinetic nursing was determined. This paper does not allow for enumeration and discussion of all the other factors considered, *e.g.* patient, comfort, sleep induction, avoidance of motion sickness, the complications of immobility, passive movement with increase in B.M.R., undesirable aspects of conventional nursing, *e.g.* Keane (1978), treatment of acute spinal injury (Keane, 1967) and nursing of the chronic patient (Keane, 1971).

The essential of kinetic nursing may be defined as: the automatic and continuous turning of a patient equally from side to side in a given posture, through a maximum excursion of 124° at a minimum rate of 124° in 4.5 minutes.

The Roto Rest beds are a practical means of providing kinetic nursing. At our spinal Centre, we have used kinetic nursing successfully in the treatment of decubiti since 1967. It is therefore a reliable preventative with a large margin of safety.

Conclusion

The important work of Grooth, Guttmann, Husain, Kosiak and Haimovici in showing that ischaemic muscle necrosis occurs in advance of skin death, due to a period of pressure, should be recognised and acted upon. The reason that decubiti are still a problem is that their prevention is based on 'skin care'. As a result, the very minimum frequency of turning is practised. There is no margin for error. The majority of decubitus lesions pass undetected. Those that become visible on the surface under conventional nursing are due more often to an accumulation of damage in the muscle. Pressure sores that develop at home, are likely to be due to the natural assumption by the patient, that the conventional treatment he received in the spinal unit, is the optimum, and therefore he has a large margin of safety. It is unlikely that a patient will turn himself more often at home than in a spinal unit. This leaves no room for the inevitable depression, lapse of self-care and intercurrent infection.

The patient must be warned of the dangers of a soft bed, and advised that if he wishes to avoid decubiti he must change his posture as frequently as did his body before his illness. This is the MPMR, *i.e.* one gross postural change every 11.6 min. However, in view of the other complications of immobility, optimum care should be adopted: a turn at least every $4\frac{1}{2}$ min. A simple, comfortable and economical means of achieving this is kinetic nursing.

RÉSUMÉ

Les soins paraplégiques conventionnels sont basés sur 'les soins de la peau' seulement c'est à dire un changement de position sur un lit doux à deux ou trois heures d'intervalles. Ceci pur donner un minimum absolu de protection.

L'homme est un animal terrestre. Le poids du corps agit à travers le squelette et il est transmis à une surface dure naturelle à travers le poids de protuberances osseuses qui protègent les tissus vitaux. Sur un lit doux, les protuberances osseuses s'enfoncent dans la surface, de larges surfaces de tissus tendres sont déformées et la nécrose ischémique peut être considérable. Le muscle peut être endommagé par vingt minutes d'ischémie. Le muscle endommagé peut se réparer ce qui veut dire que la majorité des lésions d'escarres ne peuvent pas être détectées. L'ischémie du muscle ischémique se produit avant celle de la peau. La prévention des escarres sur le lit européen devrait donc se baser sur les soins du muscle. Un sujet normal endormi change de position en moyenne une fois toutes les 11-6 minutes. On considère que ceci est le minimum de mobilité physiologique pour l'homme soutenu sur une surface molle. On a déterminé le changement de position physiologique en observant un homme endormi sur le sol. À part la position ventrale, les seules positions stables sont la position entendue sur le dos. Prenant ces éléments et bien d'autres en considération, on a déterminé les conditions optimum de soins c'est à dire, les soins kinétiques qui sont par définition: le mouvement continu et automatique d'un patient d'un côté à l'autre dans une posture donnée jusqu'à un angle de 124° à une vitesse minimum de 124° en 4-5 minutes. Les lits de Roto Rest sont un moyen efficace de faire ceci.

ZUSAMMENFASSUNG

Die übliche Pflege der Paraplegiker beruht nur auf 'Hautpflege' d.h. Umdrehung zwei oder dreimal pro Stunde auf einem weichen Bett. Diese Behandlung schafft den minimum Schutz.

Der Mensch ist ein irdisches Tier. Das Körpergewicht funktioniert durch das Skelett und wird auf eine harte Naturfläche versetzt über gewichttragende knöcherne Protuberanzen die die Lebensgewebe schützen. Auf einem weichen Bett lassen sich die knöchernen Protuberanzen in die Oberfläche nieder, grosse Zonen von weichem Gewebe und Muskel werden enstelt, ausgedehnte blutarme Nekrose kann ereignen. Durch 20 Minuten Blutarmut wird der Muskel verletzt. Der verletzte Muskel kann sich heilen, daher bleiben viele Verletzungen beim Liegen unentdeckt. Blutarme Muskelnekrose geschieht vor der Hautekrose. Deshalb soll die Verhütung vor Verletzung durch liegen auf dem europäischen Bett auf 'Muskelpflege' beruhen. Normale Personen machen im Schlaf durchschnittlich alle 11-6 Minuten einen grossen Stellungswechsel. Dieser ist vorausgesetzt als mindester physiologischer Bewegungsbedarf des Menschen der von einer weichen Oberfläche unterstützt ist. Man hat diesen physiologischen grossen Stellungswechsel festgestellt, indem man den auf dem Boden schlafenden Menschen beobachtet hat.

Die hingestreckte Position ausgeschlossen sind die völlig seitliche mit gebeugten Untergliedern oder die Rückenlage die einzigen beständigen Schlafpositionen. Als man diese und andere Umstände in Betracht zog, wurde die allerbeste Pflegebedingung festgestellt d.h. Kinetikpflege wie diese Art Pflege heisst: Man soll einen Patienten automatisch und anhaltend und in gleichem Masse von Seite zu Seite in einer bestimmten Position umdrehen durch maximum Schwingung von 124° mit minimum Geschwindigkeit von 124° pro 4-5 Minuten. Die 'Roto Rest' Betten schaffen ein praktisches Mittel um das alles zu leisten.

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