

BOMSS Guidelines on peri-operative and postoperative biochemical monitoring and micronutrient replacement for patients undergoing bariatric surgery

Authors

Ms Mary O’Kane, Consultant Dietitian, Leeds Teaching Hospitals NHS Trust

Professor Jonathan Pinkney, Professor of Endocrinology and Diabetes, Peninsula Schools of Medicine and Dentistry, Honorary Consultant Plymouth Hospitals NHS Trust

Dr Erlend T Aasheim, NIHR Academic Clinical Fellow in Public Health Medicine, MRC Epidemiology Unit, University of Cambridge School of Clinical Medicine

Dr Julian H Barth, Consultant in Chemical Pathology & Metabolic Medicine, Leeds Teaching Hospitals NHS Trust

Dr Rachel L Batterham, Head of the UCLH Centre for Weight Loss, Metabolic & Endocrine Surgery

Mr Richard Welbourn, Consultant Surgeon, Taunton and Somerset NHS Foundation Trust

Adopted by BOMSS Council September 2014

Review date September 2016

Summary

Bariatric surgery is now an essential option for the treatment of obesity and its associated comorbidities. Many patients presenting for surgery will have pre-existing low blood vitamin concentrations and all bariatric surgical procedures compromise nutrition to varying extents, and have the potential to cause clinically significant micronutrient deficiencies. Therefore, long term nutritional monitoring and follow-up are essential components of all bariatric surgical services. However, there are no current standard guidelines in the UK for the biochemical monitoring and replacement of essential micronutrients in patients undergoing different forms of bariatric surgery. Furthermore, a survey of members of BOMSS revealed a wide diversity of local guidelines and practices. This suggested a need for standard guidelines. We undertook a review of existing guidelines and the associated literature on micronutrient deficiencies following bariatric surgery. Our aim was to summarise existing evidence for the monitoring and replacement of vitamins and minerals prior to, and following bariatric surgery, and to make recommendations for safe practice in the UK setting.

Contents

Introduction	4
Background	4
Methods	5
Recommendations for safe practice in the UK setting	6
1: Preoperative care	7
2: Postoperative care and biochemical monitoring	8
2.1: Urea and electrolytes, liver function tests	8
2.2: Full blood count, ferritin, folate and vitamin B12	8
2.3: Calcium, vitamin D and PTH	8
2.4: Fat soluble vitamins A, E and K	9
2.5: Trace minerals: zinc, copper, selenium and magnesium	9
2.6: Thiamine	9
2.7: Glucose, lipids, HbA1c	9
3: Vitamin and mineral supplementation	10
3.1 Complete multivitamin and mineral supplements	11
3.2 Iron	11
3.3 Folic acid	11
3.4 Vitamin B12	12
3.5 Calcium and vitamin D	12
3.6 Vitamins A, E and K	13
3.7 Zinc and copper	13
3.8 Selenium	13
3.9 Thiamine	14
4: Abnormal results / clinical problems	14
4.1 Protein malnutrition / protein energy malnutrition / oedema	14
4.2 Anaemia	14
4.2.1 Iron deficiency anaemia	14
4.2.2 Vitamin B12 and folate	14
4.2.3 Unexplained anaemia / fatigue	15
4.3 Low vitamin D levels	15
4.4 Vitamin A deficiency / disturbances in night vision / xerophthalmia	16
4.5 Vitamin E	16
4.6 Neurological symptoms / Wernicke encephalopathy	16
4.7 Prolonged vomiting	16
4.8 Pregnancy	17
Conclusion	17
Tables	18
Preoperative blood tests to be undertaken on patients undergoing all procedures	19
Postoperative blood tests following gastric balloon	19
Postoperative blood tests following gastric band	20
Postoperative blood tests following sleeve gastrectomy/gastric bypass/duodenal switch	21
Vitamin and mineral supplements following gastric balloon	23
Vitamin and mineral supplements following gastric band	23
Vitamin and mineral supplements following gastric bypass and sleeve gastrectomy	24
Vitamin and mineral supplements following duodenal switch	25
References	26

Introduction

The incidence of obesity and associated comorbidities continues to increase (1). Bariatric surgery is an essential treatment option for patients with a Body Mass Index of 40 kg/m² or more, or between 35 kg/m² and 40 kg/m² with co-morbidity. All bariatric surgery procedures impact on nutrition to varying degrees. There are currently no UK guidelines for the nutritional monitoring and replacement of micronutrients. These guidelines make recommendations for the peri-operative and postoperative biochemical monitoring and micronutrient replacement for bariatric surgery patients.

Non-nutritional (surgical) complications can also occur during follow-up after bariatric surgery (e.g. internal herniation after gastric bypass surgery) but this falls outside the remit of this report.

Background

The National Confidential Enquiry into Patient Outcome and Death (NCEPOD) report “Too Lean a Service” recommended that all patients have a comprehensive pre-assessment, a complete discharge summary and a long term follow up plan (2). Access to the appropriate multidisciplinary healthcare professionals was emphasised. The American Association of Clinical Endocrinologist, The North American Obesity Society, and American Society for Metabolic and Bariatric Surgery (AACE/TOS/ASMBS) issued a comprehensive review of bariatric surgery and guidelines for nutritional management in 2008 with an update in 2013 (3-4). These guidelines were a significant advance although there has been uncertainty as to how well they can be applied to NHS practice in the UK.

A BOMSS survey of current practice with respect to nutritional assessment and monitoring was undertaken in 2012 which suggested areas of good practice but also considerable variation. Although most respondents were involved in assessment and preparation, almost one third had no standard protocols for preoperative nutritional screening and less than one half had no standard protocols for preoperative vitamin and mineral measurement and replacement. Only 55-60% of respondents routinely requested measurement of ferritin, vitamin B12, folate, calcium and vitamin D levels prior to surgery. Approximately two thirds of respondents involved in the aftercare of patients following a gastric balloon, and one third involved in the aftercare of patients with a gastric band, reported that they never undertook any routine blood tests. 37% of respondents did not recommend any multivitamins and minerals following the gastric balloon and 12% did not recommend any after the gastric band. The majority of respondents reported measurement of urea and electrolytes, liver function tests and vitamin B12 levels following the gastric bypass, sleeve gastrectomy and bilio-pancreatic diversion / duodenal switch (BPD/DS); however there was wide diversity regarding other blood tests and frequency of monitoring. Over 98% of

respondents recommended multivitamins or multivitamin and mineral supplements following the gastric bypass, sleeve gastrectomy and bilio-pancreatic diversion / duodenal switch (BPD/DS) but there was variation in recommendations around vitamin B12, calcium and vitamin D supplementation. These data have been summarised in a Master's dissertation at Leeds Metropolitan University (5)

The BOMSS Council recognised the need for UK guidelines. Therefore, it was agreed that the authors would undertake a review of existing guidelines and associated literature on micronutrient deficiencies following bariatric surgery. Our aim was to summarise existing evidence for the monitoring and replacement of vitamins and minerals prior to, and following bariatric surgery, and to make recommendations for safe practice in the UK setting.

Methods

Key bariatric surgery guidelines were identified through electronic searches and discussions with experts in the field. Key guidelines included American Association of Clinical Endocrinologists, The Obesity Society, and American Society for Metabolic and Bariatric Surgery (AAACE/ASMBS/TOS) "Medical Guidelines for Clinical Practice for the Peri-operative Nutritional, Metabolic, and Non-surgical Support of the Bariatric Surgery Patient"(3) ; ASMBS Allied Health "Nutritional Guidelines for the Surgical Weight Loss Patient" (6); AAACE/TOS/ASMBS "Clinical Practice Guidelines for the Peri-operative Nutritional, Metabolic, and Non-surgical Support of the Bariatric Surgery Patient- 2013 Update" (4); "Endocrine and Nutritional Management of the Post-Bariatric Surgery Patient: An Endocrine Society Clinical Practice Guideline" (7); ASMBS "Position Statement, Metabolic Bone Changes After Bariatric Surgery" (8); Canadian Agency for Drugs and Technologies in Health: "Bariatric Surgery for Severe Obesity: Systematic Review and Economic Evaluation"(9); "Interdisciplinary European Guidelines on Surgery of Severe Obesity 2007" (10) and "Interdisciplinary European Guidelines on Metabolic and Bariatric Surgery 2014" (11).

The Obesity Surgery Society for Australia and New Zealand web pages referred to the AAACE/ASMBS/TOS 2008 guidelines and the Dietitians Association of Australia (DAA) "Dietetic Practice Recommendations for obesity surgery". The DAA were contacted. They advised that the Dietetic Practice Recommendations were published in 2005 and the DAA was considering a review.

All the guidelines were reviewed. The AAACE/ASMBS/TOS (3), ASMBS Allied Health (6) and AAACE/TOS/ASMBS (4) gave the most comprehensive recommendations on peri-operative and postoperative nutritional management of patients. These were considered alongside the current practices identified by the respondents to the BOMSS survey. None of the guidelines included recommendations for patients with gastric balloons. The sleeve

gastrectomy was included in the AACE/TOS/ASMBS 2013 guidelines (4) but was considered investigational in the Interdisciplinary European Guidelines 2014 (11). The authors considered that it was essential to include recommendations for both the gastric balloon and sleeve gastrectomy as both of these procedures are commonly undertaken in the UK.

Other associated guidelines were reviewed. These included “Evaluation, Treatment, and Prevention of Vitamin D Deficiency: an Endocrine Society Clinical Practice Guideline” (12); “Guidelines for Preventing and Treating Vitamin D Deficiency and Insufficiency Revisited”(13); the National Osteoporosis Society “Vitamin D and Bone Health: A practical clinical guideline for patient management” (14) and the Centre for Maternal and Child Enquiries /Royal College of Obstetricians and Gynaecologist (CMACE/RCOG) “Joint Guideline on Management of Women with Obesity in Pregnancy” (15).

The guidelines were reviewed with respect to recommendations on peri-operative nutritional assessment, postoperative nutritional monitoring and micronutrients. A limited literature search was carried out using Medline and EMBASE to identify additional recent publications especially where more clarity was needed or there was a difference in recommendations. The journals “Obesity Surgery” and “Surgery for Obesity and Related Diseases” were also searched for relevant articles in press. The authors reached a consensus on key areas of focus and to include the management of abnormal results and clinical nutritional problems as part of the recommendations.

Recommendations for safe practice in the UK setting

Micronutrient deficiencies have been found in morbidly obese patients prior to bariatric surgery (16-19). These include low levels of ferritin, haemoglobin, vitamin B12 and others. Vitamin D insufficiency or deficiency is prevalent and Grace et al. reported that almost 90% of their patients considering bariatric surgery had an inadequate vitamin D status (20).

All bariatric procedures will affect nutritional intake and/or absorption to varying degrees. Most procedures require a phased approach to the introduction of foods beginning with liquids followed by a blended diet and progressing to a soft diet and then more solid foods. Food portions are significantly reduced. Patients must learn to eat slowly and chew their food well. Some patients may struggle to comply with the dietary recommendations and so the surgery itself may not necessarily result in a nutritionally improved diet (21-23). Although the gastric balloon and gastric band have no impact on absorption of nutrients, patients may still experience vomiting or regurgitation and develop food intolerances. The gastric bypass impacts on the absorption of iron, vitamin B12, calcium and vitamin D (3-4). The BPD/DS has the greatest impact on malabsorption affecting the absorption of protein, fat soluble vitamins and zinc in addition (3-4). The longer term impact of the sleeve

gastrectomy on nutrition is less well known but there are reports of low vitamin B12 levels and iron deficiency anaemia (24-25).

All patients should have a comprehensive assessment, including their nutritional status, prior to bariatric surgery. For patients with deficiencies identified early in assessment, it may be appropriate to inform and advise the general practitioner to treat. Any nutritional deficiencies should be corrected prior to surgery and the multidisciplinary team has a responsibility to ensure that patients are able to meet nutritional requirements following surgery.

These recommendations for bariatric surgery patients cover the gastric balloon, gastric band, gastric bypass, sleeve gastrectomy and BPD/DS procedures. They cover preoperative care, postoperative care and biochemical monitoring, vitamin and mineral supplements and the management of abnormal results / clinical problems. Although the matter of pregnancy in women who have undergone bariatric surgery was considered beyond the scope of this document a brief mention is included in section 4.

1. Preoperative care

All patients should have a comprehensive nutritional assessment prior to bariatric surgery. This should include a detailed dietary assessment by a trained dietitian with specific experience of bariatric nutrition, screening for eating disorders, and psychosocial assessment. Essential preoperative blood tests include screening for diabetes, dyslipidaemia, renal function and nutritional deficiencies (See Table 1) (3-4, 7, 11). Additional discretionary tests should be considered if clinically indicated. The NCEPOD report "Too Lean a Service" (2) emphasised the importance of the multidisciplinary assessment, so that patients have access to all the appropriate healthcare professionals.

Nutritional deficiencies identified at this stage should be investigated and corrected as clinically indicated prior to surgery (7). This may take place as part of the preoperative preparation by multidisciplinary obesity teams (26-27) (See section 4).

Many centres recommend a low calorie / low carbohydrate diet immediately prior to surgery to shrink the size of the liver (28). A multivitamin and mineral supplement may be needed as these diets are not always nutritionally complete (29).

Where patients are being considered for BPD/DS procedure, additional investigations such as baseline DEXA scans for bone mineral density (BMD) should be considered in specific patient groups (8). These groups include younger postmenopausal women and men aged 50 to 69 with clinical risk factors for fracture.

2. Postoperative care and biochemical monitoring

It is essential that patients are monitored following bariatric surgery to ensure that they are both meeting their nutritional requirements and to mitigate risks of developing nutritional deficiencies as a result of the surgical procedure. The type and frequency of monitoring should reflect the bariatric procedure, but also the needs of individual patients. There is therefore recognition that nutritional monitoring may need to be individualised. There should be full access to appropriate members of the MDT including the physician if required. Details of the suggested biochemical monitoring by procedure are shown in Tables 2-4.

2.1 Urea and electrolytes, liver function tests

It is recommended that urea and electrolytes (U&E) and liver function tests (LFT) are monitored for all procedures. The frequency of monitoring depends on the procedure. Dehydration can occur in the early stages following surgery with patients finding it difficult to maintain an adequate fluid intake. Abnormal liver function tests due to non-alcoholic fatty liver disease are common or may relate to other conditions and require further investigation. Changes such as low albumin may be a sign of dietary non-compliance or malabsorption especially following the BPD/DS (30-32). However, low albumin levels are not only an indicator of malnutrition but may also indicate underlying inflammation and infection.

2.2 Full blood count, ferritin, folate and vitamin B12

Anaemia is a common long term problem and so it is appropriate that all patients are monitored. In particular, iron deficiency anaemia can occur after gastric bypass surgery due to a combination of factors including low intake of iron (e.g. due to meat intolerance), reduced intestinal absorption of iron, and (in women) loss of iron through menstruation (33). The types of tests and frequency of monitoring should reflect the bariatric procedure. It should be noted that the megaloblastic and macrocytic anaemia associated with vitamin B12 deficiency can be masked by deficiency of either folic acid or iron and so it is essential to routinely assess all haematinics (folate, vitamin B12 and ferritin) before recommending additional folic acid supplements.

2.3 Calcium, vitamin D and PTH

All patients should have their levels of calcium, vitamin D and PTH levels monitored following the sleeve gastrectomy, gastric bypass and BPD/DS. If vitamin D supplementation

is adjusted, the serum 25-hydroxy vitamin D (25OHD) levels should be rechecked after a minimum of three months (14).

2.4 Fat soluble vitamins A, E and K

Vitamin A deficiencies has been reported following the BPD/DS (30, 32, 34-35). Following the BPD/DS procedures, patients should have their vitamin A levels routinely monitored at baseline and then at 6, 12, 18 and 24 months. Following this they should be measured at least annually. Vitamin A deficiency can be encountered after a gastric bypass although clinic problems appear rare so consideration should be given to monitoring vitamin A levels if there are any concerns (36-37). Routine monitoring of vitamins E and K is not recommended, but they may be measured in situations where this is clinically indicated (4). This includes unexplained anaemia, neuropathy and nutritional deficiencies.

2.5 Trace minerals: zinc, copper, selenium and magnesium

Zinc and copper levels should be monitored routinely following the gastric bypass and BPD/DS (4, 38). High dose zinc supplementation over time can cause copper deficiency (39-41). Selenium levels should also be monitored after these procedures if there is chronic diarrhoea, metabolic bone disease or unexplained cardiomyopathy (4). Routine monitoring of magnesium is not recommended, however patients with hypocalcaemia should be investigated for hypomagnesaemia and treated prior to calcium supplementation (42).

2.6 Thiamine

Although routine monitoring of thiamine is not recommended the possibility of deficiency should be seriously considered if there is rapid weight loss, poor dietary intake, vomiting, alcohol abuse, oedema or symptoms of neuropathy. All clinicians involved in the aftercare of bariatric surgery patients should be aware of the potential risk for severe thiamine deficiency (see Section 4.6). If thiamine deficiency is suspected, intravenous treatment should not be delayed pending tests results but initiated immediately.

2.7 Glucose, lipids, HbA1c

While this survey did not specifically address the preoperative medical assessment of diabetes, biochemical monitoring related to diabetes is an important part of pre and post-operative care for many patients undergoing bariatric surgery, since bariatric surgery is increasingly advocated to improve important obesity-related medical co-morbidity such as

type 2 diabetes (43). If bariatric surgery is being undertaken for this reason a detailed diabetes review is appropriate. Therefore, patients with known, pre-existing diabetes should have an up to date preoperative evaluation of the adequacy of current glycaemic control, treatment requirements, presence and extent of diabetes complications, and measurement of HbA1c as a baseline from which to assess the subsequent impact of bariatric surgery. An assessment of diabetes aetiology and expected impact of bariatric surgery is also appropriate. For example, patients with type 1 diabetes and other forms of diabetes that are characterised by absolute insulin deficiency will not be expected to achieve a remission of diabetes following bariatric surgery. This assessment is essential in planning the postoperative diabetes management, especially if withdrawal of insulin is contemplated.

Patients without known diabetes who are undergoing preoperative bariatric assessment are at high risk of having undiagnosed diabetes and should routinely undergo screening. Appropriate tests include HbA1c and FPG and/or a discretionary oral glucose tolerance test. Diabetes is diagnosed according to published criteria (44). Patients with known preoperative diabetes require appropriate peri-operative and postoperative diabetes management (45). Since there are currently no agreed guidelines for the postoperative medical management of diabetes following bariatric surgery, treatment monitoring, adjustment or attempted withdrawal of medications should be individualised under the supervision of a physician specialising in diabetes management. It is unknown whether patients with type 2 diabetes who enter glycaemic remission after bariatric surgery should continue to take metformin to prevent recurrence of hyperglycaemia, although this is a common practice. Glycaemic control may be monitored in the short term by regular capillary blood glucose measurements, and this is important if treatments such as insulin are being reduced or discontinued. In the longer term, repeat measurements of HbA1c are the basis for glycaemic monitoring. It is important to note that diabetes does not enter glycaemic remission after bariatric surgery in all cases, and the cumulative late relapse rate may be in the region of 40-50% (46-47) and therefore monitoring for diabetes relapse is essential. Even if patients become euglycaemic, they should remain on the diabetes register and annual diabetes screening with HbA1c, FPG or a discretionary glucose tolerance test are all appropriate approaches.

Patients with pre-existing treated dyslipidaemia should undergo a preoperative assessment with a fasting lipid profile, as a baseline from which to assess the subsequent effect of bariatric surgery during follow-up. The identification of all relevant preoperative medical comorbidity is important, including dyslipidaemia. Therefore, a fasting lipid profile is usually appropriate in the medical work up for bariatric surgery. Currently there are no generally agreed medical guidelines for the postoperative monitoring and treatment of dyslipidaemias, especially continuation or withdrawal of medication, and so these should be assessed on an individual basis. Similar considerations apply to the management of hypertension.

3. Vitamin and mineral supplementation

Tables 5-8 contain details of the recommended vitamin and mineral supplements. As patients' requirements and adherence may vary over time, these should be reviewed regularly.

3.1 Complete multivitamin and mineral supplements

A complete multivitamin and mineral supplement (containing iron, selenium, zinc and copper) is recommended after all bariatric procedures (4). It is important to note that some multivitamin supplements that are routinely available may not contain sufficient amounts of certain vitamins, depending on the recommended doses, to counter the malabsorptive effects of bariatric surgery, and some do not contain additional or insufficient amounts of minerals and trace elements. A minimum of 2 mg of copper per day is advised (see section 3.7). Although Forceval contains 2 mg copper, many over the counter preparations contain 1 mg; therefore it may be necessary to recommend that patients take two multivitamin and mineral supplements (4). The ratio of 8-15 mg of zinc for each 1 mg copper should be maintained (4).

3.2 Iron

For patients undergoing the insertion of a gastric balloon or gastric band, it should be possible for patients to meet their iron requirements by oral diet and a complete multivitamin and mineral supplement containing the recommended daily allowance of iron.

An iron intake of between 45-60 mg from multivitamin and mineral supplements and additional iron is recommended following the sleeve gastrectomy, gastric bypass and BPD/DS (4). This may be achieved with 200 mg ferrous sulphate, 210 mg ferrous fumarate or 300 mg ferrous gluconate daily in addition to the multivitamin and mineral supplement. Women of reproductive age who are menstruating have additional requirements of at least 100 mg elemental iron daily (two ferrous sulphate or ferrous fumarate daily) (48). Supplements containing iron should be taken alongside citrus fruits / drinks or vitamin C to aid absorption. Iron and calcium supplements should not be taken at the same time and preferably two hours apart.

3.3 Folic acid

For the majority of patients, the folic acid contained within standard multivitamin and mineral supplement is likely to be sufficient in addition to dietary sources of folic acid.

3.4 Vitamin B12

As patients who have had a gastric bypass often malabsorb vitamin B12 and have low levels (33, 50-51) routine supplementation with three monthly intramuscular vitamin B12 injections is recommended (52). In view of the mixed findings of reported vitamin B12 depletion after sleeve gastrectomy (24-25, 53) and BPD/DS (30-31), it is also recommended that these patients receive vitamin B12 supplements (52). In the absence of high doses of oral vitamin B12 being available on prescription, it is recommended that these patients also receive intramuscular injections of vitamin B12. Further research is needed as to whether oral supplementation with over the counter preparations is sufficient for patients who have a sleeve gastrectomy or BPD/DS or whether their needs are best met with intramuscular injections.

Untreated vitamin B12 deficiency may result in irreversible neuropathy, which may occur in the absence of megaloblastic anaemia.

3.5 Calcium and vitamin D

Patients who were found to be vitamin D insufficient prior to surgery are likely to remain on supplements following surgery however additional vitamin D supplements may be required to maintain serum 25OHD levels greater than 50 nmol/L after the gastric bypass, sleeve gastrectomy and BPD/DS (4, 7). Generally, following the gastric bypass or sleeve gastrectomy, usual practice is in the region of a minimum of 800-1200 mg calcium and 20 mcg (800 IU) vitamin D per day. For some patients, this may be sufficient but for the majority it will not be. Additional vitamin D supplementation will also be needed following the BPD/DS (30, 32, 35). Guidance for the treatment of vitamin D deficiency is given in Appendix 1 of The National Osteoporosis Society Vitamin D and Bone Health: Practical Guideline for Patient Management (14). Oral vitamin D3 is the preferred treatment for vitamin D deficiency (14). The guidance recommends loading regimes for the treatment of deficiency up to a total of approximately 300,000 IU given either as weekly or daily split doses. Preparations may be given as:

- 50,000 IU capsules, one given weekly for 6 weeks (300,000 IU)
- 20,000 IU capsules, two given weekly for 7 weeks (280,000 IU)
- 800 IU capsules, five a day given for 10 weeks (280,000 IU).

This may then be followed by maintenance regimens 1 month after loading with doses equivalent to 800 to 2000 IU daily (occasionally up to 4,000 IU daily), given either daily or intermittently at a higher equivalent dose. Serum calcium levels should be checked one month after the last loading dose. Full details can be found in Appendix 1: Guidance for treatment of Vitamin D deficiency. Alternatively many areas may have their own local

guidance for management of vitamin D deficiency in primary care. Patients who are unable to maintain vitamin D levels should be referred to a specialist in secondary care.

Patients should be encouraged to have dietary sources of calcium and vitamin D and increase weight bearing activity (6). Calcium and iron supplements should not be taken at the same time. It is recognised that calcium citrate is more bioavailable than calcium carbonate, however, it is not readily available in the UK (6, 8).

3.6 Vitamins A, E and K

For the majority of patients who have a gastric band, sleeve gastrectomy or gastric bypass, requirements for vitamins A, E and K can usually be met by oral diet and a “complete” multivitamin and mineral supplement. Patients who have undergone BPD/DS are more likely to have additional requirements for vitamin A and potentially also for E and K. Mechanik et al. suggest that these are best supplied in a water soluble form¹ (3) however continued monitoring is essential as this may still not be sufficient.

3.7 Zinc and copper

Multivitamin and mineral supplements should contain both sufficient zinc and copper. A minimum of 2 mg of copper per day is advised (4). If additional zinc supplements are required, the ratio of 8-15 mg of zinc for each 1 mg copper should be maintained (4). Patients who have had gastric bypass or BPD/DS may have additional requirements for zinc and copper. Forceval contains 2 mg copper and 15 mg zinc and doubling up on the dosage of Forceval may be sufficient in some cases to meet the additional requirements (54).

3.8 Selenium

A complete multivitamin and mineral supplement, which contains selenium, should be sufficient to meet needs after bariatric surgery. Additional selenium may be needed in some patients following gastric bypass, BPD or DS (32, 55). Patients may prefer to eat two to three Brazil nuts a day as these are a rich source of selenium. Over the counter preparations may also be used to supplement selenium.

¹ AquADEKs Softgels are water soluble however only available in the UK on a named patient basis

3.9 Thiamine

The multivitamin and mineral supplement should contain sufficient thiamine. Additional thiamine supplementation should be administered to patients at risk of Wernicke encephalopathy, such as those with prolonged vomiting, poor nutritional intake, high alcohol intake or fast weight loss. Consideration should be given to admission and immediate parenteral replacement with thiamine in patients where thiamine deficiency is suspected. See sections 4.6 and 4.7.

4. Abnormal test results and clinical problems

4.1 Protein malnutrition / protein energy malnutrition / oedema

This can present several years following bariatric surgery. Causes include poor dietary protein intake as well as malabsorption. Oedema is an important indicator of protein energy malnutrition, and may mask weight loss and muscle wasting. Whilst it is necessary to exclude the many other causes of oedema, the patient should also be referred back to the bariatric centre for further investigation.

4.2 Anaemia

4.2.1 Iron deficiency anaemia

Iron deficiency anaemia may be dietary in origin, with oral diet and iron supplements being insufficient to meet the needs of the patient. Sources of blood loss, both related and unrelated to bariatric surgery should also be considered, investigated and excluded. For patients who have iron deficiency anaemia, Malone et al. suggest an 8 week course of oral iron (325 mg ferrous sulphate b.d.) (56). For those patients who are unable to tolerate or are non-compliant with oral iron or whose levels did not respond, the authors recommend referral for intravenous iron infusions. Following this, full blood count and ferritin stores should continue to be monitored to ensure ferritin stores remain within the reference range.

4.2.2 Vitamin B12 and folate

If a patient presents with megaloblastic, macrocytic anaemia, vitamin B12 levels should be checked before giving additional folic acid, as folic acid supplementation in severe vitamin B12 depletion may lead to neurological complications. Vitamin B12 deficiency should be treated with intramuscular injections and levels maintained with three monthly vitamin B12 injections.

Folic acid deficiency may indicate non-compliance with the daily multivitamin and mineral supplement or malabsorption. Additional folic acid supplementation is recommended and further investigations if suspicion of malabsorption. Serum folate levels should be rechecked after four months. High folate levels can reflect supplementation or, in some cases, bacterial overgrowth in the small intestine.

4.2.3 Unexplained anaemia / fatigue

If anaemia or fatigue is unexplained, it may be a symptom of other nutritional deficiencies including protein, zinc, copper and selenium so it is suggested that the levels of these are investigated.

4.3 Low vitamin D levels

Whilst low vitamin D levels are not a barrier to bariatric surgery, if the patient presents with low vitamin D levels prior to surgery, treatment with vitamin D should begin preoperatively especially where the surgical procedure is likely to result in vitamin D malabsorption (7.) Following surgery, if the patient presents with vitamin D deficiency, compliance with the recommended supplements should be checked. For some patients, despite good compliance, additional supplementation with vitamin D is needed.

For bariatric surgery patients, their vitamin D levels may be affected not only by exposure to sunlight but also by the bariatric procedure. The National Osteoporosis Society Vitamin D and Bone Health: A Practical Clinical Guideline for Patient Management (14) recommends that serum 25OHD levels less than 50 nmol/L may be inadequate and need treatment. The recommended treatment regimen is explained fully and involves a loading dose of vitamin D3 over several weeks followed by a maintenance phase. For those patients who remain vitamin D deficient or need a more aggressive approach, they recommend a referral to a secondary care specialist.

4.4 Vitamin A deficiency / disturbances in night vision / xerophthalmia

Vitamin A deficiency can lead to eye problems such as loss of night vision (57) and xerophthalmia and may also result in foetal abnormalities. Vitamin A levels should be measured if there are concerns and if appropriate a referral to an ophthalmologist should be considered. For treatment of vitamin A deficiency, oral supplementation with vitamin A, 5000-10,000 IU/day is recommended however more may be needed if the patient is experiencing night blindness (3). The levels should be rechecked after two to three months (3).

4.5 Vitamin E

Mechanik et al. recommend that vitamin E (800-1200 IU/day) should be used when there is documented deficiency and should be continued until serum levels reach the normal range (3).

Vitamin E is normally assessed by serum α -tocopherol, which does not have a specific plasma carrier protein and is transported non-specifically in lipoproteins. When considering vitamin E nutritional status, adjustment should therefore be made for serum lipids (58).

Vitamin E in large doses can exacerbate vitamin K deficiency and therefore affect blood coagulation (59) so over-replacement should be avoided. Aills et al. suggest 500 mg vitamin E daily is sufficient to correct deficiency (6). Furthermore, assessment of vitamin K should be performed when there is established fat-soluble vitamin deficiency with hepatopathy, coagulopathy or osteoporosis (3).

4.6 Neurological symptoms / Wernicke encephalopathy

Wernicke encephalopathy secondary to thiamine deficiency and myeloneuropathy (which includes spinal cord changes and peripheral neuropathy) secondary to deficiencies of vitamin B12 or copper are severe complications which can sometimes occur after bariatric surgery.

A literature review found 104 cases of Wernicke encephalopathy syndrome after bariatric surgery, with an incidence of around 1 in 500 cases after BPD, suggesting that this preventable complication is not rare (60). In patients at risk of thiamine deficiency, additional thiamine and vitamin B co strong should be given immediately (thiamine 200–300 mg daily, vitamin B co strong 1 or 2 tablets, three times a day) (61). For those unable to tolerate thiamine orally or with clinical suspicion of acute deficiency intravenous thiamine should be given (62). Oral or IV glucose must not be given to patients at risk of or with suspected thiamine deficiency as it can precipitate Wernicke-Korsakoff syndrome.

Vitamin B12 and copper levels should be assessed and any deficiencies corrected. With severe copper deficiency, an inpatient admission may be required for administration of intravenous copper. Patients with neurological symptoms should be referred to a neurologist.

4.7 Prolonged vomiting

While patients may occasionally experience regurgitation of food after bariatric surgery, prolonged vomiting is not normal and should always be investigated. A referral back to the

bariatric centre is advisable. Prolonged vomiting may lead to severe thiamine deficiency. Thiamine and vitamin B co strong should be given immediately as above in section 4.6 (59). Those unable to tolerate oral thiamine, intravenous thiamine should be administered. Oral or IV glucose must not be given (63).

4.8 Pregnancy

Women are often advised to avoid pregnancy for the first twelve to eighteen months following surgery (4). The evidence base for this recommendation is limited, but it helps to ensure that the patient has reached a stable weight and facilitates appropriate planning of pregnancy and associated care.

Healthy women, planning for pregnancy, should take an additional 400 mcg/day folic acid prior to conception until the 12th week of pregnancy however in women with obesity or diabetes, the recommendation is 5 mg folic acid until the 12th week of pregnancy as there may be an increased risk of neural tube defect affected pregnancy (15, 59, 64-65). The strength of the evidence base underlying this recommended dose (5 mg) is debated.

Women, as part of preconception care, are advised to avoid vitamin and mineral preparations which contain vitamin A in the retinol form in the first 12 weeks of pregnancy. Supplements containing retinol may increase the teratogenic risk especially in the first trimester (59). There are vitamin and mineral supplements containing no vitamin A which are specifically aimed at preconception and pregnancy e.g. Pregnacare, Seven Seas Pregnancy and Centrum Pregnancy Care; however avoidance of supplements containing vitamin A may place women more at risk of low vitamin A levels especially if they have had a distal bypass or BPD/DS. The health care professional should check that any supplements contain vitamin A in the beta carotene and not retinol form.

Patients who become pregnant following bariatric surgery should undergo nutritional screening every trimester. This should include ferritin, folate, vitamin B12, calcium and fat soluble vitamins (4). Pregnant patients, especially those who have had distal bypass or BPD/DS procedures, may be at risk of low vitamin A levels and possibly vitamins E and K. Vitamin A levels (and possibly vitamin E and K levels) should be monitored during pregnancy. A more frequent review with the specialist bariatric dietitian may be required.

Conclusion

There is a wide variation in practice with respect to preoperative assessment, postoperative biochemical monitoring and vitamin and mineral supplements for patients undergoing bariatric surgery. This could result in suboptimal care and result in nutritional problems being unidentified. The literature review provides some of the evidence base that is

required for the development of consensus guidelines which have the potential to improve clinical practice and safety for patients undergoing bariatric surgery. Further research is needed to further develop the evidence base and these guidelines need to be reviewed as new evidence emerges.

5. Tables

Table 1 Preoperative blood tests to be undertaken on patients undergoing all bariatric procedures

General and nutritional
Full blood count
Ferritin
Folate
Vitamin B12
25 hydroxy-vitamin D
Calcium
Parathyroid hormone
Liver function test
Urea and electrolytes
Comorbidities
Fasting Glucose
HbA1c
Lipid profile

Table 2 Postoperative blood tests following gastric balloon

Blood test	Frequency
U+E, LFT, FBC	Monitor if any concerns regarding nutritional intake
HbA1c and/or FBG in patients with preoperative diabetes	Monitor as appropriate

Table 3 Postoperative blood tests following gastric band

Blood test	Frequency
U+E, LFT, FBC	Monitor annually and more frequently if any concerns regarding nutritional intake
HbA1c and/or FBG in patients with preoperative diabetes	Monitor as appropriate
Lipid profile	Monitor in those with dyslipidaemia
Serum 25 hydroxy Vitamin D	Routine monitoring is usually not required unless the patient has symptomatic vitamin D deficiency

Table 4 Postoperative blood tests following sleeve gastrectomy / gastric bypass / duodenal switch. Key Duodenal switch - DS

Blood test / Procedure	Frequency
HbA1c and/or FBG in patients with preoperative diabetes Sleeve Gastrectomy/ Gastric Bypass / DS	Monitor as appropriate
Lipid profile Sleeve Gastrectomy / Gastric Bypass / DS	Monitor in those with dyslipidaemia
U+E, LFT, FBC, ferritin, folate, calcium, vitamin D, PTH Sleeve Gastrectomy/ Gastric Bypass / DS	3, 6 and 12 months in first year. Annually
Thiamine Sleeve Gastrectomy/ Gastric Bypass / DS	Routine blood monitoring of thiamine is not required but clinicians should be aware that patients with prolonged vomiting can develop acute thiamine deficiency, which requires urgent treatment (see elsewhere).
Vitamin B12 Sleeve Gastrectomy/ Gastric Bypass / DS	6 and 12 months in first year. Annually No need to monitor if patient has intramuscular vitamin B12 injections
Zinc, copper Gastric bypass / DS	Annually. Monitor zinc if unexplained anaemia, hair loss or changes in taste acuity. Monitor copper if unexplained anaemia or poor wound healing. Note the zinc levels affect copper levels and vice versa
Vitamin A Gastric Bypass DS	Measure if concerns regarding steatorrhea or symptoms of vitamin A deficiency e.g. night blindness Annually May need to monitor more frequently in pregnancy
Vitamin E, K Gastric Bypass / DS	Measure vitamin E if unexplained anaemia, neuropathy. Consider measuring INR if excessive bruising / coagulopathy as may indicate vitamin K deficiency
Selenium Gastric Bypass / DS	Monitor if unexplained fatigue, anaemia, metabolic bone disease, chronic diarrhoea or heart failure

Vitamin and mineral supplements following bariatric surgery

This assumes:

- Patients have received a comprehensive preoperative assessment and any nutritional deficiencies have been treated
- Patients have biochemical monitoring as stated in the guidelines and have deficiencies investigated and corrected
- Patients are taking the minimum supplements required

Table 5 Vitamin and mineral supplements following gastric balloon

Vitamin and minerals recommended	
Multivitamin and mineral supplement	Forceval or over the counter “complete” multivitamin and mineral supplement, one daily
Thiamine	If patient experiences prolonged vomiting always prescribe additional thiamine (thiamine 200–300 mg daily, vitamin B co strong 1 or 2 tablets, three times a day) and urgent referral to bariatric centre. Those patients who are symptomatic or where there is clinical suspicion of acute deficiency should be admitted immediately for administration of IV thiamine
Vitamin D, Iron	Continue with maintenance doses if required

Table 6 Vitamin and mineral supplements following gastric band

Vitamin and minerals recommended	
Multivitamin and mineral supplement	Forceval or over the counter “complete” multivitamin and mineral supplement, one daily
Preconception and pregnancy	Additional folic acid (5 mg) preconception and first 12 weeks of pregnancy. Safe to continue with Forceval as vitamin A is in beta carotene form or consider pregnancy multivitamin and mineral e.g. Seven Seas Pregnancy, Pregnacare, Boots Pregnancy Support
Thiamine	If patient experiences prolonged vomiting always prescribe additional thiamine (thiamine 200–300 mg daily, vitamin B co strong 1 or 2 tablets, three times a day) and urgent referral to bariatric centre. Those patients who are symptomatic or where there is clinical suspicion of acute deficiency should be admitted immediately for administration of IV thiamine
Vitamin D, Iron	Continue with maintenance doses if required.

Table 7 Vitamin and mineral supplements following gastric bypass and sleeve gastrectomy

Vitamin and minerals recommended	
Multivitamin and mineral supplement should include; <ul style="list-style-type: none"> iron selenium 2 mg copper (minimum) zinc (ratio of 8-15 mg zinc for each 1 mg copper) Preconception and pregnancy	<p>The following meet these requirements (August 2014):</p> <ul style="list-style-type: none"> one daily Forceval (soluble and capsule) “Over The Counter” complete multivitamin and mineral supplement, two daily e.g. Sanatogen A-Z Complete, Superdrug A-Z multivitamins and minerals, Tesco Complete multivitamins and minerals, Lloydspharmacy A-Z multivitamins and minerals <p>Safe to continue with Forceval as vitamin A is in beta carotene form or consider pregnancy multivitamin and mineral e.g. Seven Seas Pregnancy, Pregnacare, Boots Pregnancy Support</p>
Iron 45 to 60 mg daily	200 mg ferrous sulphate, 210 mg ferrous fumarate or 300 mg ferrous gluconate daily
100 mg daily for menstruating women	200 mg ferrous sulphate or 210 mg ferrous fumarate twice daily
Folic acid Contained within multivitamin and mineral supplement Pregnancy and preconception.	<p>Encourage consumption of folate rich foods</p> <p>If deficient, check compliance with multivitamin and mineral supplement. If compliant, check for vitamin B12 deficiency before recommending additional folic acid supplements. Additional folic acid (prescribed or over the counter) if deficient. Recheck folate levels after 4 months.</p> <p>Additional folic acid (5 mg, but see text) preconception and first 12 weeks of pregnancy</p>
Vitamin B12	Intramuscular injections of 1mg vitamin B12 three monthly N.B. sleeve gastrectomy patients may need less frequent injections
Calcium and Vitamin D	<p>Ensure good oral intake of calcium and vitamin D rich foods</p> <p>Continue with maintenance doses of calcium and vitamin D as identified preoperatively</p> <p>Treat and adjust vitamin D supplementation in line with National Osteoporosis Society Guidelines. Patients are likely to be on at least 800 mg calcium and 20 mcg vitamin D e.g. Adcal D3, Calceos, Cacit D3, however many patients will require additional vitamin D</p>
Fat soluble vitamins A, E and K	<p>Sufficient contained within vitamin and mineral supplement</p> <p>Additional fat soluble vitamins may be needed if patient has steatorrhoea</p>
Zinc and copper	<p>Sufficient contained within multivitamin and mineral supplement</p> <p>If additional zinc is needed, ratio of 8 to 15 mg zinc per 1 mg copper must be maintained</p>
Selenium	<p>Sufficient contained within multivitamin and mineral supplement.</p> <p>If required, additional selenium may be provided by two to three Brazil nuts a day or by over the counter preparations including Selenium ACE, Holland and Barrett Selenium, Boots Selenium with Vitamins A, C and E</p>
Thiamine	<p>Sufficient contained within multivitamin and mineral supplement.</p> <p>If patient experiences prolonged vomiting always prescribe additional thiamine (thiamine 200–300 mg daily, vitamin B co strong 1 or 2 tablets, three times a day) and urgent referral to bariatric centre. Those patients who are symptomatic or where there is clinical suspicion of acute deficiency should be admitted immediately for administration of IV thiamine</p>

Table 8 Vitamin and mineral supplements following duodenal switch

Vitamin and minerals recommended	
<p>Multivitamin and mineral supplement should include;</p> <ul style="list-style-type: none"> iron selenium 2 mg copper (minimum) zinc (ratio of 8-15 mg zinc for each 1 mg copper) <p>Preconception and pregnancy</p>	<p>The following meet these requirements (August 2014):</p> <ul style="list-style-type: none"> one daily Forceval (soluble and capsule) “Over The Counter” complete multivitamin and mineral supplement, two daily e.g. Sanatogen A-Z Complete, Superdrug A-Z multivitamins and minerals, Tesco Complete multivitamins and minerals, Lloydspharmacy A-Z multivitamins and Minerals <p>Safe to continue with Forceval as vitamin A is in beta carotene form or consider pregnancy multivitamin and mineral e.g. Seven Seas Pregnancy, Pregnacare, Boots Pregnancy Support</p>
<p>Iron</p> <p>45 to 60 mg daily</p> <p>100 mg daily for menstruating women</p>	<p>200 mg ferrous sulphate, 210 mg ferrous fumarate or 300 mg ferrous gluconate daily</p> <p>200 mg ferrous sulphate or 210 mg ferrous fumarate twice daily</p>
<p>Folic acid</p> <p>Contained within multivitamin and mineral supplement</p> <p>Preconception and pregnancy.</p>	<p>Encourage consumption of folate rich foods</p> <p>If deficient, check compliance with multivitamin and mineral supplement. If compliant, check for vitamin B12 deficiency before recommending additional folic acid supplements. Additional folic acid (prescribed or over the counter) if deficient. Recheck folate levels after 4 months.</p> <p>Additional folic acid (5 mg, but see text) preconception and first 12 weeks of pregnancy</p>
Vitamin B12	Intramuscular injections of 1mg vitamin B12 three monthly
Calcium and Vitamin D	<p>Ensure good oral intake of calcium and vitamin D rich foods</p> <p>Continue with maintenance doses of calcium and vitamin D as identified preoperatively</p> <p>Treat and adjust vitamin D supplementation in line with National Osteoporosis Society Guidelines. Patients are likely to be on at least 800 mg calcium and 20 mcg vitamin D e.g. Adcal D3, Calceos, Cacit D3, however most patients will require additional vitamin D</p>
<p>Fat soluble vitamins A, E and K</p> <p>Additional fat soluble vitamins are needed</p>	AquADEKs Softgels provide additional high doses of fat soluble vitamins A, D, E and K and other vitamins and minerals. Recommend one to two daily. Alternatively supplement with additional vitamins A, E and K as required
Zinc and copper	<p>Sufficient contained within multivitamin and mineral supplement</p> <p>If additional zinc is needed, ratio of 8 to 15 mg zinc per 1 mg copper must be maintained</p>
Selenium	<p>Sufficient contained within multivitamin and mineral supplement</p> <p>If required, additional selenium may be provided by two to three Brazil nuts a day or by over the counter preparations including Selenium ACE, Holland and Barrett Selenium, Boots Selenium with Vitamins A, C and E</p>
Thiamine	<p>Sufficient contained within multivitamin and mineral supplement</p> <p>If patient experiences prolonged vomiting always prescribe additional thiamine (thiamine 200–300 mg daily, vitamin B co strong 1 or 2 tablets, three times a day) and urgent referral to bariatric centre. Those patients who are symptomatic or where there is clinical suspicion of acute deficiency should be admitted immediately for administration of IV thiamine.</p>

References

1. Health and Social Care Information Centre, Lifestyles Statistics. Statistics on obesity, physical activity and diet: England, 2014, [Internet], London, The Health and Social Care Information Centre. Available from: <http://www.hscic.gov.uk/catalogue/PUB13648/Obes-phys-acti-diet-eng-2014-rep.pdf> [Accessed 3 August 2014]
2. National Confidential Enquiry into Patient Outcome and Death. Too Lean a Service? A review of the care of patients who underwent bariatric surgery. London: Dave Terrey; 2012
3. Mechanick JI, Kushner RF, Sugerman HJ, Gonzalez-Campoy M, Collazo-Clavell ML, Guven S et al. American Association of Clinical Endocrinologists, The Obesity Society, and American Society for Metabolic and Bariatric Surgery. Medical guidelines for clinical practice for the peri-operative nutritional, metabolic, and nonsurgical support of the bariatric surgery patient. *Endocrin Pract*. 2008; 14(S1): 1-83.
4. Mechanick JI, Youdim A, Jones DB, Garvey WT, Hurley DL, McMahon MM et al. Clinical practice guidelines for the peri-operative nutritional, metabolic, and nonsurgical support of the bariatric surgery patient- 2013 update: Cosponsored by the American Association of Clinical Endocrinologist, The Obesity Society, and American Society for Metabolic and Bariatric Surgery. *Surg Obes Relat Dis*. 2013; 9(2):159-191.
5. O'Kane, M. Bariatric surgery, vitamins, minerals and nutritional monitoring: A survey of current practice within BOMSS. [M.Sc. dissertation]. Leeds, England: Leeds Metropolitan University; 2013.
6. Aills L, Blankenship J, Buffington C, Furtado M, Parrott J. ASMBS Allied Health Nutritional guidelines for the surgical weight loss patient. *Surg Obes Relat Dis*. 2008; 4(5):S73-S108.
7. Heber D, Greenway FI, Kaplan LM, Livingston E, Salvador J, Still C. Endocrine and Nutritional management of the post-bariatric surgery patient: An Endocrine Society clinical practice guideline. *J Clin Endocrinol Metab*. 2010; 95(11): 4823-4843.
8. Kim J, Brethauer S. ASMBS Position Statement, Metabolic bone changes after bariatric surgery. *Surg Obes Relat Dis*. [Internet] Available from <http://dx.doi.org/10.1016/j.soard.2014.03.010> [Accessed 4 May 2014].
9. Klarenbach S, Padwal R, Wiebe N, Hazel M, Birch D, Manns B et al. (2010) Bariatric surgery for severe obesity: systematic review and economic evaluation, technology report; no. 129 [Internet], Ottawa, Canadian Agency for Drugs and Technologies in Health. 2010. Available from: <http://www.cadth.ca/index.php/en/hta/reports-publications/search?&type=16> [Accessed 18 March 2012].
10. Fried MH, Hainer V, Basdevant A, Buchwald H, Deitel M, Finer N et al. (2007) Interdisciplinary European guidelines on surgery of severe obesity. *Obes Surg*. 2007; 17(2): 260-270.
11. Fried M, Yumuk V, Oppert JM, Scopinaro N, Torres A, Weiner R et al. on behalf of International Federation for the Surgery of Obesity and Metabolic Disorders—European Chapter (IFSO-EC) and European Association for the Study of Obesity (EASO). Interdisciplinary European guidelines on metabolic and bariatric surgery. *Obes Surg*. 2014; 24:42–55
12. Holick MF, Binkley NC, Bischoff-Ferrari HA, Gordon CM, Hanley DA, Heaney RP et al. Evaluation, treatment, and prevention of vitamin D deficiency: an Endocrine Society clinical practice guideline. *J Clin Endocrinol Metab*. 2011; 96: 1911-30.
13. Holick MF, Binkley NC, Bischoff-Ferrari HA, Gordon CM, Hanley DA, Heaney RP et al. Guidelines for preventing and treating vitamin D deficiency and insufficiency revisited. *J Clin Endocrinol Metab*. 2012; 97(4):1153–1158
14. Francis R, Aspray T, Fraser W, Gittoes N, Javaid K, MacDonald H et al. Vitamin D and bone health: A practical clinical guideline for patient management. National Osteoporosis Society [Internet]. 2013 Available from: <http://www.nos.org.uk/document.doc?id=1352>

15. CMACE/RCOG Joint guideline on management of women with obesity in pregnancy [Internet] 2010 Available from: <http://www.rcog.org.uk/womens-health/clinicalguidance/management-women-obesity-pregnancy> [Accessed 27 April 2014]
16. Aasheim, ET., Hofsvø, D., Hjelmæsæth, J., Birkeland, KI. and Bøhmer, T. (2008b) Vitamin status in morbidly obese patients: a cross-sectional study. *The American Journal of Clinical Nutrition*, 87, pp. 362-369.
17. Ernst B, Thurnheer M, Schmid SM, Schultes B. Evidence for the Necessity to systematically assess micronutrient status prior to bariatric s-Surgery. *Obes Surg*. 2009; 19(1): 66-73.
18. De Luis DA, Pacheco D, Izaola O, Terroba MC, Cuellar L, Cabezas G. Micronutrient status in morbidly obese women before bariatric surgery. *Surg Obes Relat Dis*. 2013; 9(2): 323-328.
19. Lefebvre P, Letois F, Sultan A, Nocca D, Mura t, Galtier F. Nutrient deficiencies in patients with obesity considering bariatric surgery: A cross-sectional study. *Surg Obes Relat Dis*. 2014; 10: 540–546.
20. Grace C, Vincent R, Aylwin SJ. High prevalence of vitamin D insufficiency in a United Kingdom urban morbidly obese population: Implications for testing and treatment. *Surg Obes Relat Dis*. 2014; 10: 355-360.
21. Elkins G, Whitfield P, Marcus J, Symmonds R, Rodriguez J, Cook T. Noncompliance with behavioural recommendations Following Bariatric Surgery. *Obes Surg*. 2005; 15(4): 546-551.
22. Sarwer DB, Wadden TA, Moore RH, Baker AW, Gibbons LM, Raper SE et al. Preoperative eating behaviour, postoperative dietary adherence, and weight loss after gastric bypass surgery. *Surg Obes Relat Dis* 2008; 4(5):640-646.
23. Sarwer DB, Dilks RJ, West-Smith L. Dietary intake and eating behaviour after bariatric surgery: threats to weight loss maintenance and strategies for success. *Surg Obes Relat Dis* 2011; 7(5):644-651.
24. Aarts EO, Janssen IMC, Berends FJ. The Gastric Sleeve: Losing weight as fast as micronutrients? *Obes Surg*. 2011; 21: 207-211.
25. Damms-Machado A, Friedrich A, Kramer KM, Stingel K, Meile T, Küper MA et al. Pre- and postoperative nutritional deficiencies in obese patients undergoing laparoscopic sleeve gastrectomy. *Obes Surg*. 2012; 22(6): 881-889.
26. British Obesity and Metabolic Surgery Society. Commissioning guide: Weight assessment and management clinics (tier 3). [Internet]. 2014 Available from: <http://www.bomss.org.uk/wp-content/uploads/2014/04/Commissioning-guide-weight-assessment-and-management-clinics-published.pdf>
27. Apovian CM, Cummings S, Anderson W, Borud L, Boyer K, Day K et al. Best Practice Updates for multidisciplinary care in weight loss surgery. *Obesity* 2009; 17: 871-89. doi:10.1038/oby.2008.580. [Internet]. Available from: <http://onlinelibrary.wiley.com/store/10.1038/oby.2008.580/asset/oby.2008.580.pdf?v=1&t=hkci74du&s=ec124201a65701c9436948e1323b4c95f10f76e3>
28. Colles SL, Dixon JB, Marks P, Strauss BJ, O'Brien PE. Preoperative weight loss with a very-low-energy diet: quantitation of changes in liver and abdominal fat by serial imaging. *Am J Clin Nutr*. 2006; 84: 304-11.
29. Baldry EL, Leeder PC, Idris IR. Pre-operative dietary restriction for patients undergoing bariatric surgery in the UK: observational study of current practice and dietary effects. *Obes Surg*. 2014; 24:416-421
30. Marceau P, Biron S, Hould F-S, Lebel S, Marceau S., Lescelleur O et al. Duodenal switch: long-term results. *Obes Surg*. 2007; 17(11): 1421-1430.
31. Skroubis G, Sakellaropoulos G, Pougouras K, Mead N, Nikiforidis G, Kalfarentzos F. Comparison of nutritional deficiencies after roux- en-y gastric bypass and after biliopancreatic diversion with roux-en-y gastric bypass. *Obes Surg*. 2002; 12(4): 551-558.
32. Dolan K, Hatzifotis M, Newbury L, Lowe N, Fielding G. A clinical and nutritional comparison of biliopancreatic diversion with and without duodenal switch. *Ann Surg*. 2004; 240: 51-56.

33. Cable CT, Colbert CY, Showalter T, Ahluwalia R, Song J, Whitfield P et al. Prevalence of anaemia after roux-en-y gastric bypass surgery: what is the right number? *Surg Obes Relat Dis.* 2011; 7(2): 134-139.
34. Aasheim ET, Sjøvik T, Bakke EF. Night blindness after a duodenal switch. *Surg Obes Relat Dis.* 2008; 4(5): 685-686.
35. Slater GH, Ren CJ, Siegel N, Williams T, Barr D, Wolfe B et al. Serum fat-soluble vitamin deficiency and abnormal calcium metabolism after malabsorptive bariatric surgery. *J Gastrointest Surg.* 2004; 8(1): 48-55.
36. Aasheim ET, Johnson LK, Hofsø D, Bøhmer T, Hjelmæsæth J.(2012) Vitamin status after gastric bypass and lifestyle intervention: a comparative prospective study. *Surg Obes Relat Dis.* 2012; 8(2):169-175.
37. Eckert MJ, Perry JT, Sohn VY, Boden J, Martin M., Rush RM et al. Incidence of low vitamin A levels and ocular symptoms after roux-en-y gastric bypass. *Surg Obes Relat Dis.* 2010; 6(6): 653-657.
38. Gletsu-Miller N, Broderius M, Fredian JK, Zhao VM, Griffith DP, DavisSS, Sweeney JF, Lin E, Prohaska JR, Ziegler TR. Incidence and prevalence of copper deficiency following roux-en-y gastric bypass surgery. *International Journal of Obesity.* 2012; 36: 328–335
39. Fischer PWF, Giroux A, L'Abbe MR. Effect of zinc supplementation on copper status in adult man. *Am J Clin Nut.* 1984; 40: 743-746.
40. Willis MS, Monaghan SA, Miller ML, McKenna RW, Perkins WD, Levinson BS et al. Zinc-induced copper deficiency. *Am J Clin Pathol.* 2005; 123: 125-131.
41. Rowin R, Lewis SL. Copper deficiency myeloneuropathy and pancytopenia secondary to overuse of zinc supplementation. *J Neurol Neurosurg Psychiatry.* 2005; 76: 750-751.
42. Zofkova I, Kancheva RL. The relationship between magnesium and calciotropic hormones. *Magnesium Res* 1995; 8:77-84
43. Dixon JB, Zimmet P, Alberti KG, Rubino F; International Diabetes Federation Taskforce on Epidemiology and Prevention. Bariatric surgery- An IDF statement for obese type 2 diabetes *Diabet Med.* 2011; 28(6):628-42.
44. American Diabetes Association. Standards of medical care in diabetes. *Diabetes Care.* 2014; 37 (1): S14-S80
45. Dhatariya K, Flanagan D, Hilton L, Kilvert A, Levy N, Rayman G et al. Management of adults with diabetes undergoing surgery and elective procedures: improving standards.). [Internet]. 2011 Available from: http://www.diabetes.org.uk/About_us/What-we-say/Improving-diabetes-healthcare/Management-of-adults-with-diabetes-undergoing-surgery-and-elective-procedures-improving-standards/
46. Chikunguwo SM, Wolfe LG, Dodson P, Meador JG, Baugh N, Clore JN et al. Analysis of factors associated with durable remission of diabetes after Roux-en-Y gastric bypass. *Surg Obes Relat Dis.* 2010; 6(3):254-9.
47. DiGiorgi M, Rosen DJ, Choi JJ, Milone L, Schrope B, Olivero-Rivera L, Restuccia N, Yuen S, Fisk M, Inabnet WB, Bessler M. Re-emergence of diabetes after gastric bypass in patients with mid- to long-term follow-up. *Surg Obes Relat Dis.* 2010; 6(3):249-53.
48. Brolin RE, Gorman JH, Gorman RC, Petschenik AJ, Bradley LB, Kenler HA et al. Prophylactic iron supplementation after roux-en-y Gastric Bypass. *Arch Surg.* 1998; 133: 740-744
49. Brolin RE, Gorman JH, Gorman RC, Petschenik AJ, Bradley LJ, Kenler HA et al. Are Vitamin B12 and folate deficiency clinically important after roux-en-y gastric bypass? *Journal of Gastrointestinal Surgery.* 1998; 2: 436-442.
50. Skroubis G, Sakellaropoulos G, Pougouras K, Mead N, Nikiforidis G, Kalfarentzos F. Comparison of nutritional deficiencies after roux- en-y gastric bypass and after biliopancreatic diversion with roux-en-y gastric bypass. *Obes Surg.* 2002; 12(4): 551-558.
51. Gudzone KA, Huizinga MM, Chang H-Y, Asamoah V, Gadgil M, Clarke JM. Screening and diagnosis of micronutrient deficiencies before and after bariatric surgery. *Obes Surg.* [Internet], 21March 201, DOI 10.1007/s11695-013-03919-x. Available from: www.link.springer.com [Accessed 23 March 2013]

52. Majumder S, Soriano J, Cruz AL, Dasanu CA. Vitamin B12 deficiency in patients undergoing bariatric surgery: preventive strategies and key recommendations. *Surg Obes Relat Dis.* 2013; 9:1013–1019
53. Saif T, Strain GW, Dakin G, Gagner M, Costa R, Pomp A. Evaluation of nutrient status after laparoscopic sleeve gastrectomy 1, 3, and 5 years after surgery. *Surg Obes Relat Dis.* 2012; 8(5): 542-547.
54. Balsa JA, Botella-Carretero JJ, Gómez-Martín JM, Peromingo R, Arrieta F, Santiuste C et al. Copper and zinc serum levels after derivative bariatric surgery: differences between roux-en-y gastric bypass and biliopancreatic diversion. *Obes Surg.* 2011; 21(6): 744-750.
55. Gong K, Gagner M, Pomp A, Almahmeed T, Bardaro SJ. Micronutrient deficiencies after laparoscopic gastric bypass: recommendations. *Obes Surg.* 2008; 18: 1062-1066
56. Malone M, Alger-Mayer S, Lindstrom J, Bailie JR. Management of iron deficiency and anaemia after roux-en-y gastric bypass surgery: An observational study. *Surg Obes Relat Dis.* 2013; 9: 969–974
57. Aasheim ET, Bjorkman S, Sjøvik TT, Engstrom M, Hanvold SE, Mala T et al. Vitamin status after bariatric surgery: a randomized study of gastric bypass and duodenal switch. *The American Journal of Clinical Nutrition* 2009; 90: 15-22.
58. Traber MG, Jialal I. Measurement of lipid-soluble vitamins-further adjustment needed? *The Lancet* 2000; 355: 2013-4
59. Food Standards Agency. Safer upper limits for vitamins and minerals. Expert group on vitamins and minerals. 2003. 1st ed. London, Foods Standards Agency
60. Aasheim ET. Wernicke encephalopathy after bariatric surgery. *Ann Surg.* 2008; 248: 714-720
61. National Institute for Health and Clinical Excellence. NICE CG32 Nutrition support in adults [Internet] 2006. Available from: <http://www.nice.org.uk/nicemedia/live/10978/29979/29979.pdf>. [Accessed 17 February 2013]
62. Stroh C, Meyer F, Manger T. Beriberi, a Severe Complication after Metabolic Surgery – Review of the Literature. *Obes Facts* 2014; 7: 246–252
63. Rahman S, Scobie AI, Elkalaawy M, Bidlake LE, Fiennes AG, Batterham RL. Can glucose make you faint? *Lancet* 2008; 372: 1358.
64. Scientific Advisory Committee on Nutrition. Folate and disease prevention. Food Standards Agency and the Department of Health (2006). The Stationery Office. London Available from: http://www.sacn.gov.uk/pdfs/folate_and_disease_prevention_report.pdf [Accessed 5th April 2014]
65. National Institute for Health and Clinical Excellence public health guidance 11 Maternal and child nutrition [Internet] 2008. Available from <http://www.nice.org.uk/nicemedia/live/11943/40097/40097.pdf> [Accessed 5th April 2014]