Weight Loss with Physiologic Impairment

A Basic Indicator of Surgical Risk

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It is a long held belief that weight loss is a basic indicator of surgical risk. Many experienced surgeons, however, think otherwise. We have investigated the proposition that weight loss is a risk factor for postoperative complications but only when associated with clinically obvious physiologic impairment. Before major surgery, 102 patients had a careful history taken to ascertain if there had been recent weight loss and a reduction in the capacity for activity. Physical examination included assessment of mood, skeletal muscle function, respiratory muscle function, and wound healing. Plasma albumin was also measured. Using this information the patients were placed into one of three groups. Group I (N = 43) were normal, group II (N = 17) had weight loss > 10% but no clinical evidence of physiologic impairment, and group III (N = 42) had weight loss > 10% with clear evidence of dysfunction of two or more organ systems. The patients in group III had significantly more postoperative complications ($p < 0.05$). They also had more septic complications ($p < 0.02$) including a higher incidence of pneumonia ($p < 0.05$) and a longer hospital stay ($p < 0.05$) than patients in each of the other two groups. Objective measurements of body stores of protein and liver, and psychologic, respiratory, and skeletal muscle function, confirmed the validity of the clinical classification into the risk groups. The results demonstrate that weight loss is a basic indicator of surgical risk in modern practice providing it is associated with clinically obvious impairment of organ function. They suggest that adequate body protein stores are necessary for normal body function and for minimizing the risks of surgery.

In 1936 an American surgeon, Hiram Studley, claimed that "weight loss was a basic indicator of surgical risk."[1] In 50 patients undergoing gastric resection for peptic ulcer disease, he showed a striking correlation between preoperative weight loss and postoperative complications.

With advances in surgical practice, including antibiotics, physiotherapy, anesthesia and fluid and electrolyte management, this relationship can no longer be clearly demonstrated. In spite of this, many continue to cite Studley's paper[1] and claim that it proves that protein energy malnutrition is an important risk factor in modern surgery.

In our clinical practice, we have observed that weight loss does not appear to be an important risk factor for postoperative complications, unless it is associated with clinically obvious impairment of physiologic function. Preliminary work suggested to us that patients who are physiologically impaired could be identified by a thorough clinical examination,[2] and because of this we embarked on a formal prospective study to determine whether a clinical assessment of weight loss and physiologic function is able to identify patients with objective evidence of abnormal body composition and function who are also at an increased risk of postoperative complications.

Methods

Patient Selection

From April 1985 to August 1986, all patients presenting to the Department of Surgery at Auckland Hospital for elective surgical procedures, in which a major resection of some part of the gastrointestinal (GI) tract was planned, and for whom preoperative intravenous nutrition (IVN) was not considered essential, were asked if they would be willing to enter this study. On the day before surgery, the 102 patients who agreed to participate in the study underwent a clinical assessment and a series of objective tests to detect the presence of nutritional depletion and physiologic dysfunction.

Clinical Assessment of Weight Loss and Functional Status

Loss of body weight. Weight loss was evaluated from the history and physical examination. A preoperative

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weight loss (recalled well weight minus current measured weight)[3] of more than 10% over the preceding 3 months was considered significant.[4] Because there are considerable difficulties in evaluating body weight loss in an individual patient, confirmation was sought by physical examination. On physical examination, confirmation that weight loss had occurred was obtained by palpating several skinfolds and muscle bellies. If there was little or no fat palpable when subscapular, triceps, and biceps skinfolds were palpated, then it was considered that considerable fat had been lost and if on palpation of the bellies of temporalis, supraspinati, biceps, triceps, and interossei muscles revealed considerable losses, then this was taken as further evidence that considerable loss of body protein had occurred.

Functional status. The overall level of physiologic function, both mental and physical, was also assessed on history and examination. Factors that related to an overall reduction in the patient's capacity for activity (including symptoms of tiredness, malaise, depression, and apathy) were particularly looked for.[5] If there had been any major recent changes in the patient's activity level around the home or at work, this was taken as physiologic impairment.[6] Some specific physiologic functions were also assessed as part of the physical examination. To categorize a patient as having an impairment of any of these functions required clear evidence of a significant change within the time period over which the loss of weight had occurred. Psychologic function was assessed by observing the patients' overall mood, taking particular note of the alertness, ability to concentrate, and irritability. Confirmation of exercise intolerance was obtained by observing the patients' general activity level and endurance around the ward.[7] Skeletal muscle function was assessed by having the patient squeeze the examiner's hand, who then determined if the squeeze strength was clearly impaired in the light of the patient's age, sex, and body habitus.[8] Respiratory muscle function was assessed in the context of a full examination of the respiratory system, and particular note was taken of the effort and sound of coughing[9] as well as the presence of shortness of breath. Impairment of the wound healing response was evidenced by unhealed wounds, sores or scratches, and/or the presence of skin sepsis. A serum albumin concentration of less than 32 g/L was also considered a significant impairment.[2]

Categorization of Patients into 3 Groups

The patients were assessed and categorized without knowledge of any objective data, into one of three groups, by a single clinician (J.A.W.): [I] weight loss of less than 10% with no evidence of abnormal physiologic function; [II] weight loss of greater than 10% with no evidence of physiologic dysfunction; and [III] weight loss of greater than 10% with physiologic impairment of at least two of the systems described above (*i.e.*, overall activity level, psychologic function, respiratory function, skeletal muscle function, wound healing, and plasma albumin concentration).

Objective Assessment of Weight Loss and Physiologic Functions

Body composition measurements were made in order to assess the total body fat and protein stores in the three categories of patients. We were also interested in objective data to validate the clinical estimate of physiologic impairment and to this end we measured liver function, skeletal and respiratory muscle function, and psychologic function.

Anthropometry. Skinfold thickness (biceps, triceps, and subscapular) was measured using Holtain skinfold calipers, and body fat was calculated according to the method of Durnin and Wormersly.[10] Midarm circumference (MAMC), an indirect measure of body protein, was calculated as midarm circumference minus triceps skinfold thickness.[11]

Body composition analysis. Prompt *in vivo* neutron activation analysis (IVNAA) and the tritiated water dilution technique were used to measure total body protein (TBP) and total body fat (TBF).[12] The protein index,[13] a measure of protein depletion, is the measured TBP divided by a predicted TBP. The predicted TBP was derived from linear regression equations using the age, height, and sex of a local normal population who had had direct measurements of TBP. In the same way a fat index was calculated from the measured and predicted TBF, and was used to measure the extent of body fat depletion. The fat free mass (FFM) was calculated as the sum of the body water, protein, glycogen, and mineral compartments.[13]

Liver function. Plasma tranferrin and prealbumin were assayed by laser nephalometry.

Skeletal muscle function. Maximum voluntary grip strength was the highest of three values measured by isokinetic dynamometry using the dominant hand. Grip strength was also expressed as a function of the patients' FFM. Using an apparatus based on the principles of Edwards et al.,[14] the relaxation of the adductor pollicis muscle was determined in the unfatigued state after a brief tetanic stimulation (3 seconds) at 50 Hz. The relaxation time was calculated as the time taken for the force of a tetanus to fall 50% of its plateau value.[14]

Respiratory function. Respiratory muscle strength was assessed by measuring mouth pressure with a Validyne bidifferential pressure transducer (Validyne Model MP45, Validyne Engineering Corp., Northridge, CA) during maximal static inspiration (MIP) at functional residual lung capacity and during maximal static expiration (MEP) at total lung capacity.[15] A respiratory muscle strength index was derived as the average of the per cent predicted MIP and MEP. These were derived from regression equations based on the patients' age, height, and sex.[16] Forced expiratory volume in 1 second (FEVI), vital capacity (VC),[17] and peak expiratory flow rate (PEFR) were measured by standard spirometric techniques and were expressed as the percentage and predicted value derived from published regression equations.[18–20]

Psychologic function. Psychologic fatigue was measured using the Profile of Mood Score (POMS) self-questionnaire.[21]

Assessment of Clinical Course after Surgery

The clinical team responsible for each patient's postoperative care was unaware of the results of either the clinical or objective assessments. They diagnosed and recorded the complications independently and determined the date of discharge from hospital according to our usual criteria (patient up and about, eating well, and free of sepsis). The patients were also seen daily by one of us (J.A.W.) who ensured that each postoperative complication was fully documented and diagnosed according to specific clinical and laboratory criteria.

Major complications included intra-abdominal sepsis (proven by culture or abnormal drainage or at reoperation), clinically apparent anastomotic leakages, wound dehiscence (requiring reoperation), proven pulmonary emboli (requiring heparinization), pneumonia (proven by a positive blood and/or sputum culture as well as clinical and radiologic evidence of consolidation; atelectasis excluded), myocardial infarction (proved by ECG changes), cerebrovascular accidents (with neurologic deficit), and any technical problem that required the patient to undergo a further major surgical procedure. Septic complications included intra-abdominal sepsis, pneumonia, septicemia (clinical evidence of systemic infection and two separate positive cultures of the same pathogen in the absence of an obvious focus), wound infection (unequivocal signs of inflammation and a positive culture of a pathogen from the pus exuded from the wound), and urinary infection (greater than 1000 organisms/mL on culture). The number of days from operation to discharge was recorded as were all deaths that occurred within 14 days of the operation.

Statistical Analysis

Quantitative data of the three patient groups were initially evaluated with a one-way ANOVA. Multiple group comparisons of these quantitative data were done using Student's *t*-test incorporating the Bonferroni method, unless it could not be assumed that the results were normally distributed, in which case the nonparametric Kruskal-Wallis test was used.[22] Categorical data, including complication rates, were evaluated using the chi square test with Yates' correction.

Results

Patients in the 3 Clinical Categories

On the basis of the clinical assessment of nutritional and functional status 43 patients were categorized as having insignificant weight loss and normal functional status (group I), 17 patients were categorized as having significant weight loss without significant impairment of physiologic function (group II), and the remaining 42 patients were found to have significant weight loss and physiologic dysfunction as well (group III). Table 1 shows that the group III patients were, on average, older than those in the other two groups. Their average weight was also less. As might be expected, the duration of anesthesia was significantly less in the patients who had significant weight loss. It averaged 2.8 ± 1.4 (SD) hours in groups II and III compared with an average time of 3.7 ± 1.7 (SD) hours in group I $p < 0.05$. The distribution of the types of operative procedures and surgical diagnoses was similar for each of the three categories of patients, with a diagnosis of colorectal cancer in approximately half of the patients, and benign disease of the GI tract in approximately a third.

The Objective Measurement of Fat Stores, Protein Stores, and Physiologic Functions in the 3 Clinical Categories of Patients

Body stores of fat and protein together with objective measurements of function for the three clinical categories of patient are shown in Tables 2 and 3. Although the loss of body weight in groups II and III was similar (13.4% and 14.8%, respectively) and significantly more than that of the patients in group I (3.9%), body composition analysis showed that only the group III patients had body fat and protein stores that were significantly less than group I. The average deficit of body protein for the group II patients was, however, more than 20%. The combined data for the measurements of body protein and body fat in the two nutritionally depleted groups were significantly less than those for body protein (6.8 ± 0.5 kg *vs.* 8.8 ± 0.4 kg, $p < 0.001$) and body fat (13.7 ± 1.6 kg *vs.* 17.3 ± 1.2 kg, $p < .05$) in group I. The fact that there was no significant difference between the patient groups for predicted TBP and TBF indicates that there were no important differences between the groups before illness. The anthropometric measurements of body fat and MAMC confirm the three clinical categories in that groups II and III are significantly different from group I.

TABLE 1. *The Demographic Data and Surgical Diagnosis of the 3 Clinical Patient Categories*

Clinical Categories	Group I Weight Loss <10% Normal Function	Group II Weight Loss >10% Normal Function	Group III Weight Loss >10% Abnormal Function	Statistical Data
Number	43	17	42	
Sex	24:18	9:8	18:24	$\chi^2 = 2.06$ (NS)
Age (yr)	60 ± 2.4 —NS—	61 ± 3.3 — * —	69 ± 2.3	$F = 7.95$ ($p < 0.005$)
	└	*	┘	
Height (cm)	166 ± 1.5 —NS—	167 ± 1.9 —NS—	162 ± 1.2	$F = 3.01$ (NS)
	└	NS	┘	
Weight (kg)	69.5 ± 2.3 —NS—	62.3 ± 2.8 — * —	54.6 ± 1.5	$F = 14.54$ ($p < 0.0001$)
	└	†	┘	
Surgical diagnoses				
Malignant disease				
Esophagus	2	0	2	
Stomach	3	1	5	
Pancreas	1	0	6	$\chi^2 = 3.09$ (NS)
Small bowel	0	0	2	
Colon	14	8	11	$\chi^2 = 0.74$ (NS)
Rectum	4	3	6	
Benign disease				
Ulcerative colitis	5	0	1	$\chi^2 = 3.75$ (NS)
Crohn's disease	1	1	2	
Peptic ulcer disease	3	2	2	
Small bowel adhesions	1	1	1	
Gallstone ileus	0	0	1	
Afferent limb syndrome	0	0	1	
Chronic pancreatitis	0	0	2	
Choledochoduodenal fistula	1	0	0	$\chi^2 = 0.16$ (NS)
Familial polyposis	1	0	0	
Villous adenoma	2	0	0	
Diverticular disease	4	0	0	
Colonic polyp	0	1	0	

Values are given as mean ± SEM. * $p < 0.05$, † $p < 0.01$.

The objective tests of physiologic function are shown in Table 3. It is shown that nearly all the indices of liver, skeletal muscle, respiratory, and psychologic function were significantly less in group III patients, confirming that the clinical assessment and categorization of the patients in terms of clinical judgment of physiologic status has some validity.

The Postoperative Course

Table 4 shows that the patients in group III had a significantly higher incidence of major complications, septic complications, and pneumonia. Group III patients also had a longer postoperative hospital stay when compared to group II patients. The incidence of other complications shows a similar trend but does not reach the same level of statistical significance.

Discussion

Fifty years ago Studley suggested that weight loss was a basic indicator of surgical risk.[1] In modern surgical practice this appears to be only partly true since our results have demonstrated that clinically obvious physiologic impairment must be present as well. We have also shown, by sophisticated methodology, that at risk patients, identified through a careful history and examination, have in association with depleted stores of protein and fat, clear evidence of liver, skeletal muscle, and respiratory dysfunction as well as an increased perception of fatigue.

The fat and protein components of weight loss have been separately measured in this study. Preliminary work[23] had suggested to us that marked body protein loss was associated with an increased number of postoperative complications. There is probably a critical extent of body protein loss that must occur before decompensation of vital physiologic functions will result, and this may depend on such factors as the age and physical fitness of the patient, the disease, and the particular physiologic function involved. The category of patients (group III) who had significant physiologic impairment and a higher incidence of complications were signifi-

TABLE 2. *Objective Validation of the Nutritional Status of the 3 Clinical Patient Groups*

Clinical Categories	Group I Weight Loss <10% Normal Function	I vs II	Group II Weight Loss >10% Normal Function	II vs III	Group III Weight Loss >10% Abnormal Function	I vs III	Statistical Data
Weight loss (%)	3.9 ± 0.7	†	13.4 ± 2.4	NS	14.8 ± 1.1	†	$F = 25.73$ ($p < 0.0001$)
Body fat stores							
Anthropometric (kg)	18.3 ± 1.1	*	13.3 ± 1.3	NS	13.7 ± 0.9	†	$F = 6.09$ ($p < 0.005$)
Measured TBF (kg)	17.3 ± 1.2	NS	14.9 ± 1.9	NS	13.1 ± 1.2	NS	$F = 2.89$ (NS)
Predicted TBF (kg)	14.7 ± 0.6	NS	14.3 ± 1.0	NS	15.6 ± 0.5	NS	$F = 1.24$ (NS)
Fat index (%)	117 ± 11	NS	102 ± 26	NS	84 ± 16	*	$F = 3.65$ ($p < 0.05$)
Body protein stores							
MAMC (cm)	264.7 ± 6.1	*	236.3 ± 6.2	NS	223.0 ± 4.9	†	$F = 15.66$ ($p < 0.0001$)
Measured TBP (kg)	8.8 ± 0.4	NS	7.9 ± 0.9	*	6.4 ± 0.3	†	$F = 8.03$ ($p < 0.005$)
Predicted TBP (kg)	9.9 ± 0.4	NS	9.9 ± 0.5	NS	9.3 ± 0.3	NS	$F = 1.12$ (NS)
Protein Index (%)	88 ± 3	NS	78 ± 6	NS	68 ± 3	†	$F = 9.67$ ($p < 0.005$)
Fat Free Mass (kg)	51.4 ± 1.9	NS	47.8 ± 2.9	NS	41.3 ± 1.5	†	$F = 8.42$ ($p < 0.005$)

Values are given as mean ± SEM. * $p < 0.05$, † $p < 0.01$.

TABLE 3. *Objective Validation of the Functional Status of the 3 Clinical Patient Categories*

Clinical Categories	Group I Weight Loss <10% Normal Function	I vs II	Group II Weight Loss >10% Normal Function	II vs III	Group III Weight Loss >10% Abnormal Function	I vs III	Statistical Data
Liver function							
Transferrin (mg/100 mL)	263 ± 10	NS	247 ± 11	NS	216 ± 12	*	$F = 5.24$ ($p < 0.01$)
Prealbumin (mg/100 mL)	23.7 ± 1.3	NS	18.9 ± 1.5	*	13.8 ± 1.2	†	$F = 15.95$ ($p < 0.0001$)
Skeletal muscle function							
Grip strength (kg)	32.8 ± 1.8	NS	34.2 ± 1.9	*	22.9 ± 1.8	*	$F = 10.46$ ($p < 0.005$)
Grip strength/FFM (%)	65 ± 3.9	NS	70 ± 3	†	53 ± 3.3	*	$F = 5.56$ ($p < 0.01$)
Relaxation time (msec)	104.5 ± 2.6	NS	100.4 ± 2.8	*	116.4 ± 2.8	*	$F = 7.71$ ($p < 0.005$)
Respiratory function							
Respiratory muscle strength index (%)	106.9 ± 7.0	NS	98.1 ± 7.6	*	72.2 ± 8.6	*	$F = 3.67$ ($p < 0.05$)
FEV_1 (% predicted)	97.8 ± 3.3	NS	98.0 ± 5.7	NS	88.8 ± 5.3	NS	$F = 1.33$ (NS)
Vital capacity (% predicted)	108.8 ± 2.6	NS	108.7 ± 5.6	*	82.6 ± 3.6	†	$F = 6.35$ ($p < 0.005$)
FEV_1/VC (%)	75.9 ± 1.8	NS	78.3 ± 2.8	NS	73.8 ± 2.1	NS	$F = 0.81$ (NS)
PEFR (% predicted)	90.9 ± 2.5	NS	89.0 ± 4.9	*	75.2 ± 3.4	†	$F = 7.21$ ($p < 0.005$)
Maximum voluntary ventilation (% predicted)	81.1 ± 3.8	NS	84.4 ± 6.8	*	63.5 ± 4.3	†	$F = 5.66$ ($p < 0.01$)
Psychologic function							
POMS Fatigue score	5.8 ± 1.5	NS	7.5 ± 1.8	NS	9.8 ± 1.4	*	$H = 6.61$‡ ($p < 0.05$)

Values are given as mean ± SEM. * $p < 0.05$, † $p < 0.01$, ‡ Kruskal-Wallis statistic.

TABLE 4. *The Postoperative Course of the 3 Clinical Categories of Patients*

Clinical Categories	Group 1 Weight Loss <10% Normal Function	Group II Weight Loss >10% Normal Function	Group III Weight Loss >10% Abnormal Function	Statistical Data
Major complications	6	3	15	$\chi^2 = 5.98$ ($p < 0.05$)
Septic complications	8	4	18	$\chi^2 = 6.36$ ($p < 0.02$)
Pneumonia	4	1	10	$\chi^2 = 4.83$ ($p < 0.05$)
Wound infection	4	1	7	$\chi^2 = 1.79$ (NS)
Death	0	1	4	— (NS)
Hospital stay (d)	15.9 ± 1.3 —NS—	12.7 ± 2.5 —*—	19.2 ± 2.2 (Group 1 vs Group III: NS)	$F = 3.11$† ($p < 0.05$)

Values are given as mean ± SEM. * $p < 0.05$, † ANOVA.

cantly older, which suggests that such patients have less reserves of functioning body protein. This may account for the well-attested fact that older patients do not withstand major surgery as well as their younger counterparts.

In this study physiologic dysfunction was diagnosed only when weight loss of greater than 10% was also present. The effect on outcome of physiologic dysfunction in the patient group who had not lost this amount of weight might be considered. Only two patients in this category of 43 patients (group I) had significant physiologic dysfunction, and in both cases the dysfunction was related to chronic respiratory disease. One of these patients developed a postoperative pneumonia, while the other had an uneventful postoperative course.

Despite the large number of recommended nutritional assessment techniques (anthropometry, biochemistry, prognostic nutritional indices) that have appeared in the literature over the past 15 years,[24] no risk indicator has been shown to be superior to a careful clinical evaluation of the patient.[2,25] In an earlier study[2] we found that although a surgeon's assessment *from the end of the bed* was able to correctly identify only a small number of very high risk patients, a careful clinical assessment of medical risk, noting in particular cardiorespiratory disease and preexisting sepsis, as well as nutritional state, was as effective as any other currently used indicator of risk. It was suggested by us then that "something more than a global assessment by the operating surgeon is required to identify high risk patients."[2] In our present study we have gone one step further by formalizing a clinical assessment that includes a particular emphasis on the functional effects that are often seen in patients with a significant loss of body weight. This approach can identify a group of patients at high risk of postoperative complications. The skills required for such an assessment are no different than those taught to every student of medicine, and we have found that when the findings are carefully tabulated, interobserver agreement reaches 95% for all patient categories (unpublished observation).

In these times of escalating medical costs, preoperative nutritional repletion in hospital must be shown to be effective. Others have presented prospective data suggesting that a 10-day course of IVN given to all patients prior to major GI cancer surgery is of real benefit.[26] Our work suggests that this approach is excessive and wasteful. It would appear that only those patients who have impairment of important bodily functions in addition to significant loss of body weight should be considered for preoperative nutritional repletion. We, like others, have shown improvement in a number of important functional indices with a course of IVN,[27,28] further emphasizing the importance of body protein stores in maintaining normal body function.

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