THE ROLE OF NUTRITION IN TISSUE VIABILITY

Nutrition plays a vital role in the prevention and treatment of wounds and ulcers. This article outlines the role of nutrition in the prevention of wounds and the function of key nutrients in tissue viability. It describes how malnutrition can impair the healing process. Practical advice is provided enabling healthcare workers to assess and manage malnutrition in this complex patient group.

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Nutrition plays a vital role in the prevention and treatment of wounds and ulcers (Thompson and Furhrman, 2005; *Figure 1*). Con-suming a healthy balanced diet and maintaining a suitable weight can reduce the risk of developing several conditions that predispose an individual to wounds and ulcers (Astrup, 2001) and encourages healing in patients with existing wounds.

Being overweight or obese is the result of excess calories and fat in the diet, combined with a lack of physical activity (World Health Organization [WHO], 1998). These factors increase the risk of developing high blood pressure (hypertension) and lipid (fat) levels (hyperlipidaemia), which may lead to the development of peripheral vascular disease (PVD) and potentially, arterial leg ulcers (Casey, 2004). Obesity also increases the risk of venous hypertension and venous leg ulcers (Rijswijk, 1993).

Diabetes (unstable blood sugar levels caused by a deficiency of, or resistance to, the hormone insulin) is rapidly on the increase in the UK, resulting from raised levels of obesity and increasingly sedentary lifestyles. The complications of diabetes include PVD, neuropathy (disease of the nervous system) and lower limb ulceration, which may lead to the need for surgical amputation (Diabetes Control and Complications Research Group [DCCRG], 1993; American Dietetic Association [ADA], 2002).

It is worth remembering that individuals who are of normal weight or even underweight, and whom consume an imbalanced diet and/or lead sedentary lifestyles, are also at risk of hypertension and dyslipidaemia.

It is the role of healthcare professionals to promote a healthy lifestyle that includes eating a

Figure 1. Robust granulation tissue appears in a sacral pressure ulcer once the nutritional needs of the patient are met.

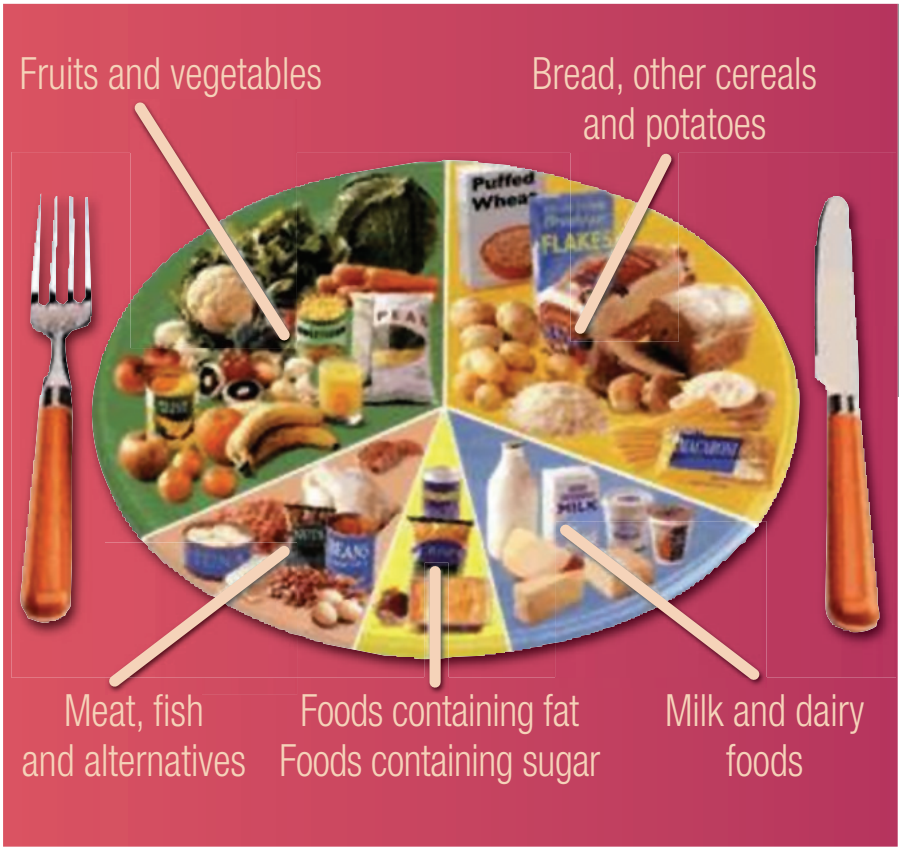

Figure 2. The Plate Model illustrates healthy eating by recommending appropriate amounts from each of five food groups (FSA, 2002).

healthy, varied diet, high in fibre, low in salt, refined carbohydrate and fat (especially saturated and trans fat). A healthy diet should include five portions of fruit and vegetables daily. Individuals should be encouraged to consume an appropriate level of alcohol. Men are advised to drink no more than 3–4 units of alcohol daily and women no more than 2–3 (Food Standards Agency [FSA], 2002; *Figure 2*; *Table 1*).

Encouraging regular, physical activity of moderate intensity is part of the healthcare professional's role in the prevention of disease (Pate et al, 1995). Exercise will be discussed later in this text.

Nutritional status has a direct influence on the health of body tissue and its repair in the event of damage. Wound healing is a complex process, which can be further complicated by chronic illness. Poor nutritional status can lead to impaired wound healing and increased risk of infection (Casey, 1998). Malnutrition is potentially reversible. It is paramount that it is identified and addressed early (Elia, 2003).

However, nutritional status is only one of a range of issues that need to be addressed to promote wound healing. A holistic approach to wound prevention and care must be employed, with adequate attention given to skin care, pain control, wound dressings, management of infection and quality of life. This management requires a multidisciplinary approach and effective communication between all healthcare workers involved.

Nutrition and the prevention of wounds

Weight management

Being overweight or obese is increasingly prevalent and has reached epidemic levels in industrialised countries (epidemic levels of obesity are defined as affecting one in five adults). In Northern Ireland, approximately half the population is overweight or obese (McCarthy et al, 2001). Body mass index (BMI) is the recognised means of assessing body weight in comparison to height (*Table 2*). A BMI figure is obtained by dividng weight in kilogram by height in metres squared (WHO, 1998). Normally healthcare facilities have BMI charts. There is often no need to use any calculations; the healthcare practitioner simply reads the result from a chart.

As mentioned earlier, obesity increases the risk of developing the following conditions which relate to tissue viability: cellulitis, venous hypertension, PVD, deep vein thrombosis (DVT), wound infections, wound dehiscence and haematoma (Perkins, 1992; Wipke-Tevis and Stotts, 1996; Armstrong, 1998; Thompson, 2003; Wilson and Clark, 2004). In addition, obesity can increase the risk of developing a pressure ulcer. The low density of blood vessels in fat tissue leads to compromised circulation. Obesity can also limit mobility, and these factors, together with the added pressure of extra weight, can lead to pressure damage (Brown, 2004).

As with most medical conditions, prevention is better than cure. Following a healthy balanced diet,

Table 1

Summary of healthy eating

Fruit and vegetables (at least five portions a day):	Fresh, frozen, tinned, dried and juice. An example of one portion is: two small fruits (e.g. plums or mandarins) one medium fruit (e.g. pear or apple) one small glass of pure fruit juice three heaped tablespoons of vegetables
Bread, pasta, rice, other cereals, potatoes (number of portions depends on activity level):	Try to base meals on these foods. They are also good for snacks. Choose wholegrain varieties
Milk and milk products (most people should consume three portions a day):	An example of one portion is: 200ml of milk 125g pot yoghurt 30g cheese Choose reduced fat varieties where possible
Meat, fish and alternatives (2–3 portions a day):	Eat moderate amounts of these foods, e.g. red meat, chicken, fish, eggs and pulses. Aim to eat fish twice weekly, one portion of which should be oily (e.g. sardines, salmon or mackerel). Choose lean meat, trim off visible fat, avoid adding extra fat when cooking
Foods containing large amounts of fat and/or sugar:	Limit these foods, e.g. butter, other spreading fats and cooking oils, cream, chocolate, biscuits, crisps, chips, sugary drinks, sweets
Alcohol:	Recommended safe limits: MEN up to 3–4 units a day WOMEN up to 2–3 units a day

Table 2

WHO classification of obesity; BMI

<18.5	Underweight
18.5–24.9	Healthy weight
25–29.9	Pre-obese (overweight)
30–34.9	Moderately obese
35–39.9	Severely obese
>40	Morbidly obese

BMI=body mass index (WHO, 1998)

as illustrated by the Plate Model (FSA, 2002) shown in *Figure 2*, and taking regular physical activity enable the individual to maintain a healthy weight. It is also important to keep within recommended guidelines for alcohol intake (*Table 1*) (Astrup, 2001; Thomas, 2001).

Risk factors for peripheral vascular disease

Abnormal lipid levels and hypertension increase the risk of PVD. Eating a balanced diet can prevent obesity and reduce the risk of developing dyslipidaemia (a disruption in the amount of lipids in the blood) and hypertension (*Table 3*) (Sacks, 2001; Hooper et al, 2003).

Dietary guidelines for prevention/treatment of dyslipidaemia

The following guidelines follow the principles of general healthy eating as discussed earlier, but also pay particular attention to the amount and different types of fat in the diet. The aim is to keep saturated and trans-fat intake to a minimum. Saturated fat is found in animal fats like butter, cream, fatty meats and cheese as well as pastries, cakes and crisps. Trans-fats are found in many processed foods and in foods that have been deep fried in oil. The trans- and saturated fat in the diet should be replaced partly by polyunsaturated and monounsaturated fats and by carbohydrate sources.

Polyunsaturated fats that are found in sunflower, soya and safflower oil can be eaten in moderation because of their beneficial effects on blood lipids (Hooper et al, 2003). Monounsaturated fats found in olive and rapeseed oil can also be enjoyed in moderation. Omega 3 oils, found mainly in oily fish such as salmon, mackerel, trout and sardines, have many benefits to health including improved blood circulation (Hooper et al, 2003). Omega 3 oils should be eaten at least once a week, depending on the individual's circumstances (Thomas, 2001; Hooper et al, 2003).

Dietary guidelines for the prevention/treatment of hypertension

Once again, general healthy eating guidelines apply (*Table 1*), with the additional focus of reducing salt intake — the aim being to consume less than 6g of salt daily (Sacks, 2001). Salt should not be taken at the table, only a pinch used in cooking if necessary and high salt foods should be avoided. If a food has 1.25g of salt (0.5g sodium) or more per 100g, it is high in salt and, conversely, if it

Table 3

Target blood lipid levels

Blood lipid	Target level
Total cholesterol	< 5 mmol/l
LDL cholesterol	<3 mmol/l
HDL cholesterol	>1 mmol/l
Triglyceride	< 2 mmol/l

Ratio total cholesterol/HDL cholesterol = < 5

LDL = low density lipoprotein

HDL = high density lipoprotein

Source: Todorovic and Mickleright, 2000

has 0.25g salt (0.1g sodium) or less per 100g it is low in salt (FSA, 2002). Herbs, spices, mustard, pepper, vinegar, garlic, lemon juice, etc can be used instead to flavour food. Salt substitutes are not recommended.

Diabetes

Strict blood glucose control (HbA_{1c}<7%) and blood pressure control can significantly help to reduce the microvascular and macrovascular complications of diabetes. Complications include PVD (Franz et al, 2002). Control of the diet plays a central role in controlling blood glucose. A registered dietitian should regularly review all patients with diabetes (Diabetes and Nutrition Study Group of the European Association for the Study of Diabetes [EASD], 2000).

Physical activity

Most of the health benefits of physical activity can be gained from about 30 minutes of moderate intensity activity most days of the week (Dunn et al, 1999). During moderate intensity activity, breathing and heart rate should increase and the body should become warmer. However, the individual should still be able to carry on a conversation. Brisk walking is an example of a moderate intensity activity.

Regular physical activity has numerous health benefits which, in turn, contribute to tissue integrity, for example, it aids weight reduction and blood sugar control, the lowering of blood pressure and lipid levels, reduces venous hypertension and improves tissue perfusion (Pate et al, 1995; Lee et al, 1999; Wissing and Unosson, 1999).

Physical activity also has psychosocial benefits including improved sleep and reduced stress levels. Encouraging physical activity is not always appropriate due to potential detrimental effects, e.g. if a patient has unstable angina (angina that occurs when no physical activity is being undertaken). Chair-based physical activity may be a practical alternative for patients who have limited mobility.

Nutrition and the treatment of wounds

When a wound develops, each stage of the healing process will require a range of nutrients in the correct quantity to prevent healing being retarded (Gray and Cooper, 2001; Thompson and Furham, 2005). *Table 4* outlines the phases of wound healing and the key nutrients necessary (*Table 5*).

Antioxidants

The removal of necrotic tissue and the inactivation of bacteria that occurs in the inflammatory stage of wound healing results in the production of high levels of free radicals (reactive, unstable molecules that can damage healthy tissue) (Todorovic, 2003). Antioxidants scavenge free radicals and neutralise them, rendering them harmless to the regenerating tissue. The following nutrients are antioxidants: vitamins A, C and E and selenium.

Nutrition and chronic wounds

So far in this article, the main focus has been on how wounds and ulcers can be prevented by eating

Table 4

Summary of the phases of wound healing and the key nutrients involved

Haemostasis: Vasoconstriction leading to reduction of blood flow. Bleeding controlled. Coagulation	Energy (see *Table 5*), protein, vitamin K
Inflammation: White blood cells and macrophages remove bacteria and necrotic (dead) tissue. Collagen synthesis initiated	Energy, protein, vitamins A, C, E, selenium, antioxidants
Proliferation: New tissue and blood vessels grow. Fibroblasts produce collagen	Energy (see *Table 5*), protein, copper, iron, vitamin A, vitamin B6, zinc, vitamin C
Remodelling: Continued collagen cross-linking increases wound tensile strength. Wound closure and contraction. Maturation of fibrous scar tissue	Energy (see *Table 5*), protein, zinc, vitamin C, iron

Table 5

Role of key nutrients in tissue viability and wound healing

Nutrient	Function	Key facts	Dietary sources
Fat	Important energy source, component of cell membranes, involved in formation of inflammatory mediators and clotting components	Dietary energy should be provided in the form of carbohydrate and fat	Butter, margarine, other spreading fats, oils, cream, full fat milk, cheese
Carbohydrate	Broken down to provide glucose which is an energy source for cellular activity	In the absence of sufficient dietary or stored energy, the body uses valuable protein as an energy source	Complex: bread, pasta, rice, noodles, scones, pancakes, potatoes Simple: jam, sugar, biscuits, honey
Protein	Protein is necessary for tissue synthesis and repair	Excess protein can tax liver and kidney function and cause dehydration	Meat, eggs, cheese, milk, yoghurt, fish, poultry, pulses, nuts
Vitamin A	Enhances immune response, antioxidant, promotes collagen synthesis and epithelialisation	Excess can cause toxicity	Butter, margarine, other spreading fats, oils, milk, cheese, carrots, red peppers, tomatoes, eggs
Vitamin C	Antioxidant, promotes collagen synthesis and angiogenesis, enhances iron absorption, promotes immune function	No benefit from giving additional vitamin C if not deficient	Oranges, grapefruit, fruit juice, green vegetables, potatoes, strawberries
Selenium	Antioxidant	Deficiency relatively common	Brazil nuts, meat, vegetables, fish, cereals
Copper	Collagen cross linkage	Deficiency rare	Meat, vegetables, cereals, tea, coffee
Manganese	Component of enzymes needed for tissue regeneration	Deficiency rare: magnesium can substitute for manganese when status of manganese is poor	Tea, widely distributed in various foods
Zinc	Fibroblast proliferation, component of enzyme systems, collagen synthesis, immune function	Zinc supplement will not accelerate healing in non-deficient patients. Can cause toxicity	Meat, milk, potatoes, bread
Iron	Promotes collagen synthesis, improves oxygen delivery to tissue, component of many enzyme systems	Poor intake and blood loss can lead to iron deficiency anaemia	Red meat, liver, fortified breakfast cereals, eggs, pulses, green vegetables, sardines
Vitamin B complex	Efficient energy usage, collagen formation, component of enzyme systems	Includes thiamin, riboflavin, niacin, folate, vitamin B12, vitamin B6	Wholegrains, breakfast cereals, milk and milk products, meat, fish, liver
Vitamin E	Antioxidant, enhances immune response	Excess can impair wound healing	Vegetable oil, egg yolk, nuts, seeds
Vitamin K	Blood clotting	Deficiency very rare	Liver, green vegetables

a healthy diet and the involvement of nutrients in the 'normal' healing process. However, the phrase 'normal wound healing process' generally only applies to acute wounds (e.g. surgical wounds). Chronic and more complex wound healing often does not follow such a logical order and is regularly complicated by malnutrition, dehydration and infection. A chronic wound is a wound that remains unhealed for longer than six weeks, influenced by multiple, complex factors that impede its healing (Collins et al, 2002). In the next section, the effects of malnutrition and dehydration on wound healing will be outlined and guidance given on how best to manage these common problems.

Malnutrition

Malnutrition is a state of nutrition in which a deficiency or excess (or imbalance) of energy, protein and other nutrients causes measurable adverse affects both on tissue/body structure and function (Abbasi and Rudman, 1993) and clinical outcome (Elia, 2003). It may take many forms. It is not always a deficiency of nutrients but is often due to excess or imbalanced nutrition. Studies have found that up to 40% of patients are malnourished on admission to hospital (Stratton et al, 2003). Malnutrition can increase the risk of developing certain wounds, such as pressure ulcers, and if a wound does develop, malnutrition can impair immune function and delay healing (McLaren, 1992; King, 2001; Litchford, 2002; *Figure 3*).

However, malnutrition is a reversible risk factor for wounds. Early identification and management of malnutrition promotes wound healing (Thomas and Furhrman, 2005). It must be remembered that obese and underweight patients can both be undernourished in essential nutrients. Undernourishment can be identified using a validated nutritional screening tool (Elia, 2003). The Malnutrition Universal Screening Tool (MUST) is a practical, reliable and valid screening tool which is evidence-based and is designed (as with all screening tools) to aid rather than replace clinical judgment.

Nutritional screening

A means of carrying out nutritional screening should be in place within all healthcare settings if malnutrition is to be identified. There are numerous screening tools available. It is important that the tool used is validated, reliable and relevant to the patient group it is assessing. Screening will pick up the less obviously malnourished patients who would otherwise go unnoticed and possibly go on to develop complications as a result (Elia, 2003). Factors commonly examined in screening tools include weight history, BMI, recent food intake, physical and mental health. A BMI less than 20 indicates that malnutrition is possible. Unintentional weight loss of >5% over the past 3–6 months is also an indicator. Other signs of protein energy malnutrition include muscle wasting, oedema, altered plasma proteins, fatigue and weakness (McIlwaine, 2003). Once a patient has been identified as being at risk of malnutrition, it is essential that guidelines are in place to help ensure the patient's nutritional status does not deteriorate further. High-risk patients may be referred to a registered dietitian, while lower-risk patients may simply need increased monitoring and basic dietary advice and support.

Treatment of malnutrition

Correcting malnutrition caused by undernutrition will involve one or a combination of the following interventions that will be detailed later:

- High protein/energy diet
- Fortified diet
- Nutritional supplements
- Vitamin/mineral supplements
- Enteral tube feeding (nutrition

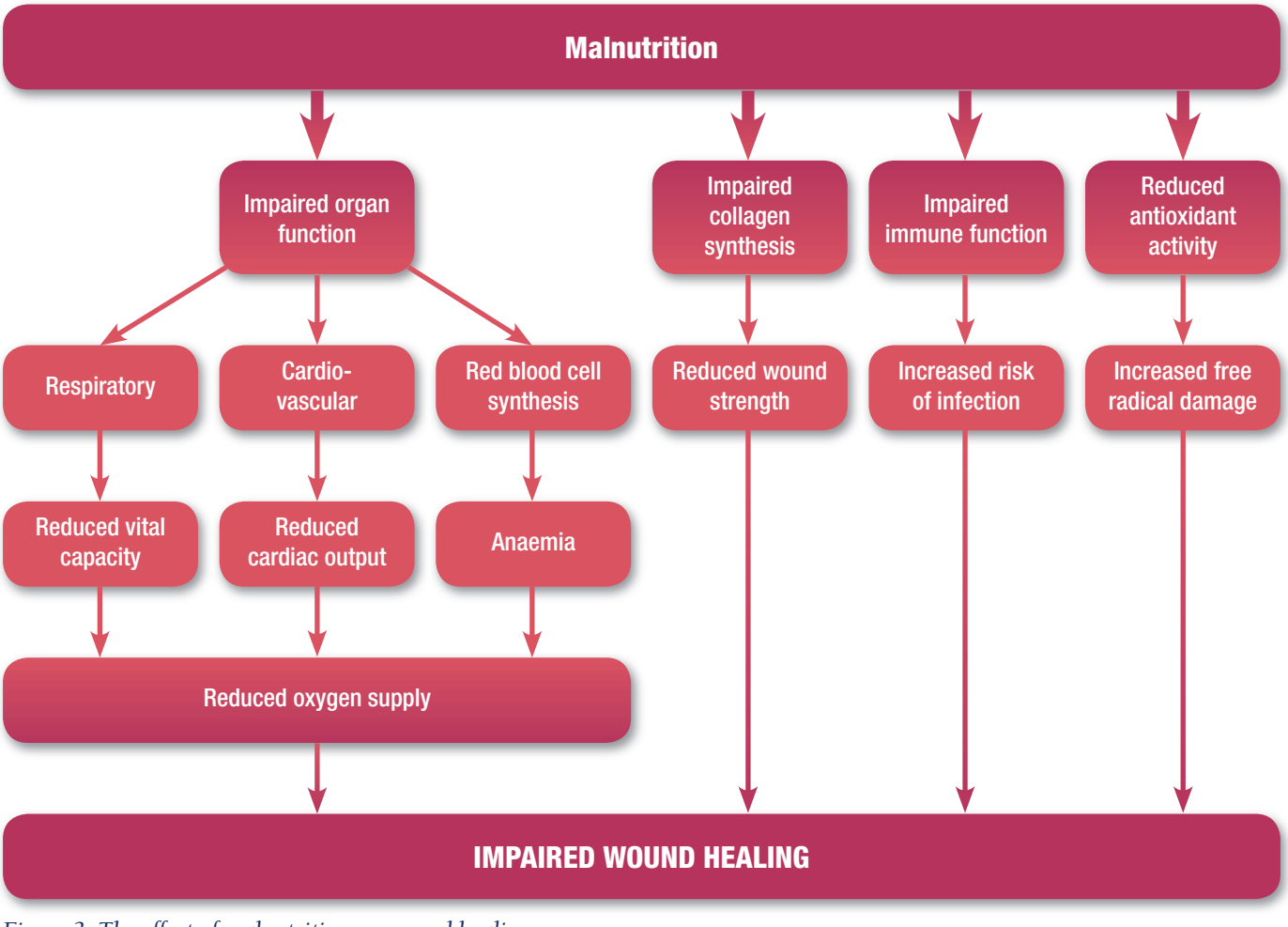

Figure 3. The effect of malnutrition on wound healing.

delivered through a tube into the gastrointestial tract)
- Parenteral nutrition (nutrition provided intravenously).

The following suggestions will help increase protein and energy intake without the need for the use of prescribed products:
- Encourage the use of full cream milk
- Encourage a yoghurt a day
- Encourage high protein/energy snacks between meals
- Add butter to mashed potato, vegetables, etc
- Add grated cheese to mashed potato, soup, vegetables
- Encourage a milky pudding with each meal
- Try ice cream, double cream, as a topping on pudding
- Avoid low-fat products
- Aim for three small meals plus two–three snacks a day.

Fortifying food and drink is a means of increasing the energy and protein content of the diet without significantly increasing the volume consumed. For extra energy, incorporate cream, butter, sugar, honey, jam and full-fat milk into foods and beverages. For extra protein, incorporate cheese, full-fat milk and milk powder. There are also products available on prescription for this purpose.

Often patients with wounds will need a combination of dietary advice, for example, a patient with diabetes may need advice to increase protein and calorie intake and also on controlling blood sugars. This advice may seem contradictory. In these cases, it is always best to refer the patient to a registered dietitian.

Nutritional supplements

There are various forms of nutritional supplements available on prescription to treat malnutrition and promote wound healing (Langer et al, 2003). Following a full assessment of dietary intake, the dietitian will recommend a particular supplement or a combination of supplements that best meet the patient's needs. Supplements may be milk-based, juice-based, yoghurt style, dessert style or soups. They come in a variety of flavours and forms. Supplements can be taken as a drink or a snack and some products can also be used in recipes. Very high protein sip feeds are often marketed to improve wound healing. Care must be taken to ensure that patients are not given too much protein, as excess can unduly tax renal and liver function and, in some circumstances, cause dehydration (Posthauer, 2003).

Vitamin and mineral supplementation

Vitamin and/or mineral supplementation may be necessary to correct a deficiency, which may be caused by inadequate dietary intake, or from increased loss of vitamins and minerals, possibly via a wound, and/or increased requirements due to tissue repair and regeneration. It is essential that the dietitian or doctor carry out a holistic assessment first, as there is no benefit from supplementation if a patient is not deficient (Wilkinson and Hawke, 1998; Furham and Parker, 2004; Shenkin, 2006). In fact, excess vitamins or minerals may be toxic and impair healing (Bradbury, 2006). Care must also be taken with drug/nutrient and nutrient/nutrient interactions. Multivitamins and minerals are often the safest option and can be very useful. Supplementation should be monitored and discontinued when appropriate (Ross, 2002).

Dehydration

Dehydration, along with malnutrition, is a common yet under-recognised problem (Posthauer, 2003). Dehydrated skin becomes inelastic, fragile and more susceptible to breakdown (Thomas, 2001). Dehydration can also reduce tissue perfusion at a wound site by reducing the blood volume, limiting the supply of oxygen and nutrients. Drainage from a wound (exudate) can be a major source of fluid loss, thus further compounding the problem.

It is important to be able to recognise the warning signs and symptoms of dehydration (Posthauer, 2003), which include:
- Dry mouth
- Cracked lips
- Dark urine

Tips to aid compliance with dietary advice

- Set SMART goals: Specific, Measurable, Achievable, Realistic, Time-specific, e.g. 6–12kg weight loss over 3–6 months
- Offer praise and encouragement
- Review diet regularly
- Change diet gradually
- Offer consistent messages from all healthcare professionals
- Enlist social support, e.g. family, friends
- Use a multidisciplinary approach

- Dysphagia (difficulty in swallowing)
- Albumin >50g/l
- Sodium >150mmol/l
- Sunken eyes
- Drinking <6 cups fluid per day
- Needing help drinking
- Frequent vomiting, diarrhoea or fever
- Becoming easily confused and tired
- Skin tenting
- Low blood pressure.

Meeting fluid requirements

As a very general guide, most people require 1,500ml of fluid daily, which equates to about 8–10 cups or glasses. However, calculating a patient's fluid requirement should be based on body weight and age. Most people should consume 30–35ml/kg/day of fluid to maintain adequate hydration. This may be adjusted depending on clinical conditions. For example, a patient may need to have a fluid restriction in place, due to renal failure. Pyrexia will increase fluid needs by a further 2–2.5ml/kg/day for each ºC rise in body temperature above 37ºC (Todorovic and Mickleright, 2000). For example, a 60kg (9 stone 6lb) individual would require approximately an extra 150ml of fluid if they had a temperature of 38ºC.

Furthermore, air-fluidised beds which are used in some specialist units can increase fluid requirement by an additional 10–15ml/kg/day, as they cause extra evaporation of fluid from the body. In this case, a 60kg person would require up to an additional 1,200ml of fluid to prevent dehydration. Monitoring of hydration status is essential. Close attention to fluid intake and output charts and to the signs and symptoms of dehydration must be paid and fluid intake adjusted accordingly (see *Tips*).

Tips to ensure fluid needs are met

- Ensure jug and cup are accessible
- Offer drinks frequently
- Check swallowing guidelines
- Offer high-fluid foods, e.g. jelly, soup, yoghurt, fruit
- Offer encouragement to drink
- Offer assistance with drinking if necessary
- Offer a straw if appropriate
- Offer a beaker if appropriate
- Ensure drinks are to patient's satisfaction
- Offer chilled drinks with ice
- Offer favourite type and flavour of supplement

Weight management

As previously mentioned, obese and overweight patients can be undernourished in essential nutrients. Weight reduction is often not a primary or appropriate aim for patients with acute wounds. The priority is to meet their nutritional requirements and preserve muscle mass. An appropriate target would be 5–10% weight loss of initial weight over 3–6 months in most chronic cases and where obesity is exacerbating the wound. Ideally, these patients should be referred to a registered dietitian for specialised advice and support (Maloney, 2000).

For underweight patients, the aim is to maintain if not increase body mass and correct nutritional deficiencies. This can be done by the use of a fortified, high protein/energy diet as previously outlined, with or without supplementation depending on the circumstances (Langer et al, 2003).

Conclusion

Healthcare professionals have an important role in promoting a healthy lifestyle. Healthy eating and regular physical activity help to prevent chronic illnesses that can lead to wounds and ulcers. If a wound has developed, adequate nutrition plays a key role in the wound-healing process. If certain nutrients are lacking or imbalanced, healing will be delayed. To allow effective nutritional intervention, it is essential that individuals who are malnourished are identified early. If necessary, patients should be

Key Points

- **If a wound has developed, adequate nutrition plays a key role in the wound-healing process.**
- **It is essential that individuals who are malnourished are identified early.**
- **Hydration status is equally important as nutritional status and care must be taken to meet fluid requirements.**
- **Improved nutrition can improve quality of life by reducing the risk of infection, increasing strength and improving appearance.**

referred to a registered dietitian for a more detailed assessment and specific advice. Hydration status is equally important as nutritional status and care must be taken to meet fluid requirements. This approach is not the responsibility of one profession; effective communication between all the people caring for a patient will improve the outcome (Gottrup, 2003). The patient must remain central to this process.

Not all wounds are preventable or will heal. In these cases the emphasis should be on the patient's quality of life. This includes attention to nutritional status. Improved nutrition can improve quality of life by reducing the risk of infection, increasing strength and improving appearance. Better nutrition may also help to prevent any further deterioration. **WE**

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Glossary

Angiogenesis: formation of blood vessels.

Arterial disease: narrowing/hardening of the arteries due to deposition of fatty material which proceeds to the formation of a fibrous patch. This narrowing can obstruct blood flow of oxygen and nutrients to the tissues and can predispose to arterial leg ulcers.

Collagen: main protein in wound healing, necessary for strengthening and giving structure.

Complex carbohydrate: the energy from this form of carbohydrate is released slowly into the bloodstream.

Dehydration: a common yet under recognised problem, which can compromise tissue integrity. It is essential to know the signs and symptoms of dehydration and to actively encourage adequate fluid intake.

Dyslipidaemia: unbalanced lipid levels where one or more blood lipid is not within the target levels, e.g. HDL of < 1 mmol/l and LDL > 3mmol/l.

Epithelialisation: formation of epithelium (the sheet of cells that covers the body surface).

Fibroblasts: cells that produce collagen.

HbA_{1c}: measurement of average blood sugar levels over previous 6–8 weeks.

HDL cholesterol: sometimes known as 'good cholesterol', this can be protective against cardiovascular disease.

Inflammatory mediators: these are needed for regulation of the stages of wound healing.

LDL cholesterol: sometimes known as 'bad cholesterol', a high blood level is a risk factor for cardiovascular disease.

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Glossary

LDL cholesterol: sometimes known as 'bad cholesterol', a high blood level is a risk factor for cardiovascular disease.

Macrovascular: relates to large blood vessels, e.g. coronary artery

Microvascular: relates to small blood vessels, e.g. blood vessels of the eye.

Nutritional screening: this should be in place in healthcare settings if malnutrition is to be identified appropriately and to allow for timely nutritional intervention.

PVD: progressive inflammatory artherosclerosis (hardening of arteries). PVD affects the peripheral vessels such as the iliac, femoral and popliteal arteries.

Saturated fats: mainly found in foods of animal origin. These increase the level of cholesterol i the blood which may increase the risk of fatty deposits in the arteries.

Simple carbohydrate: carbohydrate that is quickly absorbed into the blood stream.

Trans fat: this is found in processed foods. These increase the level of cholesterol in the blood which may increase the risk of fatty deposits in the arteries.

Unsaturated fats: this includes monounsaturated and polyunsaturated fats. These can help to lower the level of cholesterol in the blood.