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Review article

Protein–energy undernutrition in hospital in-patients

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Impaired nutritional status has been frequently reported in surveys estimating its prevalence amongst patients in hospital. While there is no doubt that protein–energy undernutrition has serious implications for health, recovery from illness or surgery and hospital costs, lack of nationally or internationally accepted cut-off points and guidelines for most nutrition-related variables make nutritional assessment difficult and proper comparisons between studies impossible. In reviewing published work in which the prevalence of undernutrition has been assessed, it can be seen that each study defined undernutrition, or nutritional risk, using different methodology. This present review aims to highlight the problems which arise when deciphering these studies, and the resulting difficulty in determining the true prevalence of undernutrition and nutritional risk, amongst both general and specific groups of hospital in-patients. It is widely agreed that routine hospital practices can further adversely affect the nutritional status of sick patients in hospital. How this occurs, and the potential effects of impaired nutritional status on clinical outcome are examined. The methods currently available to assess nutritional status are evaluated in the knowledge that such assessments are difficult in clinical practice. The review concludes by proposing that if we want the medical and nursing professions to consider the nutritional status of hospital patients seriously, definitions of undernutrition and nutritional risk, and cut-off values for the nutritional variables measured must be agreed to allow evidence-based practice. Outcome measures which allow clear comparisons between groups and treatments must be used in studies assessing the effects of nutritional interventions.

Undernutrition: Nutritional status: Nutritional risk assessment

Undernutrition, or impaired nutritional status, have been frequently reported from surveys estimating their prevalence among patients in hospital. While there is no doubt that protein–energy undernutrition has serious implications for health, recovery from illness or surgery, and hospital costs, comparison between studies and assessment of the current situation is difficult. A lack of nationally or internationally accepted thresholds and guidelines for anthropometric and biochemical variables used to define nutritional status mean that virtually all studies use different methods to assess nutritional status, and that the criteria used to define undernutrition vary greatly. In general, the anthropometric reference data used are not derived from the population being studied. Indeed, most of the anthropometric reference data currently in use in clinical practice in the UK and Ireland were derived from measurements made over 25 years ago in the USA, and do not necessarily accurately reflect the current anthropometric distribution of the population being studied. In addition, to estimate a patient's risk of nutritional deterioration in hospital, many studies use formulas including variables which more truly measure severity of illness than nutritional state. In reviewing the studies which aim to estimate prevalence of undernutrition, the variability in study methodologies and the problems which this causes in deciphering the true prevalence of undernutrition can be clearly observed.

Undernutrition has been defined as a disorder of nutritional status resulting from reduced nutrient intake or impaired metabolism (American Society for Parenteral and Enteral Nutrition, 1995). It is used to describe a broad spectrum of clinical conditions ranging from mild to very severe. The state of impending undernutrition, or increased nutritional risk, has also been included under the umbrella of 'undernutrition' (Coats *et al*. 1993; Reilly *et al*. 1995). In developed countries, undernutrition has been documented in hospitalized patients (Bistrian *et al*. 1974, 1976; Hill *et al*.

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1977; McWhirter & Pennington, 1994) and in the institutionalized elderly (Morley, 1998). Although the aetiology of undernutrition is complex, its development may be due to inadequate dietary intake, increased metabolic demands or increased nutrient losses. In hospitalized patients, these three situations can occur together. Severe protein–energy undernutrition results in extreme muscle wasting and loss of subcutaneous tissue. Known to clinicians as cachexia, it is similar to the nutritional marasmus seen in starving children and can be classified as 'adult marasmus'. Hypoalbuminaemia, with depressed cellular immunity and an expansion of extracellular water, resembling childhood kwashiorkor, is also observed. This condition has been defined both as 'adult kwashiorkor' (Hill, 1992) and 'hypoalbuminaemic malnutrition' (Bistrian, 1990). In hospitalized patients, 'marasmic kwashiorkor' is most commonly observed, consisting of wasting of muscle and fat with hypoalbuminaemia (Hill, 1992).

Practices which potentially adversely affect the nutritional status of sick patients are widespread in many hospitals. This is frequently due to poor understanding by medical and nursing staff of the effects of impaired nutritional status on clinical outcome. However, the use of different methodologies in studies which estimate the prevalence of undernutrition, and conflicting results from those which assess the results of nutritional intervention, increase staff confusion and potentiate the problem. For the nutrition status of hospitalized patients to be considered seriously by the medical and nursing professions, definitions of undernutrition and nutritional risk, and cut-off values for the variables measured must be discussed by experts in the field and agreement reached. To allow for comparisons between studies, the reference data and outcome measures to be used must be defined.

Prevalence of protein–energy undernutrition in hospitalized patients

The prevalence of malnutrition in hospitalized patients was first reported in 1974 (Butterworth, 1974). This was followed by a number of other studies which reported a prevalence of 20–50 % in medical and surgical patients (Bistrian *et al.* 1976; Hill *et al.* 1977). Moreover, nutritional status is known to deteriorate over the course of the hospital stay (Weinsier *et al.* 1979; Coats *et al.* 1993; McWhirter & Pennington, 1994; Incalzi *et al.* 1996; Corish *et al.* 1998*a*,*b*). The more recent studies examining the prevalence of protein–energy undernutrition in hospitalized patients have found a similar prevalence to that found in the 1970s (Tables 1–3). A number of additional studies have estimated the number of patients at risk of deteriorating nutritionally in hospital (Table 4). Tables 5 and 6 summarize the methods which have been used to define nutritional status in these studies. However, a careful review of the literature examining the prevalence of undernutrition and nutritional risk in hospital patients highlights several problems. Virtually every study uses a

Table 1. Prevalence of undernutrition in hospitalized surgical patients

Authors	Patient group	*n*	Prevalence (%)	Method of assessment
Forse & Shizgal (1980)	General surgery	148	36	Total exchangeable potassium
Veterans Affairs Total Parenteral Nutrition Cooperative Study Group (1991)	Abdominal or thoracic surgery	2448	39	Nutrition risk index Subjective global assessment
Spiekerman *et al.* (1993)	Gastrointestinal surgery	245	44	Serum aspartate aminotransferase activity, cholesterol, total protein, albumin and transthyretin
Larsson *et al.* (1994)	General surgery	199	35	Percentage weight loss, weight index, MAMC, TSF, serum albumin and transthyretin

MAMC, mid-arm muscle circumference; TSF, triceps skinfold thickness.

Table 2. Prevalence of undernutrition in hospitalized elderly patients

Authors	*n*	Prevalence (%)	Method of assessment
Ek *et al.* (1990)	482	28·5	Weight index, MAMC, TSF, serum albumin, transferrin, transthyretin and retinol-binding protein, delayed hypersensitivity skin testing
	482	39·5	As above, excluding delayed hypersensitivity skin testing
Lansey *et al.* (1993)	47	45	Percentage IBW*, BMI, MAC, MAMA, TSF and SSF less than the 5th percentile using age and sex specific data†
Mowe *et al.* (1994)	311	53 males and 61 females	BMI, MAMC, TSF and serum albumin in hospitalized *v.* home-living elderly
Potter *et al.* (1995)	69	22	BMI less than the 5th percentile using age and sex specific data‡
Muhlethaler *et al.* (1995)	219	14	Body weight less than 80 % of age and sex specific values§
Garriballa *et al.* (1998)	201	31	BMI below 20 kg/m^2 in elderly stroke patients

MAMC, mid-arm muscle circumference; TSF, triceps skinfold thickness; IBW, ideal body weight; MAC, mid-arm circumference; MAMA, mid-arm muscle area; SSF, subscapular skinfold thickness.
* Simopoulos (1985).
† Chumlea *et al.* (1985).
‡ Burr & Phillips (1984).
§ Master *et al.* (1960).

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Table 3. Prevalence of undernutrition in specialized groups of hospital patients

Authors	Patient group	*n*	Prevalence (%)	Method of assessment
McWhirter & Pennington (1994)	General medicine	100	46	BMI, MAMC, TSF
	General surgery	100	27	
	Respiratory medicine	100	45	
	Medicine for the elderly	100	43	
	Orthopaedic surgery	100	39	
McWhirter *et al.* (1994)	Gastrointestinal	100	38	BMI, MAMC, TSF
Madden *et al.* (1994)	Liver transplant	164	71	MAMC, TSF, adequacy of dietary intake compared with calculated requirement
Nightingale *et al.* (1996)	General medical	84	35	Percentage weight loss from normal, BMI, MAMC
Giner *et al.* (1996)	Intensive care	129	43	Serum albumin < 35 g/l, weight : height ratio < 100 %*
Naber *et al.* (1997)	Non-surgical	155	45	Subjective global assessment
			57	Nutrition risk index
			62	Maastricht Index†

MAMC, mid-arm muscle circumference; TSF, triceps skinfold thickness.
* Chicago Society of Actuaries (1959).
† Maastricht index ((20·68 – (0·24 × albumin) – (19·21 × transthyretin) – (1·86 × lymphocytes) – 0·04 × ideal weight)). (De Jong *et al.* 1985.)

Table 4. Risk of undernutrition on admission and discharge from hospital

Authors	Patient group	*n*	Prevalence on admission (%)	Prevalence on discharge (%)	Method of assessment
Weinsier *et al.* (1979)	General medical	124	48	62 (*n* 44)	Likelihood of malnutrition score
Coats *et al.* (1993)	General medical	228	38	48 (*n* 48)	Likelihood of malnutrition score
Reilly *et al.* (1995)	General hospital	153	High risk 26 Moderate risk 24	No data	Nutrition risk score
Kovacevich *et al.* (1997)	General hospital	186	45	No data	Nutrition screening tool

Table 5. Methods of nutritional assessment in hospitalized patients

Method	Variables measured	Comment
Pre-admission weight loss	Current weight/normal weight	Lack of emphasis on routine measurement of weight; difficulties with accurate recall of weight; high prevalence of fluid balance problems in sick patients*
Anthropometry	BMI, MAMC, TSF	Confusion over appropriate cut-off points for BMI and other anthropometric measurements to define undernutrition in different age and disease groups; use of outdated reference standards
Serum proteins	Serum albumin, transferrin, transthyretin, retinol-binding protein, somatamedin C and fibronectin	All are influenced by hydration and hepatocellular dysfunction; individual proteins are influenced by factors common in sick patients (e.g. catabolism, renal failure, Fe-deficiency anaemia)*
Creatinine : height index	Urinary creatinine excretion	Need accurate 24 h urinary collections from patients on a meat-free diet
Functional status	Hand-grip strength, respiratory function	The relationship between muscle function and nutritional status has not been fully clarified
Immune competence	Delayed cutaneous hypersensitivity	Affected by disease (e.g. infection, renal and liver disease, trauma, burns and haemorrhage), drugs (e.g. corticosteroids, immunosuppressants, cimetidine, warfarin) and surgery
Bioelectrical impedance	Fat-free mass	Not useful for patients with fluid balance problems

MAMC, mid-arm muscle circumference; TSF, triceps skinfold thickness.
* Comment referred to in Table 6.

different method of nutritional assessment and the criteria used to define undernutrition vary greatly between studies. Even where similar methods of assessment were used (e.g. anthropometric assessment), the cut-off values for defining nutritional status vary and, in general, the reference data used are not derived from the population being studied. Comparison between studies and assessment of the current situation is, therefore, seriously hindered. For estimating the prevalence of undernutrition in the future, it is essential that guidelines are devised which provide guidance on which anthropometric, biochemical and functional measurements should be used to assess nutritional status in different groups of hospital patients and how the variables measured should be interpreted.

Relationship between nutritional status and clinical outcome

The development of undernutrition is influenced by the existing nutritional reserves independent of the disease state. Death occurs from total starvation in normal weight, healthy adults in 60–70 d (Allison, 1992). Survival beyond 50 % weight loss or BMI (weight (kg)/height (m)^2) below 12 kg/m^2 is unlikely (Allison, 1995). Total starvation for

Table 6. Scoring systems used for nutritional assessment in hospitalized patients

Scoring system	Variables measured	Comment
Nutrition risk index (Veterans Affairs Total Parenteral Nutrition Cooperative Study Group, 1991)	Percentage weight loss from normal; current serum albumin	The factors which affect the components of this score affect the score result (see * in Table 5); designed for surgical patients
Subjective global assessment (Detsky *et al*. 1987*b*)	Percentage weight loss from normal, duration and degree of abnormal dietary intake (starvation, hypocaloric fluids, liquid diet, sub-optimal solid diet), gastrointestinal symptoms (anorexia, vomiting, diarrhoea, nausea), functional capacity (bedridden to full capacity), disease state, physical examination (loss of fat and muscle, presence of oedema or ascites)	Large subjective element to assessment; need specialized training†; technique more suitable for medical staff; designed for surgical patients
Prognostic nutritional index (Busby *et al*. 1980)	Serum albumin, transferrin, TSF, DCH	Impractical and expensive for routine pre-operative assessment; designed for surgical patients
Nutrition risk score (Reilly *et al*. 1995)	Percentage weight loss over past 3 months, BMI, food intake (appetite and ability to eat and retain food), stress factors (effect of medical condition on nutritional requirements)	Can be applied to all hospital patients, weight-recall subject to error (see * in Table 5); validated against a sixteen item index designed to assess nutritional risk among community-dwelling elderly Americans
Nutrition screening tool (Kovacevich *et al*. 1997)	Diagnosis, nutrition intake history ($<$ 50 % normal for $>$ 5 d), diarrhoea, vomiting, current weight : IBW, percentage weight loss	Can be applied to all hospital patients, weight-recall subject to error (see * Table 5); validated against transthyretin (excluding patients with disorders known to affect transthyretin)

TSF, triceps skinfold thickness; DCH, delayed cutaneous hypersensitivity; IBW, ideal body weight.
† Lupo *et al*. (1993).

less than 2–3 d in healthy adults results in glycogen and water losses predominantly and only minor or no functional consequences (American Society for Parenteral and Enteral Nutrition, 1993). However, functional deficits are apparent in normal weight, healthy adults after 10–15 d of semi-starvation. It is probable that in sick, hospitalized patients, these impairments occur more rapidly. The severity of the inadequacy and the duration of deprivation of food intake affect the rapidity with which undernutrition develops. The majority of patients who become undernourished not only lack dietary energy and protein but also micronutrients. This may accelerate the deterioration in nutritional state.

Undernutrition in sick patients is associated with impairment of every system in the body. Muscle weakness occurs (Jeejeebhoy, 1988; Windsor & Hill, 1988; Watters *et al*. 1993), particularly of respiratory muscle, resulting in reduction in vital capacity and blunted respiratory drive (Arora & Rochester, 1982). In patients with emphysema undergoing lung volume reduction surgery, 26 % of those with a low BMI required prolonged ventilatory support compared with only 4 % of the patients with a normal BMI (Mazolewski *et al*. 1999). The ability of the immune system to function effectively is reduced (Christou, 1990; Ek *et al*. 1990; Welsh *et al*. 1996; Chandra, 1997). Cellular immune function appears to be most sensitive to the effects of protein–energy undernutrition (Christou, 1990). T-cell numbers, the response to mitogen stimulation and delayed hypersensitivity reactions have all been found to be depressed. Phagocytic cell function has also been reported to be impaired and the complement system adversely affected. Elevated titres of the immunoglobulins IgG, IgM, IgA and increased B-cell numbers are reported as a result of repeated infections. However, it is important to remember that cell-mediated immunity may also be depressed by trauma, renal and hepatic diseases, haemorrhage, steroid therapy, immunosuppressants, cimetidine, warfarin, general anaesthesia and surgery, factors common among patients in hospital. Immunoglobulin, antibody responses, complement component levels, mitogen responses and delayed hypersensitivity reactions have been found to return to normal with nutritional support. The clinical significance of these effects was observed in a study on 482 elderly patients, where 45 % of anergic patients compared with 27 % of reactive patients were undernourished as defined by anthropometric and biochemical criteria. Of the anergic patients, 28 % had pressure sores on admission or developed them during their hospital stay (Ek *et al*. 1990). In the gastrointestinal system, alterations in structure and function arise from undernutrition (Reynolds *et al*. 1996). Atrophy and impairment of the epithelial integrity occurs which may facilitate gut-derived infection. The presence of injury and infection, in turn, hasten the development of undernutrition in two ways; predominantly, metabolic changes are induced by the stress hormones (e.g. catecholamines, cortisol and glucagon) and various cytokines (e.g. tumour necrosis factor-α and interleukins 1 and 6). Insulin resistance may occur which further exacerbates the situation. The net result is inappropriate mobilization, and substantial wastage of fat and protein which is difficult to rectify with nutritional therapy during the acute phase. The metabolic response frequently results in the development of anorexia which further decreases the dietary intake of nutrients. In addition, high levels of cytokines decrease intestinal motility and inhibit gastric emptying which may, in turn, cause nausea and vomiting (Yeh & Schuster, 1999). The situation worsens if infection causes an increase in body

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temperature. Each one degree rise in temperature increases energy expenditure by elevating BMR by 13 % (Elia, 1995). Moreover, critically ill patients who develop hypoalbuminaemia as a result of chronic undernutrition have a higher incidence of diarrhoea than other critically ill hypoalbuminaemic patients (Hwang *et al*. 1994). In the cardiovascular system, myocardial atrophy, oedema and occasionally patchy necrosis of the myocardium can occur as can conduction abnormalities, reductions in cardiac output and work capacity (Heymsfield *et al*. 1978) although reassuringly, a recent study (Hill *et al*. 1997) found that, in patients who were critically ill, cardiac mass does not decrease and function does not deteriorate after haemodynamic stability has been achieved despite massive losses of N from the body. Endocrine impairments which occur as a result of undernutrition are complex, but include sick thyroid syndrome and primary gonadal dysfunction with reduced reproductive potential. Amenhorrhoea is frequently the presenting symptom in patients with anorexia nervosa. In the study by Haydock & Hill (1986) it was observed that adult surgical patients with both moderate to severe, or mild malnutrition, show an impaired wound healing response as measured by the hydroxyproline content of Gore-tex tubing implanted subcutaneously along the line of a needle track wound in the lateral aspect of the upper arm. The wound healing response was no different between the mildly undernourished, and the moderate to severely undernourished groups. This, the authors suggested, meant that the wound healing response is more dependent on the direction in which the patient is moving metabolically at the time of injury than on the degree of tissue lost. They also observed that age and the presence of malignancy did not appear to influence the wound healing response to the same degree. Additionally, impaired thermoregulation (Fellows *et al*. 1985), and impaired quality of life (Larsson *et al*. 1994) are observed in patients with impaired nutritional status.

Table 7 summarizes some of the studies showing the effects of impaired nutritional status on clinical outcome. Despite the lack of consensus as to the optimal method of its assessment, protein–energy undernutrition is recognized as having serious implications for health and for recovery from illness or surgery. This is highlighted in recent reviews of the effects of impaired nutritional status on clinical outcome (Gallagher-Allred *et al*. 1996) and hospital costs (Tucker & Miguel, 1996). In surgical patients, associations have been reported between poor nutritional status and higher post-operative infection risk (Busby *et al*. 1980; Detsky *et al*. 1987*a*; Bashir *et al*. 1990; Sagar & MacFie, 1994; Giner *et al*. 1996). The average length of hospital stay is doubled in surgical patients who develop post-operative complications (McAleese & Odling-Smee, 1994). Undernourished elderly patients have a higher risk for mortality (Sullivan *et al*. 1991), while more frequent re-admission to hospital has been reported in undernourished elderly patients who continue to lose weight after discharge from hospital (Friedmann *et al*. 1997).

Routine practices which affect the nutritional status of patients in hospital

A number of routine hospital practices which potentially adversely affect the nutritional status of patients were documented by Butterworth (1974) (Table 8). It is noteworthy, if rather depressing, to observe the prevalence of such practices in our modern hospitals (Table 9). If measurements (e.g. height and weight) on admission to hospital are not made, baseline nutritional status is not noted and deterioration in hospital goes undetected (Lennard-Jones *et al*. 1995).

Length-of-stay is markedly prolonged in undernourished adult patients who receive no intake orally after major gastrointestinal surgery, even in those without peri-operative complications, by comparison with those who are well-nourished (Shaw-Stiffel *et al*. 1993). Many post-operative

Table 7. Effects of poor nutritional status on clinical outcome in hospitalized patients

Authors	Patient group	*n*	Method of assessment	Clinical outcome in high risk group
Busby *et al*. (1980)	Elective gastrointestinal surgery	100	Prognostic nutritional index	Increased post-operative complications, major sepsis and mortality
Haydock & Hill (1986)	General surgery	66	Combination of factors, including percentage weight loss from normal, BMI, MAC, TSF, serum albumin, transferrin, transthyretin	Impaired wound healing response
Detsky *et al*. (1987*a*)	Gastrointestinal surgery	202	Subjective global assessment	67 % suffered from major post-operative complications compared with 10 % overall
Sagar & MacFie (1994)	Cardiac valve replacement	936	BMI	Increased risk of major and septic complications
Potter *et al*. (1995)	Elderly	69	BMI, MAMA	Increased mortality and rate of discharge to residential care, decreased ability to go home
Muhlethaler *et al*. (1995)	Elderly	219	Weight, MAMA	Decreased overall survival and ability to live at home
Lumbers *et al*. (1996)	Fractured femur	60	Weight, TSF, MAMC, serum albumin and haemoglobin	Increased length of convalescence and dependence on walking frames
Giner *et al*. (1996)	Intensive care	129	Serum albumin, weight : height ratio	Increased complication rate, length of stay and 'not discharged'

MAC, mid-arm circumference; TSF, triceps skinfold thickness; MAMA, mid-arm muscle area; MAMC, mid-arm muscle circumference.

Table 8. Common hospital practices potentially resulting in deterioration of nutritional status (adapted from Butterworth, 1974)

Diffusion of responsibility for the nutritional care of patients
Lack of interaction between medical, nursing, and nutrition and dietetic staff
Little emphasis on nutrition education in nursing and medical schools
Limited availability of methods to assess nutritional status
Failure to record patients' height and weight
Failure to observe and record patients' dietary intake
Frequent withholding of meals because of diagnostic tests
Delay in commencing nutritional support with prolonged use of glucose and saline i.v. fluids
Widespread ignorance of the physiological effects of different feeding routes and the composition of nutritional products. This results both in the inappropriate use of route of administration and the administration of enteral or parenteral feeds of uncertain composition or in inadequate amounts

patients have inadequate or no oral intake for more than 7 d (Townsend *et al*. 1997) and, even in well-nourished patients, this may affect the length-of-stay in hospital. In reducing length-of-stay and its associated costs, the early resumption of normal gastrointestinal function appears to be as important as the prevention of the deleterious effects of muscle wasting. Nutritional depletion, diagnosed by a decrease in mid-arm circumference by 3·6 % or more from admission to discharge occurred in 27 % of patients admitted to the geriatric and internal medicine wards of an acute care university hospital (Incalzi *et al*. 1996). Another more recent study observed that 21 % of elderly patients had an average daily in-hospital nutrient intake of less than 50 % of their calculated maintenance energy requirements (Sullivan *et al*. 1999). One of the major causes of undernutrition in institutions is not the failure to provide food, but to deliver it in a manner appropriate to the particular patient (Allison, 1995). Inflexibility imposed by economic constraints (McGlone *et al*. 1995) may result in mealtimes more suited to the hospital routine than to the patients' need for adequate nutrition. Meals are frequently unpalatable or served in a way that makes them inaccessible, either being wrapped or placed outside the reach of elderly or incapacitated patients. Portion size, the temperature of hot food and poor availability of hospital food between 18.00 and 08.00 hours have been identified as areas of patient dissatisfaction (Rushe & Moloney, 1998). If food is provided by non-nursing hospital staff, the nursing staff themselves are not always aware of patients' food intakes, nor of the physical difficulties their patients may have in trying to eat the meals served. Unqualified nursing staff may not possess the knowledge and skill necessary to assist patients with complex chewing and swallowing difficulties and the involvement of unqualified personnel in meal selection is a matter for concern where risks of aspiration exist (McLaren *et al*. 1997). Food wastage during a 1-month period was observed to be 42 % in one ward caring for elderly patients (Stephen *et al*. 1997). A comparison of wastage rates among patients choosing from the standard hospital menu and capable of independent feeding in two public and one private hospital, showed that an average of 26 % of total energy was wasted (Heffernan & Moloney, 2000). Although there was no difference between public and private hospitals in the percentage of energy wasted, the greater provision of food in the private hospital meant that nutritional intakes were significantly greater for energy, Fe, Ca and vitamin C in the private hospital (Shirley & Moloney, 2000). To meet their nutritional requirements, patients may be dependent on receiving food from home, which may be contraindicated by the current hygiene regulations (McGlone *et al*. 1997). Finally, healthy eating guidelines, providing foods low in energy density and fat, may be in place throughout a hospital, which, although they may be appropriate for cardiac rehabilitation or coronary care wards and staff canteens, in general, are not appropriate on wards caring for elderly, surgical or cancer patients.

The provision of nutritional supplements and enteral feeds has been shown to improve nutritional status in patients in hospital (Potter *et al*. 1998*a*). In patients undergoing moderate to major surgery they have been shown to reduce the incidence of post-operative complications both in undernourished (Bastow *et al*. 1983; Delmi *et al*. 1990; Beattie *et al*. 1998) and well-nourished patients (Beier-Holgersen & Boesby, 1996; Keele *et al*. 1997; Doshi *et al*. 1998), although this has not been shown in all studies (Heslin *et al*. 1997; Watters *et al*. 1997). Improvement in functional status has also been observed but appears to apply only to the in-patient phase of recovery (Jensen & Hessov, 1997; Keele *et al*. 1997). The simple and inexpensive energy enrichment of normal food served to elderly patients significantly increased their energy intake (Stephen *et al*. 1998) and both energy intake and body weights (Odlund Olin *et al*. 1996). Although neither of these studies sought to document clinical outcome, the provision of oral protein–energy supplements are associated not only with improvement in energy intakes and weight gain but also with a significant reduction in mortality in undernourished elderly patients (Potter *et al*. 1998*b*). Similar improvement in patient outcome may be achievable simply and inexpensively by enriching the energy content of normal foods.

Even when attempts are made to provide adequate nutrition therapy there are potential pitfalls in practice. Physiological and infectious complications (e.g. pneumothoraces and line infections) which arise from the inappropriate use of total parenteral nutrition in hospitalized patients have been documented (Nordenstrom & Thorne, 1994). Likewise, the results of the Veterans Affairs Study Group (Veterans Affairs Total Parenteral Nutrition Cooperative Study Group, 1991) have been criticized, as those in whom total parenteral nutrition was essential were excluded from the study and those with an intact functioning gut should more appropriately have been given enteral nutrition (Moran & Jackson, 1993). The method of calculation of requirements and the quantities of substrate administered in this latter study meant that many patients were at risk of overfeeding or hyperglycaemia, both of which are likely to increase the incidence of complications. The discontinuation of enteral

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Table 9. Documented practices which can potentially reduce the nutritional status of patients in hospital

Authors	Patients in whom nutrition indicators were measured (%)	Patients at nutritional risk (%)	Patients where nutritional therapy instigated (%)	Inadequate dietary intake during hospital stay	Weight change in hospital
Butterworth (1974)	Height in 44, weight in 77	No data	50	Average NBM 3 d	66 % lost weight
McWhirter & Pennington (1994)	Undernourished 48	40	Undernourished 18	No data	70 % referred for nutritional intervention gained weight; 80 % not referred lost weight
George (1994)				No data	No data
1992 audit	26	60	57 of those at risk		
1994 audit	54	48	76 of those at risk		
Lennard-Jones *et al*. (1995)	63 % of nurses weigh patients, 11 % measure height, 66 % doctors and nurses question recent food intake, 53 % of nurses and 73 % of doctors question unintentional weight loss	No data	No data	No data	No data
Payne-James *et al*. (1992, 1995)	No data	No data	Hospital access to nutrition team: 10·5 % in 1988, 37·5 % in 1995	No data	No data
Giner *et al*. (1996)	Patients were measured for purpose of study	43	No data	In malnourished patients during 44 % of hospital stay	No data
Townsend *et al*. (1997)	No data	No data	No data	17 % of GI surgical patients	No data
Sullivan *et al*. (1999)	Patients were measured for purpose of study	No data	25 % received enteral supplements for 26 % of hospital stay; 7 % received enteral or parenteral nutrition	21 % of elderly patients	Greater weight loss in low nutrient group ($P=0.02$)

NBM, nil-by-mouth; GI, gastrointestinal.

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feeds because of arbitrarily defined residual volumes of gastric contents (McClave *et al*. 1992; Lin & Van Citters, 1997) decreases the likelihood of patients achieving adequate nutritional intakes. In many hospitals, nasogastric feeding is stopped if gastric residual volumes as low as 75–100 ml are observed, although it has been clearly shown (McClave *et al*. 1992) that in critically ill patients a gastric residual volume of up to 400 ml does not necessarily indicate gastric or intestinal intolerance. Close monitoring, and not discontinuation of feeding, should be the nutritional management of choice in these patients. Access to specialized nutrition support teams has been shown to eliminate many of these unsatisfactory practices with subsequent benefit to patient outcome (Martin, 1994; Wesley, 1995). However, in spite of the evidence showing their benefit, the percentage of hospitals with a specialized nutrition team remains small (Payne-James *et al*. 1995).

The question of educating medical and nursing staff in nutrition has stimulated much interest and concern. Physicians who are specialists in nutrition remain few in number. There are, therefore, few advocates for change in medical schools' curicula (Intersociety Professional Nutrition Education Consortium, 1998). The Stratford Executive Group of the Nutrition Society proposes that nutrition should be recognized as a medical speciality, leading to structured nutrition training by various educational and clinical departments, improved structure of nutrition services and a focus on nutrition in clinical practice (Jackson, 1996). The King's Fund report (Lennard-Jones, 1992) highlights the role of nutrition screening and assessment on admission to hospital and recommends a multidisciplinary approach to its use for all hospital patients. The study by McWhirter & Pennington (1994) observed that of fifty-five undernourished patients (defined by BMI, mid-arm muscle circumference and triceps skinfold thickness) reassessed before discharge from hospital, only ten were referred for nutritional intervention. Of those who were referred, the majority gained weight (Table 9). One could argue that this could have been due to careful referral with those most likely to gain weight being referred appropriately. Unfortunately, the authors of this study do not provide information on the outcome of those who gained weight compared with those who lost weight. Reilly *et al*. (1995) observed that no action to prevent further deterioration in nutritional status was taken in 64 % of patients (twenty-three of thirty-six) at moderate nutritional risk and in 30 % (twelve of forty) of those at high risk (defined by a nutrition risk score). Again, no data on patient outcome were provided. A higher rate of referral in undernourished (defined using the criteria of McWhirter & Pennington (1994)) patients (40 %) has been observed more recently (Corish *et al*. 1998*a*), possibly as a result of a growing awareness of the effects of undernutrition on clinical outcome among medical and nursing staff. Criteria for referral for nutritional intervention need to be defined as well as the criteria to classify nutritional status. Many departments of nutrition and dietetics follow clinical standards of care which have been devised by their professional bodies or by groups such as the British and American Associations for Parenteral and Enteral Nutrition. However, the majority of medical and nursing staff who are in a position to refer patients are not familiar with these standards.

In conclusion, it is vital that education about the nutritional needs of hospital patients and good hospital practice are promoted in medical and nursing schools. The beneficial effects of good practice and the detrimental effects of poor practice on clinical outcomes must be documented and incorporated into evidence-based medicine.

Nutritional assessment in hospital patients

Nutritional assessment is defined as a comprehensive evaluation to define nutrition status, including medical history, dietary history, physical examination, anthropometric measurements and laboratory data (American Society for Parenteral and Enteral Nutrition, 1995). The goals of nutritional assessment are to identify patients who have, or are at risk of developing, protein–energy or specific nutrient disorders, to quantify a patient's risk of developing malnutrition-related medical complications and to monitor the adequacy of nutritional therapy (Klein *et al*. 1997). Assessment of nutritional status is stated to be the first step in the treatment of malnutrition (Blackburn & Thornton, 1979). This is reiterated in a recent document published as a result of a conference sponsored by the American National Institutes of Health, American Society for Parenteral and Enteral Nutrition and American Society for Clinical Nutrition which states: 'The field of nutrition support is based on two closely related concepts: (1) nutrient depletion is associated with increased morbidity and mortality, and (2) if this association is causative, the prevention or correction of nutrient depletion can minimize or eliminate malnutrition-related morbidity and mortality' (Klein *et al*. 1997).

The need for nutritional assessment may be better understood if the deterioration in nutritional status is considered in stages. In the first stage, the availability of nutrients is inadequate due to poor diet, to increased requirements for nutrients, or to their reduced utilization or excessive loss. This stage of undernutrition is best identified by a nutrition screening process which may be carried out by nursing or medical staff using a recognized protocol. Nutrient stores then become depleted resulting in impairment of physiological or biochemical processes. Finally, severe nutrient deficiencies result in cellular or tissue deterioration. The latter stages of undernutrition require formal nutritional assessment carried out by an individual (e.g. a dietitian) with appropriate expertise. In sick patients, the metabolic changes which occur in response to trauma, sepsis and malignancy, induced by stress hormones (e.g. catecholamines, cortisol, glucagon and cytokines, tumour necrosis factor-α and interleukin 1 and 6) result in inappropriate mobilization of fat and protein. The occurrence of insulin resistance further encourages a hypermetabolic state. Additionally, the normal passage and function of bile or pancreatic secretions may be hindered or the small intestinal mucosa may be altered quantitatively (e.g. by intestinal resection), functionally (e.g. by motility disorders and/or bacterial overgrowth) or histologically (e.g. by coeliac disease) (Bettany & Powell-Tuck, 1995). Certain illnesses are associated with increased nutrient metabolism (e.g. diabetes mellitus and hyperthyroidism) while others are associated with excessive loss of nutrients (e.g. enterocutaneous fistulas).

Many of the studies which attempt to define nutritional

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Table 10. Signs of nutritional risk in adult patients admitted to hospital (adapted from the American Society for Parenteral and Enteral Nutrition, 1995)

Involuntary loss or gain before hospital admission of more than 10 % of usual body weight within 6 months or 5 % of usual body weight in 1 month
A weight of 20 % over or under ideal body weight
The presence of chronic disease
Disease induced increased metabolic requirements
Alterations to the normal diet required as a result of recent surgery, illness or trauma
Receiving artificial nutrition support as a result of recent surgery, illness or trauma
Inadequate nutritional intake including not receiving food or nutrition products due to impaired ability to ingest or absorb food adequately for greater than 7 d

variables that can be used to select undernourished patients do not take into account the severity of illness. If nutritional assessment focuses on physiological or biochemical function alone, it may be reflecting the severity of an illness that is not caused solely by inadequate intake or that can be reversed by nutritional supplementation (Detsky & Smalley, 1994). Systems for scoring the severity of illness should be used in clinical studies to stratify patients and in the evaluation of quality, quantity and costs of nutritional therapy in ill patients. A number of scoring systems are available which link severity of illness at presentation to outcome (Dionigi *et al*. 1986).

Severity of illness was the best discriminator for the development of nutrition-associated complications in one study of 231 elderly medical patients, who were assessed (clinically and nutritionally) on admission to hospital and followed to 1 month after discharge. All nutritional assessment measurements (subjective global assessment, serum proteins, anthropometrics and risk indices) discriminated poorly between those with and without complications (Kinosian *et al*. 1994).

The treatment of undernutrition is best managed by using serial measurements of nutritional status to monitor the effects of therapy. More subtle degrees of undernutrition may still have an impact on outcome in seemingly well-nourished patients and the benefits of appropriate treatment for such patients need to be assessed in well-designed studies.

Currently, there is no consensus on the best method for the assessment of the nutritional status of hospitalized patients. All the traditional markers of malnutrition lose their specificity in the sick adult (Jeejeebhoy *et al*. 1990). In choosing which variables to use, the reliability (sensitivity and specificity), the rapidity with which changes can be detected and the cost-effectiveness must be considered. It is generally recognized that all techniques used in nutritional assessment have their limitations, but if these are recognized, nutritional assessment should identify the appropriate degree of nutritional intervention for an individual patient in a timely and cost-effective manner (Charney, 1995).

The techniques used to nutritionally assess patients on admission to, or during their hospital stay, can be divided into two types: nutrition risk screening and full nutritional assessment. Nutrition screening is defined as the process of identifying characteristics known to be associated with nutrition problems (Table 10). Its purpose is to identify individuals who are at risk of becoming malnourished or who are malnourished (Dougherty *et al*. 1995). For nutrition screening to be effective, it must use existing staff, be simple and inexpensive and be initiated early in a hospital stay. A number of techniques are in routine use (Table 6). A comprehensive review on screening for nutritional risk was recently published (Reilly, 1996). The main problem with using composite indices of nutritional risk, which incorporate several variables, is that nearly all patients will be found to have at least one abnormal measure (e.g. of sixty-four surgical patients assessed using a panel of sixteen variables, 97 % had at least one abnormality and 35 % had three or more abnormalities (Mullen *et al*. 1979)).

In a formal nutritional assessment, consideration is given to recent weight loss, to measurement of body composition and biochemical status and to the effects of nutritional status on physiological function. Attention must also be given to the disease state, duration of symptoms, nutrient intake and the presence of anorexia, dysphagia or gastrointestinal symptoms (American Society for Parenteral and Enteral Nutrition, 1995).

Pre-admission weight loss as a determinant of outcome and treatment

Weight loss at the time of hospital admission reflects the energy deficit over the period before admission to hospital. Although the pathogenesis of pre-admission weight loss has not been precisely defined, the clinical disease state, depression, loss of appetite, pain and swallowing difficulties are likely to contribute to its development. The degree of weight loss believed to be clinically significant was defined by Blackburn *et al*. (1977) (Table 11). It is generally believed that more than 10 % weight loss in the 6 months, or more than 5 % in the 1 month before admission to hospital is clinically significant. When more than 20 % of body weight has been lost, accompanying physiological impairment (e.g. reduced respiratory function) is invariably present (Hill, 1992). Many patients with weight loss between 10 % and 20 % are undernourished to a degree that may affect clinical outcome significantly. The rate and timing of weight loss is postulated to be a more important predictive factor for the development of post-operative complications than the underlying diagnosis (Detsky *et al*. 1987*b*).

Table 11. The influence of duration on severity of weight loss (adapted from Blackburn *et al*. 1977)

Duration	Clinically significant weight loss	Severe weight loss
1 week	1–2 %	>2 %
1 month	5 %	>5 %
3 months	7·5 %	>7·5 %
6 months	10 %	>10 %

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Only patients with both clinically significant weight loss (i.e. more than 10 % over 6 months) and measurable physiological impairment (e.g. reduced hand-grip strength and respiratory function) were shown to have an increased incidence of post-operative complications (e.g. intra-abdominal sepsis, septicaemia, anastomotic leakages, wound dehiscence or infection, pulmonary emboli, pneumonia, myocardial infarction, cerebrovascular accidents, urinary tract infection and death) (Windsor & Hill, 1988). These patients were older (mean age 69 (SD 2·3) years) and had smaller muscle reserves. In the elderly, post-operative mortality increases as nutritional status deteriorates (Bastow *et al*. 1983; Muhlethaler *et al*. 1995). The authors (Windsor & Hill, 1988) conclude that only those patients who have impairment of important bodily functions (e.g. respiratory function) in addition to more than 10 % weight loss should be considered for pre-operative nutritional repletion. Improvement in a number of functional indices (e.g. hand-grip strength and respiratory function) has been shown with pre-operative nutritional support (Church *et al*. 1984; Haydock & Hill, 1987).

In patients with chronic obstructive airways disease, weight loss in the preceding year correlated significantly with the need for in-patient treatment (Braun *et al*. 1984) while wasting was shown to be an independent risk factor for mortality in patients with chronic heart failure (Anker *et al*. 1997). Moreover, a prospective study which examined percentage weight loss on admission to hospital, serum albumin, total lymphocyte count, total Fe-binding capacity and serum cholinesterase activity concluded that pre-admission weight loss of 10 % is the only index with a prognostic performance worth evaluating in the pre-operative nutritional assessment (Gianotti *et al*. 1995).

Anthropometric assessment of nutritional status

Anthropometry is defined as the scientific study of the measurements of the human body (Fowler & Fowler, 1991). There is currently no anthropometric measurement considered to be completely accurate and practical for use in the clinical setting although recent studies suggest that measurements such as BMI, mid-arm muscle circumference and triceps skinfold thickness can be used (McWhirter & Pennington, 1994; Edington *et al*. 1996, 1997). Anthropometric data can be used in two ways when assessing a patient's nutritional status: (1) to compare the measured values with standard values derived from population surveys. The standards routinely used in most hospitals are derived from measurements made in the early 1970s of healthy Caucasian Americans (Bishop *et al*. 1981; Frisancho, 1981) while reference data derived from people in South Wales in the UK, published in 1984, are frequently used for defining the nutritional status of those aged 65 years or more (Burr & Phillips, 1984), particularly in the UK and Ireland. A major problem occurs when the patient's measurements start out well above the normal range but the patient deteriorates nutritionally for some time and so measurements now classify the patient as normal (Smith & Mullen, 1991). Anthropometric measurements can also be used (2) to compare serial measurements over time in the same patient. If anthropometry is used to define malnutrition, it has been recommended that at least three different anthropometric criteria should be observed (e.g. height, weight, mid-arm circumference) in classifying the subject's nutritional status (Jeejeebhoy *et al*. 1990).

BMI is the simplest technique for assessment of nutritional status and requires the measurement of height and weight (for calculation of BMI, knee height (Chumlea *et al*. 1985; Han & Lean, 1996) and demi-span (Kwok & Whitelaw, 1991; Reeves *et al*. 1996) can be used as surrogates for height in adults if height cannot be measured).

Knowledge of weight loss alone does not reveal changes in body composition with loss of weight. Body reserves of fat can be estimated by measuring skinfold thickness over the triceps and biceps muscle or by measuring fat thickness at the subscapular and supra-iliac sites. Percentage body fat can be calculated from these four measurements and compared with normal ranges (Durnin & Womersley, 1974). Muscle mass can be calculated from muscle circumferences measured at the mid-arm and calf. It is vitally important that anthropometric measurements are carried out following recognized guidelines (World Health Organization, 1995). The physiological changes that occur with ageing mean that the usual anthropometric assessment variables used in younger patients may not be appropriate in assessment of nutritional status of the elderly. The redistribution of body fat with age renders skinfold thickness measurements less valid in the elderly compared with younger persons (Taren & Schler, 1990). Although there have been attempts to derive anthropometric tables of normal values (Burr & Phillips, 1984; Chumlea *et al*. 1986; Falciglia *et al*. 1988; Rea *et al*. 1997), there is as yet no universally accepted 'gold standard' measurements for the elderly population. This may well be impossible, because population reference norms differ between countries, both for young and elderly populations and make accurate comparisons impossible (World Health Organization, 1995; Launer & Harris, 1996). Normal values may need to be established, therefore, that are age, sex and population specific.

Since the publication of the paper by McWhirter & Pennington (1994), a widely accepted definition of undernutrition in clinical practice is a BMI below 20 kg/m^2 with a mid-arm muscle circumference or triceps skinfold thickness less than the 15th percentile, using reference data from the USA (Bishop *et al*. 1981) for those aged under 65 years, and from South Wales (Burr & Phillips, 1984) for those aged 65 years or more. However, the prevalence of obesity is known to be increasing worldwide (Prentice & Jebb, 1995; Galuska *et al*. 1996; Van Itallie, 1996; Flegal *et al*. 1998; Jebb, 1999) and an even greater prevalence of obesity in surgical patients than in the general population has been documented (Riley & Burke, 1997). Many patients with weight loss or other clinical or nutritional problems will not be detected if a BMI below 20 kg/m^2 is the sole determinant of patients who require nutritional intervention to prevent undernutrition-related complications. Landi *et al*. (1999) associated a BMI below 22 kg/m^2 with 1-year survival in older people living in the community. Further confusion may be caused by the recent reclassification of BMI (World Health Organization International Obesity Task Force, 1998). A normal or ideal BMI is now defined as 18·5–24·9 kg/m^2 (Expert Panel on the Identification, Evaluation, and

Treatment of Overweight in Adults, 1998) based on assessment of risk of a number of chronic diseases (e.g. hypertension, dyslipidaemia, type 2 diabetes, CHD, stroke, gall bladder disease, osteoarthritis, sleep apnoea and respiratory problems, and endometrial, breast, prostate and colon cancers). Schols *et al*. (1993) showed that depletion of fat-free mass could occur in patients apparently maintaining weight, and that it was depletion of fat-free mass that was important functionally. In addition, the anthropometric reference data routinely used in clinical practice in the UK and Ireland were derived from measurements taken over 20 years ago and no longer accurately define our current nutritional status (Finch *et al*. 1998; Corish *et al*. 2000). New reference data detailing the normal anthropometric distribution of all population age groups may be required so that thresholds suitable for nutritional assessment in clinical practice can be agreed. A number of recent studies in the UK (Paul *et al*. 1998; Savage *et al*. 1998) which have examined the current anthropometric status of babies, and compared it with the reference data used routinely (Tanner & Whitehouse, 1975) have drawn attention to this problem in that age group.

Biochemical assessment of nutritional status

A full review of the role of biochemical measurements in the assessment of nutritional status is beyond the scope of this review. However, a number of comprehensive papers have assessed the impact of disease on the biochemical markers of both macro- and micronutrient status in hospitalized patients (Shenkin *et al*. 1996; Shenkin, 1997, 1998). The 'ideal' protein to measure would have a rapid rate of synthesis, a small total pool, a short half-life, a rapid catabolic rate and few factors that alter its distribution or catabolism (Fischer, 1982) and a number of serum proteins have been extensively investigated to determine their validity in the assessment of nutritional status. These include serum albumin, transferrin, transthyretin, retinol-binding protein, somatamedin C and fibronectin. In hospitalized patients, however, no single marker or group of tests can be recommended to reliably assess nutritional status (Young *et al*. 1990). In Western society, low plasma protein levels do not usually mean a lack of nutrients but reflect an inflammatory response (e.g. acute or chronic infection or inflammation). Serum protein levels vary in response to medical conditions (e.g. serum transferrin is reduced in liver disease, protein-losing enteropathy and nephropathy, chronic infections, uraemia and acute catabolic states, and increase under other conditions (e.g. pregnancy, oestrogen therapy and Fe-deficiency anaemia); serum transthyretin is increased in patients with chronic renal failure, serum retinol-binding protein is low in vitamin A deficiency and both serum transthyretin and serum retinol-binding protein are reduced by acute catabolic states, surgery and hyperthyroidism). If we define undernutrition using anthropometric criteria, not all undernourished patients have low serum protein levels. For example, many patients with anorexia nervosa, although severely malnourished (i.e. they may have a BMI below 16 kg/m^2 and muscle and fat stores below the 5th percentile) do not necessarily have a low serum albumin.

A large proportion of patients admitted to hospital are elderly. Many of the biochemical and haematological measurements used in assessing nutritional status also change with age and medication (Taren & Schler, 1990). It is now also realized that ageing is characterized by increasing concentrations of glucocorticoids and catecholamines and decreasing production of growth and sex hormones, a pattern similar to that seen in patients with chronic stress (Yeh & Schuster, 1999). These changes that occur with ageing need to be fully reviewed in order to use biochemical measures to accurately assess the nutritional status of elderly patients.

When biochemical measurements are used, patient outcome may relate to disease severity as opposed to nutritional status (e.g. although immune function is depressed in undernourished patients, it is also depressed in ill patients who are not undernourished (Dwyer *et al*. 1993)). The measurement of an acute-phase reactant, such as C-reactive protein as an assessment of acute infection or inflammation, can assist in the interpretation of blood protein measurements in the sick patient admitted to hospital, although there is some evidence now that C-reactive protein can be used as a marker for chronic inflammation, at least in type 1 diabetic patients (Schalkwijk *et al*. 1999). A post-operative reduction in albumin has been observed to be linked to the surgery-induced increase in C-reactive protein (Reynolds *et al*. 1997) and may predict those patients likely to have a turbulent recovery and a possible need for nutritional intervention. The measurement of α-1-acid glycoprotein as a marker of chronic inflammation has been discussed in the literature and a proposal made that it should be used with C-reactive protein, albumin and transthyretin as a prognostic inflammatory and nutritional index (Inglenbleek & Carpentier, 1985). Correlations with other acute phase proteins have been reported (Thurnham, 1997). However, mean serum α-1-acid glycoprotein levels in elderly subjects were observed to be higher than in a younger reference group (Kawerk *et al*. 1991). As approximately 40 % of patients currently admitted to hospital are elderly, more research is required on the use of α-1-acid glycoprotein as an index of chronic inflammation in this age group before it could be recommended for routine use as a marker of chronic inflammation in patients in hospital.

Despite the problems associated with biochemical measurements, a review of a number of studies of between fifty and 2060 patients has related low levels of the serum proteins albumin and transferrin, and the failure of nutritional support to increase serum albumin with poor outcome (Dempsey *et al*. 1988). Measurement of the other proteins have not been shown to be superior to albumin in predicting outcome in sick patients or in identifying those who might benefit from nutritional support (Klein *et al*. 1997; Vanek, 1998) and are, in general, more expensive to measure. Albumin, therefore, remains the most widely used biochemical marker to predict outcome in sick patients, with decreased levels generally representing one component of the metabolic response to stress or illness.

Functional status as a determinant of nutritional status and clinical outcome

The objective markers of nutritional assessment (e.g. weight loss and anthropometric measurements) are sometimes criticized as they do not always reflect physiological function.

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These functional effects include muscle weakness, particularly of respiratory muscle, loss of immune function, poor wound healing, impaired thermoregulation, depression, irritability and fatigue. Physiological dysfunction may be due to undernutrition and may improve with re-feeding. Metabolic and functional (e.g. muscle cell membrane potential) changes occur earlier on initiation of energy and protein restriction and they respond more quickly than anthropometric variables to re-feeding (Jeejeebhoy *et al*. 1990). Hypoenergetic feeding results in a fall in muscle membrane potential and in the concentration of intracellular ionic K, not reversible by K supplementation (Pichard *et al*. 1991). It has been proposed that the functional effects of undernutrition (e.g. impaired respiratory function) are more important than subnormal measurements of serum proteins as an index of surgical risk (Windsor *et al*. 1988).

Muscle function may be assessed by voluntary hand-grip, by electrical stimulation of the adductor pollucis muscle or by pulmonary function testing. Voluntary hand-grip has been shown to be more sensitive than other measurements of nutritional status (weight loss, weight related to height, skinfold thickness, arm-muscle circumference and plasma proteins) in the prediction of post-operative complications and mortality (Klidjan *et al*. 1980). Values below 85 % of standard for age and sex were found to be 74 % sensitive as a prognostic indicator for post-operative complications (e.g. chest infection, local sepsis, wound infection or dehiscence, prolonged ileus, obstruction, thromboembolism, renal failure) and mortality in a study of ninety patients undergoing major surgery on the gastrointestinal tract (Webb *et al*. 1989). The authors conclude that a grip strength below the recommended cut-off for age and sex suggests that the patient is in a high-risk group and demands further investigation of nutritional status. A recent study (Keele *et al*. 1997) showed that post-operative gastrointestinal patients given oral nutritional supplements (Fortisip, Numico Nutritional Healthcare, Zoetermeer, The Netherlands) *ad libitum* in hospital, maintained hand-grip strength in comparison with those patients who did not receive nutritional supplements. This applied only to the in-patient phase of the study with no effect noted during the out-patient phase; this finding was confirmed in a Danish study (Jensen & Hessov, 1997) where, in a group of gastrointestinal surgical patients given nutritional intervention during the post-operative convalescent period, small changes in weight and lean body mass did not appear to affect physiological function or fatigue (measured by a visual analogue scale (Christensen *et al*. 1982)). However, the relationship between nutritional status and hand-grip strength requires further clarification as significant changes in body composition were not reflected in improvement or deterioration in hand-grip strength in a study of general surgical patients which aimed to evaluate a combination of anthropometric (weight/height, mid-arm muscle area, triceps skinfold thickness), biochemical (serum albumin, total protein, creatinine/height) and functional (hand-grip strength) variables to assess nutritional status (Forse & Shizgal, 1980).

As with the anthropometric reference data, a need for data for grip strength more appropriate to the population being studied may be required. The reference data currently in use were derived from healthy patients (Klidjian *et al*. 1980) and from staff at a British hospital and self-caring volunteer residents at two institutions, judged by the authors to provide nutritious food for their patients (Webb *et al*. 1989). If grip strength is to be reliably used to determine nutritional status or post-operative risk, age and sex specific data derived from healthy members of the population being studied may be required. Furthermore, the effects of medication (e.g. opiates, sedatives, etc.) and disease on hand-grip strength should be fully evaluated before it is routinely advocated as a measure of functional status in all patient groups.

Much work on lung function and the strength of intercostal muscles has been carried out in patients with chronic obstructive pulmonary disease. These studies were recently reviewed (Congleton, 1999). The studies of respiratory muscle strength and malnutrition in chronic obstructive pulmonary disease have given conflicting results. Some groups have shown reduction in inspiratory and expiratory muscle strength in underweight patients (Donahoe *et al*. 1989; Gray-Donald *et al*. 1989; Schols *et al*. 1991). However, other groups have shown that body weight makes only a small contribution to respiratory muscle strength, which is more affected by the degree of mechanical disadvantage of the respiratory muscles due to hyperinflation (Lewis *et al*. 1986; Knowles *et al*. 1988; Sauleda *et al*. 1998). However, even in this patient group, it is recognized that peripheral skeletal muscles are functionally affected. Efthimiou *et al*. (1988) showed a significantly reduced hand-grip strength in underweight chronic obstructive pulmonary disease patients. Schols *et al*. (1991) showed a correlation between the percentage of ideal body weight and walking distance.

Finally, a number of more subjective methods have been recommended to assess physiological function (Hill, 1992). These include observing the patient's activity around the ward, asking the patient to squeeze the doctor's index and middle fingers for at least 10 s and getting the patient to blow hard holding a strip of paper 100 mm from the lips to assess respiratory muscle function. Patient's self-assessment of fatigue, using a visual analogue scale has also been recommended (Christensen *et al*. 1982), and recently used as a measure of function in a number of studies assessing the effects of post-operative nutritional intervention (Jensen & Hessov, 1997; Keele *et al*. 1997; Watters *et al*. 1997). Another measure of physiological function is a modified version of the Norton scale (Ek & Bjurulf, 1987) which consists of seven subscales: mental condition, activity, mobility, food and fluid intakes, incontinence and general physical condition. This scale has been used in recent intervention studies examining the effects of nutritional supplements (Unosson *et al*. 1992) and energy enriched foods (Odlund Olin *et al*. 1996) on clinical outcome.

Conclusions

Although there are problems with the precise definition of undernutrition and debate about the factors which increase the risk of its development, a significant proportion of hospital patients do have evidence of undernutrition on admission to hospital and continue to deteriorate nutritionally during their hospital stay. As a consequence, patient outcome is adversely affected in terms of increased complications and reduced quality of life. This, in turn, has cost

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implications for the health service and the efficient distribution of health care. There is increasing recognition of the need for greater attention to be given to nutrition by both medical and nursing staff. This can be facilitated by routine nutritional screening and assessment on admission to hospital and at regular intervals during the hospital stay. Early identification of patients with poor nutritional status or with characteristics known to be associated with nutrition problems likely to result in nutritional depletion will enable nutritional intervention to be targeted at those who need it. The quality of care delivered to undernourished patients or those at risk of undernutrition can then be improved. For the future, there is an urgent need for honest discussion on the methods of nutritional assessment and the variables used to classify nutritional status in specific groups of patients. Clear distinction must be made between undernutrition and those at risk of nutritional deterioration. Guidance must be provided on what reference data are appropriate for comparative purposes. Should we all use a cut-off BMI of 20 kg/m^2 to define undernutrition, regardless of how this compares with the anthropometric profile of the normal healthy population? Is there a need for comparison with the current nutritional status of the healthy population in every study? Should we use different anthropometric and biochemical cut-off values for different age groups? Should we consider weight loss, and what degree of weight loss should we accept as detrimental? Should we consider functional status? How can we truly distinguish between measurements that reflect disease state and nutritional status? What criteria should be used to decide if referral for dietetic management is necessary? All these questions need to be fully discussed in an open and honest way, taking clinical outcomes into consideration. The current confusion over appropriate assessment criteria impedes both the recognition and provision of nutritional support to those who would most benefit from it. Furthermore, unless this problem is addressed, it will remain impossible to monitor the problem of undernutrition using criteria which allow for comparison between centres and for changes over time. Undernutrition will continue to be both unrecognized and untreated, resulting in reduced clinical outcomes and increased hospital costs.

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