STARVATION

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Introduction

The significance of starvation in clinical, forensic, or medicolegal terms depends upon the degree of malnutrition or metabolic derangements induced. These, in turn, depend upon the severity and duration of starvation and whether it is associated with exacerbating factors such as disease. In the developing world, starvation may be the primary factor responsible for malnutrition, although this increases susceptibility to infections and infestations, which are common in famine conditions. In the developed world, however, malnutrition is usually the consequence of diseases, which influence food intake, metabolism, or both. Indeed, using anthropometric criteria, between 10% and 40% of hospital admissions have been found to be undernourished and to suffer further nutritional deterioration during hospital stay, due mainly to underrecognition and undertreatment of the condition.

Malnutrition in the sense of undernutrition has been defined as: "a state of nutrition in which a deficiency or imbalance of energy, protein, and other nutrients causes measurable adverse effects on body composition and function, and on clinical outcome from disease." Clinically important malnutrition may also be defined in therapeutic terms as: "a sufficiently severe state of undernutrition that measurable improvements in function and clinical outcome result from nutritional intervention by natural or artificial means."

We are well adapted to cope with short periods of fasting, but, after a few days without food, and with loss of 5% of body weight, there are detectable impairments of mental and physical function. These changes assume major clinical importance after 10–15% weight loss, by which time, in clinical practice, nutritional intervention should have been undertaken. More than 35% weight loss is life-threatening. These considerations assume a normal premorbid weight, and are not applicable to the controlled and gradual weight loss in obese individuals, eating a diet reduced in energy but adequate in protein and other nutrients, which allows a preferential loss of adipose tissue, with only a modest reduction in lean mass, particularly when combined with an exercise program. Although 2–3 months' total starvation is usually fatal in individuals of previously normal weight, obese subjects can survive for much longer periods due to their greater energy reserves. Conversely, thin individuals, who start with lower reserves, survive for less time. Smaller body stores in childhood mean that, while a normal adult may survive 70 days of starvation, a full-term baby can only survive 32 days, and a premature infant only 5 days. While total starvation is obvious, partial starvation may be less so, immediately, unless actual intake is measured and compared with estimated needs.

Normal Nutritional Requirements

Energy

To maintain body composition at a stable level energy intake, in the form of carbohydrate ($4\,\text{kcal}\,\text{g}^{-1}$), fat ($9\,\text{kcal}\,\text{g}^{-1}$), and protein ($4\,\text{kcal}\,\text{g}^{-1}$), needs to equal energy expenditure. Total energy expenditure (TEE) is the sum of resting energy expenditure (REE), required to maintain the body at rest ($20–25\,\text{kcal}\,\text{g}^{-1}$ body weight), plus the additional expenditure from physical activity (usually 50–70% of REE) and diet-induced thermogenesis (10% of REE). Adipose tissue has a relatively low metabolic rate, so that REE depends mainly upon the size of the lean mass, which is lower in women, and reduces by up to 50% between the ages of 30 and 78 years.

These considerations mean that, to maintain energy balance, most normally active and normal-weight young to middle-aged adults need to ingest between 2000 and $3000\,\text{kcal}\,\text{day}^{-1}$, or $1.5–1.8 \times \text{REE}$, depending on age, lean body mass, and activity. Those participating in prolonged and intense exertion, such as the Tour de France cycle race, or hauling a sledge across the Antarctic, need to consume 6000–8000 $\text{kcal}\,\text{day}^{-1}$ to maintain body composition.

Protein

To maintain the mass and function of lean tissue, including the major organs, requires not only fulfillment of energy needs, but a minimum daily protein intake of $0.8\,\text{g}\,\text{kg}^{-1}$ body weight, although, in the presence of disease, this requirement may rise to $1\,\text{g}\,\text{kg}^{-1}$ body weight or more. Weight loss due to a combination of protein and energy deficiency is known as protein–energy malnutrition.

Other Nutrients

Normal tissue function also depends on an adequate intake of water, electrolytes, minerals, trace elements, and vitamins. Specific nutrient deficiencies, e.g., for individual vitamins, may occur in isolation or as multiple deficiencies, often associated with concomitant protein–energy malnutrition. The characteristics of such deficiency states are beyond the scope of this article, which will focus mainly upon global malnutrition secondary to total or partial starvation.

Disease-Associated Malnutrition

Acute or chronic disease exacerbates the problem of starvation, by increasing metabolic requirements and diminishing appetite or the capacity to swallow and digest food, so-called "disease-associated malnutrition." Figure 1 shows the rates of weight loss, with time, in three different circumstances. The first, more gradual slope is derived from the studies of Keys and coworkers on normal young male volunteers who underwent semistarvation for a period of 24 weeks. The second, steeper slope describes the weight changes in the Irish Republican Army (IRA) hunger strikers who subjected themselves to total starvation for 70 days, by which time they had lost 38% of their body weight, and one-third had died from malnutrition. The third and steepest slope defines the effect of starvation combined with critical illness, when the time taken to reach a functionally significant or fatal weight loss may be halved.

Degrees of Starvation

Fasting up to 72 h

This induces physiological adaptations designed to conserve protein, and hence the mass and function of essential tissues and organs, while mobilizing reserves of fat. REE, after an initial rise, falls by 10%. Initially glucose is released from liver glycogen,

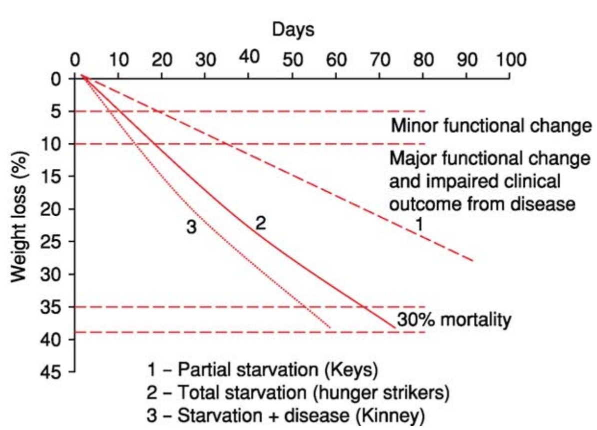

Figure 1 Percentage weight loss during semistarvation, total starvation, and disease-associated starvation. Reproduced from Allison SP (1992) The uses and limitations of nutritional support. *Clinical Nutrition* 11: 319–330. © 1992. With permission from Elsevier.

but thereafter, essential glucose is provided by new glucose derived from conversion of protein, lactate, and glycerol (gluconeogenesis). The brain, which normally derives its energy from glucose, adapts to metabolize ketones from liver fat metabolism, thereby reducing the necessity to convert protein to glucose. With longer periods of starvation metabolic rate falls further, *pari passu* with loss of lean mass. These adaptive mechanisms are overridden in the presence of acute illness or injury, which is characterized by increased metabolic rate and protein catabolism.

Such short periods of starvation result in less than 5% reduction in body weight, but identifiable, if small, reductions in function. Vasoconstriction to conserve heat is reduced, thereby impairing heat conservation in the body, an important consideration in cold environments. Mild sensations of cold, irritability, and loss of energy may be experienced. Reduced glycogen stores in liver and muscle also impair athletic performance. Short periods of starvation have also been shown to be important in patients undergoing surgery, in whom avoidance of starvation for more than 2 h preoperatively, and for more than a few hours postoperatively, has been shown to improve outcome and the rate of recovery from operation.

Partial or Complete Starvation >5 days with 5% Weight Loss

This results not only in the adaptive responses described above, but also in further impairment of mental and physical function. Individuals react by reducing their physical activity and hence TEE. Mood and muscle strength also deteriorate. If, however, sufficient food is reintroduced to maintain weight at its new level, the individual adapts to the new lower weight and function returns. However, if food intake continues to be inadequate, resulting in further weight loss, then clinically important reductions in function become apparent. It has been recommended by both American and European authorities that surgical patients should not be allowed to starve for more than 7 days postoperatively without feeding by natural or artificial means.

Starvation >7 days and Weight Loss >10%

With this degree of malnutrition or greater, a number of significant functional changes occur. Some of these are illustrated in Figures 2 and 3, taken from the studies of Keys and coworkers on young male volunteers who underwent 24 weeks of semistarvation, followed by a further 24 weeks of controlled refeeding. Expressing changes in body composition (Figure 2) and changes in function (Figure 3) as a percentage of their starting value, it can be seen that

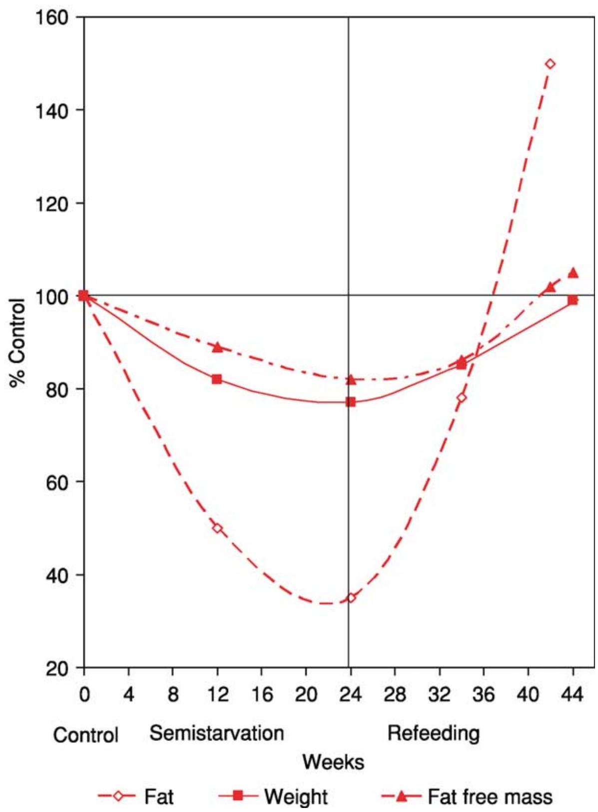

Figure 2 Body compositional changes (% starting value) in 12 male volunteers during 24 weeks of semistarvation, followed by 24 weeks of controlled refeeding. Adapted from the data of Keys *et al.* (1950) by Allison SP (1992) The uses and limitations of nutritional support. *Clinical Nutrition* 11: 319–330. © 1992. With permission of Elsevier.

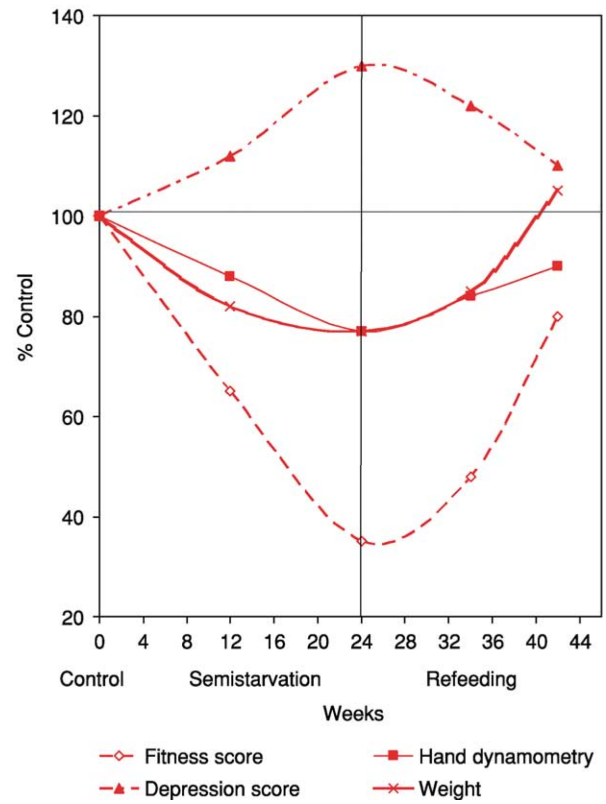

Figure 3 Changes (% starting value) in weight, depression score, hand muscle strength, and fitness score in 12 male volunteers during 24 weeks of semistarvation followed by 24 weeks of controlled refeeding. Adapted from the data of Keys *et al.* (1950) by Allison SP (1992) The uses and limitations of nutritional support. *Clinical Nutrition* 11: 319–330. © 1992. With permission of Elsevier.

there is a progressive deterioration in mental and physical function as semistarvation continues and tissue is lost. With refeeding, restoration of fat mass is faster than that of lean mass, and there is a correspondingly slow return of mental and physical function over many weeks. A large amount of detailed data have accrued in the literature concerning functional change due to starvation.

Growth and Development

In children, growth and development are retarded, with reduced height for age (stunting) and weight for height (wasting), compared with normal values for the population. Growth velocity also slows compared with premorbid values. Puberty and normal sexual development are delayed and bone age is retarded. Intellectual and cognitive attainment may also be permanently affected by prolonged infant malnutrition. Malnutrition during fetal and neonatal life, paradoxically, also predisposes to chronic diseases in later life such as obesity, diabetes, heart disease, and stroke.

Muscle Function

Muscle strength diminishes progressively, not only through reduced mass but also through metabolic effects, independent of change in mass. These changes affect particularly the type 2 muscle fibers prevalent in the diaphragm, so that respiratory capacity is impaired, causing reduced exercise tolerance and increasing the risk of respiratory complications of illness or surgery.

Immune Function

Lymphocyte count, white cell function, and immune responses are reduced, predisposing to invasive infection.

Wound Healing

This appears to be particularly sensitive to recent food intake. A combination of previous weight loss and inadequate food intake, therefore, renders patients vulnerable to failure of wound healing, as well as to other complications of surgery. Malnutrition is also a risk factor for pressure sores in the elderly and impairs their healing.

Thermoregulation

Starvation for more than 48 h reduces heat conservation by cutaneous vasoconstriction. Severe weight loss also impairs the increase in metabolic rate due to a cold stimulus. Both these physiological defense mechanisms to maintain normal body core temperature are therefore reduced in thin, undernourished individuals, rendering them prone to hypothermia in a cold environment. Since a reduction in core temperature of as little as 1–2 °C reduces coordination, cognitive function, and muscle strength, such individuals are prone to injury and death in cold conditions. In the studies of severe malnutrition, with weight loss in excess of 30%, carried out by Jewish physicians in the Warsaw ghetto in 1942, low body temperatures were noted, as well as the lack of fever in response to intercurrent infections with typhoid, tuberculosis, and pneumonia.

Gastrointestinal Function

With very low levels of body weight secondary to malnutrition, pancreatic enzyme secretion is impaired and the small-bowel mucosa may show atrophic changes. Gastric acid secretion is also blunted. In severe famines, diarrhea is also a feature, exacerbated by too-rapid refeeding, which may cause fatal fluid and electrolyte imbalance.

Cardiovascular System

Malnutrition results in loss of cardiac muscle and impaired cardiovascular reserve. Bradycardia, hypotension, a 45% reduction in cardiac output, and electrocardiographic abnormalities, including prolongation of QT interval, were observed in the semistarvation studies conducted by Keys and coworkers. Similar changes have been described in other studies, with weight loss ranging from 15% to 30%. These changes also pose risks for refeeding with its sudden increase in metabolic demand, reloading with salt and water, and falls in serum potassium, phosphate, and magnesium concentrations (refeeding syndrome). Heart failure, and even death, may be precipitated by aggressive and rapid feeding of such individuals.

Endocrine Function

With progressive starvation alone, insulin levels fall, allowing lipolysis, ketosis, and the primary use of fat as fuel. Sympathoadrenal activity is also reduced. These changes are overridden by injury, which is characterized by high insulin levels with insulin resistance, and high levels of the catabolic hormones, catecholamines, glucogen, and cortisol, explaining at least in part the overriding of the adaptive response to starvation by the catabolic response to injury. Gonadotropin and sex hormone (testosterone and estrogen) levels fall. Menstruation ceases below a body mass index (BMI) of 17, in anorectic girls, and resumes as BMI is restored above this level.

Fluid and Electrolytes

The study of Keys and coworkers showed that, as lean and fat mass decrease during starvation, the extracellular fluid volume shrinks more slowly and actually increases as a percentage of body weight. This is associated with a decreased capacity to excrete a salt and water load, a phenomenon that is further exacerbated by the response to injury and disease. Such starved individuals may therefore suffer from "famine edema," depending on their intake of salt and water. Too-rapid refeeding may worsen edema and cause death from pulmonary edema.

Clinical Outcome and Treatment

Mortality and morbidity rates from prolonged starvation, with or without injury, disease, or surgery, are increased in proportion to the degree of undernutrition. In those who survive, convalescence and rehabilitation are prolonged and quality of life is reduced. Early identification of nutritional risk and appropriate nutritional support by natural or artificial means improves function, even before any regain of lean mass, reflecting the immediate impact of nutrition on cell and tissue function. Appropriate feeding of the sick also reduces complications and mortality, and shortens rehabilitation and length of hospital stay. In a review of 166 controlled trials (7630 patients) of oral food supplements in addition to normal food, there was an average reduction in mortality of 24%, with the greatest reduction among those who were underweight ($BMI < 20\,kg\,m^{-2}$); complications were reduced from 45% to 21%; length of hospital stay was reduced by 13 days, with financial savings of between £352 and £179 per patient. A review of 121 trials (4090 patients) of artificial tube feeding by the enteral route showed mortality reduction from 23% to 11%, with complications (particularly infections) reduced from 48% to 33%. Artificial feeding by the intravenous (parenteral) route may be life-saving in conditions causing prolonged gastrointestinal failure. All artificial feeding techniques, by the enteral or parenteral route, have their own inherent risks in inexpert hands and in each case these risks must be weighed against the potential benefits of treatment. In expert hands, however (and most major hospitals should have an expert team), the risks are low. Excessive complication rates resulting from techniques of nutritional support reflect upon the standard of care provided and raise questions concerning the competence of the institution concerned to provide such care. There is sufficient evidence to support the view that failure to detect nutritional risk and to treat accordingly (subject to ethical and clinical considerations) constitutes substandard medical management. In terminal cancer and late-stage Alzheimer disease, for example, the risks of treatment usually outweigh the likely benefits. In many other medical and surgical conditions, however, nutritional support is highly beneficial. It is axiomatic that appropriate nutritional treatment (as with any other form of treatment) cannot be given unless the problem is first identified and defined.

Detection of Nutritional Risk

In community and hospital medical practice, rapid screening followed by more detailed assessment of patients found to be at risk should be part of routine protocols. These techniques have also been used in public health surveys and under famine conditions.

Nutrition Screening

Height, weight, and body mass index Height (or length in infants) and weight have long been used by pediatricians to plot serial changes in weight for age, weight for height, and growth velocity, all of which are very sensitive to the adequacy of nutritional intake. In adults, the BMI (weight in kilograms divided by height in meters squared) is the most commonly used measure of an individual's current nutritional status. In assessing BMI, racial characteristics should be taken into account. There are many thin but perfectly healthy individuals in India, for example, although with diminished reserves in the face of disease or sudden famine. The figures in Table 1 apply to a UK population.

Table 1 Body mass index correlated with risk level for a UK population

Body mass index	*Risk level*
<11 (men)	High risk of death
<10 (women)	High risk of death
<18.5	Undernourished (increased risks, decreased function)
18.5–20	Possibly undernourished
20–26	Normal range
30–40	Obese
>40	Morbidly obese

Current weight should be compared with remembered weight. An involuntary weight loss of >5% over 3 months due to illness is regarded as significant, and >10% definitely so.

Food intake and disease severity Enquiry should be made concerning any recent decrease in food intake, whether due to lack of availability or secondary to disease.

These simple measurements may be combined in a simple scoring system, which has been validated to detect nutritional risk and the need for intervention. Those found to be at risk may need more detailed assessment before an appropriate plan can be developed and a clinical decision made as to the most appropriate method and route of administration.

More Detailed Assessment

Anthropometric measurements, such as mid upper-arm circumference (MAC) and triceps skin fold (TSF) thickness, are not only surrogates for weight when compared with reference tables for age and sex, but also give a measure of body composition or the proportions of residual fat and muscle.

Functional assessment can be obtained from a history of mental and physical performance and observation during simple physical tasks, such as rising from a chair or climbing stairs. Current appetite and the ability to chew, swallow, and digest food will determine which route and method of feeding are most appropriate. A number of simple tests are useful in clinical practice: hand dynamometry for muscle strength; expiratory flow for respiratory function; mood score and cognitive tests for mental function; food intake can also be assessed formally by 5–7-day food diaries or by a recording observer; and disease severity and likely impact of this on subsequent nutritional status should be recorded.

Metabolic rate and nutritional requirements can be calculated from standard formulae or tables based on age, sex, weight, and height. Allowances can then be made for activity and the catabolic effects of disease.

Laboratory tests include hematological tests for anemia secondary to deficiency of iron, folate or vitamin B_{12}, or to disease. Lymphocyte count may be reduced in undernutrition. Biochemical tests include serum albumin, which reflects inflammation and dilution with fluid rather than protein deficiency; levels of minerals, e.g., calcium, magnesium, and zinc, and, in some cases, levels of vitamins and micronutrients, although most of these are only available in specialist laboratories. Blood and urine urea values reflect protein turnover, as well as renal function, and are reduced in starvation. Blood and urinary creatinine levels are not only tests of renal function but are proportional to muscle mass and are low in malnutrition.

Autopsy Findings

The reports of autopsies carried out in the Warsaw ghetto provide graphic accounts of the pathological changes in extreme starvation, with >30% weight loss. Length, weight, and BMI should always be reported in those dying from or with malnutrition. Calculation of BMI will, of course, be affected by the elements of edema or dehydration, which should be noted. The body appears cachectic with loss of subcutaneous fat and atrophy of muscle. The epidermis is thin with increased cornification and pigmentation due to melanin with, in severe cases, pressure sores. Dependent edema may also be present, with effusions into the pericardial, pleural, and peritoneal cavities. The organs, apart from the brain, appear atrophic. The heart weight is decreased, with brown atrophy. The spleen, liver, and kidneys may also be atrophied. The adrenals, though of normal size, have a narrow cortex. The lungs often show features of terminal bronchopneumonia. It is easy to overlook the features of malnutrition in ascribing death to the agonal event, which may be bronchopneumonia, intestinal infection, or heart failure, secondary to starvation and weight loss.

Ethical and Legal Aspects of Difficult Clinical Problems Involving Feeding

These have been reviewed in detail by Lennard-Jones in a report for the British Association for Parenteral and Enteral Nutrition, and can only be summarized briefly here.

All clinical decision-making, including the provision of adequate amounts of food and drink, is governed by ethical and legal as well as clinical considerations. The ethical principles of autonomy (patient decides), beneficence (does treatment benefit the patient?), nonmalfeasance (do no harm), and justice (equal treatment for all), are well known and have already been mentioned in relation to nutritional support in a number of clinical circumstances. These principles also underlie the law under which doctors and other carers practice. The highest judicial authorities in the USA and UK have ruled that, whereas normal feeding and drinking by mouth are parts of basic care, artificial feeding by tube into the gastrointestinal tract or into a vein is medical treatment and should be governed by the same sort of considerations as other medical treatments. Additionally, in ethics and in law, there is no difference in principle between deciding not to start treatment or to withdraw it. The patient is entitled to refuse food and drink, and this must be respected unless he/she is legally incompetent to decide or is suffering from a psychiatric condition, e.g., anorexia nervosa, within the meaning of the Mental Health Act. One may contrast the voluntary action of political hunger strikers, in whom no attempt was made at artificial feeding, with the tube feeding of a murderer undergoing a life sentence. The latter was fed, not because he was on hunger strike, but because he was deemed to be suffering from a psychiatric illness.

In general, although carers are obliged by the law concerning duty of care, and also under the European Law on Human Rights, to offer food and drink and to do their best to help patients to consume it, they are not obliged to force-feed or to give artificial feeding where consequent suffering or harm exceeds any likely benefit. Such decisions are sensitive and should only be taken after careful consultation with all those involved, although at present, in the UK, relatives or a nominated proxy cannot make a decision on behalf of an adult patient. The situation with minors is different. A legal judgment has been quoted by Ashby and Stofell that expresses this concept of the role and limitation of medicine: "Medical science and technology has advanced for a fundamental purpose: the purpose of benefiting the life and health of those who turn to medicine to be healed. It surely was never intended that it be used to prolong biological life in patients bereft of the prospect of returning to an even limited exercise of human life."

Although there are some situations, e.g., stroke, where it is appropriate to undertake a therapeutic trial of artificial feeding for an agreed period, followed by withdrawal if the treatment appears futile or harmful, there are other, more difficult circumstances in which the patient is incompetent to decide for him/herself and where the help of the courts may need to be sought. The classic example, following the Bland case in the UK, is that of severe brain damage, causing a persistent vegetative state, in which the highest legal authorities gave permission for withdrawal of tube feeding if, in the doctors' opinion, "it was in the patient's best interests."

Assessment of whether the care of any individual, in respect of food and fluid, falls below acceptable standards, is unethical or unlawful, or is negligent, requires very careful consideration of all the facts and circumstances, and whether intervention would have been beneficial, futile, harmful, ethical, or lawful. Important forensic considerations, particularly in the case of a young child or elderly and infirm person, are whether the individual was intentionally starved of food or was neglected by those with a legal duty of care. Starvation may also be a consequence of accidental entrapment, e.g., in tunnels, or kidnapping and unlawful imprisonment. In these conditions, death may occur early from dehydration or hypothermia before significant malnutrition can develop. The course of starvation in these situations may be contrasted with the slow deterioration seen in the long course of deliberate self-starvation for political ends, in which fluid intake is usually adequate, and in which survival of up to 3 months is possible, or even longer in those who were initially overweight.

It should be remembered that the dying process from old age or from disease is associated with decreased appetite and thirst. Suffering should not be increased by well-meaning attempts to press unwanted nourishment during the final phase of life.

See Also

Consent: Treatment Without Consent; **Medical Malpractice:** Nursing Issues

Further Reading

Airedale NHS Trust *v.* Bland: Judgements of Family Division, Court of Appeal (Civil Division) and House of Lords (1993) In: Fennell P, Harpwood V, Hohnson H, Ngwena C (eds.) *Butterworth Medico-Legal Reports* vol. 12, pp. 64–143.

Allison SP (1997) Impaired thermoregulation in malnutrition. In: Kinney JHM, Tucker HN (eds.) *Physiology, Stress and Malnutrition. Functional Correlates, Nutritional Intervention,* pp. 571–593. Philadelphia, PA: Lippincott-Raven.

Ashby M, Stofell (1995) Artificial hydration and alimentation at the end of life: a reply to Craig. *Journal of Medical Ethics* 21: 135–140.

Bursztein S, Elwyn DH, Askanazi J, Kinney JM (1989) *Energy Metabolism, Indirect Calorimetry, and Nutrition.* Baltimore, MD: Williams and Wilkins.

Elia M (1997) Tissue distribution and energetics in weight loss and undernutrition. In: Kinney JM, Tucker HN (eds.) *Physiology, Stress and Malnutrition. Functional Correlates Nutritional Intervention,* pp. 383–412. New York: Raven Press.

Elia M, Lunn PG (1996) Biological markers of protein-energy malnutrition. *Clinical Nutrition* 16: 1–46.

Gibson RS (1990) *Principles of Nutritional Assessment.* New York: Oxford Univeristy Press.

Gillick M (2000) Rethinking the role of tube feeding in patients with advanced dementia. *New England Journal of Medicine* 342: 206–210.

Hill GL (1992) *Disorders of Nutrition and Metabolism in Clinical Surgery.* Edinburgh, UK: Churchill Livingstone.

James WPT, Ferro-Luzzi A, Waterlow JC (1988) Definition of chronic energy deficiency in adults. *European Journal of Clinical Nutrition* 42: 969–981.

Lennard-Jones JE (1998) *Ethical and Legal Aspects of Clinical Hydration and Nutritional Support.* Maidenhead, UK: British Association for Parenteral and Enteral Nutrition.

Morgan JB, Dickerson JWT (eds.) (2003) *Nutrition in Early Life.* Chichester, UK: Wiley.

Paris JJ (1993) Ethical issues in withholding or withdrawal of nutrition and fluids. *Clinical Nutrition* 12(suppl.): S12–S15.

Payne-James J, Grimble G, Silk DBA (eds.) (2001) *Artificial Nutrition Support in Clinical Practice.* London: Greenwich Medical Media.

Rosenberg IH, Sastre A (eds.) (2002) *Nutrition and Aging. Nestlé Nutrition Workshop Series, Clinical and Performance Program*, vol. 6. Basel, Switzerland: Karger.

Royal College of Physicians Report (2002) *Nutrition and Medicine: a Doctor's Responsibility.* London: Royal College of Physicians.

Shils ME, Olson JA, Shike M, Ross AC (eds.) (1999) *Modern Nutrition in Health and Disease,* 9th edn. Philadelphia, PA: Lippincott/Williams and Wilkins.

Stratton RJ, Green CJ, Elia M (2003) *Disease-Related Malnutrition: An Evidence-Based Approach to Treatment.* Wallingford, UK: CABI Publishing.

Tanner JM, Whitehouse RH, Takaishi M (1965) Standards from birth to maturity for height, weight, height velocity and weight velocity: British children. *Archives of Diseases in Childhood* 41: 613–635.