Learning objectives:

- To be familiar with the indications and contraindications for bariatric surgery;
- To understand the principles of various bariatric surgical techniques;
- To get an impression of the routines regarding medical assessment and information prior to bariatric surgery;
- To be familiar with the expected outcomes after bariatric surgery;
- To understand the importance of patients’ attendance to follow-up programs after bariatric surgery;
- To be familiar with the principles of follow-up after bariatric surgery.

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Key Messages:

- Bariatric surgery is associated with long-lasting effects on obesity as well as on obesity-associated morbidity;

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• The number of bariatric surgical procedures performed annually is increasing;
• Bariatric surgical procedures can be divided into purely restrictive, malabsorptive, or combined types;
• In order to achieve optimal results after bariatric surgery, proper preoperative information and medical assessment is mandatory;
• Patients should be followed up life-long after bariatric surgery;
• Long-term outcome after bariatric surgery is related to attendance to follow-up.
1. Introduction

Obesity is a multifactorial disease with an increasing incidence, particularly in the western world. Its co-morbidities such as type 2 diabetes, hypertension, dyslipidaemia, joint disorders and significant reduction in health related quality of life constitute a health problem with major medical, socio-psychological as well as economic consequences. In order to acknowledge the fact that the epidemic of obesity affects developed as well as developing countries, the term “globesity” has been introduced. According to WHO, in 2008 1.4 billion adults were overweight and approximately 500 million obese (200 million men and 300 million women).

Primary treatment for obesity should include lifestyle changes such as exercise and diet, behavioural modification and/or pharmacological treatment. Unfortunately, many patients experience unsatisfactory results with such conservative treatment modalities. An increasing amount of data demonstrates that bariatric surgery is the only treatment for obesity with documented long-lasting effects not only on obesity itself, but also on associated disease. Moreover, in a large matched-control study comprising more than 4 000 subjects (1), bariatric surgery was demonstrated to be associated with a significant reduction (approximately 30%) in mortality compared to controls who were traditionally treated in primary health care. Obviously, the health-related gains with bariatric surgery should be weighed against the risks associated with the procedure. Most reports after bariatric surgery record losses of 20-30% of preoperative total body weight, corresponding to loss of 50-80% of excess body weight (EBWL) (1).

In parallel with improved results after bariatric surgery, and lower surgery-related morbidity and mortality, the number of surgical procedures for obesity has increased during the past decades, and in 2011, 340 000 procedures were performed worldwide (2).

2. Bariatric Surgical Procedures

Surgical bariatric procedures are traditionally classified as restrictive, malabsorptive, or combined. In restrictive procedures, weight loss is achieved solely by reduced capacity for nutritional intake, whereas in malabsorptive procedures, the effect is induced through bypass of absorptive and secretory areas of the stomach and small intestine. Vertical banded gastroplasty (VBG, Fig. 1), adjustable gastric banding (AGB, Fig. 2), and sleeve gastrectomy (SG, Fig. 3), are purely restrictive procedures whereas biliopancreatic diversion (BPD, Fig. 4), and biliopancreatic diversion with duodenal switch (BPD-DS, Fig. 5), are malabsorptive. In roux-en-Y gastric bypass (RYGB, Fig. 6), a small gastric pouch is connected to the small intestine. The “biliopancreatic limb” (remaining stomach, duodenum and proximal small intestine) is connected via an enteroanastomosis to the alimentary limb 120-150 cm below the gastric pouch. By this means, RYGB combines restriction of food intake with reduction of gastrointestinal absorptive area. Although RYGP is still the most commonly performed bariatric surgical procedure performed today worldwide, the number of sleeve gastrectomies is increasing and approaching the volumes encountered for RYGB (2). Nutritional deficiencies are more prone to occur after malabsorptive compared to restrictive procedures. In turn, weight loss is most commonly reported to be less after gastric banding/VBG than with RYGB or BPD/BPD-DS. Therefore, purely restrictive procedures are seldom recommended in subjects with a BMI > 45kg/m².
Fig 1. Vertical banded gastroplasty.

Fig 2. Adjustable gastric banding.

Fig 3. Sleeve gastrectomy.

Fig 4. Biliopancreatic diversion (BPD).

Fig 5. Biliopancreatic diversion with duodenal switch (BPD-DS).

Fig 6. Roux-en-Y gastric bypass (RYGB).
3. Pre-operative Medical Assessment

3.1. Indications

Today, bariatric surgery is indicated in patients with
1) Body mass index (BMI) > 40 kg/m² or
2) BMI > 35 kg/m² in the presence of co-morbidity in which surgically induced weight loss could be expected to improve the disorder (i.e. type 2 diabetes, dyslipidaemia, cardiovascular disease and joint disease)

3.2. Contraindications

Contraindications for bariatric surgery include factors such as:
- No proof of earlier serious attempts to lose weight by conservative means
- Patients who could not be expected to participate in medical follow-up
- Severe psychiatric disorders such as severe depression or binge-eating disorder
- Psycho-social factors expected to reduce the possibility of successful compliance with postoperative regimens
- Condition(s) with unacceptable high risk of postoperative complications.

3.3. Preoperative Assessment

All patients evaluated for bariatric surgery should undergo a standard routine preoperative assessment, as for any other major abdominal surgical procedure. In addition, a specific comprehensive multidisciplinary assessment should be undertaken. For general assessment, preoperative evaluation should concentrate on identifying factors which could increase the risk of intra- or postoperative complications. These include:
- Cardiovascular system, e.g.
- History of ischaemic heart disease
- Earlier thromboembolic events including transitory ischemic attack or stroke
- Uncontrolled hypertension
- Metabolic disease, in particular uncontrolled type 2 diabetes mellitus
- Liver disease; other than uncomplicated Non-Alcoholic Fatty Liver Disease (NAFLD)
- Earlier abdominal surgery with risk of postoperative adhesions which might complicate laparoscopic surgery

In addition to routine preoperative assessment and depending on what procedure is planned, further assessment should be considered in order to exclude:
- Sleep apnoea syndrome (OSAS)
- Gastro-oesophageal disorders (e.g. gastro-oesophageal reflux. H.pylori, intestinal metaplasia with dysplasia)

Blood sampling should, as a minimum, include assessment of haemoglobin, blood glucose (HbA1c in diabetics), liver enzymes, and albumin. An ECG should be performed in all patients with a history of cardiovascular disease, including those with controlled hypertension.

The multidisciplinary team responsible for assessment prior to bariatric surgery should include:
- Internist (physician with experience in obesity, metabolic medicine and nutrition)
- Bariatric surgeon
- Anaesthetist
- Dietician
- Specialist nurse
- Psychologist/Psychiatrist

The management prior to bariatric surgery aims to ensure:
- that patients are well informed regarding the realistic expected outcomes in terms of weight change, and effect on co-morbidities as well as the risks of complications
- that the patients' co-morbidities are optimized in order to minimize the risk of the surgical procedure
- that the patient is well informed regarding necessary postoperative adherence to dietary recommendations/restrictions as well as to other parts of the follow-up
- that the patient is motivated and willing to adhere to dietary recommendations/restrictions as well as to other parts of the follow-up

4. Postoperative Follow-up

Morbid obesity should be considered as a life-long disease, also after bariatric surgery. Strict adherence to follow-up programs is mandatory in order to achieve sustained weight loss and good general health. The physician and surgeon are responsible for providing long- as well as short-term follow-up programs for bariatric surgical patients.

4.1. Short-term Follow up

In the short term, patients must have 24-hour access to emergency service provided by the operating centre. Necessary facilities in order to evaluate patients who present with symptoms suggestive of postoperative complications such as anastomotic leakage, bleeding, infections, thromboembolic events or bowel obstruction should be available as well as the competence and equipment to perform acute laparoscopy/laparotomy if considered necessary. Typical symptoms include abdominal pain, tachycardia, fever, nausea/vomiting or respiratory distress. Blood should be sampled for acute phase proteins (CRP), leucocytes, haemoglobin and serum liver tests. If acute surgical intervention is not considered necessary, upper endoscopy/GI X-ray and/or CT might be chosen as first diagnostic tools.

With increasing use of minimally invasive surgical techniques for bariatric surgery in combination with higher case volumes, mortality and morbidity rates have improved. In 2012 annual report of the Scandinavian registry for bariatric surgery (3) the mortality rate at 30-days following bariatric surgery, mainly RYGB, of 7 900 patients was reported at 0.05% (SOREg). The rates for any complication and severe complication with need for operative reintervention were 7 and 3 %, respectively.

4.2. Long-term Follow up

4.2.1. General

The outcome after bariatric surgery is, among other factors, dependent on the patient’s compliance with long-term follow-up. Sustained weight loss as well as other treatment effects are improved in patients who attend support groups after bariatric surgery, in particular after RYGB and variable gastric banding. Patients should be repeatedly informed regarding the recommended nutritional intake - depending on the procedure they underwent and the time elapsed after the operation. In general, information should be given regarding:
- appropriate size of, and time intervals between, meals
- proper intake of protein to preserve lean body mass
- avoidance of simple carbohydrates in order to prevent dumping syndrome
- the beneficial health effects associated with regular physical exercise

In the long run, particular care should be taken in order to avoid nutritional deficiencies such as for proteins, vitamins and micronutrients. Deficiencies are uncommonly seen after restrictive procedures.
4.2.2. Follow up Recommendations after RYGB:

- Check-up should be performed after 1-1.5 months, every 6 months for the first year, and thereafter annually.
- Weight and general medical history should be documented
- In order to compensate for the possible reduced intake and/or absorption, oral vitamin and micronutrient supplements should routinely be prescribed:
  - Multivitamin daily
  - Vitamin B12 (350-600 mg daily)
  - Calcium citrate (1.5 g/d)
  - Vitamin D (800 i.u./d)
  - Iron (100 mg ferrous sulphate/d) (in menstruating women)

- Laboratory tests should be carried out annually in order to evaluate the metabolic and nutritional status including haemoglobin, electrolytes, liver function tests, creatinine, vitamin B12 (cobalamin), 25-OH vitamin D3, glucose, HbA1c (if diabetes)
- If deficiencies are encountered, corrections need to be undertaken by oral or, if necessary, parenteral administration.
- Despite comparable advice, in a long-term follow-up (mean 12 yr) after gastric bypass comprising 131 patients, vitamin B12 deficiency was reported in 2%, low serum iron concentration in 19%, and folate deficiency in 8% (4). Moreover, adherence to check-ups was low; only 38% of patients reported that they had attended RYGB-related check-up yearly.

4.2.3. Follow up Recommendations after AGB:

- The same general rules for follow-up as for RYGB should be adhered to, with the exception that only multivitamin supplementation needs to be prescribed routinely adding other agents only if deficiencies are actually encountered.
- Regular band adjustments need to be performed according to the individual patient weight progression and the type of band implanted.

4.2.4. Follow up Recommendations after Gastric Sleeve Resection:

- The same general rules for follow-up as for RYGB should be adhered to, and again only multivitamin supplementation needs to be prescribed routinely unless other deficiencies are encountered.

4.2.5. Follow up Recommendations after Malabsorptive Procedures:

- The same general rules for follow-up should be adhered to, but in addition:
- Laboratory checkups for: parathyroid hormone (PTH), bone alkaline phosphatase, ferritin, transferrin, pre-albumin, prothrombin time
- Urine examination (dipstick) for proteinuria
- Minimum advised protein intake of approximately 90 g/day
- In case of excessive bloating, flatulence and/or foul-smelling stools, recommended treatments include oral neomycin, metronidazole and/or pancreatic enzymes.

4.2.6. Diabetes:

For patients with type 2 diabetes, adjustment or cessation of antidiabetic treatment should be supervised by health professionals, with particular emphasis on avoidance of hypoglycaemia. In case of postprandial and possibly hypoglycaemic symptoms, low blood glucose concentrations should be looked for. Long-term continuous blood glucose monitoring might be necessary in order to evaluate the situation. If the presence of postprandial hypoglycaemia is confirmed, patients should be advised to avoid
carbohydrates (strict low-carb, high fat diet might be necessary). If symptoms do not subside, pharmacologic treatment with acarbose, calcium channel antagonists or octreotide might be considered.

5. Clinical Outcome after Bariatric Surgery

Clinical outcomes after bariatric surgery vary between the different procedures as well as between individuals. As stated above, adherence to follow-up and compliance with post-op recommendations influence long-term effects, and therefore individual outcome might be difficult to predict. In the following section, an overview of reported effects on various outcome factors is given.

5.1. Weight Loss

Reported weight loss after bariatric surgery varies according to the procedure performed. Weight loss usually reaches its maximum 12-18 months postoperatively, after which some weight regain is usually seen. RYGB is reported to result in more pronounced weight loss than AGB in most studies (5). Adherence to follow up seems to be more important for sustained weight loss after AGB than after the other techniques. At 36 months weight loss after RYGB and SG has been reported to be similar (6), but long-term data for the latter are still lacking. Ten-year total body weight reduction is in the region of 25% after RYGB and 13% for AGB (1). BPD results in more pronounced weight reduction but higher complication rates than RYGB, with similar effects on QoL and comorbidities (7,8).

5.2. Diabetes

Obesity is by itself an independent risk factor for diabetes, and bariatric surgery might improve or resolve diabetes by inducing weight loss. Interestingly, improvement of diabetes and glucose control occurs long before significant weight loss is present, suggesting that other mechanisms are involved. For RYGB and BPD such mechanisms has been demonstrated to involve improved insulin sensitivity, increased insulin production, altered release of incretin and satiety gut hormones, altered bile flow and elevated energy expenditure (9). Remission rates after BPD and RYGB are reported to be higher than after similar weight loss from AGB (10). SG has similar effect on improvement of diabetes in the short term as RYGB, again by yet not fully defined mechanisms (11).

The remission of diabetes might however be transient with relapse some years postoperatively (12). However, retrospective data show that at 9 years after RYGB 65% of patients still had reduced rates of medical treatment for diabetes (13). Predictors for high remission rates after bariatric surgery include short prior duration of diabetes, no need for insulin and lower HbA1c concentrations (14).

Due to their more pronounced effect in terms of diabetes remission, RYGB and SG might be considered as “first choice” for patients with diabetes. Although complete remission will not be seen in all patients, improvements in glucose control and reduced need for medical treatment can be expected for the vast majority of patients with diabetes undergoing these forms of bariatric surgery. Emerging data also suggest that bariatric surgery might have beneficial effects on microvascular complications such as markers of kidney damage (microalbuminuria) and kidney function (glomerular filtration) in patients with diabetic kidney disease (15).

5.3. Cardiovascular Disease

As for diabetes, obesity increases the risk of cardiovascular disease (16). In studies with long-term follow up, such as the Swedish SOS study, bariatric surgery is associated with a reduced cardiovascular mortality and morbidity in the region of 50% over time.
compared to controls matched for initial BMI and age (17). Although not defined in detail, possible mechanisms include improved glucose control, blood lipid profile and systemic blood pressure. Cardiac function has also been demonstrated to be improved up to 3 years after surgery (18). The role of a change in physical activity for the improvement of cardiovascular health seems however uncertain, since increased physical activity is not a consistent finding after bariatric surgery (19).

5.4. Fertility and Gonadal Function

In women, obesity is associated with increased rates of polycystic ovary syndrome (PCOS), ovulatory disturbances and increased risk of spontaneous abortion and other maternal as well as foetal complications during pregnancy and delivery (20). Bariatric surgery has been shown to be associated with reduced hyperandrogenism in patients with PCOS and improved ovulatory function (21). Therefore, PCOS has been suggested as a factor strengthening the indication for bariatric surgery in women with morbid obesity. Weight loss is also recognized to be associated with reduced materno-foetal risk (22), but no controlled data regarding the specific risk reduction after bariatric surgery are available.

In men, obesity is associated with reduced testosterone levels, erectile dysfunction, and reduced sperm count and function (23, 24). There are no prospective controlled data as to the effects on male fertility of bariatric surgery, although increased serum testosterone concentrations have been reported (25). Paradoxically, this was associated with deterioration in sperm quality (26).

5.5. Kidney Function

The prevalence of Chronic Kidney Disease (CKD) is increased in patients with obesity independently of concurrent diabetes, hypertension and dyslipidaemia (27). Bariatric surgery has been demonstrated to increase urine output and sodium excretion postoperatively in rats (28) and humans (29), as well as to improve urinary and systemic inflammatory markers in obese patients (30). In a retrospective pilot study markers of CKD (including urinary albumin creatinine ratio (ACR) and estimated glomerular filtration rate (GFR)) improved significantly after surgery (31). Mingrone et al showed in a prospective study that not only did markers of kidney damage such as proteinuria improve 10 years after surgery, but kidney function as measured by GFR was preserved in comparison to the progressive deterioration in both kidney damage and kidney function in a matched cohort of patients receiving best medical care without surgery (15). Schauer et al confirmed that 6 years after best medical therapy combined with RYGB in patients with CKD there were sustained reductions in microalbuminuria (32). Thus, available data strongly suggests that bariatric surgery might have the potential to improve kidney damage as well as kidney function in patients with CKD. However, since controlled data are lacking, it is not known whether these beneficial effects outweigh the possible increased risk of postoperative complications in patients with reduced kidney function.

5.6. Liver

Obesity is associated with liver disease such as Non-Alcoholic Fatty Liver disease (NAFLD), Non-Alcoholic SteatoHepatitis (NASH), liver fibrosis, and cirrhosis (33). Some reports suggest that various aspects of obesity-related liver disease improve after bariatric surgery, in particular histological appearances, but also regression of established liver disease (34). However, rapid weight loss, such as after bariatric surgery might reduce liver function and induce or worsen established liver disease, putatively through toxic effects of free fatty acids which accumulate in the liver. Therefore, the decision regarding bariatric surgery in patients with liver disease should be taken in
collaboration with hepatologists in order to consider the risk-benefit relationship and to establish plans for follow-up postoperatively.

### 5.7. Self-reported Quality of Life (QoL)

Improvement in perceived health status should be considered as one of the most important goals for all medical interventions. Patients with severe obesity are known to report poor Quality of Life (QoL) and health perception (35). Patients with obesity-associated comorbidities such as sleep apnoea, diabetes, hypertension and/or dyslipidaemia seem to score lower compared to those without (3). Moreover, female patients with obesity score lower than males. After bariatric surgery QoL scores at one year are improved for physical as well as mental domains, with effects lasting up to ten years postoperatively (35). Postoperative improvements have been reported in males as well as females and the preoperative gender-difference seems to be reduced after surgery (3). The improvement has been reported to be related to degree of weight loss with a greater effect after RYGB than after AGB (36).

### 6. Summary

The number of bariatric surgical procedures performed for morbid obesity is continuously increasing in parallel with the “epidemic of obesity”. In 2011, 340 000 operations were performed worldwide. Various surgical techniques are available with specific advantages as well as shortcomings. Bariatric surgery has been shown to result in long-lasting beneficial effects on obesity, co-morbid disease and mortality. However, bariatric surgery involves a major abdominal surgical procedure with the risk of serious complications such as anastomotic leakage, bleeding, thromboembolic events, and infection. Patient selection as well as preoperative medical assessment are crucial in order to improve results after bariatric surgery. A multidisciplinary team should collaborate in the preoperative setting with emphasis on information and medical assessment. Risk factors for poor postoperative outcome such as undetected hypertension, cardiac disease, suboptimal glucose control or sleep apnoea should be identified and controlled/optimized prior to surgery. Ultimately the outcome after bariatric surgery in terms of sustained weight loss and the resolution of comorbidities is dependent on the patient’s strict adherence to a life-long follow up programme.

### 7. References


