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Symposium on 'Nutrition and surgical practice'

Pre-operative nutritional assessment

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Protein–energy undernutrition, or the possibility of its development, has been documented to occur frequently in surgical patients admitted to hospital. Nutritional status is known to deteriorate over the course of the hospital stay, with poor awareness by medical and nursing staff as to the deleterious effects of impaired nutritional status on clinical outcome and hospital costs. While there is no consensus on the best method for assessment of the nutritional status of surgical patients pre-operatively, there are a number of techniques available. These techniques can be divided into two types, those suitable for screening for nutrition risk on admission to hospital and those used to fully assess nutritional status. Both techniques have their limitations, but if used correctly, and their limitations recognized, should identify the appropriate degree of nutritional intervention for an individual patient in a timely and cost-effective manner. The techniques currently available for nutritional screening and nutritional assessment are reviewed, and their applicability to the Irish setting are discussed in the present paper.

Undernutrition: Nutritional screening: Nutritional assessment

Protein–energy undernutrition, or the possibility of its development, has been documented to occur frequently in surgical patients admitted to hospital (Bistrian *et al*. 1974; Hill *et al*. 1977; McWhirter & Pennington, 1994). Moreover, nutritional status has been shown to deteriorate over the course of the hospital stay (Weinsier *et al*. 1979; McWhirter & Pennington, 1994; Corish *et al*. 1998*a*,*b*), a fact not recognized by medical and nursing staff (McWhirter & Pennington, 1994; Lennard-Jones *et al*. 1995; Reilly *et al*. 1995). The deleterious effects of impaired nutritional status on clinical outcome (Gallagher-Allred *et al*. 1996; Giner *et al*. 1996; Lumbers *et al*. 1996) and hospital costs (Tucker & Miguel, 1996) are widely acknowledged. If undernutrition is adequately documented on hospital admission and appropriate nutrition therapy is initiated, then an improvement in clinical outcome should be expected.

Consequences of undernutrition

Although the pathogenesis of undernutrition in surgical patients on admission to hospital has not been defined, the disease state itself, together with loss of appetite, pain and swallowing difficulties are likely to contribute to its development. In contrast, the consequences of undernutrition in surgical patients have been extensively documented. Associations have been reported between poor nutritional status and impaired wound healing (Haydock & Hill, 1986), 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), impaired quality of life (Larsson *et al*. 1994), and adverse effects on the functioning of the gastrointestinal tract (Reynolds *et al*. 1996), immune (Christou, 1990; Ek *et al*. 1990; Welsh *et al*. 1996), cardiovascular (Heymsfield *et al*. 1978) and respiratory (Arora & Rochester, 1982) systems. In addition, associations have been reported between pre-operative weight loss and both increased post-operative complications (Studley, 1936; Klidjian *et al*. 1980; Meguid *et al*. 1988; Reilly *et al*. 1988; Windsor & Hill, 1988; Von Meyenfeldt *et al*. 1992) and increased post-operative mortality (Busby *et al*. 1980; Giner *et al*. 1996). These adverse effects can result in longer post-operative convalescence times (Bastow *et al*. 1983; Lumbers *et al*. 1996) and increased duration of hospital stay (Bastow *et al*. 1983; Shaw-Stiffel *et al*. 1993). The average

Abbreviations: NRI, nutrition risk index; NRS, nutrition risk score; SGA, subjective global assessment.
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length of hospital stay is doubled in surgical patients who develop complications (McAleese & Odling-Smee, 1994), 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).

The clinical and financial benefits of nutritional intervention are well documented in undernourished surgical patients (Bastow *et al.* 1983; Delmi *et al.* 1990; Beattie *et al.* 1998). More recently, beneficial effects of nutritional intervention have been observed in patients undergoing moderate to major gastrointestinal surgery, irrespective of nutritional status at time of surgery (Beier-Holgersen & Boesby, 1996; Keele *et al.* 1997; Doshi *et al.* 1998), although these effects have not been shown in all studies (Heslin *et al.* 1997; Watters *et al.* 1997) and appear only to apply to the inpatient stage of recovery (Jensen & Hessov, 1997; Keele *et al.* 1997).

In our own studies of Irish patients the effects of undernutrition were apparent. In a mixed group of 569 medical and surgical patients, 11 % were undernourished (as defined by McWhirter & Pennington, 1994) and showed a significantly longer mean length of stay in hospital ($P < 0{\cdot}01$), a trend towards higher mortality ($P = 0{\cdot}05$), and a trend towards reduced ability to return to their own home ($P = 0{\cdot}06$; C Corish, P Flood, S Mulligan and NP Kennedy, unpublished results). In fifty-nine Irish surgical oncology patients lower percentage body fat on admission most accurately predicted both major complications ($P < 0{\cdot}05$) and major infectious complications ($P = 0{\cdot}01$). In turn, major complications most accurately predicted death ($P < 0{\cdot}001$; C Corish, P Flood, JV Reynolds and NP Kennedy, unpublished results).

Techniques for pre-operative nutritional assessment

While there is no consensus on the best method for assessment of the nutritional status of surgical patients pre-operatively, there are a number of techniques available. Methods must be reliable (sensitive and specific), practical, quick and easy to interpret, and low in cost. All have limitations, but if the technique is appropriate for the use to which it is applied, and the limitations are recognized, the use of pre-operative 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 for pre-operative nutritional assessment 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 1). 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 full nutritional assessment considers both the measurement of body composition, specifically fat and muscle stores, and the effects of nutritional status on physiological function. However, in contrast to nutrition screening, a full nutritional assessment is time-consuming, requires specialist staff and is more costly.

Methods for nutritional risk screening

An effective nutritional screening tool will generally use a combination of objective and subjective factors. A number of methods are in routine use, including the nutrition risk index (NRI), the nutrition risk score (NRS) and the subjective global assessment (SGA) among others. Probably the best known of these methods is the NRI, developed by the Veterans Affairs Total Parenteral Nutrition Cooperative Study Group (1991) for use in their clinical trial evaluating the efficacy of peri-operative total parenteral nutrition in malnourished patients undergoing major abdominal or thoracic surgery. The NRI relies on serum albumin concentration and percentage usual weight (Table 2). The NRI has been used to define nutritional risk in a number of recent studies where the effects of undernutrition (Reynolds *et al.* 1996) or nutritional intervention were investigated (Heslin *et al.* 1997; Keele *et al.* 1997). As a nutrition screening tool a drawback of the NRI is the reliance on measurements of current and previous body weight, limiting its usefulness where there is a relative increase in body weight due to an increase in total body water, e.g. in patients with hepatic, renal or cardiac disease. The use of patient recall for determining usual weight needs to be treated cautiously (Morgan *et al.* 1980; Rowland, 1990; DelPrete *et al.* 1992; de Fine Olivarius *et al.* 1997). Undernourished (BMI $< 20\ kg/m^2$) and obese (BMI $\geq 30\ kg/m^2$) Irish patients attending their general practitioner were observed to report current weight incorrectly (Doyle *et al.* 1998). They may also be unable to report usual weight accurately. A BMI of under $18\ kg/m^2$

Table 1. Signs of nutritional risk in surgical patients admitted to hospital (American Society for Parenteral and Enteral Nutrition, 1995)

Involuntary loss or gain before hospital admission of more than:
10 % of the usual body weight within 6 months
5 % of the 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

Table 2. Nutrition risk index (NRI; Veterans Affairs Total Parenteral Nutrition Cooperative Study Group, 1991)

NRI = 1·519 × serum albumin (g/l) + 0·417 × (current weight/usual weight) × 100
No nutritional risk: NRI score > 100
Borderline nutritional risk: NRI score > 97·5 – 100
Mild nutritional risk: NRI score 83·5 – 97·5
Severe nutritional risk: NRI score < 83·5

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indicates that the patient is at nutritional risk regardless of the NRI score. In these patients the NRI should not be used alone to assess nutrition risk (Stack *et al*. 1996). The NRI is open to further criticism as a nutrition screening tool for including serum albumin in its formula. Protein–energy malnutrition causes a decrease in the rate of synthesis of albumin, but this decreased synthesis has little impact on plasma concentrations, the metabolic response to stress being of greater importance (Klein, 1990; Doweiko & Nompleggi, 1991). Despite these problems, the NRI on admission was shown to predict post-operative complications in surgical patients (Veterans Affairs Total Parenteral Nutrition Cooperative Study Group, 1991).

In our mixed group of Irish medical and surgical patients (*n* 359; C Corish, P Flood, S Mulligan and NP Kennedy, unpublished results) a lower NRI correlated with prolonged length of stay in hospital ($P < 0{\cdot}01$), reduced ability to return to own home ($P = 0{\cdot}01$) and higher patient mortality ($P = 0{\cdot}01$). When the Irish general surgical patients (*n* 125) were examined separately, lower NRI correlated with longer hospital stay ($P < 0{\cdot}01$). In the smaller group of fifty-nine surgical oncology patients lower NRI most accurately predicted the development of total infectious complications ($P < 0{\cdot}01$), using a multiple regression model that included anthropometric, functional, disease stage and surgical data (C Corish, P Flood, JV Reynolds and NP Kennedy, unpublished results).

When NRI was used to define the nutritional risk of the general surgical patients on admission to hospital, 40 % were at mild or borderline nutritional risk, while 2·5 % were at severe risk. In the surgical oncology group NRI defined 63 % as mild or borderline risk and 13 % as at severe risk (Corish *et al*. 1998*b*).

The NRS was developed in 1992 by the Department of Nutrition and Dietetics in Birmingham Heartlands Hospital to assess patients' risk at admission for nutritional deterioration in hospital (Reilly *et al*. 1995). Incorporated into the NRS are the variables weight loss (amount and duration over the previous 3 months), BMI (kg/m^2), food intake (appetite and ability to eat and retain food) and stress factors (effect of medical condition on nutritional requirements). The score is intended to be completed within 24 h of admission, and repeated weekly during a hospital stay if the patient's condition has changed. Patients are categorized as at low, moderate or high risk for the development of undernutrition. Guidance for appropriate action is provided as a poster on each ward (Reilly, 1996), with nursing staff encouraged to provide nutritional supplements and monitor weight for patients at moderate nutritional risk. Patients deemed to be at high nutritional risk are highlighted for dietetic referral to enable more detailed nutritional assessment and for the provision of appropriate nutritional support. In a validation study (Reilly *et al*. 1995) the NRS correlated well ($P < 0{\cdot}001$) with a sixteen-item nutrition risk index designed to assess nutritional risk among community-dwelling elderly Americans (Wolinsky *et al*. 1990) and with the dietitian's clinical impression of the degree of risk of undernutrition ($P < 0{\cdot}001$). Reproducible scores were produced between dietitians ($P < 0{\cdot}001$) and between dietitians and nursing staff ($P < 0{\cdot}001$). The NRS has been adopted as a national standard in the UK (Sizer *et al*. 1996), despite some criticisms that the age and mental status of the patient are not considered. The NRS has also received some criticism for not considering a greater number of objective factors. A number of screening tools based on the NRS have been developed for specific patient groups but a version adapted for use in pre-operative surgical patients has not yet been developed.

In our mixed medical and surgical group (*n* 594; C Corish, P Flood, S Mulligan and NP Kennedy, unpublished results) a higher NRS on admission to hospital correlated with prolonged length of stay in hospital ($P < 0{\cdot}01$), reduced ability to return to own home ($P = 0{\cdot}01$) and higher patient mortality ($P = 0{\cdot}01$). In general surgical patients (*n* 238) higher NRS on admission correlated with longer hospital stay ($P < 0{\cdot}01$) and reduced ability to return to own home ($P = 0{\cdot}05$).

When NRS was used to assess nutritional risk on admission to hospital, 14 % of general surgical patients required monitoring of their nutritional status, while 17 % were at high risk of nutritional deterioration.

When the individual variables in the NRS were examined to assess which had more power to predict those surgical patients who continue to lose weight in hospital, a lower BMI on admission predicted patients who continued to lose weight in hospital ($P < 0{\cdot}05$), while an increased stress factor predicted those who lost most weight ($P < 0{\cdot}05$; C Corish, P Flood, S Mulligan and NP Kennedy, unpublished results).

The prevalence of subjective symptoms considered by the NRS to affect nutritional status among the 238 Irish surgical patients can be seen in Table 3. In the Irish group correlation between reduced appetite and increased length of stay ($P < 0{\cdot}01$), between reduced appetite and inability to return to own home ($P < 0{\cdot}01$) and between reduced ability to eat and increased length of stay ($P < 0{\cdot}05$) were seen (C Corish, P Flood, S Mulligan and NP Kennedy, unpublished results).

A third well-known and respected method of assessing nutritional risk is SGA. SGA is a clinical technique with subjective elements, and assesses nutritional status based on features of the patient's history and physical examination. The history includes assessment of weight loss in the previous 6 months, dietary intake in relation to usual pattern, presence of gastrointestinal symptoms, and functional capacity. The physical examination assesses loss of subcutaneous fat, muscle wasting and loss of fluid from the intravascular to the extravascular compartments. The basis for the assessment is to determine whether there is a true restriction of food intake and/or absorption, and whether there are associated effects on function and body

Table 3. Prevalence of symptoms affecting nutritional status in Irish surgical patients (*n* 238)

Symptoms affecting nutritional status	Prevalence (%)
Reduced appetite	23
No appetite or unable to eat	4
Problems handling food or mild vomiting or diarrhoea	12
Difficulties swallowing or moderate vomiting or diarrhoea	6
Unable to take food orally	6

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composition (Jeejeebhoy *et al*. 1990). SGA divides patients into three classes, well-nourished, moderately (or suspected of being)-malnourished and severely-malnourished (Detsky & Smalley, 1994). The pattern of weight loss, more than the underlying diagnosis, appears to be the most important factor in determining outcome (Detsky *et al*. 1987*b*). SGA has been shown to be 78 % sensitive and 70 % specific in predicting infection in surgical patients (Baker *et al*. 1982). Clinicians can therefore detect abnormalities that place patients at high risk. Interobserver reproducibility was found to be 81 % between two physicians, while a high degree of interobserver agreement was found between trained clinicians and trained nurses (κ 0·78; $P < 0.001$; Detsky *et al*. 1987*b*). Using receiver operating characteristic curves SGA was found to have the best combination of sensitivity (0·82) and specificity (0·72) when compared with six other methods of nutritional assessment in the prediction of risk in surgical patients (Detsky *et al*. 1984). SGA has been criticized, however, as it has been found that untrained operating surgeons could not globally assess patients at high risk for the development of complications beyond those who were quite obviously at very high risk (Lupo *et al*. 1993). Abnormal nutritional variables could not be detected clinically. Discordance occurred in the classification of patients as mildly- or moderately-malnourished. This subjective weighting is seen as one limitation of a technique more suitable for clinicians than for nursing staff.

In an attempt to improve the sensitivity and specificity of individual tests used for pre-operative nutritional assessment, a number of other indices have been developed which incorporate several variables. However, almost all tests rely on serum proteins for their power, and do not use additional methods to evaluate the severity of illness. Among these formulas are the prognostic nutritional index (Mullen *et al*. 1980), which constructs anthropometry, including measurement of triceps skinfold, delayed hypersensitivity skin testing, serum albumin and transferrin, into a formula intended for pre-operative use to identify patients at increased risk of post-operative complications who may benefit from nutritional intervention. The likelihood of malnutrition index (Coats *et al*. 1993) is another formula which considers anthropometrics, including triceps skinfold and mid-arm muscle circumference, serum albumin, packed cell volume, lymphocyte count and vitamin levels. Neither of these formulas has been shown to have advantages over the simpler methods of assessment of nutritional risk, and they are too impractical and expensive for routine pre-operative use. Finally, the instant nutritional assessment (Seltzer *et al*. 1979) considers serum albumin and total lymphocyte count only, neither of which has been shown to be sufficiently sensitive in measuring the nutritional status of sick patients.

Nutritional assessment

Nutritional assessment is defined as a comprehensive evaluation to define nutritional status, including medical history, dietary history, physical examination, anthropometric measurements and laboratory data (American Society for Parenteral and Enteral Nutrition, 1995). In choosing which variables to use a number of factors need to be considered, including sensitivity and specificity, the rapidity with which changes can be detected, and the cost : benefit value. Currently, there is no consensus on the best method for assessment of nutritional status with regard to anthropometric and laboratory measures. All the traditional markers of malnutrition lose their specificity in the sick adult (Jeejeebhoy *et al*. 1990). However, assessment measures often used when a patient is admitted to hospital include pre-admission weight loss, anthropometry, serum proteins and functional status. Attention must also be given to the disease state, duration of symptoms, nutrient intake, presence of anorexia or dysphagia and gastrointestinal symptoms. Despite the difficulties associated with nutritional assessment, the recent review of nutrition support in clinical practice from the American National Institutes of Health, the American Society for Parenteral and Enteral Nutrition and the American Society for Clinical Nutrition states that the most important goal of nutritional assessment is to quantify a patient's risk of developing malnutrition-related medical complications (Klein *et al*. 1997).

Pre-admission weight loss

Weight loss at the time of hospital admission reflects the energy deficit. It is generally believed that more than 10 % in the 6 months, or more than 5 % in the 1 month, before admission to hospital is clinically significant (Blackburn *et al*. 1977). When more than 20 % of body weight has been lost, accompanying physiological impairment is invariably present. Only patients with both clinically-significant weight loss and measurable physiological impairment have an increased incidence of post-operative complications (Windsor & Hill, 1988).

When 229 Irish patients admitted to surgical wards were examined as part of a larger study of 569 medical and surgical patients screened on admission to hospital (C Corish, P Flood, S Mulligan and NP Kennedy, unpublished results), weight loss in the 6 months before admission occurred in 39 % of the patients (mean weight loss 7·4 %). More than 10 % body weight had been lost by 10·5 % of these patients. All the undernourished surgical patients had lost weight (mean 8·1 % body weight), while 44 % had lost more than 10 % body weight. Of the 221 Irish surgical patients with data in the 1 month before admission, weight loss had occurred in 26 % (mean loss 6 %), while 10 % had lost more than 5 % body weight (mean 9·8 % loss).

In Irish surgical patients, weight loss of more than 5 % in the 1 month before admission correlated with increased length of stay ($P < 0.01$) and reduced ability to return to own home ($P < 0.05$). Increasing weight loss in the 1 month before admission predicted a reduced ability to return directly home on discharge ($P = 0.01$). Weight loss of 10 % over the 6 months before admission did not correlate with increased length of stay or reduced ability to return to own home. However, increasing weight loss over the 6 months before admission also predicted a reduced ability to return directly home on discharge ($P < 0.01$; C Corish, P Flood, S Mulligan and NP Kennedy, unpublished results). Undernutrition on admission was associated with weight loss in the 6 months before admission ($P < 0.001$) and weight loss in the 1 month before admission ($P < 0.01$;

C Corish, P Flood, S Mulligan and NP Kennedy, unpublished results).

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 to use in the clinical setting, although recent studies suggest that anthropometry can be useful (Edington *et al*. 1996, 1997). Anthropometric data are used in two ways in nutritional assessment. The first is to compare the measured values with published reference studies. In the UK and the Republic of Ireland, the standards used are derived from measurements in the early 1970s of healthy Causasian Americans (Bishop *et al*. 1981; Frisancho, 1981). Reference data derived from people in south Wales, published in 1984, are normally used for defining the nutritional status of those aged 65 years or more (Burr & Phillips, 1984). A major problem occurs when the patient started out well above the normal range, and therefore has been in a negative nutritional state for some time, although measurements now classify the patient as normal (Smith & Mullen, 1991). The second use of anthropometric measurements is 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 abnormal criteria should be observed (Jeejeebhoy *et al*. 1990).

The minimum muscle mass compatible with survival was established as an arm muscle area of between 900 and 1200 mm^2. Muscle mass can predict clinical outcome when the target is death secondary to fuel depletion, but provides only a background index in the trauma or surgical patient who is prone to infection or wound dehiscence (Heymsfield *et al*. 1982).

BMI is the simplest technique for assessment of nutritional status, and requires the measurement of height and weight (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) for calculation of BMI, although a small survey of Irish patients attending their general practitioner showed most patients reported height with reasonable accuracy (Doyle *et al*. 1998). The same survey reported that although normal and overweight Irish patients can report weight accurately for the purpose of estimation of BMI, those who are undernourished or obese cannot do so.

Knowledge of weight loss alone does not reveal the composition of lost tissue. Body reserves of fat can be estimated by measuring skinfold thickness over the triceps and biceps muscle, and 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 the maximum circumference of the calf. Anthropometric measurements must be carried out following recognized guidelines (World Health Organization, 1995).

Since the publication of their widely-cited paper, a widely-accepted definition of undernutrition is that of McWhirter & Pennington (1994), i.e. a BMI below 20 kg/m^2 and a mid-arm muscle circumference or triceps skinfold less than the 15th percentile. Using these criteria the prevalence of undernutrition in general surgical patients was found to be 27 % (*n* 100) in Dundee but only 7 % (*n* 232) in Dublin (Corish *et al*. 1998*a*). Furthermore, only 6 % of a group of fifty-nine surgical oncology patients were found to be undernourished (Corish *et al*. 1998*b*). This group, composed of patients undergoing major surgery, was expected to have a high prevalence of undernutrition, and 37 % had indeed lost more than 10 % body weight before admission to hospital. The prevalence of obesity is known to be increasing in the Republic of Ireland (Lee & Cunningham, 1990; Kilkenny Health Project, 1992), the UK (Prentice & Jebb, 1995; Jebb, 1999) and the USA (Galuska *et al*. 1996; Van Itallie, 1996; Flegal *et al*. 1998). An even greater prevalence of obesity in surgical patients than in the general population has been documented (Riley & Burke, 1997). A BMI below 20 kg/m^2 may not detect all patients who require nutritional intervention to prevent malnutrition-related complications. The anthropometric reference standards currently routinely used in clinical practice in the UK and the Republic of Ireland are probably no longer appropriate to define nutritional status in either population.

Biochemical assessment of nutritional status

Diagnosis of malnutrition cannot be adequately assessed by biochemical indices alone. Currently, no single test or group of tests can be recommended as a routine and reliable basis for the assessment of protein nutritional status (Young *et al*. 1990). The ‘ideal’ protein to measure should 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). Low plasma protein levels do not always mean a lack of nutrients. Many serum proteins are affected by the inflammatory response (Shenkin, 1997). The measurement of an acute-phase reactant, such as C-reactive protein, as an assessment of inflammation would assist in the interpretation of blood protein measurements (Benjamin, 1989). Serum protein levels vary in response to other conditions, e.g. serum transferrin is affected by Fe status, while retinol-binding protein and pre-albumin are affected by renal status (Young *et al*. 1990).

Despite this problem, 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 outcome (Dempsey *et al*. 1988). Other proteins have not been shown to be superior to albumin in the assessment of nutritional status or outcome in sick patients (Klein *et al*. 1997). Albumin, therefore, remains the most widely used indicator of nutritional status and predictor of outcome in sick patients, with decreased levels representing one component of the metabolic response to stress or illness.

In our mixed medical and surgical patient group (*n* 385) lower serum albumin was associated with increased length of stay in hospital ($P < 0{\cdot}01$), reduced ability to return to own home ($P < 0{\cdot}01$) and increased mortality ($P < 0{\cdot}01$; C Corish, P Flood, S Mulligan and NP Kennedy, unpublished results). In 128 general surgical patients, lower

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serum albumin on admission correlated with increased length of stay in hospital ($P < 0\cdot01$). However, a higher stress factor ($P < 0\cdot001$), decreasing haemoglobin ($P < 0\cdot01$) and increasing age ($P < 0\cdot05$) were the best predictors of increasing length of stay. It is important to note that not all undernourished surgical patients (as defined by McWhirter & Pennington, 1994) have low serum albumin levels. Of the undernourished Irish general surgical patients, nine of thirteen had a normal serum albumin level. 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). In the fifty-nine surgical oncology patients we studied, major non-infectious complications were predicted by the difference between pre-operative serum albumin and serum albumin day 1 post-operatively ($P < 0\cdot05$; C Corish, P Flood, JV Reynolds and NP Kennedy, unpublished results).

Functional status

Objective markers of nutritional assessment are criticized for their inability to reflect physiological function, including dysfunction due to malnutrition and improved function with refeeding. Metabolic and functional 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 are more important than subnormal body protein as an index of surgical risk (Windsor & Hill, 1988). These functional effects include muscle weakness (particularly of respiratory muscle), loss of immune function, poor wound healing, impaired thermoregulation, depression, irritability and fatigue. Functional deficits are evident in healthy normal-weight adults who voluntarily restrict their food intake after about 15 d of semi-starvation (American Society for Parenteral and Enteral Nutrition, 1993). It is probable that in sick hospitalized patients functional impairments occur more rapidly.

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 body composition measurements in the prediction of post-operative complications and mortality (Klidjan *et al.* 1980). Values below 85 % of the standard for age and sex were 74 % sensitive as a prognostic indicator for post-operative complications and mortality in a study of ninety gastrointestinal surgical patients (Webb *et al.* 1989). However, in a group of 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 and fatigue (Jensen & Hessov, 1997), while significant changes in body composition were not reflected in improvement or deterioration in hand-grip strength in a study to evaluate the validity of using a combination of anthropometric and biochemical markers to assess nutritional status (Forse & Shizgal, 1980)

In our mixed hospital group of 523 Irish patients, 69 % had a hand-grip strength below 85 % of the standard values devised by Webb *et al.* (1989). Of 218 patients reassessed before discharge, the undernourished and high-nutritional-risk patients who lost weight lost more hand-grip strength than those who did not lose weight ($P < 0\cdot05$). In the mixed hospital group, poor hand-grip strength was associated with increased length of stay ($P < 0\cdot01$), reduced ability to return home ($P < 0\cdot01$) and increased mortality ($P < 0\cdot01$). Surprisingly, although 63 % of the 216 surgical patients had hand-grip dynamometry below 85 % of the standard value, this factor was not associated with prolonged hospital stay, reduced ability to return directly home, or increased mortality. The reasons for this finding are not clear, but as with the anthropometric reference standards could perhaps reflect a need for standards for hand-grip strength more appropriate to the population being studied.

Prediction of hospital weight loss

Weight loss in hospital could not be predicted in the group of 569 medical and surgical Irish patients by any admission variable (C Corish, P Flood, S Mulligan and NP Kennedy, unpublished results). However, a greater weight loss in hospital was predicted both by reduced ability to eat on admission ($P < 0\cdot001$) and lower socio-economic group ($P < 0\cdot05$).

In the subgroup of surgical patients weight loss in hospital was predicted by weight loss in the 6 months before admission ($P < 0\cdot05$). An increased stress factor predicted ($P < 0\cdot05$) greater weight loss in hospital. Of the surgical patients reassessed before discharge, 70 % lost an average of 4 % of their admission weight during a hospital stay of 16 d. Of the patients defined as high risk using either NRI, NRS or the criteria of McWhirter & Pennington (1994), 47 % lost an average of 7·4 % of their admission weight during a

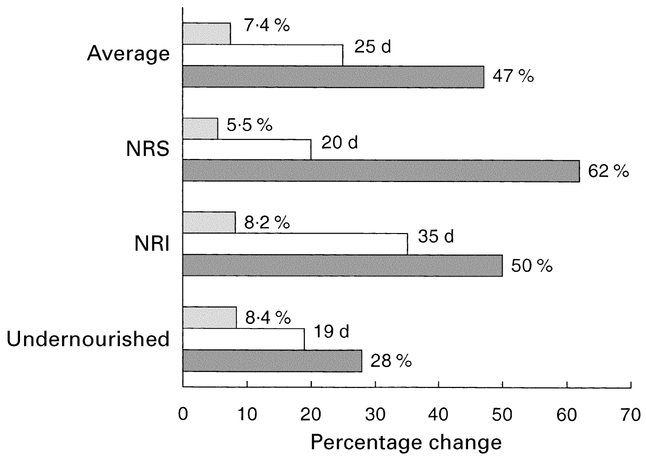

Fig. 1. Weight loss in hospital in high-risk patients defined by anthropometry (criteria of McWhirter & Pennington, 1994; undernourished), nutrition risk index (NRI; Veterans Affairs Total Parenteral Nutrition Cooperative Study Group), nutrition risk score (NRS; Reilly *et al.* 1995). (▒), Percentage weight loss in hospital; (▭), mean length of stay; (▬), percentage of patients losing weight. Average, average of values for all patients defined as high-risk (i.e. NRS, NRI and undernourished).

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hospital stay of 25 d (Fig. 1). While overall weight loss in hospital may not be regarded as clinically significant, high-risk patients who lose weight do so to a clinically significant degree.

Summary

Impaired nutritional status affects outcome in surgical patients. This relationship has been shown in numerous studies and in our own studies on Irish medical and surgical patients. Nutrition risk screening on admission is useful in surgical patients to detect those patients most likely to have increased post-operative infectious complications, greater weight loss in hospital, a prolonged stay in hospital and reduced ability to return directly to their own home. Regardless of the method of nutrition screening used, approximately 30–40 % of Irish surgical patients are at nutritional risk, with almost three-quarters continuing to lose weight in hospital. In patients who lose weight in hospital, those at highest nutritional risk tend to lose most weight. A full nutritional assessment should be carried out early in the hospital stay using a number of assessment measures in patients found to be at high risk as the result of nutrition screening. The accepted anthropometric criteria using the reference standards currently available are not suitable for defining undernutrition in Irish patients.

In conclusion, in surgical patients details of weight (particularly acute weight loss), appetite, ability to eat, serum albumin and the magnitude of the post-operative decrease in serum albumin are important indicators of the risk of post-operative complications and probable need for nutritional intervention.

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