Gastric Bypass

Facilitating the Procedure and Long-term Results

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Abstract

Gastric bypass achieves weight loss in the morbidly obese. Preoperative weight loss is used to reduce the enlarged fatty liver that otherwise reduces visibility during surgery. The purpose of gastric bypass is to provide patients with long-term weight loss. The aim of this thesis was to investigate the result of preoperative low calorie diet on liver volume and to evaluate the long-term result of gastric bypass.

Paper I showed that four weeks of low calorie diet reduces intrahepatic fat by 40% and facilitates surgery mainly through improved visualisation. Paper II demonstrated that all of the reduction of liver volume occurs during the first two weeks of treatment with low calorie diet. In paper I liver volume was reduced by 12% and in paper II by 18%. Paper III focused on long-term results and showed that gastric bypass achieves a mean 63% excess body mass index loss in obese patients after 11 years. However, of these 40% undergo abdominoplasty and 2% require additional bariatric surgery. Only 24% adhere to the lifelong recommendation on multivitamins and 72% to Vitamin B12 recommendations. Paper IV evaluated gastric bypass as a revisional procedure after earlier restrictive surgery had failed. Similar weight results as after primary gastric bypass are attained. No patient taking vitamin B12 supplementation was deficient at follow-up, regardless of whether the vitamin was taken as a pill or as intramuscular injections.

Keywords: Morbid obesity, Gastric bypass, Laparoscopy, Low-calorie diet, Magnetic resonance imaging, Magnetic resonance spectroscopy

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Abbreviations

BMI  Body mass index
CT   Computed tomography
DS   Duodenal switch
EBMIL Excess body mass index loss
EWL  Excess weight loss
FDA  United States food and drug administration
FTO  Fat mass and obesity-associated protein
GB   Gastric banding
HDL  High density lipoprotein
HGP  Horizontal gastroplasty
HRQoL Health related quality of life
JIB  Jejunoileal bypass
LCD  Low calorie diet
LRYGB Laparoscopic Roux-en-Y gastric bypass
MRI  Magnetic resonance imaging
MRS  Magnetic resonance spectroscopy
NAFLD Non-alcoholic fatty liver disease
rRYGB Revisional Roux-en-Y gastric bypass
RYGB Roux-en-Y gastric bypass
SBU  Statens beredning för medicinsk utvärdering, Swedish Council on Health Technology Assessment
SLR  Staple line rupture
SOS  Swedish Obese Subjects
VBG  Vertical banded gastroplasty
VLCD Very low calorie diet
Introduction

Obesity is a consequence of consuming more energy than expended. Fast food chains with extended opening hours and energy dense ready-made meals have allowed people access to food and calories in an unprecedented way. This energy rich diet combined with modern work being less physically demanding has gradually led to a more overweight population. The obesity epidemic has spread and for some years obesity has been responsible for more deaths worldwide than undernourishment according to the World Health Organization (1).

Various surgical procedures to treat obesity have been tried. In 1966 in the USA Dr. Edward Mason developed Roux-en-Y gastric bypass (RYGB) (2) which has become the most common bariatric procedure in Sweden (3). About 250 RYGB procedures were performed in Sweden in the year 2000; since the benefits of bariatric surgery have become more established (4), the number of procedures has increased and 7900 RYGB procedures were performed in Sweden in 2012 (3). During the same period laparoscopic bariatric surgery gained acceptance and currently more than 97% of all gastric bypass procedures in Sweden are performed laparoscopically (3).

One of the most common causes for conversion from laparoscopic surgery to open surgery is an enlarged liver (5). In study I and II we have studied preoperative weight loss as a mean to reduce liver volume.

Undoubtedly RYGB induces weight loss; however many of the earlier restrictive types of bariatric procedures led to weight regain a few years after surgery. To gain knowledge about the long-term results after RYGB study III was conducted involving patients followed for at least six years after RYGB.

Occasionally bariatric surgery fails and causes either intolerable side-effects or unsatisfactory weight loss. After earlier restrictive surgery has failed RYGB was performed as a revisional procedure (rRYGB) and long-term results in this situation were explored in study IV.
Background

Definition

The most commonly used measurement to define obesity is body mass index (BMI). A patient’s BMI is calculated by dividing body mass in kilograms by the square of the patient’s height in meters and expressed in kg/m². A BMI of 18.5-25 kg/m² is considered normal. In Table 1 grades of obesity are defined.

Table 1 - Grading of obesity (6)

<table>
<thead>
<tr>
<th>BMI (kg/m²)</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>18.5-24.9</td>
<td>Normal weight</td>
</tr>
<tr>
<td>25.0-29.9</td>
<td>Overweight,</td>
</tr>
<tr>
<td>30.0-34.9</td>
<td>Obese, class 1 obesity</td>
</tr>
<tr>
<td>35.0-39.9</td>
<td>Severely obese, class 2 obesity</td>
</tr>
<tr>
<td>40.0-49.9</td>
<td>Morbidly obese class 3 obesity</td>
</tr>
<tr>
<td>50.0-</td>
<td>Superobese</td>
</tr>
</tbody>
</table>

Abbreviations: BMI= Body mass index

BMI as a measure of obesity has certain limitations. One limitation concerns body composition; BMI does not discriminate fat tissue from muscle tissue. Thus, highly muscular persons can attain a high BMI without having surplus fat. Furthermore BMI is less suitable in children and the elderly. One advantage of BMI is that only the weight and height of a patient is required to calculate BMI. This makes it a swift evaluation with equipment already available at most clinics. BMI is therefore a good way to assess and describe how obesity rates change in a population.

Alternative ways to define obesity such as waist-to-hip ratio, waist circumference or abdominal sagittal diameter have been proposed. It is known that visceral fat is associated to a higher risk of developing cardiovascular disease (7). However, there is conflicting evidence as to which measure best predicts who will benefit from bariatric surgery, for instance insulin or glucose levels may be a better measure than BMI to decide who will benefit most from bariatric surgery (8). Thus, due to its radical improvements of met-
abolic status RYGB can be regarded not as only a bariatric procedure but as a form of metabolic surgery.

In the literature on bariatric surgery weight loss is reported in several different ways. Besides reporting the exact number of kilos lost it is often of interest to state the amount of weight lost in relation to the initial weight of the patient. There are at least three common ways to report this. First, percent total weight lost is lost weight (kg) divided by initial weight (kg); this measure is used by many endocrinologists to report weight results, e.g. in the Swedish obese subjects study (4). Second, excess weight loss (%EWL) is commonly used by bariatric surgeons; excess weight is defined as all weight above the ideal weight for that height. Metropolitan Life Insurance Company assessed the weight for each height that was associated to the lowest mortality rate and published this as Metropolitan Life Tables (9); this weight is regarded as ideal. Third, excess BMI loss (%EBMIL) defines excess BMI as all weight above BMI 25.

When comparing weight results these different ways of reporting weight loss cause some confusion (10). The ideal weight and height according to Metropolitan Life Tables is approximately BMI 22. This means that more weight will be regarded as excessive with %EWL than with %EBMIL. We have chosen primarily to report weight results as %EBMIL because it is straightforward, reproducible and will not change over time as it is based on a mathematic formula.

Etiology

Food and drinks are the source of all obesity. However, genetic and environmental differences explain why people with similar food and exercise habits can have different propensities for gaining weight. The proportion of overweight adults in the US population increased from 25% to 33% from 1976 to 1991. Surprisingly the reported average daily calorie intake, as assessed through national nutrition examination surveys, decreased during that same period (11). A dramatic decrease in total physical activity was thought to explain this difference. Manual labor has been replaced by machinery and physically active modes of transport are continuously being replaced by cars and elevators.

Cessation of smoking also leads to weight gain. About 5 kg on average is gained in patients who stop smoking compared with 2.5 kg of weight gain in patients with no change in smoking status during a five-year period (12). In addition, certain medicines such as antipsychotics and glucocorticoids cause weight gain which is troublesome since these patients often need treatment for long periods (13, 14). Some genes, such as certain variants of the FTO gene, have been associated to obesity (15). Interestingly, studies on adoptees have
suggested that the environment after birth has little effect on weight in adults; the BMI of adopted children is correlated to the BMI of the biological parents, and most strongly to the BMI of the mother, but not to the adoptive parents (16).

Epidemiology

People are becoming more overweight in Sweden, and today it is estimated that 54% of Swedish adult males and 39% of all females are overweight or obese (17). In Swedish males, aged from 30-79, it is more common to be overweight or obese than to be normal weight (17). Obesity in Swedish military conscripts increased from 0.9% to 3.2% from 1970 to 1995 (18). It is estimated that the number of overweight or obese persons were more than 1.4 billion worldwide in 2010 (19).

Risks associated with obesity

Mortality

WHO reports that obesity is responsible for more deaths than undernourishment (1). Numerous studies have shown that having a BMI of 35 or more is associated with a two-fold increase in overall mortality rate (20) and that life expectancy is 6-7 years shorter among obese than among normal weight (21). Class I obesity does not seem to be associated to increased mortality (22).

Cancer

There is compelling evidence that obesity is associated to the development of cancer in the esophagus, pancreas, gallbladder, colorectum, breast (post-menopausal), kidney and endometrium (23). It is estimated that in the US population 14% of all deaths from cancer in men and 20% of those in women can be attributed to overweight or obesity (24). It is uncertain exactly how obesity mediates the development of cancer, but increased estrogen levels from fat tissue is thought to play a part in the increase in breast cancer and endometrial cancer (25).

Diabetes

Some obese individuals become insulin resistant. This means muscle tissue, which normally responds to insulin by transporting glucose into the cells, is less sensitive to insulin. When muscle cells use less glucose, glucose levels in the blood increase. In turn this causes increased insulin production from
beta cells in the pancreas. When the beta cells are unable to increase the insulin production further diabetes ensues. Obesity is strongly associated with type 2 diabetes \( ^{26} \).

**Cardiovascular disease**

Obesity is a risk factor for cardiovascular disease. For men with a BMI of 32 or more the risk of cardiovascular death is increased almost three-fold compared with normal weight men \( ^{27} \). In obesity, hypertension which is associated to cardiovascular disease, is thought to be mediated through multiple factors such as vasoconstriction and sodium retention \( ^{28} \).

**Other diseases**

Other conditions associated to obesity are cholecystolithiasis (gallbladder stones) \( ^{29} \), non-alcoholic fatty liver disease \( ^{30} \), osteoarthritis \( ^{31} \), infertility and psychosocial difficulties \( ^{32} \). Obstructive sleep apnea, a disease with nightly desaturations due to apnea, is also linked to obesity \( ^{33} \). Equally concerning is the low quality of life reported by the severely obese; for instance, the mental well-being of severely obese is worse than that of patients suffering from spinal cord injury \( ^{32} \). Overweight is associated to lower socioeconomic status in developed countries but to high socioeconomic status in low-income countries most likely because the means to afford food is related to high socioeconomic status in low-income countries \( ^{34} \).

**Non-surgical treatments**

**Diets**

Numerous diets available are aimed at the treatment of obesity. LCD or very low calorie diets (VLCD) are products designed to induce weight loss while preserving lean body mass. LCD contains 800-1,100 kcal/day whereas VLCD contains <800 kcal/day. In general the products are rich in protein, typically 70-100 g/day, and based on milk. They include the total recommended intake of essential vitamins and minerals. Different brands are available (Modifast®, Nutrilett®, Allévo®) and most are sold as a powder which is mixed with water and then consumed.

Patients treated with VLCD or LCD as a sole treatment for obesity achieve significant weight loss and some individuals with massive initial weight loss actually maintain some weight loss five years afterwards \( ^{35} \). However, for most patients the weight loss is transient and weight is regained once the treatment is stopped, moreover mean weight loss five years after treatment is moderate (3.0 kg) \( ^{35} \).
Drugs

Extensive research has been performed to develop an effective weight loss drug without severe side effects. The only drug presently registered in Sweden is Orlistat (Xenical® or Alli®), which was approved by United States Food and Drug Administration (FDA) in 2007. Orlistat inhibits gastrointestinal lipase which is necessary to absorb triglycerides in the gut. This inhibition causes a decrease in the absorption of triglycerides which facilitates weight loss. The most common side effect is loose stools and this is caused by non-digested fat reaching the colon. In one study treatment with Orlistat led to a 5.8 kg weight loss compared to 3.0 kg weight loss in the placebo group after 4 years of treatment, both groups underwent lifestyle changes as well (36). This weight loss is moderate considering that the mean weight of a patient undergoing RYGB in Sweden was 124 kg in 2010 (37).

Rimonabant (Acomplia®) is a cannabinoid receptor 1 antagonist that was registered for treatment of obesity. Treatment lead to weight loss but the drug was withdrawn due to side effects such as mood disorders and suicidal thoughts.

Another oral anorexiant, Sibutramine (Reductil®), is a neurotransmitter reuptake inhibitor, related to amphetamines. It induced weight loss but was withdrawn due to cardiovascular side effects. Historically, both amphetamine and ephedrine have been used to induce weight loss during the 20th century.

A new, more effective medical treatment without severe adverse side effects for obesity is highly sought and would be very profitable for the pharmaceutical industry because the number of patients seeking cure is enormous. In 2012 Qsymia®, a combination of phentermine, psychostimulant drug similar to amphetamine, and Topiramate, an anticonvulsant was approved by FDA for treatment of obesity. Qsymia® is not yet approved in the European Union and further studies are needed.

Behavioral therapy

Behavioral therapy has often been assessed in combination with diets or exercise programs. Effects seem moderate in studies and to avoid weight regain the therapy must be continued. When the Swedish Council on Health Technology Assessment (SBU) evaluated different treatments for obesity, no conclusions could be drawn on the effectiveness of behavioral therapy (38).

Prevention

Obesity is evidently a disease which once established is difficult to treat with satisfactory results. The most appealing solution is therefore to prevent obesity from developing. There are randomized clinical trials concerning pre-
vention. In one trial, a population was provided a 6-year weight and cardiovascular risk reduction intervention program through mass media. The population was then compared to a control population and individuals in the treated group gained significantly less weight, 0.57 kg compared to the controls 1.25 kg (39).

Consumption of sugared beverages is linked to obesity and adding a special tax on such beverages has been proposed to reduce soda consumption (40). A ban was passed on sodas larger than 0.5 l sold in restaurants in New York City. However, that ban was overturned by the court (41).

Obesity is correlated to time spent daily in a car and inversely correlated to transport related physical activity (42). If bicycle lanes were to be more common and separated from motorized traffic, it is plausible that more people would leave the car at home. No single intervention seems sufficient in itself to prevent obesity from developing, but if several strong measures were to be taken the obese epidemic might be reduced or stopped.

Surgical treatment

The most common surgical procedure for obesity worldwide is RYGB (43) and accounts for 97% of all bariatric surgery in Sweden (3). During RYGB (Figure 1) a small gastric pouch completely separated from the remnant stomach is created with a cutting stapler device. This gastric pouch is then anastomosed to the Roux limb from the jejunum through a gastro-jejunostomy. Gastric fluid from the remnant stomach and bile is mixed with food through a second anastomosis (enteroanastomosis) to the jejunum. The laparoscopic technique was first described in 1994 by Dr. Alan Wittgrove, in the USA (44) and the technique was later refined by Dr. Hans Lööroth, Sweden (45). RYGB is now performed through laparoscopy (LRYGB) in more than 97% of the cases in Sweden (3).

The mechanism leading to substantial weight loss after RYGB is not entirely known but involves several elements. RYGB has a restrictive component so that patients are not able to eat as much as before surgery because of the small gastric pouch created. Bile facilitates the absorption of fat and because food is not mixed with bile until the enteroanastomosis, fat is poorly absorbed in the proximal part of the small bowel; this could cause a small degree of malabsorption. Moreover, RYGB induces a powerful change in gastrointestinal hormones (46, 47). In diabetics changes in hormones and glucose levels are seen immediately after surgery before any significant weight loss has occurred (48).
Gastric banding (GB) used to be the second most common bariatric procedure, but has lost popularity and is now the third most common \(^{(43)}\). GB involves a silicone band which is placed around the cardia of the stomach creating a small pouch and restricting the amount of food that the patients can eat (Figure 2). Often the width of the band is adjustable through an access port under the skin in which saline solution can be injected or withdrawn. However, the band is a foreign object in the body and erosion of the band is not uncommon \(^{(49)}\). This erosion can cause migration of the band to the inside of the stomach which can cause not only side effects such as vomiting or esophagitis but also permit weight regain \(^{(49)}\).

Vertical banded gastroplasty (VBG) is nowadays an uncommon surgical procedure (Figure 2) in which a small pouch of the cardia of the stomach is created through non-cutting stapler devices and placement of a silastic ring. The silastic ring is placed on the outlet of the created pouch and prevents the outlet from enlarging. Initial weight loss is achieved, but occasionally an opening develops through the staplers between the small pouch and the stomach. This is called a staple line rupture (SLR) and this opening permits food to enter directly into the stomach which leads to weight regain \(^{(50)}\).
Horizontal gastroplasty (HGP) was one of the first purely restrictive procedures used to treat obesity. The stomach was stapled into an upper and a lower part with a small orifice between them. The small orifice made it difficult for patients to eat large amounts of food thus inducing weight loss. The small orifice also induced difficulties swallowing as well as vomiting. In addition, dilatation of the fundus permitting weight regain led the dismissal of this procedure.

Implantable gastric stimulator is a device that has been tried for treatment of obesity. The device was most often implanted through a laparoscopic approach and electrodes were placed at the lesser curvature of the stomach giving electrical impulses to achieve a sensation of satiety. It is no longer used in Sweden due to lack of efficacy (51).

Jejunoileal bypass (JIB) (Figure 3) is a procedure in which most of the small bowel is bypassed. It was common during the 1970s and although leading to weight loss, it has serious side-effects such as polyarthritis, diarrhea, electrolyte abnormalities and renal stones (52). JIB is no longer performed in Sweden (3).
Duodenal switch (Figure 3), also called biliopancreatic diversion with duodenal switch, is a combination of two bariatric procedures, sleeve gastrectomy and a distal Roux-en-Y to the duodenal bulb. The sleeve gastrectomy is restrictive thus preventing patients from eating large amounts of food and the rerouting of the bowels causes malabsorption. Fat is only absorbed in the distal part of the ileum which induces weight loss. Diarrhea is a common side effect from duodenal switch. Although duodenal switch is a more powerful procedure to induce weight loss in superobese (53), some patients suffer from hypoproteinemia postoperatively (54). Duodenal switch patients require lifelong surveillance with regard to nutritional defects.

Sleeve gastrectomy only, i.e. duodenal switch without the malabsorptive rerouting, is becoming more common. In fact, it is globally the second most common bariatric procedure (43). In Sweden, most surgeons are awaiting more long-term results before implementing sleeve gastrectomy as a stand-alone procedure.

The role of preoperative weight loss

Non-alcoholic fatty liver disease is characterized by steatosis of the liver and is present in 30-100% of the obese (30). The pathogenesis is unclear but in-
volves accumulation of fat in hepatocytes possibly mediated through insulin resistance (30). The volume of the liver is increased by fat and in sometimes inflammation and cirrhosis ensues. Magnetic Resonance Spectroscopy (MRS) is a validated method to assess intrahepatic fat (55). Non-alcoholic steatohepatitis is the third most common indication for liver transplantation in the USA and will if the trend continues become the most common cause for transplantation (56).

RYGB requires good exposure of the gastro-esophageal junction and an enlarged left lobe of the liver makes this visualization difficult. It has been shown that preoperative weight loss diminishes liver volume. Colles et al showed that 12 weeks of VLCD reduced liver volume by 19% in obese subjects (57).

Alami et al demonstrated in a randomized controlled trial that preoperative weight loss is associated to a reduction in operative time (58) while Van Nieuwenhove et al found that preoperative weight loss is associated to a decrease in postoperative complications (59). On the other hand, Alami et al found no reduction in complications in the weight loss group and Van Nieuwenhove et al found no reduction in operating time in the weight loss group. Thus findings are somewhat incongruent.

The LCD used in Uppsala is Modifast® (Impolin AB, Danderyd, Sweden) which is a milk-protein based powder. The powder is mixed with water and then consumed. It is available in several flavors and 4-5 sachets are provided daily giving a total daily energy content of 800-1 100 kcal. The cost of 4-5 sachets for consumers is approximately 60 Swedish crowns per day (≈7 €).

Benefits of RYGB and bariatric surgery

Weight loss

The effect of bariatric surgery on obese patients is profound. RYGB provide patients with long-sought after weight loss. Published data state a mean EWL of 80% 12 months after surgery (60) and although some weight gain occur, patients maintain EWL of 43-83% at 5 years (61). Similar results are not seen with non-surgical methods.

Longer life and decreased risk of cancer

Bariatric surgery lowers the mortality rate in obese patients compared with non-operated obese controls (4, 62). Furthermore, most studies show that bariatric patients have a decreased risk of developing cancer in general and cancer of the utero (63, 64) and the breast (65) particularly.
Improved glucose control
RYGB provides improvement for most patients suffering from diabetes type 2 and often complete resolution (66). Both gastric bypass and biliopancreatic diversion give obese patients better glucose control than conventional diabetes-treatment (67).

Improved cardiac health and blood lipids
Bariatric surgery reduces the number of cardiovascular events and cardiovascular deaths (8) and patients undergoing bariatric surgery improve with regard to hypertriglyceridemia as well as HDL (68).

Improved quality of life
Morbidly obese patients who undergo RYGB improve their HRQoL assessed two years after surgery whereas non-operated controls show no improvement (69).

Resolution of other comorbidities
Other illnesses related to obesity such as obstructive sleep apnea improve after bariatric surgery (33). Weight loss improves fertility in the morbidly obese (70) and relieves symptoms from osteoarthritis of the knees (71).

Complications of RYGB and bariatric surgery
Conversion from laparoscopic to open surgery
Although not regarded as a complication per se, all patients planning to undergo LRYGB are informed of the risk of conversion from laparoscopic procedure to open surgery. At present only 1% of LRYGB procedures in Sweden are converted to open surgery (72). One of the most common reasons for conversion to open surgery is an enlarged liver (5). In obese patients fat is deposited in the liver and this causes an enlargement. In order to create the gastric pouch during RYGB it is necessary to visualize the angle of His which is located at the gastro-esophageal junction behind the left lobe of the liver. In patients with abundant fat deposited in the liver such visualization can be difficult.

Furthermore, the instruments used during laparoscopy to lift the left lobe of the liver are not as sturdy as those used during open surgery.
Leakage
Postoperative leakage at the gastro-jejunostomy is a well-known and feared complication. A hole in the gastro-jejunostomy leads to gastric fluid and saliva infecting the abdominal cavity in turn causing sepsis. This condition often requires reoperation with drainage, antibiotics intravenously, several weeks of fasting and parenteral nutrition. In some cases leakage leads to death (73).

Pulmonary embolus
All patients undergoing abdominal surgery are at risk of developing pulmonary embolus. In addition, obesity is a risk factor for thromboembolic disease. In some studies, almost 50% of the postoperative mortality after RYGB is attributed to pulmonary embolus (73). For this reason adequate thrombosis prophylaxis is essential during and after bariatric surgery.

Stomal ulcer
This is an ulcer often located just distal to the gastro-jejunostomy, most commonly observed within weeks after surgery. Often patients suffering from stomal ulcers complain of eating difficulties. In typical cases gastroscopy shows a fibrin coated ulcer. The cause of the ulcer is believed to be acid entering the small bowel (74). Such ulcers are treated with high-dose proton pump inhibitors for a few months and this is generally successful.

Dumping and new eating habits
Dumping, a condition affecting some patients after RYGB is characterized by dizziness, nausea and palpitations after eating. The bypass of most of the stomach after RYGB causes food to reach the small bowel almost immediately after ingestion. The pathogenesis of dumping is not understood but may involve carbohydrate-rich food and hyperosmolarity. Dumping might be prevented by avoiding food rich in carbohydrates and eating drier meals (75). Other gastrointestinal symptoms such as vomiting and difficulties swallowing, commonly seen after other bariatric procedures such as GB, seem rare after RYGB.

The small gastric pouch prevents patients from eating large meals; instead smaller meals are consumed and this is compensated for by eating slightly more often, 5-6 meals/day (76).
Hernias
Hernias are defects in the abdominal wall allowing contents of the abdominal cavity such as bowels to protrude. Incisional hernias are caused by incomplete healing of the abdominal wall and are more common after RYGB than after LRYGB (77), they often require surgical correction.

Internal hernias occur when small bowels protrude through one of the two mesenteric defects produced during RYGB and LRYGB (78, 79). At present, these defects are often closed during surgery (72) but substantial weight loss might cause them to reopen. Untreated hernias can lead to gangrene of the trapped bowel.

Gallstones
Rapid weight loss, regardless of cause, can cause development of gallstones, perhaps due to supersaturation of cholesterol in the bile. Some stone formation can be prevented by medicating with ursodiol for six months after RYGB (80). Some bariatric patients develop gallstones and symptoms from these and later require cholecystectomy.

Excess skin
The massive weight loss induced by RYGB is not always coupled to a retraction in the skin. This can lead to skin folds, often located on the abdomen and may lead to eczema and ulceration. Many patients seek help to surgically reduce this excess abdominal skin, a procedure known as abdominoplasty, reportedly 9-30% of patients undergo abdominoplasty after RYGB (81, 82). There are regional differences in Sweden concerning indications for abdominoplasty performed within the public health care system.

Nutritional deficiencies
Deficiencies are common after RYGB (83) although vitamin supplementation is recommended to all patients. There are several explanations for these deficiencies. Duodenum and the proximal part of the small bowel are bypassed. Iron is predominantly absorbed in the duodenum and the proximal part of the jejunum, both of which are bypassed in RYGB which might induce a deficiency (84). Uptake of vitamin B\textsubscript{12} is facilitated by intrinsic factor, which is produced by the parietal cells in the stomach. After RYGB the remnant stomach undergoes atrophy which diminishes the production of intrinsic factor and could cause deficiency in vitamin B\textsubscript{12} (84). The fact that patients eat less after surgery (76) could also contribute to development of deficiencies. It is unknown how well patients adhere to recommendations regarding supplements.
Aims

The aim of this thesis is to study the effects of preoperative weight loss and long-term results of RYGB.

The specific aims are:

I To study how liver volume and intrahepatic fat is affected by 4 weeks of low calorie diet and to determine whether this preoperative weight loss facilitated LRYGB.

II To study changes in body composition, liver volume and intrahepatic fat during a 4-week preoperative weight loss with focus on the early changes.

III To study the long-term results after RYGB, as a primary bariatric procedure.

IV To study the long-term results after rRYGB, as a revisional bariatric procedure for failed prior bariatric surgery.
Materials and methods

Paper I

Fifteen consecutive women (mean age 34.3 ±7.5 years, weight 121.3 ±13.4 kg and BMI 42.9 ±3.0 kg/m²) scheduled for LRYGB were included in the study. Patients with metal implants or weighing more than 140 kg were excluded because of MR limitations. Magnetic resonance spectroscopy (MRS) was performed at baseline to evaluate intrahepatic fat. MRS was performed using a 1.5 T clinical scanner and liver volume was assessed by two experienced operators using manual segmentation.

All subjects were treated with LCD (Modifast®) during four weeks providing patients with 800-1100 kcal per day. Subjects then underwent MRS as well as LRYGB. During surgery, liver volume, sharpness of liver edge and the thickness of the omentum were evaluated. The surgeon also evaluated the complexity of the surgery on seven parameters (exposure, bleeding, difficulty in dissection, difficulty in reconstruction, need of surgical judgment, technical demand and psychological stress). These parameters received a score from one to five, a score of five indicated that the particular procedure was among the most difficult 20% of all LRYGBs performed by that surgeon. Because the object of this study was to determine whether the most difficult cases would be facilitated, the score was then recoded so that scores of one to three (easy to normal cases) were given zero points, scores of four, one point and, the most difficult cases, with scores of five given two points.

Eighteen other women (mean age 42.2 ±7.1 years, weight 114.4 ±12.3 kg and BMI 40.8 ±3.6 kg/m²), also scheduled for LRYGB, were used as controls. They did not receive LCD and were evaluated identically.
Figure 4 - View of the hiatal region and diaphragm after the left lobe (upper right) has been elevated by an EndoPaddle (upper left). This degree of exposure corresponds to one point (best possible) on the three-graded scoring scale. The stomach is visible as the pink structure in the lower part of the picture surrounded by intra-abdominal fat (yellow).

Paper II

Twelve morbidly obese women awaiting LRYGB were asked to participate. Similar MR limitations as in paper I were applied. Two patients declined due to lack of time.

Weight loss was achieved through LCD as in paper I (Modifast®, Impolin AB, Sweden). Patients were evaluated in the morning of day 0, 3, 7, 14 and 28. To facilitate comparisons between measurements, fluid consumption 12 hours before examination was restricted to a total of 500 ml of water. Patients’ height, weight and resting blood pressure were measured. Blood and morning urine samples were collected.

Body composition was assessed through bioelectric impedance analysis (BIA) (BC-418 Segmental body composition analyzer, Tanita® Corporation, Japan). BIA measures the impedance of the body when an electrical current of low intensity is passed through four leads placed on hands and feet. From impedance, three compartments are calculated: total body water (TBW), fat mass (FM) and fat free mass (FFM).
Liver volume and intrahepatic fat was determined with MRI at 1.5 T (Achieva, Philips Healthcare, Best, The Netherlands) using the body coil. The measurement protocol was repeated by a blinded operator after 3 weeks and average liver volumes were used.

At each evaluation patients completed a questionnaire rating symptoms associated to LCD on a visual analog scale (Appendix A). A health-related quality-of-life questionnaire from Euro Qol (EQ-5D) was also administered allowing the patient to classify her health on five specific dimensions: mobility, self-care, usual activities, anxiety/depression and pain/discomfort, as well as general health assessment.

All ten patients completed four weeks of LCD, attended all examinations and underwent LRYGB without complications.

Paper III
All 539 patients residing in Sweden who had undergone a primary gastric bypass at Uppsala University Hospital or Örebro University Hospital were invited to participate through a questionnaire (Appendix B). From surgery to study, 35 patients had deceased. Thus, 384 patients (at surgery mean age 37.9 years, BMI 44.5 kg/m², 317 female) were included, which corresponds to a response rate of 71%. Charts were studied for preoperative data such as weight, comorbidities and medication. From the questionnaire information regarding subsequent surgery, present weight, medication, frequency of gastrointestinal symptoms (dysphagia, vomiting, dumping, diarrhea and abdominal pain), use of supplements, satisfaction and attendance to follow-up appointments was gathered. Patients were also asked whether they were working, retired or on sick-leave.

The guidelines from National Institute of Health were used as criteria to select patients eligible for RYGB (85). At RYGB, a Roux limb was anastomosed to a small gastric pouch and no distal RYGBs were done. Patients were recommended life-long supplementation of multivitamins and vitamin B₁₂.

Paper IV
The study design was similar to paper III but in paper IV all patients had undergone RYGB as a revisional procedure (rRYGB) due to unsatisfactory weight loss or intolerable side-effects from prior bariatric surgery; thus no primary RYGB patients were included. All living 208 patients who underwent rRYGB at Uppsala University Hospital or Örebro University Hospital from 1993 to 2003 received an identical questionnaire as in paper III (Appendix B). Eighteen patients had deceased from rRYGB to follow-up.
Patients were assessed by an internist specialized in obesity, a dietician as well as by a senior bariatric surgeon. When suitable, upper endoscopy as well as radiographic examination was performed. These investigations were done when band erosion or staple line disruption was suspected. rRYGB was then completed as an open procedure. Patients received identical recommendations as in paper III and were followed in a similar way.

The principal reason for revisional surgery was derived from charts and recorded as unsatisfactory weight loss or intolerable side effects after prior bariatric surgery. Blood samples were obtained and analyzed for anemia and vitamin deficiencies.

Statistics
For continuous parametric data Student’s $t$-test was used. For comparing non-parametric data between groups Mann-Whitney U test was used. Wilcoxon matched pairs test was used for analyzing changes in non-parametric data over time. Dichotomous data was compared using $\chi^2$ test or Fisher exact test. Correlations are reported as Pearson coefficients.

Ethics
All studies were approved by the Regional Ethical Review Board at Uppsala University, and written informed consent was obtained from all patients.
Results

Paper I

Mean weight, intrahepatic fat and liver volume decreased as shown in Table 2. The MRS image of the typical decrease in liver volume is shown in Figure 5.

Table 2 - MRS and weight results

<table>
<thead>
<tr>
<th></th>
<th>Before LCD</th>
<th>After LCD</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body weight (kg)</td>
<td>121.3 ±13.4</td>
<td>113.9 ±12.0</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Liver volume (L)</td>
<td>2.17 ±0.37</td>
<td>1.89 ±0.22</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Intrahepatic fat (%)</td>
<td>9.41 ±6.17</td>
<td>5.53 ±4.11</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Abbreviations: LCD= Low calorie diet

LRYGB was performed uneventfully. The LCD group had better scoring for volume of left liver lobe ($p<0.05$), sharpness of liver edge ($p<0.05$) and exposure of hiatal region ($p<0.01$). The total complexity score as rated by the surgeon was lower in the LCD group compared to the controls (0.60 vs. 2.22, $p<0.05$) as shown in Table 3.

Table 3 - Complexity rating of LCD-patients and controls

<table>
<thead>
<tr>
<th></th>
<th>LCD</th>
<th>Controls</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposure</td>
<td>0.00</td>
<td>0.33</td>
<td>0.03</td>
</tr>
<tr>
<td>Bleeding</td>
<td>0.13</td>
<td>0.11</td>
<td>0.85</td>
</tr>
<tr>
<td>Difficulty of dissection</td>
<td>0.13</td>
<td>0.44</td>
<td>0.10</td>
</tr>
<tr>
<td>Difficulty of reconstruction</td>
<td>0.07</td>
<td>0.17</td>
<td>0.39</td>
</tr>
<tr>
<td>Surgical judgment</td>
<td>0.01</td>
<td>0.39</td>
<td>0.11</td>
</tr>
<tr>
<td>Technical demand</td>
<td>0.13</td>
<td>0.44</td>
<td>0.10</td>
</tr>
<tr>
<td>Psychological stress</td>
<td>0.00</td>
<td>0.33</td>
<td>0.02</td>
</tr>
<tr>
<td>Sum</td>
<td>0.60</td>
<td>2.22</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Abbreviations: LCD= Low calorie diet

The mean presented above is calculated from the recoded values according to the complexity scoring system: 2 points for most difficult cases, 1 point for more difficult than normal cases and 0 points for the remaining.
Figure 5 - Magnetic resonance images from before (left) and after (right) four week of low calorie diet treatment, illustrating the typical reduction in liver volume.

Operating time showed no difference, 169 ±35 min for the LCD group compared to 172 ±32 min for controls. Perioperative bleeding was larger in the LCD group 130 ±41 mL versus 75 ±43 mL ($p<0.001$).

**Paper II**

After four weeks of LCD patients lost mean 7.4 ±1.2 kg (range 5.7 - 9.1 kg) and BMI was reduced by 2.6 kg/m$^2$ (Table 4). Weight loss was consistent among all patients throughout the study, except one patient who gained 0.1 kg between two evaluations. Weight was lost most rapidly from day 0 to day 3; mean weight loss during this interval was 0.7 kg/day. At day 3, patients had lost mean 2.0 kg of which 51% was accounted for by water according to BIA. A continuous reduction in body fat mass was recorded, mean 5.3 ±2.0 kg, equivalent to a reduction of 9% of total body fat. At day 28, 71% of the weight loss was represented by a decrease of fat mass according to BIA. Details are shown in Table 4.
Table 4 - Results from BIA, MRS and laboratory test from baseline to day 28.

<table>
<thead>
<tr>
<th>Patient data</th>
<th>Baseline</th>
<th>Day 3</th>
<th>Day 7</th>
<th>Day 14</th>
<th>Day 28</th>
<th>Total change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>42.7 ±8.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>114.3 ±12.1</td>
<td>112.4</td>
<td>111.3</td>
<td>110.1</td>
<td>107.0**</td>
<td>-7.4</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>41.7 ±2.6</td>
<td>41.1</td>
<td>40.7</td>
<td>40.2</td>
<td>39.1**</td>
<td>-2.6</td>
</tr>
</tbody>
</table>

**BIA results**

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Day 3</th>
<th>Day 7</th>
<th>Day 14</th>
<th>Day 28</th>
<th>Total change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body fat%</td>
<td>48.4 ±4.4</td>
<td>48.8</td>
<td>48.9</td>
<td>47.6</td>
<td>46.9*</td>
<td>-1.5</td>
</tr>
<tr>
<td>Body fat mass (kg)</td>
<td>55.7 ±10.2</td>
<td>55.2</td>
<td>54.8</td>
<td>52.8</td>
<td>50.5**</td>
<td>-5.2</td>
</tr>
<tr>
<td>Fat free mass (kg)</td>
<td>58.6 ±3.2</td>
<td>57.2</td>
<td>56.5</td>
<td>57.3</td>
<td>56.5**</td>
<td>-2.1</td>
</tr>
<tr>
<td>Total body water (kg)</td>
<td>42.9 ±2.3</td>
<td>41.9</td>
<td>41.4</td>
<td>42.0</td>
<td>41.4**</td>
<td>-1.5</td>
</tr>
</tbody>
</table>

**MRI results**

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Day 3</th>
<th>Day 7</th>
<th>Day 14</th>
<th>Day 28</th>
<th>Total change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liver volume (L)</td>
<td>2.1 ±0.7</td>
<td>1.9</td>
<td>1.8</td>
<td>1.7</td>
<td>1.7**</td>
<td>-0.4</td>
</tr>
<tr>
<td>Intrahepatic fat%</td>
<td>9.3 ±7.1</td>
<td>8.3</td>
<td>7.3</td>
<td>6.1</td>
<td>4.6**</td>
<td>-4.7</td>
</tr>
</tbody>
</table>

**Laboratory results**

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Day 3</th>
<th>Day 7</th>
<th>Day 14</th>
<th>Day 28</th>
<th>Total change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systolic pressure (mm Hg)</td>
<td>129 ±13.2</td>
<td>126</td>
<td>126</td>
<td>128</td>
<td>121*</td>
<td>-8</td>
</tr>
<tr>
<td>Diastolic pressure (mm Hg)</td>
<td>82 ±7.9</td>
<td>81</td>
<td>79</td>
<td>78</td>
<td>79NS</td>
<td>-3</td>
</tr>
<tr>
<td>Total cholesterol (mmol/L)</td>
<td>4.93 ±0.86</td>
<td>5.1</td>
<td>4.73</td>
<td>4.25</td>
<td>4.00**</td>
<td>-0.93</td>
</tr>
<tr>
<td>Triglycerides (mmol/L)</td>
<td>2.01 ±1.36</td>
<td>1.85</td>
<td>1.70</td>
<td>1.67</td>
<td>1.45*</td>
<td>-0.55</td>
</tr>
<tr>
<td>HDL (mmol/L)</td>
<td>1.14 ±0.25</td>
<td>1.11</td>
<td>1.01</td>
<td>0.98</td>
<td>0.91**</td>
<td>-0.23</td>
</tr>
<tr>
<td>LDL (mmol/L)</td>
<td>3.12 ±0.73</td>
<td>3.39</td>
<td>3.12</td>
<td>2.69</td>
<td>2.55**</td>
<td>-0.57</td>
</tr>
<tr>
<td>AST (µkat/L)</td>
<td>0.40 ±0.06</td>
<td>0.54</td>
<td>0.55</td>
<td>0.52</td>
<td>0.57**</td>
<td>0.17</td>
</tr>
<tr>
<td>ALT (µkat/L)</td>
<td>0.38 ±0.09</td>
<td>0.54</td>
<td>0.68</td>
<td>0.62</td>
<td>0.70NS</td>
<td>0.32</td>
</tr>
<tr>
<td>Plasma glucose (mmol/L)</td>
<td>5.8 ±0.6</td>
<td>5.9</td>
<td>5.9</td>
<td>5.7</td>
<td>5.7NS</td>
<td>-0.1</td>
</tr>
<tr>
<td>Serum insulin (mE/L)</td>
<td>21.9 ±9.41</td>
<td>17.0</td>
<td>16.2</td>
<td>14.8</td>
<td>17.4*</td>
<td>-4.5</td>
</tr>
<tr>
<td>Hemoglobin (g/dL)</td>
<td>13.6 ±1.2</td>
<td>14.0</td>
<td>13.8</td>
<td>13.7</td>
<td>13.5NS</td>
<td>-0.1</td>
</tr>
<tr>
<td>Creatinine (µmol/L)</td>
<td>67 ±9</td>
<td>73</td>
<td>76</td>
<td>75</td>
<td>76*</td>
<td>9</td>
</tr>
<tr>
<td>Urinary potassium (mmol/L)</td>
<td>35 ±18</td>
<td>53</td>
<td>45</td>
<td>42</td>
<td>44NS</td>
<td>9</td>
</tr>
<tr>
<td>Urinary acetoacetate present</td>
<td>0/9</td>
<td>4/10</td>
<td>4/10</td>
<td>4/9</td>
<td>5/10*</td>
<td>-</td>
</tr>
</tbody>
</table>

Abbreviations: BIA = body impedance analysis, MRI = Magnetic resonance imaging, HDL = High density lipoprotein, LDL = Low density lipoprotein, AST = Aspartate aminotransferase, ALT = Alanine aminotransferase, NS = non-significant, * p<0.05, **p<0.01 compared with baseline.
A large variation in liver volume, ranging from 1.6 L to 4.0 L, was seen at baseline. Mean liver volume decreased by 18 ±4.3% from day 0 to day 14 and remained unchanged over the following two weeks (Figure 6). The rapid reduction in volume for two weeks followed by stationary liver volume for the next two weeks was a trend consistently seen among patients. The individual decrease in liver volume during the study ranged from 7- 30%, and no correlation was found between the amount of weight lost and reduction in liver volume. Liver volume at baseline was however correlated to intrahepatic fat% \( (p=0.02, r=0.73) \). Mean intrahepatic fat% decreased from 9.3% to 6.1% from day 0 to day 14 and then decreased additionally, reaching 4.6% on day 28.

Figure 6 - Liver volume and intrahepatic fat% during 4 weeks of low calorie diet.

Systolic blood pressure decreased, but diastolic blood pressure remained unchanged (Table 4). Total cholesterol and triglycerides decreased, both HDL and LDL decreased and LDL/HDL quota remained unaffected. Aspartate aminotransferase (AST) increased whereas alanine aminotransferase (ALT) levels remained unchanged. Glucose levels did not change but insulin levels decreased. Serum creatinine levels increased during the study but no simultaneous change in hemoglobin indicating dehydration was observed. Although none of the patients had ketonuria at baseline 5 of 10 showed ketonuria during LCD.
In the questionnaire, patients indicated on a visual analog scale how well they agreed with statements regarding LCD. From day 3 to day 28 the urge for something to chew on increased (p=0.01, Wilcoxon matched pairs). For other statements no change was seen. One patient complained of loose stools when LCD was initiated, these symptoms receded at day 7.

According to EQ-5D moderate difficulties were frequent regarding mobility, self-care, usual activities and anxiety/depression throughout the duration of the study (Table 5). Severe difficulties concerning pain/discomfort were reported by three patients, while six experienced moderate pain. No changes occurred.

Table 5 - EQ-5D results, number of patients with no difficulties / moderate difficulties / severe difficulties in each dimension

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Day 3</th>
<th>Day 7</th>
<th>Day 14</th>
<th>Day 28</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobility</td>
<td>6/4/0</td>
<td>5/5/0</td>
<td>5/4/0</td>
<td>5/4/0</td>
<td>5/3/0 NS</td>
</tr>
<tr>
<td>Self-care</td>
<td>7/3/0</td>
<td>8/2/0</td>
<td>6/3/0</td>
<td>7/2/0</td>
<td>6/2/0 NS</td>
</tr>
<tr>
<td>Usual activities</td>
<td>4/5/1</td>
<td>4/4/2</td>
<td>2/6/1</td>
<td>3/5/1</td>
<td>4/2/1 NS</td>
</tr>
<tr>
<td>Pain/discomfort</td>
<td>1/6/3</td>
<td>1/6/3</td>
<td>1/5/3</td>
<td>1/5/3</td>
<td>1/5/2 NS</td>
</tr>
<tr>
<td>VAS (mean)</td>
<td>43</td>
<td>45.9</td>
<td>44.5</td>
<td>48.8</td>
<td>46.9 NS</td>
</tr>
</tbody>
</table>

Abbreviations: VAS= Visual analog scale, NS= non-significant compared with baseline using Wilcoxon matched pairs test.

Paper III

The questionnaire was returned by 384 patients resulting in a follow-up rate of 71% (mean age 37.9 years, 83% women. Mean BMI decreased from 44.5 kg/m² at surgery to 32.5 kg/m² (p<0.0001) at follow-up mean 11.4 years after surgery. Mean weight loss was 34.5 kg corresponding to a mean excess BMI loss (EBMIL) of 63%. EBMIL of 50% or more was achieved by 70% of the patients at follow-up. Superobese patients achieved a mean EBMIL of 53 % compared to 65% among non-superobese (p=0.002).

Resolution of orally-treated diabetes was seen in 72% but only 18 diabetic patients with only per oral medication were identified preoperatively. Continuous positive airway pressure (CPAP) requiring obstructive sleep apnea decreased non-significantly from 4% to 2% (p=0.17).

Hypertriglyceridemia was present in 45% of the patients preoperatively and was reduced to 17% at follow-up (p<0.0001). Hypertriglyceridemia was more common in those failing to achieve 50% EBMIL (31% vs. 12%, p<0.0001). The percentage of patients treated with lipid-lowering medicines increased, from 1% to 5% (p=0.002) at follow-up. No difference was ob-
served in the extent of cardiac medication but those treated with antidepressant or anti-psychotic drugs increased from 9% to 20% ($p<0.0001$).

Additional bariatric surgery had been done in 2% (n=8) and for different reasons. Subsequent cholecystectomy had been done in 10% and 9% were surgically treated for incisional hernia. Five percent underwent surgery for bowel obstruction. Abdominoplasty had been performed in 40% of the patients; these patients were younger (46.7 vs. 50.9 years, $p=0.0001$) and had a higher mean preoperative BMI (45.5 vs. 43.8 kg/m$^2$) compared to those not undergoing abdominoplasty. However, gender did not influence the likelihood of undergoing abdominoplasty. Of the 317 women in study, 8% underwent cosmetic breast surgery after RYGB.

Diarrhea weekly or more often, the most common gastrointestinal symptom, was reported by 23%. The corresponding proportions for dysphagia, vomiting, dumping and abdominal pain were 5%, 4%, 13% and 10%.

Regarding satisfaction, 79% reported being satisfied or very satisfied with RYGB and 92% would recommend RYGB to friends suffering from obesity. Patient satisfaction depended on EBMIL% as shown in Figure 7.

![Patient satisfaction correlated to Excess Body Mass Index Loss % (EBMIL%). The size of the circle represents the number of patients in each group.](image)

Of those able to work, 89% were working part-time or more, while the rest (11%) were unemployed.

Attendance to annual checkups had been reported by 37%; patients from Uppsala were more likely to be followed than those from Örebro (60% vs. 18%, $p<0.0001$). Patients attending follow-ups were more likely to follow
recommendations regarding vitamin B$_{12}$ ($p$=0.02) and multivitamins ($p$=0.0002).

Non-responders included 153 patients; they were similar in age and gender (47 years and 77% women) to responding patients. Because no consent was given by non-responders, no information about weight or other data from charts was gathered.

**Paper IV**

The completed questionnaire was returned by 131 patients, of which 85% were female. Follow-up rate was 75% at mean 11.9 (range 7-17) years after rRYGB. Mean age at rRYGB was 41.8 ±9.2 years and mean preoperative BMI 37.8 ±6.2 kg/m$^2$. Patient characteristics categorized according to prior bariatric procedure are shown in Table 6.

Five patients had a history of two or more bariatric procedures; these were categorized according to the most recent surgery. Mean interval from primary surgery to rRYGB was 5.9 years (range 3 months- 17 years).

At follow-up mean BMI was 32.0 ±6.4 kg/m$^2$. The group with unsatisfactory weight loss included 60% (n=79) of all patients and mean BMI in this group decreased from 40.1 kg/m$^2$ to 32.6 kg/m$^2$ ($p$<0.0001) (Figure 8) with a median EBMIL of 54%. Intolerable side-effects was the cause for rRYGB in 40 % (n=52) and mean BMI decreased from 34.4 kg/m$^2$ to 31.1 kg/m$^2$ ($p$<0.0001) with a median EBMIL of 28%. Three of these patients had a normal BMI (18.5-25.0 kg/m$^2$) at rRYGB.
Table 6 - Patient characteristics at rRYGB and at follow-up according to prior bariatric procedure.

<table>
<thead>
<tr>
<th>Prior procedure</th>
<th>VBG</th>
<th>GB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td>66</td>
<td>65</td>
</tr>
<tr>
<td>Gender (F/M)</td>
<td>59/7</td>
<td>53/12</td>
</tr>
<tr>
<td>Age median (years)</td>
<td>42</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>(26-60)</td>
<td>(23-60)</td>
</tr>
<tr>
<td>Weight median (kg)</td>
<td>107</td>
<td>102</td>
</tr>
<tr>
<td>Range (kg)</td>
<td>(60-171)</td>
<td>(58-200)</td>
</tr>
<tr>
<td>BMI median (kg/m²)</td>
<td>39.2</td>
<td>36.1</td>
</tr>
<tr>
<td>Range (kg/m²)</td>
<td>(25-52)</td>
<td>(23-54)</td>
</tr>
<tr>
<td>Indications for revision</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Unsatisfactory weight loss</td>
<td>77%</td>
<td>43%</td>
</tr>
<tr>
<td>-Intolerable side effects</td>
<td>23%</td>
<td>57%</td>
</tr>
<tr>
<td>Mean interval from primary surgery to rRYGB (years)</td>
<td>7</td>
<td>5</td>
</tr>
</tbody>
</table>

At follow-up

<table>
<thead>
<tr>
<th></th>
<th>VBG</th>
<th>GB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight median (kg)</td>
<td>89</td>
<td>89.5</td>
</tr>
<tr>
<td>Range (kg)</td>
<td>(60-134)</td>
<td>(52-170)</td>
</tr>
<tr>
<td>BMI median (kg/m²)</td>
<td>31.8</td>
<td>31.7</td>
</tr>
<tr>
<td>Range (kg/m²)</td>
<td>(22-47)</td>
<td>(19-50)</td>
</tr>
<tr>
<td>EBMIL% median</td>
<td>49%</td>
<td>39%</td>
</tr>
<tr>
<td>Proportion recommending rRYGB</td>
<td>93%</td>
<td>89%</td>
</tr>
</tbody>
</table>

Abbreviations: VBG= Vertical banded gastroplasty, GB= Gastric banding, F= Female, M= Male, BMI= Body mass index, EBMIL= Excess BMI loss, rRYGB= Revisional Roux-en-Y gastric bypass
Medication for diabetes was used by 4% at rRYGB; no change was seen at follow-up as shown in Figure 9. Continuous positive airway pressure was used by 2% at rRYGB, none needed this at follow-up.

Hypertriglyceridemia (triglycerides>1.7 mmol/L) was present in 25% preoperatively and in 24% (p=0.89). Hypercholesterolemia (cholesterol>5 mmol/L) was present in 63% preoperatively and in 53% postoperatively (p=0.17), thus neither change was significant. High density lipoprotein (HDL) improved from 1.46 mmol/L to 1.68 mmol/L (p<0.03).

Further medication is shown in Figure 9.

Only two patients had additional bariatric surgery after rRYGB. One reversal was done due to short bowel syndrome after extensive bowel resection caused by small bowel obstruction. Another had the Roux limb elongated due to unsatisfactory weight loss. Incisional hernia was corrected in 13% and abdominoplasty performed in 41% (n=60). No difference was observed regarding age at rRYGB or gender between those who underwent abdominoplasty and those who did not.
Postoperative gastrointestinal symptoms are shown in Figure 10 and Figure 11.

Figure 9 - Percentage of patients on medication at rRYGB and at follow-up
Abbreviations: rRYGB= Revisional Roux-en-Y gastric bypass

Mood disorder med. p<0.01
Cardiac or hypertensive med. p=0.049
Diabetes med.
Lipid lowering med. p=0.01

Swallowing difficulties
Vomiting
Abdominal pain

Dumping
Diarrhea

Figure 10 - Unsatisfactory weight loss group prior to rRYGB (above)
Regarding gastrointestinal symptoms no statistical significant differences were observed between those with unsatisfactory weight loss and those with intolerable side effects. Satisfactory result with rRYGB or better was reported by 74%.

Annual checkups were attended by 38%. Vitamin B$_{12}$ was taken by 76% and multivitamins by 21%. Supplements are shown in Figure 12.

Figure 11 - Intolerable side effects group prior to rRYGB (above)
Laboratory results showed that anemia tended to increase from 10% to 18% at follow-up but this was non-significant ($p=0.07$). Nor was the change in vitamin B$_{12}$ deficiency significant, from 0% at rRYGB to 2% ($p=0.26$). None of those taking vitamin B$_{12}$ were deficient at follow-up, regardless of whether B$_{12}$ was taken orally or as an intramuscular injection. Iron deficiency increased non-significantly from 11% to 19% ($p=0.22$) while folate deficiency decreased from 24% to 8% at follow-up ($p<0.01$). Hypoalbuminemia (albumin $<36$ g/L) increased from 3% to 16% ($p<0.01$). No differences were observed in deficiencies at rRYGB between VBG and GB patients.

Patients who did not return the questionnaires, i.e. non-responders, were similar in age and gender (51.9 years and 81% female) as responders. No more information is available about non-responders.

**Figure 12 - Percentage of patients on supplementation at rRYGB and at follow-up**

Abbreviations: rRYGB= Revisional Roux-en-Y gastric bypass
Discussion

One of the key results of bariatric surgery is long-term weight loss. This weight loss is associated to relief in comorbidities \(^{86}\). Facilitating the bariatric procedure through preoperative weight loss might lead to fewer postoperative complications. These are subjects which have been explored in our studies.

Preoperative weight loss and liver volume

In paper I, LCD treatment was evaluated through MRS examinations and scoring of the surgical complexity. Colles et al showed that 12-weeks of very low calorie diet (VLCD) in obese led to a 19%-decrease in liver volume \(^{57}\) as evaluated by a combination of computed tomography (CT) and MRI. Others have found similar results \(^{87-89}\). Interestingly, 12-weeks of VLCD resulted in a similar reduction in intrahepatic fat as our 4-week treatment of LCD, 43% compared to 40%. The decrease in liver volume of 19% was larger than the 12% decrease observed in our study but the livers were larger in the study by Colles et al. An extended period of LCD beyond 4 weeks seems to have little effect on intrahepatic fat. Healthy non-obese females have considerably smaller livers than obese females even after weight loss, mean liver volume in a group of non-obese females was 1.48 L \(^{90}\) compared to 1.89 L in our study after 4 weeks of LCD. Our patients lost mean 7.5 kg during the LCD treatment and judging from the weight loss, they had similar compliance to LCD when compared to other studies. Some of the patients complained of fatigue initially and missed the sensation of chewing.

Other studies have shown decreases in operative time \(^{58,91,92}\) attributed to preoperative weight loss. Estimating blood loss during laparoscopic surgery is difficult and although blood loss was estimated as larger in the LCD group than among controls the validity of this observation is uncertain. The operating surgeon did not rate bleeding as a larger problem among LCD patients than among controls. Fewer complications \(^{59,93}\) and shorter hospital stay \(^{94}\) have been associated to preoperative weight loss. There is conflicting evidence as to whether preoperative weight loss increases postoperative weight loss; whereas Livhits et al found such correlation \(^{91}\) others found none \(^{95-97}\). A selection bias in some studies could be that the most motivated patients
achieve weight loss preoperatively and because of their high motivation, also experience better postoperative weight loss.

Conceivably a prolonged and substantial preoperative weight loss might induce a catabolic state which could increase the risk of complications. Three of LCD patients (20%) were treated for stomal ulcers but only one of the controls needed such treatment.

The improved exposure of the operating field after LCD is likely due to several factors. The diminished liver is probably the most important. Additionally, the reduction in intra-abdominal fat leads to more space intra-abdominally and thus facilitates laparoscopy.

Paper II focused on early effects of weight loss on liver volume, intrahepatic fat and body composition. Patients achieved a similar weight loss (7.4 kg) as in paper I.

The massive reduction in liver volume (18%) occurred from day 0 to day 14. This is more pronounced than we found in paper I and in superobese similar results were achieved after nine weeks of LCD. Although intrahepatic fat continued to decrease after day 14 by an additional 1.5%, this did not result in an additional decrease in liver volume. The reason for this is unclear. In one patient liver enzymes (AST and ALT) increased, and in that patient liver volume increased (0.1 L) from day 14 to day 28. An inflammatory response in the liver with edema could explain both the increase in liver enzymes and in liver volume; however, for other patients liver volume was unaffected from day 14 to day 28. Interestingly, others have found that mean liver volume began to increase after 4 weeks of VLCD.

Colles et al found that during in a 12-week VLCD, 80% of the reduction in liver volume occurred during the first 2 weeks. Later an additional 20% decrease was observed, however only patients with very large livers (larger than 2.8 L) were selected in that study. Patients with very large livers with high fat content might consequently require longer LCD treatment than 2 weeks. However, based on the present study, for most morbidly obese women no additional reduction in liver volume occurs after two weeks of LCD.

Changes in body composition

During the initial phase of weight loss energy sources that can be rapidly mobilized are used such as glycogen. The glycogen storage is estimated to be 15 g/kg body weight; thus the total body mass of glycogen can reach up to a kilo dispersed in liver and muscle. In addition, as glycogen is hydrated, each gram of glycogen is coupled with up to 1.2-2.7 g of water. This phenomenon could explain the large decrease in total body water seen during
the first three days. The small increase in serum creatinine supports this, however a concurrent increase in hemoglobin, often noted in dehydration, was not observed. The validity of BIA is negatively affected by recent exercise and degree of hydration (101) hence fluid intake was limited to 500 mL 12 h before examination and evaluations were done in the morning. Another contributing factor in initial weight loss could be defecation; it is possible that LCD produces less fecal matter than ordinary food.

Other implications

Even in this small sample with moderate weight loss a reduction in systolic blood pressure as well as blood lipid levels was observed. It is known that also modest weight loss is associated to health benefits with regard to hypertension and hyperlipidemia (102). In addition, LCD represents a major diet change which might be beneficial regarding blood lipids.

The patients’ desire to chew increased significantly from day 3. In clinical practice, we have noticed that this is a common complaint. LCD is also available as bars that might better satisfy patients’ urge to chew. Apart from this, the only side-effect reported was loose stools in one patient, which receded spontaneously.

Morbidly obese patients have a lower quality of life than normal weight patients (103) and pain/discomfort on a moderate or severe level was experienced by 9 out of 10 patients in our study. Pain arising from the musculoskeletal system was the most common, as most earlier studies have shown (104). No improvements were observed during the study, likely because only moderate weight loss was achieved.

Limitations of paper I and II

Paper I and II have certain limitations. The surgeon was not blinded to the preoperative treatment given and this could have influenced both the complexity score and liver appearance score. In hindsight, these scores would have been better assessed by a blinded unbiased surgeon. The number of patients is low in both studies. However, principal findings such as changes in body and liver composition are homogenous and significant. MRI is a well-established method for assessment of liver volume and intrahepatic fat (55). The low number of patients in these studies makes it difficult to show statistical significance with regards to questionnaires. Possibly the differences in liver volume change (12% and 18%) reflect the low number of patients in both studies. The questionnaire regarding LCD has not been validated and we consider these results as exploratory whereas EQ-5D has been used in numerous studies (103). Only women were included in these studies
hence the findings may not be fully applicable to men, typically suffering from central obesity.
In summary, four weeks of LCD leads to 12-18% reduction in liver volume in morbidly obese women awaiting LRYGB. A preoperative two-week LCD-treatment seems optimal because no additional reduction in liver volume was observed after this period.

Long-term results

In paper III and IV, the long-term results of primary and revisional RYGB were studied. Mean EBMIL after RYGB at follow-up was 63% which is comparable to other studies with 10-year follow-up (55% - 62% EWL) \(^{(105, 106)}\). However, at the lowest postoperative weight patients had achieved mean EBMIL of 93%, which shows that certain degree of weight regain is present after RYGB.

Mean weight at follow-up was similar regardless of whether RYGB was done as a primary procedure or as a revisional surgery as shown in Figure 3. The group with unsatisfactory weight loss achieved an EBMIL of 55% in median after rRYGB; this result is similar to previous studies \(^{(107-111)}\). An EBMIL of 50 % or more was reached by 55% of those undergoing rRYGB for unsatisfactory weight loss; the same proportion for RYGB is 70%. It seems reasonable that having failed one bariatric treatment makes it more likely that also the next surgery will have a less favorable outcome. With this in mind, the results (55% and 70%) are not surprising and support the idea that patients with unsatisfactory weight loss from prior restrictive bariatric surgery should be considered for rRYGB.

Causes for revisional surgery

We found unsatisfactory weight loss to be the most common reason for revisional bariatric surgery, in agreement with other studies \(^{(108, 109, 112, 113)}\). The long interval between primary surgery and revisional surgery, mean 5.8 years highlights the importance of a long follow-up when evaluating a surgical procedure in order to correctly evaluate the need for revisional surgery.

Comorbid conditions

Orally treated diabetes resolved in 72% of patients after RYGB, a finding similar to prior studies on RYGB (83-85%) \(^{(81, 105)}\) and rRYGB \(^{(107)}\). At RYGB 6.4% were medicated for diabetes and at follow-up 3.5% (p=0.07). Although the difference lacks statistical significance it seems likely that
RYGB prevented diabetes from developing in some patients since it is known that the prevalence diabetes medication doubles with each decade of age \(^{(114)}\). Swedish obese subjects study as well as other studies supports this idea that RYGB prevents diabetes from developing. \(^{(66, 68)}\)

Some studies have shown resolution of OSA \(^{(33)}\). This is supported by paper III and IV but few patients were identified preoperatively. None of rRYGB patients needed CPAP at follow-up. There was little awareness of OSA 20 years ago which could explain why only a few patients had received the diagnosis at the time of surgery.

Hypertriglyceridemia was less common after RYGB than preoperatively and among those with successful outcomes after RYGB even fewer suffered from hypertriglyceridemia. Similar findings have been made in the SOS study in the patients with the most successful weight results \(^{(86)}\). Among patients undergoing rRYGB no significant change in hypertriglyceridemia was observed, however HDL levels increased from surgery to follow-up. It seems less weight loss is needed to produce an improvement in HDL levels than to achieve a significant decrease in the proportion suffering from hypertriglyceridemia.

Regarding changes in medication the increased use of antidepressant and antipsychotic drugs warrants further research. The use of selective serotonin receptor inhibitors increased 10-fold in Sweden from 1993 to 2003 \(^{(115)}\), and these drugs have increased in the general population as well as in bariatric patients. However, there are some studies indicating a worrying increase in death from suicide in bariatric patients \(^{(62, 116)}\).

**Additional surgery after RYGB and rRYGB**

Few patients needed revision after RYGB (2.1%) compared to revision rates after other bariatric procedures such as laparoscopic adjustable gastric banding with revision rates of 15-31% \(^{(117, 118)}\). After rRYGB the rate of revisional surgery in our study is even lower (1.3%) than reported by others (7%) \(^{(50)}\). One might think that those seeking revisional bariatric surgery represent a cohort of patients that are particularly difficult to satisfy but our findings indicate that for almost all patients rRYGB is their final bariatric procedure. At follow-up only 10% had undergone cholecystectomy after RYGB, an indication that routine simultaneous cholecystectomy might be unnecessary. Surgery for bowel obstruction had been performed on 5% after RYGB, and internal hernia is a common complication after LRYGB, but since most surgery was performed as an open procedure with retrogastric and retrocolic Roux-limbs, the rate of internal hernias might have been reduced \(^{(119)}\). The reported low incidence of incisional hernias after RYGB (9%) could be due to the practice of using a short midline incision at RYGB. Incidence of incisional hernias increased after rRYGB to 11% which is similar to results from
Spyropoulus et al (16%) (120). A laparoscopic approach would have decreased the number of incisional hernias (77), which in part explains why laparoscopic surgery now accounts for more than 97% of RYGB in Sweden (3). However, laparoscopic rRYGB is technically demanding and most patients undergoing rRYGB had had at least one midline incisions causing adhesions hence rRYGB was performed as an open procedure. Laparoscopic rRYGB was considered experimental during most of the study period, the first paper on laparoscopic rRYGB was published in 2001 (121). Abdominoplasty was the most common procedure after RYGB (40%), in addition, several patients expressed a wish to undergo abdominoplasty but had been denied coverage by the public healthcare.

Symptoms and satisfaction

Diarrhea weekly or more often was the most common postoperative symptom in both RYGB and rRYGB patients, 23% and 33% respectively. Foster et al show that gastrointestinal symptoms improved after RYGB, which indicates that diarrhea was perhaps even more manifest in obese preoperatively (122).

Satisfaction with RYGB was reported by 79% and weight loss is essential to patient satisfaction as shown in Figure 7. Most patients were satisfied after RYGB as well as after rRYGB (76%); however it is difficult to compare these rates to studies by other authors because questionnaires differ. Although more than 20% stated that they were dissatisfied in both papers, 92% of all patients would recommend RYGB to friends with morbid obesity.

Justot et al found indications that morbid obesity among women was a predictor of impending unemployment (123). The unemployment rate in paper III was 11.0% at follow-up compared with 5.6% in the general Swedish population aged 45-54 years in January 2010 (114). It has been implied that bariatric surgery might facilitate employment in morbidly obese (124) but since the preoperative status of our patients is unknown it is difficult to draw conclusions.

Compliance and deficiencies

The poor compliance to supplements is worrying. Nutritional deficits are rarely obvious, and some patients believe that vitamin supplementation is only necessary for those who do not eat well balanced meals. Compliance to vitamin supplementation was correlated to annual checkups, which seems rational; motivated patients adhere to both recommendations and are reminded about supplementation during checkups. In rRYGB patients, we found anemia and iron deficiency to be common at follow-up. Both anemia
and iron deficiency are common diseases among females with no history of bariatric surgery in this age group but the altered uptake of nutrients after RYGB make metabolic deficiencies very common in RYGB patients. Failure to adhere to vitamin recommendations put patients at risk of developing anemia as well as neurological deficits from vitamin B₁₂ deficiency. We found vitamin B₁₂ deficiency to be easily treated, regardless of whether it was ingested or intramuscularly injected none of those taking vitamin B₁₂ at follow-up were deficient.

Limitations of paper III and IV

Paper III and IV are retrospective studies and have some limitations. First, postoperative weights are self-reported and it is reported that obese persons tend to underestimate their own weight by mean 3.4 kg in women and 1.4 kg in men. Some patients are residing outside our region and in order to achieve a better follow-up rate we did not ask patients to travel to our hospital to be weighed. Second, questionnaires are susceptible to misinterpretation which could give misleading answers; nonetheless, collected data were validated by a review of medical charts and findings were generally consistent. Third, nonresponders can cause a bias, and motivating patients to complete the questionnaire, sometimes 17 years after surgery, can be difficult. Studies with 5 years of follow-up after RYGB or rRYGB provide response rates of 63-97% (81, 105, 110, 111, 126, 127), and with 8 to 10 years follow-up corresponding rates are 28-84% (4, 107, 128). Considering this, the present papers with more than 70% (71% RYGB and 75% rRYGB) follow-up rate at 11-12 years after surgery are satisfactory.
Conclusions

Paper I
Preoperative LCD during 4 weeks reduces intrahepatic fat by 40% and body weight by 7.5 kg. LRYGB was facilitated through improved exposure as perceived by the surgeon.

Paper II
All of the reduction in liver volume (18%) occurs during the first two weeks of weight loss although reduction in intrahepatic liver fat occurs also during week 3-4. Most of the initial weight loss (day 0-3) was represented by water whereas most of the weight loss during the four week period was represented by fat.

Paper III
RYGB leads to mean 34.5 kg weight loss and mean EBMIL of 63% at mean 11 years follow-up. Only 2.1% required revisional bariatric surgery. Abdominoplasty was performed on 40%. Recommendations on vitamin B₁₂ were followed by 72% and 24% took multivitamins as prescribed.

Paper IV
Patients undergoing rRYGB for failed prior bariatric surgery achieved a mean BMI of 32.6 kg/m² at follow-up, similar to the result after primary RYGB. Satisfaction was high.
Future aspects

Preoperative weight loss often through LCD has become standard in most bariatric clinics. The superobese and patients with known NASH will require further studies to determine if they might benefit from a longer preoperative weight loss period. Further studies should also be done on men. One might also explore why so few men seek surgical treatment for obesity.

The weight loss result after RYGB has stood the test of time. Other newer procedures such as sleeve gastrectomy will be benchmarked to RYGB although long-term data regarding sleeve gastrectomy will be scarce for a few more years. Post-bariatric mood disorders are likely to be addressed in the coming years.
Svensk sammanfattning

Fetma uppkommer när energiintaget hos en individ under en längre tid överstiger förbrukningen. Idag är mat mer lättillgänglig än någonsin förr och allt färre arbeten inbegriper fysisk ansträngning. Detta har bidragit till dagens fetmaepidemi och sedan en tid dör fler människor i världen av övervikt än av svält.

Gastric bypass med titthålsteknik är den idag vanligaste operationen mot övervikt. Vid denna operation kopplas större delen av magsäcken ur och en liten ficka av magsäcken kopplas till tunntarmen. Detta leder till en viktminskning.

Vid fetma förekommer ofta fettinlagring i levern. Denna fettinlagring förstör levern som då skymmer den övre delen av magsäcken vilket försvårar konstruerandet av magsäcksfickan under gastric bypass operationen. Viktminskning inför gastric bypass minskar levervolymen och tros underlättta operationen.


Syftet med arbetet var att kartlägga när och hur levervolymen utvecklas under lågkaloridiet inför operation och om detta underlättar operationen. Dessutom utvärderas långtidsresultatet efter gastric bypass, både som första operation och som räddningsoperation efter att tidigare överviktsoperationer misslyckats.

Delarbete I

Effekterna av fyra veckors lågkaloridiet på leverfettagning och levervolym med magnetkamera studerades. Vi undersökte också om den opererande kirurgen uppfattade operationerna som mindre komplicerade i den grupp som får dieten jämfört med obebhandlade kontroller.

Magnetkameraundersökningar före och efter dieten visade att fetthalten i levern minskade med 40 % och levervolymen med 12 %. Kirurgen uppfattade insynen som bättre hos de som fått dieten jämfört med de som inte gått
ner i vikt inför operationen. En del patienter drabbades av sår i anslutning till skarven mellan magsäcksficka och tunntarm, men det är oklart om detta var relaterat till lågkaloridieten.

**Delarbete II**

Tio kvinnor undersöktes under LCD behandling med bioelektrisk impedans samt med magnetkameraundersökning. Efter tre dagars behandling hade patienterna minskat två kilo i vikt, huvuddelen av denna viktminskning utgjordes av vatten. Efter två veckors behandling hade levervolymen minskat med 18 %. Trots att patienter genomgick ytterligare två veckors behandling sågs ingen ytterligare minskning i levervolym. Detta innebär att två veckors LCD är tillräckligt för att uppnå den eftersträvansvärda minskningen i leverstorlek. Merparten av den totala viktminskningen under fyra veckor utgjordes av minskning i fettmassa.

**Delarbete III**


Den genomsnittliga viktminskningen var 34,5 kg och BMI sjönk från 44,5 kg/m² till 32,5 kg/m². Endast 2 % genomgick ytterligare överviktskirurgi men 40 % opererades med bukplastik. Mer än tre fjärdedelar var nöjda med operationen men få patienter följde rekommendationen om livslång vitami-

**Delarbete IV**

Patienter som fått biverkningar eller otillräcklig viktminskning efter andra överviktsoperationer har omopererats till gastric bypass och långtidsresultaten av detta undersöktes. BMI vid uppföljning var 32,6, således ett likartat slutresultat som sågs hos de som opererats med gastric bypass från början (delarbete III). Patienterna var nöjda med operationen (76 %).

**Sammanfattning**

Fyra veckors LCD ger en betydande minskning i levervolym och leverfett, detta underlättar gastric bypass med titthålsteknik. Denna minskning i lever-
volymen uppnås dock redan efter två veckor varför två veckors behandling
synes tillräcklig. Gastric bypass ger en bestående viktminskning och fodrar
sällan ytterligare överviktskirurgi, detta oavsett om operationen görs som en
första överviktsoperation eller sekundär operation efter att tidigare övervikts-
kirurgi fällerat. Många genomgår dock bukplastik efter att ha uppnått bety-
dande viktnedgång. Rekommendationer rörande vitaminsättning behöver
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Appendix A

Questionnaire regarding low calorie diet

Mark with a cross on the line how well you agree or disagree with the following statements today.

1. Adhering to the low calorie diet is going well
   Agree _____________________________ Disagree
2. The diet makes me feel more active in the coming change of lifestyle
   Agree _____________________________ Disagree
3. I feel annoyed
   Agree _____________________________ Disagree
4. I miss the sensation of chewing
   Agree _____________________________ Disagree
5. I am tired
   Agree _____________________________ Disagree
6. I am hungry
   Agree _____________________________ Disagree
7. The diet makes it complicated for me to have social interactions
   Agree _____________________________ Disagree
8. The diet is affecting the eating habits of my relatives in a negative way
   Agree _____________________________ Disagree
9. Apart from the low calorie diet I have since the last visit eaten something extra with additional energy
   Agree _____________________________ Disagree
10. My present health status is good
    Agree _____________________________ Disagree
Appendix B

Questionnaire after RYGB and rRYGB (Study III and IV)

1. Have you had other surgery after the gastric bypass procedure?
   Yes/No   If yes, what year
   Cholecystectomy, Incisional hernia, Bowel obstruction
   Other intestinal surgery, what kind?

2. Have you needed reoperation of your gastric bypass?
   Yes           No
   If so when and where?

3. Have you undergone cosmetic surgery due to excess skin?
   Yes           No
   If so what kind of surgery, when and at which hospital?

4. Have you been admitted to a hospital since your gastric bypass surgery for anything else?
   If so why, when and where?

5. How much do you weigh today?
   What is the lowest weight you achieved after surgery and when did that occur?
   How tall are you?

6. How often are you troubled by:
   Swallowing difficulties?
   Vomiting?
   Abdominal pain?
   Dumping?
   Diarrhea?
   1=daily, 2=once to several times a week, 3=once to several times a month, 4=once to several times a year, 5=never.

7. Which of the following health problems are you currently taking medication for:
   Diabetes
   High blood pressure
   Hyperlipidemia
   Cardiac condition
   Muscular conditions
8. Please write all medication you are currently taking including supplements for example iron, B12, multivitamin and vitamin D?

9. Are you currently using Continuous Positive Airway Pressure (C-PAP) to avoid sleep apnea at night?

10. Did you use Continuous Positive Airway Pressure (C-PAP) before your gastric bypass surgery?

11. Are you ever feeling dizzy/ tired and need to sit down or feel like you need to eat something sweet?

12. Have you had kidney stones? If so, where were you treated?

13. Are you satisfied with your teeth?
   1=Yes, very satisfied, 2=Yes, generally satisfied, 3=No, generally dissatisfied, 4=Absolutely not
   How many of your permanent teeth remain?
   1=All, 2=Missing one or two, 3=Missing more teeth, 4=Missing most teeth, 5=None remain

14. Have you had checkups yearly concerning your gastric bypass surgery? If so, where?

15. Have you in the last year attended a checkup regarding your gastric bypass surgery? If so, where?

16. Are you attending checkups for any other disease? If so, what disease and where?

17. What is your opinion on the effects of gastric bypass surgery on your general wellbeing?
   1=Very satisfied, 2=Satisfied, 3=Dissatisfied, 4=Very dissatisfied

18. Would you recommend gastric bypass to others who need treatment for obesity?

19. Are you currently working?
   1= Fulltime, 2=Part-time, 3=No. If no, are you on sick leave, unemployed or retired?
References


105. Pories, W.J., M.S. Swanson, K.G. MacDonald, et al., Who would have thought it? An operation proves to be the most effective


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