Current status of bariatric surgery in the treatment of type 2 diabetes

J. Pinkney[1] and D. Kerrigan[2]

[1]Department of Medicine, University of Liverpool; [2]Department of Surgery, University Hospital Aintree, Liverpool, UK

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Address reprint requests to: J Pinkney, Diabetes and Endocrinology Research Group, Clinical Sciences Centre, University Hospital Aintree, Longmoor Lane, Liverpool L9 7AL, UK. E-mail: jpinkney@liverpool.ac.uk

Summary

Bariatric surgery (from the Greek words *baros* meaning 'weight' and *iatrikos* 'the art of healing') is a rapidly evolving branch of surgical science. The aim is to induce major weight loss in those whose obesity places them at high risk of serious health problems. In an attempt to balance the risks of surgery against the benefits of weight loss, bariatric operations are currently performed only in the morbidly obese, or those with a body mass index (BMI) > 35 kgm^{-2} who already have developed comorbidity such as type 2 diabetes. Although weight loss is beneficial for obese patients with diabetes, current medical treatment for obesity is difficult. In contrast, observational studies show a major impact of bariatric surgery on diabetes, raising the question whether this approach should be used more widely to treat diabetes in obese patients? If bariatric surgery were shown to be the best way to treat diabetes in obese subjects the implications for health services would be wide-ranging. Bariatric surgery leads to withdrawal of diabetic treatment in about 60% or more of patients, and reductions of therapy for many others. Although data on bariatric surgery in subjects with diabetes are provocative, most studies have been uncontrolled or flawed in other ways. Most importantly, bariatric surgery has not yet been compared against standard medical treatment for diabetes in randomized controlled trials with diabetes-specific endpoints in all relevant patient groups. Potential indications for bariatric surgery are discussed, and the unanswered questions that need to be addressed by clinical trials are summarized. Although small numbers of patients may be interested in bariatric surgery for type 2 diabetes, current data are insufficient to endorse its wide scale use for this indication. Until essential studies are undertaken the role and economics of bariatric surgery in the diabetic clinic will remain uncertain.

Keywords: Bariatric surgery, diabetes, obesity.

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Rationale for weight loss in type 2 diabetes

Obesity and type 2 diabetes

Obesity is so closely associated with type 2 diabetes (1,2) that a causal role for obesity – or very closely related factors – is beyond doubt. In the morbidly obese, the relative risk of type 2 diabetes is at least 5% in men and 8–20% in women (3–5), while approximately 30% of those considered for bariatric surgery are found to have type 2 diabetes (6–10). In the surgical arm of the Swedish Obese Subjects (SOS) study the prevalence of diabetes was 10.8% at baseline and remained 10.5% 8 years after surgery. In contrast, however, the prevalence of diabetes in the control group increased from 7.8% to 24.9% over the same period (11). In the Greenville series an additional 13% of patients had impaired glucose tolerance (IGT) pre-operatively (7), confirming that without intervention many severely obese patients are at high risk of progressing to diabetes. In subjects with IGT, bariatric surgery also has a powerful

preventive effect on progression to diabetes (12). Even allowing for selection bias, these data confirm that type 2 diabetes and IGT are common in people with morbid obesity and that bariatric surgery has a major impact on the natural history of diabetes.

Despite medical treatment, type 2 diabetes decreases life expectancy and is a leading cause of blindness, renal failure, neuropathy, amputations and cardiovascular disease. On average, life expectancy for middle-aged people with diabetes is reduced by about 8 years (13,14). Moreover, obesity is associated with additional serious risks for people with diabetes, notably coronary heart disease (15). In a recent audit of patients with type 2 diabetes attending our hospital diabetes clinic in Liverpool, a particularly high prevalence of obesity was observed. About 49% of patients had body mass index (BMI) > 30, 24% BMI > 35, and 7.8% BMI > 40 kgm^{-2}. These figures exceed by far the expected prevalence of obesity in the background population. Furthermore, increasing obesity was associated with increased prevalence of coronary heart disease, hypertension, and stroke (16). Thus, obesity is highly prevalent in people with type 2 diabetes and is associated with worse outcomes. Clearly, the prevention and treatment of obesity has the potential to make a big impact on type 2 diabetes.

Weight loss prevents and controls type 2 diabetes

Weight loss has a remarkable salutary effect on type 2 diabetes, both as a primary prevention strategy and in restoring glucose tolerance to normal in subjects with IGT and those with established diabetes. Recently landmark studies demonstrate that intervention programmes which bring about modest weight loss in overweight populations with IGT (who are at a high risk of type 2 diabetes), reduce the incidence of new diabetes by 58% over 4 years (17,18). In morbidly obese subjects in the SOS study the incidence of new diabetes also was dramatically reduced by bariatric surgery (5). Therefore, good evidence supports weight loss, including bariatric surgery, in diabetes prevention.

Traditionally, however, most physicians have been sceptical about medical treatment of obesity as a worthwhile strategy for glycaemic or cardiovascular risk control in type 2 diabetes. Among the reasons for this are the undeniable difficulties of non-surgical weight loss, and a conviction that type 2 diabetes is a largely irreversible disease. Insulin resistance and impaired insulin secretion are the key metabolic lesions of type 2 diabetes (19), and both are evident in newly diagnosed patients (20). The deterioration of insulin secretion and action that leads to diabetes is present for many years before the diagnosis of diabetes is finally made (21). Morphologic changes present in the islets of Langerhans (22) have lent additional support to the view that insulin secretory failure is well established and perhaps irreversible in most patients.

In contrast to this view, however, short-term experimental studies in overweight patients with type 2 diabetes clearly showed that weight loss can restore blood glucose and insulin sensitivity to near-normal levels (23). A variety of other mainly short-term studies using intensive dietary interventions (24–31), or diets supplemented with exercise (32) or behavioural therapy (33), also have demonstrated significant improvements in glycaemic control in obese patients with type 2 diabetes. Furthermore, epidemiological evidence suggests that intentional weight loss reduces mortality in people with diabetes (34). However, it has been far more difficult to reproduce these results in the clinical arena, where it is found that a minority of unselected patients with diabetes respond well to treatment for obesity, and many of those who do so initially eventually relapse, perhaps because of long-term difficulties in adherence to hypocaloric diets and maintenance of modified lifestyle (35). Thus, modest dietary weight loss of a magnitude that is currently realistic by non-surgical methods has a variable impact on glycaemic control, and only a proportion of diabetic patients have a worthwhile response (36). This certainly reflects clinical experience. One possible interpretation is that patients with advanced insulin secretory failure might respond less well to modest weight loss, and perhaps a far greater magnitude of weight loss is necessary to improve insulin sensitivity sufficiently to have a major impact on diabetes. It is also clear that the lifestyle and behaviours responsible for obesity and type 2 diabetes (37) are deeply ingrained and resistant to current medical approaches to treatment.

In conclusion, the view that type 2 diabetes is unresponsive to weight loss is at variance with some of the scientific evidence from weight loss studies both with and without bariatric surgery, which indicate potential reversibility in a significant proportion of obese patients. Weight loss, if it could be achieved in the real world, would be a highly worthwhile goal for most obese patients with type 2 diabetes. Although diabetic patients with more severe obesity do not usually lose and maintain weight well with non-surgical treatment, bariatric surgery seems far more effective in this patient group. Increasingly, bariatric surgery is being discussed as a realistic treatment option for at least some obese type 2 diabetic patients.

Metabolic impact of bariatric surgery in type 2 diabetes

The most remarkable single finding of the Greenville study, which was an uncontrolled observational series, was that 82.9% of 165 patients with type 2 diabetes at baseline remained in remission from diabetes after an average 14 years follow-up (6). The second major study with important data on this issue is the SOS study. The SOS study is a well-designed prospective study on obese patients

in which bariatric surgery was compared with a non-surgical comparison group. Treatment assignment is non-random in this study. Some 156 patients with type 2 diabetes were recruited into the SOS study. In this data set the number of patients not requiring drug treatment to maintain glycaemic control after 2 years in the surgical arm was about double that in the control group (38). Although less dramatic than the Greenville experience, these results are still far more impressive than anything physicians currently offer. A variety of other smaller studies (39–45) support the general findings of Greenville and SOS. These data are summarized in Table 1. The studies included here were all identified by Medline search, and are those containing original data on outcomes in patients known to have diabetes. By the nature of some of these reports, several contained few details on the patients with diabetes and few if any metabolic data, and so a formal meta-analysis is not possible. The results of these studies are consistent in suggesting that many – although it should be noted not all – patients with type 2 diabetes can reduce or stop their diabetic medication after bariatric surgery. The problem that is frequently overlooked by commentators in this field is that none of these studies were designed specifically to test the efficacy of bariatric surgery as a treatment for diabetes and in patients with diabetes. The recruitment of patients with diabetes into these studies was haphazard or unintentional. The diabetologist will note that many patients were identified as having diabetes only at baseline screening, and therefore, they do not necessarily resemble the typical type 2 diabetic clinic population with emerging macrovascular disease. In a retrospective analysis, the Greenville investigators observed that life expectancy was improved in a group of obese type 2 patients undergoing bariatric surgery, compared with obese diabetic patients not undergoing surgery. Unfortunately, the groups were not well-matched, and so it has remained uncertain whether life expectancy is indeed increased (46). Lastly, there are no data on the key issue of the impact of bariatric surgery on the progression of microvascular complications – an essential endpoint for any diabetes treatment study. It is also questionable whether previously diabetic patients could ever be discharged permanently from follow-up. Thus, the cost-utility implications of bariatric surgery for diabetes are unclear and ought to be investigated.

Bariatric surgery has favourable effects on cardiovascular risk factors – undoubtedly another reason to consider this treatment for patients with diabetes. Gleysteen and colleagues reported the beneficial effects of gastric bypass (GBP) on diabetes, hypertension and lipid profiles (8). The SOS study confirmed the impact of bariatric surgery, including both GBP and laparoscopic gastric banding (LGB), in large numbers of patients (5). Bariatric surgery also has a significant favourable impact on left ventricular hypertrophy and carotid artery intima-media thickness (47).

Although post-gastroplasty weight loss was clearly associated with a favourable change in insulin sensitivity and blood glucose levels in non-diabetic obese women when studied 14 months post-operatively (48), the data of Pories and colleagues suggested that improvements in insulin sensitivity and blood glucose levels in diabetic patients who had undergone GBP were apparent within one week of surgery, in advance of major weight loss (6). Therefore, weight loss is probably a surrogate marker for other mechanisms that improve insulin sensitivity and reduce insulin secretion. Caloric restriction, independent of adipose tissue

Table 1 Impact of bariatric surgery on medical treatment requirements for type 2 diabetes

n	Operation	Follow-up interval	Weight loss	Preoperative treatment for diabetes	Post-operative treatment for diabetes	Reference
165	GBP	7.6y	33%	N/S	83% 'remission'	6
23	Various	20 m	27.2 kg	Insulin *n* = 23	Insulin *n* = 7; reduced dose in *n* = 6	39
21	GBP	12 m	N/S	Insulin *n* = 21	Insulin *n* = 7	40
N/S	GBP	5y	N/S	Insulin/OHA 11.6%	Insulin/OHA 5.8%	41
12	Various	3–13y	N/S	Insulin *n* = 10	Insulin *n* = 2	42
24	VBG	28 m	30 kg	Insulin/OHA *n* = 7/22	Insulin/OHA *n* = 4/6	43
20	LGB	1y	N/S	N/S	14/20 'remission'	44
50	LGB	12 m	27 kg	Insulin/OHA *n* = 4/29	Insulin/OHA *n* = 4/8	45
119	Various	2y	28 kg	Insulin/OHA *n* = 8/40 Diet/no therapy *n* = 70	Insulin/OHA *n* = 6/16 Diet/no therapy *n* = 86	SOS*
	Non-surgical control group (*n* = 77)	2y	–	Insulin/OHA *n* = 3/32 Diet/no therapy *n* = 42	Insulin/OHA *n* = 5/44 Diet/no therapy *n* = 26	

GBP, gastric bypass; LGB, laparoscopic gastric banding; N/S, not stated; OHA, oral hypoglycaemic agent; VBG, vertical band gastroplasty; SOS, Swedish Obese Subjects.

*C.D. Sjöström personal communication, discussed in (38).

mass, is one candidate mechanism. Another important factor for glycaemic control after bariatric surgery may be the alterations in gut physiology that result from surgical bypass of the duodenum and proximal jejunum. Bypass procedures increase production of glucagon-like peptide-1 from the intestine, which promotes insulin secretion (49). Although this argument has been advanced to justify bypass procedures rather than gastric restrictive procedures in patients with diabetes, we are not aware of any randomized data specifically comparing diabetic endpoints following these two approaches. This is another study which is waiting to be performed.

Although major improvements, and frequently remission of diabetes often follow bariatric surgery, such improvements are not inevitable, perhaps implying that patients with specific characteristics may derive most metabolic benefit from bariatric surgery. The characteristics predicting a good glycaemic response are not clear, and if they exist it would be important to identify them. One factor that might affect the response of diabetes to bariatric surgery is post-operative dietary behaviour, because this is known to influence the final achieved weight. Another possibility is that insulin secretory failure and/or insulin resistance are less reversible with weight loss in some subjects than in others. In theory, insulin secretion and insulin sensitivity could be estimated from basal plasma insulin, homeostasis model assessment, or insulin response to glucose, although it has not been determined whether these parameters might predict the glycaemic response to bariatric surgery. Although a dramatic metabolic response can not be guaranteed, it is nevertheless clear that a high proportion of obese patients with diabetes derive substantial metabolic benefit from bariatric surgery.

Which surgical technique?

If the decision is made to employ bariatric surgery, what is the evidence that any one type of operation is superior for patients with diabetes? Bariatric operations fall into one of two groups; gastric *restrictive* procedures, and those that combine restriction of gastric size with a degree of *malabsorption*. The history and efficacy of these procedures has been reviewed in detail elsewhere (47).

Restrictive procedures

Purely r*estrictive* procedures limit the patient's capacity for food intake by creating a small pouch from the proximal stomach, just beneath the gastro-oesophageal junction. The pouch is constructed in such a way that it must drain via a narrow opening, which effects a degree of resistance to the emptying of solid food (although liquids empty normally). The most widely practised restrictive operation in the 1980s and early 90s was the vertical band gastroplasty (VBG), first reported by Mason in 1982 (50) (Fig. 1). More recently, the VBG has been superseded largely by LGB, a 'keyhole' technique which avoids stomach stapling and does not permanently alter gastric anatomy (Fig. 2). Laparoscopic gastric banding has an excellent safety record with operative mortality approaching zero in many large series (44,51–56). Although some centres have experienced

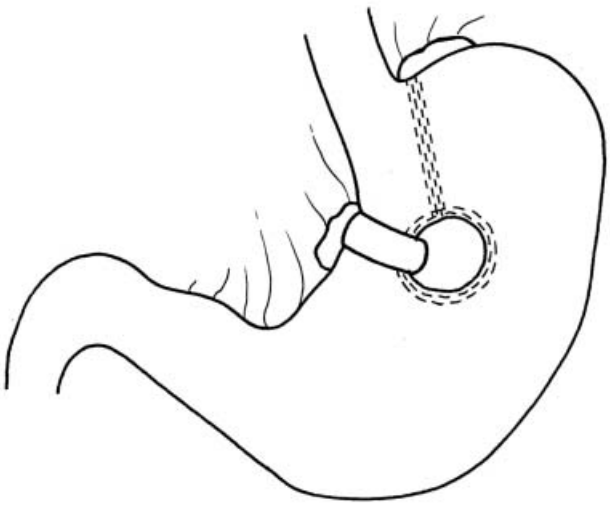

Figure 1 Vertical band gastroplasty (VBG).

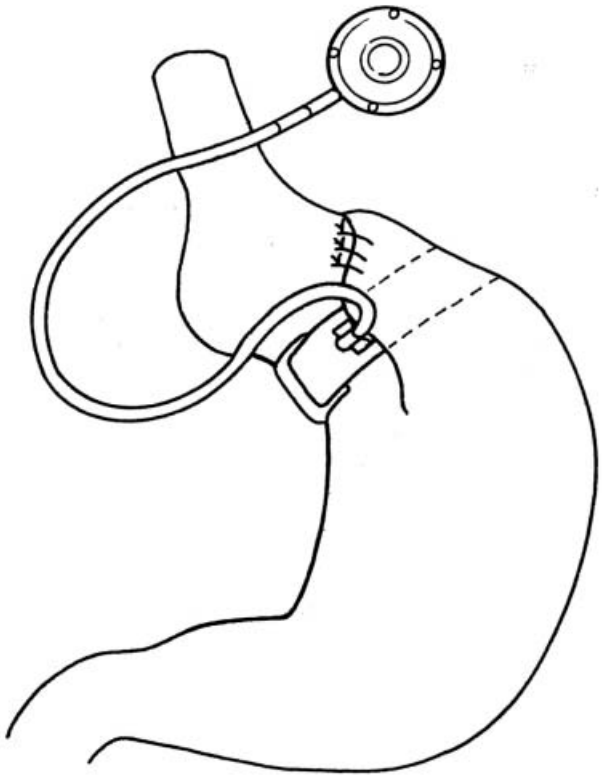

Figure 2 Adjustable gastric banding.

relatively high reoperation rates for minor problems (56), these probably decline as experience with the method increases.

Malabsorptive procedures

Malabsorptive procedures result in weight loss from malabsorption, usually with an element of gastric restriction. The first procedures of this type involved a long jejunoileal bypass. Unfortunately, the excellent weight reduction achieved was marred by an unacceptably high incidence of serious long-term complications such as protein and vitamin malabsorption, osteoporosis and liver failure (57). Although these operations were abandoned in the early 1980s, a certain stigma became attached to bariatric surgery, which still persists today to some extent. In contrast, GBP (58) (Fig. 3) and biliary pancreatic diversion (BPD) (59) (Fig. 4) are two malabsorptive operations that have proven much more successful. Gastric bypass is currently more widely performed, and is widely considered the safest of the malabsorption procedures. Gastric bypass is performed in combination with the creation of a gastric pouch to produce an element of gastric restriction (60). Although GBP is a safe operation, perioperative mortality is somewhat higher than with LGB. Gastric bypass is, increasingly, being performed by using laparoscopic techniques, and this has the potential to reduce further the post-operative recovery time and complications such as incisional hernia. However, a variety of significant long-term complications of GBP were encountered in the Greenville series including vitamin B12 deficiency (40%), anaemia (39%), incisional hernia (24%), cholelithiasis (11.4%), staple line failure (15%), and 38% of patients were readmitted to hospital at some time during follow-up (32). Cholecystectomy can be undertaken concurrently to prevent cholelithiasis becoming a problem. However, these results highlight the need for surgical expertise, long-term micronutrient replacement and life-long follow-up. Clearly, bariatric surgery should not be considered lightly as a primary treatment for diabetes.

The malabsorptive procedures generally result in 10–20% more weight loss than the purely gastric restrictive procedures, as was illustrated in the SOS study (47), and so it is widespread practice to offer malabsorptive procedures to more obese patients, such as those with BMI > 50 kgm^{-2}. However, individual centres and surgeons often specialize in one type of procedure with which they

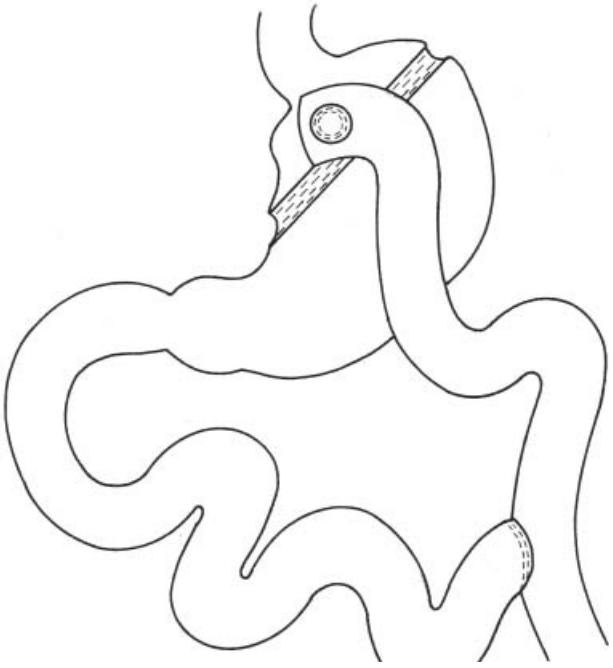

Figure 3 Gastric bypass (GBP).

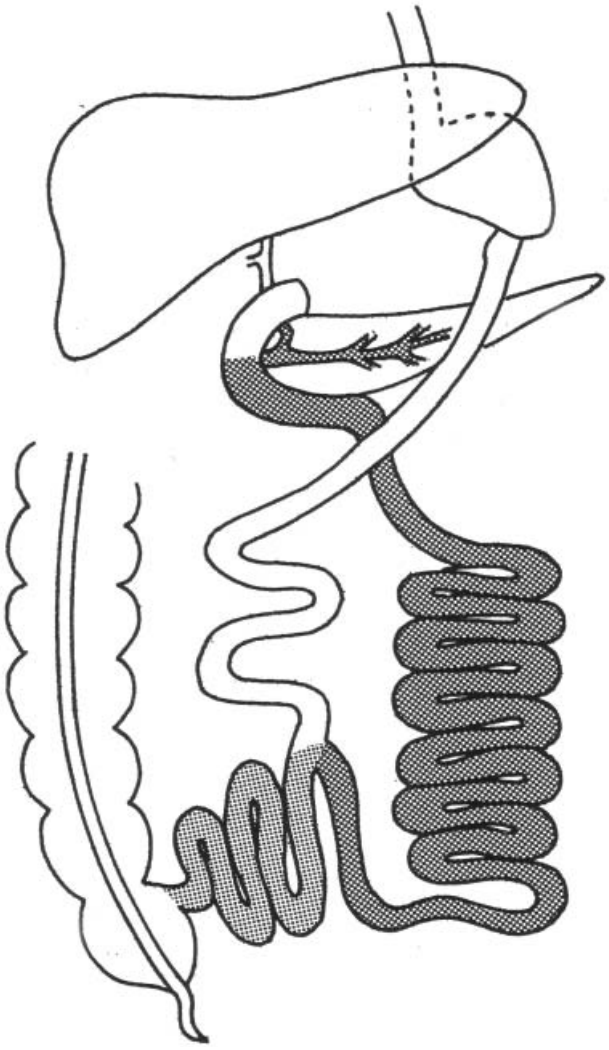

Figure 4 Biliary pancreatic diversion (BPD).

have built up most experience. It is debatable whether the various bariatric procedures vary significantly in their suitability and efficacy in patients with diabetes. It is a widely held view in the surgical world that patients with diabetes and people who eat lots of sweet foods may benefit more from malabsorptive rather than purely gastric restrictive procedures. However, the evidence for the superiority of any one procedure in either of these groups is not strong. People who eat many refined carbohydrates often get 'dumping' symptoms after GBP and by a process of aversion this facilitates dietary re-education. Dumping is very common after GBP, occurring in some 71% of patients in the Greenville series, but is controlled by avoidance of refined carbohydrates (6). It is also unclear how much weight loss is needed to produce and maintain metabolic improvements in people with type 2 diabetes. If the answer were as much as possible, a malabsorptive procedure might be a better option. In more obese populations such as North America this argument might also be invoked. However, no prospective randomized study has been performed to examine this question properly. In summary, there is not currently any objective evidence in favour of gastric restrictive or malabsorptive procedures for patients with diabetes, and so the choice of operation generally depends on the existing BMI-based consensus criteria (61), the expertise and preferences of the individual surgeon, and the personal choice of the patient.

Selection of patients for surgery

Experience has suggested a set of selection criteria for all prospective bariatric surgery candidates. In 1986, Stunkard and colleagues (62), reviewing the psychological impact of bariatric surgery, emphasized the need for detailed informed consent for bariatric surgery, clear explanation of complication rates, and that few long-term outcome data were available and so long-term follow-up was essential. It was recommended that individuals with histories of alcoholism, drug misuse, or other serious psychiatric or psychological problems would be best excluded. This advice is no less pertinent to patients with diabetes. Although good prevalence data are lacking, disordered eating such as bingeing and carbohydrate craving may be more common in diabetic populations. Unless such behaviours can be modified, it is likely that patients will not achieve the best outcomes from bariatric surgery.

One of the current problems is whom to offer treatment from the many diabetic patients who might potentially benefit? Although this is a complex question, some practical suggestions can be made. Generally speaking, bariatric surgery has not been tested extensively in people aged >60 years or in children and adolescents, and pending further study bariatric surgery could not be advocated for treating diabetes in these groups. Although there is a consensus that bariatric surgery should be reserved for diabetic patients with BMI > 35 kgm^{-2} (61), about 24% of patients in our own secondary care diabetic clinic population have BMI > 35 kgm^{-2} and might potentially qualify. Although this figure is alarming, experience in the obesity clinic suggests that a significant proportion of obese patients are reluctant to consider a surgical treatment, even in the face of a poor response to medical treatment for weight loss. It is likely, therefore, that only a minority of potentially eligible diabetic patients would agree to surgery. An emphatic result in favour of surgery from a major controlled trial on diabetic subjects would probably be required to change this in most countries. Whether people of BMI < 35 would also benefit from bariatric surgery has not been determined, but this would be another particularly interesting and valuable study to perform. Imposition of an upper age limit would also restrict numbers considerably. In one study, patients over the age of 55 years had a threefold increased risk of serious complications from GBP (63), although it is possible (but unproven) that LGB may be safer in older diabetic patients. Until recently, there were also few data on bariatric surgery in severely obese adolescents, but a recent report suggests that good outcomes also can be achieved in this small but difficult group of patients (64). Taking into account all of these factors it is likely that a relative minority of diabetic patients would accept bariatric surgery as a treatment for diabetes.

Although modern bariatric surgery is safe, with operative mortality approaching 0% for LGB and usually <1% for GBP, and no specific problems for diabetic patients have been reported in the literature, it is important to note that most of the studies on diabetic patients are very small, and none were designed to examine safety issues in diabetic patients. Diabetic patients with multiple serious complications, particularly coronary heart disease, inevitably would pose an increased operative risk. Clinical and silent ischaemia are especially common in people with type 2 diabetes. It is not unusual also for patients with diabetes to be hospitalized occasionally with metabolic instability, and severe vomiting is often a feature of diabetic ketoacidosis and the hyperosmolar non-ketotic state. Whether gastric restriction might cause difficulties or dangers is uncertain. These are additional reasons why, in our view, more long-term experience is essential before large numbers of bariatric operations are performed specifically as a treatment for diabetes. Taken together, these various factors suggest that younger, fitter patients, without significant coronary heart disease might be the group with most to gain from bariatric surgery. This suggestion could be tested by prospective randomized controlled studies.

Finally, it will be important for future research to explore whether there are any specific patient characteristics that predict a favourable metabolic response to bariatric surgery as a treatment for type 2 diabetes. Type 2 diabetes arises

as a result of the combination of deteriorating insulin sensitivity and insulin secretory reserve (65). It is known that patients with type 2 diabetes have already had diabetes for many years at the time of presentation (66), and this group already has markedly impaired insulin secretion (20). It is apparent from the studies cited in this review that not all patients achieve treatment withdrawal after bariatric surgery, and it is possible that these may be individuals with more severe insulin secretory failure or more impaired insulin sensitivity, which are not sufficiently improved by weight loss. The metabolic lesions might be expected to be more reversible in more recent-onset type 2 diabetes, but this should be tested. Persisting high caloric intake may be another factor detrimental to diabetes remission, because insulin sensitivity is impaired in the presence of high caloric intake (67).

Conclusions and recommendations

We draw the following conclusions about the appropriateness of bariatric surgery *as a treatment for diabetes* in obese patients. Although the impact of bariatric surgery on type 2 diabetes in obese patients is impressive, this evidence comes from diabetic patients who have undergone bariatric surgery primarily for other reasons. Whether bariatric surgery should be suggested to obese people with new or existing diabetes, specifically to control their diabetes, is a different question. In order for this question to be answered in the affirmative, bariatric surgery would have to be shown to have more favourable long-term effects on diabetes-specific endpoints. Although it is plausible that this may be the case, there are currently no data to prove this hypothesis. Therefore, scientific evaluation of bariatric surgery in the treatment of type 2 diabetes has become a priority.

The place of bariatric surgery in the treatment of an obese patient with, or at risk of diabetes will be strongly influenced by the willingness of physicians to accept weight loss as a feasible treatment goal. Bariatric surgery, which offers the possibility of preventing diabetes and of achieving a durable diabetes remission, could change current opinions. An important question that will influence the acceptance of bariatric surgery is how much weight loss is required to make a major impact on co-existing diabetes? Whereas it is likely that modest weight loss of 5–10% through non-surgical treatment in overweight and grade I obese subjects will prevent a substantial proportion of diabetes, and it is possible that this might also apply to morbidly obese subjects, clinical experience suggests strongly that modest weight loss is usually inadequate to make a substantial impact on already-established diabetes in those with morbid obesity. Therefore, diabetic patients who are more severely overweight (e.g. BMI > 35), and who fail to achieve sufficient weight loss using non-surgical approaches, and who fail to derive significant metabolic benefit (e.g. major treatment reductions or remission), might be considered for bariatric surgery. Given the apparently limited impact of non-surgical weight loss strategies on glycaemic control in obese diabetic patients (68,69), it is possible that non-surgical strategies, including current anti-obesity drugs, will turn out to have relatively little to offer in terms of treatment withdrawal or diabetes remission in obese diabetic patients. This draws into question whether there is much point in subjecting obese diabetic patients (especially those with BMI > 35) to long-term non-surgical treatments that are both arduous and ultimately expensive. Once again, these questions could be resolved by a prospective randomized controlled trial.

Other important questions for clinical trials are whether an arbitrary cut-off for surgery at BMI 35 is justifiable for all patients with diabetes – a patient with BMI 32 might have a far better response than a more obese patient who is currently eligible. Thus, an ability to predict the likelihood of a good metabolic response to surgery could enhance patient selection and counselling. Another major question is whether procedures involving bypass of the foregut are superior to purely gastric restrictive procedures, taking into account all of the risks and complications. Last, but by no means least, the long-term cost-effectiveness of bariatric surgery in the treatment of diabetes remains unknown. From the health economic perspective it would be important to know whether resources required for bariatric surgery could be saved from rapidly spiralling medical budgets for diabetes.

Given the number of unanswered questions, in our view it would be premature and inappropriate to recommend bariatric surgery on a large scale as a treatment for diabetes. Therefore, current evidence could support only limited

Table 2 Possible indications and contraindications for bariatric surgery in obese patients with type 2 diabetes

Suggested current indications for bariatric surgery in type 2 diabetes
BMI > 35
Younger patients (e.g. age < 60)
Recent diagnosis
Failure to lose weight with conventional treatment
Highly motivated
Other metabolic syndrome risk factors
Favourable anaesthetic/surgical risk
Recommended contraindications to bariatric surgery in type 2 diabetes
Coronary Heart Disease (both clinical and silent)
Advanced nephropathy
Eating disorders and alcoholism
Poor motivation and social support
Untested potential indications for bariatric surgery in type 2 diabetes
Grade I obese (BMI 30–35)
Obese elderly (age > 60)
Obese adolescents

BMI, body mass index.

Table 3 Key unresolved questions about bariatric surgery as a treatment for diabetes in obese type 2 diabetic patients

- How much weight loss is needed to control type 2 diabetes?
- Is any one type of procedure superior for diabetes?
- What is the long-term safety of bariatric surgery, as compared with medical treatment, for diabetes?
- What are the long-term economic consequences and effects on diabetes-related quality of life of adopting surgical treatment?
- Is it possible to predict the metabolic response to surgery?
- Could medical anti-obesity treatments play a role in the treatment of some obese patients with diabetes?
- What are the long-term effects of bariatric surgery, compared with medical treatment for type 2 diabetes, on diabetes-specific endpoints?
  - Glycaemic control
  - Microvascular disease endpoints
  - Cardiovascular risk factors
  - Cardiovascular disease events
  - Diabetes-related and total mortality
- What types of diabetic patients would be most suitable for bariatric surgery?
  - Young obese?
  - Everyone?
  - Should there be an upper age limit?
  - Should there be a lower BMI-limit for surgery?
  - What is the safety of bariatric surgery in *typical* obese diabetic patients with overt or underlying heart disease (who are poorly represented in clinical trials undertaken so far)?

BMI, body mass index.

use of bariatric surgery for the sole indication of controlling type 2 diabetes in selected patients (BMI > 35). If bariatric surgery is considered, however, the operative risks should be acceptable, and before giving consent patients need to be aware of all risks and the paucity of detailed long-term data. In Table 2 we suggest possible indications and contraindications for bariatric surgery in obese patients with type 2 diabetes, and Table 3 summarizes the principal unresolved questions about this type of treatment. Naturally, while these questions are being answered it is hoped that measures to prevent obesity and diabetes in the population may limit the future need for this type of treatment.

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