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Nutritional status and wound healing in open fractures of the lower limb

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Abstract Forty-three patients averaging 28.2 (range 16–74) years with open fractures of the lower limbs were studied prospectively for 40 weeks using anthropometrical, biochemical and haematological parameters to ascertain their relationship to wound healing following injury. Nearly half (21/43) of the patients were malnourished at admission and the number increased to 22 a week after injury. Dietary advice and better food intake improved nutritional status with only 13 patients remaining malnourished at the 40th week. Wound healing was earlier when creatinine-height index was normal throughout the course of treatment and was delayed when serum albumin level was low.

Résumé Nous avons suivi prospectivement, pendant quarante semaines, 43 malades avec des fractures combinées du membre inférieur en utilisant des paramètres anthropométrique, biochimique et hématologique pour étudier leur relation avec la cicatrisation des parties molles après l'accident. Prés de la moitié des patients (21/43) étaient considérés comme malnutris à leur admission. Les conseils diététiques et une meilleure prise de la nourriture ont

amélioré le statut nutritionnel avec seulement treize malades dans le groupe malnutris à la quarantième semaine. La guérison des blessures était plus précoce quand l'index de créatinine était normal durant le cours du traitement et a été retardée quand le niveau de sérum albumine était bas.

Introduction

Trauma and surgical stress produce a catabolic state that results in net loss of body protein with excessive nitrogen excretion and is proportional to the magnitude of the insult [1, 15]. Severe trauma is followed by a period of food deprivation accompanied by an increased demand by the body for metabolic fuels [14] adding to the impaired hormonal and cellular immunity that follow injury [15]. It is well recognised that malnutrition causes wounds to heal inadequately and incompletely [17] and that wound healing improves 1–2 weeks after adequate food intake, regardless of the patient's nutritional status [6, 18]. Protein depletion is correlated with increased mortality and morbidity, increased surgical failure rates, impaired wound healing, increased rate of wound infection, sepsis, pneumonia, progressive weakness, apathy, delayed union and delayed physical rehabilitation [12]. We made an attempt to study the correlation of nutritional status using anthropometrical, biochemical and haematological parameters in relation to wound healing among patients with open fractures of the lower limb.

Materials and methods

Forty-three consecutive patients with open fractures of the lower limb who presented between October 1996 and September 1997 were studied prospectively for a period of 9 months following injury. The parameters applied to assess nutritional status were triceps skin-fold thickness, mid-arm muscle area, creatinine-height index, serum albumin, serum transferrin and total lymphocyte count. Body

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height was measured in all patients. Skin-fold thickness was measured, as described by Frisancho [8], at a point marked in ink with the help of a measuring tape, mid-way between the angle of the acromion and the upper border of the ulna with an extended elbow. The skin fold was pulled out in the vertical plane at the mid-point (marked in ink) with the left thumb and forefinger. Holding the Holtain calliper (Fig. 1) horizontally in the right hand, the jaws

were applied such that the ink mark was in the centre of the jaws, which were then allowed to grip the skin fold whilst it was gently released from the forefinger and thumb. The dial was read when the indicator needle stopped moving. The mid-arm muscle circumference was measured at the same point with the help of a tape measure that was kept just distal to the marked point, and the mid-arm muscle area was calculated with the following formula:

$$\frac{[\text{mac} \times (3.14 \times \text{tsft})]^2}{4 \times 3.14} \quad (\text{mac} = \text{mid arm circumference; tsft} = \text{triceps skin fold thickness})$$

The normal levels of triceps skin-fold thickness and mid-arm muscle area were taken as per normative values for triceps-fold thickness and mid-arm muscle area [16]. Patients with values greater than the tenth percentile of the normal values for the same age group and gender were taken as nourished while the ones with values lower than the tenth percentile were categorised as malnourished. Creatinine-height index was measured on a 24-h urine sample using Jaffe's deproteinisation method adapted for the auto-analyser (RA-XT). It was calculated as the patient's 24-h excretion of urinary creatinine in relation to the 24-h urine creatinine excretion of a normal adult of the same height and gender [2].

Patients were categorised according to normative values for creatinine excretion based on height [16]. Values of above 0.9 were considered nourished, and the ones lower than that were malnourished. Patients with serum albumin >3.5 g/per cent, serum transferrin >199 mg/per cent and total lymphocyte count >1,500/mm³ were categorised into the nourished group while patients with values lower than these were considered malnourished. All patients were advised to have a 2,000-kcal diet with 80 g protein, 320 g carbohydrate and 55 g fat at presentation and during the follow-up period by our hospital dietician. The patients were motivated to take oral feeds as soon as possible after admission and, if operated upon, immediately within 4–6 h after surgical treatment. All investigations were sent on the day of admission and at the end of

first, fourth, eighth, 16th, 24th, 32nd and 40th week. However, nutritional parameters for wound healing were taken at admission and at the fourth week when wound healing is expected. All the criteria could not be studied in every patient for a number of reasons; a few patients were lost to follow-up or could not come to the hospital for investigation as required. Being a tertiary referral centre, we see many patients who come from great distances. It is often not possible for these patients to return on time for follow-up.

Results

Average patient age was 28.2 (16–74) years, and most patients (29/43) were in between 25 and 50 years. Men were more frequently injured (40/43). There were 24 patients with Gustilo [10] grade III compound fractures of the tibia, 15 with open fractures of the femur and four with open fractures of the ipsilateral femur and tibia. The height varied between 130 and 200 cm. Most patients (28) measured between 170 and 189 cm in height, ten patients were in the range of 150–169 cm, four over 190 cm and one between 130 and 149 cm. Nearly half (21/43) of the patients were categorised as malnourished at the time of admission, and the number increased to 22 a week following injury.

Relationship of wound healing to nutritional status When considering the skin-fold thickness of the 35 patients in the nourished group at presentation, 29 could be followed up at the fourth week and were still in the nourished category. Among them, 11 wounds healed within 3 weeks, and 18 wounds took more than 3 weeks to heal. In the malnourished group, there were initially eight patients, of whom half the number of wounds healed within 3 weeks and the remaining half in more than 3 weeks. According to the mid-arm muscle area, there were 21 nourished patients at presentation, of whom 12 were nourished at the fourth week. Of these 12, four wounds healed within 3 weeks while eight took more than 3 weeks. In the malnourished group, with reference to the mid-arm muscle area, there were initially 22 patients rising to 25 at the fourth week, despite nutritional advice. Among these, 11 patients' wounds healed within 3 weeks while in the remaining

Fig. 1 Holtain calliper for measurement of skin-fold thickness and a tape measure for measuring mid-arm circumference

14 the wound took more than 3 weeks. Assessing the creatinine-height index of the 15 patients in the nourished group, 12 were found to be nourished at the fourth week, and nine of those had wound healing in less than 3 weeks while the remaining wounds took more than 3 weeks to heal. In the malnourished group, there were initially 28 patients, and 17 remained at the fourth week. Wound healing within 3 weeks was observed in four patients while wound healing took more than 3 weeks in 13 patients. Serum transferrin levels demonstrated that of the 20 patients that were nourished at presentation, the number increased to 26 at the fourth week, and ten wounds healed within 3 weeks while 16 wounds healed in more than 3 weeks. Of the malnourished group, the initial number of 23 patients came down to 15, and seven wounds healed within 3 weeks while eight wounds took more than 3 weeks. Serum albumin: there were 30 patients in the nourished group at presentation, and their number increased to 31 at the fourth week. Of these, 14 wounds healed within 3 weeks and in 17 it took more than 3 weeks. In the malnourished group, 13 patients were reduced to ten at the fourth week, and all these wounds healed within 3 weeks. Total lymphocyte count, done at presentation, categorised 13 patients in the nourished group at the time of presentation, and their number increased to 20 at the fourth week. Of these, eight wounds healed within 3 weeks and 12 took more than 3 weeks. The malnourished group had 30 patients to begin with, and at the fourth week, there were 18 in this group. Seven wounds healed within 3 weeks while it took more than 3 weeks in the remaining 11 (Table 1). Wound healing was earlier among patients who had a normal creatinine-height index throughout the course of treatment and was delayed among all patients with low serum albumin levels.

Discussion

Men and a younger age group were most commonly involved, which parallels earlier reports of 89.1% men among trauma patients [12]. Also, the mean age of 28 years of our patients was in accordance with earlier reports [11, 12]. Nearly half of the patients were diagnosed as malnourished at admission, and their number increased at the end of 1 week following injury, which is consistent with earlier reports [5, 7]. However, a higher percentage (90%) of malnutrition has been reported among older (average age 80 years) below knee amputees who are at a special risk to become malnourished because of decreased food intake due to pain, nausea, confusion, increased loss of nutrients from the wounds, diarrhoea, vomiting and the increased requirements of major surgery or infection [6].

No clear relationship between rate of wound healing and malnourishment could be found in the present study when skin-fold thickness was used for categorising the patients. There was a higher number of nourished patients with wound-healing problems in the beginning, and a greater number of malnourished patients whose wounds healed in less than 3 weeks (Table 1). The results of mid-arm muscle area and total lymphocyte count were similar to the results of the skin-fold thickness. We have been unable to find a study correlating mid-arm muscle area measurements with wound healing. However, delayed wound healing has been observed in nearly 81% of patients with a total lymphocyte count of $<1,500/\text{mm}^3$ [4]. A decreased risk of healing complications is reported among lower-limb amputees with a normal total lymphocyte count [13]. Most (9/12) patients with a normal creatinine-height index had wound healing in less than 3 weeks, and three fourths of patients had delayed wound healing when creatinine-height index was

Table 1 Relationship of wound healing and nutritional status

	No. of cases initially	No. of cases at 4 weeks	Wound healing in <3 weeks	Wound healing >3 weeks
Skin-fold thickness				
Nourished group	35	29	11	18
Malnourished group	8	8	4	4
Mid-arm muscle area (mm^2)				
Nourished group	21	12	4	8
Malnourished group	22	25	11	14
Creatinine-height index				
Nourished group	15	12	9	3
Malnourished group	28	17	4	13
Serum transferrin levels				
Nourished group	20	26	10	16
Malnourished group	23	15	7	8
Serum albumin				
Nourished group	30	31	14	17
Malnourished group	13	10	0	10
Total lymphocyte count				
Nourished group	13	20	8	12
Malnourished group	30	18	7	11

lower than 0.9. A majority of wounds healed in more than 3 weeks even though the patients had serum transferrin levels below normal, and thus a positive correlation could not be found. However, in contrast to our observations, timely wound healing among patients with normal serum transferrin undergoing vascular surgery [3], and delayed wound healing among patients with low serum transferrin levels following total hip arthroplasty, have been reported [9]. Serum albumin: Though nearly half the number of patients in the nourished group had wound healing in less than 3 weeks, all patients in the malnourished group had delayed wound healing. Delayed wound healing with low serum albumin level has also been reported among diabetics as well as non-diabetics undergoing Syme's amputation [4, 13].

Our study revealed that nearly half (21/43) of the patients were malnourished at admission, and the number increased to 22, one week after injury. Dietary advice and better food intake improved nutritional status to only 13 patients remaining malnourished at the 40th week. Wound healing was earlier when creatinine-height index was normal throughout the course of treatment and was delayed when serum albumin level was low.

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